innovative policy solutions TO GLOBAL CLIMATE CHANGE
In Brief, November 2006

Building Solutions to Climate Change

Buildings are the single most important contributor to the greenhouse gas emissions that cause climate change. The built environment can make an important contribution to climate change mitigation while providing more livable spaces. With current technologies and the expansion of a few key policies, significant reductions in greenhouse gases can be realized in the near term. A combination of technology research and development and clear and sustained climate and energy policies would drive more dramatic reductions over time.

I. Introduction

Energy used in residential, commercial, and industrial buildings produces approximately 43 percent of U.S. carbon dioxide (CO_2) emissions.[1] Carbon dioxide is the major greenhouse gas that contributes to global warming.

Given the magnitude of this contribution, it is essential that efforts to control global warming include an explicit focus on the buildings sector. This brief provides an overview of technologies and policies, examines current public and private initiatives to promote greenhouse gas (GHG) reductions in buildings, and makes recommendations for moving toward a climate-friendly built environment.

The United States has made remarkable progress in reducing the energy and carbon intensity[2] of its building stock[3] and operations in the last few decades. Energy use in buildings

Figure 1

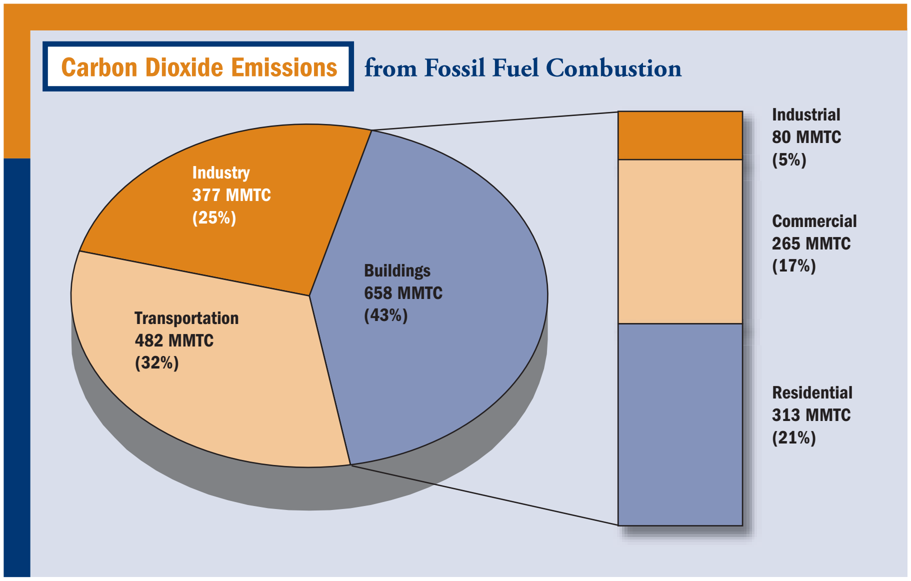
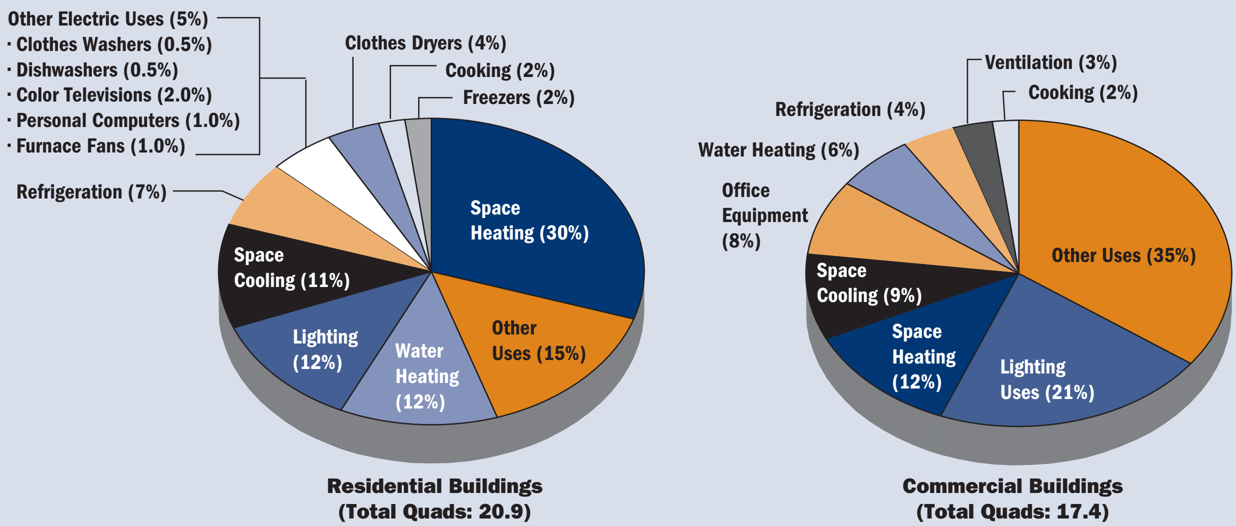


Figure 2

Primary Energy Consumption in Residential and Commercial Buildings, 2002



Note: Other energy uses in the residential sector includes small electric devices, heating elements, and motors; such appliances as swimming pool and hot tub heaters, outdoor grills, and outdoor lighting (natural gas); wood used for primary and secondary heating in wood stoves or fireplaces; and kerosene and coal.

Note: Other energy uses in commercial buildings include service station equipment, automated teller machines, telecommunications equipment, medical equipment, pumps, emergency electric generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings.

Source: Energy Information Administration. 2004. Annual Energy Outlook 2004. DOE/EIA-0383, p. 139–142, tables A4 and A5. EIA, Washington, DC.

since 1972 has increased at less than half the rate of the nation's economic growth, despite the increase in average home size and growth in building energy services such as air conditioning and consumer and office electronic equipment. Although progress has been made, abundant untapped opportunities still exist for further reductions in energy use and emissions. Many of these—especially energy-efficient building designs and equipment—would require only modest levels of investment and would provide quick pay-back to consumers through reduced energy bills. By exploiting these opportunities, the United States could have a more competitive economy, cleaner air, and lower GHG emissions.

II. The Challenge

GHG emissions from the building sector in the United States have been increasing at almost 2 percent per year since 1990, and CO_2 emissions from residential and commercial buildings are expected to continue to increase at a rate of 1.4 percent annually through 2025. These emissions come principally from the generation and transmission of electricity used in buildings, which account for 76 percent[4] of the sector's total emissions. Due to the increase in household appliances and equipment that run on electricity, emissions from electricity are expected to grow more rapidly than emissions from fuels used on-site in buildings. In addition to the growth in demand for energy services within individual buildings, the U.S. building stock is also expected to double in the next 30 years.

Despite efficiency gains, emissions from the buildings sector are rising because the U.S. building stock continues to grow annually and the size of homes has increased significantly, which in turn increases energy requirements. Additionally, the range of electric equipment provided in buildings has increased significantly, especially air conditioning in the South and electronic equipment, televisions, and other "plug loads"[5] in buildings nationwide. Central air conditioning is now a standard feature of commercial and institutional buildings as well as 85 percent of homes in the United States, up from 34 percent in 1970. In order to compensate for this increase, more effort must be focused on increasing the efficiency of the buildings as well as providing affordable, low-carbon on-site electricity, and using waste thermal energy. Based on energy usage, opportunities to reduce GHG emissions appear to be most significant for space heating, air conditioning, lighting, and water heating.

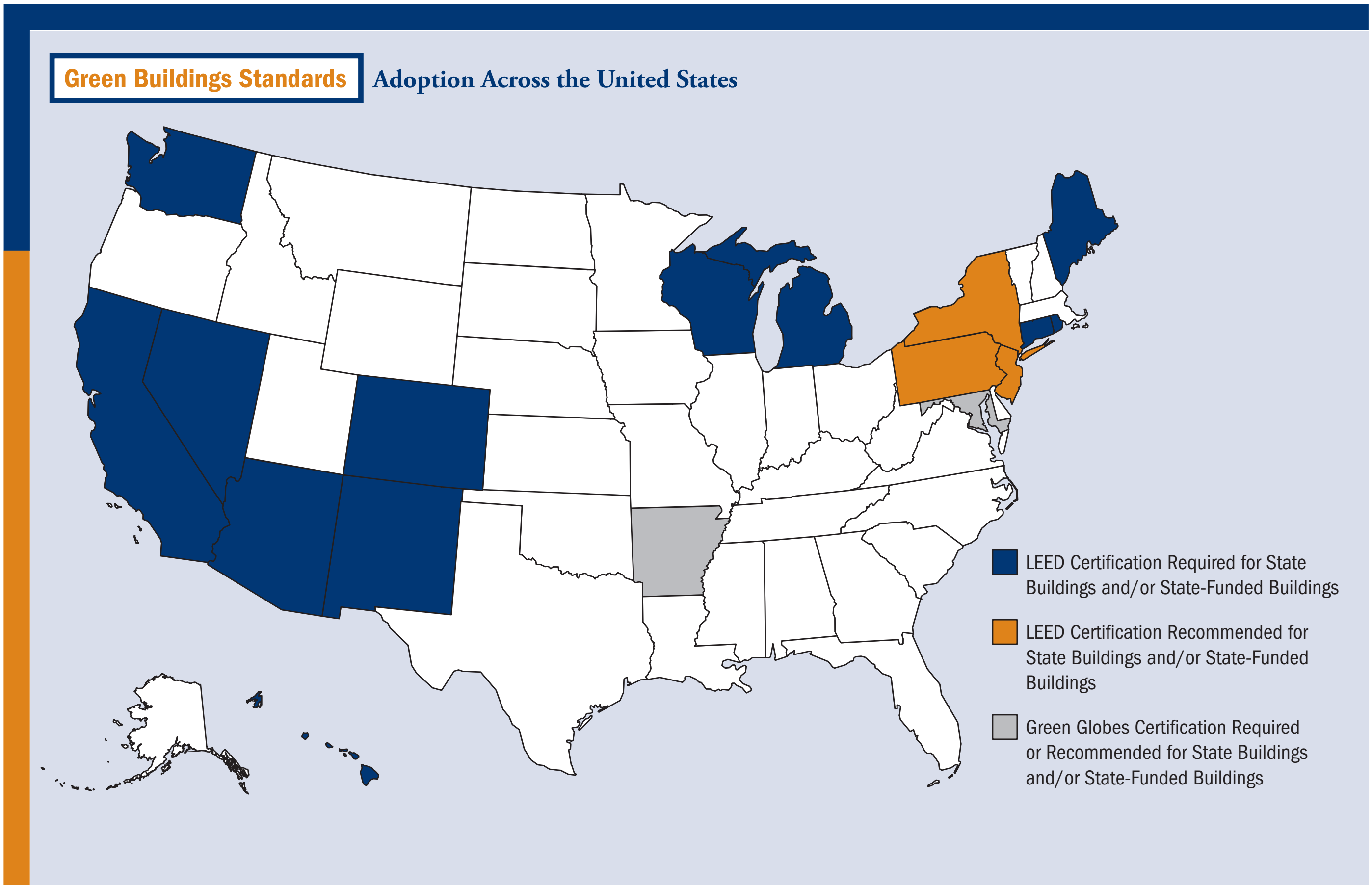
The fragmented nature of the building sector poses additional challenges to promoting climate-friendly actions—distinct from those in transportation, manufacturing, and power generation. The design of effective policy interventions must take into account the multiple stakeholders and decision-makers in the building industry and their interactions. Major obstacles to energy efficiency exist, including:

- Insufficient and imperfect information (e.g., electricity bills bundle the consumption of numerous end uses; at industrial facilities electricity use is charged to an overhead account.)
- Distortions in capital markets (e.g., electric utility profits are tied to sales in most markets, creating a disincentive for utilities to implement demand-side management (DSM) programs.)
- Split incentives that result when intermediaries are involved in the purchase of low-GHG technologies (e.g., incentives vary for the architect, builder, owner, and operator in terms of realizing cost savings from energy-efficient features of buildings.)

Most commercial buildings are occupied by a succession of temporary owners or renters, each unwilling to make long-term improvements that would benefit future occupants. Regulations, fee structures in building design and engineering, electricity pricing practices, and the often limited availability of climate-friendly technologies and products all affect the ability to bring GHG-reducing technologies into general use. Some of these obstacles are market imperfections that justify policy intervention. Others are characteristics of well-functioning markets that simply work against the selection of low-GHG choices in the absence of mandatory GHG policy.

Despite these challenges, numerous individuals, corporations, communities, cities, and states are driving the implementation of "green" and carbon-reducing building practices in new residential and commercial development. Affordability, aesthetics, and usefulness have traditionally been major drivers of building construction, occupancy, and renovation. In addition to climatic conditions, the drivers for energy efficiency and low-GHG energy resources depend heavily on local and regional energy supply costs and constraints. Other drivers for low-GHG buildings are clean air, occupant health and productivity, the costs of urban sprawl, and stress on the electric grid that can be relieved by managing electricity demand.

Figure 3



III. Current Developments in Green Buildings

In the absence of federal legislation on green buildings, or a comprehensive federal strategy to reduce GHG emissions, numerous stakeholders have begun taking actions that address the built environment's role in climate change. A combination of voluntary and mandatory measures taken at the local, state, federal, international, and corporate levels have all provided steps in the right direction. Whole Buildings Standards, for example, have provided a metric by which to compare buildings based on a variety of characteristics. Some of the most impressive progress is the result of communities and developers wanting to distinguish themselves as leaders in the efficient use of resources and in waste reduction in response to local issues of land-use planning, energy supply, air quality, landfill constraints, and water resources. Building owners and operators who have a stake in considering the full life-cycle cost and resource aspects of their new projects are now providing green building leadership in the commercial sector. However, real market transformation will also require buy-in from the supply side of the industry (e.g., developers, builders, and architects).

The term "green building" is used by a number of public and private programs to promote environmentally friendly construction practices. Most of these programs use labeling based on a point system to communicate to the market the relative environmental value of these practices. The standards currently serve a useful role in guiding stakeholders towards more climate-friendly green building practices. However, further research is needed to better understand the life-cycle of GHG emissions of various building materials and appropriately account for them in building standards. Also, most standards are flexible enough to enable buildings to receive a "green" rating if they perform well on, for example, indoor air quality, even if they perform less well on energy efficiency and GHG emissions. This needs to change to ensure that buildings reduce their contribution to climate change. The U.S. Green Buildings Council (USGBC) has its Leadership in Energy and Environmental Design (LEED) standard,[6] which is perhaps the most well known whole building standard.[7] In addition to its well-established standards for new buildings, USGBC recently developed standards for building retrofits and for neighborhood development. There are several other whole building standards in addition to LEED: Model Green Home Building Guidelines, the Minnesota Sustainable Design Guide, and the Green Building Initiative (the Green Globes certification is administered through the Green Building Initiative). Currently 14 states[8] have adopted LEED as the standard for government buildings, and two states have adopted Green Globes.

Many states are going above and beyond traditional building codes by instituting their own green building standards. California and New York have both announced Green Building Initiatives. Governor Schwarzenegger has committed California to leading by example in improving the energy performance of existing and new State buildings by mandating that they reduce electricity consumption 20 percent by 2015. New York offers tax credits for energy efficiency measures and provides low-interest loans for building materials that meet LEED or other accepted green building standards.

Furthermore, a number of progressive groups are spearheading several initiatives to address this issue. In January 2006, the group Architecture 2030 publicly issued the "2030 Challenge" (www.architecture2030.org). Since then, the American Institute of Architects has adopted the "Challenge" calling for architects and others in the buildings industry to reduce GHG emissions in new and renovated buildings 50 percent by 2010 and to make all new buildings "carbon-neutral"[9] by 2030. In June 2006, the U.S. Conference of Mayors unanimously passed Resolution #50 urging cities across the country to adopt the "2030 Challenge" for all buildings, and setting benchmarks and timelines to achieve the goals. In July 2006, the International Council for Local Environmental Initiatives (ICLEI) North America unanimously supported the "2030 Challenge" and embedded its targets in ICLEI's "Statement of Action." New Mexico Governor Bill Richardson issued an executive order in 2006 committing the state to the 50 percent reduction target for new state buildings. And ASHRAE, the USGBC, and the Illuminating Engineering Society (IES), with input from the AIA, are in the process of developing ASHRAE #189, a new high performance building standard that will incorporate similar targets.

On the international scene, the World Business Council for Sustainable Development (WBCSD) launched an Energy Efficiency in Buildings initiative in March 2006. United Technologies Corporation[10] and construction giant Lafarge are the two primary corporate partners, and the initiative aims to determine how buildings can be designed, constructed, and operated so that they use zero net energy, are carbon neutral, and can be built and operated at fair market value by 2050.[11] Initial findings indicate that technologies are available today to reach the energy and carbon goals. Also at the international level, the

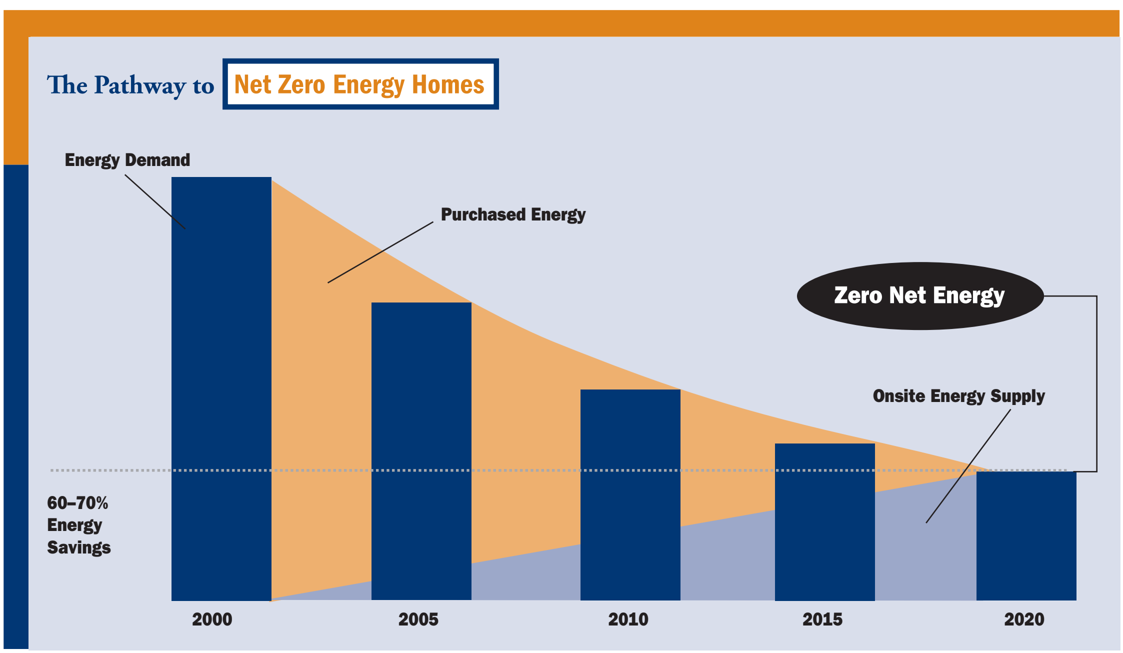
United Nations Environment Program (UNEP) announced in February of 2006 a Sustainable Building and Construction Initiative (SBCI). The purpose of the SBCI is to achieve world-wide adoption of sustainable building and construction practices that can address the issue of climate change.[12]

Finally, many corporations are taking progressive steps with the buildings that they construct, own, and operate. Wal-Mart, who has taken on aggressive targets to eliminate 30 percent of the energy used by its stores in the long term, is investing $500 million per year in technologies and innovations to reduce GHG emissions in stores around the world by 20 percent over the next seven years. It is also designing a prototype store that is 25–30 percent more efficient, produces 30 percent less emissions, and will be in operation within four years.[13] A number of other large corporations have taken on significant GHG reduction targets and have focused much of their efforts on their buildings. Swiss Re plans to be carbon neutral by 2013, and to achieve that goal, the company will have to reduce the emissions from its buildings by 33 percent.[14] Bank of America is in the process of building the first LEED Platinum[15] high rise as its new corporate headquarters; Toyota's headquarters in Torrance, CA is LEED certified; and Exelon Corporation is seeking LEED Platinum certification for its newly renovated headquarters building in Chicago.

IV. Looking Ahead

Although private investment in green buildings and energy-efficient technologies is growing rapidly, coherent national policies on buildings are essential to address the built environment's role in climate change. The U.S. needs policies such as model building codes to raise the minimum standards for energy and GHG performance, as well as incentives for industry leaders to continually improve. One key focus should be on the construction of net-zero energy homes. On-site renewable energy such as solar photovoltaic technologies offer the possibility of net-zero-energy homes, when combined with 60–70 percent whole building energy reductions. This goal may be achievable as a cost-competitive hous-

Figure 4



ing alternative by 2020 (see Figure 4). The estimated cost premium for such a system today is approximately 25 percent.[16]

The U.S. Department of Energy's Building America Program is a public/private partnership that develops energy solutions for new and existing homes that can be implemented on a production basis (http://www.eere.energy.gov/buildings/building_america/). The program focuses on increasing the energy efficiency of homes and installing on-site renewable energy systems. Fully funding and expanding existing public/private partnerships such as the Building America Program and developing new, innovative partnerships to promote the growth of sustainable building practices at a commercial scale is essential to demonstrate the feasibility of these practices and the direct costs savings from decreasing energy use within homes.

The U.S. Department of Defense (DoD) can be used as a model for its work on net-zero energy buildings. Because DoD operates so many buildings in remote locations, it has invested substantial resources into funding remote power generation. In addition, DoD puts a lot of time, money, and research into developing the most efficient ways to use energy in its buildings. Domestically, DoD is the single largest energy user in the nation; it spends over $2.5 billion per year on facility energy consumption. Photovoltaic (PV) companies such as Daystar technologies and Evergreen Solar have won large contracts with DoD to develop affordable, renewable energy systems for buildings. By reducing the demand for energy within its buildings and increasing the supply of on-site, renewable energy, DoD is pursuing the goal of net-zero energy buildings, a perfect fit for its remote facilities. It is making a concerted effort to reduce the energy demand of its buildings in order to decrease its single largest operating cost.

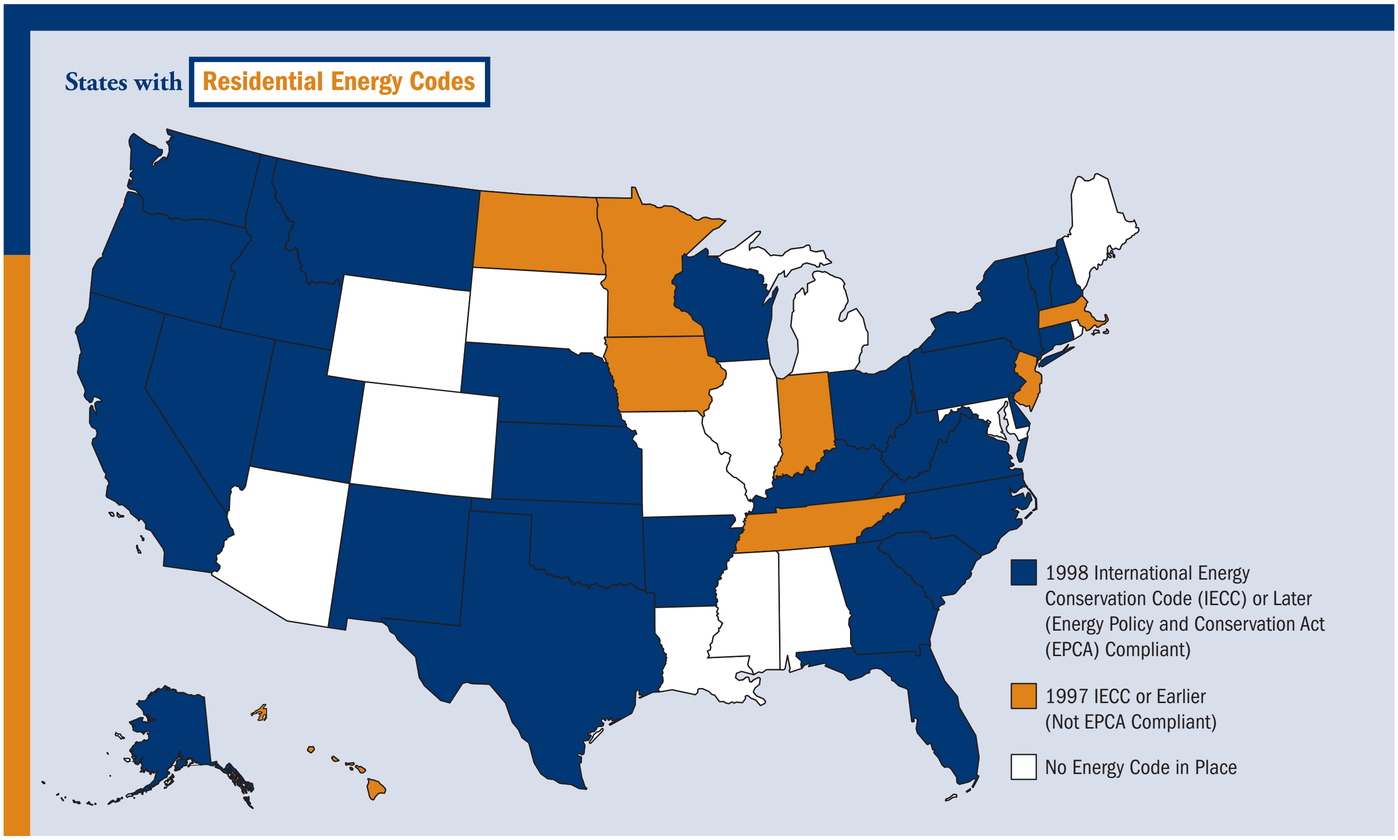
V. Tremendous Potential for Future Progress

Applying currently available cost-saving and low-cost building design strategies, developed in the late 1970's and 80's, can cut fossil-fuel energy consumption in buildings by 30 to 80 percent. These include building siting, shape, color and orientation, and daylighting, passive solar heating, cooling, natural ventilation, and shading strategies.

New technologies can cost-effectively save an additional 30 to 40 percent of energy use and GHG emissions in new buildings, when evaluated on a life-cycle basis.[17] Technology opportunities are more limited for the existing building stock, and the implementation rate depends on the replacement cycles for building equipment and components. However, several opportunities worth noting apply to existing as well as new buildings, including efficiencies in roofing, lighting, home heating and cooling, and appliances. Emerging building technologies, especially new lighting systems and integrated thermal and power systems, could lead to further cost-effective energy savings. Past experience has shown that policy intervention is most likely needed for serious market penetration of efficient energy systems and on-site electricity technologies.

In addition to building design strategies and technological advances in buildings, it is essential to focus on community and urban systems to cut associated GHG emissions from the building sector. Evidence suggests that higher-density, more spatially compact and mixed-use building developments can offer significant reductions in GHG emissions through three complementary effects: (1) reduced vehicle miles of travel, (2) reduced consumption for space conditioning as a result of district and integrated energy systems[18], and (3) reduced municipal infrastructure requirements. In total, therefore, smart land-use planning policies across

Figure 5



the country could yield GHG reductions of 3 to 8 percent by mid-century.

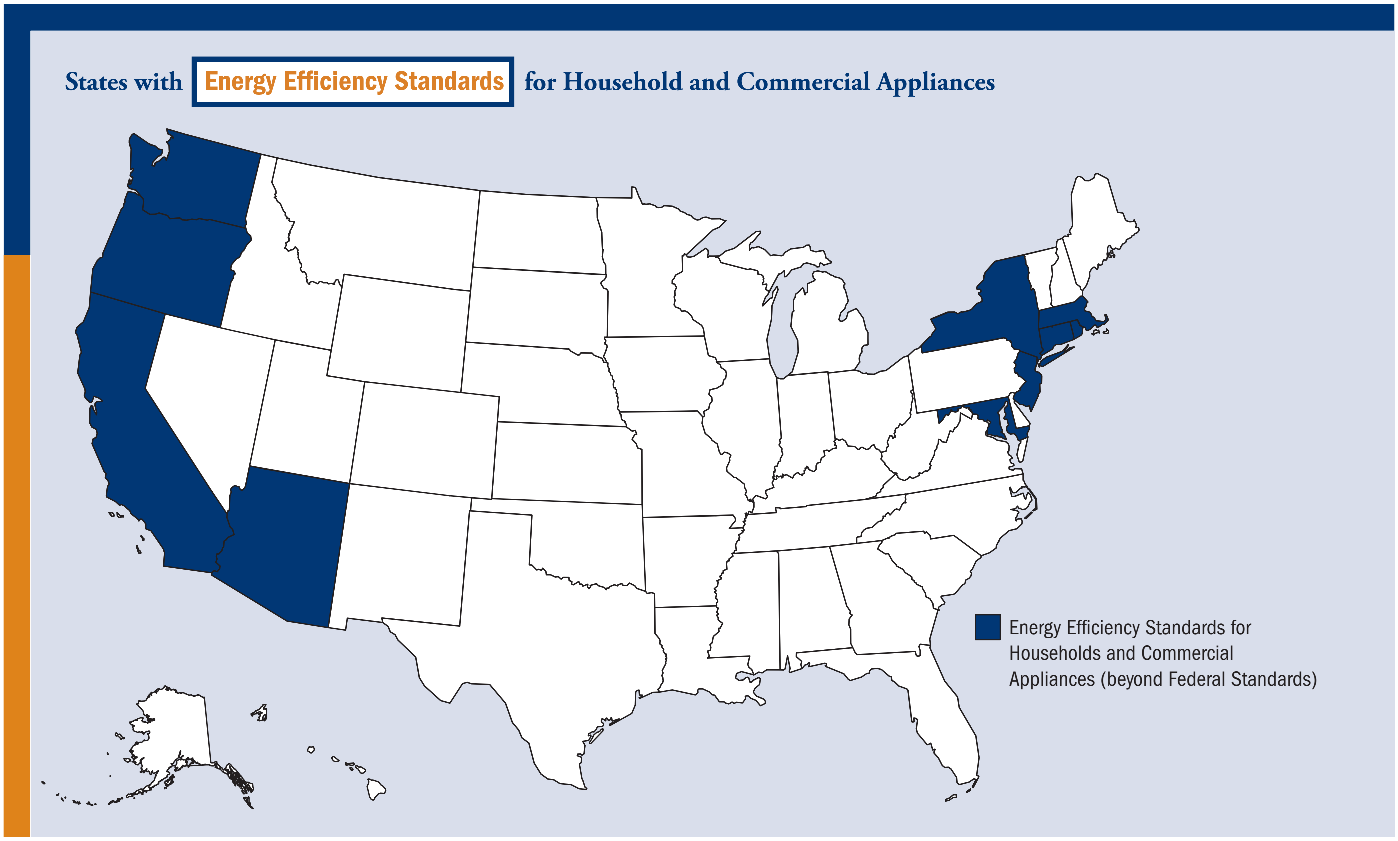
Numerous individual, corporate, community, and state initiatives are leading the implementation of green building practices in new residential development and commercial construction. Significant progress in reducing GHG emissions from the building sector depends on federal, state, and local policymakers adopting whole building standards that put an emphasis on reducing these emissions. At the least, updating building codes to reflect the best local climate-specific codes is necessary. As shown in Figure 5, there is substantial opportunity to improve building codes.

VI. Policy Options Toward Zero Net-Energy Buildings

Research suggests that public interventions could overcome many of the market failures and barriers hindering widespread penetration of climate-friendly technologies and practices. The mosaic of current policies affecting the building sector is complex and dynamic, ranging from local, state, and regional initiatives, to a diverse portfolio of federal initiatives. Numerous policy innovations could be added to this mix, and many are being tried at the state and local level.

Ten states[19] have set minimum energy efficiency standards for household and/or commercial appliances not covered by mandatory federal standards (see Figure 6). Without a waiver from

Figure 6



the U.S. Department of Energy, states may not set standards for products covered by existing federal standards. Increasingly, many corporations are pushing for comprehensive federal standards that are applicable throughout the nation so they have a well-defined market against which they can judge their investment decisions.

Emissions can be addressed through labeling and expanded and tightened standards for products (including buildings), focusing on those that would result in significant GHG reductions through reduced energy use.[20] By requiring a minimal level of efficiency and providing consumers with information on products that do better than the minimum, standards and labeling can overcome the obstacles described earlier—insufficient and imperfect information; market distortions; and split incentives—and advance building efficiency.

According to the Pew Center's "Agenda for Climate Action,"[21] building codes can require that new buildings meet a certain level of energy efficiency, maximizing efficiency opportunities during construction. Policies to encourage states to adopt enhanced or updated building codes could include linking a state's adoption of model codes to its receipt of federal funds (e.g., weatherization assistance and federal support for state public benefit funds). Incentives could come in the form of a minimum requirement to receive federal funding (i.e., states would be required to adopt a certain standard level to be eligible for any funding), or as encouragement to receive additional or "bonus" funding (i.e., above the level that a non-adopting state receives). Increasing the funding level for the DOE's building energy code program would also facilitate GHG emissions reductions from further building code adoption—by providing stakeholders with technical assistance such as software tools to help builders, designers, and code officials upgrade and comply with energy codes.[22] Likewise, continued funding for R&D on advanced materials and cost-reduction opportunities for on-site renewable generation can have a considerable impact.

The 2005 Pew Center report[23] reviewed buildings energy research and development (R&D) and six deployment policies that have a documented track record of delivering cost-effective GHG reductions and that hold promise for continuing to transform markets. The six deployment policies include (1) state and local building codes, (2) federal appliance and equipment efficiency standards, (3) utility-based financial incentive and public benefits programs, (4) the low-income Weatherization Assistance Program, (5) the ENERGY STAR Program, and (6) the Federal Energy Management Program.

Annual savings over the past several years from these R&D and six deployment policies are estimated to be approximately 3.4 quadrillion Btu (quads) and 65 million metric tons of carbon (MMTC), representing 10 percent of U.S. CO_2 emissions from buildings in 2002. The largest contributors are appliance standards and the ENERGY STAR Program. Potential annual effects in the 2020 to 2025 time frame are 12 quads saved and 200 MMTC avoided, representing 23 percent of the forecasted energy consumption and carbon emissions of buildings in the United States by 2025.

While some of these policies were incorporated in the Energy Policy Act of 2005 (EPACT 2005), it is necessary to expand them further to realize more reductions in energy costs and GHG emissions from the buildings sector.

Several portions of the Energy Policy Act of 2005 focus on increasing building efficiency such as renewed incentives for energy efficient appliances, insulation in homes, and solar tax credits. Focusing mainly on commercial products, the Energy Policy Act requires DOE to set standards for certain equipment and appliances including exit signs, traffic signals, torchiere lights, compact fluorescent lightbulbs, many types and sizes of heating and cooling equipment, refrigerators, freezers, automatic ice makers, clothes washers, and even spray valves. The Act also established tax credits for the construction of a qualified new energy-efficient home that meets Energy Star criteria and a tax deduction for energy-efficient commercial buildings that reduce annual energy and power consumption by 50 percent compared to the mandated standard. But it is essential to take steps beyond the Act to achieve the necessary GHG reductions in the building sector—for example, expansion of the Building America Program, a greater focus on net zero energy buildings, and continuing to expand federal tax credits for on-site renewable power.

VII. Conclusions and Recommendations

An expansive view of the building sector is needed to completely identify and exploit the full range of GHG-reduction opportunities. Such a view needs to consider future building construction (including life-cycle aspects of buildings materials, design, and demolition), use (including on-site power generation and its interface with the electric grid), and location (in terms of urban densities and access to employment and services).

There is no silver bullet technology in the building sector because there are so many different energy end uses and GHG-relevant features. Hence, a vision for the building sector must be seen as a broad effort across a range of technologies and purposes.

Furthermore, an integrated approach is needed to address GHG emissions from the U.S. building sector—one that coordinates across technical and policy solutions, integrates engineering approaches with architectural design, considers design decisions within the realities of building operation, integrates green building with smart-growth concepts, and takes into account the numerous decision-makers within the fragmented building industry.

Current building practices seriously lag best practices. Codes must be upgraded to improve the performance of the average building, and vigorous market transformation and deployment programs are critical to success. They are also necessary to ensure that the next generation of low-GHG innovations is rapidly and extensively adopted. To that end, green building standards must more explicitly incorporate GHG performance standards and metrics. In order for a building to be considered "green," it needs to fully address climate concerns.

Given the durable nature of buildings, the potential for GHG reductions resides both with new construction and the existing building stock for some time to come. The WBCSD initiative described earlier intends to commercialize newly constructed and retrofitted zero net energy homes and climate-friendly designs for large commercial buildings and industrial facilities by 2012. By mid-century, land-use policies could have significant impact on GHG emissions, as well. This inter-temporal phasing of impacts does not mean that retrofit, new construction, and land-use policies should be staged; to achieve significant GHG reductions by 2050, all three types of policies must be strengthened as soon as politically feasible.

Similarly, applied R&D will lead to GHG reductions in the short run, while in the long run basic research will produce new, ultra-low GHG technologies. This does not mean that basic research should be delayed while applied R&D opportunities are exploited. The pipeline of technology options must be continuously replenished by an ongoing program of both applied and basic research and a combination of public policies and private initiatives must pull these technologies into the marketplace.

For the complete text of this "In Brief" and other Pew Center reports or to order a free copy, visit our website at www.pewclimate.org.

[1] This In-Brief draws heavily on the Pew Center report entitled: "Towards a Climate-Friendly Built Environment." Brown, M., Southworth, F., and Stovall, T. 2005. *Towards a Climate-Friendly Built Environment*. (Arlington, VA: Pew Center on Global Climate Change).

[2] Carbon intensity is the ratio of carbon emissions to economic activity.

[3] Building stock refers to the number of total square feet included in all building types.

[4] This includes the electrical energy for industrial buildings operations.

[5] A plug load is an appliance or a piece of household equipment that draws electrical power.

[6] Under LEED, building projects are awarded points in six categories: sustainable sites, water efficiency, energy and atmosphere, incorporation of local and recycled materials and resources, indoor environmental quality, and innovation and design process. It has proved to be an effective voluntary standard, although some concerns exist regarding a lack of direct correlation between some of the points awarded and the life-cycle GHG reductions (or life-cycle costs) from the building.

[7] See: Green Building Alliance. 2004. *LEED-NC: The First Five Years, Report on the Greater Pittsburgh Region's Experiences using Leadership in Energy & Environmental Design for New Construction,* Green Buildings Council, Pittsburgh, PA (www.gbapgh.org/MiscFiles/LEEDSurveyReport_Final.pdf. February 13, 2005). Also see: Rachel Reiss and Jay Stein. 2004. *LEED Scores Early Successes but Faces Big Challenges,* ER-04-3, Platts Research & Consulting, New York, NY.

[8] California, Arizona, New Mexico, Colorado, Nevada, Washington, Wisconsin, Michigan, Connecticut, Rhode Island, and Maine require LEED certification for state and state-funded buildings, and New York, Pennsylvania, and New Jersey recommend LEED certification for state and state-funded buildings.

[9] Carbon neutral means they will have zero net GHG emissions—either by using only non-fossil fuel energy or by offsetting their GHG emissions.

[10] United Technologies Corporation provides a range of high-technology products and services to customers in the aerospace and buildings industry worldwide.

[11] "Top global companies join with WBCSD to make energy self-sufficient buildings a reality." See: http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MTg2MTU, viewed 9/15/06.

[12] "UNEP launches Green Building Initiative." http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=469&ArticleID=5204&l=en, viewed 9/15/06.

[13] Scott, L. 2005. *21st Century Leadership*. Speech to company employees, October 24 (Bentonville, AR: Wal-Mart).

[14] Hoffman, Andrew. 2006. *Corporate Strategies That Address Climate Change*. (Arlington, VA: Pew Center on Global Climate Change).

[15] LEED Platinum is the highest ranking for certification under the U.S. Green Building Council's LEED program.

[16] Zero Energy Homes brochure, NAHB Research Center, Upper Marlboro, MD, http://www.toolbase.org/docs/MainNav/Energy/4339_ZEH_Brochure-final-screen.pdf, December 6, 2004.

[17] Brown, M., Southworth, F., and Stovall, T. 2005. *Towards a Climate-Friendly Built Environment.* (Arlington, VA: Pew Center on Global Climate Change).

[18] District and integrated energy systems refer to systems that provide energy services (heating, cooler, electricity) to a community.

[19] Arizona, California, Connecticut, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Washington.

[20] Examples include boilers and furnaces, digital cable and satellite TV boxes, and digital converter TV boxes. Nadel, S. 2003. "Appliance and Equipment Efficiency Standards in the U.S.: Accomplishments, Next Steps and Lessons Learned," ECEEE 2002 Summer Study Proceedings, European Council for an Energy Efficient Economy, 1: 75-86.

[21] *The Agenda for Climate Action.* (Arlington, VA: Pew Center on Global Climate Change).

[22] The Building Energy Code Program also provides financial and technical assistance to help states adopt, implement, and enforce building energy codes. For more information, see http://www.energycodes.gov/.

[23] Brown, M., Southworth, F., and Stovall, T. 2005. *Towards a Climate-Friendly Built Environment*. (Arlington, VA: Pew Center on Global Climate Change).

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