

GreenSource

THE MAGAZINE OF SUSTAINABLE DESIGN

new
havens

sustainable buildings that
respond to place

Bill McKibben's
climate campaign

Questions brew
over geothermal heat

Green architecture's
school daze

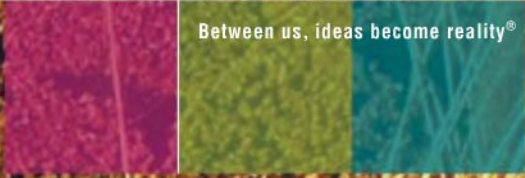
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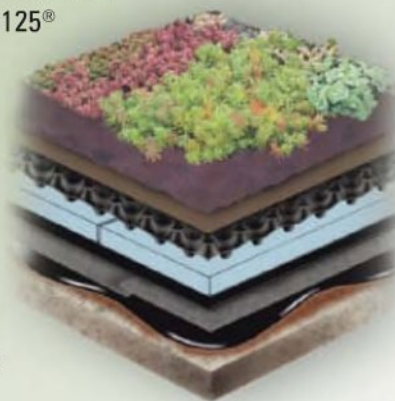
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Every month, *GreenSource* explores an innovative solution to the challenges presented by designing for sustainability.

New this month ELS Architecture and Urban Design devise several strategies for mitigating strong winds—and water loss—at a Silicon Valley swimming complex.

> GREENSOURCE VIDEO

In our growing library of videos, we tour important projects, explore ecologically attuned features, and speak with the people behind noteworthy green design.

New this month We tour New York City's largest green roof, 2.5-acres on top of the **U.S. Postal Service's** midtown mail-processing facility designed for exclusive use by employees.

READER GALLERY

Share images of your projects, and view and comment on photos contributed by others.

Right **Clemson University's Harris A. Smith Building** by **Lord, Aeck & Sargent**. Photo submitted by **LBOYD**



> BEST GREEN HOUSES

In our newest Web exclusive, *GreenSource* presents a running list of residential projects that exemplify creativity and sustainability through their designs. Every month, we select a different home for an online tour that highlights green features.

New this month We tour the 100K House, a townhouse prototype by Philadelphia's **Interface Studio Architects** that proves sustainability doesn't have to cost a premium.

PLUS

Visit GREENSOURCEMAG.COM to rate and comment on projects, submit photos, and join our community of green-design professionals.

Join other knowledgeable designers in discussions that cover everything from policy and rating systems to materials and products in our **FORUMS**.

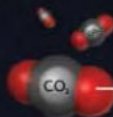
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Technologies For Energy Efficiency

Professionals have many choices for the delivery of energy-efficient solutions to their clients, from harnessing the sun for solar hot water, to providing options for indoor air delivery and using energy-efficient windows.



Photo courtesy of Amador Solar

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Conserving Water for a Thirsty Planet

Conserving water by using low-flow fixtures and low-impact stormwater design requires system thinking and integrative design.



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Beginning with a full scale Green Building Charrette, the MDIBL team combined planning, detailed

material sourcing and selection with LEED Platinum USGBC guided commissioning. The result? A sophisticated green and energy efficient working space for their scientists and staff. This project is a living example of what science, innovation and environmental leadership can accomplish.

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GreenSource Supports Global Grassroots Effort

Bill McKibben, author, academic, and a pioneer of the environmental movement, spearheaded the founding of the grassroots environmental group and its website called *350.org* in March of 2008. He was inspired by a team of young organizers who ran a campaign called "Step It Up" in 2007 that organized over 2,000 rallies in 50 states to bring awareness to the goal of cutting carbon emissions 80 percent by 2050.

The number 350 derives from the scientific finding that **350, as in parts per million (ppm), is the safe upper limit that scientists have identified for CO₂ emissions in the atmosphere.** The group uses the number as a symbol denoting this upper limit, but mostly to bring awareness

to this benchmark as the limit before our planet reels dangerously out of control and without recourse. (Reality check: we're already well past that limit, at about 390 ppm, so it's not enough to slow the increase; we actually have to reverse it.)

The group has gathered **a global community of supporters** representing a variety of perspectives, including many youth organizations, major international NGOs, and local grassroots organizations to raise awareness, bring hundreds of organizations together, provide on-line resources, and leverage the power of their global community for meaningful political change.


They plan to launch **a guerilla-marketing campaign through the media and on the Internet, on October 24, 2009, called the "Day of Action,"** to bring attention to

their concerns that the global treaty on cutting emissions to be discussed by world leaders in Copenhagen in December does NOT meet the 350 upper limit.

As journalists, we're wary of becoming advocates for a specific cause, but this one isn't partisan or political; **it's about following the scientific evidence.** So, we direct your attention to McKibben's commentary on the back page of this issue of *GreenSource*, where he spells out his views and the importance of this moment in history. As professionals involved in the single most important source of greenhouse gases, buildings, we hope you'll hear McKibben's message. 



THE EDITORS

 Watch an animated video about 350.org and an interview with Bill McKibben at greensourcemag.com



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TELEGRAMME

FIRST READ

By DAVID SOKOL

Taking the Pulse

Interest in building-performance metrics is reaching fever pitch as operational-data reporting is incorporated into requirements.

Proponents of sustainability are looking to prove what they're preaching. Efforts are underway to find out whether green buildings actually are using less energy than standard-issue structures, and how much.

This recent push follows regulations already in place in Europe, yet observers say reasons for the shift run deeper than parroting. Gauging real-world building performance signals the maturation of green building—there is a data set large enough to do so, for example.

Moreover, the sustainability community has long known that a building's measured performance does not often synchronize with its energy model. "As a guy who's spent a lot of his career doing energy modeling, you should always doubt every energy model," says Ron Jamagin, a staff scientist at Pacific Northwest National Laboratory. "It's rare to find a building with people in it that agrees with its model." Performance-data collection can help building owners reduce

operating costs, which is especially seductive in recessionary times, allow engineers to revise subsequent energy models for greater accuracy, and validate or disprove the efficacy of existing benchmarks like LEED.

With the U.S. Green Building Council's (USGBC) April 27 implementation of LEED v3, buildings seeking certification must record operational-performance metrics on a regular basis as a minimum requirement. To do so, program participants have three choices: Recertify their buildings on a two-year cycle via LEED for Existing Buildings Operations & Maintenance, submit energy- and water-usage data annually, or authorize the USGBC to access the data from the building's utility provider.


Scot Horst, senior vice president of LEED, says the USGBC is trying to ease this data-recording requirement. Information could flow directly from utility companies into the USGBC's operations-metrics database. Or, for owners of new properties who choose to transition to LEED for Existing Buildings as a building ages and operates, the USGBC will continue its policy of providing free registration.

The LEED v3 operations-metrics requirement is just one of several moves to take the pulse of completed sustainable buildings. In June, at its conference in Louisville, Kentucky, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) unveiled its Building Energy Quotient program, or Building EQ. Focusing solely

data, you have to collect energy bills for the building, and to get an operational rating through Building EQ, ASHRAE is promulgating precisely the same thing." That these systems—in addition to other efforts like the EPA's 17-year-old voluntary program Energy Star, which requires participating buildings to report performance—complement one another makes choosing a program contingent on "the statement you're trying to make." A building could just as swiftly apply for all badges of merit.

Will, in fact, buildings hop on the bandwagon? Some observers say that client confidentiality may prevent buildings from abiding by the new LEED reporting requirement, for example. (Refusal to report data would be cause for revocation of certification.) Yet Horst says the USGBC honors confidentiality, and that most participants in the program thrive on elevated standards like this. As of early August, 688 projects have registered under LEED v3.

Soon, though, participation may not be entirely of a building owner's choosing. Obligatory operations-metrics reporting standards are being implemented throughout the country: In California, Bill No. 1103 requires utility companies to maintain energy consumption data for all nonresidential buildings in a format that's compatible with Energy Star; in Washington, D.C., under the Clean and Affordable Energy Act, the Office of Property Management is tracking all District-owned buildings, next year phasing in commercial buildings, with the District Department of the Environment charged as the repository of those statistics. And should the American Clean Energy and Security Act of 2009 pass the Senate and become law, Section 204, the Building Energy Performance Labeling Program, empowers the EPA to establish a nationwide reporting standard.

This critical mass of interest and obligation may yield more profound consequences. Jean Lupinacci, chief of the Energy Star commercial and industrial branch, says, "While the actual knowledge of energy performance should be as easy and low-cost as possible to get, that information can motivate real action and improvement." In a kind of feedback loop, rising standards would increase the Department of Energy's statistical baseline, which would, in turn, create even more stringent benchmarks in programs like Energy Star. And Horst says that growing comfort with these measures could pave the way for establishing new performance-metrics requirements in sustainable-design categories like indoor-air quality, access to public transportation, and stormwater runoff. 

OBLIGATORY OPERATIONS-METRICS REPORTING STANDARDS ARE BEING IMPLEMENTED THROUGHOUT THE COUNTRY.

on energy use, ASHRAE's labeling program offers an "asset rating" (based on simulations) to new commercial and institutional buildings, and an "operation rating" (based on utility bills) upon one year of data collection at those properties. That effort, too, stresses ease of use. "Once the normalization procedures are established, a lot of this can be automated," concurs Jarnagin, who chairs the committee developing Building EQ.

Jarnagin further notes the potential synchronicity of Building EQ and LEED v3's operations-metrics requirement. Building EQ "could be deemed to meet one of the three [data-collection] methods already established," he says. "You have to collect energy-use

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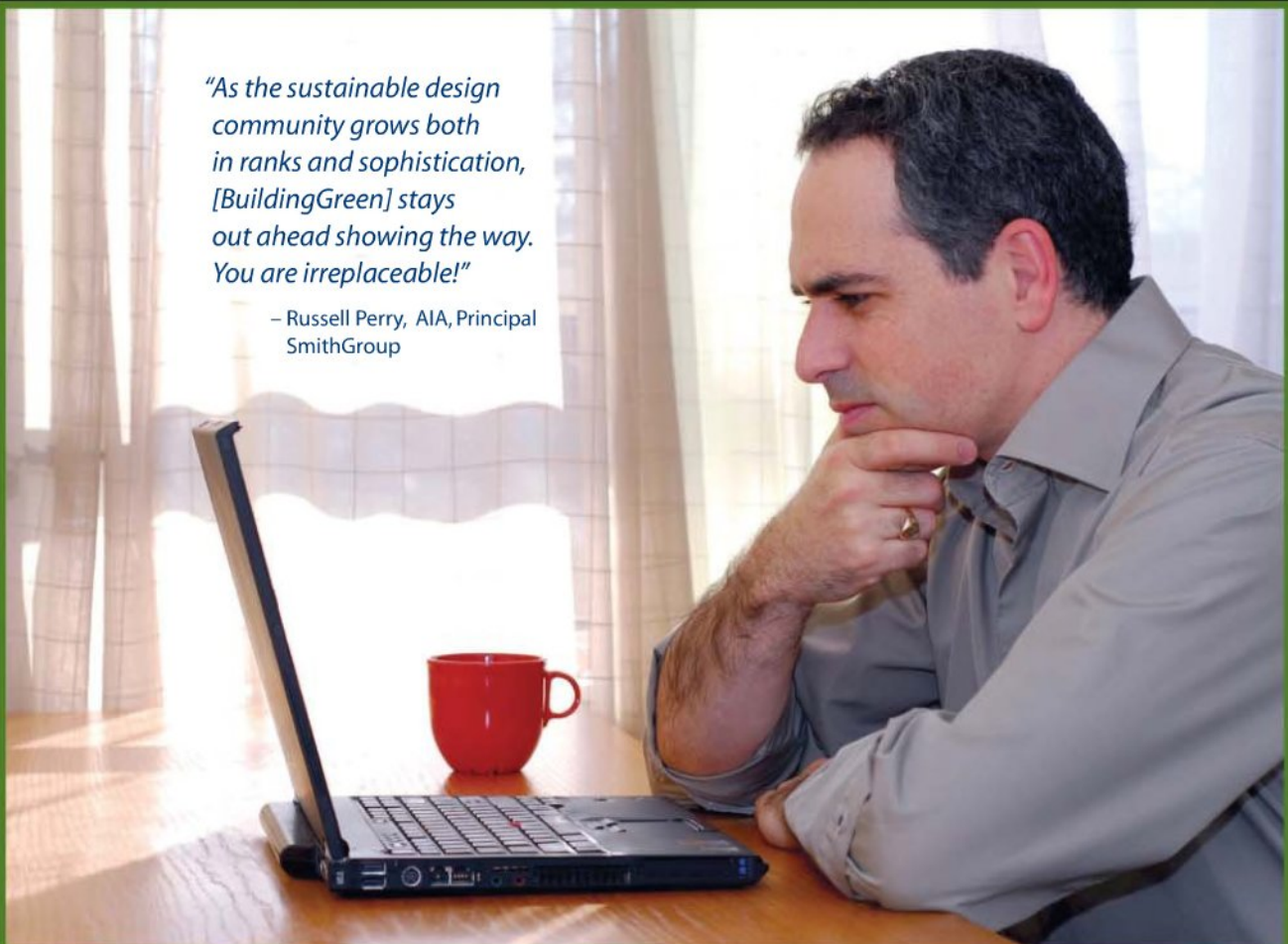
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The Second Time Around

Congress's stamp of approval for the sustainable retrofit of buildings bears good tidings for green-collar jobs.

In his July 11 weekly radio address, President Obama observed that the \$787-billion American Recovery and Reinvestment Act (ARRA) was already energizing the green economy—citing the 3,000 people who will build a California solar plant and the 2,600 Michigan jobs spawned by investment in wind turbines.

In addition to opening new taps of renewable energy, the Recovery Act is supporting green retrofits. Here, too, some spending has been immediate. The \$4.5 billion intended for the General Services Administration to convert facilities to high-performance green buildings was allocated entirely to shovel-ready projects, for example.

Further down the road, funds dedicated to residential weatherization projects should save a family \$344 per year on average, according to Jason Hartke, U.S. Green Building Council's director of advocacy and public policy. "For a long time we've seen a focus on greening new construction," he says. "Now we're seeing greening existing building stock. There is a lot of bang for your buck."

The American Clean Energy and Security Act of 2009 (ACES, or the Waxman-Markey bill) is taking an even longer view, looking beyond the Recovery Act's two-year lifespan and potentially concretizing the push toward a green economy. Multiple components of ACES, which the House of Representatives passed in late June, authorize funds from cap-and-trade allowances for job training and green business grants. According to a National Wildlife Fund report that predated House passage of ACES, the program could spur 250,000 new jobs overall by 2020.

ACES also highlights this new emphasis on old buildings. Section 202, known as the Retrofit for Energy and Environmental Performance, or REEP, supports large-scale retrofitting of residential as well as commercial and institutional buildings through incentives that include interest rate subsidies and capital for revolving loan funds. Hartke says, "It will translate to billions of dollars for energy efficiency in buildings."



IN ADDITION
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GREEN
RETROFITS.

Jason Walsh, national policy director of Green for All, agrees that REEP could be a boon for the building-retrofit private market. "Most of the job creation is going to be within existing building trades occupations," he posits. "Think labor metalworkers, electricians, pipe fitters. Most of these jobs do not require a four-year college degree. And because of that they are more accessible to low-income folks, with the proper training and support." Moreover, Section 202 stands to benefit large energy-service companies like Johnson Controls and Honeywell, as well as more local entrepreneurs who specialize in smaller buildings and residences.

ACES is not a done deal. As of press time the bill had not gone to the Senate, and the slim margin it won in the House suggests a tough fight ahead. Yet most Senators' disagreement with ACES concerns the calculus of cap-and-trade, not REEP: Just as REEP cuts across demographics and geography, it appeals to myriad constituencies. So even if ACES doesn't get signed into law, some version of REEP may be introduced separately. Indeed, observers note that community colleges' green-economy programs already are expanding as a result of the federal stimulus and whatever more permanent incarnation follows it. **GS**



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Stable-Wedge Theory

Robert Socolow is a professor of mechanical and aerospace engineering and the co-director of the Carbon Mitigation Initiative at Princeton University. Originally a theoretical physicist, he now devotes his time to studying global carbon management and fossil-carbon sequestration. Socolow recently spoke with contributing editor Charles Linn, FAIA, about his influential stabilization wedge idea and the role architects can play in decreasing carbon emissions.



GREENSOURCE: What inspired you to study the viability of reducing carbon emissions on a global scale? **ROBERT SOCLOW:** We have a long-term challenge, which I call fitting on the planet. There are many of us, and we want to live well but we don't fit. Even after we stabilize the world population, we will be pressing against global limits in the atmosphere, absorptive capacity for carbon dioxide, fossil-fuel resources, water, and land. We live on a single planet; everybody's carbon emissions get stirred together to give you a single rising number.

Can you explain the main concepts from your paper entitled "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies"? When Stephen Pacala and I developed this idea in 2004, the world was putting 25 billion tons of carbon dioxide into the atmosphere every year (right now it's 30 billion). At this rate, we estimated that the number would rise to 50 billion tons per year by 2055. We sought to understand

As the world continues to emit carbon into the atmosphere at a dizzying rate, Robert Socolow advocates using a variety of new technologies that will curb future emissions.

 For charts on the wedge theory and a more extended interview, go to greensourcemag.com

how the world could keep this from happening, so we decided to cut the problem into wedges. Each wedge corresponds to an environmental strategy that would stop the world from emitting 4 billion tons of carbon dioxide on a yearly basis. For example, building one million 2 mW windmills instead of coal plants between now and 2055 would reduce global emissions by 4 billion tons of carbon dioxide per year. You need about eight of these wedges to get the job done, and this aggregate of solutions has the potential to take care of our planetary problems.

How does architecture fit into the wedge theory? If electricity use in buildings is reduced by one-fourth using advanced lighting, improved air conditioning and appliances, and cogeneration systems that integrate heat and electricity in building structures, you would have a wedge. If the energy efficiency in

 ENERGY EFFICIENCY IS THE MOST ADDRESS CLIMATE CHANGE.

buildings isn't measured, it isn't going to happen. We must start with the goal of improved performance and the expectation that we don't exactly know how to do it. If we spend the time and money researching and learning, then we will see much deeper reductions in energy use in buildings. I started this initiative in the 1970s, and there is still not as much progress as I would have hoped.

In your view, what can architects do in order to mitigate the effect of carbon on the environment? Most architects consider my stance a performance-oriented view of building design. Another view of architecture focuses on what the building looks like, its historical references, and how people use it, but not the resources that go into it. Every building is a resource-consuming machine, and many architects put that issue into a subordinate category. Energy efficiency is the most benign way to address climate change; the alternative is to generate more energy, but every energy source has its dark side. Architects can work with policy-makers to create strong incentives to achieve energy efficiency. The world will be well served if the next generation of architects creatively addresses these environmental challenges. 

Edited by Mae Ryan

Only 600 feet wide, this tiny Alaskan island is populated with 70 homes, most of which have no running water and rest above the permafrost on short stilts. The fate of Kivalina may be a preview of the lasting effects of global warming.



Vanishing Village

As the shores of Kivalina, Alaska, disappear at an alarming rate, residents decide to speak up.



On February 26, 2008 a small Alaskan town eighty miles north of the Arctic Circle took a bold move against global warming; they sued Exxon, Shell, BP, ConocoPhillips, and twenty other big-name energy companies for environmental damage. Home to just under 400 native Inupiat, Kivalina has been rapidly losing its shoreline to the Arctic Sea. Residents continue to put 2,500-pound sandbags in the \$3 million seawall, shown in the adjacent photo, but their efforts have failed to mitigate the effects of severe winter and fall storms.

Residents claim that major energy companies have expedited the degradation of their land by contributing greenhouse gases to the atmosphere, which have increased the frequency and intensity of nearby sea storms and melted permafrost that usually protects the shoreline. The plaintiffs also claim that these big-name companies knowingly deceived the public about the effects of global warming. No matter what the outcome of the lawsuit is, it's clear that Kivalina residents will have to relocate soon. The U.S. Army Corps of Engineers estimates that moving residents to another location and creating new infrastructure will cost \$250-400 million. **GS**



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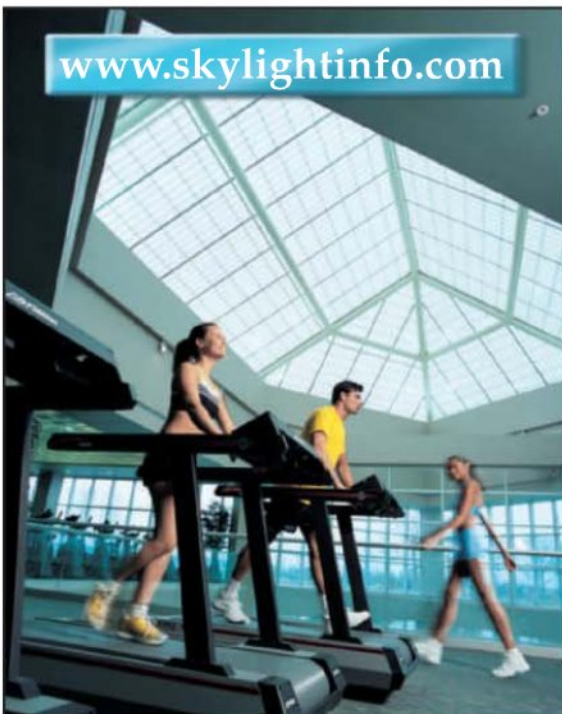
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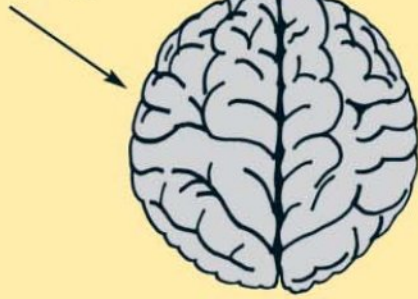
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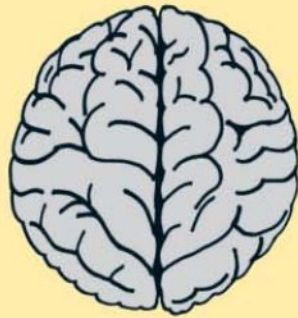
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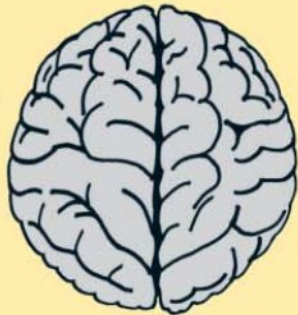
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9:33 AM Page 1

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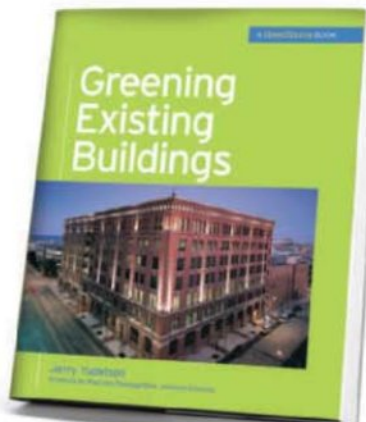
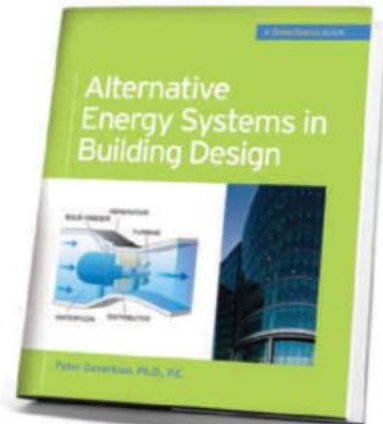
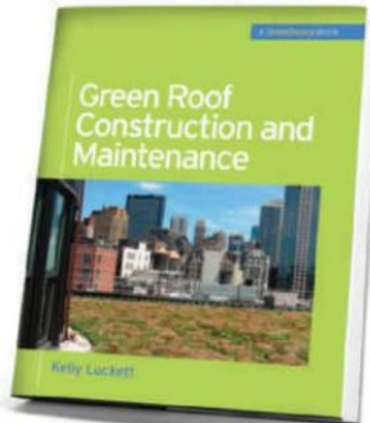


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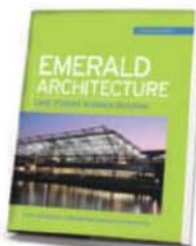
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CIRCLE 43



Letter from
KIMBERLY LEWIS



I've always loved autumn—the colors, the cooler air, football, the beginning of the holiday season... But since 2002, autumn has meant something else to the green building community, and I'm thrilled that it's that time of year again: time for me to invite you to join us in Phoenix for the U.S. Green Building Council's 2009 Greenbuild International Conference and Expo.

Many of you have been with us at Greenbuild for several years, and you know how tremendous and exciting its growth has been. We started Greenbuild with slightly more than 4,000 attendees in Austin, Texas, in November 2002. Last year, we had almost 30,000 people with us in Boston: more than 600% growth in just six years! This is proof that you are part of the community that is truly revolutionizing the way we see things, the community that will make our future better for everyone.

You can see this shift reflected in our Greenbuild theme this year: "Main Street Green: Connect to the Conversation." Last year, we were focused on "Revolutionary Green"—the innovations, the changes in the public's consciousness, the revolution that we needed to win in order to make the next big leap in our goal of market transformation. This year, we've made so much progress as a community that we are ready to step it up: Green building and a larger green agenda can and must come home to all people, where they live, Main Street America and main streets across the globe. That means in every small town and big city, everywhere around the world, people can and must be connected to the important conversations we are having about building economic, environmental and social sustainability into the very fabric of our communities.

And this year's program is certain to ratchet that conversation up a few notches. I couldn't be more excited about this year's keynote speaker. Former Vice President Al Gore's pioneering work in politics, on the lecture circuit and in film has been a major force in bringing climate change to the forefront of global consciousness. Add to that a remarkable list of world-renowned master speakers, more than 150 educational sessions, and special events such as the Greenbuild Residential Summit and the World Green Building Council International Congress, and you are certain to leave Greenbuild ready to tackle humankind's biggest challenges right in your neighborhood.

Greenbuild is many things to many people: It's a chance to network, to meet new clients and customers, to learn from your colleagues as well as your competition. It's the year's biggest collection of professional development and educational opportunities for professionals at all stages of their careers. And it's a blast! This year, you'll see a lot of big changes at Greenbuild that reflect the dramatic growth of this industry, from the largest expo floor yet to an Opening Keynote & Celebration that features a concert by nine-time Grammy winner Sheryl Crow. But you'll also see that a lot has stayed the same. Greenbuild is still all about the green building community—it's about the inspiring stories, innovative ideas and boundless energy we share every year at Greenbuild. I look forward to seeing you there!

Kimberly Lewis
Vice President, Conferences & Events
U.S. Green Building Council

FORMER VICE PRESIDENT **AL GORE** TO KEYNOTE GREENBUILD PHOENIX



Nobel Laureate, best-selling author, and the subject of an Oscar-winning documentary, the Honorable **Al Gore** will address thousands of Greenbuild attendees at Chase Field, home of the Arizona Diamondbacks, as part of the Greenbuild Opening Keynote & Celebration on the night of **Wednesday, November 11**. Featuring an opening plenary address by USGBC President, CEO and Founding Chair Rick Fedrizzi and a closing concert with nine-time Grammy winner Sheryl Crow, the new event combines the opening plenary presentation and the annual closing gala into one conference-wide celebration open to all full conference attendees.

CONNECT TO THE CONVERSATION

Greenbuild is the place to be for anyone involved in the green building movement. Almost **30,000 ATTENDEES IN 2008** make it the biggest gathering of green building professionals and businesses in the world.

6 REASONS TO ATTEND GREENBUILD 2009

1 THE ECONOMY

From Main Street to Wall Street, families and businesses alike are looking for ways to live and do business in a more economically sustainable way. Green building offers many opportunities for driving an economic recovery—from family budgets to the global marketplace. Green building is a vibrant part of our economy, expected to contribute \$554 billion to the U.S. GDP from 2009-2013. Professionals and businesses alike need to be actively engaged now to grab their place in this new green economy. Greenbuild connects you to the conversations you need to drive your own green economic recovery:

- **Forums for networking** with potential new customers, clients, employers and partners.
- The first-ever **Greenbuild job fair**.
- **Top-notch education from USGBC** to help you grow as a green building professional, build the knowledge you need to earn your LEED professional credentials, and earn credit toward LEED credentialing maintenance.

2 THE LOCATION

The American Southwest is a unique region with unique environmental and social challenges and opportunities, and Phoenix is full of examples of green building leadership and innovation. The Phoenix metropolitan area is one the nation's fastest-growing, a city that represents the kind of place more and more Americans are calling home. As a Greenbuild attendee, you can see the best Phoenix has to offer by joining us on a number of green building tours.

Arizona is also a state rich in stunning natural surroundings and famous for its warm weather in November. With unique family programming for significant others and children, you can make your trip to Greenbuild a family vacation.

3 THE PROGRAMMING

The diverse slate of speakers and presenters offering educational sessions at Greenbuild 2009 have found some very creative ways to address the theme "Main Street Green: Connect to the Conversation." The more than 150 sessions at Greenbuild will help you learn how to connect with potential customers and clients and have the conversations that will turn into business. And you can find the sessions most relevant to your market sector at www.greenbuildexpo.org/market-sector.

In addition to the educational sessions, you will enjoy hearing from an impressive group of inspiring master speakers and keynote guests. This year's keynote is **The Honorable Al Gore**, former U.S. Vice President.

4 THE EXPO FLOOR

The world's largest expo hall devoted to green building is bigger than ever this year: more than 1,800 exhibit booths from more than 1,000 exhibitors. Full-conference attendees and single-day attendees have unlimited access to the floor. Special rates are also available if you only want to visit the expo. And conference attendees' paying guests can also visit the exhibit floor. Learn more at www.greenbuildexpo.org/expo.

5 THE SPECIAL EVENTS

The expo floor, the opening and closing plenary events, the educational sessions—Greenbuild really is about bringing together all the diverse and essential pieces of the green building movement. But in addition, Greenbuild offers several special events with a targeted focus:

- **The Greenbuild 2009 Residential Summit** is a multi-day summit featuring educational tracks specifically focused on the green residential market. This year's opening general session, "Greening Our New Housing Stock: A Discussion Across Multiple Sectors," will feature KB Home CEO Jeff Mezger, Bensonwood Homes company steward Tedd Benson, UDR, Inc. President & CEO Thomas Toomey, and "Renovation Nation" host Steve Thomas. Learn more at www.greenbuildexpo.org/residential-summit.

- **The World Green Building Council International Congress** will allow you to interact with international experts in sustainable development who will showcase projects from both developed and developing countries focusing on disaster recovery, existing building retrofits, neighborhood development and policy. Learn more at www.greenbuildexpo.org/international-congress.

- You can catch a few movies with the **Greenbuild Film Festival** and a special IMAX presentation of "Grand Canyon Adventure: River at Risk."

- Participate in intimate, interactive conversations with cutting-edge speakers discussing the intersection of art, technology and sustainability at the **Greenbuild Salons**, Greenbuild's own version of the Actor's Studio. Learn more at www.greenbuildexpo.org/greenbuild-salons.

- Noted environmental activist and nine-time Grammy winner **Sheryl Crow** will cap off the Opening Keynote & Celebration and kick off Greenbuild with lots of fun and great music.



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THE WORLD'S LARGEST EXPO HALL devoted to green building is bigger than ever this year: more than **1,800 EXHIBIT BOOTHS** from more than **1,000 EXHIBITORS**.

6 THE BUZZ

Every year, Greenbuild is the place to be for anyone and everyone involved in the green building movement. The number of people at Greenbuild grows every year—almost 30,000 in 2008—and attendees are part of the biggest gathering of green building professionals and businesses in the world. From students to seasoned pros, everyone who attends Greenbuild leaves with a renewed sense of purpose, new ideas and excitement.



Learn more about Greenbuild and register today at www.greenbuildexpo.org



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architecture schools in North America and around the world have been teaching sustainable practices for decades, while others have neglected the field altogether. By now, most green practitioners are familiar with the “2030 Challenge,” developed and promoted by architect/activist Edward Mazria. This challenge, adopted by the American Institute of Architects, the U.S. Green Building Council, and many other groups, is to reach carbon neutrality—using no fossil-fuel greenhouse gas-emitting energy to operate buildings—by the year 2030. Possibly less familiar is the companion “2010 Imperative,” to achieve “complete ecological literacy in design education” by next year. Authors of the imperative believe such a crash course is needed to produce the next generation of architects capable of rising to the challenge. While most educators are struggling to incorporate sustainable design into the curriculum, some schools are way ahead of the game.

In the 1960s, interest in passive solar heating, cooling by natural ventilation, and daylighting took root thanks to pioneers such as John Reynolds at the University of Oregon and the late Jeffrey Cook at Arizona State University. They inspired several generations of students, dozens of whom now teach sustainability-in-design programs.

The issues broadened in the 1980s. Indoor-air quality, water management, and construction waste reduction were added to the curriculum. Added, that is, at a few schools. Then, as now, such curriculum changes depended on local champions, and this gradual evolution has depended on individuals’ willingness to compete for space in a crowded course catalogue. Individuals also fought for scarce funding and developed research institutes, such as the respected Center for Building Performance and Diagnostics (CBPD) in the School of Architecture at Carnegie Mellon University. There, Volker Hartkopf, Vivian Loftness, FAIA, and others conduct research in the evaluation and

improvement of high-performance buildings and healthy workplaces.

During this time, another important transformation took place as sustainability issues found their way into design studios, the core of architectural education. The once-prevailing attitude that energy had no place in design has gradually faded as more professors understand the importance of sustainability and integrated design in shaping buildings.

state of the schools

Now, about half the accredited members of the Association of Collegiate Schools of Architecture (ACSA) have “environment/sustainability” as a specialization, though with a great deal of variation. Some schools, for instance, include sustainability only in introductory environmental controls lecture courses; others offer advanced seminars in daylighting, passive heating and cooling, sustainable materials, and integrated design. There is little effort to achieve nationwide uniformity. The organization responsible for maintaining academic standards, the

National Architectural Accrediting Board (NAAB), keeps its requirements deliberately broad. The 2004 version of its accreditation requirement states that graduating students must demonstrate an “understanding of the principles of sustainability in making architecture and urban design decisions that conserve natural and built resources, including culturally important buildings and sites, and in the creation of healthful buildings and communities.” According to Lee Waldrep, NAAB’s associate executive director, a school could satisfy this minimum requirement of “understanding” with a course, through a lecture series, or in some other way. He says: “Accreditation tells the schools what to teach, but not how to teach it.”

The USGBC is actively encouraging universities to share their curriculum success stories. The council publishes green-education best practices and organizes conferences for educators. The USGBC also offers recognition awards and incentive grants for “replicable pedagogical efforts.”

In 2006, the AIA’s Committee on the Environment (COTE) sponsored a report on the state of green education. Written by Kira Gould, associate AIA, and Lance Hosey, AIA, “Ecology and Design: Ecological Literacy in Architecture Education” presented a survey of North American schools. The report also proposed greater cooperation between academia and the profession. Although awareness of climate change has mushroomed since the report came out, the work still represents the variety of activities in architecture schools. These include not only courses and design studios but student-run conferences, collaboration with regional research centers, work toward greening campuses, community outreach, and educator networks. Author Gould notes: “Some schools have been better than



others about embedding social issues in green design. Some feel that just taking on the environmental part is hard enough. But for those really redesigning their curriculum, we recommend trying to see this as holistically as possible.”

Ironically, some of the most explicitly sustainability-related programs in the country are not accredited. These include the Ecosa Institute and the San Francisco Institute of Architecture. The Boston Architecture College (BAC), which is accredited, offers a Sustainable Design Certificate that is separate from the college's more traditional degree programs. This

relatively new program, conducted online only, is available for architects interested in continuing their education who don't need or want another professional degree, for anyone in the construction industry interested in learning more about sustainability, and for newcomers hoping to break into the industry. The BAC's program, developed in conjunction with BuildingGreen LLC, offers over a dozen courses, soon to double in number. A list of topics reveals a growing awareness of the issues emphasized by the USGBC's LEED program and the 2030 Challenge: “Building Envelope,” “Materials, Resources,

The once-prevailing attitude that energy had no place in design has gradually faded as more professors understand the importance of sustainability and integrated design in shaping buildings.

and Indoor Environmental Quality,” “Site Design, Landscaping, and Site-Water Issues,” “The Zero-Energy Home,” and “Sustainable Design as a Way of Thinking.”

The BAC is also collaborating with the engineering school at nearby Tufts University to send “Team Boston” to the fourth Solar Decathlon in the fall of 2009. The BAC's Director of Sustainable Design, Lance Fletcher, AIA, explains: “Architects and engineers tend to be trained separately, but a key ingredient of anything that purports to be sustainable design is integrated design. It's great that these students have been working together from the outset.”

sustainable design/build

The Solar Decathlon is sponsored by the U.S. Department of Energy to promote the benefits of energy efficiency, renewable energy, and other green building technologies. Participating schools send student teams to Washington, D.C. to reassemble houses they have designed and built over the previous year. The houses are graded on performance in 10 areas, and the hands-on learning is reportedly a “peak experience” in a student's education. Nevertheless, the event has its critics. Construction and transportation are expensive; there is more emphasis on photovoltaics than passive design; and the mild October days in Washington do not test the extremes of whichever climate the team hails from.

HANDS-ON TEACHING

- 1 Peter Kitchen and Connor O'Grady use a smokebox to test airflow through a space at the University of Waterloo.
- 2 Dan Rockhill's Studio 804, University of Kansas, is currently building a residence with reclaimed lumber that aims to achieve LEED Platinum.
- 3 Led by John Quale, University of Virginia's (UVA) 2002 Solar Decathlon team won first prize in design and second prize in overall energy efficiency.
- 4 Students pictured here are working on ecoMOD4 at UVA, a project started by John Quale that creates sustainable and affordable housing units.
- 5 In 2008 Studio 804 built the 5.4.7 Arts Center in tornado devastated Greensburg, Kansas. It is the first LEED Platinum building in the state.

To watch a video about one team preparing for the Solar Decathlon, go to greensourcemag.com



Former decathlon faculty sponsor John Quale, of the University of Virginia, recalls: "We spent \$350,000-400,000 on a 750-square-foot house. It was an amazing experience, but it felt wrong to be putting so much effort into something that couldn't be replicated affordably." Since then, Quale and his students have engaged in other design/build projects, dubbed ecoMOD. Their goals, in addition to giving students the intensely instructive experience of designing something they actually build, are sustainability and affordability in modular designs that manufactured housing companies can replicate realistically. EcoMOD4 is in construction during the summer of 2009, and Habitat for Humanity of Greater Charlottesville is considering construction based on the ecoMOD3 prototype.

Compared to design-only studios, Quale thinks design/build gives the students an opportunity to take their intentions to the next level. "Students today are excited about sustainability, and they want to be sophisticated about this issue once they graduate. But intentions only go so far. You can say, 'I want to use this passive design strategy,' but when you're building something, you have to do the simulation

that proves the strategy makes sense." Importantly, Quale's teaching paradigm is design/build/evaluate, so students monitor performance data in occupied houses and send their drawings to modular builders to assess affordability. In ecoMOD4, they expect to realize zero-net energy, thanks to a geothermal system and photovoltaic panels.

Another of the few sustainable design/build programs in the country is in Lawrence, Kansas. Architecture students work with Professor Dan Rockhill under the umbrella of Studio 804, a nonprofit corporation. Most of their projects are houses and, over the years, have become increasingly green. The 2008 project was the 5.4.7 Art Center for Greensburg, Kansas. The town had been devastated by a tornado on May 4, 2007, and the town leaders had decided to rebuild as the greenest town in the United States. The students achieved LEED Platinum by using recycled timbers, installing a green roof, harnessing the sun and wind for heating and cooling, and more.

Rockhill emphasizes that he's not interested in training students to become builders; he wants this experience to make them better architects by demystifying construction. Even though his students are

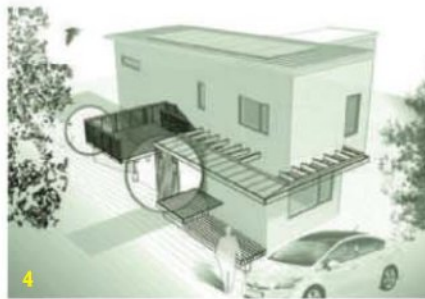
near the end of their schooling, they're constantly surprised, he says, at how little they really know. "The way architects normally teach and practice has been diluted by a detachment from any comfort with building," he remarks. "This experience gives students an opportunity to confront their demons."

Rockhill has always been proud of the design awards his students' work has received, and he believes design excellence has remained high even in buildings that earn LEED certification. This is critical, he says, to show the world that good design and sustainability are not mutually exclusive.

next steps

Some professors teaching sustainability are breaking new ground. One of them is James Wasley, who teaches in the School of Architecture and Urban Planning at the University of Wisconsin-Milwaukee. He has recently tackled carbon-neutral design, which he sees as both a subset and an extension of sustainable design.

"With carbon-neutral design, the conversation is getting more nuanced," Wasley says, "but the fundamentals are the same: efficiently shaping form,



orientation, aperture, envelope, and internal loads.” He suggests the first 80 percent of carbon neutrality is contributed by these factors, which lower the loads to the point where the needed energy can be provided by on-site renewable sources.

Wasley’s students see LEED accreditation as a vital job skill. One way he gives them real-world experience is to have them challenge renovation projects underway within the university system. When there are plans to build or remodel a campus facility, the students conduct analyses and simulations and offer alternate design proposals to show how the project could be greener.

Wasley and colleagues are currently working on a project, sponsored by COTE and the Society of Building Science Educators, to develop and publish a set of carbon-neutrality resources for students, teachers, and practitioners. In the first phase, they’re focusing on the carbon emissions related to building operations. If these emissions can be lowered, they will be reduced for the lifetime of the building. Future research will look at emissions related to the embodied energy, such as that used in manufacturing materials.

the future of change

One obstacle to a quick adoption of sustainability in schools is the lack of teachers. Many of today’s professors were educated before sustainability awareness was common. Those who can teach these subjects are in high demand, according to Alison Kwok, who teaches in the Department of Architecture at the University of Oregon. She examined ACSA-advertised job openings between 2001 and 2009 and found that 60 percent of schools were looking for faculty in the environmental area.

When in graduate school at the University of California at Berkeley, Kwok worked with professor Cris Benton on a project called Vital Signs. They assembled a lending library of equipment—light meters, sensors, data loggers—to analyze physical spaces and conduct post-occupancy evaluations. The packages were loaned out to other architecture schools, along with guidelines for using the instruments to compile instructive case studies.

Kwok took a similar approach with her Agents of Change project, with the goal of “training the trainer.” With funding from the U.S. Department of Education, she

conducted workshops to train faculty and students interested in becoming teachers. A generation of students now has hands-on experience in producing hard data on the results of design decisions. The hands-on work is more effective than lectures and book-learning, she says, because, “it’s more fun, and the ideas stay in your head longer than traditional ways of learning. Also by doing case studies, you create a stronger ‘need to know.’”

In 2003, Margot McDonald, AIA, with colleagues at California Polytechnic State University in San Luis Obispo, proposed a model curriculum for sustainable environmental design education. They advocated fundamental changes to existing professional schools, which now support specialization among faculty. But sustainable design requires interdisciplinary integration and a holistic approach to teaching. How schools take this challenge will, as always, vary nationwide depending on the dedication of individuals. But some change is needed to educate the architects who will make sustainability universal. As Wasley notes: “It seems like it’s now or never.” **GS**

T H E N E C A - I B E W R E P O R T

Leading the Green Revolution

The Green Energy Revolution is fully underway. And leading the charge for American workers are the International Brotherhood of Electrical Workers (IBEW) and the National Electrical Contractors Association (NECA), who together have created the country's largest training program in energy alternatives, comprehensive and poised to keep the nation atop a rapidly greening world.

According to a recent report from the American Solar Energy Society, the renewable energy and energy efficiency industries have already generated 8.5 million U.S. jobs and could grow to as many as 40 million by 2030, encompassing one out of every four workers and producing up to \$4.5 trillion in revenue.

"These new jobs are not just engineering-related, but include millions of jobs in construction and maintenance," says IBEW president Ed Hill. "The Green Revolution of the 21st century is opening a sweeping set of opportunities for

"The United States, once a world leader in renewable energy technology, is slipping behind."

American workers unseen in this country since the Industrial Revolution of the 19th century."

Indeed, a study from the Renewable and Appropriate Energy Laboratory at the University of California, Berkeley, concluded that renewable energy generates "more jobs per megawatt of power installed, per unit of energy produced, and per dollar of investment than the fossil fuel energy-based sector." And despite some job losses in the switchover, the gain for union workers is overall positive, with four jobs created



Wind turbines installed by IBEW Local 48 rise for miles in North Central Oregon.



Solar panels installed by IBEW Local 103 atop the visitor's center on Spectacle Island in Boston Harbor.

for every three lost.

"These green jobs are especially good for American workers because they can't be outsourced," says Hill. "You can't ship an office building overseas to have solar panels installed. The work remains right in our own communities."

And yet, the United States, once a world leader in renewable energy technology, is slipping behind Japan, Germany and Spain in the race to go green. Germany, a country half the size of Texas, today employs more than 40,000 workers in the wind energy industry alone. The American Wind Energy Association estimates that nationwide the U.S. employs only about 20,000 people in wind power -- and that 90 percent of the turbines installed come from overseas.

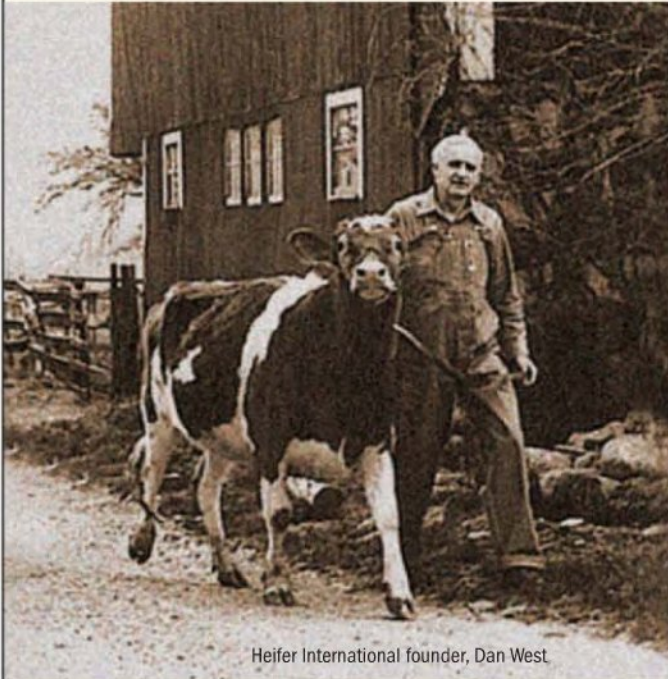
What concerns American businesses and governments is having the right infrastructure in place to train a sufficient number of green workers, to keep pace with the world. Yet, through their National Joint Apprenticeship and Training Committee, NECA and IBEW have found a winning combination to produce the skilled new-energy electricians needed to fill the burgeoning, highly specialized green jobs. Through the advanced course offerings of a nationwide network of state-of-the-art training centers, apprentices and journeymen alike are honing the skills demanded by an ever-changing industry.

Says E. Milner Irvin, president of NECA, "Taking steps now to prepare for the jobs that are coming is critical for future success. But we don't need to reinvent the training wheel. NECA and IBEW have the mechanism in place right now. And knowing where our nation's interests in alternative energies lie, and producing the strongest possible workforce, will keep us all at the head of the line."

For more information, visit thequalityconnection.com and our online video magazine, ElectricTV.net.



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Heifer International founder, Dan West

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CASE STUDIES

CULTURAL AND NATURAL CONTEXT

Each of the buildings represents the integration of the natural and the built environment with varying degrees of connectivity.

The projects featured here occur in places that abound with both culture and nature, and the grace with which they respond to each is key to their architectural and ecological success. **The Laurance S. Rockefeller Preserve [p58]** occupies a site of stunning natural beauty. It has an interesting history, but that history was largely erased from the site in deference to its environmental and recreational significance.

Kroon Hall [p64] sits among Yale University gothic edifices, reinterpreting their form for a new millennium. Nature's presence isn't nearly as strong in this location, yet the building's wooden roof structure and finishes and daylight space celebrate nature nonetheless, with a minimal carbon footprint to boot.

Cavallo Point, The Lodge at the Golden Gate [p70], has a setting that marries both culture and nature. Culture is present in both the elegantly restored military history and in the views across to contemporary San Francisco and its famous bridge. While the site isn't pristine, many of its native plants have been carefully restored, making the most of its almost secluded setting.

Finally, **Founding Farmers Restaurant [p76]** uses decor to showcase the agricultural context of the food, raised and prepared with a sustainable agenda. The eatery is all about connecting diners to the origins of their food, which it does, ironically, in stark contrast to its sleek modern setting.

All these projects are about connecting people to places, which is central to the sustainable design mission even though it is not always discussed explicitly because it is so hard to measure and certify. How we live our lives and operate our buildings is at least as important in terms of ecological impacts as how efficient those buildings are. Fortunately we have projects like these to inspire us to honor that natural connection. —NADAV MALIN

p58



p64



p70



p76



| **CASE STUDY**

| LAURANCE S.
ROCKEFELLER PRESERVE

| By JANE KOLLEENY

Moose, Wyoming



WHERE BUFFALO ROAM

The 10,400-square-foot Laurance S. Rockefeller Visitors Center, part of the Grand Teton National Park, prepares visitors to appreciate the vast natural resources and beauty of the place.

Rockefeller wanted every aspect of the building to reinforce a message of conservation and the restorative power of nature.

For a slide show of additional images, go to greensourcemag.com @

>KEY PARAMETERS

Location Grand Teton National Park, Moose, WY (shoreline of Phelps Lake)

Gross Square Footage 10,400 ft² (966 m²)

Completed November 2007

Annual purchased energy use (from utility bills, facility open seasonally) 11 kBtu/ft² (127 MJ/m²)

Annual carbon footprint 3 lbs. CO₂/ft² (15 kg CO₂/m²)

Program Welcome and orientation areas, staff and resource space, galleries, 3 restroom outbuildings

>TEAM

Owner Grand Teton National Park, Laurance S. Rockefeller Preserve

Architect and interior design Carney Architects

Landscape Hershberger Design

Engineers KL&A (structural); M-E Engineers (MEP); Jorgensen Associates (civil)

Lighting design David Nelson & Associates

Acoustical D.L. Adams Associates

Commissioning agent Engineering Economics

Environmental consultant Pioneer Environmental Services

Sustainability consultant Rocky Mountain Institute (formerly Ensar Group)

General contractor GE Johnson Construction

CASE STUDY

LAURANCE S. ROCKEFELLER PRESERVE



Jackson Hole occupies a 48-mile-long, 13-mile-wide valley between the Teton and Gros Ventre mountain ranges in western Wyoming. In this extravagantly beautiful locale, the jutting peaks of the Grand Tetons tower over glacial lakes, buttes, and the high valley floor. About 97 percent of the land here is federal land, providing domicile for a profusion of native wildlife. While the original preserve consisted of 96,000 acres back in the 1920s, today the Grand Teton National Park includes 310,000 acres of land, portions of it given over in perpetuity by philanthropist John D. Rockefeller, Jr., whose family had summered in Jackson

Hole since the 1920s.

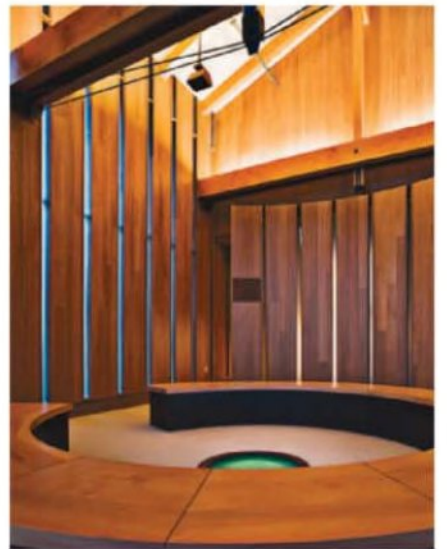
The final chapter in this legacy began in 2001, when Laurance S. Rockefeller, John D. Rockefeller, Jr.'s son, announced his intention to give over a 1,100-acre parcel of land, which had served as the Rockefeller family's retreat, to the Park Service, at his father's behest. The land was conveyed to the National Park Service in 2007, after the visitors center was largely completed. The project's LEED Platinum rating is a first, both for the Park Service and for the state of Wyoming. Opened to the public in 2008, it stands as testimony to the family's long-time stewardship of the land.

The simple program of the Laurance S. Rockefeller (LSR) Interpretative Center consists of a resource center, multimedia

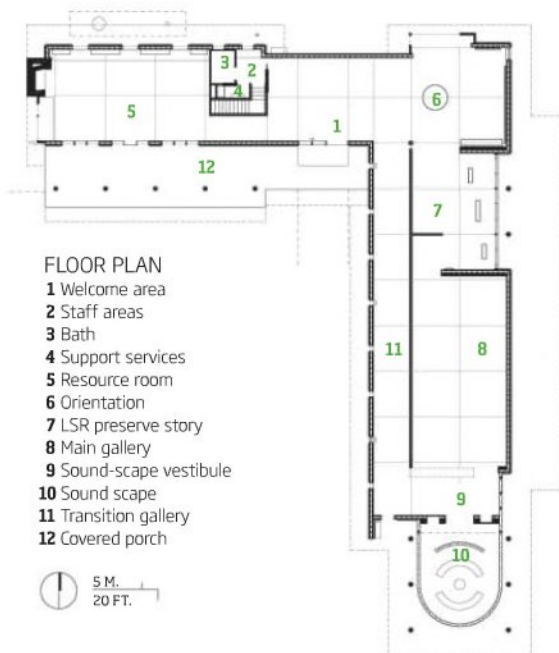
display galleries, and support services in a 7,000-square-foot L-shaped building. The project's modest but elegant exhibitions serve to create an atmosphere for appreciating the vast natural resources and beauty of the property. In addition to the main building, the project includes parking and three restroom outbuildings with composting toilets. A major reclamation effort was undertaken to remove all roads, horse trails, and about 30 buildings that provided accommodation for the Rockefellers at the edge of pristine

Below Carney Architects designed all the furniture in the resource center. Boulders and rocks were assembled from the site and used to design the chimney, while abundant light flows into the space from large operable windows.





NIC LEHOUX, PREVIOUS PAGE; PAUL WARCHOL, THIS PAGE



Phelps Lake, returning it to its original state before occupation. “To minimize impact, the team strove to merge proposed interventions with prior conditions—existing roads became trails and former building sites became lookouts,” explained landscape architect Mark Hershberger.

Though Laurance Rockefeller passed away in 2004 and did not live to see the finished building, he played a significant role in the visioning, planning, and interpreting of the project. He had assembled a board of directors led by Douglas Horne, of D.R. Horne & Company. Horne explained that originally the project was conceived without a building, but once the board decided there would be one, they agreed it “should be an example of sustainability,” in keeping with Rockefeller’s message of stewardship. Still they were not initially committed to LEED certification, only

Left On the entrance side, a wrap-around porch overlooks an aspen grove.

Top right Multimedia displays of the varying sounds of nature and pictures of wildlife occupy the main gallery.

Bottom right Vertical wood slats with gaps between boards bring narrow slits of light into the chapel-like space at the south end of the building.

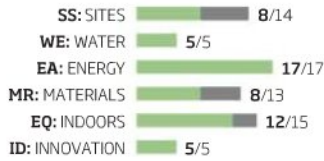
CASE STUDY

LAURANCE S. ROCKEFELLER PRESERVE



LEED SCORES

ROCKEFELLER PRESERVE
NC VERSION 2 PLATINUM

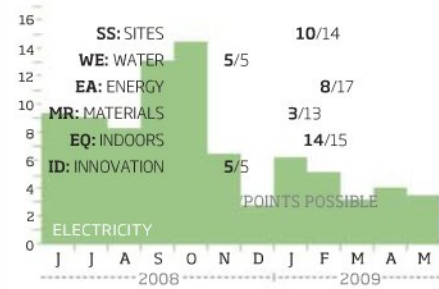


POINTS/POINTS POSSIBLE

ROCKEFELLER monthly energy use

MONTHLY ENERGY USE

MILLION BTUS TOTAL



deciding to go that route in late 2003 to “set a bar for the Park Service and serve as a touchstone for the public,” he continued.

From the get-go, the project team undertook an integrated-delivery model. No one discipline dominated the evolution of design—it had to work in so many ways,” explained Horne. John Carney, FAIA, of Carney Architects served as architect and interior designer. In which team, he said that while “the team rolled its collective eyes at the length to which Horne and the board members went to ensure that we had it right,” in the end the deliberative process and tenacity for perfection was well worth the trouble.

Visitors enter the building from the south. Inside, exhibitions begin at the bend of the L, where visitors are oriented geographically with a 3-D model, photos, and full-scale maps of the property. Progressing through the space, one finds oversized black-and-white historic photos and text telling stories of the history of the site. Multimedia displays, complemented by the poetry of Terry Tempest Williams, guide visitors onward. The building terminates in an apse-like form at its south end. Here, a recorded orchestra of wildlife sounds creates an almost spiritual atmosphere, in keeping

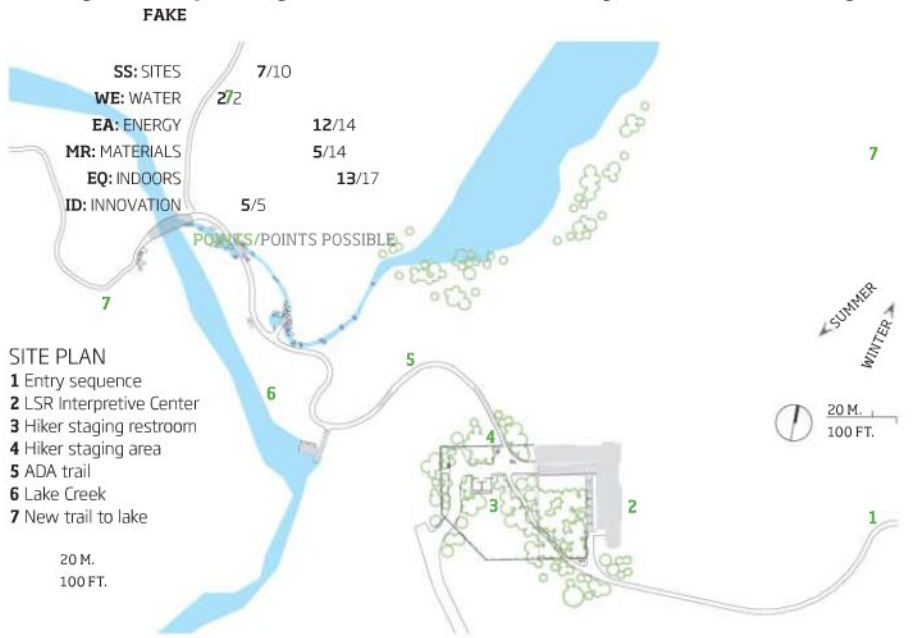
with Laurance Rockefeller’s sensibility.

Since the exhibits are not light-sensitive, daylight is used to illuminate interiors, reducing the need for artificial light. Early in the design process the team undertook daylighting studies, which informed the shape and orientation of the buildings. In the main gallery, clerestory windows and extended overhangs allow daylight in without direct sun. Low-voltage lighting controls, with time clock, daylight, and occupant sensors, optimize energy savings and reduce maintenance. Since the building is closed in winter and only open during the day, there is no site or landscape lighting.

These limited operating hours also made temperature control relatively easy; in fact, completing the maximum number of points for LEED 2.0 energy and atmosphere category was a breeze. The building’s many operable windows provide fresh air and “electronically controlled high windows open at night to allow the building to ‘flush’ out the day’s warm stale air, while bringing in cool fresh air for the next day,” explained project architect Kevin Burke, FAIA, of Carney Architects. A variable-mode mechanical system utilizes a ground source heat pump. A 10 kW photovoltaic system mounted on the restroom buildings is designed to provide 45 percent of the building’s electricity, although efforts are

now underway to investigate recent metering data that indicates far less. According to Burke, the Green-e power agreement with the local utility provides an additional 50 percent; the remaining 5 percent is supplied by nonrenewable power.

So, too, exemplary water conservation is possible in a building with so short a season and with so simple a program. Water in the main building is used for hand-washing and



CASE STUDY 2

KROON HALL, YALE UNIVERSITY

By JOANN GONCHAR, AIA

New Haven, Connecticut



With its rustic stone facades and vaulted roof supported by glue-laminated beams, Kroon Hall, the new home for Yale University's School of Forestry and Environmental Studies, looks a bit like an elegant rendition of a New England barn. But the reference wasn't intentional, insist its architects, London-based Hopkins with the Connecticut firm Centerbrook. Instead, they say, Kroon's cladding and roof form are an interpretation of the campus's gabled stone buildings, while its thin profile and east-west orientation are the result of efforts to minimize heat gain and maximize reliance on the sun for daylighting and energy generation.

But orientation and configuration are just the most fundamental of a host of

>KEY PARAMETERS

Location New Haven, CT (New Haven Harbor, on the northern shore of Long Island Sound)

Gross square footage 66,800 ft² (6,206 m²)

Cost \$33.5 million

Completed May 2009

Annual purchased energy use (based on simulation) 25 kBtu/ft² (227 MJ/m²), 58% reduction from base case

Annual carbon footprint (predicted)

7 lbs. CO₂/ft² (36 kg CO₂/m²)

Program Administration, faculty, and research spaces, library, student learning center, cafe, meeting rooms, student lounge, auditorium, classrooms

>TEAM

Owner Yale University

Architect Hopkins Architects; Centerbrook Architects (architect of record)

Landscape OLIN

Engineers Arup (structural, MEP, lighting, acoustical); Nitsch Engineering (civil)

Environmental consultant Atelier Ten

General contractor Turner Construction Company



VAULTED ROOF, AMBITIOUS GOALS

Yale transforms the site of a defunct powerplant into a low-carbon home for its School of Forestry and Environmental Studies.

Kroon's sandstone cladding and vaulted roof reinterpret the university's neo-Gothic architecture.

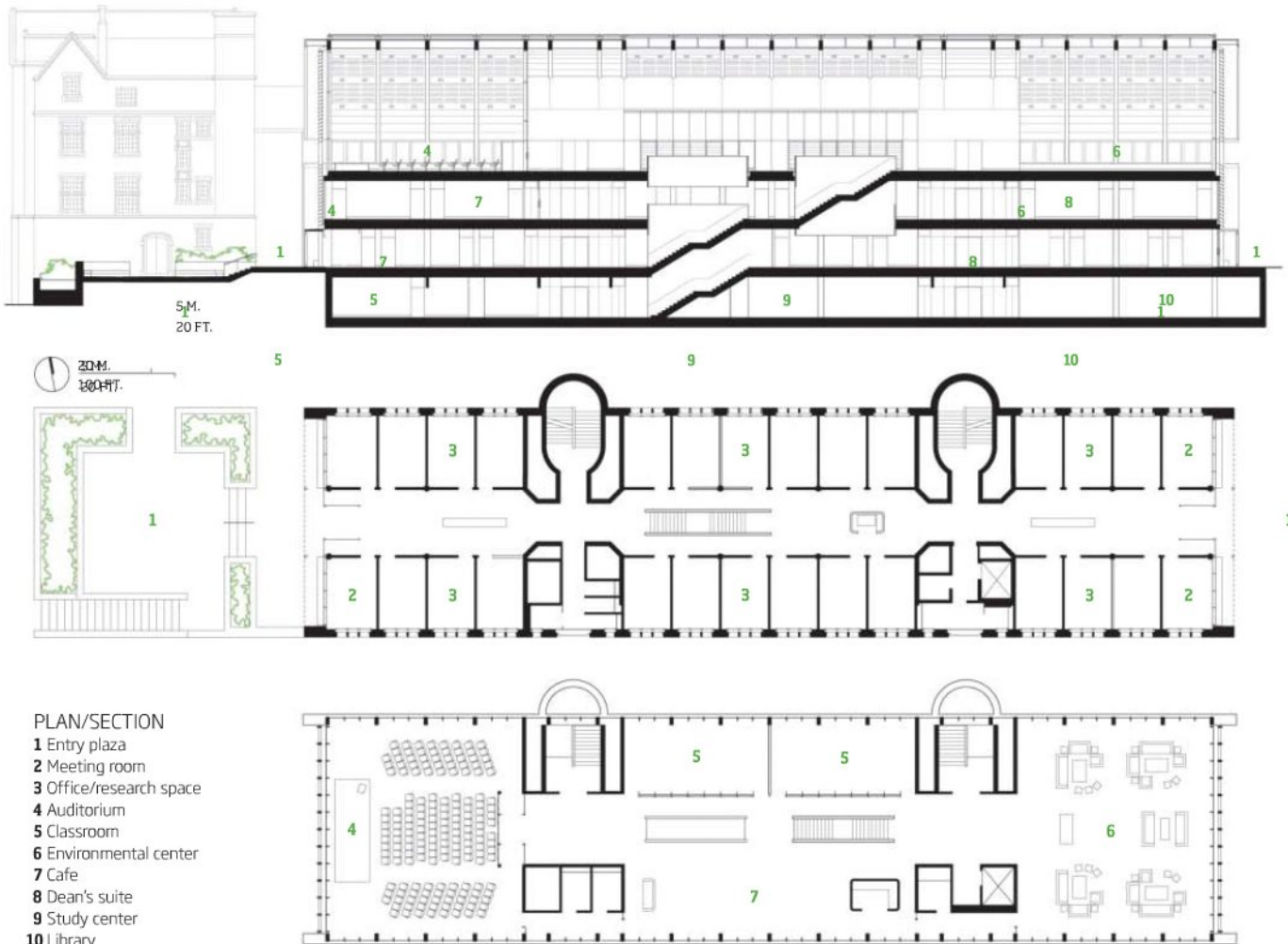
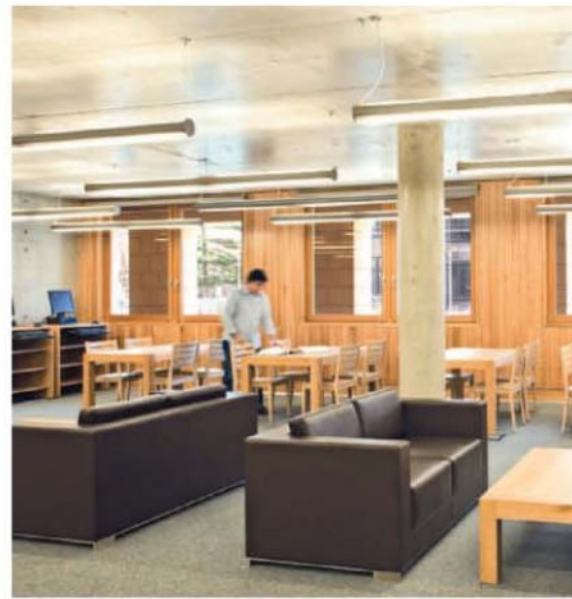


tightly integrated features that make Kroon Yale's greenest facility to date. Taking into account on-site renewable energy generation, the 67,000-square-foot academic building is projected to consume 58 percent less energy than a code-compliant building of similar size and use, according to its project team. The addition of purchased green power allows Kroon, which opened this past spring, to claim carbon-neutral status. The building is on track to become Yale's second LEED Platinum project, following completion of a studio facility for the graduate sculpture program two years ago (*GreenSource*, July 2008, page 76). Ambitious construction projects like these, along with campus-wide conservation efforts and renewable energy initiatives, will be key to helping the

university meet its goal to reduce greenhouse-gas emissions 10 percent below 1990 levels by 2020.

Kroon is organized around a slot-like stair that cuts through a narrow, skylit atrium, and provides a route from a lower-level library and learning center through two levels of offices to more social functions on the top floor. Here, under the vaulted roof are classrooms and a cafe between an auditorium at one end and an environmental center at the other. This center functions like a "big living room," says Mark Simon, FAIA, a Centerbrook partner. Sun filters in through the glazed and louvered eastern facade as students study in groups around tables or sit in overstuffed chairs with their laptops.

To achieve Kroon's high level of perfor-





Left In much of Kroon, including the learning center, the concrete structure is left exposed to take advantage of its thermal mass. The strategy is expected to drive consumption below that indicated by the energy model.

Below A slot-like stair cuts through a narrow, skylit atrium, providing Kroon's main organizing element.

mance, the project team didn't rely on any one strategy or technology. "We took a multi-headed approach," says Mike Taylor, a Hopkins director. In addition to optimizing its solar orientation, Kroon's basic scheme includes a highly insulated envelope, a concrete structure largely exposed on the interior to take advantage of its thermal mass and a raised-floor ventilation system, says Paul Stoller, a director in the New York City office of Atelier Ten, the project's environmental consultant.

Interior climate control is provided via super-efficient air-handling units that recover heat from exhaust air in the winter. During the summer, the units spray water on the return air stream, transferring the resulting "coolth" to the incoming air, explains London-based Dave Richards, a

director of Arup, which provided multi-disciplinary engineering on the project. Even in New Haven's humidity, this indirect evaporative cooling allows the introduction of a large volume of outdoor air, ensuring excellent indoor-air quality, but without consuming huge amounts of energy.

On the hottest days of the year, a geothermal heat pump system provides additional cooling. On mild days, Kroon operates in natural ventilation mode, and occupants are prompted to open windows by a color-coded notification system.

A 100-kW rooftop photovoltaic (PV) array is designed to satisfy about 23 percent of Kroon's annual energy needs. For the remaining site energy needs, about 415,000 kWh per year, the project team evaluated on-site renewable generation options, but found none to be practical within site and budget constraints. For example, enough additional PV capacity to allow the building to operate completely off-the-grid would have required an array the size of a soccer field, says Taylor. The designers also explored adding PVs to the south facade. "But they would have had limited production capacity and would have been challenging to incorporate in an architecturally satisfying way," says Stoller. The team did decide to include solar-thermal panels in the south elevation to heat the water supplied to sinks and showers, but opted to purchase renewable energy certificates for the rest of the building's power needs.

The new forestry building isn't only notable for its energy-saving features. Kroon is also an important component of a masterplan that aims to remake the part of campus known as Science Hill into an area that would be more sustainable and people friendly. The 3-acre plot where Kroon now sits was a prime candidate for such a transformation. The site, bounded by two L-shaped neo-Gothic academic buildings, was home to a long-defunct gas-fired powerplant and oddly shaped leftover lots used for surface parking. The project team forged an inviting series of outdoor spaces from this neglected parcel by inserting the long and thin Kroon between the two older buildings. The new and existing structures





KROON PRECIPITATION ROUGH
KROON PRECIPITATION ROUGH

INCHES/MILLIMETERS
INCHES/MILLIMETERS



KROON temperature ROUGH
KROON temperature ROUGH

FAHRENHEIT/CELCIUS
FAHRENHEIT/CELCIUS



KROON PRECIPITATION ROUGH
KROON PRECIPITATION ROUGH

INCHES/MILLIMETERS
The top floor contains several spaces for social interaction sheltered by the building's glue-laminated-beam soaring roof. Opposite Red oak paneling is found throughout the building, even in classrooms. About half this wood was obtained from Yale's own sustainably managed forest.

define a pair of grassy courtyards, both of which have a visual connection to Sachem's Wood—a green space to the east of Kroon, where its geothermal wells are buried. The

new southern courtyard is essentially a ground-level green roof built atop loading docks and utilities serving Kroon and the entire southwestern corner of Science Hill. These new green spaces play an integral role in Kroon's water conservation and stormwater-mitigation strategies.

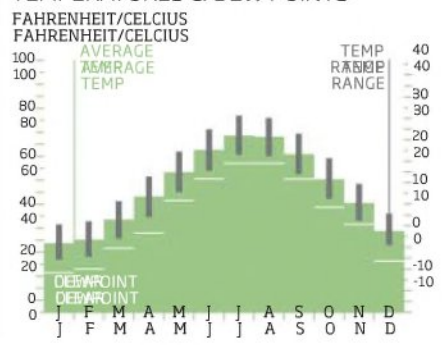
An underground tank below the service courtyard collects runoff from the southern part of the site and slowly discharges it, lessening the burden on New Haven's combined sewer system. From the roof and

the northern part of the site, a rainwater-harvesting system collects runoff and channels it to a pond at the border between the southern courtyard and Sachem's Wood. Here, native wetland plants such as cattail, iris, and lotus remove impurities, including nitrogen, phosphates, and particulates, before the water is directed for use either in irrigation or toilet flushing.

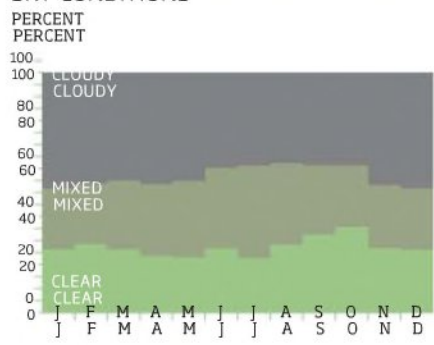
The design team estimates that these measures, in combination with water-conserving plumbing fixtures, will result in

KROON temperature ROUGH
KROON temperature ROUGH

TEMPERATURES & DEW POINTS

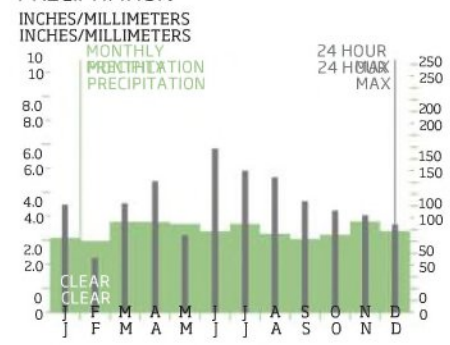


KROON CLOUDINESS ROUGH
KROON CLOUDINESS ROUGH



KROON PRECIPITATION ROUGH
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PRECIPITATION



KROON temperature ROUGH
KROON temperature ROUGH

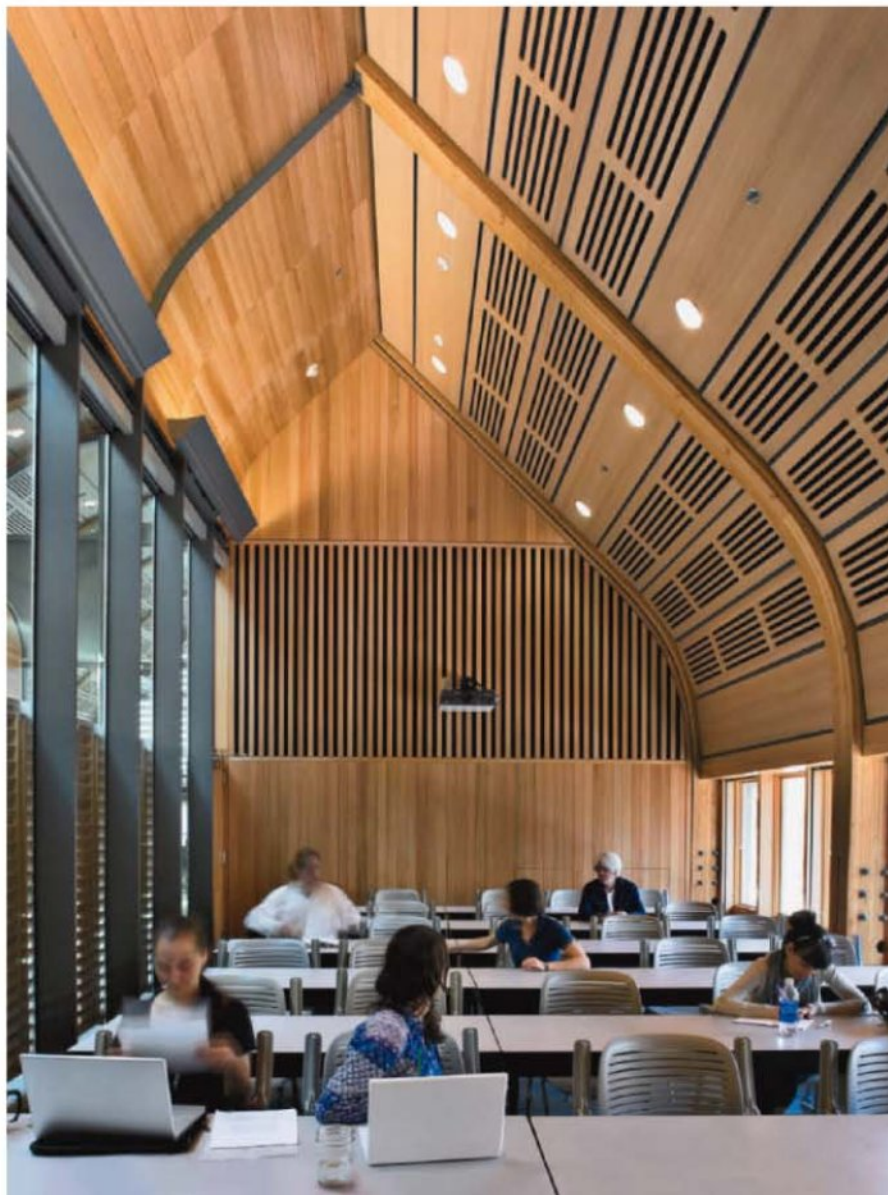
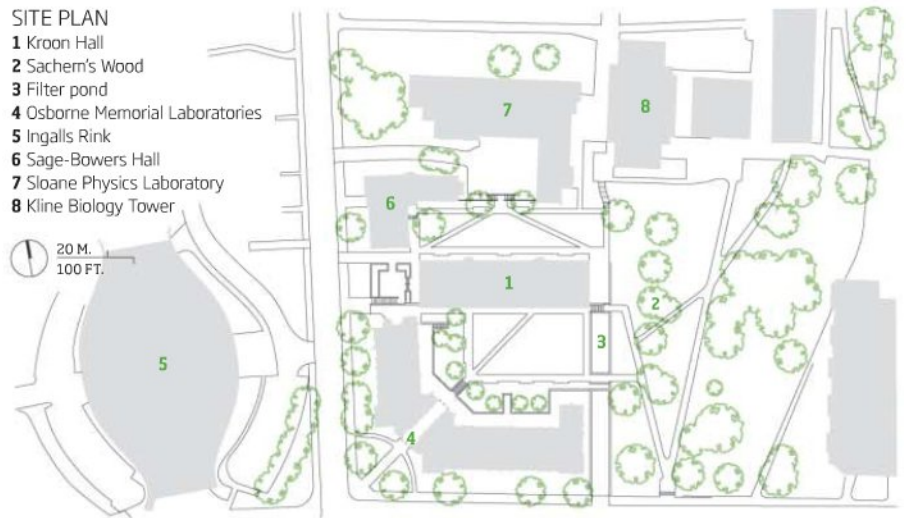
a 75-percent reduction in potable water use when compared to a standard building, or a savings of about 500,000 gallons per year. The strategies could also have energy-saving implications, especially if they were to proliferate regionally, points out Nicole Holmes, project manager for Boston-based civil engineering firm, Nitsch Engineering. “Municipal treatment and conveyance of potable water requires energy,” she says.

Embodied energy was a consideration in materials selection as well. For example, about half of the interior’s red oak paneling came from very nearby—the university’s own forest in northern Connecticut certified by the Forest Stewardship Council (FSC). The rest came from a variety of

SITE PLAN

- 1 Kroon Hall
- 2 Sachem’s Wood
- 3 Filter pond
- 4 Osborne Memorial Laboratories
- 5 Ingalls Rink
- 6 Sage-Bowers Hall
- 7 Sloane Physics Laboratory
- 8 Kline Biology Tower

20 M.
100 FT.



sources, all FSC-certified and within 500 miles of the building site.

The designers also considered the life of the building well into the future. For the exterior cladding, they selected sandstone from Ohio because it is more resistant to deterioration than the relatively more local choice, brownstone. But durability wasn’t the only concern—Kroon is also intended to be flexible. One example is its two floors of offices, laid out on a module, to ease later adaptation. Part of being green is anticipating change, says Simon. “Whatever is deemed as immutable now could be useless in 150 years.” ^{GS}

>SOURCES

- Curtainwall** Kawneer North America
- Windows** Marvin
- Skylights** Wasco Products
- Woodwork and paneling** Legere Group
- Ceiling panels** Rulon
- Carpet** Interface
- Office chairs** Steelcase; Kusch+Co
- Lighting** Winona Lighting (interior ambient); Gammalux Systems (downlights); Artemide (task); Quality Lighting (exterior); nLight Control System (sensor switch)
- Photovoltaics** SunPower, model 225, solar PV panel
- Chiller** Florida Heatpump, model WW 420 (water-to-water reverse cycle heat pump)
- Custom solar-thermal domestic hot water array** Solar UK, LaZer2
- Custom reclaimed water tank** Fibre Technology Corporation
- Solar-powered faucets, fixtures, flush valves** Sloan
- Urinals** Waterless Company
- Building-management system** Automated Logic Corp.
- Air-handling unit** Menerga, Adsolair 561901 (double-pass heat recovery and indirect evaporative cooling)

Fort Baker, Sausalito, California



PHOTO CREDIT: TEEKAY ILLUSTRATOR: GREGORY

HISTORIC EXPANSION


Combining meticulously restored buildings with unobtrusive new ones turns an army base at the Golden Gate into a luscious resort.



Winding through curvaceous hills just north of San Francisco's Golden Gate Bridge, the narrow road leads to a grassy field bordered by colonial revival buildings: the old Fort Baker parade ground, officers' quarters, and barracks. The manicured but rustic exterior does little to hint at the five-star service within, where the meticulously restored interiors have been upgraded to convert simple shelter into a luxury resort. Beyond the residences that overlook the parade ground are additional buildings, some original, some newly added, that contain a spa, a chapel, administrative offices, and additional lodging for a total of just over 140 rooms.

Cavallo Point, The Lodge at the Golden Gate, sits within the Golden Gate National Recreation Area, which is controlled by the National Park Service. It is owned and managed by the Fort Baker Retreat Group. Completed in 2008 by a consortium led by Equity Community Builders, Cavallo Point represents an impressive

Guest rooms and suites now occupy the original Fort Baker officers quarters, keeping most of the original floor plans and architectural details intact.

 To comment on this project, visit greensourcemag.com/projects

>KEY PARAMETERS

Location Fort Baker, Sausalito, CA (shoreline of San Francisco Bay)

Gross square footage 146,000 ft² (13,570 m²)

Cost \$23 million (new lodge and spa);

\$34 million (historic buildings)

Completed 2008

Annual purchased energy use (based on simulation) 49 kBtu/ft² (550 MJ/m²), 24% reduction from base case

Annual carbon footprint (predicted) 8 lbs. CO₂/ft² (39 kg CO₂/m²)

Program Lodging units, spa with treatment, steam and locker rooms, therapy pool, lounge, library, office, retail

>TEAM

Owner Fort Baker Retreat Group

Architect Leddy Maytum Stacy Architects (new buildings); Architectural Resources Group (historic buildings and site plan)

Interior designer BraytonHughes Design Studios

Landscape Office of Cheryl Barton

Engineers Murphy Burr Curry (structural); WSP Flack+Kurtz (MEP); URS Corporation (civil)

Lighting Architectural Lighting Design

Acoustical Charles M. Salter Associates

Waterproofing Simpson Gumpertz & Heger

Commissioning agent Enovity

General contractor Herrero Contractors Inc.

integration of three agendas: historic preservation, modern amenities, and green performance—any two of which can be challenging to combine in most settings.

This integration is the result of intensive collaboration and negotiation throughout the design process, which led to some innovative solutions. For example, even though the Park Service and Historic District officials support sustainable design goals in principle, the historic roofs were off-limits to photovoltaics because their rich red is a defining feature. Conventional PV panels were deemed out of place even on the modern lodging units. Initially the historic preservation agent on the project decreed that photovoltaics would only be used “over my dead body.”

Thin film photovoltaics came to the rescue, however. While somewhat less efficient on a per square-foot basis than standard panels, these strips adhere to the metal roofing between the standing seams. Their super-low profile makes them attractive architecturally, and according to Tom Sargent of Equity Community Builders, they win out on constructability as well because roofers can be trained to install them so electricians aren’t needed on the roof. It turns out that these thin-film PVs are also less sensitive to partial shading of the solar cells, making them a good choice in general, according to Marsha Maytum, FAIA, whose firm Leddy Maytum Stacy Architects designed the new buildings on the site.

In the old barracks, Deborah Cooper, AIA, and her colleagues at Architectural Resource Group were studying how best to remove layers of lead paint from the decorative tin ceiling in the public spaces, later to serve as a bar, restaurant, gift shop, and reception lobby. After considering sand-blasting with special sponges and other options, they decided that the metal ceilings had to come down anyway so that modern services and acoustic separation could be added between the floors. Once the metal was removed, freezing it in a refrigerated cargo container caused the metal to contract, breaking its bonds with the paint, which fell off in large chunks. This solution made the hazardous lead mess easier to





Above The waiting area of the Healing Arts Center features soft, natural finishes and a strong visual connection to the flora outside.

Opposite New lodging is nestled into the hillside overlooking the old barracks, parade ground, and Golden Gate Bridge beyond. Many invasive species were removed as part of the restoration, but mature eucalyptus were kept because of their cultural and aesthetic importance on the site.

Right The restored tin ceiling is a highlight in the bar. Only the commercial kitchen required significant alterations to the historic buildings.

contain, revealed the original patterns better, and cost less than the other options they considered.

The team struggled, as so many do, with how to deal with the historic windows. In the end they decided to tighten up the seals and restore them for about \$400 per window instead of replacing the single panes with insulated glass, according to Sargent. "The historic requirement to keep those windows proved to be the most



DAVID WAKELY

FLOOR PLAN

- 1 Entry
- 2 Living room
- 3 Dining room
- 4 Pantry
- 5 Kitchen
- 6 Porch
- 7 Sitting room
- 8 Bedroom
- 9 Bath



buildings that historically had large, open spaces for the restaurant and meeting rooms. Overall, the team saved 97 percent of the exterior envelope and 67 percent of the interior surfaces, earning all three available LEED points. "Applying for LEED gave us a new data point on this that we might not have had otherwise," Cooper notes.

The new buildings are beautifully designed and detailed in an understated way, to avoid intruding on the historically significant site. They rely extensively on the use of bio-based and salvaged materials, as much as possible, in their natural state. Redwood reclaimed from old buildings in California is naturally fire-resistant, which made it an ideal choice for exterior trim in compliance with the urban wildfire code. In the spa and guest-room baths, eucalyptus leaves from the site are encased in 3form's recycled-content translucent panels.

The new lodging units are sited on the footprints of pre-existing buildings that were not worth keeping, where they nest into the

green approach. The mullions and glass will be there for another 100 years," Sargent says. He credits the site's mild climate for supporting that choice, noting that in a more severe climate, additional panes would have been necessary.

Rejecting conventional arguments that pit sustainability and historic preservations against each other, Cooper argues that they are inherently compatible because both push for preserving the existing environment. "They both root people in place and in time," Cooper notes. "Our project has the opportunity to highlight both of those."

In landscaping the project, 52,000 seedlings were planted, all raised from seeds collected in the immediate area. The seedlings were very small when installed, but they quickly thrived. "You have to credit their health to the fact that the plants were adapted to that soil and climate," says Sargent.

It might seem obvious, but the most important step in preserving the historic fabric is fitting appropriate new uses to each of the existing spaces. "The most logical thing that we did was take the historic officers' quarters and use them for guest lodging," says Cooper. Similarly, they used

the parade ground and facing out onto the Golden Gate Bridge. The rooms glow with daylight and benefit from natural ventilation, which is made possible because each guest room has openings on two facing walls. Ventilation is aided by ceiling fans when necessary. Air-conditioning is only available in eight of the 142 units, and that was only done because the resort had to offer it as an option to achieve its five-star rating, according to Maytum. Even the bathrooms have high windows that let in lots of light. "It really does reduce electricity use," reports Maytum, based on observations of how the rooms are used.

KROON PRECIPITATION ROUGH

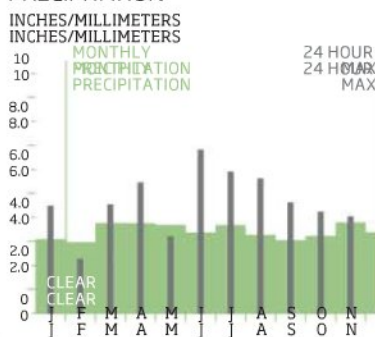
LSR PRECIPITATION ROUGH

CAVALLO PRECIPITATION ROUGH

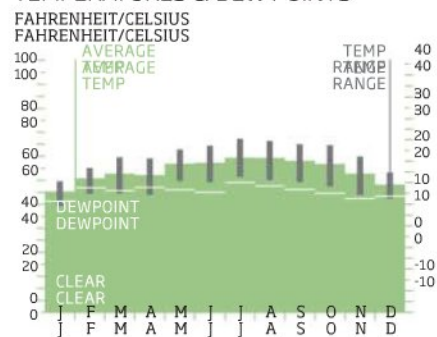
CAVALLO temperature ROUGH

CAVALLO HDD/CDD ROUGH

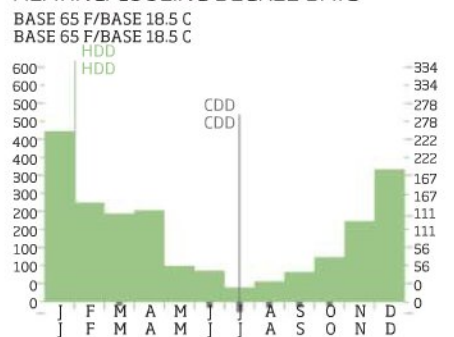
PRECIPITATION



TEMPERATURES & DEW POINTS



HEATING/COOLING DEGREE DAYS



Right Outdoor gathering places like this terrace help visitors make the most of the area's comfortable climate.

Below A training kitchen on the second floor of the historic barracks is set up for cooking classes.

Bottom New lodging units, built on the site of old buildings that were not worth saving, take advantage of the views while maximizing daylight and cross-ventilation.



Units in the historic buildings are equally compelling, but with a very different flavor—more like a room you'd find at a fancy bed-and-breakfast in a colonial house. Only the entertainment centers feel out of place in these suites. All the units use bulk-dispensers for soap and shampoo—a move that's unfortunately rare, given the savings in wasted cleansers and little plastic containers.

Tying these different spaces together, the two architecture firms worked with interior designers Brayton + Hughes Design Studios to establish a shared palette of furnishings. Large slabs of local Clara Walnut, for example, crown both the reception desk in the old barracks and



the retail counter in the tea rooms.

In spite of the historic context, the design team embraced high-tech solutions. In the laundry facility—by far the biggest water users at most resorts—they installed a system that filters water from the laundry and reintroduces it, reducing water use by

about 60 percent and contributing to the overall 30-percent water-use reduction for the project.

Both from a historic and environmental point of view, the team's biggest achievement was to keep the site intact. "It's an absolutely compelling site," notes Sargent, "with its natural setting and location next to the Golden Gate Bridge." It's quite an achievement to insert an attractive, high-end resort into this setting, while retaining its core values. [GS](#)

>SOURCES

Rehabilitated existing wood Herrero Contractors Inc.

Rehabilitated wood windows Woodworks

Glazing glass Restoration Glass by Bendheim

Skylights The Collier Warehouse; Acralight International Skylights

Metal roofing Firestone Una-Clad

Low-slope roofing Siplast Paradiene 30

Curtainwall US Glass

Translucent panels 3form, with eucalyptus leaves from site

Acoustic wall panels Wall Technology

Operable sound partitions QuikWall

Cabinetwork and custom woodwork

SMI Architectural Millwork

Paint Sherwin-Williams

Floor and wall tile Ceramic Tile Design (spa);

Dal-Tile; Ann Sacks; Subway Tile

Cork flooring Expanko; Wicanders

Furniture SMI Woodworks

Lighting Metalux, Peerless, Alkco, Corelite, Kurt

Versen, Edison Price, Lightolier, Selux, Elan, Prudential,

Sistemalux, Seagull, Translite, Bega, Cole, B-K Lighting

Photovoltaics Uni-Solar PV Laminate

Dual-flush toilets Toto Aquia

Wall-hung boilers Buderus

Heating radiators Runtal

Ceiling panel heaters Twa Panels

Water heaters A.O. Smith, Rinnai

AGRARIAN VALUES IN THE CITY OF PORK

In its design, construction, and even its operation, a Washington, D.C., restaurant provides healthy portions of sustainability along with some attention-getting spaces.



At a time when bestselling books and widely distributed films are exposing the evils of industrialized food, a restaurant owned by family farmers makes sense to a lot of people. The challenge for Peter Hapstak, III, AIA, and his design firm, CORE, was finding a way to bring the spirit of the farm to an odd location: the headquarters of the International Monetary Fund (IMF) in downtown Washington, D.C. So as he designed Founding Farmers, an 8,500-square-foot restaurant at the base of the IMF's new Pei Cobb Freed-designed office building on the corner of Pennsylvania Avenue and 20th Street, NW, Hapstak focused on the ethos of the venture—healthy foods grown or raised with sustainable practices—and looked for ways to express this architecturally.

Owned by the North Dakota Farmers Union, a cooperative of 40,000 family businesses, the two-story, LEED-Gold certified restaurant showcases a wide range of green strategies, from its design and construction to the operation of its kitchen. Even the servers taking orders and bringing out food have been trained to talk about the restaurant's environmental mission.

"We used a deconstructed metaphor of the barn, but did it a little tongue-in-cheek," says Hapstak. He and his team created much of the interior with salvaged wood, contrasting the material with the building's glass-and-steel envelope so that the vernacular elements never seem corny. They designed a pair of booths on the second floor to recall corn cribs, inserted a barn ladder in a glass corner, and used the kind of standing-seam metal you would find on a farmhouse. Despite concerns, the country theme comes across as being comfortable, not contrived. For flooring they specified wood reclaimed from a textile mill outside Atlanta and for walls they used wood taken from a barn in West Virginia. Original paint on some



Washington, D.C.

In the first-floor dining room, a modern vocabulary mixes comfortably with vernacular elements such as hand-painted "signs" on concrete columns and display cases made from salvaged medicine cabinets.

For a slideshow of additional images, visit greensourcemag.com



>KEY PARAMETERS

Location Washington, D.C. (Chesapeake Bay Watershed)

Gross square footage 8,500 ft² (790 m²)

Completed September 2008

Program Restaurant

>TEAM

Owner North Dakota Farmers Union

Architect CORE architecture|design

Lighting MCLA

Engineers Tadjer Cohen Edelson Associates

(structural); FACE Associates (MEP)

Commissioning agent: A2 Services

Environmental consultant EMSI

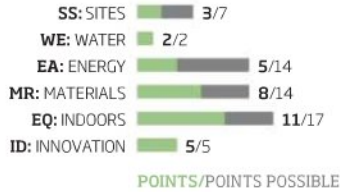
General contractor Forrester Construction Company

CASE STUDY

INTERIORS

I FOUNDING FARMERS RESTAURANT

FOUNDING FARMERS CI VERSION 2 GOLD



of the wood retained lead, but the designers wanted to retain the weathered look of these pieces so they encapsulated the paint with a clear sealer. Walnut tables and chairs came from a manufacturer in North Carolina who used wood harvested from forests in Pennsylvania. Altogether, about 45 percent of the materials in the project came from sources within 500 miles, just as the restaurant tries to buy produce and foods from local farms and enterprises.

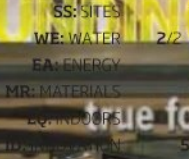
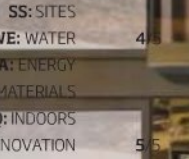
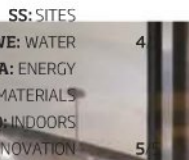
When CORE started working on the project, it faced significant challenges,

including structural columns and a mezzanine floor slab that made laying out a 263-seat restaurant difficult. “We needed an architect with real spatial vision,” explains Dan Simons, a principal at Vucurevich Simons Advisory Group, which served as the owner’s representative for the project.

CORE made the most of the situation by placing a large bar in the center of the ground-floor space to serve customers or wait staff on four sides and then arranging dining tables below the cantilevered mezzanine slab and around the perimeter of the restaurant. The firm created a variety of dining areas on each of the two floors, using recycled content acrylic screens with embedded natural elements to separate spaces and seating some diners at long communal tables. According to Christian Holmes, the restaurant’s general manager, repeat customers favor the two “corn crib” booths on the second floor and the perimeter tables on the ground floor where



MICHAEL MORAN



jewish recon. cong.

FAKE

FOUNDING FARMERS

true food & drink



they can enjoy the double-height space.

Two-story-high glass on the north and west sides of the restaurant bring abundant daylight into the space, reducing the need for electric lighting. (Shades can be lowered on the west to protect the space from the afternoon sun.) The designers reduced energy use further by specifying LED lighting in many places and using incandescent bulbs only in a few locations to warm up the ambiance.

More than 80 percent of the restaurant's appliances are Energy Star-rated, including all freezers, refrigerators, fryers, steam cooker, the main dishwasher, the bar

Opposite, bottom The 8,500-square-foot restaurant sits within the new International Monetary Fund headquarters designed by Pei Cobb Freed Architects on Pennsylvania Avenue, just a few blocks west of the White House.

Middle Curving booths on the second level have proved to be some of the most requested seating, according to the restaurant's manager.

This page Recycled-content acrylic screens with natural grasses embedded in them help separate tables in the two-story-high space around the north and west sides of the restaurant. The architects used a range of recycled materials including salvaged wood and reused paper.

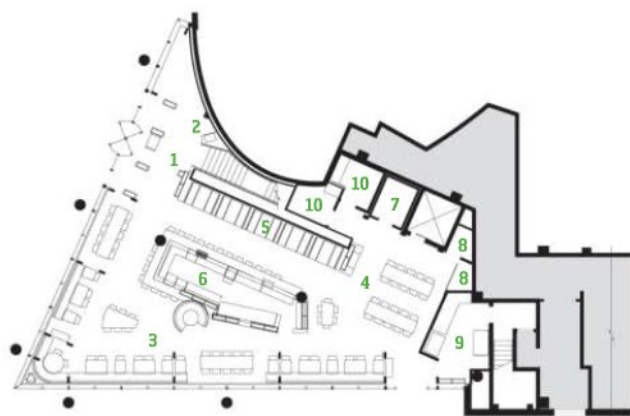
dishwasher, and the hot-food holding cabinet. In addition, a high-efficiency HVAC system and heat pump exceed Advanced Buildings Energy Benchmark and ASHRAE standards. The restaurant also purchases green-power credits, accounting for half of its electricity consumption. In the restrooms, waterless urinals and low-flow lavatories save 192,000 gallons of water each year, while countertops are made from 100-percent post-consumer recycled paper and non-petroleum-based phenolic resin.

Sustainability drove decisions affecting the construction and operation of the restaurant, not just its design. As a result, 90 percent of all construction waste and materials were recycled or diverted from landfill. The restaurant has a waste, recycle, and compost area and is certified by the Green Restaurant Association, which reviews its operation each year.

The North Dakota Farmers Union hopes to open more restaurants using the same environmental mentality as its flagship on Pennsylvania Avenue, says Simons. "You can take this sustainable approach and make money," he explains. "The people eating here really care about these things." 

>SOURCES

Wallcoverings Designtex Duraprene
Countertops PaperStone
Resin panels 3form
Brick Vintage Brick Salvage
Reclaimed heart pine flooring sourced by Wiggins and Company and manufactured by ecofinishes
Carpet Blueridge, Antron Legacy Nylon with Dura Tech
Wood furniture Dunbar Furniture
Pastry lights Produzione Privata
Cloud lights Studio Italia
Bird lights Perch
Water closets and waterless urinals Kohler



FIRST FLOOR

- 1 Vestibule
- 2 Host station
- 3 Dining
- 4 Communal tables
- 5 Booth seating
- 6 Bar
- 7 Beer and wine storage
- 8 Storage
- 9 Beverage service
- 10 Restroom

SECOND FLOOR

- 11 Open to first floor
- 12 Pastry bar
- 13 Office
- 14 Kitchen
- 15 Coolers
- 16 Receiving



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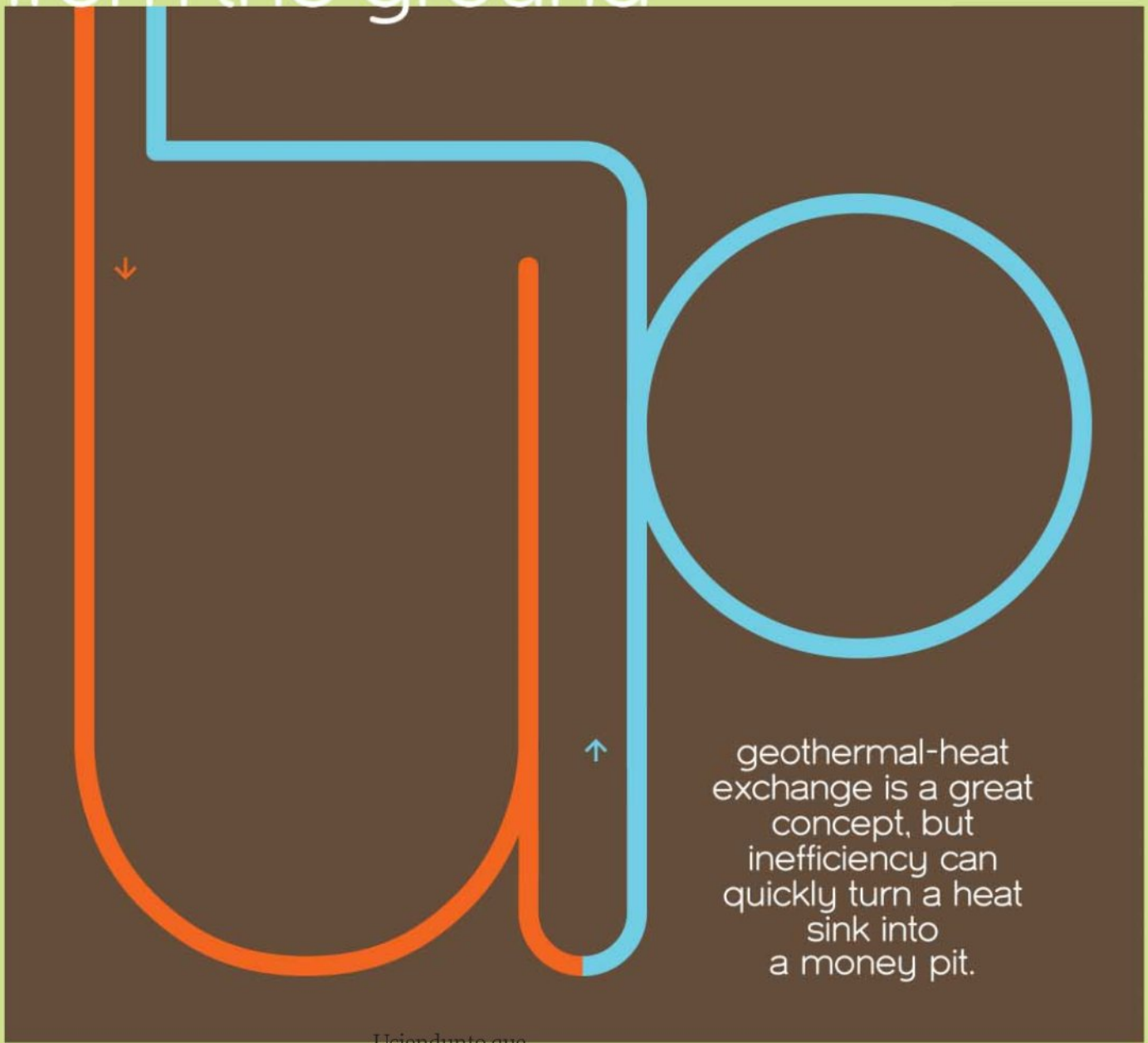
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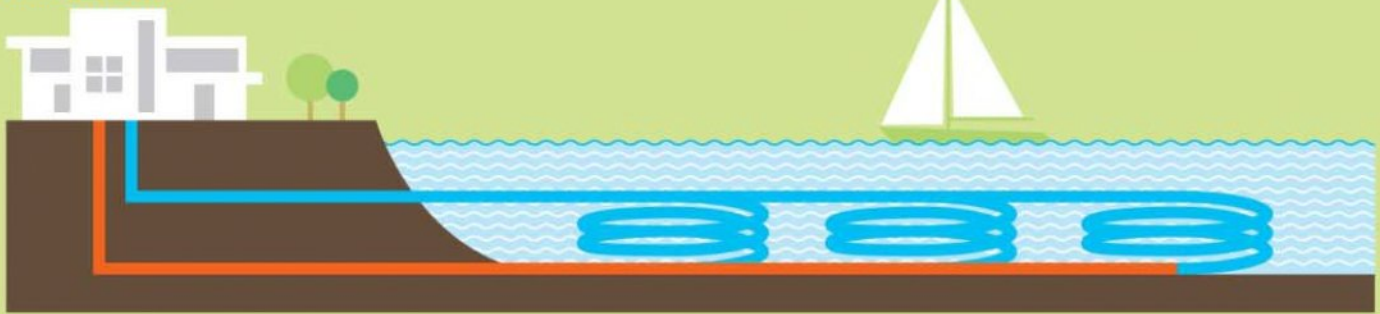
from the ground



Uciendunto que

 **CONTINUING EDUCATION** USE THE LEARNING OBJECTIVES below to focus your study while reading "From the Ground Up." To earn one AIA learning unit, including one hour of health, safety, and welfare/sustainable design (HSW/SD) credit, turn to **PAGE 90** and follow the instructions.
AFTER READING THIS ARTICLE, YOU SHOULD BE ABLE TO: • Understand the concept of geothermal heating and cooling. • Explain the benefits and drawbacks of geothermal systems. • Discuss the various types of geothermal systems. • Identify the necessary components of these different systems.

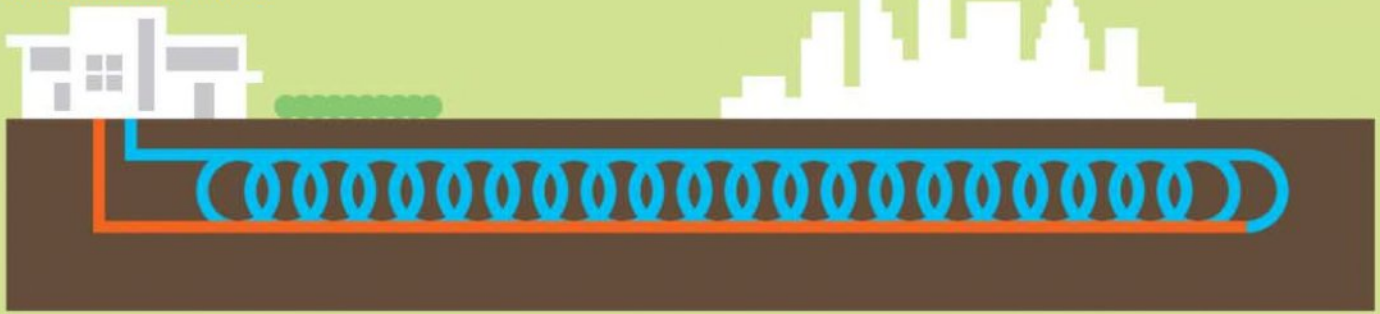
surface water loop



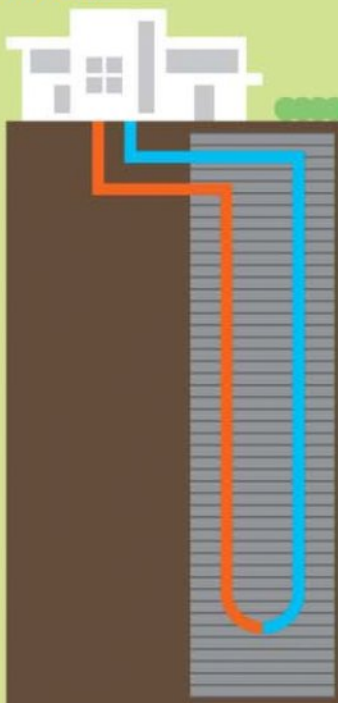
ground horizontal loop



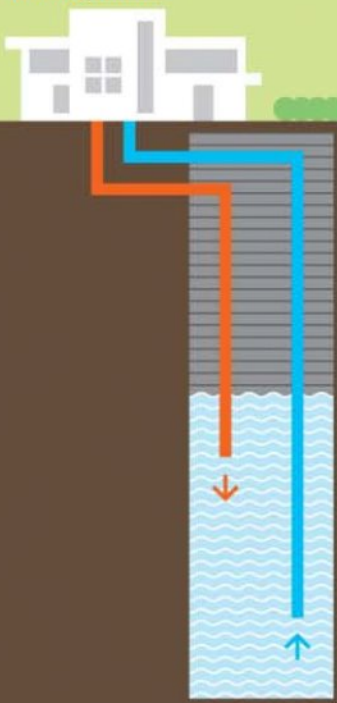
ground horizontal slinky loop



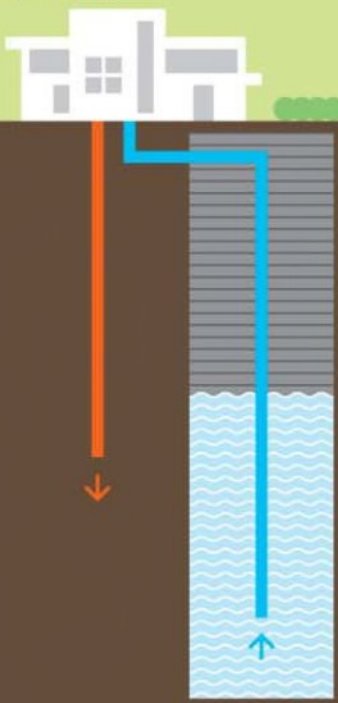
closed loop



standing column

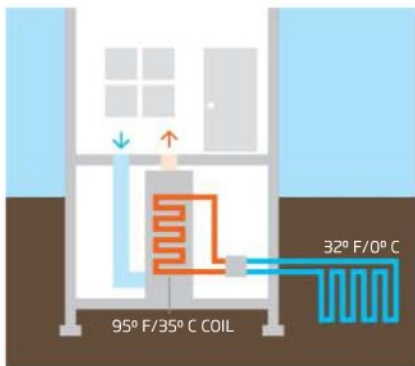


open to recycle



real estate & earth couplings

Only the imagination limits the different ways geothermal heating and cooling systems can be designed, but available space is a key factor. Open, water-source systems are the most efficient; however, without a nearby pond, lake or river, drilling or trenching is required to bury loops of pipe in the ground. Flow direction can be reversed seasonally to either collect or reject heat.



how heat pumps work

Heat pumps “cheat” the Second Law of Thermodynamics by pumping heat in the opposite direction than it naturally flows. A working fluid such as refrigerant leaves a compressor as a hot, high-pressure gas. It moves through a condenser coil, where it gives off heat, while a fan blows that heat to the outside air. As the gas cools down, it transforms into a liquid. That liquid then flows through an expansion valve and turns into a cool, low-pressure gas that absorbs heat.

A fan delivers air through an evaporator coil filled with this chilled gas, cooling the interior room. Condensation that forms on the evaporator coil is drained away from the building and dehumidifies the space. As the gas moves back into the compressor, it is changed again into a high-pressure gas, giving off heat. The process repeats until the desired indoor temperature is reached, and the compressor shuts off.

The fluid in some buildings can run backwards, that is, it can draw heat from cool, outdoor air in the winter to heat interior spaces, then reverse in the summer to cool. The efficiency of the heat pump depends largely on the temperature of the outside air. Because ambient air temperatures can fluctuate from hour to hour, the earth and bodies of water can provide a more reliable source, but if the heat is not extracted later, the heat pump will run less efficiently in future cooling seasons. Balanced loads are key to designing and maintaining an efficient GHP, experts say.

a For an additional sidebar on the new climate risk that refrigerants pose, go to greensourcemag.com

On Oct. 25, 1948, a short article appeared in the back of *LIFE* magazine entitled the “Fireless Furnace.” There, postwar America witnessed the emergence of a futuristic technology that Lord Kelvin, the King of Cold, only dreamed about nearly a century earlier.

The fireless furnace ran water through coils in the ground, and then sent it through a heat pump to eliminate burning fossil fuels. But the technology was too expensive—about \$3,000 installed—and too new to gain acceptance. “However, as the efficiency of getting heat from the earth improves, it is almost certain that eventually the heat pump will be able to compete successfully with conventional heaters in most localities,” said the story.

Sixty years later, geothermal-heat pumps (GHPs) and related systems are competing. If designed efficiently, the systems can produce more energy than they consume—three to five times as much on average—yielding a positive coefficient of performance (COP). They tap the natural heating and cooling properties of the earth by “pumping,” or extracting heat from it. Homes and commercial buildings in the southern United States have been “recycling” this ambient heat for years using what are called air-source heat pumps (ASHPs).

As soil is a more stable heat-exchange medium than air, so-called “ground-source” heat pumps (GSHPs) are becoming a more attractive option. Nearby bodies of water can provide green sources of heating and cooling as well, using “water-source”

heat pumps (WSHPs). The medium is different—earth vs. water—but the mechanics and components are basically the same. However, not all geothermal systems require heat pumps, and as such are even more efficient than GHPs.

The U.S. Department of Energy estimates that “aggressive deployment” of GHPs alone could save up to \$38 billion annually in reduced energy bills, put a significant dent in greenhouse gases, and reduce the need to build 105GW of electrical capacity by 2030. If not designed well, GHPs can have unintended consequences, such as astronomical costs, increased energy use, and polluted groundwater. The devil, as they say, is in the details.

Energy prices are not the only things contributing to the increased popularity of geothermal heaters. Growing environmental concerns are helping to drive increased use of all alternative systems. And geothermal systems that use refrigerants are also becoming useful to recoup efficiency losses as non-ozone-depleting refrigerants begin to replace ozone-depleting ones on January 1, 2010 under the Montreal Protocol.

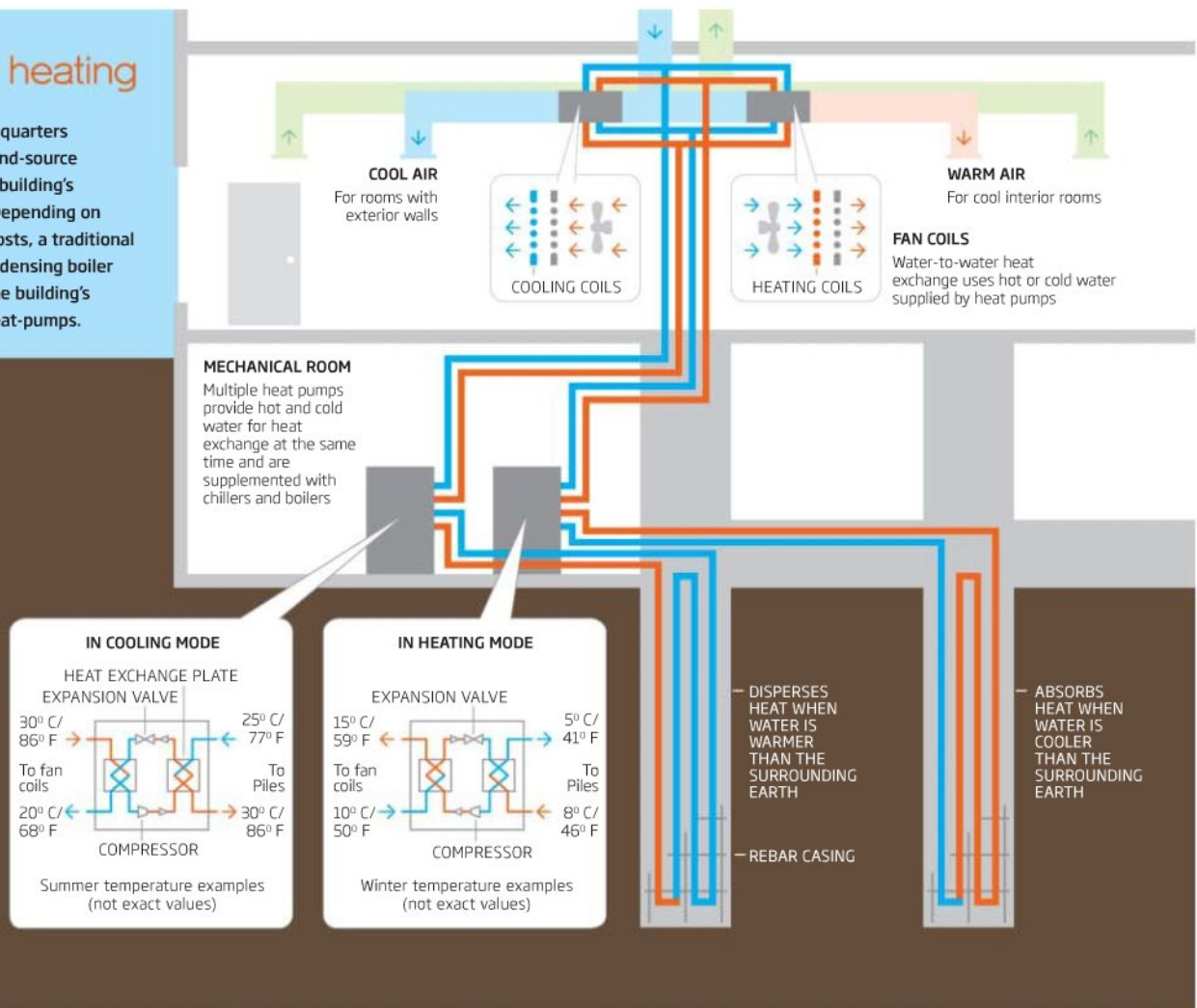
It is important, however, to note the following: We are not talking about Icelandic hot springs. Geothermal heaters do not generate electricity; they consume it. They achieve a positive COP by exchanging heat with soil or water within the earth’s first several hundred feet, and they largely take advantage of solar heating, making a case that they are a renewable source. But more on that debate later.

By tapping into shallow soils—some systems go as deep as 2,000 feet due to space constraints—GHPs benefit from ground temperatures that are a relatively constant 50 to 60 degrees Fahrenheit, requiring less “lift” to pump heat. Especially in regions with balanced seasonal loads, buildings can use the earth as a storage device, a battery of sorts, to reject heat during the cooling season that can be extracted at a later date. This environmental harmony is making the market for heat pumps red hot around the world.

Heat pumps in their simplest form are

hybrid heating

WestJet's headquarters integrate ground-source loops into the building's foundations. Depending on daily energy costs, a traditional chiller and condensing boiler supplement the building's geothermal heat-pumps.



found in every typical American kitchen: the fridge. Refrigerators use a mechanical compressor and two coils that pump heat from the icebox and reject it to the outside air. That is why the back or bottom of the fridge is warm to the touch, while the contents inside remain nicely chilled.

Home air conditioners are another example. Typical, “split” air conditioners feature an evaporator coil that rests inside the building while the condenser coil sits outside. With GHPs, you can imagine the “condenser” as a continuous loop of high-density polyethylene (HDPE) pipe, from 3/4 inch to 2 inches in diameter, buried underground or submerged in a body of water. A solution of water, methanol, or glycol provides heat transfer between the

ground source and the heat pump. Unlike a home air conditioner, the flow can be reversed in winter to heat the building.

water sources

A limnologist is a person who studies the properties of lakes and other inland bodies of water. This specialized field includes the movement of heat between the water’s surface—exposed to solar heating during the day and evaporative cooling as wind passes over it at night—and the very depths, which are denser and cooler. As WSHPs have matured, designers have increasingly employed limnologists to create more efficient systems.

WSHPs comprise both open- and closed-loop systems. In an open-loop system, water

is pumped from a lake, pond, aquifer, or other nearby source of water, exchanges heat inside the building via a heat pump, and is returned back to its source along with rejected heat. In a closed-loop system, HDPE tubing is submerged in the water and relies on conduction through the tubing to transfer heat.

Examples of open-loop systems are scattered across the campus of Harvard University, where installed WSHPs on seven buildings use “standing-column wells,” about 6 inches in diameter and drilled as far as 1,500 feet. These wells—an average of three per building—use a pump that extracts water from the bottom of the well where the water is cooler, exchanges it with heat pumps in the building, and



Sherman Health's runoff-retention pond doubles as a 15-acre water-source loop. The 650,000-square-foot facility expects to save \$1 million a year in heating and cooling costs.

returns it to the top of the well, where the water is naturally warmer.

Naturally, as these wells heat up, COP drops. Poorly designed and constructed wells inhibit heat dissipation, so owners may need to dump or “bleed” water to offset the heat spike. Wells that are not drilled down deep enough, or “short-drilled,” also may lack the capacity to allow heat to escape quickly enough, warns Nathan Gauthier, assistant director of Harvard's sustainability office and a member of the U.S. Green Building Council's Energy and Atmosphere Technical Advisory Group.

Another environmental problem is the cross-linking of aquifers. Since drilling exposes soil strata, underground water that may not naturally come into contact with other sources is suddenly introduced. “If there is an aquifer at 100 feet and another one at 300 feet, a gas station may have contaminated the one at 100 feet,” Gauthier explains. While geotechnical consultants can help identify the risks, the construction industry as a whole has not yet solved this potential problem.

Heat pumps are dependent on compressors and refrigerants to transfer energy to and from the ground loop. However, not all geothermal systems rely on heat pumps. One such system, popular in Europe and quickly gaining traction in North America, is deep-water source cooling (DWSC).

Cornell University uses a DWSC system to cool its classrooms in Ithaca, New York. A 2-mile-long intake pipe located about 250 feet below the surface of nearby Lake

Cayuga delivers 39-degree Fahrenheit water into onshore heat exchangers located in a special utility building. A second, closed loop running through the heat exchangers brings chilled water to campus at about 47 degrees Fahrenheit. Warmer water is rejected through a 500-foot-long diffuser pipe closer to the lake's surface. The chilled water is piped directly through the classrooms, eliminating the school's previous chillers, which ran on ozone-depleting refrigerants.

Cornell's system, designed for 20,000 tons, allows the \$58-million investment to reach a COP of 25 and reduce overall cooling energy by 86 percent. Cornell estimates that the cost premium over conventional methods is on track to pay for itself in an estimated 10 to 13 years from its 2000 completion date, a payback that is now not too far away.

“The savings is on the order of 25 million kWh,” says William S. “Lanny” Joyce, Cornell's senior manager of engineering, planning, and energy. “That's almost 10 percent of our campus electrical use.” The local community also benefits, he notes, from reduced peak loading on the electrical grid.

Because the loops never mix, this is a type of closed-loop, geothermal system that does not rely on heat pumps. A more typical, closed-loop system that uses heat pumps can be found in Elgin, Illinois, but the size of the system is anything but typical.

There, Sherman Health, owner of a 255-bed hospital going up in the Chicago suburb, plans to save more than \$1 million a year by tapping into a 15-acre, 17-foot-deep

geothermal pond—one of the world's largest—which will provide heating and cooling for the 650,000-square-foot facility. Sherman knew that it needed to build a 5-acre stormwater-detention pond on its 154-acre site, so it tripled the size to accommodate a geothermal loop.

While in planning, the owner figured that its loop would cost \$4.5 million to install. Add to that \$1.6 million for the land, and the hospital was looking at a \$6.1-million investment. At a savings of over \$1 million per year, though, it wouldn't take long to pay off. The system sports 150 miles of tubing, 175 underwater heat exchangers, and 750 heat pumps. A nontoxic methanol solution flows through the loop, essentially turning the lake into a 15-acre cooling tower.

ground sources

All GSHPs are closed loops arranged in either a vertical or horizontal fashion. The arrangement depends on real-estate constraints, and all the tubing is buried at least below the frost line to prevent damage.

Heat pumps generally do not cost more than conventional furnaces, but the ground loops are an added cost. They require expensive, shallow trenching, more expensive deep drilling, or a combination of both. Installation equates to a few dollars per foot and on up to \$25 per foot, according to government statistics. Heat pumps are flexible, though. Users can tailor them to their regional needs; some are even designing “hybrid” systems to take advantage of local power, geology, and climate.

One such system, designed for airline company WestJet's headquarters in Calgary, Alberta, incorporates heat sinks into the six-story, 314,000-square-foot building's foundations. By looping tubes inside 105 bored piles, “we reduced the capital cost,” says Jim Bererton, senior project engineer for consulting engineer Stantec. This method is more mature in Europe, where foundations commonly double as heat exchangers.

Because geothermal systems are still relatively new, the unexpected often arises during installation. WestJet lost 30 percent of its loop due to pier-construction problems, requiring it to drill 20 additional,



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Normally, the building would have needed 200 holes drilled to 300 feet, so the owner still saved more than \$700,000 in installation and is expected to save \$200,000 per year in energy. Part of the savings is due to the unusual addition of a conventional chiller and condensing boiler. The “secret sauce” is a computer controller that takes into account daily costs of electricity and natural gas and cycles the systems on and off accordingly to deliver the best bang for the buck.

Drilling equipment is another low-hanging fruit ripe for innovation. In Chicago, a homebuilder whose friend, and now wife, convinced him to build her a greener home is leading the charge to cut costs for vertical-well construction in tight, urban environments. David Dwyer, president of American Renewable Energy and author of *Green Power Blue Collar*, helped local-physician Toni Bark design her green home in Evanston, Illinois. The 4,700-square-foot home has 16 wells drilled to 125 feet and two heat pumps that play a part in holding their utility bills under \$100 per month.

Both LEED-accredited professionals, they

further shaving costs off the more expensive vertical construction. As the world goes geothermal, more advances will continue to drive down the cost of these systems.

but how green are they?

All geothermal heaters require electricity. Heat pumps require even more. The “green-ness” is determined by the efficiency of the overall design and the type of electricity going in. There is no shortage of strong opinions here.

Before designers even consider adding a geothermal system, it is critical to reduce building energy loads by upgrading the envelope and, if appropriate, HVAC ductwork. “The technology is fundamentally sound,” explains Joe Lstiburek, principal of Building Science Corp. “But a lot of people are using them for really, really poor buildings.” For every dollar spent on conservation—better windows, insulation, ductwork—two dollars can be saved on the size of the geothermal system. But as many buildings are designed inefficiently, geothermal has become the “greenie-weenie technology du jour,” Lstiburek says.

integrated properly across various trades.

This brings us back to the question of whether or not geothermal is renewable. Again, no shortage of opinions. Lstiburek points out that the “geothermal” moniker is nothing more than smart marketing. Others think they “should be considered the same as solar energy,” says Bererton. “It’s exactly like solar power for heating. If you look at a COP of four for a heat pump in heating mode, one unit of electricity gives you four units of heat, so where did those three units of heat come from? They came from the sun, so you really are 75 percent solar.”

But if we take into account that on average, grid electricity in the U.S. delivers a negative COP of three, this argument loses traction: “I’m 100 percent convinced that it should not be included as a renewable energy,” Gauthier responds. “You are still using electricity to pump heat. You wouldn’t call a window unit [ASHP] a renewable-energy technology, would you? All that makes GSHPs unique is that they are doing it more efficiently.”

As we showed earlier in the Cornell case study, geothermal systems that use no

ESPECIALLY IN REGIONS WITH BALANCED SEASONAL LOADS, BUILDINGS CAN USE THE EARTH AS A STORAGE DEVICE, A BATTERY OF SORTS. THIS ENVIRONMENTAL HARMONY IS MAKING THE MARKET FOR HEAT PUMPS RED HOT AROUND THE WORLD.


are pushing for more homes—which make up a significant portion of the building stock—to go geothermal. Both are aware of the high costs, too, so Dwyer has built what he calls the first geothermal drill designed for urban jobsites. While reluctant to showcase his system just yet, he described it as a three-wheeled machine that weighs about 2,500 pounds, or 10 times less than a typical, truck-mounted rig.

“Our cost of drilling is about half of what our competitors’ [costs] are,” Dwyer says. Stantec’s Bererton also has worked with a rig called a “SpiderPlow,” which simultaneously digs a shallow trench and lays HDPE pipe in a horizontal fashion,

Carbon is another factor. In areas where electricity is derived from coal, heat pumps will slow energy use but never stop emissions. “In the United States, we don’t typically use electricity for heating,” says Cornell’s Joyce. “We haven’t had as much of a need to conserve electricity, but now as the society tries to do heating without fossil fuels, that’s pushing us toward heat pumps because you can get electricity from [cleaner] sources like hydro, wind, solar, and nuclear.”

Dwyer adds that solar panels can be used to power the heat pump, lessening the home’s dependence on the grid. He also says that the entire building team has to be “on board” to ensure that the system is

refrigerant have much higher COPs because there is no need to run a compressor. The LEED rating system does not recognize geothermal heating as renewable, but many projects that earn the Energy and Atmosphere Optimize Energy Performance credit get a boost from their geothermal systems.

Like it or not, the debate over geothermal heating as a source of renewable energy remains highly political. After all, the Internal Revenue Service now provides special tax credits for renewables, including GHPs. The debate rages on, but experts unanimously agree: These systems are green so long as they are intelligently planned, executed, and maintained. 



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CONTINUING EDUCATION

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Learning objectives: After reading the article, you should be able to

- Understand the concept of geothermal heating and cooling.
- Explain the benefits and drawbacks of geothermal systems.
- Discuss the various types of geothermal systems.
- Identify the necessary components of these different systems.

1 All the following are true regarding geothermal systems except which?

- A They generate electricity
- B They achieve a positive COP by exchanging heat with the earth or a body of water
- C They benefit from ground temperatures that are relatively constant
- D In regions with balanced seasonal loads, buildings with such systems can use the earth as a storage device

2 Unintended consequences of poorly designed GHP systems include which?

- A High costs
- B Increased energy use
- C Polluted groundwater
- D All of the above

3 All of the following are true, except which?

- A Some geothermal systems include heat pumps
- B All geothermal systems include heat pumps
- C All heat pumps include compressors
- D All heat pumps include refrigerants

4 The WSHPs at Harvard University:

- A Have a closed-loop system
- B Have an open-loop system
- C Rely on evaporative cooling to offset rejected heat
- D Extract and return water to the bottom of standing-column wells

5 The DWSC system at Cornell University:

- A Is an open-loop system
- B Runs chilled lake water directly through classrooms
- C Relies on chillers
- D Helps reduce peak demand on the electrical grid

6 All of the following are true regarding GSHPs, except which?

- A They can be open-loop systems
- B They can be closed-loop systems
- C They can have tubing buried horizontally
- D They can have tubing buried vertically

7 The geothermal system at the WestJet Headquarters in Calgary, Alberta, uses which as a heat sink?

- A Nearby lake
- B A stormwater detention pond
- C The building's foundations
- D None of the above

8 Electricity is required to operate which?

- A Geothermal heaters
- B Heat pumps
- C Both A and B
- D None of the above

9 Before considering a geothermal system, designers should

- A Reduce building energy loads
- B Upgrade the building envelope
- C Upgrade the HVAC ductwork
- D All of the above

10 The LEED rating system recognizes which of the following as renewable energy?

- A All geothermal systems
- B No geothermal systems
- C Only geothermal systems that operate without heat pumps
- D Only geothermal systems that operate without refrigerants

PROGRAM TITLE "From the Ground Up," *GreenSource* (September 2009, page 82).

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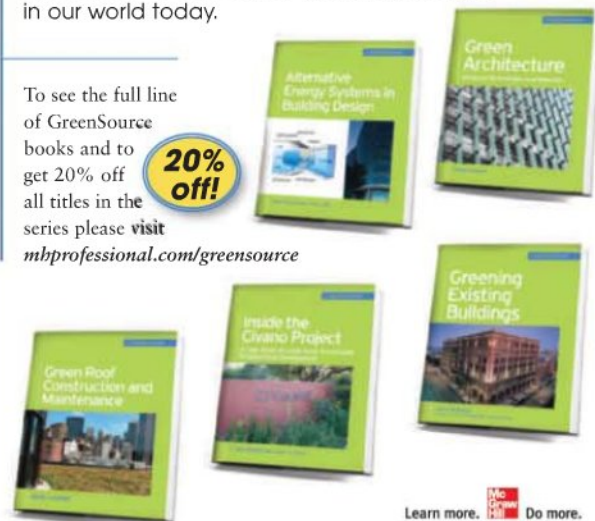
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Fossil Fools: Is it Too Late?

With the world on the brink of change, we can only hope that this current sense of urgency is enough to reverse generations of damage.

For 250 years now, our economy has mostly been about one thing: figuring out more ways to burn fossil fuel. That's what we do; that's who we are. If an alien landed in the United States, they'd doubtless send word back to headquarters that they'd discovered a race of flesh-colored devices for combusting coal and gas and oil.

The year 2009 is such an interesting moment because after 20 years of thinking and talking and worrying about global warming, the world is finally edging closer to actually doing something about it. In December, the world's leaders meet in Copenhagen to negotiate a new climate treaty. Since "doing something" about the climate can only be defined as weaning ourselves off that coal, gas, and oil, any effective treaty will in essence reboot civilization. If all goes well, 2009 will be the watershed year—the year the planet begins to turn its back on one way of doing business and starts to finally embrace a new way.

Does this sound like overstatement? It almost certainly is, at least in the sense that we won't notice huge shifts immediately. The built infrastructure can't change overnight, but if the political system manages to actually stick a real price on carbon, then our sense of the future will alter. Anyone building a new house or factory will suddenly have to imagine a world very different from the past or present: a future where the design will need to make sense for the world 40 years hence. The force of economic gravity will shift. What used to sink will suddenly float. Even our sense of identity will shift. Look at what happened in 2008 when the price of gasoline briefly skyrocketed. All of a sudden, millions of Americans discovered that they weren't forest rangers after all, and maybe didn't need 18 inches of clearance and a winch in order to get the groceries.

Which is why it's fine to be optimistic—but only cautiously. Because just as human assumptions are finally starting to change, so are basic physical



[a](#) Watch an animated video about 350.org and an interview with Bill McKibben at greensourcemag.com

WE'VE
LEARNED
THAT CLIMATE
CHANGE IS
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conditions. We used to think that climate change was going to take a while. Twenty years ago, when I wrote the first book on the issue, we thought it would be mid-century before we really saw big shifts. We underestimated how finely balanced the planet is, an illusion that finally had to crumble in the summer of 2007 when Arctic ice suddenly melted, decades ahead of schedule. Since then, we've seen the rapid spread of drought across Australia and the Southwest, the sudden destruction of western Canada's pine forests, the acidification of the oceans and worse. We've learned that climate change is not a future problem, not something for our kids to solve. It's a current crisis, one that our parents should have foreseen.

In essence, we're running a race. Will we change fast enough? Can we shift our economies as quickly as science demands? Everyone can see where we'll need to be in 100 years—a world of solar and wind power. The question is, will it take that long? If it does, global warming wins. Instead of a clean energy future, we have a future filled with disaster and tragedy.

Humans too often imagine that they're living in historic times, that their moment is special. Ours actually is—which means we better rise to the occasion. **GS**

Bill McKibben, a scholar in residence at Middlebury College, is coordinating the 350.org global campaign for climate action.

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