volume 4 | issue 4 | fall 2009

A quarterly journal published by MIT Press

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Moving Toward High-Performance Buildings

At the end of May 2009, a group of 60 prominent scientists and other notables in attendance at the St. James's Palace Nobel Laureate Symposium, including U.S. Secretary of Energy Steven Chu, declared that, to prevent irreversible damage to the world's climate, worldwide carbon emissions must begin to decline in just six years and be reduced by 50% by 2050. They believe that damage will occur if average global temperatures increase by more than two degrees centigrade. In developed countries like the U.S., the carbon footprint is stabilizing, but rapid growth in the use of fossil fuels in developing countries means the worldwide footprint has been increasing steadily by about one percent per year. Between 1980 and 2006, the U.S. share of the world's climate footprint decreased from 26% to 20% while the Asian share, led by China, doubled to 37%, with the largest growth in energy use in Asia and the Middle East. The United States is currently a heavy and wasteful energy user, but not as unique as some would have us believe. In 2006, the United States was second to China in total carbon footprint and 13th out of 207 nations in its per-capita carbon footprint.

The St. James Palace group concluded that even a rise of two degrees centigrade in the global temperature will have adverse consequences, but that a bigger increase would create "unmanageable climate risks"; if total carbon emissions worldwide continue to rise after 2015, the cuts required to keep temperature increases at just two degrees centigrade would likely become unachievable. In light of these sobering facts, Professor Hans Joachim Schellnhuber, Director of the

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Potsdam Institute for Climate Impact Research, called for reductions by all nations and asked developed countries to aim for a reduction of 25% to 40% in carbon emissions by 2020.

The St. James Palace manifesto is a call for a major acceleration in international efforts to control global warming. It marks a dramatic change in U.S. policy, from being a leader of skeptical nations who want as little change as possible to joining those calling for the most urgent action. It was only 14 months earlier, on April 15, 2008, that President Bush chose income tax day to reject new taxes and trade barriers as part of the solution to climate change and to push back until 2025 the target date for stopping the growth of U.S. greenhouse gas (GHG) emissions, effectively giving U.S. utilities and industry an additional 10 to 15 years of GHG growth. He offered few specifics for achieving even that weakened objective. He expressed concern that Congress might pass climate legislation that would hurt the country's economic growth and encouraged accelerated development and deployment of new technologies, while pointing out that all countries, including China and India, would have to be a key part of any world approach to cutting greenhouse gases.

At the end of June 2009, the U.S. House of Representatives, with the support of President Obama, narrowly passed and sent to the Senate the American Clean Energy and Security (ACES) Act. ACES would put the United States firmly in the St. James Palace Group camp by setting goals of cutting global warming pollution by 17% compared to 2005 levels in 2020, by 42% in 2030, and by 83% in 2050; it also aims to set up a carbon trading system to enforce these levels. Virtually all Republican representatives opposed the legislation, along with many of the Democrats from states dependent on fossil fuels. Some of the conservative Democrats who voted for the bill in the House almost immediately drew new political opponents, who are focusing on the consequences of this vote in districts that depend on fossil energy.

In the Senate, one does not achieve the 60 votes needed to move major legislation forward without bipartisanship; Republicans are currently unified in opposition, while Democrats are currently facing the same divisions as in the House. The Senate Republican Caucus, through its Chairman Senator Lamar Alexander, has floated an alternative approach. It features rapid expansion of nuclear power and energy research, two positions popular with Republicans and swing Democrats but given short shrift in the House-passed bill, and strongly opposes the House carbon-trading provisions which the House Democratic sponsors consider essential. How compromise will be reached at this time is unclear, but approximately 15% of the Senate would have to change their positions before a bill with a rigorous cap-and-trade provision could be passed. In recent years, it has been the rule rather than the exception, that major environmental legislation can take multiple Congresses to enact into law.

If the United States did reduce carbon emissions by 83 percent by 2050, this would be one of the most revolutionary changes in the way Americans live their lives in our nation's history. An American public that has grown comfortable with

old transmission lines, inefficient appliances and vehicles, incandescent light bulbs, leaky, low-quality construction, and behaviors borne out of the belief that energy is cheap and abundant is being asked to make a significantly larger reduction than the worldwide average because its per capita usage of fossil fuels is over four times the world average. If the world carbon footprint is cut in half and the U.S. carbon footprint is cut by 83%, U.S. per-capita carbon use would still be over 50% larger than the average world per-capita use and the U.S. would find itself in the same relative position where the "developed" nations with the smallest carbon footprints—France, Sweden, and Switzerland—find themselves today.

But neither these countries nor the U.S. has had to face the proposed 50% worldwide reduction in carbon use, which would have us getting by on half the per-capita carbon that those European countries now use. The U.S. per-capita levels of carbon emissions in 2050 would be below the current levels of Mexico and China, and total U.S. emissions would fall below current levels in India. Think pre-Henry Ford. To find a U.S. carbon footprint that small, we have to go back to the period from 1905 to 1910, when the U.S. population was around 90 million. In the debate to date, there has been little focus on just how big an 83% reduction in carbon emissions would be and what it would take to win public acceptance of the changes. Preserving a standard of living that Americans will accept while displacing this much carbon will require us to replace most current energy technologies. Cars will need to run on alternatives to fossil fuels, dramatic changes will be required in the industrial sector, and in the building sector we will need to employ highly efficient technologies and designs, renewable energy, and a conservation ethic at a level as yet unheard of in the United States.

This is what leading scientists say we must do to save our environment, but George Bush's skeptical outlook on climate change still resonates with the public, depending on how polling questions are written. A March 2009 Gallup Poll survey recorded the highest level of public skepticism about mainstream reporting on global warming in Gallup's history of polling on the issue: 41% of respondents said the news media exaggerates the problem, a 6% swing in just one year away from concerns about global warming. Of the eight environmental issues polled, global warming came in as the least worrisome. In April 2009, a Rasmussen Poll showed just 34% of respondents feel that human activities are a factor in global warming, down from 47% a year earlier. In a June 30 Rasmussen poll, immediately after the House of Representatives vote, 42% of respondents felt that the bill's policies would hurt the U.S. economy and just 19% believed that they would help it. Other polls showed the majority feeling that the bill is a mistake. An August *Washington Post* Poll showed a small majority favoring the cap-and-trade provisions of the ACES bill, with a hardening of Republican opinion against cap and trade, but this same poll showed that feelings on energy are less intense than those on health care and the economy. This is in keeping with the general rule that environmental concerns take second place to fiscal concerns in tough economic times.

The date for Senate consideration of the bill has slipped and may slip further as the ante is raised. On August 25, 2009, the *Los Angeles Times* reported that

despite an overwhelming consensus in the scientific community that global warming is real, the U.S. Chamber of Commerce is raising the stakes: it is calling on the Environmental Protection Agency to hold a public trial on global warming, complete with witnesses, cross-examinations and a judge who would be asked to rule on whether human activities are a dangerous component in global warming before any efforts are made to regulate carbon dioxide under the Clean Air Act. Two other business groups, the National Association of Manufacturers and the National Federation of Independent Business, are starting to make major purchases of ads opposing cap and trade in states represented by swing senators.

If current trends continue and the Senate bill goes forward, it will be substantially changed from the House-passed version; it will take into consideration some of the views of the opposition, and it will require a substantial amount of time to work out differences with the House of Representatives. This means the Obama Administration will need to look to Executive Branch actions rather than those of the Congress if it wants to show attendees at the international meetings on climate change in Copenhagen in December that the United States is committed to doing its share to meet worldwide 2015 and 2020 carbon-reduction goals.

Assuming that the Nobel laureates of the St. James Palace Symposium are correct in stating that we have just six years to stop growth in the global carbon footprint, and that we must begin significant reductions by 2020, then the carbon reduction goals in the ACES legislation must immediately be considered a national imperative. We cannot afford to wait for Congress to endorse them. Perhaps President Obama can use an executive order to make achieving the 2015 and 2020 goals official administration policy and focus the Executive Branch on achieving them using available authority from existing law. If the Congress later succeeds in passing legislation on climate change or energy, the executive order and the implementation could be modified accordingly.

We would need strong leadership from our Executive Branch to explain this plan to the American people, since success requires hundreds of millions of individual citizens making the right decisions about purchases of energy-efficient vehicles, appliances, and electronic equipment, while living in energy-efficient buildings and practicing old- fashioned conservation. At the same time, improvements in building codes, appliance standards, efficient vehicle design and use, and a host of coordinated public policies must be put in place to support positive choices and phase out energy waste.

THE PROMISE OF THE BUILDING SECTOR: THE EUROPEAN EXPERIENCE VERSUS THE AMERICAN EXPERIENCE

While energy efficiency improvements will occur throughout all sectors over time, Secretary Chu has described the building sector, including residential housing, as the low-hanging fruit in efforts to reduce the worldwide carbon footprint. In the U.S., the building sector accounts for almost 40% of total energy use and carbon emissions,and 70% of electricity consumption. And unlike some of the most visi-

ble efficiency opportunities in the transportation and industrial sectors, such as electric cars and advanced manufacturing techniques, key technologies for significant efficiency gains in buildings are already available and cost effective. Secretary Chu is correct that we must switch to low-energy buildings in new construction and perform energy upgrades on a large percentage of our installed building stock, as that is our best chance of meeting 2020 goals and creating momentum for the changes that are projected between 2020 and 2050. In the short term, achieving major improvements in energy use in the building sector could buy us time to improve building technology further and to make breakthroughs in other sectors, with longer lead times and more dramatic need for new technologies. Therefore, the U.S. building sector is our focus in the balance of this essay.

It is generally understood that Germany, with its Passivhaus Standard, and Switzerland, with the related Minergie-P-ECO Standard, are among the nations that have surpassed the United States in several areas: understanding and constructing low-energy buildings, developing highly efficient windows and certain other building components, designing and operating buildings as efficient systems, and adopting a national environmental ethic. Although the earliest prototypes of low-energy buildings originated in the United States and Canada more than 30 years ago, they were taken more seriously and perfected abroad. In the United States, a small number of building scientists in and outside of government have the expertise to design and construct high-quality, low-energy buildings, but they face low expectations, financial barriers, and regulatory disincentives, while in Germany and Switzerland, increasing expertise finds a ready market.

Minergie is a voluntary energy efficiency standard that has been used over the past decade to certify over 14,000 Swiss buildings, each of which uses at least 60% to 80% less energy than a conventional building, with less than 10% additional building cost. This compares to savings of 20% to 40% for U.S. Energy Star homes; the rate per capita of Minergie certifications is over twice the Energy Star rate in the United States. In practice, though, Minergie's influence on Swiss building practices is much higher because many of Switzerland's cantons have offered financial incentives for Minergie buildings and have adjusted their energy codes to require energy efficiency at levels very close to the original Minergie level. In Switzerland, Minergie is the basic low-energy standard. A newer variant, Minergie-P, incorporates traditional passive design and passive solar techniques, and Minergie Eco is Switzerland's green building standard. Minergie buildings always take into consideration the benefits of the earth as a heat sink, and aim to use solar energy and natural ventilation. If solar is not yet economical for a Minergie building, the building is designed to allow easy solar installation when the technology becomes economical. The highest efficiency buildings based on Minergie-P go beyond the rated savings and are virtually off the grid.

Passivhaus is an even more exacting German voluntary private-sector standard, and design software that relies on very thick insulation, triple-glazed windows, air-tightness, heat recovery, elimination of thermal bridging and unintentional air changes, elimination of conventional heating systems, and careful opti-

mization to reduce energy and building costs even further. Solar technologies are always considered for Passivhaus buildings. Worldwide, 15,000 buildings have been built to the Passivhaus Standard, and experienced German designers and builders can now bring in these buildings at a cost only 3% to 5% above the cost of a conventional building. The designs are primarily oriented toward cold climates and it takes some work to apply them to other regions, but many of the Passivhaus principles have been shown to work with warm-weather buildings. The technology is sophisticated enough to require extensive training for both designers and constructors as well as extreme attention to detail by the designer and builder; it has led to the development of better windows and more sophisticated HVAC systems than can currently be purchased in the United States. Overall, both Switzerland and Germany have higher-tech construction industries than the U.S. and are moving steadily on the path to zero-energy homes.

In the U.S., the building sector accounts for almost 40% of total energy use and carbon emissions, and 70% of electricity consumption. And unlike some of the most visible efficiency opportunities in the transportation and industrial sectors such as electric cars and advanced manufacturing techniques, key technologies for significant efficiency gains in buildings are already available and cost effective.

Compared to the amount of energy used in the world's most energy-efficient buildings, in the U.S., the typical new or substantially remodeled building is an energy guzzler. Yet, based on the European experience and that of the few U.S. builders who have constructed buildings using Passivhaus, Minergie, or other low/zero energy designs, there is clear hope that the U.S. building sector can contribute significantly to meeting the ACES 2020 and 2050 goals of carbon stabilization by eventually matching what world-class designers and builders can do today. Various projects in the United States have shown that extensive retrofits of existing buildings also can lower energy usage 25% to 40%. The big questions are whether our builders, remodelers, and building owners can change to take advantage of these opportunities, and whether as a nation we will eventually have the political will to raise the bar in our building codes and require what is already technologically possible.

CONSIDERING THE WHOLE BUILDING

While energy is a primary driver of a high-performance building, other design objectives are very important. The average person spends most of his or her life in buildings, so it is important to design not just for energy efficiency and renewable technologies, but also for high overall building quality, including safety, security, accessibility, resistance to hurricanes and earthquakes, fitness for intended use, and ease of retrofit as technology improves and as building inhabitants age.

LEED® (Leadership in Energy and Environmental Design), one of the leading rating systems for green buildings, has received much attention in recent years, and many people think of a LEED building as the gold standard for a high level of energy conservation and even for high overall quality. In providing and promoting a system for evaluating the "greenness" of buildings, LEED has done much to raise the consciousness of the building industry and the American people regarding energy and environmental considerations, such as choice of materials, water use, green roofs, energy efficiency, and renewable energy. Many architects have become LEED accredited. LEED certifies design rather than building performance, and sometimes LEED buildings use far more energy than expected; a 2008 study by the New Buildings Institute found that half of LEED buildings deviate by more than 25% from their designed energy use intensities. Through regular updates to LEED, the U.S. Green Building Council is working to overcome these and other problems, but LEED is still primarily an environmental rating system that does not give any credit for other important aspects of buildings.

This has caused some to look beyond green design to high-performance buildings. A good example of the potential of high-performance, factory-produced buildings is the Mississippi Cottage project of the State of Mississippi, Habitat for Humanity, and the Federation of American Scientists. After Hurricane Katrina, the project showed that modestly priced housing units could be dramatically more energy efficient than earlier manufactured houses; they could also be environmentally sound, accessible to the disabled, and capable of withstanding hurricane-force winds. As described by its president Henry Green, the National Institute of Building Sciences (NIBS) is taking the lead in rethinking building standards for high performance; he hopes its work will lead to powerful design tools for identifying the win-win situations in energy conservation and overall usefulness of buildings that only optimizing for high performance can bring to the building sector. Another win-win situation would evolve if, after the DOE fully funds and NIBS completes its work on assessing and harmonizing standards for high-performance buildings, the developers of the various green building rating systems use what NIBS produces as the technical basis for their rating systems. This would help the rating systems become an effective performance measurement tool for achieving the intended performance of certified buildings.

THE STATE OF THE BUILDING INDUSTRY

In new construction, decisions on energy use are generally made by those who design and build buildings rather than those who use them, and savings in construction costs often trump even larger savings in operating costs. While major construction companies and a few architects and builders are able to use the most sophisticated software and employ business practices that can lead to world-class buildings, much of the industry is less sophisticated. In 2006, there were 883,000 construction establishments with 7.1 million workers in the United States; 65 percent of them employed fewer than five workers. The workforce may have little formal education regarding energy-related decisions, since small construction firms are dependent on the job training or apprentice training conducted by experienced workers. Much work is carried out by subcontractors, so the workforce varies from one building to the next. In any given year, new construction adds only 1% to 2% to the installed base of buildings, so energy decisions made in a building's construction remain in effect for many years. Builder supply chains provide the materials and components that builders want, including builder-grade doors and windows that are lower quality than those sold as replacements to remodelers. Absent more stringent building codes or government financial incentives, energy efficiency is unlikely to happen in new buildings because contractors have no incentive to include energy-efficiency improvements that add to their costs but do not increase profits.

In contrast, the energy efficiency of retrofits, remodeling, and other home improvements depends on the level of sophistication of the building owners and whether they consider the operational costs of their buildings in their remodeling plans. Remodelers deal directly with the homeowners who pay the utility bills, so they are much more likely than home builders to use energy efficiency as a selling point. Also, builders rarely maintain a business relationship with the people who ultimately occupy the building and pay for its energy use, while some energy-oriented remodelers continue to monitor and "tune up" the performance of buildings they have worked on. These ongoing business relationships, which are not the case for all energy remodeling, can involve energy service contracts or other financial incentives for continued efficiency performance that are much more closely aligned with efficiency than is the case with builders.

BARRIERS TO HARVESTING THE LOW-HANGING FRUIT

Low-hanging fruit will remain on the tree as long as those making decisions about building construction, renovation, and operation are unaware of its value or do not have an easy way to harvest it. We need to re-engineer the building sector so that energy conservation happens routinely and easily. How do we get to a tipping point in public opinion so that the average person will be motivated to insist on living and working in low-energy buildings? Who are the players who can make this happen?

A major difference between the United States and Switzerland or Germany is the relative lack of precision in our buildings. European buildings are engineering-driven and their builders continuously look for improvements in energy efficiency through tighter fits, better materials, and manufacturing improvements. Because they look at the building as an integrated whole rather than as a collection of parts, they reap the associated energy savings. They pay attention to the details that save energy and measure precisely to make sure the savings will occur. In the United States, we seem to accept mediocrity, incorporate only minimum code requirements in most buildings, and focus on architectural awards rather than building performance. While the highest-quality buildings are significantly beyond code requirements, seven states do not even have building codes to set minimum standards for buildings and half of the states do not have up-to-date codes. Even when current codes are in place, they are ineffective unless they are enforced by properly trained code officials and inspectors. Differences between expectations and actual performance can be even larger in remodeling and retrofit, where estimates of energy savings may be used as a sales tool but often no reliable measurements are available to determine whether or not the energy upgrades worked.

Another problem is public apathy, coupled with industry inertia. Most Americans do not understand that their homes, lighting, and appliances are inefficient, and typically the potential buyers of a new or used home have almost no knowledge of the energy performance of the homes they are considering, unlike vehicles (where MPG ratings are universally available) and major appliances (which often display an energy label). It is hard to find out how much energy a home has used historically, or what energy savings are possible through remodeling/retrofitting, which upgrades make economic sense, or how to get the work done. This translates into relatively low demand for low-energy homes and energy retrofitting, compared to Europe. With little public demand for better products and services, builders have little reason to change—and the same is true for those who design, construct, market, renovate, and sell buildings. Therefore, in terms of energy efficiency, most builders, real estate agents, lenders, and insurers are doing business much the same as they did years ago.

Unfortunately, we are also falling short of the challenge of developing the next wave of innovation that will be needed to meet carbon goals after 2020. Federal budgets for research into energy and energy efficiency soared in the second half of the 1970s, when the American people were reeling from our first energy crisis. These programs were cut back to perhaps 25 percent of their peak in the early 1980s, when economic problems led to major cuts across the government, and the cuts were not restored when times got better. Now, when we really need advanced energy technologies at competitive prices, we do not have them. Some observers have noted that we have lost our knowledge about using indigenous building materials. Just as we have much to learn from research and development, they argue, we have much to learn from those who came before us. Re-discovering, re-thinking, re-purposing, and re-combining low-tech and local resources can also be important sources of innovation and improvements.

WHAT CAN BE DONE TO BEGIN THE HARVEST?

We can meet the 2015 and 2020 carbon footprint goals only if millions of retrofits accompany a general upgrading of the energy efficiency of most new construction. This will require governments at all levels and the private sector to step up to the challenge; the White House, Department of Energy, and Department of Housing and Urban Development (HUD) will have to play leadership roles. It will also require active participation by state and local government, code developers and officials, and the appropriate parts of the private sector. Some of the pieces already are in place, but a major effort to scale-up these efforts is needed as soon as possible. Several steps can be taken without waiting for the ACES legislation.

Show White House Commitment

The direction we need to go is clear, but the will to act is not. A major thrust is necessary to overcome inertia and move forward. The State of the Union address or a major presidential speech to the American public would be a powerful way to kick off a national challenge, assuming that the President shares the conviction of the Secretary of Energy that the world absolutely must begin to reduce the world carbon footprint between 2015 and 2020.

Take Advantage of the Conservation Dividend

Our best short-term hope is playing to the economic self-interest of individual building owners and of others in the real estate and construction business. In 2005, U.S. households spent $201 billion on utility bills and other building owners spent $150 billion more. Reducing the energy use of a year's worth of new buildings by 25% to 40% would save a billion dollars or more for those buildings' owners each and every year of the buildings' useful life. Yet, the much bigger pot of gold is in retrofits. If 25% to 40% of the total energy costs of existing buildings can be saved through cost-effective efficiency improvements using technologies currently available, an additional $85 billion to $135 billion per year is currently waiting to be claimed.

Additional savings are increasingly available from cost-effective use of renewable energy. Of course, investment is needed to claim these savings, but the payback periods are short enough to reward those who try to save energy. Other savings go begging, despite government incentives to make the investment. To achieve these reductions we need to understand our behavior: Why are virtually all of us leaving significant amounts of money on the table each and every year by not making the buildings we own or control more energy efficient? Why have utility energy conservation programs, energy efficiency mortgages, and other innovative programs had such low levels of participation? And what can be done to make it easy for businesses to see the money we are wasting and devise profitable means of helping us claim it?

Benchmark the Best Solutions Around the Country and Around the world

The United States has a large second-mover advantage in energy. Above we described how the Germans and Swiss are years ahead of us in thinking through high-performance, low-energy buildings. They also are ahead of us in setting up the infrastructure for bringing both new low-energy buildings and retrofits to the market. They have delivery systems in place. They have trained their construction industry. They have tried various incentives. Switzerland is one of a very few countries that have reached a tipping point: energy-efficient buildings are now so pervasive that the Swiss public demands them and the real estate market and the regulatory environment are responding. We need to study Switzerland and other progressive nations to figure out how they got to this point and which parts of their experience and their policies are applicable to the United States either regionally or nationally.

Also, some progressive communities across the United States have begun to require all new buildings to be energy efficient and/or have launched major programs to retrofit the least energy-efficient buildings in their communities. For instance, Austin, Texas, created its own green building program in 1990 and recently enacted an Energy Conservation Audit and Disclosure ordinance to improve the energy efficiency of Austin homes and buildings that receive electricity from Austin Energy. The goal of the ordinance is, by 2020, to reduce electricity bills for renters and owners of homes, multifamily properties, and commercial buildings through improved energy efficiency that is comparable to the original Minergie levels. In cities like Austin, builders and their suppliers have adjusted; now high-quality materials are readily available, real estate professionals have changed their marketing strategies, and inspections are effective and lead to energy efficiency improvements.

Other cities have adopted specific programs. The 2030 Challenge is a goal announced by the American Institute of Architects, and endorsed by the U.S. Conference of Mayors, to reduce building energy use and carbon emissions incrementally, and to achieve net-zero-energy buildings by 2030. The Cities for Climate Protection Campaign is a program from ICLEI-Local Governments for Sustainability to assist cities in adopting policies and implementing "quantifiable measures to reduce local greenhouse gas emissions, improve air quality, and enhance urban livability and sustainability."

And a growing number of local initiatives are too new to have any reliable measures of their success but show substantial promise. For instance, the City of Cambridge, Massachusetts, joined the Climate Protection Campaign and set a goal to reduce its greenhouse gas emissions by 20% by 2015. Cambridge is a dense, walking-oriented city with very little new construction, so smart growth was not the priority issue. Instead, retrofitting the city's large stock of 80-year-old buildings offered the best opportunity for energy savings. With partnership and funding from the Kendall Foundation, the city created a nonprofit agency, the Cambridge Energy Alliance, to help residents and business owners invest in making their

homes and buildings work smarter and more efficiently to save energy, water, and money. The city has been mobilizing volunteer climate activists to canvass neighborhoods and offer free basic energy audits and retrofit information to homeowners. Since the program started last August the number of residential audits has tripled and many retrofits have gotten underway. A dozen or more small businesses have also signed up. While the Alliance coordinates consumers, contractors, and banks, utility partner N-Star is monitoring energy use and beginning to measure success in terms of energy saved and carbon emissions reduced.

While these progressive city-scale programs are already having a local impact, their true power is in serving as test beds and models to inform and inspire other city- and town-level retrofit programs across the country. We need to capture the lessons learned from these early programs and make them available to other communities that are less familiar with energy issues and have shorter histories of energy-conscious behavior. The structures of the programs in Cambridge, Austin and elsewhere have important differences, including the relative involvement of the utilities, the role of various business and supply chains, the approach to auditing and verification, and the mechanisms for financing. These structural differences will presumably affect their relative success. We need to ensure that their lessons learned are captured in a coherent way that helps other communities avoid common mistakes and copy winning strategies. There are many places to start. Forty-two out of the 50 United States have taken formal steps to address climate change through some means, either by a statewide climate action plan or regional agreement. But without a coordinated effort to translate that emerging political will into practical programs, local governments will keep reinventing the wheel. This coordination must be led by the federal government, and must include a significant effort to study and synthesize the experiences of these local programs and to communicate the lessons and best practices to the rest of the country.

Expand Financing Structures and Explore Innovative Revenue Streams

Innovation is often a matter of figuring out the appropriate financial structure to allow for a profitable investment. One of the most notable recent financial innovations is the use of property-assessed clean energy (PACE) programs, in which municipalities loan money to homeowners to install efficiency measures and/or renewable generation, and the homeowners repay the loans through additions to their property taxes. This approach has the benefit of tying the repayment of the loan to the home itself rather than to the homeowner, since the ongoing benefits of reduced utility bills accrue to the current owner, who may not necessarily be the owner who arranged for the energy-efficiency improvements. Utility-based on-bill financing has also been used in a number of programs, in which loans for efficiency upgrades are repaid through the utility bill, with savings offsetting loan repayments in a format that homeowners can understand easily.

While direct savings on utility bills are the bulk of the returns from harvesting the low-hanging fruit of building efficiency upgrades, other revenues can be had

through financial mechanisms that are almost completely unexplored. One of these is aggregating efficiencies from multiple building retrofits and selling them into carbon offset markets or forward capacity markets. The state of Maine is exploring how to aggregate carbon savings from low-income weatherization work for sale in carbon offset markets. The state has noted that this class of offsets is particularly attractive to purchasers because they are unambiguously avoiding emissions that would otherwise have occurred, and they have a redeeming social aspect because they lower utility bills for low-income families.

An important development for this kind of alternative financing is last year's FERC Order 719, which explicitly permits aggregators of retail customers to bid demand response into forward capacity markets, paving the way for the possibility that large-scale retrofit work could be partly funded by revenues from installed demand-response measures. We also need to extend innovative financing to renewable energy, where powerful ideas are beginning to emerge, such as power purchase agreements that permit owners to lease photovoltaic equipment installed on their building and pay only for the power, rather than for the entire capital equipment.

Make Energy Efficiency and Cost-Effective Renewable Energy a Priority in Government Programs

Even in the absence of cap-and-trade legislation, the federal government is heavily involved in the housing sector, and impacts the rest of the building sector as well. It is time to look comprehensively at ways to use existing authorities of the federal government: what steps can be taken through executive, departmental, and agency orders to take us closer to meeting the 2015 and 2020 goals? This recommendation is obvious enough that the Obama Administration has already begun to work on it, and it is one of the most important topics other than cap-and-trade in the ACES legislation.

For over 30 years, programs have been addressing energy efficiency in federal buildings, but it is time to go well beyond the *status quo*. Federal buildings are in a position to serve as demonstrations of energy conservation best practices and of how to positively affect construction supply chains, but they often fail to do so. A vital first step is for the federal government to overhaul its approach to efficiency in its own facilities, seizing opportunities to install all cost-effective retrofit measures. It can then use federal facility retrofits as a communications opportunity to advertise cost savings from and best practices for efficiency. This will require better resources for the government offices assigned to carrying out these programs; too often in the past, the Federal Energy Management Program (FEMP) and the agencies that support it were not considered mission critical, and had too few resources to implement even the existing executive orders for efficient energy management.

It will also be necessary to amend some federal accounting rules, which often constrain the options that agencies have for financing energy purchases.

Ultimately, federal agencies should have access to an integrated set of best practices for planning, financing, implementing, and publicizing energy efficiency upgrades at their facilities, since projects that lack any one of those components are missing opportunities to save energy and money while promoting efficiency beyond the agency's own properties. Leadership on this issue must come from FEMP, GSA, and the White House itself.

The Department of Housing and Urban Development (HUD) is involved in providing housing for millions of people; it has been estimated that as much as $5 billion of its budget goes to pay utility bills in subsidized housing, some of which is in highly inefficient buildings. This happens partly because HUD allows landlords to pass utility costs on to tenants and the government without requiring the buildings to be energy efficient. It is time for HUD to add energy-efficiency requirements to the upgrades already expected of those who benefit from its programs and to require landlords to absorb utility costs if they do not upgrade their buildings. Fortunately, important steps in this direction are included in the Fiscal Year 2010 budget request and in legislation that Congress is currently considering.

The federal government is heavily involved in the housing sector and impacts the rest of the building sector as well. It is time to look comprehensively at ways to use existing authorities of the federal government: what steps can be taken through executive, departmental, and agency orders to take us closer to meeting the 2015 and 2020 goals?

The Department of Energy provides home retrofit services to low-income families around the country through the low-income Weatherization Assistance Program; through the Recovery Act, this program has received enough appropriations to increase its efforts several fold and reach hundreds of thousands of homes annually. While the increased weatherization is an excellent first step, it is clear that the expansion's most lasting impact could be stimulating the expansion of private-sector retrofit efforts by training weatherization specialists and by integrating and disseminating knowledge of retrofit engineering. This program is also an opportunity to explore different retrofit strategies on a large scale, effectively conducting in-the-field R&D on retrofit technology. By capturing this information and publicizing its knowledge base about what does and does not work in home retrofitting, this program could accelerate the entry of new private-sector retrofit companies into the industry.

These companies could also use weatherization-trained workers to build their core competencies and expand their workforce rapidly.

Much of the federal government's support of the housing industry occurs through organizations that guarantee or subsidize home loans, such as the Veterans Administration, the Federal Housing Administration, the Department of Agriculture, and (as of recently) Fannie Mae and Freddie Mac. In fact, as reported in the *Washington Post* on September 7, 2009, the federal government now stands behind 86% of home loans, a dramatic change from just 18 months ago. These organizations think of themselves more as bankers than as institutions that can affect the quality of housing stock. However, the government has traditionally protected its investment by requiring that building defects be repaired before a loan on that building will be approved. Since the average home is sold every several years, curing "energy defects"—i.e., requiring a high level of energy efficiency—before loans are approved may be our best chance of encouraging the volume of retrofits needed to make a difference in the U.S. carbon footprint. If novel approaches for financing these repairs and upgrades, such as PACE, become generally available, the upgrade costs could be rolled into the mortgage or handled through property tax adjustments. Related strategies include energy efficiency rating and labeling similar to systems being implemented in Europe, and providing buyers with a recommended retrofit list beyond those made by the seller. These mechanisms would allow buyers to comparison shop for energy efficiency and make it more likely that new homeowners would undertake retrofit work. Another strategy would be asking the lending institutions that benefit from federal insurance to make energy efficiency a condition of their construction loans and mortgages.

If implemented correctly, these approaches, and other variations on them, can contribute significantly to meeting energy conservation goals. Perhaps most important, this approach would reduce the chance of the purchaser defaulting, a key policy goal in the current economic environment, given that the efficiency improvements lower the net average monthly costs of operating a building. Unfortunately, the federal home loan agencies have not yet embraced this harmonization of energy and housing finance goals, as they are under immense pressure to minimize risk and are therefore averse to any kind of innovation in areas outside of their expertise. Actors within the federal government must figure out how to overcome this reluctance, both by enhancing the level of cooperation between the financial and energy-oriented agencies, and by clear White House leadership on the issue.

An added advantage of federal energy efficiency requirements is their educational impact on the building workforce. If architects, builders, permit issuers, inspectors, and real estate agents all have to become familiar with energy-efficient practices before they can qualify for federally-backed loans, this knowledge can spill over to other construction. If the building supply chain stocks energy-efficient products and components for the federally-backed market, then these products are also available to others remodeling their buildings. State and local governments

have their own set of pressure points to encourage energy conservation, and many of them will have to act if enough retrofits are to occur in time. However, given the magnitude of needed retrofits, state and local programs will not obviate the need for strong federal leadership.

Make Better Use of the Power of Codes, Standards, and Data. Give Businesses the Power of Data and Measurement

One key component in establishing new energy practices is developing strong standards and building codes and then ensuring that they are adopted. The current process of developing building codes relies on private-sector organizations to develop codes through a consensus process among their members. Consensus can lead to robustness because the concerns of all parties are considered, but it can also lead to weakness because the parties tend to adopt what is acceptable to a majority of participants rather than relying on the most advanced technology available. The new versions of the model codes are adopted by perhaps half of the state and local governments, sometimes in modified form; this process has led to great variations in the minimum efficiency requirements around the country and a tenuous link between research on buildings and the implementation of research results in the field.

Fortunately, this situation may be improving, at least regarding energy efficiency. Earlier this year, Congress spoke clearly in the Recovery Act about setting a floor on building quality and energy use. For the jurisdictions that receive the state energy funding that the act provides, significant amounts of that funding will be contingent on their making progress towards adopting the current building codes. For this mandate to have its intended effect, the Department of Energy will need to take robust steps to track progress in implementing current codes and to help states and localities set up the infrastructure to ensure that these codes are followed, including supporting the training of code officials and building inspectors. This is a good starting point because our energy goals for buildings will not be met unless the heartland moves from an informal building culture to one with performance expectations.

The ACES legislation would build on this floor through provisions that require private-sector code developers to meet specified national targets for efficiency improvements in their building codes; if they fail, they face the prospect that federal mandates would supersede the energy portion of their codes. While this outcome is unlikely and not optimal, the threat of these provisions being enacted is already giving federal agencies the leverage they need to work with code developers to encourage them to regularly strengthen the codes' energy provisions in each revision cycle.

An important emerging supplement to stronger mandatory building codes is new efforts to develop voluntary codes as guides for those who want to build buildings that exceed the minimum requirements. If the Swiss experience is any guide, these codes are likely to play an important role: they will also serve as initial

drafts for the next round of minimum requirements, driving the cycle of continuous improvement and allowing progressive builders and localities to test various code approaches before they incorporate them into regulations. They also can serve as the threshold for various subsidy programs, allowing policymakers at all levels to link incentives to explicit code documents and guidelines. An important recent example of voluntary codes is the joint effort of the International Code Council, ASTM, and the American Institute of Architects to develop an International Green Construction Code.

This development increases the importance of the NIBS standards integration work described in Henry Green's article in this issue. While Passivhaus has shown us how to optimize a building for energy efficiency, the NIBS work will illustrate how to optimize whole-building performance; for code writers, as well as architects, builders and their customers, it will provide a framework for understanding all aspects of what we need from buildings and for capturing that portion of energy savings that is only possible in optimally designed, high-performance buildings.

Finally, it is important to be creative in looking for ways that the IT revolution can help achieve our goals. The advent of a smart grid is an obvious example and it should be developed aggressively. Geospatial databases also have a lot to offer; because a building is at a fixed location, it can be treated as a specific location in such a database. To enable this use of geospatial information requires standards for identifying buildings, and a promising effort towards that goal is now underway. The Open Standards Consortium for Real Estate and the Open Geospatial Consortium are developing open identifier data formats for buildings related GIS information. This has the potential to be an extremely powerful tool, since it is now possible to mine geospatial databases for location-specific information on weather, geology, traffic patterns, neighborhood socioeconomics, and hundreds of other geographic-specific inputs. The missing ingredient for this approach is the baseline for the building. If building permit records become automated, we will have a wealth of information on a building's size, design, and suitability for upgrading that can be used to optimize original building designs and determine the likely economics of renewable and traditional energy systems at the property. Entrepreneurs are starting to see this data as a business opportunity. These databases should also prove valuable to local leaders and planners as they look beyond buildings to energy savings in communities by properly structuring transportation systems and locating key facilities and services in relation to concentrations of buildings.

Make it Easy to Opt for Low-Energy Buildings by Putting a Low-Energy Infrastructure in Place for Builders, Renovators, and Building Users

Reaching the 2015 and 2020 goals requires major action by three groups: designers and constructors of new buildings; individuals with the authority to upgrade existing buildings; and owners and managers of existing buildings and residences.

Many builders do not build low-energy buildings because they do not have the knowledge, supply chain, or financial incentives to do so. As discussed above, the level of energy efficiency built into new buildings relates directly to the codes that are being enforced in building design and construction. However, the final energy performance of new buildings also depends heavily on construction techniques and experience, so improving the skills of the construction workforce should be a priority. As small builders improve their skill sets, local jurisdictions should lower their resistance to adopting adequate building codes and using voluntary codes. One obvious partial solution is to have the Manufacturing Extension Partnership (MEP) of the Department of Commerce and the states move toward aiding builders. Home construction in many ways is a branch of manufacturing, and builders are increasingly using manufactured components and subassemblies. MEP has the ability to move the building sector toward adopting lean-six sigma and other techniques that have brought precision, cost reductions, and energy savings into the manufacturing sector. Additional certificate and training programs can be set up within institutions of higher education and high school evening programs, perhaps in cooperation with manufacturers of sophisticated equipment and controls.

Financial incentives for contractors' first high-performance buildings may also be important. Builders make their profits on the difference between their costs and the sales price of the building. If it costs less to use a lower-grade window or insulation and the buyer does not complain, it is in the builder's financial interest to go with the cheaper alternative. The question becomes how to lower the price differential between an energy-efficient and an energy-inefficient building to the point where a buyer will pay enough of a premium for the energy efficiency so that the builder can make more money by building an efficient building. Demonstrations may show builders that they really can make money on low-energy buildings. A Michigan home builder who builds only Energy Star-qualified homes that cost less to operate than conventional homes reported steady sales throughout the worst of the recession. Another possibility is to encourage volume sellers of building materials like Home Depot to buy quality products in volume, and then to pass on savings and to offer training in how to use the products, perhaps in conjunction with Energy Star or federal procurement programs. If energy-efficient products are readily available and understood they are more likely to be used.

Another key driver is labeling and other techniques for disclosing energy savings that encourage builders to advertise the fact that their energy efficient models will result in lower monthly operating costs for the building purchaser. It also may become necessary to remove the lower-grade products from the market. Just as the federal government establishes minimum efficiency standards for appliances, it could consider expanding this approach to building components. Since these components are manufactured assemblies, it would be possible to sample part of a production run and determine if a product meets these standards, similar to testing for appliance standards. One obvious complication is that acceptable performance levels for building components would vary by climate zone, an aspect of the regu-

latory framework that does not exist for appliance standards. Also, this authority does not currently exist and would require a legislative change. Still, as long as unambiguously inefficient building components are available on the market, they facilitate poor building energy performance, and a strong case can be made that these components should no longer be sold in a carbon-constrained world.

Finally, reaching rural areas can present a special challenge. The Department of Energy will have to work closely with the Farmers Home Administration and state rural development authorities, and the Cooperative Extension Service should become involved in promoting energy efficiency.

If we are going to expect millions of commercial building owners and homeowners to upgrade voluntarily, we must make it easy and desirable for them to do so. Large buildings are often managed professionally and building engineers handle the building's energy performance. Upgrading could be a company business decision or a decision by a condominium board wishing to save money. New laws, enhanced software, and new standards are making these decisions easier. California has just enacted a new law directed at benchmarking energy in existing commercial buildings, and ASTM is beginning to develop a new standard, the Guide for Building Energy Performance Disclosure, to standardize the traditional real estate disclosures as to the condition of the property. The ASTM standard will cover a building's history of energy audits, energy and water usage, carbon footprint, building certifications and ratings, benchmarking against existing buildings, and applicable federal, state, local, and utility requirements. This will provide incentives for landlords and tenants to consider these elements and reach a contractual understanding on what renovations will be done and what price will be charged for the property. Additionally, the National Institute of Building Sciences has advanced its Building Information Modeling (BIM) software to the point where it has the potential to save, or replace with renewable alternatives, as much as 20% of energy use.

Government efforts must focus on allowing a private market, whether it is utilities or full service energy efficiency contractors, to expand quickly.

Homeowners will not have the patience to seek out an energy auditor, to locate the contractors who can do the recommended work, and to function as their own general contractors. They may also not have the financial means to pay for the improvements up front, even though the large energy savings would offer generous payoffs year after year. Therefore, government efforts must focus on allowing a private market, whether it is utilities or full service energy efficiency contractors, to expand quickly. This is the premise of the Rebuilding America effort: a public/private partnership with the goal of building up a retrofit market and put-

ting thousands of people to work upgrading 50,000,000 homes by 2020. It is also worth considering the power of competition and the power of praise and to look for ways for communities or even subdivisions to compete against each other in saving energy and to honor those who have been especially successful in doing so.

The point of sale for homes is also an important window of opportunity for renovation, and real estate agents are important advisors in deciding what upgrades are made. Perhaps governments at various levels can work with real estate agents to ensure that energy is a major consideration in these upgrades and in popularizing labels, energy warranties, and advertising a home's low energy usage to teach potential buyers that low energy use increases home value and reduces a homeowner's monthly costs. Also, home energy costs vary by as much as 20% depending on the owner's energy usage and conservation practices. It may be worth thinking about energy analogies to coupons and rebates, cell phone pricing plans, and gas station signs as we decide how to motivate consumers. These practices prove that, if they are marketed correctly, small rewards, pricing schedules, and prominent display of prices all affect consumer behavior and may have a role in getting large numbers of people to reduce their carbon footprints.

KEEPING ONE EYE ON 2020 AND BEYOND

We must keep in mind that the carbon reduction goals for the year 2020 and beyond are dramatic and represent one of the largest re-engineering challenges the United States and the world have ever faced. At some point in the process, perhaps as early as 2020, the remaining energy savings in the United States will cease to be low-hanging fruit and will make economic sense only if significant changes have been made in technology and government regulation, and the government has carefully developed incentives to save energy. These changes will be costly in terms of both money and political capital. We will need considerably better technological options, so it is crucial to revolutionize energy R&D now. In his Compton Lecture at MIT this year, Secretary Chu said that the American energy industry will have to move from being one of the least likely industries to invest in research and development to embracing the research spending levels and speed in adopting new technology that is now associated with information technology or biotechnology.

Worldwide, the challenges related to moving beyond fossil fuels will be greater because billions of people desperately need to improve their standards of living. Without a worldwide enforceable agreement on reducing carbon, the fossil energy not used in this country will be gobbled up by the developing world as it strives to meet their aspirations. Therefore, research and development into environmentally friendly technologies is as crucial there as in the United States. It is imperative, even if it is not possible immediately, to keep pushing for a strong, equitable, worldwide agreement on fossil fuel use that is then reflected in U.S. law, whether the mechanism for achieving the limits be cap and trade or an alternative mechanism that turns out to be more politically acceptable.

As the choices get tougher, strong public support will be crucial. This will not happen unless the American people feel that the cause is just and the means of achieving it worldwide is fair to them. In a democracy, it is impossible for governments to limit people's choices if they do not have the voters behind them, so it is important to plan ahead. We need an ongoing, honest, objective public debate about the severity of our environmental problems and we must collectively make intelligent decisions in response. The needed changes in laws, the market, and building codes will happen here in the United States once we cross the tipping point in public opinion and a majority of people feel strongly that reducing atmospheric carbon is the right thing to do. That is the Swiss experience, and it can happen here too.

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