Building a Better America

Reducing Pollution and Saving Money with Efficiency

Environment Texas Research & Policy Center

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Table of Contents

Executive Summary

We can save money and help solve global warming by reducing the amount of energy we use, including in the buildings where we live and work every day. More than 40 percent of our energy — and 10 percent of all the energy used in the world — goes toward powering America's buildings.[1] But 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 energy use in our homes and workplaces by a quarter, lowering global warming pollution from buildings 30 percent by 2030.

Actions taken by local, state and federal governments and by the private sector have already led to major gains in the energy performance of buildings. The Energy Information Administration (EIA)'s projections of energy use per square foot in our buildings go down every year. Energy intensity projections in the commercial and residential sectors have gone down 10 percent, and projections accounting for the use of best available technology go even further — up to 30 percent better than we predicted just a handful of years ago.[2] But we can and we must improve, implementing an aggressive two-part strategy that sets bold efficiency standards for new buildings and encourages investments in energy-efficiency improvements in the buildings we already have.

This report analyzes the effects of meeting bold efficiency goals and provides state-by-state data on the economic and environmental benefits as compared to a business-as-usual scenario. The policies needed to meet those goals are outlined in the report and we highlight forward-thinking cities and states where these policies are already making a difference for home and business-owners.

Taking decisive action to improve the energy performance of our buildings through a combination of policy and public and private investments would go a long way toward reducing our nation's energy use:

- Cutting natural gas and fuel oil consumption in buildings by over 20 percent each by 2030.
- Cutting total energy use in our existing building stock 30 percent by 2030.
- Newly constructed buildings will consume 50 percent less energy in 2020 and 75 percent less energy in 2030 than new construction did in 2008

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

- Electricity bills will decline by 34 percent by 2030, saving households an annual average of $450 on residential energy bills compared to what they pay today.
- Heating oil and natural gas bills will decline in every state.

And, better, more energy-efficient buildings will reduce our global warming emissions.

- Global warming pollution from buildings will fall 11 percent by 2020, with that reduction increasing to 30 percent by 2030.
- By 2030, the cumulative avoided emissions will total 696 million metric tons of carbon dioxide, the equivalent of shutting down more than 150 coal-fired power plants in two decades.[3]

Achieving these benefits will require strong policies that promote energy efficiency and educate builders, building-owners and renters about the energy performance of buildings, including:

- Adoption of strong building energy codes targeting reductions in energy use versus today's average homes and commercial buildings. The codes should target 50 percent reductions by 2020 and 75 percent by 2030. We will also need strong commitments from cities and other stakeholders: a goal of achieving zero net energy buildings — buildings that produce as much energy as they consume — by 2030, and incentives to increase distributed renewable energy generation.
- An aggressive program of energy efficiency retrofits sufficient to reduce energy consumption by 30 percent in households and 50 percent in commercial facilities by 2030, including financing programs like Property Assessed Clean Energy, on-bill financing, weatherization programs, utility-funded incentive programs and public private partnerships.
- Adoption of strategies to increase transparency and develop consumer demand for energy-efficient apartments, homes and businesses, including energy use disclosure and incorporation of efficiency measures into the real estate appraisal process.
- Adoption of strong energy efficiency standards for household appliances and commercial equipment used in buildings.

Table 1. Top states for global warming pollution reductions:

Cumulative savings (MMT CO_2)	
California	61.4
Illinois	44.2
New York	39.7
Ohio	36.3
Michigan	25.7
Texas	20.0
Colorado	19.8
Missouri	17.5
Pennsylvania	17.4
Indiana	16.8

As a percentage of today's emissions	
Hawaii	73%
Washington, D.C.	56%
California	47%
New Mexico	42%
Wyoming	41%
Colorado	39%
Illinois	39%
Ohio	36%
Delaware	36%
Oklahoma	35%

Introduction

A Solution to Global Warming

Despite decades of research and a concerted effort by hundreds of thousands of citizens, the United States remains on a path that science tells us is unsustainable. Global warming threatens our health and our way of life, promising rising seas, more destructive extreme weather events and shifting ranges for wildlife, crops and infectious diseases.

We need to take action now to avert the worst potential impacts of global warming: we need to use far less dirty and dangerous energy sources, such as coal, oil, natural gas and nuclear power. And the energy we do use must come from renewable sources like the sun, wind and the thermal power of the earth.

Luckily, when searching for a place to make a difference, we need look no further than the buildings where we live and work every day. The building sector consumes more energy than any other sector of the economy, including transportation and industry.[4] The buildings where we live and work account for about 40 percent of our total energy consumption and nearly three quarters of our electricity use.[5] This level of energy use costs the United States approximately $400 billion every year.[6]

The building sector, therefore, represents one of the most important opportunities to reduce the amount of energy we use. And the good news is that energy efficiency is widely acknowledged as a win-win solution; improving the energy performance of our homes and businesses saves money and creates local jobs in addition to reducing global warming and other pollutants that result from burning fossil fuels. We have the ability to dramatically reduce energy waste using tried-and-true methods such as sealing up air leaks, installing more and better insulation, and investing in appliances that "sip" rather than "gulp" electricity. By implementing the policies outlined in this report, we can reduce global warming pollution 11 percent by 2020 and 30 percent by 2030.

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 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.

Efficiency through smart policies

The good news is that we've already begun the transition to a more efficient economy. A diverse set of stakeholders — from the Obama administration and the Department of Defense to utilities that find it cost effective to invest in efficiency programs for their customers rather than constructing new generating capacity — has begun developing policies that promote efficiency in a number of ways, raising minimum energy standards and lowering the upfront barriers for home and business owners to invest in efficiency improvements.

Analysis of the latest energy use forecasts released by the Energy Information Administration (EIA) indicates that estimates of residential and commercial building energy use through 2030 have been dropping dramatically since 2005 — by nearly 70 percent — due to considerable movement within the building sector to improve building design and efficiency.

In its most recent estimate, the EIA's 2011 Annual Energy Outlook forecasts that American consumers will spend $3.66 trillion less on energy between 2012 and 2030 than was originally projected in 2005. If, by 2030, we embrace the most efficient building technologies available, these savings will top $6 trillion.[8]

But, we can and must do more to unlock the true potential of building efficiency to reduce global warming pollution. Our analysis models the following energy efficiency goals needed to achieve that pollution reduction:

- Reductions in the energy use of new construction: 36 percent improvement by 2020 and a 63 percent improvement by 2030 for residential and commercial buildings, coupled with the distributed renewable energy generation needed to achieve zero net energy buildings by 2030.
- An aggressive program of energy efficiency retrofits sufficient to reduce energy consumption 30 percent on average by 2030 (22.5 percent in households and 37.5 percent in commercial facilities).
- Adoption of strong energy efficiency standards for household appliances and commercial equipment used in buildings.

I. Environmental and Economic Benefits of Efficiency

With benefits on the table like lower energy bills, a reduced need for imported fuels, and lower global warming emissions, the time has come to take bold action. We modeled the potential for reducing energy waste in the residential and commercial sectors and found that every state stands to reduce emissions and save residents money by investing in policies that reduce upfront costs and technical barriers to efficiency investments. We learned how much each state stands to benefit by coupling strong energy efficiency policies with the power of distributed renewable energy generation.

By tapping into the immense amount of energy wasted in our buildings and supplementing it with onsite renewable energy in our buildings, we can reduce total energy use in the United States by nearly a quarter. Some states perform well above this average: Washington, D.C., leads the way in our policy scenario, reducing energy use in the building sector by more than half by 2030. Rapidly growing states will see benefits from advanced energy codes for new construction, whereas states with aging building stock will see significant benefits from programs that lower the cost of energy retrofits.

Based on the types of energy generating capacity in use today, states will benefit in different ways from investments in efficiency and renewable energy (see Tables 3a-c). States in the Northeast can address the high cost and security concerns of dependence on heating oil (see table 3c). States dependent on air conditioning for the majority of the year will see tremendous benefits from reductions in electricity consumption. And residents everywhere stand to benefit from the lower electricity bills that result from a combination of higher standards for new construction and greater financing for efficiency retrofits.

Table 2. Top states for global warming pollution reductions:

Per capita 2009-2030 reductions	
New York	130.05
Virginia	48.04
Alabama	17.58
Wisconsin	16.91
North Carolina	15.77
Illinois	15.03
Missouri	13.02
Iowa	12.51
Indiana	12.19
Massachusetts	11.44

Per capita reductions in 2030, vs. no action	
New York	98.76
Virginia	81.74
Alabama	38.19
North Carolina	28.68
New Jersey	24.49
Wisconsin	18.42
Missouri	16.92
Massachusetts	15.74
Arizona	13.28
Iowa	12.67

Table 3a. Ten states with greatest electricity savings in 2030 vs. no action

As a percentage	
Hawaii	67%
California	45%
Washington, D.C.	44%
Massachusetts	43%
Oregon	42%
Connecticut	39%
Colorado	38%
New Mexico	37%
Nevada	36%
Utah	36%

Per capita (GWh/million people)	
New York	64.04
Virginia	56.21
Alabama	26.30
North Carolina	22.11
New Jersey	14.06
Massachusetts	13.88
Arizona	9.97
Wisconsin	9.50
Missouri	8.30
Iowa	5.65

Annual residential electricity bill savings	
Hawaii	$1,020.20
Connecticut	$668.82
Iowa	$635.26
Massachusetts	$634.96
Florida	$589.61
Washington, D.C.	$579.66
Maine	$576.54
Texas	$525.02
Alabama	$523.42
Georgia	$515.76

Table 3b. Ten states with greatest natural gas savings in 2030 vs. no action

As a percentage	
Delaware	28%
New Hampshire	26%
Washington, D.C.	26%
Arkansas	26%
Nevada	26%
Virginia	25%
Maryland	25%
Arizona	24%
Washington	24%
Hawaii	24%

Per capita (cubic feet/person)	
New York	90.38
Virginia	26.43
New Jersey	21.14
Massachusetts	12.99
Wisconsin	10.48
Illinois	5.44
North Carolina	5.72
Indiana	5.22
Iowa	5.63
Alabama	5.67

Table 3c. Top ten states with greatest heating oil savings in 2030 vs. no action (in millions of gallons)

New York	193.03
Pennsylvania	84.82
Massachusetts	71.99
Connecticut	53.66
New Jersey	46.99
California	46.11
Texas	40.44
Florida	37.47
Maine	36.73
Ohio	32.63

 # II. Residential and Commercial Energy Codes: Building Right the First Time

The Edge House in Boulder, CO was built with a careful attention to energy use, in particular by sealing up the home's energy envelope. The house is LEED-Platinum certified and produces as much energy as it needs through a 10KW photovoltaic system.

The cheapest way to ensure energy efficiency in our homes and office buildings is to build right the first time. 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 easier and cheaper to install when a building is constructed than to make those same modifications in a building that's already fully built. Codes can also ensure that buildings are designed today so that future actions, such as the installation of on-site renewables, can be accomplished with minimal reconstruction expense. And the average building will go 30 years before undergoing a significant energy upgrade, so the decisions we make today regarding energy performance will be felt for years to come.

The process through which minimum energy standards are developed varies widely by state, but most states and local governments base their minimum standards on one of a handful of model codes, developed by state and local energy officials, building professionals, and manufacturers of insulation, windows, and other efficient building products. A recent focus on building energy

Mary and George Keithan's house in Killingworth, CT[13]

Mary and George's home in Connecticut is an example of the kind of house we could achieve anywhere one day. In New England — where winters are bitterly cold — they constructed a beautiful, livable house that produces 7 percent more energy than it consumes. By using energy codes to require 75 percent more efficient buildings by 2030, we can ensure that everyone has access to an energy-saving home just like the Keithans'.

Here's how the Keithans achieved these results:

- A sealed-up building envelope. The house is equipped with thick insulation and triple-paned windows, and all of the joints are sealed to guard against air leakage.
- Panels on the roof of the house that produce hot water and heat the home's radiant flooring
- Solar photovoltaic panels on the roof of the Keithans' barn provide all the electric power needed on the property
- Heat is provided in the residence via a geothermal heat pump and radiant flooring, a highly efficient system that stores heat and releases it slowly, over time

codes as a way to tackle global warming has resulted in tremendous steps forward, improving energy efficiency in the national model code 30 percent since 2006.[9]

Many states have updated their residential and commercial energy standards since the summer of 2008 as a result of policies in the American Recovery and Reinvestment Act linking code updates to stimulus funds. In addition to statewide requirements, many cities and towns have gone farther, stretching beyond the statewide minimum to ensure greater energy savings and healthier homes for their citizens for years to come. But despite significant progress, we can and must improve.

Setting a strong standard for new buildings is critical because more than 40 percent of the homes that Americans will need by 2050 haven't been built yet.[10] And for those states that do not adopt the more updated building codes, their residents will continue to experience more energy waste and higher energy bills for decades to come.[11] We can reduce global warming pollution from the buildings sector 30 percent by 2030; within two decades, 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 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 median U.S. home is 40 years old, so enacting strong codes today locks in energy savings for decades to come.[12]

Policies and Initiatives

2A. Set Zero Net Energy Goals

Commitments from decision-makers to meet the targets set by Architecture 2030 in the 2030 Challenge (a goal of incremental energy reductions, progressing to carbon neutral or zero-net energy (ZNE) buildings by 2030) are one way that mayors and governors are taking leadership to promote a vision of efficiency nationwide.[15,16] By committing their cities or states to this goal, decision-makers help to de-

Ferreira Construction Headquarters in Branchburg, NJ[14]

Ferreira's corporate headquarters in Branchburg, N.J., sets high standards for reduced energy consumption and carbon emissions. Designed by Ferreira professionals and completed in 2006, the 42,000-square-foot building is recognized as the first net-zero electric commercial building in the United States and features:

- 223 kW solar photovoltaic system
- Solar hot water installation
- Nine miles of radiant heat
- High performance rooftop heating and cooling units
- 96 percent efficient condensing boiler

velop the market for highly efficient homes as well as increase demand for efficient materials and construction methods. In 2007, Congress passed and President Bush signed the Energy Independence and Security Act, requiring that all new federal buildings and major renovations meet the energy performance targets of the 2030 Challenge beginning with a 55 percent energy consumption reduction in 2010, with incremental reductions to carbon neutral by 2030.[17] In 2009, Massachusetts and California made similar commitments to the goal of zero-net energy buildings and formed task forces to develop plans to make those goals a reality. Following up on those compelling examples, President Obama issued executive order 13514,[18] calling on the federal government to lead by example in the efficiency sector, including requiring buildings to be zero-net energy by 2030.

California's Zero Net Energy Action Plan[19]

The California Public Utilities Commission (CPUC) joined California business leaders last year to launch an action plan designed to help commercial building owners take advantage of the latest technologies and financial incentives to reduce energy use to net-zero.

The Zero Net Energy Action Plan was developed over a collaborative 11-month period and represents the work of more than 150 stakeholders in commercial building, architecture, finance, clean energy, technology and various state agencies. The plan lays out a strategy for achieving zero-net energy, one of the "Big, Bold, Energy Efficiency Strategies" (BBEES) identified by the state in 2008. Altogether, the long-term Strategic Plan's BBEES will save an estimated 2,056 megawatts (MW), avoiding the need for four new 500-MW power plants. The four BBEES are:

1. All new residential construction in California will be ZNE by 2020
2. All new commercial construction in California will be ZNE by 2030
3. Heating, ventilation and air conditioning (HVAC) will be upgraded to ensure that its energy performance is optimal for California's climate
4. All eligible low-income customers will be given the opportunity to participate in the low-income energy efficiency program by 2020

2B. "Beyond Code" efforts

In a few places, forward-thinking energy officials are pushing beyond the statewide minimum to lock in greater energy savings for citizens. In states without a statewide minimum standard, cities and counties such as Denver, Boulder and St. Louis have recently updated their energy standards, protecting their citizens from the failure of the state to establish standards. In other states, including Massachusetts and Oregon, optional "stretch" or "reach" codes have been developed to lay out a clear path to energy savings. By setting standards higher than the national average, these jurisdictions guide the development of updates to minimum standards elsewhere in the country by demonstrating consumer demand for greater efficiency.

Massachusetts' "Stretch Code"

The Stretch Code in Massachusetts is an optional energy code that goes up to 20 percent beyond the state's baseline energy standards. Each city and town in Massachusetts can decide whether to adopt the stretch code or to simply stick with the baseline standards. A wide range of stakeholders including utilities, municipalities and energy efficiency experts, were involved in the development of the stretch code.

More than 100 cities and towns in Massachusetts have adopted the stretch code, including Boston. Not only does this represent huge energy savings to Massachusetts residents, but it was also important for national code developers, demonstrating consumer demand for greater efficiency and encouraging the development of a nationwide model code of similar strength.

2C. Establish high-efficiency districts or "Ecodistricts"

Led by the U.S. Conference of Mayors and other local advocates, cities across the country — from Seattle to Cleveland — are setting goals for high-efficiency districts, establishing plans to reduce energy use in buildings, from transportation, and from water use. These districts are partnerships of the public and private sector, guided by experts and dedicated to achieving those goals together. These successful districts demonstrate what is possible for the rest of the country.

Efficient communities: Seattle's 2030 District

An unprecedented partnership of businesses, Seattle's 2030 District is a unique collaboration of public and private stakeholders and advocates. The goal of the district is to meet the targets of the 2030 Challenge for Planning by significantly reducing energy use in existing buildings and requiring new construction in the district to be zero net energy by 2030.Achieving these goals district-wide is possible because of shared resources, collaboration and financing opportunities that would not be available to individual companies or properties.[20]

Seattle 2030 district goals:

- Energy Use: A minimum of 10 percent reduction below the national average by 2015 with incremental targets, reaching a 50 percent reduction by 2030.
- Water Use: A minimum of 10 percent reduction below the district average by 2015 with incremental targets, reaching a 50 percent reduction by 2030.
- CO_2 emissions of auto and freight: A minimum of 10 percent reduction below the current district average by 2015 with incremental targets, reaching a 50 percent reduction by 2030.
- Energy use: An immediate 60 percent reduction below the national average with incremental targets, reaching carbon neutral by 2030.
- Water use: An immediate 50 percent reduction below the current district average.
- CO_2 emissions of auto and freight: An immediate 50 percent reduction below the current district average.

Participants in the Seattle 2030 District include:

- The Seattle Central Library, which was designed to outperform the Washington energy code by 10 percent. The building uses 50 percent less energy and 10 percent less water than buildings of a similar size without efficiency measures.
- The Dexter Horton building, a historic landmark located in the heart of downtown Seattle. In 2006, the building management team made a commitment to energy efficiency and began a series of retrofits to improve energy and water use in the building. Most of these improvements will pay for themselves in less than three years with energy savings, and the improvements have also allowed the building to retain tenants longer than unimproved properties, remaining competi-

tive in a tight real estate market.

- The Russell Investments Center in downtown Seattle, a 42-story office building that received the highest Energy Star score possible when it was built in 2007 — the first building in Seattle to achieve such a high rating. The building is home to some of the area's most prestigious financial and professional service companies, and has an energy performance 66 percent better than the baseline energy use for a similar building.

2D. Develop Distributed Renewable Energy Generation

Zero-net energy buildings use very little energy — and what energy they do use comes from truly clean energy sources like the sun. Renewable energy generation — particularly solar photovoltaic installations and solar hot water — complements the efficiency efforts outlined in this report to maximize the impact that buildings policies can have on the level of global warming emissions in the United States. Local, state and federal governments can implement public policies that remove the barriers currently impeding the spread of solar energy and adopt policies to make solar energy an important part of America's energy future.[21] Some of these policies include:

- Financial incentives, such as grants, tax credits and feed-in tariffs help to compensate homeowners and business owners for the benefits their investments in solar energy deliver to society and can create a robust early market for solar technologies, building the economies of scale needed to lower the price of solar energy.
- Renewable electricity standards (RES), such as those now in place in 29 states, can ensure that utilities integrate solar into their energy profiles. Solar carve-outs, which require that a share of the RES be met with solar energy, can ensure a diversified mix of renewable resources and encourage the development of distributed renewable resources.
- New financing tools can help individuals and businesses absorb the large upfront costs of solar installations and begin reaping benefits immediately. Municipalities can use their power to borrow at low interest rates to finance residential solar installations, which can be paid back through assessments on property tax bills. Utility on-bill financing can achieve similar aims, while low-interest loans and loan guarantees can help reduce the payback time for solar energy investments by businesses.
- Advanced building codes and standards can ensure that builders take maximum advantage of passive solar heating and lighting in new buildings and create new opportunities for integrating solar energy into existing buildings. Solar-ready building standards guarantee that new homes are built with solar energy in mind, and can be broadened to require that solar energy be offered as an option on new homes. Some states and countries have gone so far as to require the use of solar energy (specifically, solar water heating systems) on new residential buildings. The recently approved International Green Construction Code requires minimum amounts of installed renewable energy systems on commercial buildings.

III. Retrofit Financing and Rebates: Making Existing Buildings Better

After a renovation in 2006 to incorporate more daylight and seal up energy leaks, the Santa Rita Elementary School in Los Altos now beats California's minimum energy standards — already some of the strongest in the country — by 35 percent.

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.[22] This state of affairs explains why basic retrofits that replace old technology and seal up energy leaks typically reduce household energy use 20 to 30 percent. A more intensive, whole-building approach known as a deep energy retrofit can achieve energy savings of 50 percent or more, which shows just how much energy we waste in our buildings today.[23]

Most current existing building efforts, while valuable, fail to deliver these deep energy savings. Examples of deep savings in existing buildings do exist,[24] and policies and

The Empire State Building

This commercial retrofit is one of the best examples of how an integrated approach and smart planning can produce significant savings. The Empire State Building — once the tallest building in the world, and billed as the "world's largest office building" — underwent a significant retrofit and energy upgrade in 2010. The building's owners replaced all 6,500 windows in the building with triple-paned, high efficiency windows. The building's heating and cooling systems were also upgraded to ensure efficiency, and insulation was installed behind radiators to direct heat more effectively. Because of the massive scale of the Empire State Building, the energy saved from this project is enough to power 2,100 New York homes.

These retrofits will save the building's owners $4.4 million every year in energy costs. Furthermore, having a state-of-the-art, environmentally friendly building will help to attract and retain better clients, according to the building's manager. And the company's investment is already starting to pay off; the retrofit should pay for itself in energy savings in about three years.[26]

initiatives that leapfrog current efforts to get to the deep savings possible are being developed across the country.

In 2006, Chesapeake Habitat for Humanity renovated five row houses in Baltimore. Four were renovated using Department of Energy best practices, sealing in the energy leaks that are prevalent in Baltimore row homes — which are often 80 to 120 years old — and outfitting the homes with more efficient heating systems and appliances. A fifth house was built using standard building practices, which meet but do not exceed the statewide energy code. The Habitat for Humanity group estimates that the more efficient retrofits average 32 percent lower energy use, ensuring that those homeowners will benefit from lower energy bills for years to come.[25]

But, despite a reasonable payback period for many efficiency improvements, the high upfront cost of these projects is still a deterrent for many home- and business-owners. The policies in this section are designed to lower the barriers to upfront cost and make sure that common sense, energy-saving measures like insulation, daylighting and sealing up energy leaks are available to everyone. By implementing these successful programs on a wider scale, we can retrofit more than 35 percent of homes and businesses by 2030, saving home — and business-owners money on their energy bills for years to come.

Policies and Initiatives

3A. Better Buildings Initiative

In December 2011, the Obama administration announced[27] $4 billion in combined federal and private sector funds for investments in energy efficiency improvements over the next two years. This fund includes a $2 billion commitment, made through the issuance of a Presidential Memorandum, to energy upgrades of federal buildings using long-term energy savings to pay for up-front costs, at no cost to taxpayers. In addition, 60 CEOs, mayors, university presidents and labor leaders committed to invest nearly $2 billion of private capital into energy efficiency projects, and to upgrade energy performance by a minimum of 20 percent by 2020 in 1.6 billion square feet of office, industrial, municipal, hospital, university, community college and school buildings. Mayor Annise D. Parker of the city of Houston, Texas announced in January 2012 that Houston would participate in the Better Buildings Initiative. The city and its corporate partners are committing a total of 30 million square feet of property for energy-efficient upgrades as part of its participation in the program. Houston already boasts the fifth highest number of LEED-certified buildings and ranks seventh on the EPA's list of cities for number Energy Star buildings as well.[28]

The Better Buildings Initiative is one example of how federal programs such as tax credits, knowledge sharing, and leveraging private sector financing through judicious public sector investments can create significant energy savings. This program should be championed and expanded to meet the President's energy savings goal of a 20 percent reduction in total commercial energy use by 2020.[29]

3B. Clinton Climate Initiative's Energy Efficiency Building Retrofit Program

The approach to efficiency retrofits at the Clinton Climate Initiative (CCI) is threefold: by working with the building industry, government partners, and financial partners, CCI aims to overcome market barriers and fully tap into the efficiency resource. CCI is working on more than 250 individual and multi-building energy efficiency projects around the world. Together, these projects encompass more than 500 million square feet of building space in more than 20 cities. Already more than 400 buildings are in or have completed construction and will prevent the release of over 120,000 metric tons of carbon into the atmosphere each year. These include:

- Public buildings in cities such as Houston, London, and Melbourne
- More than 20 schools and universities
- The largest public housing stock in North America
- Commercial buildings such as hotels, office buildings and malls, including the Empire State Building in New York City and one of the largest malls in Indiai[30]

3C. Property Assessed Clean Energy

Property Assessed Clean Energy (PACE) is a program that allows property owners to finance energy efficiency and renewable energy projects for their buildings and then repay that financing through an assessment on their property taxes for up to 20 years. By financing the project, the upfront cost of the improvements is mitigated, and the loan is transferred automatically to the next owner if the property is sold. Twenty-seven states have adopted legislation enabling local jurisdictions to implement PACE programs.

Efficiency Maine, a trust created by the Maine Legislature, has been administering loans via a variation on the PACE structure since 2009. Maine's climate and reliance on heating oil make it an ideal candidate for efficiency programs like PACE. Indeed, Efficiency Maine estimates that every dollar spent on efficiency incentives in Maine generates $3 in lifetime economic benefits. In total, the program has generated:

- Total lifetime economic benefits of approximately $400 million
- Savings of approximately four million megawatt hours of electricity — enough to power all Maine homes for a year
- Avoided emissions of two million metric tons of global warming pollution

3D. Energy Efficiency Resource Standards

Inspired by the environmental and economic benefits of energy efficiency, about half of the states now embrace specific energy efficiency savings goals, known as Energy Efficiency Resource Standards (EERS). An EERS requires utilities to save a certain amount of energy each year, typically expressed as a percentage of annual retail energy sales or as specific energy savings amounts set over a long-term period.

Illinois' Energy Efficiency Resource Standard commits the state to saving 2 percent of the energy it would otherwise use every year. By 2010, this policy resulted in an estimated 670 MW of saved energy, versus a goal of 543 MW.[31] Policies promoting efficiency in Illinois have resulted in a growing, thriving efficiency sector. A recent report by Environment Illinois[32] documented some of the benefits to the state:

- Illinois' energy efficiency industry creates jobs across the entire economy. More than 330 independent companies and 737 independent and chain retail outlets work to make the state more energy efficient, employing thousands of workers.
- Illinois' energy efficiency companies are part of a growing national industry. In 2006, the nation's energy efficiency industry employed 2.1 million people, a number that could skyrocket by 2030 if the nation continues to prioritize efficiency.
- Sieben Energy Associates of Chicago

is one of at least 40 Illinois companies that perform energy ratings and audits to identify opportunities for homeowners and businesses to improve energy efficiency. Since 1990, the company has grown to employ 25 people and regularly takes on large-scale projects.

- The Sangamon County Department of Community Resources is one of at least 63 businesses or agencies in Illinois that weatherize homes and buildings, providing free services to low-income clients. Thanks to funding from the American Reinvestment and Recover Act (ARRA), the department was able to hire four new full-time auditors and weatherized four times as many buildings in 2010 as in 2009.
- Serous Materials of Chicago is one of at least 73 companies that manufacture energy-efficient products in Illinois. After learning of new incentives for efficiency under the ARRA, Serious Materials purchased the recently closed Republic Window and Door factory in Chicago, and rehired some of the laid-off workers.
- Better Way Builders of Brighton is one of least 120 companies that design or build energy-efficient buildings. As a small business in the homebuilding industry founded shortly before the housing crash, Better Way actually reported strong demand for energy-efficient homes. They have been busy right through the recession.
- At least 21 Illinois companies provide commercial efficiency services, guiding companies and institutions through the process of identifying and taking advantage of opportunities for efficiency savings.

3E. Regional Climate Programs

The Regional Greenhouse Gas Initiative (RGGI), which first took effect in 2009, is the first mandatory cap on global warming pollution implemented anywhere in the United States. RGGI reduces global warming pollution from power plants, makes polluters pay for those emissions, and invests the revenue in clean energy and efficiency programs. These investments further reduce global warming pollution. In auctions through 2011, RGGI has generated $912 million for the member states to invest in clean energy. A report by Environment Northeast (ENE) found that states have spent $465 million of that income on energy efficiency, bringing in lifetime savings of $1.2 billion and creating over 21,000 jobs.[33]

One of the successful programs launched with New Hampshire's RGGI funds is a revolving loan fund operated by the state's Business Finance Authority (BFA). Revolving loan funds are a form of financing that allows an initial grant to fund multiple improvements over time. The fund issues low-interest loans to businesses to enable cost-saving improvements like energy efficiency measures. As the loan recipients realize the savings from those improvements, they pay back the loan fund with a portion of the savings, allowing the fund to issue more loans.

The New Hampshire BFA's efficiency loan fund began with a $2 million grant from New Hampshire's RGGI funds. In 2009, the BFA's loan fund made one of its first loans to Foss Manufacturing Company, a manufacturer of advanced fibers and fabrics located in the town of Hampton. The $750,000 loan allowed the company to invest in more efficient motors, replace its lighting fixtures with efficient alternatives, and rewire a poorly configured electrical system, and led to a $65,000 reduction in the company's energy bill in just two months. In total, Foss expects that the project will save it $750,000 annually on electricity — an impressive return on investment and a quick return for the BFA, which will be able to recoup its loan and assist other businesses.[34] To build on this success, the BFA received a second $2 million grant in 2010.[35]

In 2009, New Hampshire implemented efficiency measures that will reduce energy costs for customers in the state by $1.5 million annually, and prevent the emission of more than 4,000 metric tons of greenhouse gases every year. The program's managers expect those figures to increase to $4.2 million in savings annually and annual greenhouse gas reductions of over 13,000 metric tons in the second year of the program.[36]

3F. On-bill financing

Efficient retrofit financing can take a number of forms. One innovative way is to establish a system through which loans can be paid back over time on one's energy bills. These loans, also called "meter loans," often leverage private financing by arranging for utilities to act as an intermediary. This financing method can also addresses the issue of changing ownership; the loan can remain with the property in the event that the original owner moves.

Clean Energy Works Oregon was formed to administer the on-bill financing program in 2009; the program finances projects ranging in energy savings from 10 to 30 percent and boasts a .002 percent default rate.[37] On-bill financing has been considered in other states since then, but remains a largely untapped method for leveraging private financing for retrofits.

3G. Federal and state agencies leading the way

Early in his term, President Obama issued an executive order instructing federal agencies to set an example of sustainability through their own facilities. The federal government occupies nearly 500,000 buildings, operates more than 600,000 vehicles, employs more than 1.8 million civilians, and purchases more than $500 billion per year in goods and services.[38] By committing the government's agencies to reduce greenhouse gas impacts in all aspects of the agency's business, the president will be making a significant impact on global warming.

Each agency has since produced and updated a sustainability plan, outlining the concrete measures it will take to reduce direct and indirect global warming pollution. A scorecard posted on the White House's website depicts the progress these agencies have made toward the president's sustainability goals.

Many state and municipal governments have developed similar standards for their own buildings:

- In 2010, Rhode Island became the first state to endorse the newly developed International Green Construction Code, requiring all buildings owned, leased or controlled by the state to be built to the Green standard, which represents significant energy and water savings over the previous minimum standards.[39]
- The state of Washington requires all Washington state agencies to lease space only in buildings with an energy performance rating of 75 or greater on the EPA Energy Star benchmarking scale, or where the building owner conducts an energy audit and implements cost-effective energy efficiency upgrades within the first two years of the lease.[40]

IV. Providing Buyers and Renters the Information They Need about Building Efficiency

An energy audit is a comprehensive assessment of a building's energy consumption, including systems, insulation, operational characteristics and other elements. Energy audits help building owners and operators understand energy costs, produce recommendations for energy performance improvements within the building as well as estimates of capital costs and energy/cost savings when measures are implemented.

Requiring audits at the time of sale or lease of a building is one way that many localities and even some states are creating greater demand for energy efficiency through the real estate market, by educating consumers about long-term energy costs. The city of Austin, for example, 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.[41]

The real estate market would also benefit from a better incorporation of energy costs into the appraisal process. Several legislators are working to address this issue; the Sensible Accounting to Value Energy (SAVE) Act is proposed legislation that would improve the accuracy of mortgage underwriting used by federal mortgage agencies by ensuring that energy costs are included in the underwriting process. The SAVE Act would help revitalize the hardest hit sectors of the economy by providing lower rate mortgage financing for cost-effective energy improvements; allowing homebuilders and homeowners to recover the cost of efficiency investments; and enabling better mortgage underwriting while lowering utility bills for American households.[42]

V. Appliance Energy Efficiency Standards

Energy efficiency standards for residential appliances have proven to be an effective way to cut the energy consumption of refrigerators, water heaters, furnaces and other types of equipment used in homes. Yet, there remain many types of appliances with the potential for energy savings through improved efficiency — including clothes washers, external power supplies and room air conditioners.[43]

Over the past decade, state officials, frustrated by federal inaction and responding to public concern about the amount of energy wasted in heating and cooling systems, took action and adopted state standards for furnaces, air conditioners and other heating and cooling equipment. These efforts at the state level have since spurred action by the Department of Energy, setting standards for 30 additional appliance classes since 2007 and updating the standards for an additional 15 appliances.[44]

The Department of Energy sets energy use standards for a wide range of appliances, often spurred on by forward-thinking states. California frequently sets strong appliance standards that are then followed by the rest of the country — for example, the state recently passed the first standards in the country for battery chargers; the Appliance Standards Awareness Project (ASAP) estimates that these standards will save consumers $300 million per year.[45]

Furnaces, Boilers and Air Conditioners

For the first time, the Department of Energy in 2010 set appliance standards that vary based on climate; states in the northern part of the country will now benefit from stronger standards for furnaces and boilers, whereas southern states will reap the economic benefits of more efficient air conditioners and heat pumps. Development of these standards took many years. For furnaces, the Department of Energy initiated work on revised standards in 2001. In the ensuing years, several states, including Massachusetts, Rhode Island, Vermont, New Hampshire and Maryland, frustrated with slow federal progress, enacted their own furnace standards, indicating their strong interest in moving to higher efficiency. This bold action by state energy officials is the primary reason that we now have a strong national standard for energy use in these appliances.

Based on the Department of Energy's analysis, the new standards will provide significant benefits for the nation including:

- Net consumer savings of about $18.7 billion over 30 years
- 156 billion kWh of electricity savings from the AC and heat pump standards over 30 years (roughly enough to power 8.7 million U.S. homes for a year)
- 31 billion therms of natural gas savings from the furnace standard over 32 years (roughly enough to heat two out of three U.S. homes for one year)
- CO_2 emission savings of 143 million metric tons over 30 years (roughly equal to the amount emitted by 25 million cars in a year)[46]

Conclusion

Putting it all together: The City of New York

As New York City demonstrates, cities can adopt a number of the efficiency measures outlined above, achieving synergies and maximizing energy savings. Roughly 80 percent of New York City's carbon footprint comes from buildings' operations, and 85 percent of existing buildings today will still be in use by the year 2030. According to city estimates, the Greener, Greater Buildings Plan (described below) will create more than 10,000 jobs in the building and construction sectors, and save consumers $700 million each year in energy costs.[47]

Forward-thinking policies like those outlined

Key Provisions of the Greener, Greater Buildings Plan

Audits and Retro-commissioning
Requires owners of existing buildings over 50,000 square feet to conduct an energy audit and retro-commissioning of building systems once every 10 years. Buildings are exempt if they achieve certain ENERGY STAR performance minimums or LEED 2009 certification for existing buildings, or demonstrate compliance with a prescriptive list of building efficiency measures referenced in the bill. City-owned buildings are also required to retrofit systems when audits show such work would generate an energy-cost-savings pay-back in seven years or less.

Energy Rating and Disclosure
Requires annual ENERGY STAR benchmarking and disclosure for private buildings over 50,000 square feet and city buildings over 10,000 square feet. City buildings began benchmarking in 2010 and disclosing energy use in 2011, while private buildings began benchmarking in 2011 and will disclose in 2012 (multifamily buildings will disclose in 2013.) Information will be posted to a public, online database that displays a building's energy utilization index (EUI), ENERGY STAR rating and water use for multiple years. Utilities are encouraged to automatically upload utility bills into ENERGY STAR.

Lighting
Requires lighting upgrades to comply with the New York City Energy Conservation Code. The lighting upgrades include the installation of more efficient fixtures and sensors and controls to increase energy conservation.

New York City Energy Code
Creates a local energy code that existing buildings and their systems and equipment must meet upon renovation. The new code closes a loophole that previously exempted many existing buildings from having to comply with energy efficiency code requirements during renovation.

Financing and Workforce Development Initiatives
The legislation also includes initiatives to train new workers for green jobs and help building owners finance energy efficiency retrofits. In partnership with NYSERDA, the city is launching a workforce development and training program to support construction and building-related jobs that will be created by the legislation. The city is also using $16 million of federal stimulus money to provide loans to property owners for energy efficiency upgrades.

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 1: Global Warming Emissions from buildings ($MMTCO_2e$)

State	2009	2020 "no action" scenario	2030 "no action" scenario	2020 with policies	2030 with policies	% reduction from 2009 to 2020	% reduction from 2009 to 2030	% reduction in 2020 versus no action	% reduction in 2030 versus no action
AK	6.88	6.75	7.09	5.95	4.92	14%	29%	12%	31%
AL	36.11	38.04	42.75	33.97	30.45	6%	16%	11%	29%
AR	21.37	21.66	20.85	19.39	15.29	9%	28%	11%	27%
AZ	37.42	48.14	51.92	42.30	34.36	-13%	8%	12%	34%
CA	130.28	99.09	105.51	87.22	68.89	33%	47%	12%	35%
CO	51.05	45.59	46.99	39.89	31.20	22%	39%	13%	34%
CT	19.03	18.55	19.55	16.80	14.08	12%	26%	9%	28%
DC	8.13	6.56	5.97	5.72	3.56	30%	56%	13%	40%
DE	6.36	5.75	5.94	5.08	4.10	20%	36%	12%	31%
FL	134.54	159.80	184.35	141.50	119.85	-5%	11%	11%	35%
GA	70.23	72.26	82.30	64.21	57.70	9%	18%	11%	30%
HI	5.71	4.71	3.93	4.13	1.53	28%	73%	12%	61%
IA	31.53	30.22	31.64	26.99	22.63	14%	28%	11%	28%
ID	8.49	8.57	9.53	7.64	6.87	10%	19%	11%	28%
IL	114.02	99.62	97.16	90.32	69.82	21%	39%	9%	28%
IN	56.38	54.36	53.45	49.23	39.54	13%	30%	9%	26%
KS	35.59	30.30	33.78	26.85	23.64	25%	34%	11%	30%
KY	34.38	37.81	41.79	33.74	29.77	2%	13%	11%	29%
LA	33.92	34.35	31.66	30.88	23.54	9%	31%	10%	26%
MA	30.64	30.53	33.23	27.56	23.75	10%	22%	10%	29%
MD	42.59	43.00	46.36	37.81	31.69	11%	26%	12%	32%
ME	7.32	6.76	6.95	6.22	5.24	15%	28%	8%	25%
MI	85.97	86.30	82.49	77.18	60.32	10%	30%	11%	27%
MN	53.37	52.29	54.02	47.02	38.61	12%	28%	10%	29%
MO	72.06	68.10	77.31	60.63	54.54	16%	24%	11%	29%
MS	20.73	21.84	23.95	19.42	16.97	6%	18%	11%	29%
MT	10.50	10.35	10.49	9.18	7.57	13%	28%	11%	28%
NC	66.77	65.95	77.47	58.25	53.71	13%	20%	12%	31%
ND	9.79	9.21	9.60	8.21	6.85	16%	30%	11%	29%
NE	20.91	20.31	22.16	18.05	15.52	14%	26%	11%	30%
NH	6.48	6.93	7.89	6.27	5.85	3%	10%	10%	26%
NJ	61.99	70.94	77.73	62.76	54.86	-1%	11%	12%	29%

NM	13.54	12.15	11.47	10.75	7.85	21%	42%	11%	32%
NV	14.21	19.20	22.24	16.75	14.87	-18%	-5%	13%	33%
NY	115.43	103.96	105.88	92.72	75.75	20%	34%	11%	28%
OH	100.61	93.51	85.09	85.23	64.26	15%	36%	9%	24%
OK	40.25	37.64	36.23	33.61	26.21	16%	35%	11%	28%
OR	19.02	17.62	19.90	15.24	12.51	20%	34%	13%	37%
PA	85.99	88.54	93.70	79.89	68.60	7%	20%	10%	27%
RI	5.34	5.54	5.82	5.05	4.39	5%	18%	9%	25%
SC	31.39	28.67	31.73	25.60	22.54	18%	28%	11%	29%
SD	9.65	9.07	9.73	8.06	6.83	16%	29%	11%	30%
TN	49.91	57.91	67.92	51.23	47.51	-3%	5%	12%	30%
TX	174.77	204.81	222.54	179.83	154.73	-3%	11%	12%	30%
UT	14.06	13.99	15.97	12.38	11.08	12%	21%	12%	31%
VA	65.58	66.29	75.15	58.27	51.94	11%	21%	12%	31%
VT	3.32	3.34	3.57	3.09	2.74	7%	17%	8%	23%
WA	35.69	33.07	38.17	29.40	26.67	18%	25%	11%	30%
WI	51.52	50.13	52.78	44.55	37.31	14%	28%	11%	29%
WV	17.61	16.52	15.90	14.99	11.87	15%	33%	9%	25%
WY	6.32	5.48	5.23	4.82	3.70	24%	41%	12%	29%
U.S.	**2184.76**	**2182.08**	**2324.86**	**1941.81**	**1628.59**	**11%**	**25%**	**11%**	**30%**

Appendix 2: Electricity Consumption in Buildings (GWh)

State	2009	2020 "no action" scenario	2030 "no action" scenario	2020 with policies	2030 with policies	% reduction from 2009 to 2020	% reduction from 2009 to 2030	% reduction in 2020 versus no action	% reduction in 2030 versus no action
AK	4,958	5,099	5,788	4,407	3,783	11%	24%	14%	35%
AL	53,403	56,774	62,905	50,487	44,223	5%	17%	11%	30%
AR	28,460	30,811	32,112	27,553	23,295	3%	18%	11%	27%
AZ	62,227	71,156	82,634	62,169	53,562	0%	14%	13%	35%
CA	210,886	202,303	227,947	171,385	124,396	19%	41%	15%	45%
CO	37,418	38,475	42,643	32,988	26,378	12%	30%	14%	38%
CT	25,833	26,543	29,638	22,882	18,198	11%	30%	14%	39%
DC	11,572	9,070	8,416	7,764	4,684	33%	60%	14%	44%
DE	8,519	7,374	7,837	6,459	5,245	24%	38%	12%	33%
FL	207,730	238,471	295,126	211,080	189,808	-2%	9%	11%	36%
GA	101,229	104,280	116,226	91,938	79,607	9%	21%	12%	32%

HI	6,443	5,242	4,061	4,606	1,351	29%	79%	12%	67%
IA	25,427	26,214	28,173	23,091	19,311	9%	24%	12%	31%
ID	14,558	15,969	18,004	14,089	12,511	3%	14%	12%	31%
IL	94,645	82,901	78,967	73,769	53,213	22%	44%	11%	33%
IN	56,232	52,791	50,303	47,487	36,215	16%	36%	10%	28%
KS	28,154	30,120	33,697	26,275	22,660	7%	20%	13%	33%
KY	45,217	49,102	54,350	43,481	38,021	4%	16%	11%	30%
LA	53,043	57,178	57,375	51,222	42,216	3%	20%	10%	26%
MA	37,246	37,745	43,205	31,715	24,763	15%	34%	16%	43%
MD	56,746	54,446	60,063	47,408	39,453	16%	30%	13%	34%
ME	8,430	8,852	9,905	7,892	6,871	6%	18%	11%	31%
MI	70,718	74,238	74,770	64,717	51,414	8%	27%	13%	31%
MN	44,342	44,787	45,753	40,010	31,442	10%	29%	11%	31%
MO	64,609	69,480	79,121	61,301	54,495	5%	16%	12%	31%
MS	31,106	33,196	36,963	29,344	25,688	6%	17%	12%	31%
MT	9,553	9,915	10,182	8,692	7,090	9%	26%	12%	30%
NC	102,543	109,251	125,416	95,796	85,035	7%	17%	12%	32%
ND	9,007	9,135	9,666	8,061	6,723	10%	25%	12%	30%
NE	18,940	19,767	21,928	17,350	14,897	8%	21%	12%	32%
NH	8,862	10,445	12,540	9,113	8,481	-3%	4%	13%	32%
NJ	67,204	76,015	85,724	65,890	56,777	2%	16%	13%	34%
NM	15,237	12,779	13,086	11,123	8,224	27%	46%	13%	37%
NV	20,828	26,575	32,911	22,978	21,039	-10%	-1%	14%	36%
NY	123,582	110,390	121,076	95,256	78,000	23%	37%	14%	36%
OH	96,766	87,046	75,883	78,700	55,436	19%	43%	10%	27%
OK	40,300	42,001	43,431	37,223	30,771	8%	24%	11%	29%
OR	35,779	36,329	41,548	30,744	23,993	14%	33%	15%	42%
PA	99,308	100,410	109,408	89,463	77,007	10%	22%	11%	30%
RI	6,627	7,252	8,066	6,306	5,432	5%	18%	13%	33%
SC	50,992	50,126	53,700	44,591	37,518	13%	26%	11%	30%
SD	8,749	8,979	9,844	7,890	6,706	10%	23%	12%	32%
TN	68,073	77,607	90,807	68,372	62,538	0%	8%	12%	31%
TX	248,272	291,903	336,245	254,748	229,730	-3%	7%	13%	32%
UT	18,959	20,287	23,858	17,472	15,321	8%	19%	14%	36%
VA	91,583	97,414	108,315	85,000	73,140	7%	20%	13%	32%
VT	4,113	4,669	5,353	4,163	3,728	-1%	9%	11%	30%
WA	66,802	67,604	79,149	59,414	53,566	11%	20%	12%	32%
WI	43,893	47,597	54,062	41,674	36,465	5%	17%	12%	33%
WV	19,280	17,695	16,933	16,010	12,463	17%	35%	10%	26%
WY	7,007	6,900	6,902	5,973	4,675	15%	33%	13%	32%
U.S.	**2,671,407**	**2,780,706**	**3,082,014**	**2,437,521**	**2,047,558**	**9%**	**23%**	**12%**	**34%**

Appendix 3: Fuel Oil Consumption in Buildings (million gallons)

State	2009	2020 "no action" scenario	2030 "no action" scenario	2020 with policies	2030 with policies	% reduction from 2009 to 2020	% reduction from 2009 to 2030	% reduction in 2020 versus no action	% reduction in 2030 versus no action
AK	111.69	81.50	64.21	74.11	47.50	34%	57%	9%	26%
AL	46.81	34.24	31.68	29.08	20.26	38%	57%	15%	36%
AR	42.49	31.31	29.23	26.35	18.39	38%	57%	16%	37%
AZ	37.90	33.93	35.80	28.60	25.34	25%	33%	16%	29%
CA	179.79	145.09	133.73	122.60	87.62	32%	51%	16%	34%
CO	62.29	45.68	41.71	38.41	26.26	38%	58%	16%	37%
CT	622.12	509.60	421.72	492.96	368.06	21%	41%	3%	13%
DC	20.45	10.96	7.88	10.03	5.57	51%	73%	9%	29%
DE	37.23	25.81	19.85	23.99	15.47	36%	58%	7%	22%
FL	136.55	121.56	128.58	102.48	91.11	25%	33%	16%	29%
GA	41.81	32.44	30.93	27.21	19.62	35%	53%	16%	37%
HI	11.85	9.24	8.24	7.76	5.26	35%	56%	16%	36%
IA	29.95	22.45	19.02	19.62	13.09	34%	56%	13%	31%
ID	18.30	13.78	11.83	12.26	8.40	33%	54%	11%	29%
IL	41.85	32.24	30.39	27.50	19.92	34%	52%	15%	34%
IN	54.62	42.46	39.50	37.07	27.27	32%	50%	13%	31%
KS	13.53	10.51	9.56	8.80	6.01	35%	56%	16%	37%
KY	31.69	22.13	18.20	19.71	12.77	38%	60%	11%	30%
LA	65.43	47.87	42.98	40.44	27.30	38%	58%	16%	36%
MA	752.79	611.52	517.22	588.13	445.23	22%	41%	4%	14%
MD	211.70	154.16	122.54	142.80	95.16	33%	55%	7%	22%
ME	323.43	267.85	223.27	254.62	186.54	21%	42%	5%	16%
MI	98.15	79.63	69.58	71.35	51.00	27%	48%	10%	27%
MN	88.96	73.41	65.77	66.53	50.43	25%	43%	9%	23%
MO	28.52	22.23	20.36	18.95	13.27	34%	53%	15%	35%
MS	28.79	22.51	20.49	18.86	12.83	34%	55%	16%	37%
MT	11.30	7.89	6.06	7.06	4.36	37%	61%	10%	28%
NC	133.31	101.19	91.15	89.93	66.11	33%	50%	11%	27%
ND	22.31	15.89	12.60	14.72	9.87	34%	56%	7%	22%
NE	11.49	8.67	7.71	7.41	5.06	35%	56%	15%	34%
NH	192.37	172.20	154.33	163.83	131.11	15%	32%	5%	15%
NJ	381.86	333.63	293.49	316.36	246.50	17%	35%	5%	16%
NM	11.91	8.63	7.24	7.22	4.55	39%	62%	16%	37%
NV	15.72	13.85	13.31	12.26	10.00	22%	36%	11%	25%
NY	1415.93	1133.91	969.75	1059.63	776.72	25%	45%	7%	20%

OH	184.22	140.60	121.30	126.76	88.68	31%	52%	10%	27%
OK	32.36	22.82	21.08	19.15	13.26	41%	59%	16%	37%
OR	54.52	40.86	34.59	36.25	24.64	34%	55%	11%	29%
PA	753.75	615.20	520.98	585.62	436.16	22%	42%	5%	16%
RI	167.88	143.32	118.66	136.97	100.85	18%	40%	4%	15%
SC	29.09	21.00	18.45	18.18	12.35	38%	58%	13%	33%
SD	12.81	9.35	7.90	8.40	5.77	34%	55%	10%	27%
TN	59.83	46.67	45.21	39.66	30.27	34%	49%	15%	33%
TX	146.13	117.45	120.50	98.05	80.05	33%	45%	17%	34%
UT	23.62	17.64	16.99	14.86	10.75	37%	54%	16%	37%
VA	188.25	135.55	109.13	125.99	85.62	33%	55%	7%	22%
VT	117.30	101.18	86.65	96.19	72.63	18%	38%	5%	16%
WA	85.70	63.76	53.99	57.02	39.37	33%	54%	11%	27%
WI	96.60	77.84	67.27	71.65	52.26	26%	46%	8%	22%
WV	21.86	14.28	10.62	12.81	7.65	41%	65%	10%	28%
WY	7.47	5.02	4.00	4.29	2.62	43%	65%	14%	35%
U.S.	**7316.25**	**5872.53**	**5077.23**	**5440.51**	**4016.92**	**26%**	**45%**	**7%**	**21%**

Appendix 4: Natural Gas Consumption in Buildings (billion cubic feet)

State	2009	2020 "no action" scenario	2030 "no action" scenario	2020 with policies	2030 with policies	% reduction from 2009 to 2020	% reduction from 2009 to 2030	% reduction in 2020 versus no action	% reduction in 2030 versus no action
AK	35.81	37.56	39.19	33.67	29.01	6%	19%	10%	26%
AL	60.20	58.95	55.13	54.86	45.10	9%	25%	7%	18%
AR	68.60	72.24	70.24	64.71	53.67	6%	22%	10%	24%
AZ	66.36	86.70	103.05	79.87	77.82	-20%	-17%	8%	24%
CA	728.18	754.31	773.73	695.71	612.96	4%	16%	8%	21%
CO	189.14	200.35	205.16	184.97	161.83	2%	14%	8%	21%
CT	83.43	99.08	106.70	89.83	81.58	-8%	2%	9%	24%
DC	32.42	26.03	22.54	23.97	16.59	26%	49%	8%	26%
DE	21.83	21.47	21.72	19.06	15.74	13%	28%	11%	28%
FL	65.82	84.33	99.78	76.09	81.71	-16%	-24%	10%	18%
GA	171.62	186.11	196.48	172.75	157.27	-1%	8%	7%	20%
HI	2.29	2.35	2.27	2.08	1.72	9%	25%	11%	24%
IA	124.33	120.19	113.51	111.28	90.90	10%	27%	7%	20%
ID	41.12	46.89	49.59	42.54	38.11	-3%	7%	9%	23%
IL	653.66	587.04	574.21	551.48	460.65	16%	30%	6%	20%
IN	215.99	215.08	213.84	199.02	169.13	8%	22%	7%	21%
KS	102.84	101.54	99.01	95.50	81.64	7%	21%	6%	18%

KY	87.86	87.93	82.21	81.74	65.67	7%	25%	7%	20%
LA	60.28	62.13	57.55	57.89	47.16	4%	22%	7%	18%
MA	205.15	238.00	260.54	220.32	205.21	-7%	0%	7%	21%
MD	153.13	173.35	179.24	155.37	135.29	-1%	12%	10%	25%
ME	6.93	8.38	9.12	7.63	7.01	-10%	-1%	9%	23%
MI	488.25	466.60	413.44	438.03	339.91	10%	30%	6%	18%
MN	230.29	251.12	258.85	228.30	199.42	1%	13%	9%	23%
MO	164.25	164.63	164.18	153.80	133.08	6%	19%	7%	19%
MS	42.39	42.69	41.89	39.39	33.99	7%	20%	8%	19%
MT	44.63	47.83	45.92	42.92	35.17	4%	21%	10%	23%
NC	116.83	132.29	144.44	121.53	113.05	-4%	3%	8%	22%
ND	23.12	22.07	20.57	20.32	16.26	12%	30%	8%	21%
NE	70.90	69.39	67.67	64.24	53.12	9%	25%	7%	22%
NH	17.27	22.58	26.26	20.21	19.31	-17%	-12%	11%	26%
NJ	407.19	465.65	497.25	421.29	378.76	-3%	7%	10%	24%
NM	57.10	60.14	56.76	55.02	45.93	4%	20%	9%	19%
NV	68.44	90.79	105.49	80.89	78.18	-18%	-14%	11%	26%
NY	682.04	716.17	732.91	654.58	566.78	4%	17%	9%	23%
OH	459.84	447.39	429.20	415.83	348.49	10%	24%	7%	19%
OK	104.27	103.72	98.92	96.23	79.24	8%	24%	7%	20%
OR	74.45	78.53	82.98	71.83	64.47	4%	13%	9%	22%
PA	376.45	399.24	409.49	365.48	318.76	3%	15%	8%	22%
RI	28.55	35.59	38.02	32.76	30.22	-15%	-6%	8%	21%
SC	49.32	51.75	52.84	47.54	42.66	4%	14%	8%	19%
SD	24.55	23.68	22.85	21.87	18.13	11%	26%	8%	21%
TN	118.02	124.73	123.96	113.16	96.79	4%	18%	9%	22%
TX	358.79	409.79	436.12	376.53	342.92	-5%	4%	8%	21%
UT	104.17	113.06	123.15	103.10	93.65	1%	10%	9%	24%
VA	153.38	172.18	181.44	155.22	136.88	-1%	11%	10%	25%
VT	5.54	7.00	7.74	6.55	6.30	-18%	-14%	6%	19%
WA	140.27	148.18	160.13	135.39	120.93	3%	14%	9%	24%
WI	221.76	228.67	227.36	209.02	177.29	6%	20%	9%	22%
WV	52.62	51.79	47.35	47.59	37.66	10%	28%	8%	20%
WY	23.13	22.94	21.18	20.87	16.64	10%	28%	9%	21%
U.S.	**7,884.85**	**8,240.21**	**8,373.15**	**7,579.82**	**6,579.74**	**4%**	**17%**	**8%**	**21%**

Appendix 5: Total energy consumption in buildings (Btu)

State	2009	2020 "no action" scenario	2030 "no action" scenario	2020 with policies	2030 with policies	% reduction from 2009 to 2020	% reduction from 2009 to 2030	% reduction in 2020 versus no action	% reduction in 2030 versus no action
AK	79,372	77,172	78,792	68,891	57,190	13%	28%	11%	27%
AL	261,058	268,218	285,027	244,358	216,473	6%	17%	9%	24%
AR	183,312	192,960	195,688	174,362	149,457	5%	18%	10%	24%
AZ	297,734	349,552	409,195	313,919	301,480	-5%	-1%	10%	26%
CA	1,565,722	1,553,811	1,665,759	1,404,056	1,251,213	10%	20%	10%	25%
CO	352,396	363,562	383,233	331,592	291,642	6%	17%	9%	24%
CT	271,973	274,379	281,093	252,750	219,451	7%	19%	8%	22%
DC	76,132	59,558	53,253	54,081	37,419	29%	51%	9%	30%
DE	61,801	55,248	56,044	49,614	41,171	20%	33%	10%	27%
FL	862,022	985,766	1,200,153	878,176	872,231	-2%	-1%	11%	27%
GA	543,145	565,553	617,894	513,431	464,246	5%	15%	9%	25%
HI	34,619	29,704	27,510	26,441	19,636	24%	43%	11%	29%
IA	259,919	251,948	249,639	230,975	194,526	11%	25%	8%	22%
ID	101,422	111,472	122,613	100,848	92,365	1%	9%	10%	25%
IL	1,039,968	928,869	903,495	864,019	710,963	17%	32%	7%	21%
IN	465,123	448,634	443,639	413,123	349,093	11%	25%	8%	21%
KS	216,140	219,035	228,258	201,197	176,968	7%	18%	8%	22%
KY	265,501	275,608	287,556	251,921	220,284	5%	17%	9%	23%
LA	257,976	271,260	266,438	247,758	207,414	4%	20%	9%	22%
MA	458,285	472,957	502,626	438,150	395,257	4%	14%	7%	21%
MD	395,231	399,472	422,597	357,842	310,448	9%	21%	10%	27%
ME	100,715	94,652	94,844	87,606	74,022	13%	27%	7%	22%
MI	815,652	801,953	753,424	740,337	600,414	9%	26%	8%	20%
MN	431,314	449,802	461,498	411,968	358,020	4%	17%	8%	22%
MO	422,624	434,425	467,620	397,794	358,811	6%	15%	8%	23%
MS	164,788	169,670	181,386	154,063	137,735	7%	16%	9%	24%
MT	90,808	94,023	93,010	84,848	71,086	7%	22%	10%	24%
NC	538,797	570,074	639,709	513,205	473,410	5%	12%	10%	26%
ND	67,358	64,169	63,257	58,524	48,481	13%	28%	9%	23%
NE	149,161	148,170	153,331	135,532	116,977	9%	22%	9%	24%
NH	90,915	99,661	110,286	91,070	84,917	0%	7%	9%	23%
NJ	716,774	800,544	863,356	721,597	650,992	-1%	9%	10%	25%
NM	121,905	115,204	113,207	104,919	87,747	14%	28%	9%	22%
NV	149,823	192,798	230,541	172,104	170,327	-15%	-14%	11%	26%
NY	1,423,249	1,373,040	1,412,405	1,243,702	1,064,846	13%	25%	9%	25%

OH	868,549	813,866	756,154	754,220	608,790	13%	30%	7%	19%
OK	258,812	261,675	261,521	238,836	201,267	8%	22%	9%	23%
OR	215,746	219,316	242,472	197,484	181,057	8%	16%	10%	25%
PA	875,285	880,907	912,014	806,626	703,611	8%	20%	8%	23%
RI	77,668	83,519	85,460	76,872	67,115	1%	14%	8%	21%
SC	238,601	235,703	249,640	213,905	188,592	10%	21%	9%	24%
SD	65,735	63,621	65,147	58,093	49,905	12%	24%	9%	23%
TN	377,589	414,211	459,927	373,925	345,048	1%	9%	10%	25%
TX	1,269,933	1,468,361	1,653,190	1,317,764	1,226,446	-4%	3%	10%	26%
UT	179,306	191,858	214,914	172,905	158,433	4%	12%	10%	26%
VA	527,542	557,624	607,279	499,006	447,185	5%	15%	11%	26%
VT	46,719	47,954	49,993	44,597	39,891	5%	15%	7%	20%
WA	401,152	408,282	460,396	367,197	334,898	8%	17%	10%	27%
WI	425,538	441,954	465,165	402,072	355,719	6%	16%	9%	24%
WV	128,704	120,350	113,172	110,524	88,923	14%	31%	8%	21%
WY	56,738	54,724	52,412	49,025	39,368	14%	31%	10%	25%
U.S	**19,348,363**	**19,826,846**	**20,967,232**	**18,017,823**	**15,912,957**	**7%**	**18%**	**9%**	**24%**

Appendix 6: Methodology

We began by constructing a baseline scenario — or a "reference case" — that reflects one vision for how the nation might consume energy in the absence of any changes in existing public policy. Our reference case was based largely on energy use forecasts produced by the U.S. Energy Information Administration (EIA) and published in its *Annual Energy Outlook 2011* report.

Because the EIA does not issue state-level forecasts of energy use, we divided forecast energy consumption in the reference case among the 50 states, assuming (in most cases) that the EIA's regional forecasts of growth in energy consumption were applied to each of the states in that region, adjusted for projected growth in population.

Then, for each scenario, we conducted a literature review to develop an understanding of how each set of policies could be expected to affect energy consumption in each of the states. These estimates were fed into a simple Excel-based spreadsheet model that translated anticipated energy savings from each of the policies (calculated either as percentage reductions in energy use or specific numerical reductions) into reductions in carbon dioxide emissions for each of the 50 states. In addition to estimating the impact of each policy in isolation, we also constructed separate scenarios that modeled the impact of the policies in combination, taking into account the potential overlap among policies.

What Are the Limitations of this Analysis?

Assembling this overall picture of how local, state and federal clean energy policies could affect emissions across the country required us to make many simplifying assumptions about how the various policies would be implemented and would interact with other policies.

Among the key simplifying assumptions are the following:

- The state-by-state breakdown of emissions in our reference case is based on regional forecasts of the growth of energy consumption from the U.S. Department of Energy (DOE). The DOE does not publish state-by-state energy use forecasts. Our attempt to distribute future growth in energy consumption and emissions among states in a given region may fail to account for some state-specific factors that affect changes in energy use over time.
- States have developed, and likely will continue to develop, differing methods for implementing particular clean energy policies. For example, states may choose to develop different rules for what counts as "renewable" energy under a renewable electricity standard, or for which utilities are required to comply with that policy. While every effort has been taken to account for these variations in existing state policies, we developed uniform definitions of future policies that are applied to all states, regardless of their historic or likely future choices for how to implement clean energy policies.

A final — and significant — limitation of this analysis is that it only addresses *emissions of carbon dioxide from the consumption of fossil fuels and electricity*. In other words, this analysis does not include or address the emissions of global warming pollutants other than carbon dioxide, which make up approximately 17 percent of U.S. global warming pollution.[48] State-by-state data on emissions of global warming pollutants other than carbon dioxide are difficult and cumbersome to obtain and were, therefore, omitted from this analysis.

Understanding the Data and Making Accurate Comparisons

To properly understand the data presented here, it is important for readers to be clear about what those data represent and how they might be compared with other published estimates.

First, emission inventories vary depending on the scope of their coverage, leading to inconsistencies among published accounts. The emission figures presented in this report include the following:

- Carbon dioxide emissions resulting from direct combustion of fossil fuels in homes and businesses.
- Carbon dioxide emissions resulting from the residential and commercial consumption of electricity in the United States (including, in limited cases, emissions from power plants in Canada or Mexico that supply power to the U.S.)

Excluded from this analysis are emissions resulting from non-energy uses of fossil fuels, as well as from the production of geothermal energy. Following conventions used by the EIA and others, the use of biogenic energy sources was assumed to have net carbon dioxide emissions of zero.

The data on state-by-state emission reductions describe, in most cases, the impact of adopting the particular policy under discussion *in that state*. There is one very important exception to this approach relating to policies that affect the production of electricity. Most electricity grids in the United States span state lines — in New England, for example, the electricity consumed in Connecticut may be supplied from power plants as far away as Maine. And because of interconnections among electricity grids, some electricity may be imported from even farther away.

To account for this, the state-by-state carbon dioxide emission estimates in this report are calculated *on a consumption basis*, not the production basis that is commonly used in publications such as the EIA's estimates of state carbon dioxide emissions.[49] In other words, the emission figures used in this report account for direct fossil fuel combustion in homes and businesses within the state's borders, as well as the emission impacts of electricity *consumed* in homes and businesses, regardless of where it is produced.

The use of a consumption basis for emissions from electricity means that emission reductions for any particular state resulting from any policy that impacts the carbon-intensity of the electricity grid should be understood as representing the impact of *regional* adoption of that policy within the entire electricity grid serving that state.

The Business-as-Usual Alternative (Reference Case)

The reference case scenario in this report was based on two sources of data from the Energy Information Administration. First, it uses the *Annual Energy Outlook* (AEO), which forecasts future energy consumption at the national and regional level. Second, it utilizes the State Energy Data System (SEDS), which provides historical data (with 2009 being the most recent year) at the state level.[50] These sources are, respectively, the official U.S. government forecast of future energy use and the only comprehensive database of state energy consumption available in the public domain. Thus, they represent a generally accepted, if imperfect, starting point for evaluating the impact of policies that shift America's patterns of energy consumption.

We altered the reference case energy use figures presented in the *Annual Energy Outlook 2011* to account for the impact of existing state energy efficiency resource standards (EERS), which were largely excluded from the EIA's reference case modeling.

Some state policies that were not included in the EIA's reference case were also not included in our reference case scenario, including the state-level caps on global warming pollution in seven states. Because these caps affect multiple sectors of the economy, it is difficult to anticipate how they would affect consumption of specific fuels in particular sectors of the economy.

These fuel-by-fuel and sector-by-sector energy consumption figures are the building blocks of our analysis, leaving us unable to include the impact of these policies in our reference case scenario.

Developing a Scenario for Future Energy Consumption
We developed state-level scenarios for future energy use by combining actual 2009 energy consumption by sector and fuel from the *SEDS* with regional forecasts of changes in the use of that fuel in that sector from the *AEO 2011*.

For each category of energy use in the SEDS, we calculated a "regional multiplier" for each census division for 2020 and 2030, representing the amount by which the AEO forecasts usage of energy in that category to increase between 2009 and that year, using the following formula:

$$Multiplier_{FY} = \frac{Usage_{FY}}{Usage_{2009}}$$

Where:
$Multiplier_{FY}$ is the regional multiplier for a given future year,
$Usage_{2009}$ is the amount of energy used in 2009,
And $Usage_{FY}$ is the amount of energy forecast to be used in the future year.

Figure 1. Map of Census Divisions[51]

To make this regional multiplier specific to individual states, we adjusted it for the change in the balance of population within each region over time. We distributed future energy consumption within
the states of the region by assigning a greater share of forecast regional energy consumption to states that are projected to grow faster than the region as a whole, and a lower share to states that are projected to grow more slowly than the region as a whole, according to the following formula:

$$StateEnergy_{FY} = \frac{\left(\frac{StateEnergy_{2009}}{StatePop_{2009}}\right) * \left(\frac{RegionPop_{2009}}{RegionEnergy_{2009}}\right) * RegionEnergy_{2009}}{\sum_{i=1}^{NumStates} (State(i)Pop_{FY} * \left(\frac{State(i)Energy_{2009}}{State(i)Pop_{2009}}\right) * \left(\frac{RegionPop_{2009}}{RegionEnergy_{2009}}\right))}$$

Where:
NumStates is the number of states in the region
All variables subscripted "FY" refer to that quantity in the future year, while all variables subscripted "2009" refer to the quantity in 2009,
StateEnergy refers to the energy value of a particular fuel, in British Thermal Units (BTU), consumed in the state in a given year,
RegionEnergy refers to the amount of a particular fuel, in Btu, consumed in the census division in a given year,
StatePop refers to the projected or estimated population of the state in a given year,
And RegionPop refers to the projected or estimated population of the census division in a given year.
State and regional energy consumption figures in 2009 were drawn from the EIA's State Energy Data System (SEDS).[52] State and regional population figures (estimated for 2009, projected for future years) were drawn from the U.S. Census Bureau.[53]

Translating Fossil Fuel Consumption to Carbon Dioxide Emissions
Having developed a scenario for future energy consumption in each of the states, we then determined what percentage of each fuel was consumed for energy (as opposed to incorporated into consumer products or used for other purposes) and assigned a carbon coefficient to each fuel. Carbon coefficients for all fuels except electricity were drawn from the Energy Information Administration's *Emissions of Greenhouse Gases in the United States report*.[54]

Electricity
For each state, we derived a carbon dioxide coefficient for electricity generation (the amount of carbon dioxide produced in generating a given amount of electricity in that state) in each of the years in our projection as follows.

First, we calculated the percentage of each state's electricity that it receives from various regions of the electricity grid, based on the electricity sales numbers from the EIA's form 861 for 2010.[55] We assigned sales (which are listed by utility in Form 861) to the regions used in the Electricity Market Module of the EIA's Annual Energy Outlook (AEO) using a list of utilities and their associated AEO region provided to us by EIA staff. The percent of a state's electricity received from each region was calculated as the percent of total electricity sales in that state in 2010 made by bundling and distribution utilities in the region in question.

Next, we calculated a projected value for the carbon dioxide coefficient of electricity generated in each of the regions used in the Electricity Market Module of the Annual Energy Outlook in each year, by dividing the quantity of electricity projected to be generated in the region by the amount of carbon dioxide the region's power plants were projected to emit.[56] This figure was used as the carbon dioxide coefficient of electricity at the point of generation, for that region in that year. We then assumed that 6.5 percent of electricity at the point of generation would be consumed by line losses; to reflect this, we divided our figure by .935 to obtain the carbon dioxide coefficient of electricity at the point of consumption.

We calculated a state figure for the carbon dioxide coefficient of electricity at the point of consumption in each year by taking a weighted average of the carbon dioxide coefficients for that year of the regions that the state received electricity from in 2010, weighted by the percent of the state's electricity that came from each region in 2010.

A Note on Units and Conversions

The raw analysis of the data for this report was conducted in Btu. To present our savings in terms of gallons, we converted our data on fuel consumption from Btus to physical units using the methodology presented by EIA in *State Energy Data 2008: Consumption, Appendix B, Thermal Conversion Factor Source Documentation,* 30 June 2010.

Estimating the Benefit of the Scenarios

This section describes how the impacts of the clean energy policies modeled in this report were estimated.

Residential Energy Retrofits

We calculated the potential impact of a residential building energy retrofit program by estimating the total energy use that would take place in residential units built during or before 2008, assuming that the average home retrofit achieves 30 percent energy savings, applying an assumption for market penetration, and calculating the resulting reduction in global warming emissions.

Forecast of Housing Units Out to 2030

We first estimated the number of housing units in each state through 2030 using data from the U.S. Census Bureau. Using 2008 estimates of population and housing units, we calculated a ratio of residents per household by state.[57] Holding this ratio constant, we then applied population projections by state to obtain an estimate of total housing units in each state and each census division for 2020 and 2030.[58]

We assumed that residential units built during or before 2008 would be retired at a rate of 0.4 percent per year, per EIA, Assumptions to AEO 2010, obtaining a forecast of the number of housing units dating to 2008 or earlier, by state out to 2030. Further, we assumed that all housing units built to accommodate new population or to replace units removed from the housing stock after 2008 would be new.

Assigning Residential Energy Use to Existing Residential Units

We assigned a portion of total residential energy use to residential units built during or before 2008 across the forecast period, assuming some improvement in energy efficiency of existing homes, using the following steps.

1) Using the EIA *Residential Energy Consumption Survey 2005*, we broke down energy use by end use for each fuel and census division.[59]

2) We combined these data with forecast improvements in building envelope efficiency for existing buildings and improvements in efficiency for appliances and equipment, per *EIA AEO 2010*, to estimate the relative improvement in energy use for an average existing home by census division in the reference case.[60]

3) We then multiplied the average energy use of an existing home in each census division by the number of existing housing units by state within that census division to estimate the total energy use of existing homes by state and fuel. In some cases, this estimate for minor residential fuels, such as coal, exceeded EIA's total residential sector consumption forecasts. In those cases, we assigned no more than 100 percent of that fuel consumption to existing housing units.

4) On average, based on this methodology, existing homes in each state increase in efficiency by 9 to 13 percent between 2008 and 2030 in the absence of an additional retrofit policy.

Applying the Impact of the Residential Energy Retrofit Policy

To estimate the additional impact of an enhanced residential energy retrofit policy, we assumed that an average home in existence as of 2008 would see an average energy use reduction of 30 percent vs. 2008 average energy use following a retrofit. We also assumed that energy retrofits affect all energy end uses across all fuels equally. Further, we assumed that retrofit policies would be sufficient to reach 75 percent of all homes in America by 2030, with progress building evenly over time beginning in 2012. It is likely that this assumption understates the prospect for short-term emission reductions from home retrofits, since it is likely that the least-efficient homes will be the first to be addressed by such a program.

This translates into an energy efficiency improvement across all existing homes according to the schedule in Table 4.

Building Energy Codes for New Residential Buildings

To estimate the impact of new home building energy codes, we first determined the fraction of energy use attributable to newly built homes by subtracting energy use from homes built in 2008 or earlier (as described in the "Residential Energy Retrofits" case above) from total reference case

Table 4: Residential Sector Energy Efficiency Improvement Relative to 2008 due to Residential Energy Retrofit Policy

Year	2015	2020	2025	2030
Energy Efficiency Improvement	4%	10%	16%	23%

Table 5: Average New Residential Unit Energy Efficiency Improvement by Year of Construction due to Residential Building Energy Codes, Relative to Average 2008 Unit

Year of Construction	2009-2015	2016-2020	2021-2025	2026-2030
Average Efficiency Improvement	10%	36%	52%	63%

residential energy use. We then calculated the total energy use by fuel and state for housing units built in the periods between 2008 and 2015, 2016 and 2020, 2021 and 2025, and 2026 and 2030.

We assumed that building code enforcement would begin in 2012, and that enforcement efforts would achieve 90 percent compliance with the building code, with builders delivering business-as-usual performance 10 percent of the time. This compliance assumption follows the target set as part of the American Recovery and Reinvestment Act of 2009.[61]

Table 5 breaks down the resulting efficiency improvement by year of home construction.

We assume, therefore, that homes built between 2009 and 2015 would be 10 percent more efficient, on average, than a typical home in existence in 2008, due to the building energy code policy. All homes built between 2016 and 2020 would be 36 percent more efficient, on average, and so on.

We assumed that new homes would increase in efficiency in the range of 10 to 17 percent (with results varying by census division) from 2008 to 2030 in the absence of strengthened building energy codes, per assumptions in the *AEO 2010*.[62] Accordingly, we reduced the energy savings percentages in Table 2 by this percentage, calculated by time period and census division, to yield the additional impact of the policy.

To estimate the overall impact of the strengthened building code policy, we reduced forecast energy consumption for homes built within each of the four time periods by the percentage savings we attributed to the policy as described above. We assumed that retrofits would affect all fuel uses equally.

Residential Appliance Efficiency Standards
Estimated energy savings from the efficiency standards were based on estimates from a 2009 report by the American Council for an Energy-Efficient Economy and the Appliance Standards Awareness Project, *Ka-Boom: The Power of Appliance Standards, Opportunities for New Federal Appliance and Equipment Standards*. Using the national-level savings estimated in the report, we calculated the percentage reduction in gas, distillate fuel, and electricity consumption below the baseline that would result from stronger appliance standards and applied that percentage reduction across the states. We also assumed that savings would increase linearly between 2012 and 2020, and between 2020 and 2030.

Commercial Building Energy Retrofits

We estimated the potential impact of a commercial building energy retrofit program by estimating the energy use that would take place in commercial buildings built in 2008 or earlier, applying a percentage improvement in average energy use per square foot, including a market penetration trajectory, and then calculating the resulting reduction in global warming pollution.

Estimating Area of Commercial Building Space by State Through 2030

To estimate the growth in commercial building space by state through 2030, we began with a 2004 Brookings Institution Metropolitan Policy Program report called *Toward a New Metropolis: The Opportunity to Rebuild America*. This report estimates the number of commercial workers by state in 2000 and 2030, and the building space that they require. To interpolate those figures for intervening years, we assumed that the percentage of the population engaged in commercial work (determined using the Brookings Institution commercial workers data and U.S. Census Bureau population projections) would change at a steady rate between 2000 and 2030. Then, we calculated the total square footage of building space that those commercial workers would require using the Brookings Institution estimates of space requirements per worker.

We divided commercial building space into two categories — buildings built in 2008 or earlier and newly built buildings — and assumed that buildings in existence as of 2008 would be retired at a rate of 1.37 percent per year, per the Brookings Institution report cited above. All square footage in between the total estimated building space and existing building space was assumed to be new construction.

Estimating Energy Use by Existing Commercial Buildings

We assigned a fraction of total commercial energy use to commercial buildings in existence as of 2008 across the forecast period using the following steps.

1) We assumed that the rate of energy usage per square foot in existing buildings (by state and fuel) would remain constant in the reference case over the forecast period. (Unlike in the residential sector, where the EIA assumes improvements in building envelope efficiency over time, the EIA does not provide data for assessing trends in the efficiency of existing commercial structures.) Applying this rate to the amount of existing building space in each year gave an estimated energy consumption level in existing buildings.

2) In cases where this estimate exceeded the total forecast commercial energy usage for that fuel, we capped existing building energy usage at 100 percent of the sector total. (This only occurred for fuels whose use varies greatly from state to state, including distillate fuel, wood and waste.)

Table 6: Average Commercial Sector Building Energy Efficiency Improvement due to Energy Retrofits, Relative to Average 2008 Building

Year	2015	2020	2025	2030
Energy Efficiency Improvement	6%	17%	27%	38%

3) All additional energy use was assigned to new commercial buildings.

Estimating the Impact of the Commercial Building Energy Retrofit Policy
We assume that 75 percent of commercial buildings built in 2008 or earlier receive retrofits by 2030, with an average energy efficiency improvement per square foot of 50 percent. We assume an even rate of market penetration beginning in 2012, achieving an overall improvement in energy use per square foot according to the schedule in Table 6.

We then multiplied the new, post-policy energy use rate per square foot by the projected total area of existing commercial building space by state to obtain an estimate of the overall impact of the policy. We assumed that energy retrofits affect all energy end uses across all fuels equally.

Commercial Building Energy Codes
To estimate the impact of new commercial building energy codes, we began with the fraction of energy use in newly built (post-2008) commercial buildings, as described in the "Commercial Building Energy Retrofits" case above. We then calculated the average energy use per square foot of building space by fuel and state for commercial buildings constructed between 2008 and 2015, 2016 and 2020, 2021 and 2025, and 2026 and 2030.

To estimate the impact of new commercial building energy codes, we assumed that the energy use per square foot of an average new building would improve, relative to an average building in existence in 2008, by 50 percent by 2020 and 75 percent by 2030.

Further, we assumed that enforcement efforts would begin in 2012 and achieve 90 percent compliance with the building code, with builders delivering business-as-usual performance 10 percent of the time. This compliance assumption follows the target set as part of the American Recovery and Reinvestment Act of 2009.[63]

Because these targets will be reached gradually, Table 7 breaks down the average efficiency improvement by five-year period of building construction.

All commercial buildings built between 2009 and 2015, therefore, are assumed to be 7 percent more efficient per square foot, on average, than a typical building in existence in 2008, due to building energy code improvements. All buildings built between 2016 and 2020 are assumed to be 37 percent more efficient per square foot, on average, and so on.

In the event that the reference case energy use per square foot in new commercial buildings already exceeded this level of improvement for a particular fuel and state, the reference case

Table 7: Average Commercial Sector Building Energy Efficiency Improvement due to Energy Retrofits, Relative to Average 2008 Building

Year of Construction	2009-2015	2016-2020	2021-2025	2026-2030
Average Efficiency Improvement	7%	37%	52%	63%

value was not changed. Finally, total commercial energy use was estimated by multiplying the new energy use per square foot of building space by the projected amount of new commercial building area to be built during each construction period.

Commercial Appliance Efficiency Standards

Estimated energy savings from the efficiency standards were based on estimates from the American Council for an Energy-Efficient Economy/Appliance Standards Awareness Project report described above. We assumed that boiler standards would save natural gas fuel. Using the national-level savings estimated in the report, we calculated the percent reduction in natural gas, distillate fuel, and electricity consumption below the baseline that would result from appliance and equipment standards and applied that reduction across the states. We also assumed that savings would increase linearly between 2012 and 2020, and between 2020 and 2030.

Distributed Renewable Energy Generation

To model the impact of a suite of policies designed to increase the rate of market penetration of distributed renewable energy technologies, such as rooftop solar photovoltaic panels, we began with market penetration projections developed by Navigant Consulting for the National Renewable Energy Laboratory in a 2008 report called Rooftop Photovoltaics Market Penetration Scenarios.[64] Under a "best case" scenario, the report considered the impact of policy changes including net metering availability, federal tax credit extension, favorable interconnection standards, enforcement of existing solar requirements in state Renewable Electricity Standards and the impact of achieving the progress in photovoltaic module pricing targeted by the U.S. Department of Energy's "Solar America Initiative" for technology development. The report then predicted the pace of solar photovoltaic capacity installation by state through 2015, taking into account a wide variety of factors from local electricity market prices to the overall availability of appropriate residential and commercial rooftop space.

We adjusted this forecast, generally downward, based on the ratio of actual installations of PV capacity that had occurred by state as of 2009, as tracked by the Interstate Renewable Energy Council, vs. projected 2009 capacity.[65]

For the United States as a whole, these conditions yielded an average installed capacity growth rate of 56 percent per year from 2008 through 2015. To extend this forecast to 2030, we assumed that the overall market for rooftop solar panels would grow at an annual rate of 30 percent in 2016, gradually and evenly declining to 6 percent in 2030. (This scenario roughly approximates the "Moderate Case" used by the European Solar Photovoltaic Industry Association in a 2008 analysis of global achievable solar potential through 2030.[66]) Under this scenario, rooftops in the United States would host 210 GW of solar photovoltaic modules by 2030 — enough to generate about 6 percent of the nation's total electricity supply.

Breaking Down Solar Panel Installations by State

To break down the overall rooftop solar photovoltaic installation scenario by state, we considered three pieces of information:

- We calculated the percentage of total nationwide capacity located in each state in 2015 according to Rooftop Photovoltaics Market Penetration Scenarios. This scenario places some states in the vanguard for total capacity installed by 2015 — notably California, but also including Arizona, Nevada, Oregon, New England, New York, New Jersey, Pennsylvania and Texas. The markets in these states, because they are better developed than other parts of the country, and/or have favorable conditions such as high market prices for electricity, account for a larger fraction of the overall future growth.

- We calculated the ratio of total area of commercial rooftop space in each state to total rooftop area nationwide, beginning with the forecast of total commercial building space as described in "Estimating Area of Commercial Building Space by State Through 2030" on page 28, divided by the average number of floors per building by census division, per the U.S. Department of Energy's *Commercial Buildings Energy Consumption Survey 2003*.
- We also calculated the ratio of the total number of housing units in each state to total housing units nationwide across the study period, per "Forecast of Housing Units out to 2030" on page 24.
- For 2015, we simply used the state by state capacity breakdown in our adjusted version of the forecast in *Rooftop Photovoltaics Market Penetration Scenarios*. For 2020, 2025 and 2030, we used the average of the three ratios described above to act as a scaling factor to break down the percentage of national solar photovoltaic installation activity happening in each state.
- We also used figures from *Rooftop Photovoltaics Market Penetration Scenarios* to estimate the market potential for rooftop solar in each state. Our scenario did not exceed 65 percent of these market potentials in any state by 2030, and was only 20 percent of total potential on average.

Estimating Solar Photovoltaic Energy Generation

We calculated energy output by multiplying installed capacity by estimated capacity factor by state, averaged across every hour of one year. We estimated capacity factors using the National Renewable Energy Laboratory's *PV Watts* tool.[67] The resulting figures described electricity generation in terms of billion kWh per year across the study period. We translated electricity generation in kWh into Btu using a conversion factor of 3412.14 Btu per kWh.

Additionally, in order to estimate the fraction of solar energy consumed in the residential vs. commercial sectors, we assumed that 40 percent of rooftop solar installation would be on residential buildings, and 60 percent on commercial buildings.

Combined Residential and Commercial Scenarios

To achieve the greatest reductions in global warming pollution, states will need to implement multiple pollution reduction programs simultaneously. Many of the policies discussed above contain elements that overlap in part or in whole with other policies, and thus the savings from one policy cannot be added directly to the savings from another policy. We created a combined scenario that eliminated the overlapping elements of the policies in order to estimate the benefits of adopting the entire package of policies proposed in this paper.

We assumed that residential and commercial retrofits and building codes would reduce energy consumption relative to the reference case and then assumed that a distributed renewable energy policy would curb the amount of conventionally generated electricity used to meet the remaining energy demand in buildings. In this case, distributed renewable energy generation is assumed to be additive to the increases in utility renewable energy delivery created by existing and new renewable electricity standards.

We also assumed that appliance standards would overlap with both stronger building codes and home retrofit policies. Central air conditioning units, furnaces, and water heaters would clearly be affected by building codes and could be a focus of home retrofits. For this reason, we assume no additional benefit from appliance efficiency standards when paired with home retrofits and energy codes. This is likely a very conservative assumption.

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