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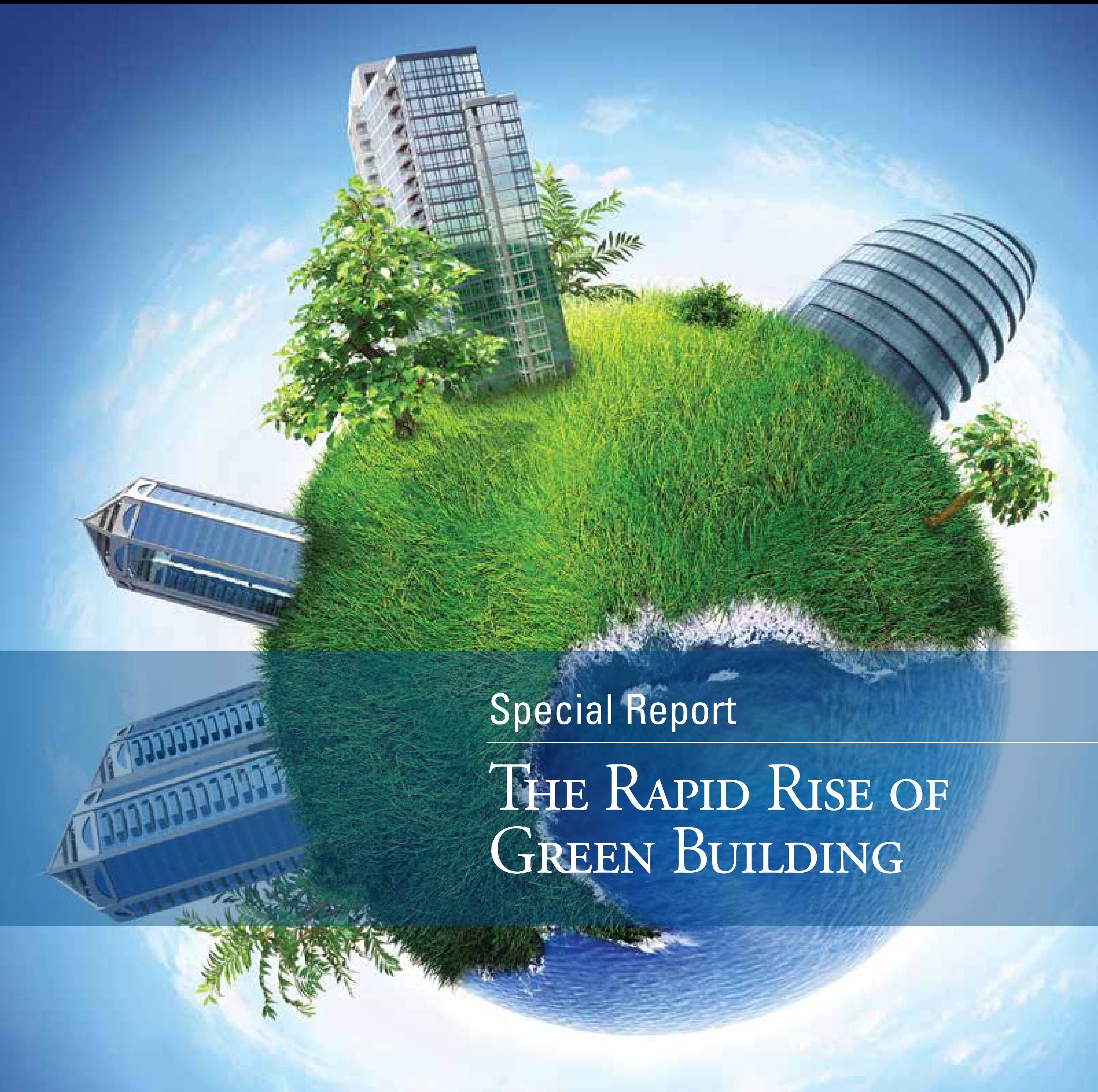
May 2013



Special Report

The Rapid Rise of Green Building

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The Rapid Rise of Green Building

Nobody can deny that the sustainable building movement's rise has been meteoric. In a 2012 Turner Construction survey of 718 U.S. real estate owners, developers and tenants, 90% were committed to environmentally sustainable practices. More than half were "extremely" or "very" committed to green principles. And a 2013 McGraw-Hill Construction global report found that 51% of architects, engineers, contractors, consultants and building owners surveyed in 62 countries say it's likely that more than 60% of their work will be "green" by 2015.

Last year, there were more than 13,500 commercial buildings certified to meet the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) standards in the U.S. Another 30,000 applied, and LEED has spread to 139 countries. Green building is maturing, especially in American cities, which are developing innovative regulations to drive positive outcomes.

Even without new laws, forward-looking companies find options — such as the use of energy services companies, green leasing and affordable approaches to solar and other renewables. They're motivated by more than "eco correctness" — adding sustainable features reduces operating costs (and often increases a building's value and the rent levels it can command), though payback periods can be long.

Some strategists go beyond more modest standards to the "net zero" building that generates as much energy as it uses. Cities are developing their own audit and energy management procedures, often using software unavailable 10 years ago. Clearly, green building has gone from a feel-good exercise to an impending baseline for all construction. This special report was produced in coordination with Wharton's Initiative for Global Environmental Leadership (IGEL).

Re-energizing Aging Cities: The Green Building Option

One hundred years ago, only 20% of the world's population lived in cities — but that number topped 50% by 2010. Every year, the United Nations reports, nearly 60 million people move to cities worldwide. Today, cities make up just 2% of the world's surface, but hold more than half of the human population. They consume three quarters of global energy, and are responsible for 80% of carbon emissions, according to a Schneider Electric white paper, "The Smart City Cornerstone: Urban Efficiency."

And the urban population is growing, adding one million people every week, and expected to increase 1.5% annually, from 3.4 billion in 2009 to as much as 6.4 billion by 2050. At mid-century, it is projected that 70% of the world's population will be urban.

Growth is concentrated in the world's "mega-cities," with populations of 10 million or more people. Nearly all of these cities have significant infrastructure challenges, and a majority of older, inefficient buildings. Buildings are themselves energy hogs, consuming almost 40% of U.S. energy, and more than 70% of produced electricity, as well as generating approximately 40% of American global warming gas. And old buildings, designed for a time of inexpensive energy, are prodigious wasters. Thanks to the growing science and practice of retrofitting older structures, however, they don't have to stay that way.

The waste problem is compounded in the United States, which has historically benefited from abundant, inexpensive sources of oil, natural gas and other resources. In early 2013, the U.S. won the dubious distinction of being the world's number one energy waster, using only 43% of the total generated power entering the economy.

But studies show that relatively minor adjustments to monitoring buildings' energy use — and adding efficiency measures — could reduce energy use dramatically. The American Council for an Energy-Efficient Economy (ACEEE), for instance, found that building shell improvements could reduce the need for space heating and cooling in both residential and commercial buildings by up to 60% in existing construction, and by 70% to 90% in new structures.

The marketplace is responding to that opportunity — and the chance for positive publicity — by creating a record number of urban buildings (both new construction and retrofits) that meet the high but voluntary standards of the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED). Green building is an increasingly visible and fast-growing presence — it was an $85 billion industry in 2012, and could reach 200 billion by 2016.

Cities have to get smarter, and that's beginning to happen. As a report from IBM points out, today's green buildings incorporate "systems that talk to systems," such as smart electric meters, lighting that senses when a space is being occupied and water faucets that control use and flow.

Some ambitious construction goes beyond LEED with more rigorous protocols such as the Living Building Challenge (LBC), which requires water and energy self-sufficiency. The Bullitt Center office building in Seattle, for instance, bills itself as "the greenest commercial building in the world." Opening on Earth Day 2013, it's a pioneering LBC structure that collects rainwater and generates all of its own energy from a 242-kilowatt photovoltaic array. It also uses composting toilets.

The U.S. headquarters of German software giant SAP outside Philadelphia is also built to a high standard, and is certified LEED Platinum. The airy building features a green roof, rainwater collection and geothermal energy.

A Green Makeover for Philadelphia's Navy Yard

Philadelphia has become a leader in energy efficiency under Mayor Michael Nutter. According to a 2012 progress report from the city's Greenworks Philadelphia, municipal energy use has been cut 5% since 2009 — enabling the city to avoid nearly $4 million in energy costs from 2009 to 2011. Christina Simeone, director of the Energy Center at the PennFuture environmental group (with a green economy and clean energy focus), says that the state of Pennsylvania has been less proactive on these issues, with the legislature declining to endorse greener federal building code revisions for 2012. "They missed a chance to be more energy efficient," she notes.

Given the city's long history, it is not surprising that innovative green-building efforts are focusing on Philadelphia's aging buildings. What is possible to accomplish even with very old structures will be showcased at Building 661 at the huge Philadelphia Navy Yard (the nation's oldest.) The age of the buildings, some of which date to the Civil War, was a challenge when they were repurposed following the 1995 cessation of naval activities at the yard.

The Navy Yard totals 1,200 acres, and currently supports more than 10,000 employees. After investment of $2 billion through public/private partnerships, it will have 15 million square feet of usable space and a workforce expected to reach 20,000.

"With its existing stock of old buildings, the Navy Yard is in effect a sandbox or experimental test bed for technologies and practices," says Mark Alan Hughes, a distinguished senior fellow at PennDesign at the University of Pennsylvania, and a lead investigator at Energy-Efficient Buildings Hub (EEB Hub). "There's a nice mix of uses, retaining a large industrial presence with more traditional office space, data centers and small technology startups. It's a super-cool place."

The Navy Yard, just three miles from Philadelphia's urban center, is working from a 2004 master plan created by Robert A.M. Stern Architects with a number of sustainable elements. In 2010, the federal government awarded $129 million to the umbrella Greater Philadelphia Innovation Cluster for Energy-Efficiency Buildings (GPIC), which includes Pennsylvania State University and the University of Pennsylvania, as well as partners from local and state government and industry. The goal is to cut energy use in commercial buildings in the Philadelphia region 20% by 2020.

In 2011, the Building 661 energy-efficiency retrofit moved forward with a two-day conference organized by a task force of the EEB Hub, which became the new name for GPIC as it was launched that same year by the Department of Energy. The two-story Building 661 is a former gymnasium that sat empty for 15 years. It dates to the 1940s, and in early 2014 will become the energy-efficient showcase headquarters for the EEB Hub.

According to Laurie Actman, deputy director of EEB Hub, "We go first for the lowest-hanging fruit — making these very inefficient brick-building envelopes more air tight. By installing controls and sensors, we gather information about how energy is being used in the building. Analyzing that data gets us to how we can get the best return in the retrofit."

Building 661, to be renamed the Building Energy Sciences Center, will feature a wide range of energy-efficiency measures, including demand-controlled ventilation, a high-efficiency condensing water boiler, second-story under-floor air delivery with displacement diffusers, automatic and time-of-day lighting controls, LED lighting, R-24 and R-30 insulation, double-glazed low-emissivity (low-e) argon-filled windows, and trees placed to provide shading.

The building will reduce overall lighting power for a complex its size by 8.5%, and will have a federal Energy Star rating between 94 and 97. It's impressive, but will the savings pay back the investment? "The market drivers haven't always been there for energy-efficiency investments," Actman notes. "Every step is complex. I'd like to see a more integrated approach to retrofits, rather than actions taken piece by piece."

New, But Retrofit

The University of Pennsylvania's Jon M. Huntsman Hall, known as the Wharton School's "newest, biggest building," is more than 300,000 square feet with 48 classrooms and 57 group study rooms. It was built in 2002, which would presumably give it an advantage in terms of energy efficiency over older campus buildings. But Ken Ogawa, executive director of operations at Penn's facilities and real estate services office, explains that it doesn't work that way. Yesterday's technology, even when it's only a decade old, can quickly become counter-productive.

"Huntsman Hall is one of the biggest energy users on campus," says Ogawa, who pinpointed a major reason for that: "Every classroom was equipped with carbon dioxide sensors, which help manage air quality in the classroom," he notes. "But they need a lot of calibration, and have to be reset inside the classroom. If the sensors fail they assume a lot of CO2 is present, and max out the air flow — which uses a lot of energy."

As part of a retrofit that included the switching of more than 600 lamps to LED (reducing annual energy costs by $13,500 and annual maintenance by $49,000), Huntsman is being equipped with a modern digital CO2 sensor system with centralized calibration. "The new system will really improve energy efficiency," Ogawa states. "It's realistic to expect that it will function effectively."

Before coming to Penn, Ogawa was a public works officer at the Navy Yard, and worked in Building 1, which dates to the yard's earliest days. He notes that older buildings are often subject to historic preservation restrictions. Building 1, for instance, is of brick construction, with huge north- and south-facing windows. "There was a temperature delta [difference] of more than 10 degrees between the building's north and south side offices," Ogawa recalls, "with the latter benefiting from considerable solar gain. We couldn't replace the windows, but I put in interior storm [windows] that reduced the delta to three or four degrees."

Overcoming hurdles like that are regular occurrences at Penn. According to Rafe de Luna III, associate director of sustainability for Wharton operations, approximately 40 buildings are being studied for energy-efficiency upgrades as part of the university's Century Bond program. At Steinberg-Dietrich Hall, improvements include LED lighting, occupancy and day lighting sensors, a green roof and chilled beam technology (a convection HVAC system that uses a heat exchanger). The building was constructed in 1950, but that hasn't prevented Penn from seeking LEED Silver certification for it.

According to de Luna, Wharton currently has two LEED Gold buildings, and the LEED Silver pending for Steinberg-Dietrich Hall. LEED Silver is a minimum requirement for new construction at Penn. "We're also trying to conserve energy through our operations," de Luna adds. "It's not just about capital improvements: For example, we've experimented with off-peak escalator shutdowns, which have the potential of saving 20% to 40% in utility costs annually. We've placed air-handling units on shut-down schedules instead of running them 24/7, and even de-lamped hundreds of fixtures in areas that may have been over-lit."

Since Penn President Amy Gutmann signed the American College and University Presidents' Climate Commitment in 2007, the school's dedication to sustainability has deepened. John Keene, professor emeritus of city and regional planning at Penn, says that the building retrofits are part of a larger plan. "We realized we'd have to take a broader view than just focusing on reducing our carbon footprint," he notes. "We now have a sustainability plan with six or seven components, addressing, energy, buildings, transportation, teaching and other areas."

According to William W. Braham, a Penn professor of architecture, "The plan is to get the university to some form of carbon neutrality. So far, almost all of the decisions that have been made are business-positive or cash-positive. We're investing, but at the end of the day you save more than you spend if you look at it over decades."

At Tulane University in New Orleans, the devastation of Hurricane Katrina presented an opportunity to update seriously inefficient buildings with HVAC and water systems that were 40 or more years old. At Richardson Memorial Hall, for instance, analysis from new smart sensors on boiler, air ducts, lights, water pipes and chillers demonstrated that heating and cooling were sometimes operating simultaneously. With that situation addressed through an IBM energy optimization program, efficiency is up dramatically in the building.

"Every valve, every thermostat, potentially every light switch is talking to you, and if you listen, you can make intelligent decisions to optimize the comfort of the building and minimize the resource consumption," says Charles P. McMahon, a Tulane technology services vice president.

Complementing Retrofits with Local Energy Generation

A large-scale solar farm of up to 1.5 megawatts is part of the energy master plan for the Philadelphia Navy Yard, though it may be realized on a smaller scale. There is currently no centralized renewable energy source to replace the grid, but planners are taking a variety of approaches to greening the Navy Yard's electricity supply, including the installation of smart meters.

David Riley, associate professor of architectural engineering at Penn State University, lead EEB Hub partner at the Navy Yard, says that among the technologies being pioneered there are an experimental 125-kilowatt-hour utility-scale lithium-ion battery (with 250-kilowatt inverter) stored in a shipping container that will be integrated into the grid. It can provide solar load leveling and frequency regulation services. "This is a $200,000 prototype that will demonstrate the value of these systems," Riley notes. "The next one will be much cheaper." The developer of the system, SolarGrid Storage, estimates a less than 10-year payback period for the system.

Two other commercial buildings at the Navy Yard will also be generating much of their own power. The Navy Yard's visitors' center will combine solar panels and micro-wind turbines with such advanced technology as electrochromic windows, LED lighting, a geothermal heat-pump HVAC system and several kinds of high-performance insulation to create a net zero energy user. "This basically means the project produces as much or more energy in a year than it consumes," says Steven Miller, the design project manager and an architect with Public Works Department Washington.

And Urban Outfitters, also a Navy Yard tenant, has already installed a 600-kilowatt Bloom Energy hydrogen fuel cell that is expected to provide 60% of its electricity needs, greatly reduce carbon dioxide emissions and pay for itself in five years.

As a result of all of the retrofitting and energy generation, Hughes estimates that utility bills in Navy Yard office space could be half what they are in similar square footage structures elsewhere, and that this will translate to market value — and the ability to charge tenants higher rent.

In order to roll out the kinds of innovative strategies being pioneered at the Navy Yard, some innovative approaches to local government also have to be developed. In 2011, PennFuture secured a $315,000 federal Department of Energy grant aimed at removing barriers to solar installation in southwestern Pennsylvania. In part, the money will be used to help create and standardize local solar codes and ordinances, and create educational campaigns for local officials.

"We're getting municipalities to sign on to purchase agreements," notes Simeone. "If 100 people in a community commit to buying solar, then each customer can buy in at $4 a watt. If there's 200 or more, it's $3.50 a watt, or 300 at $3 a watt."

Eric W. Orts, director of the Initiative for Global Environmental Leadership (IGEL) and a professor of legal studies and business ethics at Wharton, says that widespread dissemination of such best practices for companies "can advance the business case for moving in this direction." Best practice documents would also be useful in dealing with zoning laws and municipal permitting on such issues as solar installation and electric car recharging stations.

Finding the Financing

The process of creating sustainable buildings would probably be moving even faster if a return on investment could be guaranteed. "There are a lot of questions on payback, but green building upgrades can be cost-effective, especially if you take a long-term view," notes Orts. "There are effective arguments for a return as long as you allow a five- or 10-year time horizon. That can be a problem for nonprofit groups and universities that expect quicker returns."

Ali Malkawi, a professor of architecture at Penn and the director of the T.C. Chan Center for Building Simulation and Energy Studies, says that only recently has technology evolved that can prove to clients that their sustainable high-performance buildings really will realize the energy savings embodied in the plans. "If we can't prove that buildings will perform as expected, it's harder to justify the expense," he points out. "Computer simulations help us bridge the gap between engineers and architects."

For small businesses, the upfront costs of greening buildings can be prohibitive, according to Therese Flaherty, director of the Wharton Small Business Development Center. That problem needs innovative solutions, she says, pointing to new approaches to retrofitting fast-food restaurants that don't require them to close while the work is being done — a huge savings for the bottom line.

Another timely option for building owners and managers, she adds, is the energy services companies, or ESCOs, developed in the 1980s. According to Flaherty, "ESCOs can absorb the upfront cost of an efficiency upgrade and get paid out of the energy savings. ESCOs can also provide project management and engineering services. The concept has so far been applied mainly to larger buildings, because the companies need to guarantee performance, and that requires a larger balance sheet." But if the technology is extremely efficient, it would work well for smaller businesses, too.

ESCO offerings come from manufacturers, brokers, contractors and utilities. Performance contracting can be offered by a company that makes energy-efficiency products to build up the business. Brokers and contractors hire others to do the actual work. Utilities can offer ESCO services as part of an energy-efficiency portfolio.

"When done right, these services are invaluable," reports Energy and Environmental Management magazine. "This is especially so when the engineering and contracting resources work together to identify and implement cost-effective retrofits, which otherwise would be overlooked through the more traditional plan-and-spec/competitive-bid method of design and contracting." Unfortunately, ESCO isn't always done right — wildly overestimating projected savings is one of the pitfalls.

Another way of encouraging energy-efficiency building improvements is via green leasing. In a typical net lease, building owners have no incentive to retrofit their buildings because energy costs are passed along to tenants. In many cases, tenants aren't motivated either, because their energy bills are based on the square footage they occupy, not their actual energy use.

Adam Sledd, program manager of green leasing and federal buildings for the Institute for Market Transformation, says that in a more equitable "high-performance lease," owner and tenant can negotiate an agreement that splits the cost of efficiency upgrades. According to EEB Hub, green leases "align the financial and energy incentives of building owners and tenants so they can work together to save money, conserve resources, and ensure the efficient operation of buildings."

San Francisco officials, working with the city's Business Council on Climate Change, created the free Green Tenant Toolkit to guide both building owners and tenants through the process of creating a green lease.

The Solar Leasing Option

Going solar — sometimes to the point of self-sufficiency, as Seattle's Bullitt Center demonstrates, is also greatly enabled by the growing practice of solar leasing. As offered by SolarCity and other companies, this innovative approach allows landlords to install panels at no upfront cost and then make fixed lease payments, akin to a rental of the equipment, with the savings realized via lower monthly energy bills.

A variation is the solar power purchase agreement, which is similar but payments are based on the amount of solar energy actually produced by the panels — billed at a fixed rate per kilowatt hour. Many corporations have favored this approach, including Whole Foods, Walmart and Staples.

But there is a drawback to a solar lease or power purchase agreement, at least for some participants: it shifts subsidy benefits. Thus, ownership remains with the companies that provide the panels, so if eligible they get a federal tax credit of up to 30%, as well as cash incentives available from states and utilities. The solar company also retains the lucrative renewable energy credits (RECs), which can be sold to offset carbon emissions.

Real Value

Such improvements reduce operating costs and increase real estate value, though as Orts points out, the payback may be on a longer time horizon than some building managers have seen in the past. According to McGraw-Hill Construction, building green reduces operating costs by 8% to 9% on average, increases building value 7.5%, improves return on investment 6.6%, increases occupancy ratios 3.5% and rent ratios by 3%.

A recent federal General Services Administration post-occupancy report on 22 GSA green buildings (16 of them LEED certified or registered) found even better results — 25% less energy use, 19% lower aggregate operational costs, 27% higher occupant satisfaction and a 36% decrease in carbon dioxide emissions. "In short, the GSA's 12-year commitment to green building practices is paying off," the report concluded.

The U.S. Green Building Council certified 2,491 buildings to LEED standards in 2011, more than eight times as many as five years earlier. By 2012, more than two billion square feet of building space had been LEED certified. LEED is increasingly an international standard, and 40% of projects pursuing certification are outside the U.S. China, Brazil, India, Canada, Qatar and the United Arab Emirates are all green building leaders.

But LEED, while the leading player, is not the only green building certifier. California's strong CalGreen building code (mandatory for new construction in the state) took effect in 2011. The Green Building Initiative offers the streamlined Green Globes, an environmental assessment and certification program for commercial buildings. Build it Green adopted the GreenPoint standards, which look at improvements in such areas as energy efficiency, indoor air quality and water conservation.

Clearly, the urban green building movement is gaining ground, both as new construction and renovations. The momentum has been sustained not just because sustainability is the "right" choice, but because it is seen as ultimately cost-effective in today's increasingly populous — and increasingly challenged — cities.

Getting to Green — New Tools and Policies Boost Sustainable Building

It should come as no surprise that cities and states are rethinking their approach to green building. Not only do buildings consume more than 40% of the energy in this country and more than two-thirds of the generated electric power, but in cities where effective transit systems take cars off the road, building energy use also accounts for the vast majority of greenhouse gas emissions. (According to a recent press release from New York City Mayor Michael Bloomberg's office, "Buildings account for 75% of all greenhouse gas emissions in New York City.")

So cities like New York and Philadelphia are moving beyond business as usual in standards and practices. While the LEED (Leadership in Energy and Environmental Design) certification system has been the most significant measure of green building achievement in the U.S. for some time, when New York City recently launched PlaNYC, a groundbreaking approach to green buildings and energy efficiency, it decided against using LEED standards, opting instead to develop its own measures of performance.

Other cities and states are also taking a fresh look at how energy is actually consumed in buildings, and developing new policies and approaches designed to foster energy efficiency in both residential and commercial structures.

Challenge #1: Bridging the Energy-efficiency Gap

Any new approach confronts two major challenges, the first of which seems to defy both logic and the very premise of capitalism. When it comes to saving energy, people often don't act in their own best interests. One problem, points out Christina Simeone, director of PennFuture's Energy Center for Enterprise and the Environment, is that people "tend to discount consumption in the future." It's hard for most of us, she explains, "to give up dollars spent now to save more dollars in the future."

But according to Eric W. Orts, director of the Initiative for Global Environmental Leadership (IGEL) and a professor of legal studies and business ethics at Wharton, the vast majority of us (well informed university professors included) never even get around to taking energy-saving steps that are "financial no-brainers in the short term."

This failure of decision makers to take cost-effective energy-saving steps is an important element in what has become know as the energy-efficiency gap. While many different groups have estimated the size of the gap, its enormity is not in question. According to a 2012 working paper by the Congressional Budget Office, energy consumption by residential and commercial buildings could be reduced by 10% to 20% globally in a little more than a decade if people would simply make smarter decisions.

One cause of the gap is the opportunity cost of information: The fact that people are not acting in their own self-interest, says Arthur van Benthem, a professor of business economics and public policy at Wharton, is a clear signal that among other things "there must be a huge informational cost to doing so for some people."

The informational cost can be thought of as opportunity cost. According to van Benthem, it's hard for some people to translate kilowatt-hour savings into terms that will help them decide if a $300 investment upfront will save them money over the long term. And for many, the scale of any possible gain simply doesn't justify the amount of time and energy they would have to invest in figuring out the payback.

Even for owners of larger single buildings or groups of them, opportunity costs can remain an issue because the challenge of deciding whether or not to make improvements grows increasingly complex as structures themselves increase in size and complexity.

Understanding all the inter-related systems and dynamics involved in major structures "is not rocket science — it's more complicated than that," says Mark Allan Hughes, distinguished senior fellow at PennDesign at the University of Pennsylvania and lead investigator at the U.S. Department of Energy's Energy Efficient Buildings Hub (EEB Hub) at the Philadelphia Navy Yard. Hughes doubts that asking even major building owners and investors to spend the large sums currently needed to evaluate their buildings' energy performance is going to work.

A growing number of cities are using benchmarking to encourage energy efficiency: One way to lower the opportunity cost of information is to simplify the task of deciding whether energy-efficiency steps are warranted. Government incentives do this effectively by reducing decision making to a simple choice about whether or not to participate and by decreasing the upfront cost of taking action.

But money for incentives is hard to come by and even successful programs tend to have limited life spans. One new policy that is gaining some traction in the field is benchmarking and disclosure. In 2007, California became the first state to require benchmarking. Since then, Hughes told NextCity.org, "Five U.S. cities [including Philadelphia and New York] and two states have passed laws that mandate benchmarking energy use in some form. Connecticut, Vermont and Massachusetts are considering similar policies now."

Benchmarking obligates and empowers owners to rate their buildings' energy performance, using common metrics, and then report their findings to the city or state. The Department of Energy (DOE) and the Environmental Protection Agency (EPA) jointly developed the Energy Star "Portfolio Manager" software that is provided free to building owners, who can complete the necessary inputs in an hour or two — even faster when utilities make the raw data available for easy downloading.

The end result of the process is a measure of how much power a building is using per square foot. Portfolio Manager also includes a set of standards by building type, so owners get quick access to vital information about how well their building is performing relative to similar structures. And because each building's score is made public in some way, owners and tenants can compare the relative performance of buildings in the area.

Hughes says the policy puts "information into the marketplace that everyone assumes will reward people who have invested in improving their buildings' energy performance. And it incentivizes people whose buildings are energy hogs to make some of these improvements." The expectation, adds Hughes, is that third parties will "translate this information into buyer-sensitive information." A leasing agent or real estate broker, for instance, might tell a client that since he or she will be spending less on energy, he or she can afford to spend a little more on a lease or mortgage.

In New York City, which last September became the first city in the country to make benchmarking information public, the data certainly got people's attention. The New York Times quickly pointed out that 7 World Trade Center, a modern 52-story office tower with a LEED Gold rating, scored just below the minimum for high-efficiency buildings set by the EPA, while buildings from the 1930s, such as the Chrysler Building and the Empire State Building, scored far better (thanks to thick walls, fewer windows and extensive upgrades).

And the public rankings sparked just the kind of competition Hughes described. As Simeone notes, in New York, "some of the people who owned buildings that were at the top of the list started competing for the top positions, asking themselves what they could do to get even better. And the people with buildings at the bottom of the list really did not like being at the bottom, which prompted them to take action."

Simplified modeling tools can also help lower the opportunity cost of information: While most privately owned buildings are individually metered, others are not. The buildings on the University of Pennsylvania campus, for instance, are just now being set up to measure their own electricity usage. But when University President Amy Gutmann became the first Ivy League president to sign the American College and University Presidents' Climate Commitment (ACUPCC) in 2007, "Nobody at that point had any clue which buildings on campus ... should be using more energy or less energy or for what," says William W. Braham, a professor of architecture at the University of Pennsylvania and director of the university's Master of Environmental Building Design program.

So Braham and others spent two years doing what he calls walk-around audits of each building on campus; then analyzed the data using a predictive simulation model developed by Penn's T.C. Chan Center. The Building Performance Assessment Tool (BPAT) provided detailed, if simplified evaluations of how each building would be expected to perform given its design. With a margin of error of plus or minus 10%, BPAT yielded a good deal of actionable analysis. It was found, for example, and much to everyone's surprise, that laboratory equipment was the second-biggest consumer of building energy on campus. As a result, the university is now focusing on ways to reduce laboratories' energy consumption.

Because it lacks the actual performance data provided by utility bills, however, BPAT can only make predictions based on design. A rat stuck in a duct or a malfunctioning valve can cause major differences between what is predicted and what actually happens. When in-depth audits were conducted in half a dozen of the previously audited UPenn buildings, Braham says that the process showed everyone "just how different a building could perform from how it was designed to perform."

But as long as people understand this limitation, the value of simplified simulation tools like BPAT is clear; they provide valuable information at very low cost. BPAT can be completed by a couple of graduate students in two or three days, making it far less expensive than more sophisticated models that require teams of experts and weeks or even months to complete. It also offers advantages that benchmarking's Portfolio Manager does not: It does not require that buildings be metered and it provides detailed information about which steps should be taken first. (Portfolio Manager gives only a single score; additional work must be done to prioritize corrective measures.)

A new financial model does away with the opportunity cost entirely: According to Hughes, "One of the things that the market is moving toward is a new financial model," one that relieves building owners of having to acquire any energy-efficiency information at all. The owner simply hires a third party provider to create the kind of environment he or she wants in the building (temperature, humidity, daylight, etc.) and gives that firm access to the building. The provider in turn guarantees to deliver the desired environment for a given price. Behind the scenes, the provider conducts any analyses it needs, brings in vendors to make needed improvements and tinkers with the building until the desired outcome is achieved.

Since the provider has guaranteed the owner price for performance, it is clearly in the provider's interest to keep energy costs as low as possible. But the owner doesn't have to pay any attention to energy information or bear any opportunity cost for acquiring it.

Challenge #2: Realigning Costs and Benefits

Green leases can help heal split incentives: The energy-efficiency gap is one major obstacle to energy efficiency. The other is misalignment of costs and benefits. The classic example, known as "split incentive," arises when the people who pay for the energy are not the ones who control its use. "There's a huge disconnect between who gets the benefit, who's responsible for managing and measuring those expenses, and who is actually consuming them through their behavior," notes Joseph Stettinius, CEO of commercial real estate services company Cassidy Turley.

Tenants who do not pay their own utilities have no financial incentive to help their landlord pay for energy-saving improvements that will lower only the landlord's costs. Conversely, when tenants do pay their own utilities, the owner of the building has no incentive to invest in efficiency since the tenants are the ones who will reap the benefits.

An innovative solution to this problem is the creation of "green leases," which align the financial and energy incentives of building owners and tenants. This is not a simple undertaking. In New York City, a group that included some of the city's largest building owners, tenants, management companies and engineers worked for six months to develop a prototype of such a lease. And in Philadelphia, the EEB Hub has joined with others to create the Green Lease Library, an online resource that provides guidance, case studies and tool kits to help cities create green leases of their own.

Innovative financing aligns owners' short-term interests with long-term investments: Another common misalignment of incentives concerns time horizons. A given improvement may eventually prove profitable, but the building owner may not want — or be able — to wait long enough to enjoy the net gain. Companies with impatient stockholders may have trouble justifying major improvements that will not pay off for many years, and individual building owners may not own the property long enough to reap the benefits of their investment.

One answer policymakers have developed for this problem is a new kind of financing that ties the capital cost of the improvement to the property instead of to the owner. PACE, or Property Assessed Clean Energy, says Simeone, provides "a great way to allow the private sector to come in and make really safe investments." Banks, which are less enamored of the mortgage market than they have been in the past, are attracted to these investments, Simeone notes, because they are "collateralized to the property, with a first lien on the property, which even the mortgage is subordinate to, and because the energy savings that will be realized by the property is very easy to prove.... Performance is almost guaranteed."

And the PACE program is just as attractive to building owners, who benefit from reduced energy costs right from the start, without onerous down payments or high short-term repayment costs. Instead, the cost of the loan typically adds a relatively small charge to the property tax bill. And because the loan is tied to property taxes, it stays with the building if the owner decides to sell.

Connecticut launched the nation's first statewide commercial PACE program in June 2012, and Riverside County, Calif., created the first, and one of the very few, residential PACE programs in 2011. Today, nearly 30 states have passed legislation enabling PACE programs.

Decoupling aligns energy generators with energy conservation: Since utilities are in the business of selling energy, it may appear unreasonable to expect them to actively support the state's goal of reducing energy consumption (although many do). For the utilities, lower consumption has always meant lower profits. Yet as Hughes notes, "Utilities are a crucially important part of energy conservation all over the country. The places where you see the most progress are where you've got the most engaged utilities." So finding a way to align the power of utilities with energy conservation is an important policy goal.

The approach a number of states are taking to achieve this goal is "decoupling," which detaches how much a utility is paid from how much energy it sells. The fundamental idea is that state regulators adjust utility rates to compensate utilities for any revenue they lose as a result of their own efforts to reduce energy consumption among their customers, whether through incentives, subsidies or educational programs. And the gradually increasing utility rates further motivate consumers to consume less energy.

Those familiar with the politics of decoupling note that some utilities have been wary of any change to the traditional system, which offers them and their stockholders a guaranteed rate of return. But as the Natural Resources Defense Council (NRDC) notes, "Half the states in the nation now have policies to break the link between recovery of fixed costs and sales for natural gas and electric utilities."

Ultimately, building codes have to be aligned with all of the other initiatives: At Philadelphia's EEB Hub, the Policy, Markets and Behavior Task Force has a motto: Make it hipper, make it cheaper and then make it mandatory. That last part is key. While policies try to incentivize and reward the best energy efficiency behavior, building codes ultimately establish the worst behavior that will be tolerated.

For years, energy efficiency was not even part of most building codes, which addressed issues of health, safety and accessibility. But this has been changing. The International Code Council (ICC), which establishes new model codes every three years, has been steadily sharpening its focus on energy issues — so much so that Hughes describes the last two rounds of model codes, in 2009 and 2012, as "major improvements" in terms of energy efficiency.

But Christina Simeone points to the weakness of these model codes: While most U.S. communities and many global markets choose to adopt the new, stronger codes every three years, the decision to do so is voluntary. For a time, states were motivated to accept the new codes because federal stimulus funds required that they do so. But now that those funds have dried up, Pennsylvania, for instance, has decided against adopting the 2012 code. And some other states, says Hughes, are actually thinking about rolling back their building codes to even earlier versions.

At the other end of the spectrum, New York City and others are demonstrating how building codes can be aligned with other initiatives. The city has opted to go beyond its legal obligation to enact building codes that are as stringent as the state's energy code. Instead, New York has enacted its own tough municipal energy approach, the New York

City Energy Conservation Code (NYCECC), which guarantees alignment of city building codes with all the other New York City policies and programs to reduce energy consumption in buildings.

Each of these policy initiatives advances the overall goal of reducing energy consumption in buildings. But 'in the end," says Hughes, "it's about connecting the dots." That's what the EEB Hub in Philadelphia is hoping to do: "serve as a broker across all of these different things, making sure everyone is on the same page, making sure everyone is moving in the same direction and making sure that there is follow-up." It's this kind of coordination that will ultimately make all the new policies that are developed truly effective.

The Future of Green Building May Be Closer than You Think

Buildings that consume no outside energy are being developed today using existing technology. Innovation is critical to the success of green building, and according to Harvey Bernstein, vice president of Industry Insights and Alliances at *McGraw-Hill Construction*, "The acceleration of the green building marketplace around the world is creating markets for green building products and technologies, which in turn will lead to faster growth of green building."

Even smaller innovative companies are getting into the game, thanks to Hartford, Conn.-based United Technologies Corporation (UTC). According to Jacqueline Jenkins, program executive for the Wharton Small Business Development Center's Energy Efficient Buildings project, UTC is subcontracting with smaller companies, "providing revenue for the companies, as well as a track record, which is key." And, she notes, the relationship with UTC allows innovations that might not otherwise get into the market to be tested there.

But while considerable attention is being focused on innovative products and technologies — the means of achieving green building — another kind of innovation has given birth to an exciting new approach.

The net-zero energy building, or NZEB, focuses less on the means and more on the end result, which is a building or group of structures that generate as much energy as they use. A building's energy production may be more than it needs at certain periods in time, explains David Riley, professor of architectural engineering at Pennsylvania State University and executive director of the university's Center for Sustainability. But it qualifies as net-zero only if "the meter has not moved by the end of the year."

The NZEB approach has been gaining momentum for some time, but in the past few years virtually all the major players — government agencies, academia, the military, not-for-profits and increasingly the business community — have become actively engaged in demonstrating the near-term potential of NZEB at residential, community and commercial scales.

The residential challenge is affordability: As part of a research project, The National Institute of Standards and Technology (NIST) recently built a net-zero test home in the Washington, D.C. area. "This home has all the features and aesthetics you would find in an upscale Washington, D.C. metro home," Hunter Fanney, chief of NIST's energy and environment division, told *U.S. News and World Report*. "There's really nothing exotic about it and nothing that can't be readily done with conventional construction."

But the challenge at the residential level isn't technical; it's financial. Betsy Pettit, president of Building Science Corporation, told Reuters that a house similar to the NIST house, built in Concord, Mass., cost about $600,000 — and that didn't include the cost of the land. While it is possible to build a net-zero house for less, it usually means a much smaller building with fewer amenities. According to Pettit, a house that approached net-zero energy use was built for Habitat for Humanity for just $150,000, but it measured only 1,200 square feet, less than half the size of an average single-family house in the U.S. in 2011.

In an effort to bring NZEB within reach of the average homeowner, the GridSTAR Center, a smart-grid education and research institute at Penn State, is focusing much of its work on the development of an affordable net-zero demonstration house. The goal, says Riley, who is also the principle investigator for the GridSTAR Center, is to create a home that generates all of the energy necessary "to meet the needs of the house and is a wise investment for the homeowner." And the first step toward achieving that aim is to make the 2,400 square-foot demonstration house, located at the Philadelphia Navy Yard, as energy efficient as possible. That way, Riley explains, "It won't need a whole lot energy generation to serve its needs."

None of the energy-saving features in the modular home is exotic and many are installed in the controlled environment of the factory that is making the building components. In addition, since the emphasis is on reducing both construction and operating costs, load-managing appliances are being installed. Homeowners can run these appliances whenever they want, but the appliances advise the owners when electricity is least expensive in the region, and can be programmed by the homeowner to run when the rates are lowest.

The amount of energy that the house generates and consumes at any one time depends on a number of constantly shifting variables — time of year, time of day, weather conditions and the owner's behavior, to name just a few. On a sunny summer day, when the family is out of the house, the photovoltaic roof shingles (installed at the factory) and the solar thermal collector, which helps provide both hot water and space heat, are likely to generate more energy than the house uses, in effect running the meter backwards. But on a cold winter night, when family members are home cooking and using everything from computers to televisions, the meter is likely to be running in the other direction. The net-zero goal is achieved if at the end of a year, the meter is in the same place that it was at the beginning — in other words, the net energy use for the year is zero.

One element that is critical to achieving this goal is the 10-kilowatt battery that sits inside the house. It serves two essential purposes. One is as a backup in case the grid ever goes down (according to *Bloomberg Business Week,* 18% of American households have either permanent or portable backup generators, a number that continues to climb as mega-storms like Sandy continue to knock out the grid).

The battery's other use is to "level the load," says Riley. "That battery can charge up at night when the electricity is cheap and deploy during peak times to discharge into the grid. So instead of just sitting there waiting for the grid to go down, this battery can actually generate revenue every day." And the battery may turn out to be less expensive than it might otherwise have been. GridSTAR is evaluating the practicality of re-using the 16.5 kilowatt-hour lithium-ion battery pack from a Chevy Volt plug-in hybrid after its useful life in the car is over. (GridSTAR is the first test site for the reuse of a Volt battery in a residential storage application.)

"General Motors engineered the battery to outlast the car," explains Riley. "The company doesn't want someone to buy a Volt and have to face an expensive battery replacement over the life of the car. But that battery is still going to have some use and discharges left, and it actually has the perfect capabilities to become a community-storage or a residential-scale battery."

The recycling of used hybrid car battery packs for stationary use is also being explored at the University of California, San Diego.

The next net-zero frontier is at the community level: "At the level of a single home, it's generally not a good investment to have a house that produces a lot more energy than you need," Riley states. While utilities may allow a homeowner to run his or her meter backwards at times, very few will actually pay for excess power beyond what the house uses in the course of a year.

But things change when a whole community of houses, or a neighborhood of mixed residential and commercial buildings, aims for net-zero. Katrina Managan, of Johnson Control's Institute for Building Efficiency, notes in a recent white paper ("Net Zero Communities: One Building at a Time") that such communities offer two key advantages: economies of scale in energy generation and a mix of buildings with varying occupancy patterns and energy use that can balance the energy load across an entire neighborhood. Communities also have the potential to generate enough excess energy to interest local utilities in negotiating revenue-generating agreements.

Such communities are just starting to appear. Motivated by the need to achieve energy security and independence, the U.S. Army is piloting a net-zero installation at Fort Bliss, located outside of El Paso, Texas. Occupying more than one million acres of land in Texas and New Mexico, and with a total population in excess of 90,000, Fort Bliss is aiming to transform the base into a net-zero energy community by 2015. Balancing budgetary and security concerns, Fort Bliss is modeling various possibilities, ranging from a waste-to-energy system, using the waste from the city of El Paso, to a geothermal plant, to be used in conjunction with energy-efficiency projects and load-balancing solutions, such as solar photovoltaics.

Outside of the military, the largest net-zero energy community in the U.S. is already nearing its goal of generating on site all of the energy used in its residential, community and commercial spaces. When completed, the West Village at the University of California, Davis, will include a village square and a network of open spaces, parks, gardens, pathways and courtyards; housing for 3,000 students, faculty and staff (in 662 apartments and 343 single-family homes); 42,500 square feet of commercial space; a recreation center; and eventually, a preschool/day care center.

As with the Grid STAR demonstration house, the first concern at West Village was energy efficiency. The roof uses solar-reflective material and radiant barrier sheathing, and thick 2" x 6" exterior walls add an extra level of insulation. Other architectural features, such as roof overhangs and window sunshades, combine with high-efficiency lighting, air conditioning units and appliances to reduce energy consumption to 50% below what would normally be expected if the buildings were simply built to code.

A four-megawatt photovoltaic system, including rooftop solar installations and solar canopies over parking areas, is designed to meet the needs of the first 1,980 apartment residents and commercial spaces. After that, the plan calls for a biogas generator, based on technology developed at UC Davis, which will convert dormitory table scraps, animal waste from the campus dairy and plant waste from agricultural research fields into electricity.

Residents also play a key role, and are being given access to a web-based tool that enables energy use monitoring by unit. And a smartphone app lets residents turn off lamps and plugged-in electronics remotely.

A little more than a year into the project and about halfway toward its target population of 3,000, West Village appears to be on track to achieve zero net energy use in 2013. The preliminary data is promising but not definitive, according to developer Carmel Partners of San Francisco. The solar panels are performing as expected and residents are using the anticipated amount of electricity. Efforts are underway to educate those residents whose energy use is higher than average on ways to reduce consumption.

All of this comes at a cost, however. In addition to \$300 million invested by West Village Community Partnership, a joint venture of Carmel Partners of San Francisco and Urban Villages of Denver, the project received nearly \$7.5 million in federal and state energy research grants. And apartment rents are said to be at the high end of the Davis market.

But then, West Village is a demonstration project intended to test and refine ideas that can be replicated elsewhere at market rates. Other projects around the country are also developing concepts and tools that can help make net-zero communities a reality, including the following:

- One challenge to planning such communities, especially in existing neighborhoods and cities, is figuring out which retrofits make the most sense and where. Simulation models exist for single buildings, but using these to try to make sense of large groups of buildings is nearly impossible, says Ali Malkawi, a Penn architecture professor and the director of the T.C. Chan Center for Building Simulation and Energy Studies. As part of his work at the U.S. Department of Energy's Energy Efficient Buildings Hub (EEB Hub) at the Philadelphia Navy Yard, Malkawi's team has come up with "computational tools that enable us to simulate a large number of buildings of varying types and to test interventions in neighborhoods and cities." This allows architects and engineers to test ideas at scale before making decisions, and it allows developers and investors to evaluate, ahead of time, which interventions will be most cost-effective.
  Cassidy Turley, a leading commercial real estate services provider, takes a different approach. The company was recently recognized by the EPA as a 2013 Energy Star Partner of the Year for its centralization of more than 350 buildings into one Energy Star Portfolio Manager account — creating a virtual community of sorts. This aggregation of buildings, notes CEO Joseph Stettinius, allows the firm to set benchmarks, and quickly identify and deal with anomalies that pop up any of the buildings. As a result, says Stettinius, "We can more effectively manage where we want to focus our remediation efforts." The portfolio approach also allows the company

to replicate what they learn in one building throughout the portfolio.

- The National Renewable Energy Laboratory (NREL) estimates that 62% of commercial buildings could reach net zero by 2025, but "it is rarely cost-effective to upgrade all buildings and equipment at once to get to net zero energy," notes Managan. She recommends developing an optimal sequencing of steps — delaying upgrades to HVAC systems, for instance, until load-reducing steps have been taken, or taking advantage of "compelling events," such as tenant vacancies or the end-of-life replacement of building systems to make needed upgrades.
- Energy storage is even more important at the community level than it is in single-family homes, both for backup in the event of disruptions to the grid and for load balancing. Riley notes a promising pilot program involving several hundred homes and a nearby wind farm. Wind power is notoriously variable: Sometimes the wind farm generates not only more energy than the community can use, but even more than the grid can safely absorb. At such times, the water heaters in all the homes are turned on, acting essentially as batteries by storing the energy for use later on.

The American headquarters of German software giant SAP points the way toward net-zero commercial buildings: Of the 21 commercial building identified as net zero by the New Buildings Institute (15 measured as net zero, plus six "credibly modeled"), 15 are less than 10,000 square feet and only one is at the same scale as the SAP facility in Newtown Square, Pa., near Philadelphia. (The building is also built to a high standard, and is certified LEED Platinum. The airy structure features a green roof, rainwater collection and geothermal energy.)

The relatively small scale of these buildings points to the difficulty of creating a large net zero energy building. As Malkawi notes, "As you get into larger and more complex structures, it is very difficult to figure out how the building is going to perform," which is why the T.C. Chan Center and other research institutions are working to develop sophisticated simulation models for larger buildings.

But thanks to the pioneering work of SAP and others — including the National Renewable Energy Lab (NREL) in Golden, Colo., which built the one net-zero building of comparable scale, the $64 million, 220,000 square-foot Research Support Facility (RSF) — a few strategies have been identified that will support the design and construction of large-scale commercial net-zero buildings.

Hermetically sealed high-rises won't get you to zero: Until recently, most large commercial structures have been sealed off from the natural world. But future energy-efficient buildings will undoubtedly take the opposite approach, responding continually to what is happening outside. The SAP facility, for example, has a lighting system that "harvests daylight" by using sensors to dim the lighting levels and raise or lower window shades based on the level of sunlight coming through the triple-glazed glass exterior wall. The NREL facility combines a similar window-shading technology with light-bending window louvers that cast rays up into the interior office spaces. And lower-than-average cubicle partitions allow the daylight to penetrate deep into the building.

The same openness to nature characterizes both buildings' approach to heating and cooling. The SAP building uses geothermal wells to both heat and cool areas of the building whenever the temperature inside rises above or falls below the constant temperature of the earth tapped by the wells. The NREL building uses both a massive concrete heat sink in the sub-basement to store radiant heat and windows that open automatically or manually to use outside air whenever it's efficient to do so.

Design and construction are a team sport: In order to ensure that all the various systems and features of a building work well together, everyone involved in the design, construction and maintenance of the building also needs to work together from the very beginning. At a recent conference in San Francisco, speakers from NREL made this point, discussing how the architects, engineers, contractors and operations/maintenance company involved in the RSF communicated with each other to ensure that their individual efforts would support the goal of net-zero energy. The result of this kind of teamwork is a building that functions as the SAP facility does. Brian Barrett, SAP's manager of capital projects, who coordinated construction of the Newtown Square building, notes how systems throughout the facility "are interconnected and are part of a holistic system."

Occupants are central to the success of net-zero buildings: "There has been a lot of work done related to human behavior in relation to energy reduction," says Malkawi. "It is very well understood from a psychology perspective." (He points out, however, that developing computational models that can incorporate this information is a work in progress.)

People use less energy, for instance, when they are made aware of how much they are using and how they can cut back. At the RSF, an icon pops up on occupants' computer screens whenever it makes sense for them open a nearby window (windows that are out of reach are operated automatically).

At SAP, says Barrett, "Education was provided to each employee who was moved into the building so they would understand key features. Informing the people who will actually use the building is important. There were notes on the waterless urinals and explanation of the light sensors at the desk outlets and the lights above, which turn off after a selected period of time. A great deal of time was spent with literature and tours at the onset of the move-in process for the employees."

The result of all these efforts is that the SAP facility is performing even better than expected, consuming 49% to 51% less energy than a conventionally built and managed building. And both SAP and NREL are continuing to make improvements and help nudge the commercial building sector toward net zero.

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