Building a better future:

Moving Toward Zero Pollution with Highly Efficient Homes and Businesses

ENVIRONMENT TEXAS

RESEARCH & POLICY CENTER

Building a better future

Moving toward zero pollution with highly efficient homes and businesses

Charlotte Jameson & Rob Sargent
Environment Texas Research & Policy Center, April 2009

Cover Photos: Photo of farm house with solar panels, source: Photo taken by Brigetta Johnson of GreenWorks Realty.; A 2350 sf net-zero energy community building and pool to serve the residents of the Hyland Village neighborhood located in Westminster, CO., source: Soft Mirage; Solar panel installation on a residential roof, source Rob, Flickr commons; city skyline, source: Shutterstock.com.

Acknowledgements

The author wishes to thank Edward Mazria, Founder and Executive Director of Architecture 2030; Jim Edelson from the Advance Codes Team of the New Buildings Institute; Jennifer Amann, the Director of the Buildings Program with the American Council for an Energy Efficient Economy; Aleisha Khan, the Executive Director of the Building Codes Assistance Project; and Cosimina Panetti from Building Codes Assistance Project for their review and insightful comments. Thanks also to the many Environment America state advocates and directors, including Nathan Willcox, Energy and Clean Air Advocate for Environment Texas; Luke Metzger, Director of Environment Texas; and Brian Granahan, Staff Attorney for Environment Texas, among others who provided edits and insightful comments. Finally, thanks to Tony Dutzik of Frontier Group and Rob Sargent, the Director of Environment America's Energy Program, for their editorial assistance.

Environment Texas Research & Policy Center wishes to thank the Energy Foundation for making this project possible.

The recommendations are those of Environment Texas Research & Policy Center. The views expressed in this report are those of the author and do not necessarily reflect the views of our funders or those who provided review. Any factual errors are strictly the responsibility of the author, Charlotte Jameson.

Environment Texas Research & Policy Center

Environment Texas Research & Policy Center is a 501(c)(3) organization. We are dedicated to protecting Texas's air, water and open spaces. We investigate problems, craft solutions, educate the public and decision makers, and help citizens make their voices heard in local, state and national debates over the quality of our environment and our lives.

For more information about Environment Texas Research & Policy Center, or for additional copies of this report, please visit http://www.EnvironmentTexas.org.

Table of contents

Executive Summary

America is the largest consumer of energy in the world. The majority of this energy is derived from dirty, polluting sources such as coal, oil, natural gas and nuclear power. Our consumption of these fuels exacerbates global warming, keeps us dependent upon oil and other fossil fuels, and undermines our economy.

40 percent of America's energy—ten percent of all the energy used in the world—goes towards powering our buildings. Much of this energy is simply wasted through poor insulation, leaky windows, inefficient lighting, heating or cooling systems, and poor construction techniques.

If we stay on our current unsustainable path, the energy we use in buildings will:

- Grow by 6.61 quadrillion British Thermal Units (BTUs) between 2010 and 2030—a 16 percent increase, or as much energy as is used to power 86 million homes for 2 years;[1]
- Account for 43 percent of total U.S. energy consumption by 2030, making us even more dependent on imported and polluting fossil fuels;[2] and
- Have increased emissions of carbon dioxide by 323.95 million metric tons, roughly equivalent to the annual carbon dioxide emissions of 80 coal-fired power plants.[3]

For us to make meaningful progress in reducing our energy consumption and our nation's global warming emissions, we must use far less energy in our buildings.

With approximately 75 percent of our buildings scheduled to be new or renovated by the year 2040,[4] we have a huge opportunity to save energy. By taking bold action to improve the energy efficiency of our nation's buildings, we can put America on track to meet our energy challenges and reduce our global warming emissions. President Obama has announced an ambitious but achievable goal of making all new buildings zero-net energy, or "zero energy", by 2030. The economic recovery bill recently passed by Congress has provided some much-needed momentum, by providing more than $25 billion for weatherization, and energy efficiency upgrades for commercial and government buildings.[5]

Through ongoing investments in making our existing buildings more efficient and by committing to higher performing new buildings—which cut energy use in half within ten years and which should generate as much energy as they use by 2030—we can make major progress toward achieving energy independence, reducing global warming emissions and improving our economy.

By adopting and implementing the following policies we can promote the construction of high performance, energy-efficient buildings:

- Improving and enforcing building energy codes. National model code standards should require 30 percent greater efficiency by 2010 and 50 percent greater efficiency by 2016, and state and local codes should match or exceed the model codes. This would ensure that the 2012 and 2018 code releases would meet these targets;
- Adopting the President's target of all new buildings being zero energy by 2030; and
- Retrofitting all existing commercial and residential buildings before the year 2030.

By 2030, America will see the following benefits from adopting these policies:

- Saving 144 quadrillion BTUs, or enough energy to power all of America's homes, businesses, cars and power plants for a year and a half;
- Preventing a total 11.2 billion metric tons of carbon dioxide from being emitted, equivalent to nearly the annual carbon dioxide emissions of the U.S. and China combined;
- Paying back upfront costs in eleven years and netting more than $542 billion in energy savings by 2031; and
- By 2050 we will have cut U.S. carbon emissions by 34 percent from projected levels—securing a major portion of the reductions necessary to meet the nation's target of 80 percent cuts in global warming emissions below 2005 levels by 2050.

Introduction

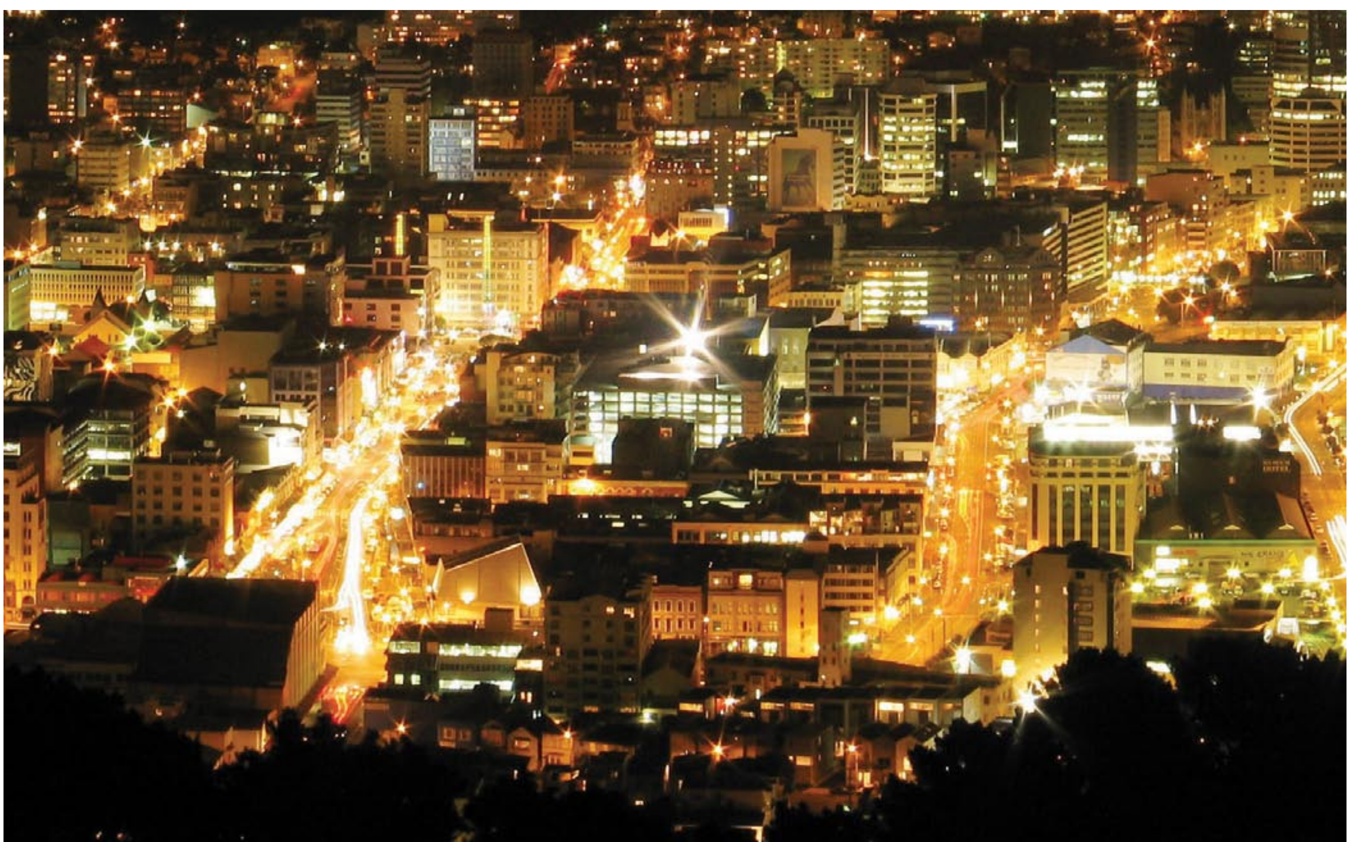
Currently, America's buildings consume far too much polluting energy. Commercial and residential building operations account for about 40 percent of total energy consumption in the U.S. and more than 70 percent of total electricity consumption.[6] This level of energy consumption costs the U.S. approximately $240 billion annually—a tremendous burden on families and businesses nationwide in a time of economic duress.[7] The vast majority of this energy is derived from fossil fuels. As a result, building operations are the source of nearly 40 percent of U.S. carbon dioxide emissions and a significant portion of other U.S. greenhouse gas emissions.[8]

If we continue on our current path, the energy we use in buildings will grow by 6.61 quadrillion BTUs between 2010 and 2030, or as much energy as is used to power about 86 million American homes for two years.[9] Building operation energy consumption would account for 43 percent of total U.S. energy consumption by 2030, making us even more dependent on imported and polluting fossil fuels.[10] In addition, by 2030 the building sector will have increased its emissions of carbon dioxide by 323.95 million metric tons, which is roughly equivalent to the annual carbon dioxide emissions of 80 coal-fired power plants.[11] This growth in energy consumption and greenhouse gas emissions by the building sector directly fuels global climate change and threatens our health and economic stability.

According to leading climate scientist James Hansen, the Earth is "nearing a tipping point" and we must take dramatic action to avoid irreversible damage.[12] Changes to the Earth's climate and landmass are already apparent; the Arctic sea ice is slowly melting and the overall temperature of the planet is rising. During his bid for the presidency, Barack Obama called for an 80 percent reduction in U.S. carbon dioxide emissions below 1990 levels.[13] According to a report released by the United Nations Intergovernmental Panel on Climate Change, industrialized countries need to reduce their greenhouse gas emissions 80 percent by 2050 in order to avoid a two degrees Celsius temperature increase and the tipping point described by Hansen.[14]

America is simultaneously facing a deep economic recession. According to the U.S. Bureau of Labor Statistics the U.S. rate of unemployment is 8.1 percent—the highest level since 1983.[15]

The U.S. needs a new direction and must recognize that



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

the economy and the environment are intertwined. To address the serious economic and environmental problems facing us, we must move towards an economy based on clean, renewable energy and energy efficiency.

Imagine living in a world where buildings produce as much energy as they consume, use no polluting energy sources, and account for no global warming emissions. Imagine living in a home that is so energy-efficient that there is no electricity bill, as the solar panels on your roof provide all the electricity your home needs. And imagine a world where thousands of new, local jobs have been created constructing highly efficient commercial and residential buildings.

This vision is not a far-fetched dream, but rather a reality that could be right around the corner. Highly efficient and zero energy buildings are being constructed around the country. President Obama, the nation's mayors and a number of governors have embraced a vision that would make all new buildings zero energy by 2030. The recently passed American Recovery and Reinvestment Act lays the groundwork for this vision by investing tens of billions of dollars in making homes, businesses and government buildings more efficient.

We have the technology, the know-how and a workforce that is ready and able to retrofit our existing building stock to make it dramatically more energy-efficient and to construct highly efficient new buildings. Not only would initiatives aimed at increasing the energy efficiency of our buildings result in a dramatic reduction in dirty, polluting energy consumption, but they would also create millions of jobs. Weatherization and retrofit projects could be commenced immediately and would put back to work a significant portion of the nearly 10.8 percent of construction workers who are currently unemployed.[16] Furthermore, an investment in energy-efficient retrofits and the construction of highly efficient new buildings would put resources back into communities that desperately need them and create countless indirect jobs where people live—jobs that could not be outsourced.

Building a more energy-efficient America is one of the most effective and least expensive ways to increase our energy security and reduce global warming pollution, while creating jobs and improving our economic competitiveness. In this report, we illustrate the immense opportunity we have to lessen the environmental, economic and energy challenges facing the United States by improving the energy performance of our nation's buildings. Specifically, our analysis a) highlights the best local, state, and national policies that work effectively to increase the energy efficiency of our buildings, b) outlines the real benefits gained, in terms of energy saved, carbon dioxide avoided, and jobs created, through implementation of these policies, and c) describes existing green building and energy efficiency technologies. By undertaking initiatives that ensure that all new and existing buildings are increasingly energy-efficient—and ultimately zero energy—we can put America on track to meet global warming emissions targets while strengthening our economy and creating jobs.

Windmills on top of a London building provide clean, renewable energy for the building's operations.

Genzyme, a biotechnology company, designed its corporate headquarters in Cambridge, MA to be extremely energy-efficient, with electricity costs about 42 percent less than a comparable building. Use of daylight allows 75 percent of employees to work with natural light alone.[17]

Locking energy savings in for the future

Improved building codes

Americans in their day-to-day lives use a staggering amount of energy—we account for only five percent of the world's population, yet we consume 23 percent of its energy.[18] Only a small percentage of this energy is derived from clean, renewable sources; the rest comes from natural gas, oil, nuclear power and coal. On an individual level this high consumption of polluting energy is largely out of our control. For example, we can turn down the thermostat in our homes, but not in the stores where we shop, the restaurants where we eat, or many of the buildings where we work.

Regulating the energy efficiency of buildings is one method through which decreased energy consumption can be assured. The U.S. buildings sector accounts for approximately 10 percent of total world energy use.[19] Much of this energy is wasted through poor insulation, air loss, and inefficient appliances and lighting systems. This waste and inefficiency represents a great opportunity for action. We could see real and positive results immediately by strengthening state and national building codes.

By getting states and localities to adopt the latest model code, strengthening those codes on a regular basis, and setting targets for zero energy buildings, future increases in building sector energy consumption and carbon dioxide emissions could be avoided. If the entire building stock of the U.S. was covered by the 2009 International Energy Conservation Code (IECC), we could save 61 trillion BTUs in the first year—equivalent to the energy required to power approximately 19 million American homes for a year. And, we would also avoid 4 million metric tons of carbon dioxide emissions in the first year alone, an amount equal to the annual carbon dioxide emissions of one coal-fired power plant.[20]

But to maximize these benefits, we must continually strengthen our building energy codes. The 2012 IECC should be 30 percent more efficient then the 2006 version and the 2018 IECC should be 50 percent more efficient. Adopting stronger building codes in the near term, combined with constructing zero energy buildings, would reduce overall building sector energy consumption by 4 quadrillion BTUs by 2031. This reduction is significant; it is roughly equivalent to the energy required to power 52 million American homes for two years.[21]

Stronger building codes would also contribute to a large reduction in emissions of carbon dioxide. With the adoption of strengthened building codes, by 2030 our carbon dioxide emissions would be 26.5 million tons below Energy Information Administration projections for that year. And these reductions would continue for the life of these buildings, sometimes over a century or more. A similar but shorter-lived reduction in carbon dioxide emissions could only be gained by taking 4.5 million American cars off the road.

Making homes more energy-efficient

Further and more immediate decreases in energy consumption and carbon dioxide emissions can be realized through energy efficiency retrofits. An average investment of $4,500 to retrofit a home would decrease per-unit energy consumption by 22 percent and carbon dioxide emissions by 17 percent annually, and save an average of $358 on annual energy bills.[22] With our economy on its heels, solutions that save families on utility bills must be on the table.

The city of Portland, Oregon has implemented a "Block-By-Block Weatherization Program" providing free basic weatherization to low-income households. The Portland weatherization program weatherizes approximately 120 homes each year, reducing the average participant's energy use by 15 percent and saving the average family $100 annually on energy bills. By 2030, the Portland weatherization program will have saved Portland residents $2.5 million.[23]

The ultimate goal of the Portland program is to facilitate building energy efficiency and to maximize the number of buildings that are retrofitted or weatherized. Indeed, this should be the overall goal for the U.S. in terms of energy efficiency; the most far-reaching and significant reductions in energy consumption and carbon dioxide emissions could be realized by retrofitting all homes across the nation.

According to the 2000 U.S. census, the U.S. will have approximately 129 million units of housing by 2010.[24] If $4,500 is invested to retrofit all of these units, we will have saved 6.9 quadrillion BTUs of energy in two years, or as much energy as is produced annually by 165 nuclear power plants.[25] Under this initiative we would also prevent 631 million metric tons of carbon dioxide emissions, which is equivalent to taking 109 million cars off the road.

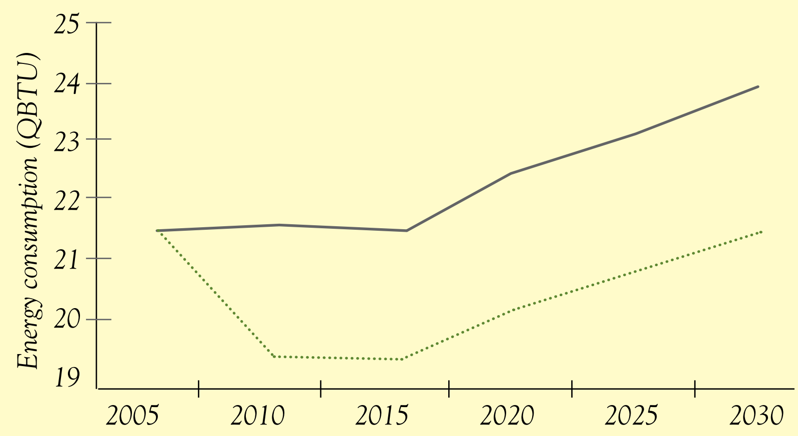
In addition to the Portland model, many jurisdictions have adopted a phased-in approach to residential retrofits, setting targets each year for the number of buildings to be upgraded. Most of these policies require retrofits at the time a building is sold. The benefits of a phased-in approach would not be as dramatic as the more immediate approach, but it would still highlight the importance of energy efficiency and facilitate upgrades across the country.

The graphs below show the potential energy savings and carbon dioxide emissions reductions gained through retrofitting all American homes within two years.

Residential energy consumption with retrofits

EIA projected residential energy consumption with Portland retrofits

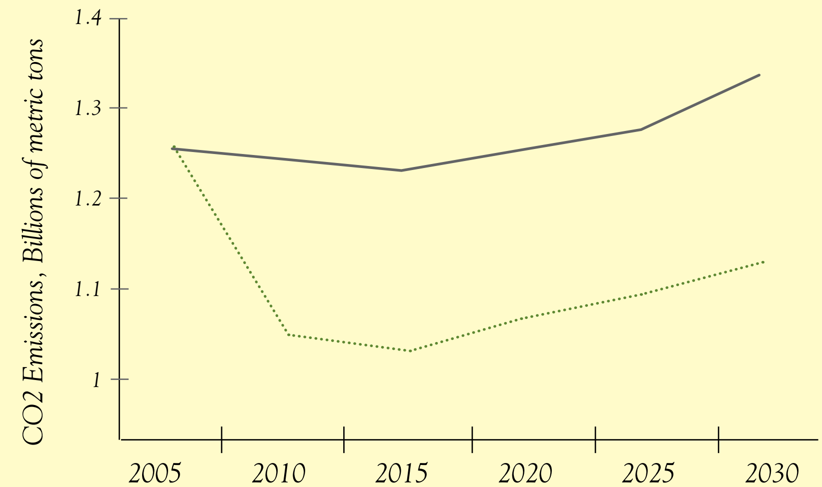
Adjusted annual energy consumption with residential Portland retrofits



Residential sector CO2 emissions with retrofits

EIA projected residential sector carbon dioxide (CO2) emissions

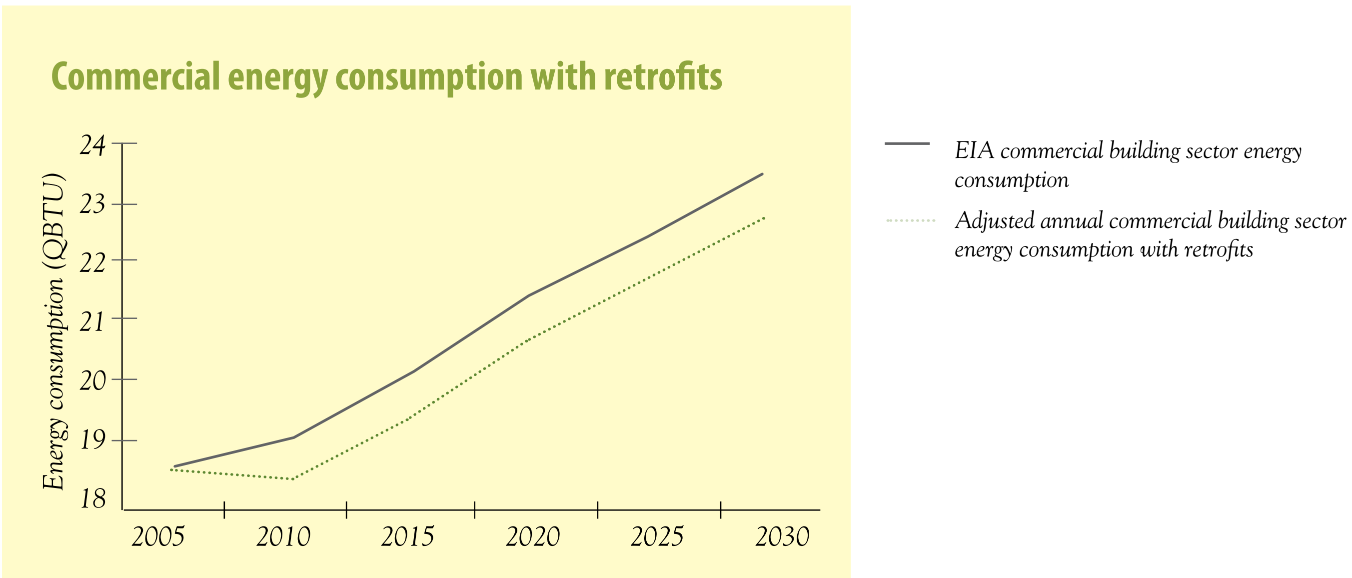
Adjusted annual residential CO2 emissions with residential Portland retrofits

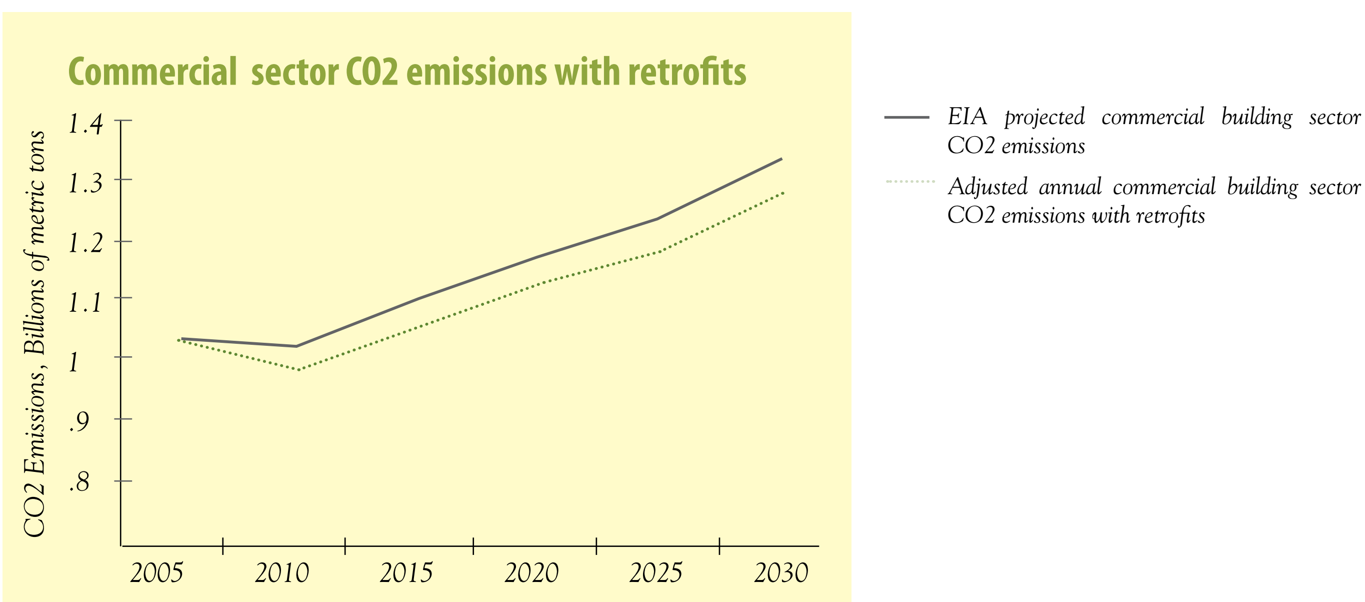


Helping businesses save money and reduce pollution

Commercial buildings account for a large percentage of the overall building infrastructure in the U.S. Therefore, a retrofit program that targets commercial buildings would have a significant impact upon overall U.S. energy consumption. If 10 percent of U.S. commercial buildings were retrofitted annually and thereby made 40 percent more energy-efficient, we would save 41.8 quadrillion BTUs of energy over ten years. That amount of energy is equivalent to the annual power production of 989 nuclear power plants.[26] This program would also avoid 2.1 billion tons of carbon dioxide emissions over 10 years, equal to the annual carbon emissions of 526 coal-fired power plants.[27] The graph below highlights the effect on energy consumption and carbon dioxide emissions levels from commercial retrofits.

Taken in conjunction, commercial and residential retrofits would yield significant gains in energy efficiency and would drastically reduce total U.S. energy consumption and greenhouse gas emissions.





Policy recommendations

The following policies can help promote building energy efficiency:

Building codes

- Model building energy codes should be continually improved, strengthened, and enforced. By 2012, building codes should be 30 percent more efficient than the 2006 version and by 2018 they should be 50 percent more efficient.
- National and state codes should match or exceed model codes. In addition, the federal government and state governments should put in place regulations for the regular and timely adoption of the latest versions of the model codes.
- Local jurisdictions should be allowed to adopt "stretch codes," which require building beyond the level of efficiency in the state code.
- Local, state and federal governments should adopt policies to accurately assess code compliance.
- Policies should be adopted that allow for expedited permitting for buildings constructed to a highly efficient green building standard or beyond code.

Retrofits and weatherization

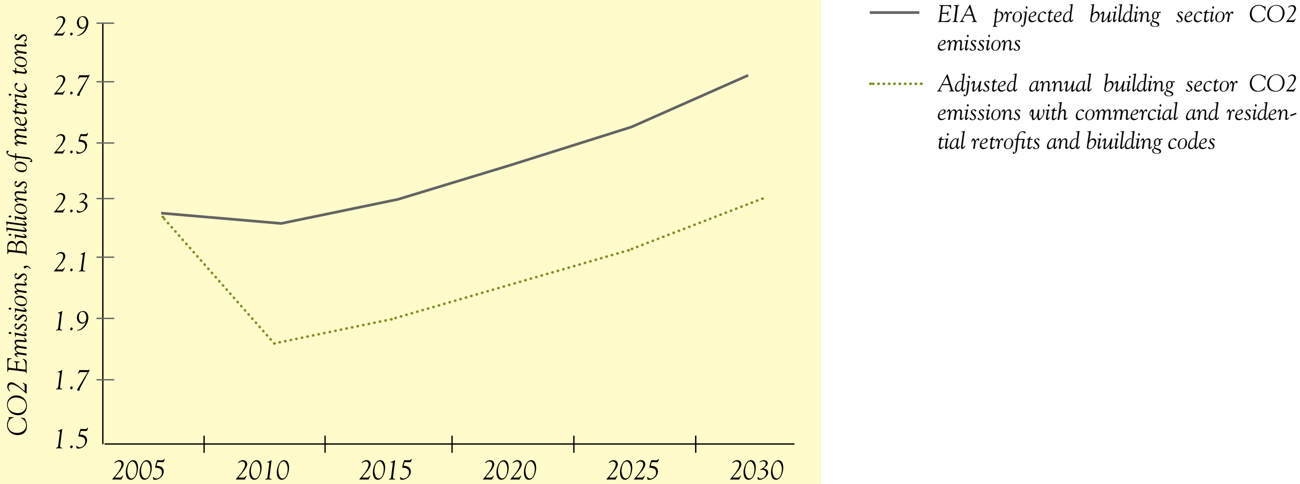
- States should mandate energy efficiency audits at the time a building is sold. States should further require that the results of the audit are disclosed to the buyer before the purchase of the property.
- States should further update their building codes to require that all retrofits with a payback of seven years must be implemented at the time a property is sold.
- The funds for weatherization and retrofits in the American Reinvestment and Recovery Act should be maximized through the Department of Energy's Weatherization Assistance Program to weatherize one million homes.

Zero energy buildings

- Policies should be designed to encourage on-site clean, renewable energy, like wind and solar.
- Federal, state and local governments should set goals for all new buildings to be zero energy by 2030.

By implementing policies at the local, state, and national level that strengthen building codes, ensure commercial and residential retrofits and require zero energy buildings by 2030, the U.S. could save 144 quadrillion BTUs of energy, or as much energy as it takes to power approximately 1.8 billion American homes for two years.[28] We would also prevent 11.2 billion metric tons of carbon dioxide emissions, equivalent to the annual carbon dioxide emissions of approximately 1.9 billion American cars.[29] The graphs below illustrate the benefits of implementing all of these policies.

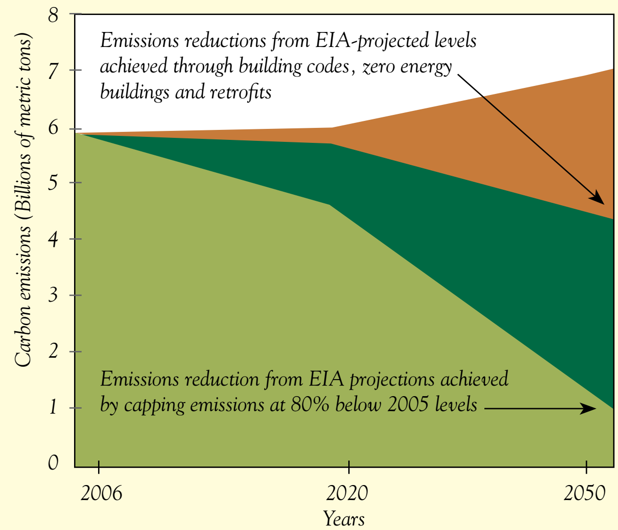
Building sector CO2 emissions



With these policies, we can move our country past our dirty and ineffective energy past, and begin to move toward the real greenhouse gas emissions reductions that will allow us to avoid the worst effects of global climate change.

President Obama has called for capping our global warming emissions and achieving an 80 percent reduction in these emissions by 2050. We can meet these goals, and adopting strong building efficiency measures will help to get us there. The graph to the right shows the EIA projected carbon dioxide emissions for the years 2020 and 2050, the carbon dioxide emissions reductions gained through building codes and retrofits for those same years, and a 35 percent reduction in emissions below 2005 levels by 2020 and an 80 percent reduction by 2050.

Getting to an 80% reduction through building-efficiency measures

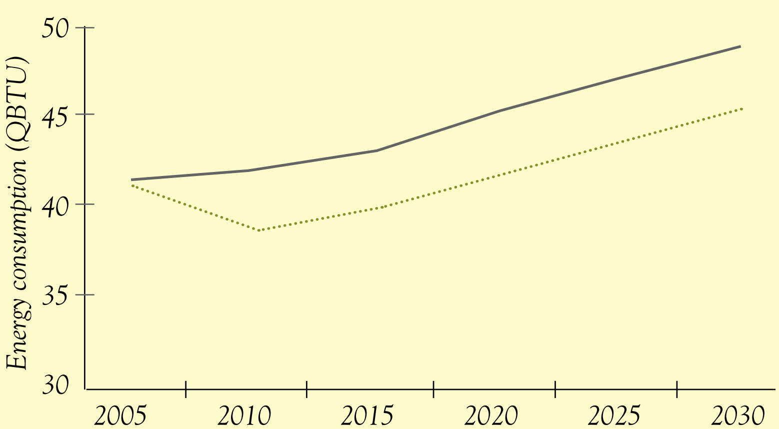


EIA projected total U.S. CO2 emissions

Total U.S. CO2 emissions wiht building efficiency measures

Total U.S. CO2 Emissions 35% and 80% below 2005 levels

Building sector energy use with building codes, and commercial and residential retrofits



EIA projected building sector energy consumption

Adjusted annual building sector energy consumption with commercial and residential retrofits and biuilding codes

Policy implementation

Building codes

At its most basic, the debate surrounding building efficiency reliably comes back to building codes. Energy codes set the minimum standard for energy efficiency—they are the baseline from which increasingly efficient buildings are constructed. Energy codes require new buildings and existing buildings that undergo renovations, repairs or additions to meet a set of efficiency standards. The two most commonly used building energy codes are the International Energy Conservation Code (IECC) and standards determined by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE 90.1). The IECC is developed by the International Code Council (ICC) and is part of a set of codes that gets updated every three years. The latest version of the IECC is the 2009 IECC, which was published in January of 2009. The ASHRAE 90.1 standard is usually published every three years and a new version of the ASHRAE standard will be made available in 2010. ASHRAE 90.1 is the standard for commercial buildings, whereas the IECC governs both commercial and residential buildings.[30]

Once the ICC or ASHRAE publish a new model code, it is up to the individual states—and in some cases individual municipalities—to adopt those codes. Furthermore, many states, such as Florida and California, choose to create their own energy codes based on the model codes. Indeed, code adoption is by no means uniform. The current state of energy codes within the U.S. varies largely from state to state and in some cases from city to city.

Most states fall into three categories: those that have no statewide energy code, those that have adopted a previous version of the IECC or the ASHRAE standard without guidelines to adopt a future version, and those that regularly update their codes with the publication of new versions. In addition, individual municipalities may or may not have the legal authority to adopt stretch codes that go beyond the energy efficiency of the statewide code.

The regular and timely adoption of new versions of the model codes and the implementation of stretch codes are the most effective ways to address building energy consumption. In combination with appliance standards, energy codes that are well-designed, implemented and enforced can lock in cost-effective energy savings of 30 to 40 percent at the time of building construction compared to standard practices.[31] Several states, including California, Massachusetts, Pennsylvania and Maryland, have legislation in place that requires the regular review of the latest model building code as well as the regular updating of their state code.[32]

By requiring the adoption of the latest building codes upon their publication, states can see significant energy, environmental and economic benefits. For example, the California Energy Commission estimates that California's building energy codes have saved consumers $15.8 billion since their first use in 1975.[33] The Texas Building Energy Performance Standard is expected to reduce nitrogen oxide emissions by nearly two tons during days with the highest energy demand and one ton on an average day.[34] Increasing the energy efficiency of buildings through building energy codes also improves a state's economy. Money that is saved through energy efficiency, unlike spending on energy services, typically remains in the local economy.[35]

Adobe Systems Incorporated has slashed energy use and global warming pollution at its San Jose headquarters while also saving money. (Credit: Proehl Studios April 2006)

In order to see these benefits realized, not only must all states adopt the latest national model code (or a code that is equally as energy-efficient) but also the model codes themselves must be continually strengthened. The 2009 version of the IECC is on average 15 percent more efficient then the 2006 version, and the upcoming ASHRAE 90.1 standard is expected to produce even greater efficiency gains. ASHRAE 90.1 2010 is slated to be 30 percent more efficient then the 90.1 2004 version. The 2012 IECC should be 30 percent more efficient then the 2006 version. By 2018 and 2019 the IECC and ASHRAE standards should be 50 percent more efficient. These gains in energy efficiency will put us on track toward zero energy buildings by 2030 and will produce dramatic energy savings.

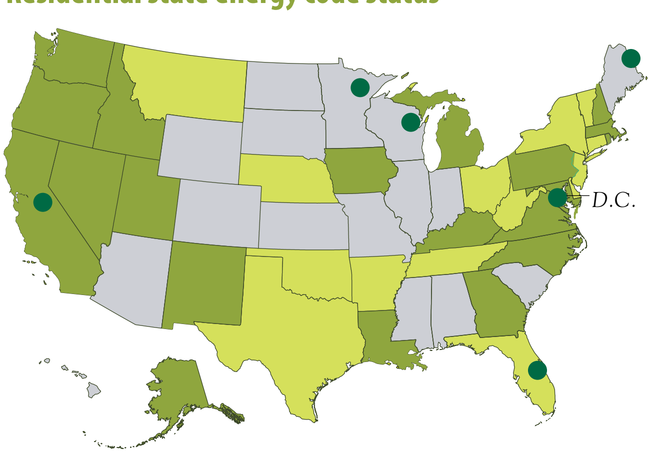
Updated building codes

States across the country are leading the way towards building a more energy-efficient America. At the forefront are states that are on track to implement the latest IECC and ASHRAE 90.1 standard. For example, California has legislation in place that calls for the review and adoption of the latest building codes every three years. After reviewing the recently published 2009 IECC, California adopted a new 2008 Building Energy Standard that will take effect on August 1, 2009.[36] The sweeping Massachusetts Green Communities Act, which was signed into law in 2008, includes language that requires the Board of Building Regulations and Standards to adopt the latest edition of the IECC and to update its code within one year of any IECC revision.[37] In Pennsylvania, the Uniform Construction Code contains similar language and regulates the timely adoption of up-to-date building energy codes.[38] Maryland is also poised to adopt the latest edition of the IECC.[39] These and similar initiatives ensure that states see real progress and energy savings; in California alone it is estimated that its current and future energy codes will save the state $23 billion by 2013.[40]

But code adoption in the U.S. is by no means uniform and many states have adopted previous versions of the model codes without setting guidelines for future code adoption. The maps below outline the current state of commercial and residential code adoption in the U.S.[41]

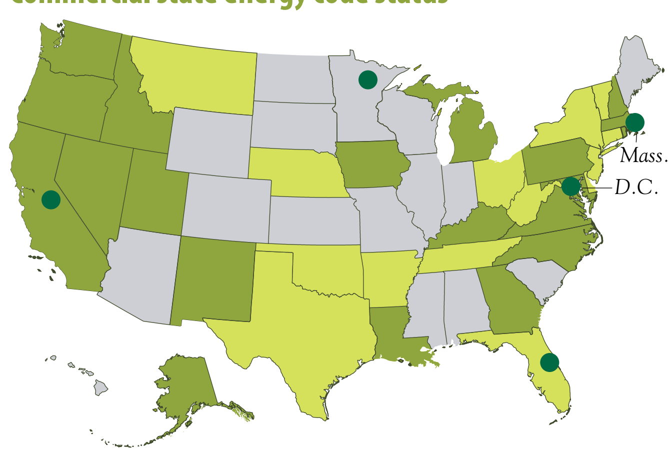
States such as Florida and Washington have residential codes that exceed the energy efficiency requirements of the 2006 IECC, and Washington also has strong commercial codes that go beyond ASHRAE 90.1 2007.[44] The District of Columbia has perhaps moved farthest

Residential state energy code status



More efficient — *Meets 2009 IECC or equivalent*
Meets 2006 IECC or equivalent
Meets 1998-2003 IECC or equivalent (meets EPCA)
Less efficient — *Preceeds 1998 IECC or has no statewide code*

Commercial state energy code status



Meets 2009 IECC/ASHRAE 90.1-2007 or equivalent
Meets 2006 IECC/ASHRAE 90.1-2004 or equivalent
Meets 1998-2003 IECC/ASHRAE 90.1-1999/2001 or equivalent
Preceeds 199 IEC/ASHRAE 90.1-1999 or has no statewide code

The current state of residential[42] and commercial[43] code adoption in the US. Source: Building Codes Assistance Project, www.bcap-energy.org

● *State has adopted a code effective at a later date* on building energy codes. It recently adopted the 2008 D.C. Construction Codes which are based on the principals of the "30 percent solution," a comprehensive set of requirements proposed by the Energy-Efficient Codes Coalition that would boost the residential energy efficiency of the 2006 IECC by 30 percent.[45] With this legislation, minimum building energy efficiency for all new residential construction and major renovation in D.C. will be 15 percent more efficient than the 2009 IECC and 30 percent more efficient than the 2006 IECC.[46]

We have a great opportunity to construct increasingly energy-efficient buildings to reconstruct our built environment. According to Architecture 2030, approximately 75 percent of our built environment will be either new or renovated by 2040.[47] Unless we put into place up-to-date energy-efficient building codes and set goals for buildings to be zero energy by 2030, we will have missed a chance to increase the energy efficiency of three-fourths of our buildings, transform the energy consumption of our building infrastructure, and drastically reduce our greenhouse gas emissions.

Going beyond code: Green building standards

Building codes set the *minimum* standards for energy efficiency. Therefore, many local and state governments have put into place policies that govern building beyond the energy efficiency mandated in those codes. In most cases states either develop their own "green building standard," or use a third party rating system like the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) standard or the Green Building Initiative's Green Globes.

Where implemented, these standards can achieve an average energy savings of 25 to 30 percent above standard practices. The New Buildings Institute conducted a study of the energy intensity of LEED buildings in comparison to standard construction, and found that "the energy use intensity is 26 percent lower for [LEED] certified projects, 32 percent lower for silver and 44 percent lower for gold-platinum" certified projects.[48] Implementing a green building standard ensures both increased energy efficiency and added environmental benefits, such as dramatic carbon dioxide emissions reductions.

Several states and municipalities have adopted LEED-based green building standards for public buildings or for buildings constructed with a percentage of public funds. South Carolina requires that all state-funded construction greater than or equal to 10,000 square feet obtain a LEED silver certification.[49] Massachusetts has adopted legislation that governs the creation of a green building standard for municipal buildings and requires LEED certification based on building size. The legislation works to improve the energy efficiency of state buildings by mandating that they use 20 percent less grid energy by 2025.[50] The District of Columbia passed legislation that requires all new government buildings larger than 50,000 square feet to conform to a green building standard by 2012.[51]

In addition, many localities and states have adopted legislation that would allow for expedited permitting for building construction that meets a green building standard or goes beyond code. Chicago has a Green Permit Program that incentivizes constructing highly energy-efficient buildings by reducing permitting time to six weeks and lowering permitting fees. To qualify, commercial buildings need to meet LEED standards and residential buildings need to use the Chicago Green Home Standard.[52]

The recently passed American Recovery and Reinvestment Act includes significant funding for state programs that promote energy efficiency. The Act allocates an

Zero energy homes, like those under construction in this Sacramento subdivision, couple energy-efficient design with small-scale renewable energy generation to dramatically reduce consumption of fossil fuels. (Credit: Sacramento Municipal Utility District) additional $3.1 billion for the State Energy Program, which provides funding for energy efficiency and renewable energy projects within the states. This funding is conditional and requires states to assert that they have a plan to adopt the latest model building code or a code equivalent in efficiency, and show 90 percent compliance to the code within a specified time. The Act also includes $9.75 billion for modernizing and upgrading public school buildings in accordance with a green building standard, and $5 billion in additional funding for the Weatherization Assistance Program.[53]

This additional funding, together with the steps that states are already taking to go beyond code, set the stage for constructing zero energy buildings by 2030. By building on these steps towards advanced energy efficiency, we can aggressively address global climate change, reduce greenhouse gas emissions, and develop a clean energy economy that promotes both economic and energy security.

Retrofits and weatherization

Adopting the latest national model building energy code is only the first step towards reducing the building sector's overall consumption of polluting energy. The great majority of building sector energy consumption comes from pre-existing buildings. In fact, in 2007 new building construction accounted for only 1.7 percent of the total number of buildings in the U.S. While it is important to establish baseline energy efficiency through strong building energy codes, retrofitting and weatherizing our existing building stock is critical to maximizing the energy efficiency of our building infrastructure.

The Betty Lou Cottage, built by Coastal Habitats Construction and Development. This project utilized Earthcraft House green building guidelines with OneWorld Sustainable acting as the third party verifier and Energy Efficiency Consultant.

Weatherization:

Weatherizing existing buildings is an effective means to reduce energy consumption and to create jobs. On average, weatherization makes a building 22 percent more energy-efficient and creates 75 direct and indirect jobs for every million dollars invested.[54] And while upfront costs for weatherization and retrofitting can be prohibitive in some cases, most projects pay for themselves through energy savings within five to eight years.[55] Families with weatherized homes spend on average $358 less per year in energy bills.[56]

Currently, the Department of Energy's Weatherization Assistance Program weatherizes around 100,000 homes each year, only a small fraction of the total number of homes that qualify under this program.[57] The American Reinvestment and Recovery Act dramatically increased funding for weatherization. This extra funding will weatherize at least one million homes across the country, cutting overall U.S. energy consumption by 130 trillion BTUs and total U.S. carbon dioxide emissions by 352,500 metric tons in the first year. Funding weatherization programs on this magnitude will also put resources into largely neglected communities, creating jobs and jumpstarting the economy.

Retrofits:

Of the nearly 300 billion square feet of existing building stock, we renovate approximately five billion square feet every year.[58] Through policies that target renovation projects and push for mandatory energy efficiency upgrades we can encourage increased energy efficiency and witness significant benefits.

The city of Austin, Texas recently enacted an ordinance that requires an energy audit at the time a property is sold and sets voluntary phased-in targets for time-of-sale energy efficiency retrofits. The ordinance calls for approximately 25 percent of all properties to undergo energy efficiency upgrades in the first year after enactment. That number increases to 45 percent in the second year, 65 percent in the third year, and 85 percent in the fourth year. Furthermore, the audits required at the time of sale would detail the energy consumption levels of the property and outline means through which that consumption level could be improved. This will allow Austin residents to take into consideration energy efficiency when buying a property and to receive expert guidance on how to maximize the energy efficiency of their property through retrofits.

Implementing strong policies that encourage retrofitting our commercial and residential buildings is no easy task and would require a large upfront investment to achieve high levels of energy efficiency. That said, the programs would more than pay for themselves in a matter of years and would go on to provide enormous savings to individuals and businesses through decreased energy consumption. Retrofitting all commercial and residential units as described in this report would cost approximately $632 billion in private and public funds—less than the recently approved bailout of the banks. However, these costs would be paid back in full within eleven years. Moreover, by 2031 we would have saved an additional $542 billion.

Through the implementation of innovative legislation such as time-of-sale energy audits and retrofits, we can capitalize on a significant opportunity to improve the energy efficiency of existing buildings. To realize these dramatic benefits we need to implement policies that encourage building and retrofitting beyond code, and that put us on a path towards zero energy buildings.

Zero energy buildings

Zero energy—or "carbon neutral"—buildings are highly efficient and meet all of their energy needs by producing their own on-site clean, renewable energy. They are not a vague idea, but rather a reality being discovered across the country. The first-ever zero electric commercial building was constructed in 2006 in Branchburg New Jersey. 31 Tannery Project, the corporate headquarters for Ferreira Construction, generates all of its electricity from solar photovoltaic panels. It is also equipped with a highly efficient boiler system and a solar hot water heating system. Within its second year of operation 31 Tannery not only generated enough clean energy to power all of its operations, but also produced an excess of 21,120 kWh of electricity, roughly equal to the energy needed to power 23 homes for one month.[59, 60]

Programs have been started across the country to encourage the construction of zero energy homes. The Department of Energy has established a Zero Energy Homes Program within the Office of Energy Efficiency and Renewable Energy. The Building Industry Research Alliance also created a Zero Energy House Program and has thus far built 416 low-energy homes in California alone. These homes consume 51 percent less grid energy then a standard home—32 percent from increased energy efficiency and 19 percent from on-site renewable energy generation.[61] With new high-tech building products, advanced construction techniques, and increasingly affordable solar panels, we have the ability to construct highly efficient and zero energy homes on a large scale.

Many argue that it is simply too expensive to construct a zero energy building, and indeed the upfront costs can be prohibitive. Furthermore, other barriers exist to the con-

Solar hot water systems can supply most of a home's hot water without the use of fossil fuels. Israel is a world leader in solar water heating. (Credit: VELUX/ESTIF).

Ferreira Construction's zero energy office.

struction of zero energy buildings apart from the initial cost. The current set-up of the electricity system in the United States makes it hard to connect small renewable energy projects to the larger grid. Other policies limit the amount of energy that consumers will be compensated for by utilities. However, the benefits of zero energy buildings, in terms of money and energy saved and carbon dioxide emissions avoided, far outweigh any barriers to construction. If all new construction were zero energy in the year 2030 we would save 437 trillion BTUs of energy. This reduction is equal to the amount of energy needed to power 6 million American homes for two years. We would also avoid 26.5 million metric tons of carbon dioxide in one year, equivalent to taking 4.6 million cars off the road.

Local, state, and national governments should implement policies that set goals for the construction of zero energy buildings and make it easier for homeowners and businesses to install on-site renewable energy systems. California adopted legislation that sets goals for constructing zero energy residential buildings by 2020 and zero energy commercial buildings by 2030.[62] Governor Patrick of Massachusetts has convened a zero energy taskforce and charged it with drafting recommendations and setting goals for zero energy construction within the state.[63] States should follow California's and Massachusetts' lead and strive for zero energy buildings by 2030.

Other policies can help to facilitate the construction of zero energy buildings, including incentives for renewable energy, requiring renewable energy system on-site hookups, and setting net metering standards. To date 38 states have adopted net metering standards, whereby utilities are required to buy energy from small renewable energy systems when those systems are producing energy beyond what it takes to run the building's operations.[64] In this way consumers can sell energy to a utility when the on-site renewable system generates a surplus of energy.[65] Furthermore, incentivizing the installation of on-site renewable technology can greatly reduce upfront costs. The Department of Environmental Protection in Florida offered a solar rebate program that was so successful in 2007 and 2008 that it exhausted its $5 million fund and has begun to place applicants on a waitlist until further funding is provided.[66] Eventually similar programs in states across the country will increase the market for renewable energy and eliminate the need for incentives at all.[67]

Recommendations

We need to put America on the path towards zero energy buildings, and start taking advantage of the many energy efficiency measures that are available and cost-effective today. Every new building or renovation that does not improve energy efficiency locks in energy waste and pollution for decades. Quick action will require strong leadership from policymakers to make energy-efficient buildings the norm instead of the exception.

Government leaders should commit to a goal of zero energy buildings for all new construction by 2030, and 30 percent less energy use for all new and renovated buildings by 2012.

Building energy codes should be improved and enforced:

- The ICC and ASHRAE should update the next versions of the model codes to require a 30 percent increase in energy efficiency of buildings by 2012 and a 50 percent increase by 2018;
- The federal government should exercise its authority to require all states to adopt model codes or equally energy-efficient codes soon after any updates, and to enforce the codes much more stringently;
- State and local governments should pass legislation requiring adoption of model codes soon after they are updated and set high goals for enforcement;
- Federal and state policy should provide for increased training of relevant officials and require commissioning of large buildings that are newly built or renovated.

Federal, state, and local governments should pass policy packages that encourage building far beyond code and retrofitting existing buildings for increased efficiency:

- Federal and state officials should work to mandate uniform home energy rating systems and require disclosure of a building's energy rating at the point of sale;
- Federal and state policy should include stretch codes that can be adopted by jurisdictions that want to go further than the code;
- Incentives that encourage energy-efficient building beyond the model code should be ramped up at all levels, including the federal government, state governments, and within utilities;

- Funding should be increased for other government programs that increase the reach of energy-efficient building technologies, such as the Weatherization Assistance Program and Building America;

Policies should be designed to encourage on-site renewable power:

- States should improve net metering and interconnection laws to encourage distributed generation;
- Federal and state incentives for renewable technologies should be established or increased;
- Where appropriate, state governments should require all new houses to have solar power as a standard feature.

Finally, political leaders should work hard to meet President Obama's goal of having all new buildings be zero energy by 2030.

As this report demonstrates, taking these actions will yield tremendous environmental and economic benefits for our nation. We have the technology to save ourselves from the impending energy crisis, through new and traditional techniques that increase building efficiency and allow us to meet any remaining building energy needs with clean, renewable energy. Strong policies can put these building methods and technologies into widespread use so that inefficient, wasteful buildings are a thing of the past. All we need is the commitment to make this vision a reality.

Appendix

Energy-efficient building technology

Methods for reducing building energy use fall into two categories: increasing efficiency and design strategies, and using on-site renewable sources of power in place of energy from the grid. Highly energy-efficient products, appliances, and design and construction techniques already exist. We can significantly reduce the energy consumption of our buildings by taking advantage of these existing technologies.[68]

Residential Buildings:

Space Heating and Air Conditioning: Space heating is the largest source of energy consumption in homes, accounting for nearly a third of residential energy use nationally.[69] Air conditioning accounts for an additional 12 percent of consumption.[70]

High-efficiency residential furnaces, such as those meeting the federal government's Energy Star standards, can reduce fuel use by about 20 percent compared to furnaces meeting the government's minimum furnace efficiency standard, and by 40 percent or more compared to older furnaces.[71] Considering that about one quarter of all homes have furnaces or heating equipment that is 20 years old or older, the opportunity for energy savings is large.[72] New federal standards for residential and commercial air conditioners will improve efficiency for new units by 30 percent and 26 percent, respectively.[73] However, air conditioners currently exist that exceed the new federal standard by 15 percent or more.

Weatherization: Air sealing, insulation and window replacements can reduce energy consumption by 20 percent.[74] Air escaping through cracks around doors, windows, and other pathways increases the load on heating and air conditioning systems, wasting energy that could easily be saved by ensuring that the building envelope is completely sealed. Installing better windows and better insulation can dramatically increase the energy efficiency of a building.

Cool Roofs: During the summer, significant heat is gained through the roof of a building, which increases the amount of energy used in air conditioning. Simply by changing roof materials, much of this energy can be saved. Light-colored "cool roofs" that reflect rather than absorb the sun's heat have been shown to reduce cooling energy use by approximately 40 percent.[75] For cold and variable climates, "smart" roofing materials are being developed which would absorb heat from the sun in cold weather and reflect it in warm weather.[76]

Water Heating: Water heating accounts for about 12 percent of household energy use.[77] As with other sources of household energy demand, significant energy savings are possible from switching from less energy-efficient to more energy-efficient equipment. Better insulated and more efficient water tanks can save energy. Heat pump water heaters work like refrigerators in reverse, moving heat from the surrounding air into the water tank instead of heating the water directly.[78] They use less than half as much electricity as traditional electric water heaters.[79] Tankless water heaters heat water instantly as it flows through the system (instead of keeping a large tank of water hot regardless of how often it is in use) and use 24-34 percent less energy than conventional water heaters in homes that do not use large amounts of hot water.[80] In addition, some technologies that save water—such as front-loading clothes washers—can also reduce the amount of water that needs to be heated and thereby reduce energy use.

Commercial Buildings:

Lighting: State-of-the-art lighting systems in commercial establishments have the potential to reduce energy consumption of lighting by up to 40 percent nationally.[81] Wal-Mart has reduced its lighting expenses by approximately 66 percent in all new stores by installing motion sensor-activated LED case lighting.[82]

Combined Heat and Power (CHP): Many large apartment buildings, commercial developments and industrial facilities could make greater use of CHP, in which heat produced to warm buildings or power industrial processes is also used to generate electricity. CHP systems can reach 70 to 90 percent thermal efficiency, compared to the 33 percent efficiency of today's power plants.[83]

Many industrial facilities already use CHP, but the potential for growth is enormous. Studies conducted for the U.S. Department of Energy found a market potential of 33,000 megawatts for industrial CHP systems (compared to current deployment of 11,000 megawatts), and as much as 77,000 megawatts in the commercial and institutional sector (compared to deployment of 5,000 megawatts as of 1999).[84] Building out this existing CHP potential would equal about 10 percent of America's current electric generation capacity, and technological improvements could allow CHP technologies to spread even further in the years to come.[85]

Chicago's City Hall was retrofitted with a green roof in 2000.

Methodology

Commercial Retrofits

To calculate the total energy saved through commercial retrofits, several assumptions were made. First, the savings from retrofits was based on an average energy savings per unit of 40 percent. Second, it was assumed that 10 percent of all commercial buildings would undergo retrofits over a period of ten years, with 100 percent compliance. With this information in hand the average energy use per unit was calculated by dividing the total commercial building sector operational energy use by the number of commercial buildings. This number was then multiplied by the number of units to be retrofitted in one year (e.g. ten percent of the commercial building stock), in order to derive the total energy use, without retrofits, for that percentage of the building sector. The calculated energy use per unit was then multiplied by .4 to derive the adjusted energy use per unit with commercial retrofits included. To calculate the total annual energy saved in the commercial building sector with retrofits, the adjusted energy use per unit was multiplied by the number of units retrofitted that year (e.g. ten percent of the commercial building stock). The adjusted energy consumption for that year was then calculated by subtracting the adjusted total commercial building sector energy consumption from the projected total commercial building sector energy consumption. The total energy saved from 2010 to 2020 was calculated by multiplying the annual savings by ten and then every number below ten except zero and then taking the summation of that multiplication series. The total energy savings from 2010 to 2031 was calculated by adding the total energy saved from 2010 to 2020 to the result of the multiplication of the annual energy saved in the commercial building sector by ten.

To calculate the total carbon dioxide emissions avoided through commercial retrofits, several further assumptions were made. A 35 percent reduction in carbon dioxide emissions is achieved through commercial retrofits. The average carbon dioxide emissions per unit was calculated by dividing the total commercial sector operational energy use by the number of commercial buildings. This number was then multiplied by the number of units to be retrofitted (e.g. ten percent of the commercial building stock), in order to derive the total carbon dioxide emissions, without retrofits, for that percentage of the building sector. The calculated carbon dioxide emissions per unit was then multiplied by .35 to derive the adjusted carbon dioxide emissions per unit with commercial retrofits included. To calculate the total annual carbon dioxide emissions avoided in the commercial building sector with retrofits, the adjusted carbon dioxide emissions per unit was multiplied by the number of units to be retrofitted that year (e.g. ten percent of the commercial building stock). The adjusted carbon dioxide emissions for that year was then calculated by subtracting the adjusted total commercial building sector carbon dioxide emissions from the projected total commercial building sector carbon dioxide emissions. The total carbon dioxide avoided from 2010 to 2020 was calculated by multiplying the annual carbon dioxide emissions avoided by ten and then every number below ten except zero and then taking the summation of that multiplication series. The total carbon dioxide emissions avoided from 2010 to 2031 was calculated by adding the total carbon dioxide avoided from 2010 to 2020 to the result of the multiplication of the annual carbon dioxide emissions avoided in the commercial building sector by ten.

The total upfront costs of retrofitting all commercial buildings over a ten year period were calculated by multiplying the total number of units retrofitted each year by $300,000—the average upfront cost of retrofitting a commercial building. The monetary savings gained through commercial retrofits was calculated by multiplying the total number of units retrofitted annually by $24,000—the average annual savings gained through retrofits. The savings gained from 2010 to 2030 were calculated by multiplying the annual savings by 20.

Residential Retrofits

To calculate the total energy saved through residential retrofits, several assumptions were made. First, a 22 percent energy savings was estimated for retrofits per unit of residential housing. Second, it was assumed that all units of housing would undergo a retrofit over the course of two years with 100 percent compliance. The total annual energy savings with residential retrofits were calculated in much the same way as the energy savings for commercial retrofits. The total energy use per unit was multiplied by the number of units to be retrofitted in order to obtain the projected energy usage, without retrofits, for those units. It was then multiplied by .22 to determine the energy saved per unit of residential housing. The energy savings per unit was then multiplied by the total number of units to be retrofitted in order to obtain the annual energy savings through residential retrofits. The adjusted energy consumption for this section of the residential sector was calculated by subtracting the energy savings from the projected energy use without retrofits. These calculations were made for both years of retrofits. The total energy saved over the two years of retrofits was calculated by multiplying the first year's energy savings by two and then adding it to the second year's energy savings. The energy saved from 2010 through 2030 was calculated by multiplying the annual energy savings by two and then multiplying the result of that multiplication by 18. This result of that multiplication was then added to the total energy saved in the first two years of retrofits.

It was assumed that 17 percent of carbon dioxide emissions were avoided by retrofitting residential buildings. The carbon dioxide emissions per unit were multiplied by the number of units to be retrofitted in order to obtain the projected carbon dioxide emissions, without retrofits, for those units. The carbon dioxide emissions per unit were then multiplied by .17 to determine the carbon dioxide emissions avoided per unit of residential housing. The carbon dioxide emissions avoided per unit was then multiplied by the total number of units to be retrofitted in order to obtain the annual carbon dioxide emissions avoided through residential retrofits. The adjusted carbon dioxide emissions for this section of the residential sector were then calculated by subtracting the carbon dioxide emission avoided from the projected energy use without retrofits. These calculations were made for both years of retrofits. The total carbon dioxide emissions avoided over the two years of retrofits were calculated by multiplying the first year's carbon dioxide avoided by two and then adding it to the total carbon dioxide emissions avoided. The carbon dioxide emissions avoided from 2010 through 2030 was calculated by multiplying the annual carbon dioxide emissions avoided by two and then multiplying the result of that multiplication by 18. The result of that multiplication was then added to the total carbon dioxide emissions avoided in the first two years of retrofits.

The upfront cost of the residential retrofits was calculated by multiplying the total number of units retrofitted by $4,500—the average investment in each unit.

The total monetary savings produced through the residential retrofits was based on an assumed annual savings of $358 per unit. The annual savings for the first year were calculated by multiplying the number of units retrofitted by the annual savings per unit. The second year of savings was calculated by multiplying the first year's number of retrofitted units by two and then multiplying the resulting figure by $358. The total savings from 2010 to 2030 was calculated by multiplying the second year's savings by 18 and then adding the first year's savings.

Building Codes:

Energy and carbon dioxide savings from 2010 to 2029 through adopting stronger building codes was obtained from the Building Codes Assistance Project. The adjusted energy consumption for the year 2030 taking into account one year of zero energy buildings was calculated by taking the total energy produced by the new construction sector in the year 2030 and subtracting it from the projected total building sector energy consumption for that year. The carbon dioxide emissions avoided through zero energy buildings was calculated in the same way.

Energy & CO2 Savings: 30% improved code implemented by 2012, 50% improved code implemented by 2022

	Residential		Commercial		Total		
Year	Trillion BTU (primary)	Million metric tons CO2	Trillion BTU (primary)	Million metric tons CO2	Trillion BTU (primary)	Million metric tons CO2	Year
2010	34	2	26	2	61	4	2010
2011	68	5	53	4	121	8	2011
2012	127	9	139	9	266	18	2012
2013	185	12	226	15	411	28	2013
2014	243	16	314	21	557	38	2014
2015	301	20	403	27	704	47	2015
2016	358	24	492	33	850	57	2016
2017	416	28	582	39	998	67	2017
2018	472	31	673	46	1,146	77	2018
2019	529	35	765	52	1,294	87	2019
2020	585	39	858	58	1,443	97	2020
2021	641	43	952	64	1,593	107	2021
2022	729	49	1,101	75	1,831	123	2022
2023	817	54	1,252	85	2,069	139	2023
2024	905	60	1,404	95	2,309	155	2024
2025	992	66	1,557	105	2,549	171	2025
2026	1078	72	1,712	116	2,791	188	2026
2027	1165	77	1,869	126	3,033	204	2027
2028	1250	83	2,027	137	3,277	220	2028
2029	1335	89	2,186	148	3,521	237	2029

**Data obtained from Building Codes Assistance Project*

Total Energy Saved between 2030 and 2031 by Zero Energy Buildings (Qbtu): 0.473459219
Total Energy Saved from 2010- 2030 by strengthening building codes and zero energy buildings: 3.994804186
Total CO2 avoided between 2030 and 2031 by Zero Energy Buildings: 26450761.03
Total CO2 avoided from 2010 -2030 by stregthening building codes and zero energy builidngs: 263092324.8

Citations

1 U.S. Department Of Energy, Frequently Asked Questions- Electricity, downloaded from http://tonto.eia.doe.gov/ask/electricity_faqs.asp 3 February 2009. The average American home consumes936 kWh of energy each month.

2 Federation of American Scientists, Home Energy Retrofits and Green Jobs for the Stimulus Package, downloaded from http://www.fas.org/programs/energy/btech/policy/retrofits.html 12 February 2009.

3 Environmental Protection Agency; eGRID, Downloaded from http://www.epa.gov/cleanenergy/energyresources/ egrid/index.html 28 January 2009. Average US coal fired power plant emits 4 million tons of carbon dioxide annually.

4 Architecture 2030, The Building Sector: A Historic Opportunity, downloaded from http://architecture2030.org/current_situation/hist_opportunity.html 22 January 2009.

5Alliance to Save Energy, Energy Efficiency in the Economic Recovery Bill, downloaded from http://ase.org/content/article/detail/5388 29 February, 2009.

6 Energy Information Administration, U.S. Department of Energy, Annual Energy Outlook 2008 With Projections for 2030, January 2009. See Also: Massachusetts Office of Energy and Environmental Affairs, Sustainable Design Roundtable Report: An Action Plan for Green Buildings in Massachusetts State Construction Projects, Downloaded from http://www.mass.gov/?pageID=eoeeaterminal&L=4&L0=Home&L1=Grants+%26+Technical+Assistance&L2=Guidance+%26+Technical+Assistance&L3=Greening+State+Government&sid=Eoeea&b=terminalcontent&f=eea_lbe_lbe_roundtable&csid=Eoeea October 2008.

7 U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, FY09 Budget Request: Building Technologies Program, downloaded from http://www1.eere.energy.gov/buildings/ 26 January 2009.

8 Energy Information Administration, U.S. Department of Energy, Annual Energy Outlook 2008 With Projections for 2030, January 2009. See Also: Massachusetts Office of Energy and Environmental Affairs, Sustainable Design Roundtable Report: An Action Plan for Green Buildings in Massachusetts State Construction Projects, Downloaded from http://www.mass.gov/?pageID=eoeeaterminal&L=4&L0=Home&L1=Grants+%26+Technical+Assistance&L 2=Guidance+%26+Technical+Assistance&L3=Greening+State+Government&sid=Eoeea&b=terminalconten t&f=eea_lbe_lbe_roundtable&csid=Eoeea October 2008.

9 U.S. Department Of Energy, Frequently Asked Questions- Electricity, downloaded from http://tonto.eia.doe.gov/ask/electricity_faqs.asp 3 February 2009. The average American home consumes 936 kWh of energy each month.

10 Federation of American Scientists, Home Energy Retrofits and Green Jobs for the Stimulus Package, downloaded from http://www.fas.org/programs/energy/btech/policy/retrofits.html 12 February 2009.

11 Environmental Protection Agency; eGRID, Downloaded from http://www.epa.gov/cleanenergy/energyresources/ egrid/index.html 28 January 2009. Average US coal fired power plant emits 4 million tons of carbon dioxide annually.

12 James Hansen, The Observer, "Coal-fired Power Stations are Death Factories. Close them," February 15, 2009.

13 Environmental Protection Agency; eGRID, Downloaded from http://www.epa.gov/cleanenergy/energyresources/ egrid/index.html 28 January 2009.

14 Intergovernmental Panel on Climate Change, 4th IPCC assessment report, Climate Change 2007, downloaded from http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf 24 January 2009.

15 U.S. Bureau of Labor Statistics, February 2009 Unemployment Rate, downloaded from http://www.bls.gov/CPS/ 24 February 2009.

16 Federation of American Scientists, Home Energy Retrofits and Green Jobs for the Stimulus Package. downloaded from http://www.fas.org/programs/energy/btech/policy/retrofits.html 12 February 2009.

17 Genzyme Corporation, What Makes Genzyme Center a Green Building?, factsheet downloaded from http://www.genzyme.com/genzctr/genzctr_home.asp 8 February 2008.

18 World Population Balance, downloaded from http://worldpopulationbalance.org/pop/energy/index.php 2 February 2009.

19 Siena Kaplan, Environment America Research and Policy Center, "Building an Energy Efficient America," May 2008.

20 Building Codes Assistance Project, compiled, Energy Saved and CO2 avoided with 2009 IECC, 30 percent more efficient by 2012 and 50 percent more efficient by 2020. For full chart see appendix.

21 U.S. Department Of Energy, Frequently Asked Questions- Electricity, downloaded from http://tonto.eia.doe.gov/ask/electricity_faqs.asp 3 February 2009. The average American home consumes 936 kWh of energy each month.

22 Linda Berry, Martin Schweitzer, Metaevaluation of National Weatherization Assistance Program Based on State Studies, 1993-2002, Oak Ridge National Laboratory, U.S. Department Of Energy, February 2003. U.S. Department of Energy, Weatherization Assistance Program, "Weatherization Works!" October 2001.

23 Smart Communities Network: Creating Energy Smart Communities, "Block-by-block Weatherization Program," downloaded from http://www.smartcommunities.ncat.org/success/block.shtml 16 January 2009.

24 U.S. Census Bureau, 2000 U.S. Census, downloaded from http://www.census.gov/main/www/cen2000.html 16 January 2009. See also: U.S. Department of Energy, Energy Information Administration, Average Annual New Building Construction, Annual Energy Outlook 2008.

25 U.S. Department of Energy, Energy Information Administration, downloaded from http://tonto.eia.doe.gov/ask/electricity_faqs.asp 12 February 2009. Average nuclear power plant produces 12.4 billion kWh.

26 U.S. Department of Energy, Energy Information Administration, downloaded from http://tonto.eia.doe.gov/ask/electricity_faqs.asp 12 February 2009. Average nuclear power plant produces 12.4 billion kWh.

27 Environmental Protection Agency; eGRID, Downloaded from http://www.epa.gov/cleanenergy/energyresources/egrid/index.html 28 January 2009. Average US coal fired power plant emits 4 million tons of carbon dioxide annually.

28 U.S. Department Of Energy, Frequently Asked Questions- Electricity, downloaded from http://tonto.eia.doe.gov/ask/electricity_faqs.asp 3 February 2009. The average American home consumes 936 kWh of energy each month.

29 JATO Dynamics, "U.S. Car Market "Half" as Green", downloaded from http://www.jato.com/Pressreleases/US%20car%20market%20'half'%20as%20green%20-%2013.11.2008.pdf 13 November 2008. The average American car emits 5.77 metric tons of carbon dioxide annually.

30 The IECC is most often used for residential buildings as the commercial portion is a weaker standard than the ASHRAE standard. For more information on the ASHRAE standard see http://www.ashrae.org/

31 EPA, national action plan for energy efficiency „building codes for energy efficiency" EPA

32 Building Codes Assistance Project, Code Status and Maps, downloaded from http://www.bcapenergy.org/node/5

33 U.S. Environmental Protection Agency, National Action Plan for Energy Efficiency, Building codes for Energy Efficiency, downloaded from http://www.epa.gov/renewableenergy/documents/vision_execsumm.pdf 12 February 2009.

34 U.S. Environmental Protection Agency, National Action Plan for Energy Efficiency, Building codes for Energy Efficiency, downloaded from http://www.epa.gov/renewableenergy/documents/vision_execsumm.pdf 12 February 2009.

35 U.S. Environmental Protection Agency, National Action Plan for Energy Efficiency, Building codes for Energy Efficiency, downloaded from http://www.epa.gov/renewableenergy/documents/vision_execsumm.pdf 12 February 2009.

36 Building Code Assistance Project, Code Status and Maps, Code Status: California, downloaded from http://www.bcap-energy.org/node/56

37 Environment Northeast, "Massachusetts 2008 Energy Bill: An Act Relative to Green Communities, Senate Bill No. 2768," June 25, 2008.

38 Pennsylvania Department of Labor and Industry, Pennsylvania Uniform Construction Code 35 P.S. §§7210.101 to 7210.1103, downloaded from http://www.dli.state.pa.us/landi/CWP/view.asp?a=185&Q=160464

39 Building Code Assistance Project, Code Status and Maps, downloaded from http://www.bcapenergy. org/node/5

40 California Energy Commission, California Code of Regulations, Title 24, Part 6, downloaded from http://www.energy.ca.gov/title24/

41 Building Code Assistance Project, Code Status and Maps, downloaded from http://www.bcapenergy.org/node/5

42 Building Code Assistance Project, Code Status and Maps, downloaded from http://www.bcapenergy.org/node/5

43 Building Code Assistance Project, Code Status and Maps, downloaded from http://www.bcapenergy.org/node/5

44 Building Code Assistance Project, Code Status and Maps, downloaded from http://www.bcapenergy.org/node/5

45 Energy Efficient Codes Coalition (EECC), About the 30 Percent Solution, downloaded from www.thirtypercentsolution.org. "The 30% Solution" is a comprehensive proposal designed to boost the residential energy efficiency of America's model energy code, the International Energy Conservation Code (IECC), by 30%. Recognized officially as EC14 07/08 by the ICC, "The 30% Solution" was developed and submitted to the International Code Council by the Energy Efficient Codes Coalition and is the only proposal before the ICC that has been independently estimated to achieve roughly a 30% improvement over the current IECC. 'The 30% Solution" boosts energy efficiency in virtually every part of the house subject to code requirements – space heating and cooling (including ducts), thermal envelope, air sealing, hot water heating and lighting.'"

46 Building Code Assistance Project, Code Status and Maps, Code Status: District of Columbia, downloaded from http://www.bcap-energy.org/node/60

47 Architecture 2030 The Building Sector: A Historic Opportunity, downloaded from http://architecture2030.org/wurrent_situation/hist_opportunity.html 13 January 2009.

48 Cathy Turner, Mark Frankel, New Buildings Institute, "Energy Performance of LEED for New Construction Buildings" March 4, 2008.

49 Building Code Assistance Project, Level II Policy Action: Pursuing „Beyond Code" Efforts- http://www.bcap-energy.org/node/159. See also South Carolina House Bill 3034

50 Massachusetts Senate Bill no. 1820, An Act Promoting the Development of Green Buildings, downloaded from http://www.bcap-energy.org/files/Level%20II%20MA%20SB%201820%20Green%20Buildings.pdf.

51 Building Code Assistance Project- Level II Policy Action: Pursuing "Beyond Code Efforts," downloaded from http://www.bcap-energy.org/node/159

52 Seattle New Building Energy Efficiency Policy Analysis, Chicago Green Permit Program Case Study, 6 October 2008.

53 Alliance to Save Energy, Energy Efficiency in the Economic Recovery Bill, downloaded from http://ase.org/content/article/detail/5388 29 February, 2009.

54 Linda Berry, Martin Schweitzer, Metaevaluation of National Weatherization Assistance Program Based on State Studies, 1993-2002, Oak Ridge National Laboratory, U.S. Department Of Energy, February 2003. U.S. Department of Energy, Weatherization Assistance Program, "Weatherization Works!" October 2001

55 Massachusetts Office of Energy and Environmental Affairs, Sustainable Design Roundtable Report: An AtionPlan for Green Buildings in Massachusetts State Construction Projects, Downloaded from http://www.mass.gov/pageID=eoeeaterminal&L=4&L0=Home&L1=Grants+%26+Technical

+Assistance&L2=Guidance+%26+Technical+Assistance&L3=Greening+State+Government&sid=Eoeea&b=terminalconten t&f=eea_lbe_lbe_roundtable&csid=Eoeea October 2008.

56 Federation of American Scientists, Home Energy Retrofits and Green Jobs for the Stimulus Package, downloaded from http://www.fas.org/programs/energy/btech/policy/retrofits.html 12 February 2009.

57 Federation of American Scientists, Home Energy Retrofits and Green Jobs for the Stimulus Package, downloaded from http://www.fas.org/programs/energy/btech/policy/retrofits.html 12 February 2009.

58 Architecture 2030, The Building Sector: A Historic Opportunity, downloaded from http://architecture2030.org/current_situation/hist_opportunity.html

59 Reuters, "Ferreira Construction Building Maintains „First Net Zero Eclectic" Status," August 14, 2008. 60

61 Leonardo Energy, "Zero-Energy Homes: Reducing Residential Energy Consumption," downloaded from http://www.leonardo-energy.org/drupal/node/2067

62 California Assembly Bill No. 2112, downloaded from http://info.sen.ca.gov/pub/95- 96/bill/asm/ab_2101-2150/ab_2112_bill_960130_introduced.pdf, 30 January 1996.

63 Massachusetts Zero Net Energy Buildings Task Force, downloaded from http://www.mazneb.org/ 25 February 2009.

64 Network for New Energy Choices, "Freeing the Grid," 2007 Edition, downloaded from http://www.newenergychoices.org/ November 2007

65 Siena Kaplan, "Building an Energy Efficient America: Zero Energy and High Efficiency Buildings, Environment America Research and Policy Center, May 2008.

66 Florida Department of Environmental Protection, Solar Energy System Incentives Program, downloaded from http://www.dep.state.fl.us/energy/energyact/solar.htm

67 Siena Kaplan, "Building and Energy Efficient America: Zero Energy and High Efficiency Buildings," Environment America Research and Policy Center, May 2008.

68 Siena Kaplan, "Building An Energy Efficient America: Zero Energy and High Efficiency Buildings," Environment America Research and Policy Center, May 2008.

69 U.S. Department of Energy, Energy Information Administration, 2007 Buildings Energy Data Book, downloaded from http://buildingsdatabook.eere.energy.gov, 8 February 2008.

70 U.S. Department of Energy, Energy Information Administration, 2007 Buildings Energy Data Book, downloaded from http://buildingsdatabook.eere.energy.gov, 8 February 2008.

71 Based on American Council for an Energy-Efficient Economy, Consumer Guide to Home Energy Savings: Condensed Online Version, downloaded from www.aceee.org/consumerguide/mostenef.htm, 22 May 2006.

72 Based on U.S. Department of Energy, Energy Information Administration, 2001 Residential Energy Consumption Survey, Table HC3-1a.

73 Residential savings: American Council for an Energy-Efficient Economy, Consumer Guide to Home Energy Savings: Condensed Online Version, downloaded from www.aceee.org/consumerguide/mostenef.htm, 22 May 2006; Commercial savings: Greenbiz.com, "U.S. Manufacturers Reach Landmark Agreement on Air Conditioner Efficiency Standards," 15 November 2004.

74 Jennifer Thorne, American Council for an Energy-Efficient Economy, Residential Retrofits: Directions in Market Transformation, December 2003.

75 Lawrence Berkeley National Laboratory, Heat Island Group: Cool Roofs, downloaded from eetd.lbl.gov/HeatIsland/CoolRoofs/, 2 October 2006.

76 Marilyn A. Brown, Therese K. Stovall, and Patrick J. Hughes, Oak Ridge National Laboratory, "Potentia Carbon Emissions Reductions in the Buildings Sector by 2030," Charles E. Kutscher, Ed. American Solar Energy Society, Tackling Climate Change in the U.S., January 2007, available at http://www.ases.org/climatechange.

77 U.S. Department of Energy, Energy Information Administration, 2007 Buildings Energy Data Book downloaded from http://buildingsdatabook.eere.energy.gov, 8 February 2008.

78 U.S. Department of Energy, A Consumer's Guide to Energy Efficiency and Renewable Energy: Heat Pump Water Heaters, 12 September 2005, available at http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12840

79American Council for an Energy-Efficient Economy, Consumers Guide to Home Energy Savings: Condensed Online Edition: Water Heating, updated September 2006.

80 U.S. Department of Energy, A Consumer's Guide to Energy Efficiency and Renewable Energy: Demand (Tankless or Instantaneous) Water Heaters, 12 September 2005, available at http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12820.

81 Steven Nadel, American Council for an Energy-Efficient Economy, Saving Lighting Energy in Commercial Buildings, downloaded from www.aceee.org/press/op-eds/op-ed5.htm, 3 October 2006.

82 Wal-Mart, Environment: Our Footprint, downloaded from http://walmartfacts.com/reports/2006/sustainability/index.html, 11 January 2008.

83 70 to 90 percent from U.S. Combined Heat and Power Association, CHP Basics, downloaded from uschpa.admgt.com/CHPbasics.htm, 25 May 2006; 33 percent from U.S. Department of Energy and U.S. Environmental Protection Agency, Carbon Dioxide Emissions from the Generation of Electric Power in the United States, July 2000.

84 Industrial: Resource Dynamics Corporation, Cooling, Heating, and Power for Industry: A Market Assessment, prepared for the U.S. Department of Energy and Oak Ridge National Laboratory, August 2003, Commercial and institutional: ONSITE SYCOM Energy Corporation, The Market and Technical Potential for Combined Heat and Power in the Commercial/Institutional Sector, prepared for the U.S. Department of Energy, January 2000.

85 1 percent based on comparison of potential levels above with U.S. Department of Energy, Energy Information Administration, Electric Power Annual with Data for 2004, November 2005.

Report design by Big Green Line Design, www.biggreenlinedesign.com
Printed on recycled paper.

815 Brazos, Suite 600 • Austin, TX 78701

Phone (512) 479-0388 • Fax (512) 479-0400

E-mail: center@environmenttexas.org