



Building Better

How High-Efficiency Buildings Will Save Money and Reduce Global Warming

ENVIRONMENT
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Executive Summary

America is the largest consumer of energy in the world, and the majority of this energy comes from dirty and dangerous sources like coal, oil, natural gas, and nuclear power. Our continued reliance on these fuels contributes to global warming, undermines our energy independence, and costs American families and businesses more and more money every year.

We can save money and help solve global warming by reducing the amount of energy we use, and the best place to start is in the buildings we live and work in every day. Over 40 percent of our energy—and 10 percent of all the energy used in the world – goes toward powering America's buildings[1], but it doesn't have to be this way. Today's high-efficiency homes and buildings prove that we have the technology and skills to drastically improve the efficiency of our buildings while simultaneously improving their comfort and affordability. If we apply those lessons to all buildings, we can reduce overall building energy consumption 35 percent by 2030 and 50 percent by 2050.

A recent study by the National Academy of Sciences confirmed that these goals are well within our reach.[2] We can achieve them by implementing an aggressive two-part strategy that sets bold efficiency standards for new buildings and encourages retrofits to improve the efficiency of the buildings we already have.

Because building operations are responsible for such a huge proportion of our energy use, making buildings more efficient is a great way to work on a number of energy-related problems at once. This report analyzes the effects of meeting those efficiency goals and provides state-by-state data on the economic and environmental benefits as compared to a business as usual scenario.

Investing in building efficiency would go a long way toward reducing our energy use, yielding the following benefits:

- A 15 to 20 percent reduction in fossil fuel use in our buildings by 2020, with that reduction increasing to 40 to 60 percent by 2050. We can also cut our overall natural gas consumption from all sectors by almost 10 percent.

- Reducing building energy use over 20 percent by 2020, saving enough energy every year to provide power to almost 100 million homes.[3]

- By 2050, saving almost 5 quadrillion BTUs of energy every year, which is enough power to meet the total residential and commercial energy needs of 12 U.S. states.

Table 1. Top Ten States for Residential Energy Bill Savings in 2050

Top ten average savings on energy expenditures for a family of four	
1. Maine	$3,207.16
2. Vermont	$3,066.97
3. New Hampshire	$2,862.22
4. Pennsylvania	$2,675.03
5. Massachusetts	$2,603.59
6. Rhode Island	$2,545.26
7. Arkansas	$2,533.93
8. Connecticut	$2,523.78
9. Oklahoma	$2,521.12
10. New York	$2,498.68

Thanks to this reduction in energy use, Americans will reap great financial benefits as a result of lowered energy expenditures:

- Reducing energy bills by over 20 percent by 2020, saving $150 to $200 per person every year.
- By 2050, saving American families over $80 billion a year in residential energy spending alone, which means average annual savings of over $800 per family compared to what they pay today.

Minimizing building energy consumption will also reduce our global warming emissions. For example:

- Cutting our projected global warming pollution from buildings almost 20 percent by 2020.
- By 2050, preventing the emission of 1.8 billion tons of carbon dioxide every year, more than Germany's total annual emissions.

Table 2. Top Ten State Annual Emissions Reductions in 2050

Top ten absolute reductions in annual global warming pollution (MMT CO2E)		Top ten percentage emissions reductions compared to 2010	
1. Texas	173.1	1. Wyoming (tied)	37%
2. Florida	154.7	1. North Dakota (tied)	37%
3. Ohio	97.3	3. Iowa	36%
4. New York	87.1	4. Nebraska	34%
5. California	84.4	5. Montana	34%
6. Michigan	83.2	6. Connecticut	34%
7. Illinois	80.3	7. Rhode Island	34%
8. North Carolina	69.3	8. Maine	33%
9. Georgia	66.5	9. Massachusetts	33%
10. Pennsylvania	60.3	10. South Dakota	33%

- Bringing America's total building-related emissions 25 percent below our current levels by 2050.

Achieving these benefits will require strong policies that promote energy efficiency in buildings:

- Building codes should be steadily strengthened so they are 30 percent more efficient in 2012 and 50 percent more efficient in 2018, with the goal of a zero net energy standard by 2030. The federal government should provide states with resources to implement and enforce codes.

- Governments at all levels should expand programs that invest in energy retrofits and weatherization with the aim of reaching a 30 percent improvement in the efficiency of existing buildings by 2030.

Introduction

As America enters a new decade, we are facing a number of serious challenges. 85 percent of our energy comes from dirty fossil fuels like coal and oil, and we're projected to spend another $23 trillion dollars on these polluting energy sources over the next twenty years.[4] Not only does this increase our reliance on imported fuels, but rising energy costs are burdening families at a time of widespread economic hardship. In fact, almost 20 million American households struggle to pay their energy bills, and some of them spend months without heat every year.[5] Meanwhile, legislators at all levels of government are looking for ways to take action on the growing threat of global warming to help meet President Obama's goal of reducing emissions 17 percent by 2020.

These challenges may seem unrelated, but there's an underlying problem that contributes to all three of them: right now, America's buildings consume far too much energy, most of which comes from finite and polluting fossil fuels. The buildings we live and work in account for about 40 percent of our total energy consumption and more than 70 percent of our electricity use, and this level of energy use costs the U.S. approximately $400 billion every year.[6]

This high rate of energy consumption also results in the release of millions of tons of global warming pollution into the atmosphere, deepens our dependence on fossil fuels, and puts a huge financial burden on Americans at a time of severe economic distress. Worst of all, much of the energy used in our buildings is simply wasted due to insufficient insulation, inefficient heating and cooling systems, or poor design.

The good news is that it doesn't have to be this way. We have the ability to drastically reduce our buildings' energy use, and there are already tens of thousands of such high-efficiency buildings all around the country.

Unlike many public policy challenges, energy efficiency investments generate a positive cash flow that more than covers their cost. What's more, the benefits for owners and occupants don't stop at reduced energy bills: it's well-documented that high-efficiency buildings stay occupied for longer, sell for a greater value, increase productivity, and improve the health of those who live, work, and study

Building operations are responsible for almost half of total U.S. energy consumption and greenhouse gas emissions.

in them.[7] As more and more buildings benefit from energy efficiency, the combined benefits create a ripple effect, with the result that implementing large-scale energy efficiency improvements would yield tremendous benefits for the nation as a whole.

With benefits at stake like lower energy bills, less need for imported fuels, or reduced global warming emissions, the time has come to take bold action. This report highlights those benefits, showing that every single state in the country has the chance to capitalize on building upgrades to take advantage of all the benefits energy efficiency has to offer. The final section presents a number of policy recommendations, outlining the steps we can take to improve our buildings, protect our environment, and revitalize our economy.

What We Can Achieve

In 2007, the town of Greensburg, Kansas was completely destroyed by a tornado. The town residents decided to use the disaster as an opportunity to rebuild their community better than ever, and made significant investments in renewable energy and highly efficient buildings. Today, a 12.5-megawatt wind farm supplies enough electricity to power 4,000 homes, and the buildings there consume on average 40 percent less energy than the buildings they replaced.[8] The residents of Greensburg made the most of a chance to maximize the efficiency of every building in their town. It's time we did the same for the hundreds of thousands of new buildings that go up every year in the United States.

Improving the efficiency of America's buildings offers us a great opportunity to reduce our energy use, including our reliance on dirty and dangerous fossil fuels. The National Academy of Sciences estimates that widespread implementation of today's technology would yield an efficiency increase of 25 to 30 percent by 2030, and with the rapid march of technological innovation and increased investment in efficiency from governments

A small wind turbine provides a source of clean, renewable energy for this building's operations. Credit: renaissanceronin.wordpress.com and consumers, much bigger gains are certainly possible.[9] If we take strong action now, we can reduce our overall energy use in buildings 35 percent by 2030 and 50 percent by 2050.

To get there, we must commit ourselves to an aggressive plan to dramatically improve the energy performance of our nation's buildings, a two-part strategy that will strengthen the energy efficiency requirements for new buildings being built, while at the same time improving the efficiency of the buildings we already have. Setting a 2030 target for making all new buildings zero net energy and making all existing buildings 30 percent more efficient would put us on track to meet our building energy reduction goals and to take advantage of all the economic and environmental benefits energy efficiency has to offer.

Building Codes: Locking in Savings for New Buildings

The best time to invest in a building's energy efficiency performance is when it's first being built. Some major opportunities for energy savings can only be realized if they're designed into the shape and features of the building. Others, like efficient water heaters, insulation, and energy-saving lighting systems, are much easier and much cheaper to install when a building is constructed than to make those same modifications in a building that's already fully built.

For a long time, forward-thinking homebuilders all around the country have been designing and constructing buildings that use far less energy than typical buildings of similar size. In 1998, for example, two homes with the same floor plan were built in Lakeland, Florida. The only difference between them was that one home was built to meet the standard Florida building code, while the other was designed to maximize energy efficiency with features like better wall insulation and high-efficiency lighting and appliances. Over the course of the next year, the energy-efficient home consumed 70 percent less energy than its built-to-code counterpart. When a solar panel was installed on the roof, its energy use dropped to less than 10 percent of what the other house consumed.[10]

That was 1998. As energy efficiency and renewable energy technology has improved, so has our ability to drastically reduce the energy needs of our buildings. In 2006, Habitat for Humanity set out to build a high-efficiency home in Wheat Ridge, Colorado. It wasn't a mansion commissioned by a wealthy family, but a moderately sized home built for a single mother and her two sons. In the end, the house was so efficient that the solar panel on its roof produced more energy than the house consumed. Projects like these demonstrate that zero net energy buildings are not a dream waiting to be realized; there are already tens of thousands of them all around the country.[11] If Habitat for Humanity can find a way to build them, then surely they're within the reach of large homebuilders and developers.

Logan Wiggins House 3, pictured here, is a zero net energy home in in Boulder, Colorado. It was designed by Jim Logan Architects to be carbon-neutral and to produce more energy than it consumes. Credit: jlogan.com

Setting a strong standard for new buildings is critical because over 40 percent of the homes America will need in 2050 haven't been built yet.[12] Committing to a zero net energy standard by 2030 means that within 20 years, every new home and office building will be so efficient that it can produce as much energy as it consumes by tapping into clean, renewable sources right on-site. Rather than paying high energy bills, the owners of these buildings can actually make money by selling their excess power back to the utility companies. Rather than having to build new power plants to provide electricity to thousands of new homes, we can allow zero net energy buildings to feed their extra power back into the grid to help charge plug-in cars or power streetlights. The imperative for swift action on building codes is clear: the average building lasts for over 40 years, so enacting strong codes today lets us lock in energy savings for decades to come.[13]

Retrofits and Weatherization: Maximizing the Efficiency of Existing Buildings

New buildings can be designed to minimize their energy use from the beginning, but there are substantial gains to be made in the millions of buildings we already have. Many of our existing buildings are poorly insulated or rely on outdated technologies for lighting, heating, and cooling, so energy retrofits to improve the efficiency of older or poorly designed buildings can reap significant energy savings.

For example, almost a fifth of American homes are heated by furnaces that are more than 20 years old, and these furnaces require almost twice as much energy as newer models.[14] This explains why basic retrofits that replace old technology and seal leaks in attics and windows typically reduce household energy use by 20 to 30 percent. A more intensive, whole-building approach known as a deep energy retrofit can achieve energy savings of well over 50 percent,[15] which shows just how much energy we waste in our buildings today.[16] We can achieve a 30 percent reduction in the energy use of our existing buildings by 2030 by employing these techniques, and best of all, these improvements pay for themselves over time through reduced energy bills.

The city of Portland, Oregon created the Block-By-Block Weatherization Program to provide free weatherization to approximately 120 low-income homes every year. Simple things like weatherstripping windows and doors reduced families' energy consumption by an average of 15 percent and saved them $100 a year on their energy bills. By 2030, the Weatherization Program will have saved Portland residents an estimated $2.5 million.[17] We

Simple retrofits that implement energy-saving solutions like sealing windows and doors can reduce a home's energy use by 30 percent and save the occupants hundreds of dollars on energy bills. Credit: www.icra.org need to create and expand programs like this one so Americans everywhere can reap the benefits of energy efficiency.

Families and businesses can get an energy audit and schedule their own retrofits at any time, but energy efficiency improvements are especially easy to include as part of regular renovations, which typically involve work on walls, floors, and electrical and heating systems anyway. By increasing awareness and funding for retrofits, we can take advantage of the huge potential for hidden energy savings in buildings all over the country.

Protestors demand increased funding for green jobs like the ones proposed in Vice President Biden's "Recovery Through Retrofit" report. Credit: www.atlantaprogressivenews.com

Making it Happen

Public officials at all levels of government are starting to recognize the importance of investing in energy efficiency, and early examples of successful policies encourage legislators in other states to follow suit. In 2006, the U.S. Conference of Mayors adopted a resolution endorsing an aggressive schedule of improved building codes to achieve a zero net energy standard by 2030, as well as encouraging the inclusion of energy retrofits in all regular building renovations.[18] In October of 2009, President Obama signed an Executive Order calling for all new federal buildings to be zero net energy by 2030,[19] and a few weeks later, Vice President Joe Biden partnered with the Council on Environmental Quality to release a report outlining the benefits of investing in large-scale retrofits for America's buildings.[20]

Initiatives that echo these goals are being put in place in states all around the country. In 2008, Maine Governor John Baldacci passed a comprehensive energy package that aims to weatherize all homes and 50 percent of commercial buildings by 2030.[21] The city of Austin, Texas recently passed an ordinance requiring time-of-sale energy audits for all buildings and mandating energy retrofits for the buildings that fail to meet minimum efficiency standards.[22] In Massachusetts, Governor Deval Patrick established the Zero Net Energy Buildings Task Force, which produced a report in early 2009 recommending that Massachusetts set a goal for zero net energy construction techniques within the next two decades.[23]

Legislators everywhere are taking advantage of the enormous potential to save money and cut pollution by investing in the efficiency of our buildings, both by designing highly efficient new buildings and improving the efficiency of the ones we already have. What we need now is a coordinated strategy that combines federal, state, and local policies to secure the maximum possible energy savings for the country as a whole.

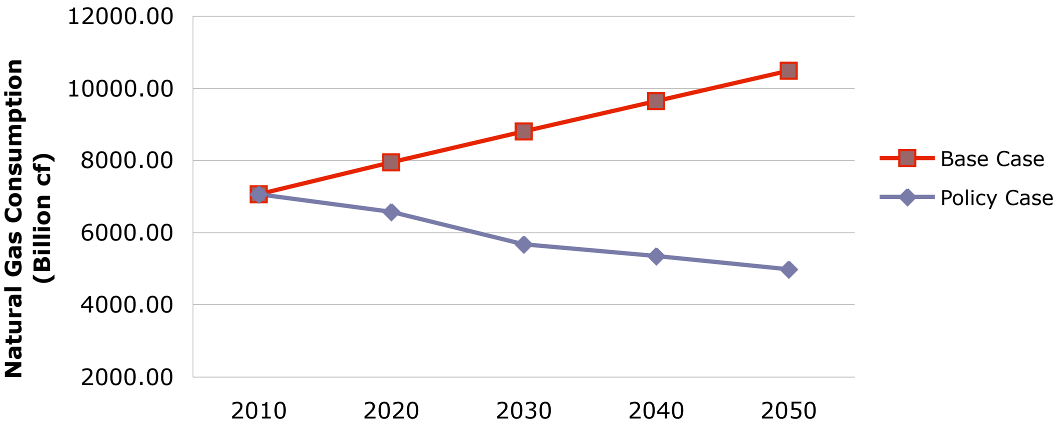
Avoiding Pollution and Saving Money

See Appendices for full state-by-state and national data.

Improving the energy efficiency of our buildings is a great way to work on a number of problems at once. Reducing our energy demand allows us to lessen our dependence on imported oil, as well as our need for dirty sources of power like coal-fired power plants. As we decrease overall demand by investing in energy efficiency and increase our reliance on renewable sources of energy like wind farms and solar power, we can finally cure our long-standing addiction to fossil fuels.

For example, about a third of America's natural gas consumption is used in our buildings for space heating and hot water, but energy efficiency improvements can significantly reduce our need for this polluting source of fuel.[24] As Figure 1 shows,

Figure 1. Natural Gas Consumption in Buildings



Note: In the figures in this section, the "Base Case" refers to a business as usual scenario in which buildings continue to be constructed as they were in the 2000s. The "Policy Case" line shows the projected impact of meeting the energy reduction targets laid out in the previous section.

Reducing New England's Dependence on Oil

Over 8 million households in America rely on oil to heat their homes, and almost 80 percent of those homes are in the northeast region of the country.[25] Making our buildings more efficient would cut almost half our building-related fuel oil use, which represents major savings for states that rely heavily on oil for heating. In New England, for example, investing in efficiency could reduce total oil usage for all sectors (including transportation) by almost 15 percent.[26]

we can reduce projected natural gas use in buildings almost 20 percent over the next 10 years. By 2050, we'll cut our usage in half, which amounts to a reduction of almost 10 percent of our total natural gas consumption from all sectors today. The saved natural gas would be enough to provide heat to over 75,000 homes, showing that building efficiency can put a serious dent in our use of this dirty power source.[27]

Shifting away from fossil fuels will cause a dramatic reduction in our emission of dangerous global warming pollution. Right now, building operations are responsible for nearly 40 percent of U.S. carbon dioxide emissions, so reducing the energy use of our buildings is a critical part of our efforts to stop global warming.[28] Figure 2 shows us that efficiency improvements could make a big difference right away, cutting projected annual global warming pollution from buildings almost 20 percent by 2020. Projected reductions increase to 55 percent over the next 40 years, bringing emissions down more than 25 percent below our current levels. By 2050, these investments would prevent the emission of more than 1.8 billion tons of carbon dioxide every year, which is more than the total annual emissions from all sectors in countries like India, Japan, and Germany.[29]

Figure 2. Global Warming Pollution from Buildings

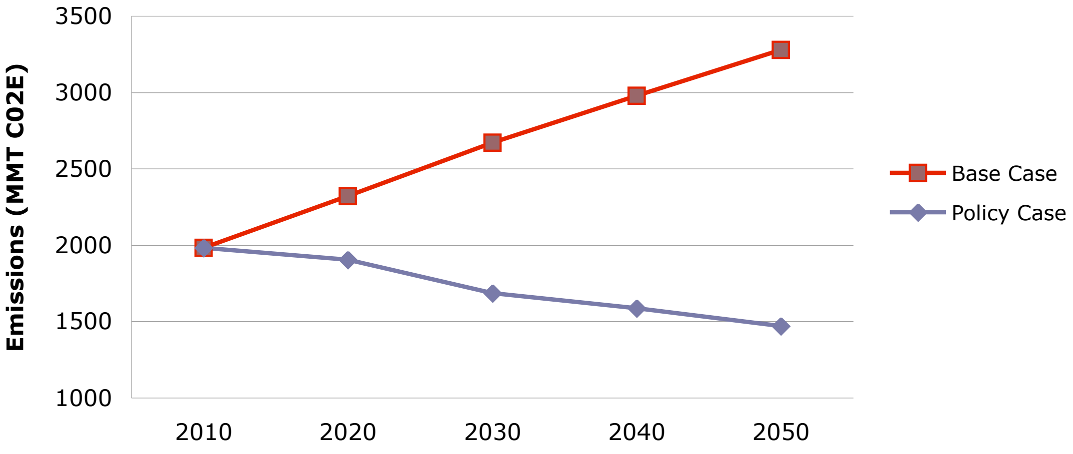


Table 1. Top Ten State Annual Emissions Reductions in 2050

Top ten absolute reductions in annual global warming pollution (MMT CO2E)		Top ten percentage emissions reductions compared to 2010	
1. Texas	173.1	1. Wyoming (tied)	37%
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4. New York	87.1	4. Nebraska	34%
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6. Michigan	83.2	6. Connecticut	34%
7. Illinois	80.3	7. Rhode Island	34%
8. North Carolina	69.3	8. Maine	33%
9. Georgia	66.5	9. Massachusetts	33%
10. Pennsylvania	60.3	10. South Dakota	33%

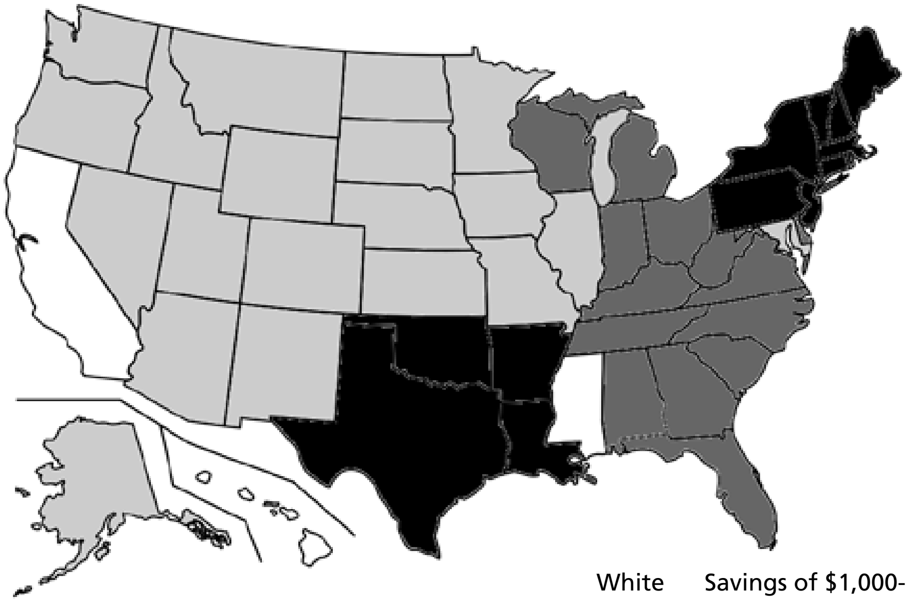
For consumers, reduced energy use means money saved in the form of lower energy bills. That's the best part about making energy efficiency improvements: they pay for themselves many times over as consumers reap the financial benefits of decreased energy use year after year. Investing in energy efficiency would cut Americans' energy bills by 20 percent over the next 10 years, with savings increasing to over 50 percent by 2050. This would save the average family of four more than $800 a year on energy costs compared to what they pay today. The savings are even higher when compared to a business as usual scenario in 2050, and Figure 3 shows how those savings vary by state. Even states like California, which have already invested heavily in energy efficiency and enjoy moderate climates, can expect savings of over $1,000 per household. For families in states with older buildings that rely on outdated oil heating like those in the Northeast, the savings are as high as $3,000 a year.

There are also huge efficiency-related savings on the commercial side. As Figure 4 indicates, businesses stand to save almost $200 on energy per worker every year by 2020. By 2050, the savings increase to $850 per worker, which represents a 60 percent reduction in projected energy expenditures. What's more, it means saving $300 per worker compared to what they pay today, which benefits companies of all sizes. From small businesses with five employees up to large firms with 500, those numbers really add up. Both for families and for businesses, choosing energy efficiency just makes economic sense.

Additional Savings

In addition to cutting energy use in buildings, efficiency improvements also reduce the amount of electricity lost in transmission. As electricity travels along power lines, almost 10 percent of it is lost in transit and gets used up along the way.[30] The less energy we use in our homes and office buildings, the less electricity we need to send along the power lines, and the less energy will simply disappear through

Figure 3. Prospective Annual Residential Savings For a Family of Four in 2050



White	Savings of $1,000-1,400
Light gray	Savings of $1,400-1,800
Dark gray	Savings of 1,800-2,200
Black	Savings of $2,200+

See Table 2 for state numbers

Table 2. Average State-by-State Savings on Energy Costs for a Family of Four in 2050

WHITE	
California	$1,241.67
Hawaii	$1,259.07
Mississippi	$1,387.96

LIGHT GRAY	
Iowa	$1,402.51
Kansas	$1,425.38
Utah	$1,436.32
Nebraska	$1,438.67
Minnesota	$1,459.16
South Dakota	$1,461.43
Alaska	$1,464.66
Missouri	$1,488.44
Oregon	$1,528.29
North Dakota	$1,530.20
Washington	$1,534.69
New Mexico	$1,602.11
Idaho	$1,650.09
Wyoming	$1,671.78
Montana	$1,689.99
Colorado	$1,713.68
Maryland	$1,722.59
Illinois	$1,731.91
Nevada	$1,764.11
Arizona	$1,769.21

DARK GRAY	
Virginia	$1,807.22
Georgia	$1,814.07
Ohio	$1,837.13
Michigan	$1,850.22
West Virginia	$1,872.46
Indiana	$1,878.92
Dist. of Columbia	$1,912.93
South Carolina	$1,916.55
Wisconsin	$1,930.20
Tennessee	$1,935.98
Alabama	$1,940.92
North Carolina	$1,988.74

BLACK	
Louisiana	$2,323.76
Texas	$2,408.55
New Jersey	$2,479.60
New York	$2,498.68
Oklahoma	$2,521.12
Connecticut	$2,523.78
Arkansas	$2,533.93
Rhode Island	$2,545.26
Massachusetts	$2,603.59
Pennsylvania	$2,675.03
New Hampshire	$2,862.22
Vermont	$3,066.97
Maine	$3,207.16

Colors correspond to Figure 3, above.

Figure 4. Per Worker Commercial Energy Spending

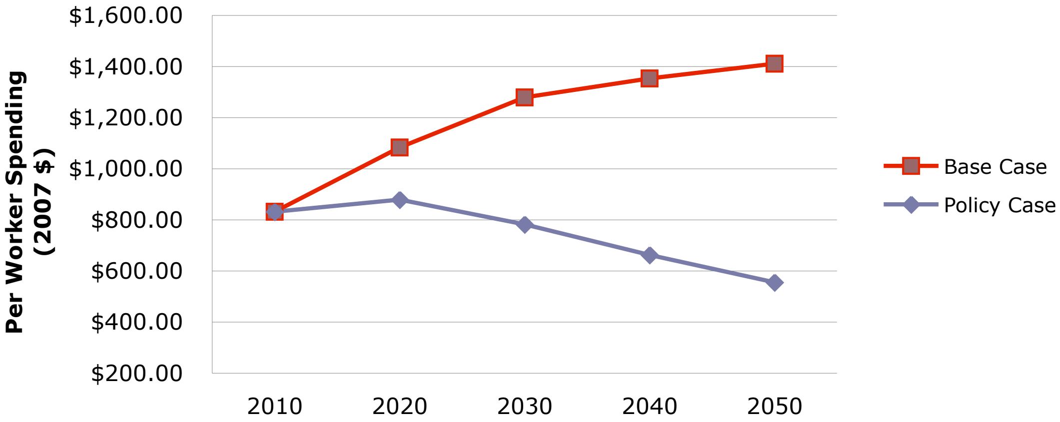
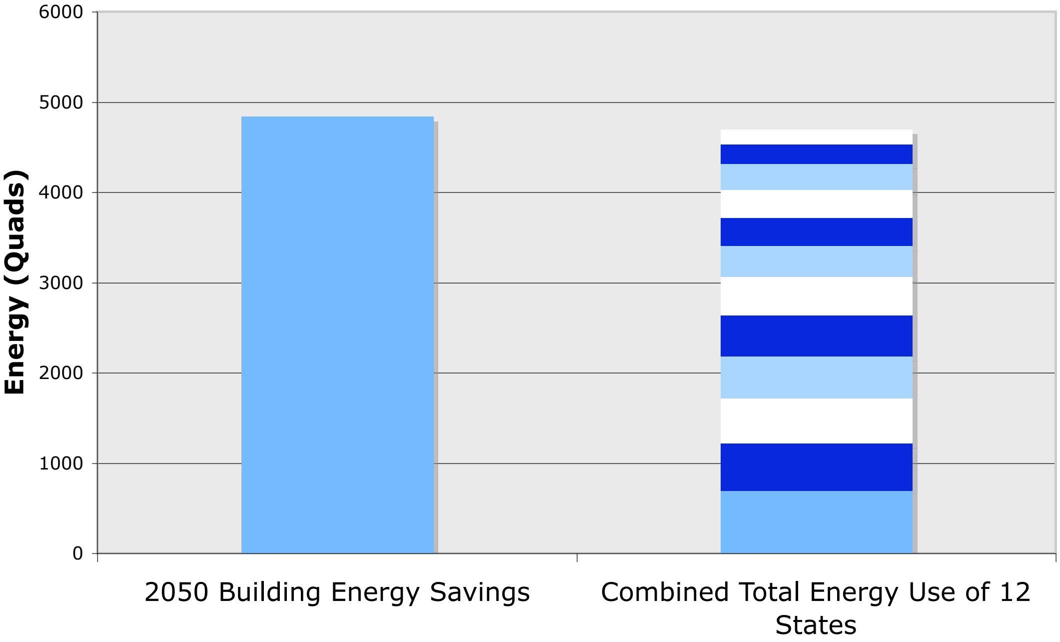


Figure 5. National Building Energy Savings in 2050



Note: The 12 states, in ascending order of energy use, are Vermont, Rhode Island, South Dakota, Delaware, New Hampshire, Hawaii, North Dakota, Maine, Montana, Wyoming, Idaho, and Nebraska.

transmission losses. This only increases the amount of money we save and the amount of pollution we prevent by making our buildings more efficient.

All told, making America's buildings more efficient would reduce America's energy consumption from buildings by over 20 percent in the next 10 years. By 2050, we can cut our building energy use by more than half, which brings us more than 25 percent below our current level of consumption. As Figure 5 indicates, this would save 4.84 quadrillion BTUs of energy every year in 2050, which is enough to meet the total energy needs of 12 U.S. states.[31]

These huge reductions in energy use translate into significant changes in our energy infrastructure over time as we eliminate the need to build new power plants and expand the electricity transmission network. Throughout our history, increases in population and economic prosperity have invariably resulted in a rising demand for energy, but now we're seeing a change: as the growth in our energy use slows and begins to turn around, long-planned energy development projects to meet anticipated increases in demand may no longer be needed.

In January, for example, a proposal for a 276-mile mid-Atlantic power line was put on hold due to a reduced forecast for energy demand. The scaled-down energy projections are due in part to developments like a $15 million rebate program for energy retrofits in Virginia and Maryland's new Greenhouse Gas Reduction Act, which increases investment in energy efficiency and renewable energy to reduce the state's greenhouse gas emissions 25 percent by 2020. The estimated cost for the Potomac-Appalachian Transmission Highline (PATH) project is $1.8 billion dollars, a price tag that the energy companies would end up passing on to consumers in the form of higher energy prices, so this represents another source of future savings over time.[32] Halting the construction of the transmission line will also prevent immense amounts of pollution by eliminating markets for dirty coal plants.

Policy Recommendations

With benefits like these at stake, it's clear that we should do everything we can to improve the efficiency our buildings as soon as possible. We know how to make super efficient new buildings, and there are already companies out there doing deep energy retrofits and saving consumers hundreds of dollars a year on their bills. We have the technology and skills to make this happen; what we need now are policies that will help pay for the upfront costs of energy efficiency investments and ensure that buildings and developers are taking advantage of all available efficiency improvements.

Here is a list of policies that will help us achieve our goals to guarantee a high level of energy efficiency in new buildings and maximize the efficiency of existing ones:

Building Codes: Locking in Savings for New Buildings

At the national level:

- The IECC and ASHRAE model building codes should continue improving so their efficiency measures are 30 percent more efficient in 2012 and 50 percent more efficient by 2018, with steady ramp-ups thereafter.

- The federal government should enact legislation to require all states to adopt these improved model codes or codes with at least an equivalent level of efficiency.

- The federal government should establish a nationwide goal for all new commercial and residential buildings to be zero net energy by 2030.

- Federal policies should provide funding for state-level programs that train code officials to administer and enforce the new standards.

Model Building Codes

Currently, building code adoption is a very decentralized process with states (and sometimes counties or cities) free to adopt their own regulations. These state and local codes are typically based on the national model building codes: the International Energy Conservation Code (IECC) and the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Standard 90.1. The IECC, which is updated every three years and has standards for commercial and residential construction, was last published in January, 2009. ASHRAE 90.1 is an alternative standard for commercial construction only, and the next update in its three-year cycle will be published later this year.

States are required under federal legislation (EPAct 1992) to adopt an energy code at least as stringent as the most recent national model codes, but they are permitted to opt out of this requirement, and most states have not kept up to date. Some automatically review and adopt the latest model codes each time they are published, others occasionally update their outdated codes on a more irregular schedule, and still others have no statewide code at all.

Regular adoption of the latest codes is a proven way to reduce energy use and save money. California has been at the forefront of code adoption since it instituted its first code in 1975, and the state recently enacted a statewide green building code that surpasses even the most recent IECC. By 2011, the California Energy Commission estimates that their building codes will have saved consumers $59 billion in electricity and natural gas costs.[33]

The 2009 IECC is more than 15 percent more efficient than the 2006 version, which is the largest efficiency increase in the code's history. For us to achieve our zero net energy goal by 2030, we need the model codes to continue improving their efficiency provisions, and we need the federal government to enforce policies requiring states to improve outdated building codes so we can take advantage of all that energy efficiency has to offer.

At the state and local level:

- States should enact legislation requiring review and adoption of the most recent model building codes when they are published and should set high goals for enforcement.

- Local jurisdictions should be allowed to adopt "stretch codes" with efficiency standards above the required statewide minimum.

- Code enforcement authorities should incentivize buildings that significantly exceed the minimum standards by offering expedited permitting or tax rebates. Expedited permitting could also be offered to builders who consistently demonstrate code compliance.

Success Story: Federal Standards Work

Building codes are set at the state level, but the American Recovery and Reinvestment Act passed by Congress in February 2009 required states to pledge adoption of the latest model building codes to be eligible for stimulus funding. As a result, 2009 saw the largest wave of adoptions in code history, with 13 states adopting new codes by the end of the year and almost 20 more currently in the process of doing so. These states accounted for 60% of all new U.S. housing in 2008, and while some states already had codes that met or exceeded the new federal requirements, many had policies that hadn't been updated in over a decade, and some had no statewide code at all.[34] Clearly, a federal mandate is the most effective way to guarantee minimum standards across the board.

Retrofits and Weatherization: Maximizing the Efficiency of Existing Buildings

At the federal level:

- Utilities should be required to invest in energy efficiency upgrades whenever doing so would cost less than adding extra generating capacity.

- The Home Star and Building Star programs should be established and funded to help consumers and business owners pay for energy efficiency improvements in their homes. These proposed programs would grant thousands of dollars in rebates to consumers and businesses that purchase efficiency upgrades.

- Federal funding should also be available for state and local programs that perform retrofits and weatherization.

- The federal government should promote energy efficient mortgages that allow borrowers to finance cost-effective energy-saving measures as part of a single mortgage.

At the state and local level:

- States should require energy efficiency audits at the time a building is sold, and the results should be disclosed to prospective buyers so they are aware of the building's energy performance.

- Programs should be established to help fund energy audits, weatherization, retrofits, and on-site renewable energy generation. Possible funding mechanisms include:

    - Direct subsidies to help lower costs

    - Tax rebates to consumers

Success Story:
The Massachusetts Green Communities Act (2008)

In addition to updating the state building code, the Green Communities Act established the Green Communities Program, which awards millions of dollars in grant funding to individual communities that meet a number of environmental criteria, most notably the enactment of a set of stretch building codes that are 15 percent more efficient than the state's already high minimum codes. The Act also requires utilities to offer rebates for customer efficiency upgrades when doing so would cost less than generating the extra electricity. These measures are expected to reduce fossil fuel use in Massachusetts' buildings by at least 10 percent over the next 10 years.

  - o Low-interest loans that consumers can pay back as they begin to reap the benefits of lower energy bills
  - o Property assessed clean energy (PACE) bonds, in which the costs of renewable energy and energy efficiency improvements are repaid over several years via an annual assessment on the property taxes, significantly lowering the price of the initial investment.

- States should establish energy performance benchmarking systems to educate consumers about building energy use. The information about energy performance should be made available to a building's occupants and to potential buyers at time of sale.
- States should expand programs that offer free or heavily discounted weatherization and retrofits to low-income families.

Success Story: The Weatherization Assistance Program

The Department of Energy's Weatherization Assistance Program (WAP) was created in 1976 to assist low-income families who lacked the resources to invest in energy efficiency. Since then, it has funded the weatherization of over 6 million homes, with an average energy use reduction of 23 percent. Low-income families saved an average of $350 a year on energy costs, and all told, every dollar invested in WAP returned $2.73 in energy savings and new jobs.

Success Story: Oregon's 2009 Building Efficiency Package

In 2009, Oregon passed two bills that together provide free energy audits to homeowners, fund low-interest PACE loans for energy retrofits, require significant improvements in energy codes, and establish an energy performance rating system for all buildings so owners and potential buyers can monitor a building's energy use and compare it to other buildings of similar size. These measures support Oregon's 2012 goal of increasing efficiency by 15 percent in commercial buildings and 25 percent in residential buildings.

Forward-thinking policies like those outlined above have shown us how much we can achieve. It's time to put those lessons to work in cities and states around the country. By enacting strong policies at every level of government, setting a high minimum standard and exceeding it wherever possible, we can secure the greatest possible overall energy savings.

Making our buildings more efficient reduces the amount of energy we use, the amount of money we spend, and the amount of global warming pollution we emit into the atmosphere. We already know how to achieve vast gains in efficiency, and strong policies can put these building methods and technologies into widespread use so that inefficient, wasteful buildings become a thing of the past. All we need is the commitment from our leaders to make this vision a reality.

Appendices

Appendix A.
Total Building Energy Consumption (Quads), State and National

State	2010	2030 Policy	2030 Base	2050 Policy	2050 Base	% red 2010 to 2030	% red from base in 2030	% red 2010 to 2050	% red from base in 2050
Alabama	0.25946	0.20730	0.32395	0.18148	0.39631	20%	36%	30%	54%
Alaska	0.02991	0.02549	0.04060	0.02239	0.04872	15%	37%	25%	54%
Arizona	0.36541	0.36527	0.60432	0.32066	0.70787	0%	40%	12%	55%
Arkansas	0.14484	0.12481	0.19725	0.11070	0.24784	14%	37%	24%	55%
California	1.45888	1.23766	1.95296	1.08351	2.34347	15%	37%	26%	54%
Colorado	0.30459	0.25282	0.40070	0.21899	0.47199	17%	37%	28%	54%
Connecticut	0.27268	0.21200	0.32337	0.18477	0.39434	22%	34%	32%	53%
Delaware	0.04863	0.04137	0.06421	0.03575	0.07765	15%	36%	26%	54%
Dist. of Columbia	0.05090	0.03545	0.05318	0.03001	0.06719	30%	33%	41%	55%
Florida	1.02460	0.99942	1.65133	0.87243	1.97213	2%	39%	15%	56%
Georgia	0.48366	0.43148	0.68418	0.37406	0.82350	11%	37%	23%	55%
Hawaii	0.05631	0.04353	0.06609	0.03800	0.07975	23%	34%	33%	52%
Idaho	0.08402	0.07338	0.11642	0.06403	0.13685	13%	37%	24%	53%
Illinois	0.96686	0.75971	1.17408	0.65957	1.43255	21%	35%	32%	54%
Indiana	0.48585	0.38920	0.60445	0.33925	0.73516	20%	36%	30%	54%
Iowa	0.19955	0.15020	0.22719	0.12972	0.26699	25%	34%	35%	51%
Kansas	0.18411	0.14289	0.21980	0.12358	0.25808	22%	35%	33%	52%
Kentucky	0.23966	0.19396	0.30187	0.16953	0.36902	19%	36%	29%	54%
Louisiana	0.22975	0.18417	0.28603	0.16257	0.36252	20%	36%	29%	55%
Maine	0.11904	0.09244	0.13968	0.08117	0.16924	22%	34%	32%	52%
Maryland	0.30122	0.25859	0.40728	0.22352	0.49308	14%	37%	26%	55%
Massachusetts	0.52290	0.41122	0.63536	0.35829	0.77460	21%	35%	31%	54%
Michigan	0.78878	0.61673	0.94117	0.53755	1.14679	22%	34%	32%	53%
Minnesota	0.35834	0.29390	0.45817	0.25448	0.53770	18%	36%	29%	53%
Mississippi	0.16791	0.12805	0.19594	0.11165	0.22766	24%	35%	34%	51%
Missouri	0.39039	0.30558	0.47195	0.26503	0.55292	22%	35%	32%	52%
Montana	0.06029	0.04734	0.07226	0.04103	0.08524	21%	34%	32%	52%
Nebraska	0.12058	0.09303	0.14314	0.08031	0.16842	23%	35%	33%	52%
Nevada	0.15998	0.15965	0.26054	0.13938	0.30534	0%	39%	13%	54%
New Hampshire	0.10969	0.09356	0.14669	0.08200	0.17712	15%	36%	25%	54%
New Jersey	0.63910	0.53898	0.84244	0.47099	1.06023	16%	36%	26%	56%
New Mexico	0.11620	0.09156	0.13880	0.07936	0.16369	21%	34%	32%	52%
New York	1.40393	1.09949	1.68788	0.96202	2.14397	22%	35%	31%	55%
North Carolina	0.48193	0.43971	0.70889	0.38261	0.84972	9%	38%	21%	55%

Appendix A. (cont'd.)

State	**2010**	**2030 Policy**	**2030 Base**	**2050 Policy**	**2050 Base**	**% red 2010 to 2030**	**% red from base in 2030**	**% red 2010 to 2050**	**% red from base in 2050**
North Dakota	0.04666	0.03504	0.05296	0.03021	0.06224	25%	34%	35%	51%
Ohio	0.90255	0.69302	1.06157	0.60221	1.29657	23%	35%	33%	54%
Oklahoma	0.18637	0.15417	0.24382	0.13641	0.30774	17%	37%	27%	56%
Oregon	0.16653	0.14667	0.23643	0.12889	0.28310	12%	38%	23%	54%
Pennsylvania	0.94126	0.76009	1.17295	0.66504	1.47793	19%	35%	29%	55%
Rhode Island	0.08175	0.06326	0.09559	0.05535	0.11623	23%	34%	32%	52%
South Carolina	0.23274	0.20209	0.31927	0.17515	0.38377	13%	37%	25%	54%
South Dakota	0.05438	0.04260	0.06533	0.03674	0.07672	22%	35%	32%	52%
Tennessee	0.35900	0.31337	0.50047	0.27373	0.60844	13%	37%	24%	55%
Texas	1.18960	1.17614	1.92830	1.04197	2.38041	1%	39%	12%	56%
Utah	0.13960	0.12683	0.20694	0.10965	0.24318	9%	39%	21%	55%
Vermont	0.05571	0.04502	0.06927	0.03944	0.08387	19%	35%	29%	53%
Virginia	0.41471	0.36454	0.57995	0.31549	0.69991	12%	37%	24%	55%
Washington	0.28202	0.25235	0.41154	0.22211	0.49234	11%	39%	21%	55%
West Virginia	0.09794	0.07482	0.11285	0.06476	0.13645	24%	34%	34%	53%
Wisconsin	0.45339	0.36619	0.56481	0.31905	0.68679	19%	35%	30%	54%
Wyoming	0.03313	0.02493	0.03748	0.02155	0.04428	25%	33%	35%	51%
US Total	**18.26729**	**15.38111**	**24.20168**	**13.42815**	**29.42760**	**16%**	**36%**	**26%**	**54%**

Appendix B.

Per Worker Commercial Energy Spending (2007 $), State and National

State	2010	2030 Policy	2030 Base	2050 Policy	2050 Base	% red 2010 to 2030	% red from base in 2030	% red 2010 to 2050	% red from base in 2050
Alabama	$769.99	$667.19	$1,097.33	$473.40	$1,201.22	13%	39%	39%	61%
Alaska	$710.51	$496.11	$805.93	$348.63	$840.15	30%	38%	51%	59%
Arizona	$743.27	$615.25	$1,041.12	$433.54	$1,085.70	17%	41%	42%	60%
Arkansas	$671.11	$657.56	$1,079.21	$464.37	$1,152.18	2%	39%	31%	60%
California	$712.91	$500.11	$808.11	$351.25	$841.58	30%	38%	51%	58%
Colorado	$736.19	$618.70	$1,019.89	$435.81	$1,071.75	16%	39%	41%	59%
Connecticut	$1,054.20	$1,073.57	$1,712.66	$762.61	$1,909.95	-2%	37%	28%	60%
Delaware	$910.46	$856.65	$1,385.72	$608.42	$1,535.24	6%	38%	33%	60%
District of Columbia	$873.71	$812.72	$1,248.06	$579.55	$1,444.77	7%	35%	34%	60%
Florida	$912.83	$839.12	$1,439.08	$596.90	$1,570.31	8%	42%	35%	62%
Georgia	$912.99	$851.83	$1,407.12	$605.25	$1,549.30	7%	39%	34%	61%
Hawaii	$711.33	$512.07	$794.19	$359.12	$832.43	28%	36%	50%	57%
Idaho	$739.56	$623.19	$1,025.88	$438.76	$1,075.69	16%	39%	41%	59%
Illinois	$873.83	$852.41	$1,381.09	$605.68	$1,532.77	2%	38%	31%	60%
Indiana	$878.80	$856.19	$1,399.93	$608.16	$1,545.15	3%	39%	31%	61%
Iowa	$674.49	$588.06	$937.08	$416.79	$1,032.63	13%	37%	38%	60%
Kansas	$673.43	$582.34	$945.65	$413.03	$1,038.26	14%	38%	39%	60%
Kentucky	$773.47	$672.36	$1,100.45	$476.80	$1,203.27	13%	39%	38%	60%
Louisiana	$668.06	$659.23	$1,063.79	$465.47	$1,142.04	1%	38%	30%	59%
Maine	$1,061.23	$1,084.89	$1,724.22	$770.05	$1,917.54	-2%	37%	27%	60%
Maryland	$902.56	$843.06	$1,380.39	$599.49	$1,531.73	7%	39%	34%	61%
Massachusetts	$1,051.21	$1,063.74	$1,718.49	$756.15	$1,913.78	-1%	38%	28%	60%
Michigan	$879.96	$864.16	$1,388.77	$613.40	$1,537.82	2%	38%	30%	60%
Minnesota	$675.91	$583.14	$956.90	$413.56	$1,045.66	14%	39%	39%	60%
Mississippi	$594.67	$513.52	$838.73	$364.10	$917.09	14%	39%	39%	60%
Missouri	$672.70	$580.10	$946.57	$411.56	$1,038.87	14%	39%	39%	60%
Montana	$737.75	$634.95	$1,012.19	$446.50	$1,066.69	14%	37%	39%	58%
Nebraska	$672.78	$581.44	$943.42	$412.44	$1,036.80	14%	38%	39%	60%
Nevada	$745.84	$624.50	$1,041.17	$439.63	$1,085.74	16%	40%	41%	60%
New Hampshire	$1,065.48	$1,076.68	$1,765.16	$764.65	$1,944.45	-1%	39%	28%	61%
New Jersey	$1,011.78	$1,223.32	$2,003.15	$877.82	$2,331.77	-21%	39%	13%	62%
New Mexico	$740.93	$639.95	$1,017.41	$449.78	$1,070.12	14%	37%	39%	58%
New York	$994.26	$1,196.79	$1,925.39	$860.39	$2,280.67	-20%	38%	13%	62%
North Carolina	$912.43	$844.21	$1,423.38	$600.25	$1,559.99	7%	41%	34%	62%

Appendix B. (cont'd)

State	2010	2030 Policy	2030 Base	2050 Policy	2050 Base	% red 2010 to 2030	% red from base in 2030	% red 2010 to 2050	% red from base in 2050
North Dakota	$676.28	$590.98	$942.26	$418.71	$1,036.03	13%	37%	38%	60%
Ohio	$876.07	$857.34	$1,381.88	$608.92	$1,533.29	2%	38%	30%	60%
Oklahoma	$666.77	$652.49	$1,067.73	$461.04	$1,144.63	2%	39%	31%	60%
Oregon	$713.70	$491.86	$815.04	$345.84	$846.13	31%	40%	52%	59%
Pennsylvania	$1,012.40	$1,228.11	$1,998.04	$880.97	$2,328.41	-21%	39%	13%	62%
Rhode Island	$1,057.32	$1,081.09	$1,710.98	$767.55	$1,908.84	-2%	37%	27%	60%
South Carolina	$917.05	$854.37	$1,420.95	$606.92	$1,558.39	7%	40%	34%	61%
South Dakota	$680.28	$590.64	$957.57	$418.49	$1,046.10	13%	38%	38%	60%
Tennessee	$775.28	$668.34	$1,117.21	$474.16	$1,214.29	14%	40%	39%	61%
Texas	$672.58	$652.59	$1,089.37	$461.10	$1,158.85	3%	40%	31%	60%
Utah	$741.35	$612.00	$1,038.14	$431.41	$1,083.75	17%	41%	42%	60%
Vermont	$1,062.77	$1,080.37	$1,746.67	$767.08	$1,932.30	-2%	38%	28%	60%
Virginia	$906.92	$843.66	$1,398.58	$599.89	$1,543.69	7%	40%	34%	61%
Washington	$712.59	$487.97	$815.17	$343.28	$846.22	32%	40%	52%	59%
West Virginia	$912.56	$863.69	$1,374.31	$613.05	$1,527.74	5%	37%	33%	60%
Wisconsin	$880.57	$862.45	$1,397.81	$612.28	$1,543.76	2%	38%	30%	60%
Wyoming	$737.07	$639.76	$1,005.42	$449.65	$1,062.24	13%	36%	39%	58%
US Total	**$830.05**	**$780.47**	**$1,279.14**	**$554.36**	**$1,410.23**	**6%**	**39%**	**33%**	**61%**

Appendix C.
Per Capita Residential Energy Spending (2007 $), State and National

State	2010	2030 Policy	2030 Base	2050 Policy	2050 Base	% red 2010 to 2030	% red from base in 2030	% red 2010 to 2050	% red from base in 2050
Alabama	$733.62	$609.17	$922.45	$484.54	$969.77	17%	34%	34%	50%
Alaska	$543.67	$421.51	$667.47	$335.92	$702.08	22%	37%	38%	52%
Arizona	$609.51	$511.83	$840.38	$405.89	$848.20	16%	39%	33%	52%
Arkansas	$740.04	$712.52	$1,101.53	$570.62	$1,204.11	4%	35%	23%	53%
California	$468.74	$366.49	$572.03	$291.94	$602.36	22%	36%	38%	52%
Colorado	$627.30	$553.87	$855.16	$438.53	$866.95	12%	35%	30%	49%
Connecticut	$923.87	$904.52	$1,333.00	$714.54	$1,345.48	2%	32%	23%	47%
Delaware	$710.77	$618.20	$928.92	$490.00	$955.48	13%	33%	31%	49%
District of Columbia	$798.49	$702.73	$990.04	$556.95	$1,035.19	12%	29%	30%	46%
Florida	$753.51	$618.66	$1,009.38	$491.33	$1,030.04	18%	39%	35%	52%
Georgia	$671.28	$573.22	$885.65	$454.62	$908.14	15%	35%	32%	50%
Hawaii	$499.06	$395.66	$593.49	$315.02	$629.79	21%	33%	37%	50%
Idaho	$598.90	$526.30	$819.19	$416.73	$829.25	12%	36%	30%	50%
Illinois	$647.63	$576.41	$860.18	$457.16	$890.13	11%	33%	29%	49%
Indiana	$697.64	$619.42	$929.74	$491.30	$961.03	11%	33%	30%	49%
Iowa	$656.06	$536.41	$779.97	$422.51	$773.14	18%	31%	36%	45%
Kansas	$653.33	$522.49	$774.51	$411.83	$768.18	20%	33%	37%	46%
Kentucky	$716.88	$598.98	$902.36	$476.26	$947.76	16%	34%	34%	50%
Louisiana	$698.35	$665.15	$1,006.57	$533.18	$1,114.12	5%	34%	24%	52%
Maine	$1,180.38	$1,160.20	$1,702.48	$916.37	$1,718.16	2%	32%	22%	47%
Maryland	$643.67	$551.87	$845.09	$437.67	$868.31	14%	35%	32%	50%
Massachusetts	$940.27	$910.50	$1,357.99	$719.54	$1,370.43	3%	33%	23%	47%
Michigan	$701.45	$630.47	$929.66	$499.83	$962.39	10%	32%	29%	48%
Minnesota	$657.30	$513.14	$775.13	$404.76	$769.55	22%	34%	38%	47%
Mississippi	$636.59	$509.61	$754.87	$401.67	$748.66	20%	32%	37%	46%
Missouri	$676.62	$535.67	$800.74	$422.35	$794.46	21%	33%	38%	47%
Montana	$647.29	$591.83	$876.88	$468.01	$890.51	9%	33%	28%	47%
Nebraska	$660.57	$529.94	$783.89	$417.67	$777.33	20%	32%	37%	46%
Nevada	$616.44	$524.79	$849.05	$415.94	$856.97	15%	38%	33%	51%
New Hampshire	$1,012.71	$961.75	$1,464.54	$760.44	$1,476.00	5%	34%	25%	48%
New Jersey	$792.39	$780.76	$1,178.68	$621.07	$1,240.97	1%	34%	22%	50%
New Mexico	$620.94	$572.90	$840.16	$452.89	$853.42	8%	32%	27%	47%
New York	$816.92	$805.48	$1,193.90	$640.89	$1,265.56	1%	33%	22%	49%
North Carolina	$721.08	$606.93	$955.66	$481.62	$978.81	16%	36%	33%	51%

Appendix C. (cont'd)

State	**2010**	**2030 Policy**	**2030 Base**	**2050 Policy**	**2050 Base**	**% red 2010 to 2030**	**% red from base in 2030**	**% red 2010 to 2050**	**% red from base in 2050**
North Dakota	$719.39	$592.44	$856.90	$466.54	$849.09	18%	31%	35%	45%
Ohio	$696.57	$623.16	$919.55	$494.17	$953.45	11%	32%	29%	48%
Oklahoma	$737.43	$700.86	$1,084.00	$561.83	$1,192.11	5%	35%	24%	53%
Oregon	$563.06	$435.14	$693.93	$346.80	$728.88	23%	37%	38%	52%
Pennsylvania	$873.02	$862.58	$1,279.69	$686.24	$1,355.00	1%	33%	21%	49%
Rhode Island	$937.89	$922.73	$1,352.54	$728.79	$1,365.10	2%	32%	22%	47%
South Carolina	$721.21	$620.30	$944.15	$491.90	$971.04	14%	34%	32%	49%
South Dakota	$677.34	$547.91	$803.83	$431.71	$797.07	19%	32%	36%	46%
Tennessee	$710.75	$588.04	$912.05	$467.65	$951.65	17%	36%	34%	51%
Texas	$664.92	$645.67	$1,046.53	$516.39	$1,118.52	3%	38%	22%	54%
Utah	$511.20	$441.52	$700.57	$349.83	$708.91	14%	37%	32%	51%
Vermont	$1,109.34	$1,075.01	$1,602.25	$849.48	$1,616.22	3%	33%	23%	47%
Virginia	$667.98	$568.85	$879.84	$451.24	$903.04	15%	35%	32%	50%
Washington	$556.27	$426.52	$690.34	$340.05	$723.72	23%	38%	39%	53%
West Virginia	$754.20	$667.28	$960.48	$528.73	$996.85	12%	31%	30%	47%
Wisconsin	$721.00	$644.44	$961.76	$510.99	$993.54	11%	33%	29%	49%
Wyoming	$654.10	$606.17	$882.11	$479.15	$897.09	7%	31%	27%	47%
US Total	**$685.12**	**$599.92**	**$923.36**	**$476.63**	**$959.07**	**12%**	**35%**	**30%**	**50%**

Appendix D.
Global Warming Emissions from Buildings (MMT $C0_2E$), State and National

State	2010	2030 Policy	2030 Base	2050 Policy	2050 Base	% red 2010 to 2030	% red from base in 2030	% red 2010 to 2050	% red from base in 2050
Alabama	14.9156	13.5670	22.0300	11.3673	27.7766	9%	38%	24%	59%
Alaska	2.1003	1.7834	2.8673	1.4986	3.4308	15%	38%	29%	56%
Arizona	48.4197	49.9925	83.3065	43.7088	98.8541	-3%	40%	10%	56%
Arkansas	21.0598	17.6166	27.7120	15.4593	33.7666	16%	36%	27%	54%
California	98.4269	82.7894	130.6734	72.4054	156.7816	16%	37%	26%	54%
Colorado	40.6154	35.0924	56.1854	30.2993	67.4341	14%	38%	25%	55%
Connecticut	19.3315	14.6101	22.2606	12.7465	27.0373	24%	34%	34%	53%
Delaware	5.9871	4.9662	7.7338	4.3225	9.5398	17%	36%	28%	55%
District of Columbia	6.2073	4.0514	6.0618	3.4540	7.8822	35%	33%	44%	56%
Florida	144.4227	136.3003	226.8072	120.0563	274.7682	6%	40%	17%	56%
Georgia	66.0496	60.8855	97.2201	53.0026	119.4623	8%	37%	20%	56%
Hawaii	7.8799	6.1623	9.3934	5.3421	11.4351	22%	34%	32%	53%
Idaho	6.7302	5.7001	9.0735	4.9843	10.7616	15%	37%	26%	54%
Illinois	96.3720	75.3428	117.3570	65.3671	145.6355	22%	36%	32%	55%
Indiana	61.0093	50.8496	79.8919	44.1238	99.1026	17%	36%	28%	55%
Iowa	24.6208	18.2169	27.7413	15.8691	34.4089	26%	34%	36%	54%
Kansas	26.3204	21.8629	34.1360	19.0067	42.4874	17%	36%	28%	55%
Kentucky	39.5348	32.5802	50.9719	28.5446	63.2200	18%	36%	28%	55%
Louisiana	33.0559	26.0613	40.3726	22.7689	49.5297	21%	35%	31%	54%
Maine	8.4410	6.3926	9.6488	5.6170	11.6321	24%	34%	33%	52%
Maryland	33.3458	27.9289	44.1799	24.3182	54.4858	16%	37%	27%	55%
Massachusetts	37.0663	28.3207	43.7024	24.7010	53.0788	24%	35%	33%	53%
Michigan	97.7361	79.2467	122.2566	68.7771	151.9418	19%	35%	30%	55%
Minnesota	47.8112	39.2063	61.8780	34.2880	76.0885	18%	37%	28%	55%
Mississippi	17.4226	13.8955	21.5113	12.1837	26.2724	20%	35%	30%	54%
Missouri	46.8167	38.2191	59.8163	33.3657	73.7326	18%	36%	29%	55%
Montana	4.8341	3.6644	5.6086	3.1833	6.6901	24%	35%	34%	52%
Nebraska	15.7422	11.8837	18.4683	10.3557	22.8952	25%	36%	34%	55%
Nevada	13.6199	13.3058	21.8015	11.6268	25.7714	2%	39%	15%	55%
New Hampshire	7.7720	6.4439	10.0878	5.6516	12.1346	17%	36%	27%	53%
New Jersey	55.9057	46.3193	72.7342	40.4648	92.6207	17%	36%	28%	56%
New Mexico	15.9805	13.1198	20.0723	11.3292	24.1286	18%	35%	29%	53%
New York	100.6368	79.3010	122.1205	69.4108	156.5369	21%	35%	31%	56%
North Carolina	65.8013	62.2107	101.1178	54.3569	123.6399	5%	38%	17%	56%

Appendix D. (cont'd)

State	**2010**	**2030 Policy**	**2030 Base**	**2050 Policy**	**2050 Base**	**% red 2010 to 2030**	**% red from base in 2030**	**% red 2010 to 2050**	**% red from base in 2050**
North Dakota	6.1787	4.4982	6.8397	3.9138	8.5118	27%	34%	37%	54%
Ohio	113.6692	91.0413	141.1116	78.7946	176.1441	20%	35%	31%	55%
Oklahoma	34.7118	28.1214	44.2238	24.5700	53.8377	19%	36%	29%	54%
Oregon	13.6242	11.4137	18.4130	10.0381	22.0924	16%	38%	26%	55%
Pennsylvania	70.1222	55.5241	85.8856	48.6333	108.9650	21%	35%	31%	55%
Rhode Island	5.7954	4.3674	6.5927	3.8248	7.9798	25%	34%	34%	52%
South Carolina	31.7183	28.3717	45.1263	24.6866	55.4493	11%	37%	22%	55%
South Dakota	6.7352	5.1615	7.9765	4.4914	9.8428	23%	35%	33%	54%
Tennessee	45.1966	40.3156	64.7355	35.2904	79.7133	11%	38%	22%	56%
Texas	169.0020	158.6111	258.0473	139.0811	312.2183	6%	39%	18%	55%
Utah	11.2476	9.8576	16.1557	8.5410	19.1671	12%	39%	24%	55%
Vermont	3.9492	3.1063	4.7737	2.7235	5.7547	21%	35%	31%	53%
Virginia	46.1296	41.7294	66.8339	36.2747	82.2820	10%	38%	21%	56%
Washington	23.0583	19.6426	32.0603	17.3025	38.4311	15%	39%	25%	55%
West Virginia	18.9514	14.7049	22.2713	12.7755	27.7621	22%	34%	33%	54%
Wisconsin	46.4932	37.1818	57.7727	32.3568	71.2955	20%	36%	30%	55%
Wyoming	2.6566	1.9260	2.9033	1.6696	3.4718	28%	34%	37%	52%
US Total	**1981.2309**	**1683.4641**	**2668.5232**	**1468.9243**	**3277.8826**	**15%**	**37%**	**26%**	**55%**

Appendix E.
Natural Gas Consumption in Buildings (Billion CF), State and National

State	2010	2030 Policy	2030 Base	2050 Policy	2050 Base	% red 2010 to 2030	% red from base in 2030	% red 2010 to 2050	% red from base in 2050
Alabama	73.0688	56.7154	88.0688	49.3992	105.2199	22%	36%	32%	53%
Alaska	12.6977	10.1550	15.8640	9.0103	18.2593	20%	36%	29%	51%
Arizona	161.4871	157.9348	259.8313	139.5164	301.1286	2%	39%	14%	54%
Arkansas	43.7447	37.9698	59.9681	34.1360	76.8708	13%	37%	22%	56%
California	610.7734	485.7467	752.0035	429.8408	865.7473	20%	35%	30%	50%
Colorado	133.2583	106.4259	166.9201	92.6803	193.2549	20%	36%	30%	52%
Connecticut	82.7312	64.3067	97.7628	57.0448	122.9417	22%	34%	31%	54%
Delaware	10.8059	8.7808	13.4879	7.6228	15.8690	19%	35%	29%	52%
District of Columbia	10.7727	7.2369	10.8183	6.1427	13.1805	33%	33%	43%	53%
Florida	229.9623	213.1787	347.8238	186.8519	406.3869	7%	39%	19%	54%
Georgia	107.7521	91.6500	143.6800	79.8039	168.6128	15%	36%	26%	53%
Hawaii	23.3627	17.2015	25.7558	15.1821	29.6495	26%	33%	35%	49%
Idaho	37.0452	31.4022	49.4146	27.5616	57.3054	15%	36%	26%	52%
Illinois	494.8446	370.8874	565.6102	324.1523	667.4605	25%	34%	34%	51%
Indiana	251.6854	191.8865	293.9047	168.3316	346.0460	24%	35%	33%	51%
Iowa	91.1457	62.1242	91.8850	53.3995	95.7377	32%	32%	41%	44%
Kansas	83.9826	58.1821	86.9268	50.0484	90.8292	31%	33%	40%	45%
Kentucky	67.4760	52.9970	81.9948	46.0885	97.9201	21%	35%	32%	53%
Louisiana	68.5330	54.6933	84.7255	48.9621	109.8384	20%	35%	29%	55%
Maine	37.0335	29.0111	43.7073	25.9218	54.9160	22%	34%	30%	53%
Maryland	66.7414	54.7627	85.2922	47.5411	100.4966	18%	36%	29%	53%
Massachusetts	158.1657	124.6095	192.2510	110.5062	241.2704	21%	35%	30%	54%
Michigan	409.6021	305.4710	460.4384	267.9606	542.3460	25%	34%	35%	51%
Minnesota	161.5811	115.4576	174.0818	99.3464	182.9757	29%	34%	39%	46%
Mississippi	78.5337	53.7740	79.9449	46.6008	82.4267	32%	33%	41%	43%
Missouri	178.6922	124.2081	185.9345	107.0719	193.9784	30%	33%	40%	45%
Montana	26.4702	20.0120	30.2467	17.4352	35.0792	24%	34%	34%	50%
Nebraska	54.8377	37.8933	56.6350	32.5437	59.2808	31%	33%	41%	45%
Nevada	70.1293	68.1881	110.6008	59.9241	128.0141	3%	38%	15%	53%
New Hampshire	33.9497	29.7761	46.7818	26.5601	57.9858	12%	36%	22%	54%
New Jersey	277.1175	236.2615	369.3871	207.8475	467.8399	15%	36%	25%	56%
New Mexico	51.0423	38.6459	57.9868	33.6827	67.2961	24%	33%	34%	50%
New York	609.5504	481.9059	739.8433	424.6817	946.1913	21%	35%	30%	55%
North Carolina	108.2341	93.9539	149.5734	82.1002	174.9762	13%	37%	24%	53%

Appendix E. (cont'd)

State	**2010**	**2030 Policy**	**2030 Base**	**2050 Policy**	**2050 Base**	**% red 2010 to 2030**	**% red from base in 2030**	**% red 2010 to 2050**	**% red from base in 2050**
North Dakota	21.3485	14.5519	21.5166	12.4974	22.4162	32%	32%	41%	44%
Ohio	465.6115	341.0166	515.5694	298.3096	608.2293	27%	34%	36%	51%
Oklahoma	55.7771	46.2377	73.0972	41.4805	94.2094	17%	37%	26%	56%
Oregon	71.0077	58.1411	91.6652	51.6056	105.4980	18%	37%	27%	51%
Pennsylvania	411.4764	334.7455	516.4055	294.8107	654.1040	19%	35%	28%	55%
Rhode Island	25.1417	19.5610	29.4569	17.4193	37.0439	22%	34%	31%	53%
South Carolina	52.2692	43.1463	67.3071	37.5651	78.8071	17%	36%	28%	52%
South Dakota	24.6756	17.2302	25.7184	14.7956	26.9216	30%	33%	40%	45%
Tennessee	101.0790	85.1122	134.9552	73.9773	160.6660	16%	37%	27%	54%
Texas	357.6607	363.6029	597.8182	326.3124	746.6864	-2%	39%	9%	56%
Utah	60.6878	52.7894	85.1247	45.9141	98.4203	13%	38%	24%	53%
Vermont	17.2139	14.0937	21.6623	12.5670	27.0686	18%	35%	27%	54%
Virginia	92.1127	77.2239	121.4004	67.1261	142.7552	16%	36%	27%	53%
Washington	120.5846	100.2748	159.8245	89.1105	183.9522	17%	37%	26%	52%
West Virginia	22.1949	16.2324	24.2357	14.1138	28.3772	27%	33%	36%	50%
Wisconsin	234.1952	180.1067	274.2431	157.9372	322.9185	23%	34%	33%	51%
Wyoming	14.5243	10.5007	15.6337	9.1250	18.1323	28%	33%	37%	50%
US Total	**7064.3715**	**5667.9726**	**8794.7851**	**4980.1664**	**10473.5377**	**20%**	**36%**	**30%**	**52%**

Appendix F.
Fuel Oil Consumption in Buildings (Million Gal), State and National

State	2010	2030 Policy	2030 Base	2050 Policy	2050 Base	% red 2010 to 2030	% red from base in 2030	% red 2010 to 2050	% red from base in 2050
Alabama	2.4072	5.5857	10.2738	5.7718	22.1692	-132%	46%	-140%	74%
Alaska	2.6026	1.5892	2.2819	1.3712	2.0063	39%	30%	47%	32%
Arizona	1.5369	4.4488	8.3429	3.7895	12.0122	-189%	47%	-147%	68%
Arkansas	0.4458	0.3209	0.4991	0.2544	0.5276	28%	36%	43%	52%
California	123.7596	75.5734	108.5418	65.1171	95.4528	39%	30%	47%	32%
Colorado	1.2559	3.4688	6.4057	2.9921	9.8040	-176%	46%	-138%	69%
Connecticut	644.6827	424.7753	621.3936	372.4115	647.6588	34%	32%	42%	42%
Delaware	6.9496	4.4522	6.4558	3.8772	6.1331	36%	31%	44%	37%
District of Columbia	6.1224	3.4383	5.1063	2.9118	4.6163	44%	33%	52%	37%
Florida	150.2590	102.9120	153.8622	90.2474	149.7490	32%	33%	40%	40%
Georgia	69.4648	45.4812	66.5572	39.6986	63.7527	35%	32%	43%	38%
Hawaii	4.7430	2.8824	4.1315	2.4804	3.6249	39%	30%	48%	32%
Idaho	0.3359	0.9118	1.6647	0.7821	2.5014	-171%	45%	-133%	69%
Illinois	94.5053	62.4261	91.0834	55.8793	93.2058	34%	31%	41%	40%
Indiana	50.1626	33.4184	48.8881	29.9211	50.0603	33%	32%	40%	40%
Iowa	3.8147	9.2508	16.0067	8.0281	25.9975	-143%	42%	-110%	69%
Kansas	3.4367	8.8475	15.7456	7.6708	25.0942	-157%	44%	-123%	69%
Kentucky	2.6055	5.6412	9.9838	5.7411	20.7529	-117%	43%	-120%	72%
Louisiana	0.7838	0.5462	0.8389	0.4324	0.8824	30%	35%	45%	51%
Maine	293.7283	195.9334	285.7323	172.8642	299.6877	33%	31%	41%	42%
Maryland	42.6778	27.4438	40.0055	23.8768	38.0250	36%	31%	44%	37%
Massachusetts	1230.5657	815.3737	1201.5536	714.5515	1253.0930	34%	32%	42%	43%
Michigan	82.3484	54.2424	78.7050	48.5455	80.3678	34%	31%	41%	40%
Minnesota	7.0351	18.6511	33.5287	16.1009	52.2001	-165%	44%	-129%	69%
Mississippi	2.6440	6.7831	12.1082	5.8548	18.9072	-157%	44%	-121%	69%
Missouri	6.8702	17.9332	32.1702	15.5561	51.1692	-161%	44%	-126%	70%
Montana	0.2441	0.6128	1.0726	0.5283	1.6836	-151%	43%	-116%	69%
Nebraska	2.3160	5.9345	10.5637	5.1513	16.9169	-156%	44%	-122%	70%
Nevada	0.7892	2.1845	3.9949	1.8557	5.7511	-177%	45%	-135%	68%
New Hampshire	261.7187	185.0277	276.4748	163.1685	291.9500	29%	33%	38%	44%
New Jersey	781.1915	516.3382	758.4916	449.5269	758.3427	34%	32%	42%	41%
New Mexico	0.4970	1.2250	2.1199	1.0506	3.2704	-146%	42%	-111%	68%
New York	1761.2023	1133.7796	1652.3372	987.1213	1640.4017	36%	31%	44%	40%
North Carolina	71.3010	47.2187	69.5588	41.3241	66.9958	34%	32%	42%	38%

Appendix F. (cont'd)

State	2010	2030 Policy	2030 Base	2050 Policy	2050 Base	% red 2010 to 2030	% red from base in 2030	% red 2010 to 2050	% red from base in 2050
North Dakota	0.9253	2.2628	3.9059	1.9578	6.2709	-145%	42%	-112%	69%
Ohio	91.6402	59.6015	86.5003	53.3254	88.1711	35%	31%	42%	40%
Oklahoma	0.6220	0.4365	0.6763	0.3457	0.7123	30%	35%	44%	51%
Oregon	14.5004	8.8818	12.7668	7.6705	11.2421	39%	30%	47%	32%
Pennsylvania	1192.1784	774.7915	1130.9819	675.5507	1123.8141	35%	31%	43%	40%
Rhode Island	197.4808	130.8776	190.7455	115.1234	199.4281	34%	31%	42%	42%
South Carolina	34.6287	22.2886	32.4481	19.4732	30.9642	36%	31%	44%	37%
South Dakota	1.1548	2.8988	5.1011	2.4953	7.9310	-151%	43%	-116%	69%
Tennessee	5.0659	12.3685	22.4352	12.1314	38.8964	-144%	45%	-139%	69%
Texas	4.0641	2.9890	4.7060	2.3716	4.9910	26%	36%	42%	52%
Utah	0.6958	2.0285	3.8367	1.7327	5.5679	-192%	47%	-149%	69%
Vermont	134.9276	91.7735	135.2209	80.8733	142.0589	32%	32%	40%	43%
Virginia	59.1604	38.3689	56.1272	33.4317	53.5528	35%	32%	43%	38%
Washington	24.6679	15.1099	21.7249	13.0520	19.1310	39%	30%	47%	32%
West Virginia	15.2396	9.3910	13.4565	8.1969	12.6681	38%	30%	46%	35%
Wisconsin	46.1860	30.9728	45.2045	27.7335	46.3428	33%	31%	40%	40%
Wyoming	0.1341	0.3216	0.5516	0.2782	0.8869	-140%	42%	-107%	69%
US Total	**7538.2756**	**5030.0152**	**7402.8693**	**4402.1978**	**7607.3933**	**33%**	**32%**	**42%**	**42%**

Appendix G. Decade-by-Decade National Data

	Total Building Energy Consumption (Quads)	
	Policy Case	Base Case
2010	18.26728842	18.26728839
2020	17.49689164	21.25441180
2030	15.38110630	24.20168359
2040	14.47469673	26.85684247
2050	13.42815213	29.42759969

	Per Worker Commercial Energy Spending (2007 $)	
	Policy Case	Base Case
2010	$830.05	$830.05
2020	$878.37	$1,083.00
2030	$780.47	$1,279.14
2040	$662.59	$1,352.51
2050	$554.36	$1,410.23

	Per Capita Residential Energy Spending (2007 $)	
	Policy Case	Base Case
2010	$685.12	$685.12
2020	$697.55	$841.42
2030	$599.92	$923.36
2040	$536.30	$942.83
2050	$476.63	$959.07

	Global Warming Emissions from Buildings (MMT CO_2E)	
	Policy Case	Base Case
2010	1981.230889	1981.230885
2020	1,904.310000	2319.578919
2030	1683.464142	2668.52321
2040	1584.427232	2978.60950
2050	1468.924317	3277.8826190

	Natural Gas Consumption in Buildings (Billion CF)	
	Policy Case	Base Case
2010	7064.37	7064.37
2020	6570.32	7944.18
2030	5667.97	8794.79
2040	5347.10	9646.06
2050	4980.17	10473.54

Appendix G. (cont'd)

	Fuel Oil Consumption in Buildings (Million Gal)	
	Policy Case	Base Case
2010	7538.275584	7538.275575
2020	6298.2314	7484.969247
2030	5030.015187	7402.869306
2040	4718.849173	7499.298823
2050	4402.19777	7607.393309

	Electricity Consumption in Buildings (Billion KWh)	
	Policy Case	Base Case
2010	2532.53	2532.53
2020	2527.60	3088.09
2030	2277.99	3643.33
2040	2139.10	4094.72
2050	1976.59	4529.09

Methodology

Building Energy Use Analysis

Population and Building Demand

All assumptions regarding demand for building space were based on a combination of US census data on population and existing ratios of building requirements to population. Demand for housing units was obtained by holding the ratio of housing units from the 2005 census estimates constant over time, and multiplying it by population estimates for other years. Thus, for any state in a given year the estimated number of housing units needed is (2005 housing units / 2005 population * YEAR population).

Estimates for commercial space requirements are more difficult to obtain. The 2004 Brookings Institution Metropolitan Policy Program report "Toward a New Metropolis: The Opportunity to Rebuild America" contains privately generated estimates of the number of commercial workers in 2000 and 2030, and of the space that they require. To extrapolate those figures for other years, we assumed a steady change in the percentage of the population engaged in commercial work between 2000 and 2030, and held that percentage constant after 2030 to obtain estimates for 2040 and 2050. For any state in a given year, our estimate of commercial square footage required is equal to (YEAR population * YEAR workers/resident * STATE square feet/resident). The workers/resident figure for each state in the years in between 2000 and 2030 is equal to ((2030 workers / resident – 2000 workers/resident) / 30 * (YEAR-2000)).

The census bureau estimates population down to the state level for each year ending in 5 or 0, up to 2030. To obtain estimates for years in between these years, we assumed steady population growth during the intervening periods. To carry state level population projections past 2030, we held the relationship between each individual state's growth rate and the national growth rate constant, and distributed the additional population projected by the census bureau's national level estimates for 2040 and 2050 accordingly. No estimates for intervening years were required for this period. State population in 2040 and 2050 is determined by the following equation: ((2030 state population / 2000 state population) / (2030 US population) / 2000 US population)) * (YEAR US population / 2000 US population) * 2000 state population.

Building Energy Intensity

The underlying data for all building energy intensity assumptions is drawn from two Energy Information Administration publications, the 2003 Commercial Building Energy Consumption Survey and the 2005 Residential Energy Consumption Survey.

We extracted two sets of data from these reports. First, we used the reports' regional estimates of energy use, square feet of commercial building space, and number of households to produce energy intensity figures for both residential and commercial buildings in each census division. Next, we divided the overall energy intensity of each of those categories as a by the energy intensity of average US buildings. We performed the same calculation for buildings constructed in the 2000s. We assumed that the improved efficiency of buildings was approximately constant across regions, and multiplied each region's ratio by the ratio of 2000s buildings to all buildings to obtain a ratio of the energy intensity of 2000s buildings in each region to the energy intensity of average existing US buildings, and multiplied this figure by the average energy intensity of US buildings to obtain an estimate of the energy intensity of buildings constructed in the 2000s in each census division. We assumed that energy intensity was constant across census divisions to assign energy intensity figures to each state. The energy intensity for 2000s buildings in census division was determined as follows:

For any category, energy intensity = Btus consumed / square feet (commercial) or households (residential)

Census division 2000s buildings energy intensity = (Census division energy intensity / national average energy intensity) * (2000s buildings energy intensity / national average energy intensity) * national average energy intensity

Separate energy intensity numbers were derived for each fuel.

The RECS and CBECS data we used had to be adjusted to match the housing units and commercial square feet data we were using in our census-based projections. The RECS provides its data by household, rather than by existing housing unit; we multiplied all our energy intensity numbers by the ratio of housing units found by the census to households counted in the RECS to establish the correct balance of population and energy consumption. The CBECS, meanwhile, counts commercial square feet nationwide, but arrived at an appreciably different count than did the private estimate used in the Brookings report. Since only the latter dataset provided a state by state level breakdown of commercial space, we adjusted the energy intensity figures obtained by the CBECS to match an underlying building stock of the size suggested by the Brookings report. Neither of these adjustments affects our model's output for overall or per capita energy consumption.

The components of the building stock in our model were assigned energy intensities as follows:

- Buildings existing as of the 2003 CBECS and 2005 RECS were treated as uniformly having the energy intensity of an average building in their state from that survey.

- Buildings constructed between those years and 2010 were assumed to have the same energy intensity as an average existing building constructed after 2000.

- In the base case scenario, buildings constructed after 2010 were also assumed to have the same energy intensity as average 2000s buildings in their state.

- In the policy case, 90% of buildings constructed after 2010 were assumed to comply with more stringent building codes and use less energy than 2000s buildings by the amount prescribed by the policy. The remaining, noncompliant buildings were assumed to use as much energy as 2000s buildings.

Building Stock Composition

Following the 2004 Brookings Institution report cited above, we assumed an annual rate of loss of 1.37% for commercial buildings, and .63% for residential buildings. The building stock in each year, then, was composed of the existing building stock from the previous year, minus building space destroyed in that year, and plus whatever new construction was required to make up the losses and expand the building stock to meet the current year's needs. Under the policy case, a portion of the old building stock was renovated each year and transferred into the retrofitted building stock.

Loss rates were applied equally to all buildings, irrespective of when they were constructed. For instance, our model assumes that, each year, 1.37% of still-standing commercial square footage from the 1920s will be demolished, and 1.37% of the commercial square footage constructed the previous year will also be demolished. This assumption contributes to conservative estimates of the difference between the policy and base case scenarios, since in actuality older buildings are more likely to be demolished than newer buildings. As a result, our model gives a conservative estimate of the percentage of the building stock in each year that will be composed of post-2010 construction—and therefore also of the effect of the building codes we are examining.

In each case, then, the building stock for a given year consists of:

- Policy Case:
    - o Surviving pre-2003/2005 buildings. This number declines every year as buildings are renovated and demolished, reaching 0 in 2030.
    - o Buildings constructed 2003/5-2010. These buildings are not renovated, but do decline every year due to demolition.
    - o Renovated buildings. These suffer demolition losses every year, but are replenished by a stock of newly renovated buildings every year until 2030.
    - o Post-2010 new construction: Each year, the number of buildings required to make up the difference between the number of buildings remaining from the previous year's total and the total number of buildings needed in that year is added to the pool as that year's stock of newly constructed buildings. Once constructed, those buildings are demolished at the same rate as other buildings.
- Base Case:
    - o Surviving pre-2003/2005 buildings. The number of these declines every year due to demolition.
    - o Post-2003/2005 construction. Any buildings required in a given year above the amount in the surviving pre-2003/2005 stock are post 2003 construction. Since

all post-2003 buildings have identical energy efficiency in this scenario, any building in this pool that is demolished is replaced by a building that is fundamentally identical for our concerns.

Cost and Pollution

Energy cost estimates come from the Energy Information Administration's Annual Energy Outlook 2009, Updated Reference Case, April 2009. All states within a census division were assumed to have identical energy costs. Energy costs in 2040 and 2050 were assumed to be the same as in 2030. Since the annual energy outlook does not provide a cost estimate for kerosene, the 2005 RECS cost estimate for kerosene was used for all years. All fuel oil used in commercial buildings was assumed to be distillate fuel oil.

To generate state-specific emission factors for electricity generation, we relied on AEO 2009 Updated for data on projected electricity generation and power plant emissions for each EIA electricity market module (EMM) region. For states in a single EMM region, the emission factor was calculated by dividing carbon dioxide emissions by total electricity generation in the region, with both data points coming from AEO 2009 Updated.

For states with utilities in more than one EMM region, we used a weighted average emission factor, with the emission factors from the various EMM regions in the state weighted by the percentage of electricity sales by utilities in each region. Utilities were assigned to EMM regions using EIA's Form 861 database for 2005 (the last year in which Form 861 used the same regional definitions as used in AEO 2009 Updated). The one exception to this was Iowa, where the 2004 version of Form 861 was used. Electricity sales by utility were based on the 2007 edition of the Form 861 database. For future year projections, it was assumed that the share of electricity delivered by utilities in each EMM region in a state would remain constant through 2020.

Emissions factors for direct consumption of fossil fuels are drawn from EIA, Documentation for Emissions of Greenhouse Gases in the United States 2006, October 2008.

Building Codes Analysis

To analyze the impact of state building codes, we began by cataloguing existing building codes, and changes scheduled to come into effect in coming years. We also followed the Energy Information Administration in assuming that, by 2018, all states will adopt the 2009 IECC code for residential construction and the ASHRAE 90.1-2007 code for commercial construction.[36]

For estimates of building construction and demolition rates, we followed the methodology of the 2004 Brookings Institution Metropolitan Policy Program report "Toward a New Metropolis: The Opportunity to Rebuild America." That report estimated need for residential and commercial space based on constant ratios of state residents to residential units and commercial workers to square feet of commercial space. It also provided a figure for the annual rate of loss of existing residential and commercial space for each state.

To estimate residential construction, we multiplied the figure for residential units/state resident in 2000 by the US census department's estimate of the state's population in 2020. We used the difference between that figure and the existing number of residences in 2000 as the basis for our annual growth figures, assuming linear growth during those years. To this annual growth figure, we added the annual loss figure, multiplied by the existing number of residential units in 2000, to obtain an estimate of the number of residential units constructed each year. This form of estimation is conservative as a result of subtracting loss rates from a constant, rather than expanding, baseline, and as a result of using the Brookings report's intentionally conservative numbers.

To estimate commercial construction, we took the Brookings report's figure for the size of the commercial workforce in each state in 2030, and assumed a constant rate of growth 2000-2030 to obtain estimates for annual growth and the size of the workforce in 2020. We multiplied this annual growth number by the ratio of square footage of commercial space to workers that the Brookings report provides for each state to obtain an estimate for growth in commercial space each year. We then derived a number for square feet lost each year, and total annual construction, in a manner directly analogous to that used for residential construction. As with our estimate of residential construction, this estimate is conservative in its estimation of annual construction rates.

We next broke down each state's population by DOE climate zone. To do this we combined a list of which counties fall into each climate zone with the US census's estimates of 2008 population for each county. By this method, we were able to identify what percentage of each state's population falls into each climate zone that state contains. We used these population breakdowns as a proxy for breakdowns of new construction between the state's climate zones.

Impact of Commercial Codes

The basis for our analysis of the effect of commercial codes is an invaluable 2009 report from the US Department of Energy Building Energy Codes Program, "Impacts of Standard 90.1-2007 for Commercial Construction at State Level." This report compares the efficiency of newly constructed buildings built to the state's existing code and the ASHRAE 90.1 2007 code in each climate zone of each state. For each climate zone in each state, we used the estimates of electricity usage and natural gas usage under both standards to obtain an annual, per square foot reduction number from the old standard to 90.1 2007. We then combined the climate zone numbers into a weighted average for the state as a whole. We then credited each state with the reduction that would result from construction between the adoption of the 2007 standard and 2020. (We assumed that ASHRAE 90.1-2007 would be adopted in 2018 in all states that had not made specific plans to adopt it sooner.) For four states (Washington, Oregon, California, and Florida), we were not able to obtain estimates, since they use building codes of their own that differ significantly from the codes the DOE modeled.

Impact of Residential Codes

The basis for our estimate of the impact of residential code changes is the data compiled on the effect of the transition from the 2006 IECC to the 2009 IECC in each climate zone compiled by ICF International for the Energy Efficient Codes Coalition.[37] This source provided us with an estimate of electricity and natural gas savings per residential unit in each climate zone. We took weighted averages of these numbers for each state to produce statewide per-unit savings figures, and then followed the same methodology as with commercial codes to estimate the energy savings in 2020 from the adoption of the 2009 IECC. (We assumed that the 2006 IECC was the baseline standard in all states; this leads to an extremely conservative estimate of the savings estimated for upgrading to the 2009 version of that code.) States were assumed to adopt the 2009 IECC by 2018, in the absence of plans calling for its adoption before that time. To estimate savings in Florida, we used the Building Codes Assistance Project's estimate that the Florida Residential Construction code is 17% more efficient than the 2006 IECC, but 3% less efficient than the 2009 IECC, to obtain a figure for expected savings from the FRCC over the 2006 IECC.[38] In the case of Washington and Oregon, we treated their existing codes as equivalent to the 2006 IECC and credited them, as with most other states, with the savings that would come from transitioning to the 2009 IECC in 2018. No estimate was obtained for California.

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