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Building Information Modeling and Green Design

IN A PERFECT WORLD, ENERGY simulations and design tools would be so well integrated that each time an architect moved a wall, added a window, or changed a lighting specification, the building's predicted energy performance would be updated and displayed instantly. With that sort of real-time feedback, designers would quickly become skilled at optimizing the energy performance of their designs, and new buildings would be rapidly approaching carbon neutrality. Along the way, other aspects of a building, such as how well it uses daylight, how procuring its material will affect the planet, and even how much it will cost to build, could be similarly tracked and optimized. And all of this would be done while sharing a design seamlessly across disciplines.

That world has not yet arrived, and the path to it is strewn with obstacles. But in some settings it is becoming tantalizingly close, thanks to the convergence of data-rich, three-dimensional (3D) design tools, ever-faster computers, and accepted protocols for sharing digital information about buildings across platforms. In spite of the significant investment that designers and contractors have to make to adopt building information modeling (BIM), they are flocking to it because it can reduce errors, streamline costs, and improve the performance of a facility in dozens of ways, not least of which is green performance.

(continued on p. 12)

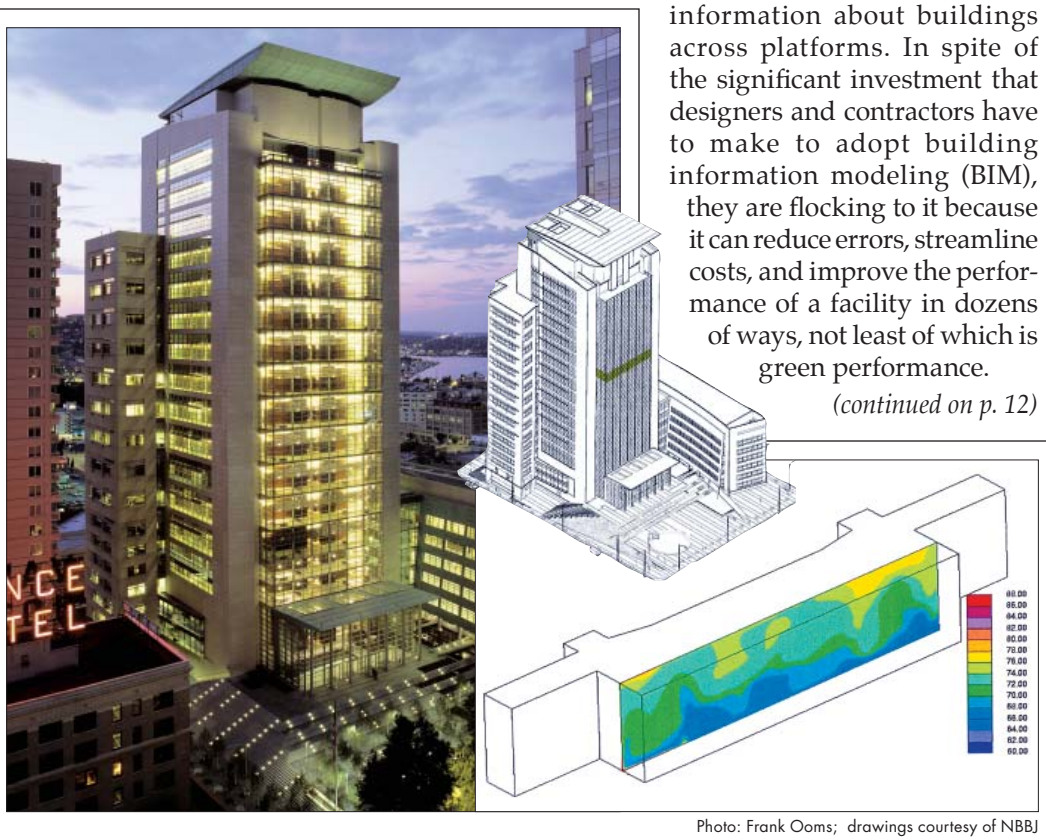

Photo: Frank Ooms; drawings courtesy of NBBJ

When designing the U.S. Federal Courthouse in Seattle, NBBJ and its consultants used computer modeling to analyze air temperature distribution to determine the benefits of displacement ventilation in the courtroom lobby, halfway up the tower (indicated with a green stripe on the drawing).

In This Issue

Quote of the month:

"There is a lot of art to the science of energy modeling. You can't just take an architectural model and run a thermal analysis on it."

Kevin Pratt, KieranTimberlake

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Environmental Building News

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USGBC Report Supports Screening of PVC

Much has changed in the U.S. Green Building Council's Technical Scientific Advisory Committee [TSAC] final report on PVC [see *EBN* Vol. 16, No. 3]. In this round, TSAC expanded its analysis to account for life-cycle issues that traditional LCA (life-cycle analysis) tools often miss, such as disposal issues and occupational exposures, and found that PVC leads to the release of dangerous quantities of dioxin and other carcinogens. The report authors specifically found that "when we add end-of-life with accidental landfill fires and backyard burning, the additional risk of dioxin emissions puts PVC consistently among the worst materials for human health impacts."

TSAC looked at a range of health and environmental impact indicators and provided in its report a low, average, and high estimate for each category. Predictably, the results vary depending upon which estimates are used. Even using the low-end estimates, PVC is rarely superior in any product type. Low-end estimates are not, of course, protective of human health. Taking a precautionary principle approach to examining the report's data using the average and high estimates of impact for all materials leads to the following conclusions:

- In the report's cancer ranking, PVC is consistently the absolute worst for each of the four product types studied. On the report's total human health ranking, PVC consistently comes out either tied for worst or absolute worst.
- In the report's environmental ranking, PVC's performance is mixed—still absolute worst in the case of flooring, compared with both VCT and sheet vinyl—but better than one alternative and roughly equal to the other alternatives in the other three cases studied. Specifically it ranked better on environment than cast-iron pipes, aluminum siding, and aluminum windows and not significantly different from ABS pipes, wood windows, wood siding, and fiber-cement siding.

Overall one can conclude that screening out PVC will lead to consistently better cancer and overall health results. Other environmental impacts will vary depending upon the material chosen, requiring other screening approaches.

Instead of recommending a specific credit on PVC alone, the report recommends issue-based credits, specifically suggesting "comprehensive approaches to issues such as bioaccumulative pollutants," an approach that has been gaining momentum in healthcare green design in recent years, screening out materials based on a suite of persistent bioaccumulative toxicants, like dioxin, halogenated flame retardants, heavy metals, and perfluorocarbons.

The report represents an important step for the Council and LEED in signaling the importance of addressing health issues and precaution across the full life cycle of materials.

Tom Lent, Policy Director
Healthy Building Network
Washington, D.C.

Letters Policy

Environmental Building News welcomes your letters and prints them when space allows. We reserve the right to edit for length, clarity, and style. We review any substantive changes with the author prior to publication. Priority is given to letters that reference a recent article, bring new information to our readers, and make their points in 300 or fewer words.

What's Happening

White House Aims to Curtail Federal Energy Use

Noting that "it is the policy of the United States that federal agencies conduct their … missions in an environmentally, economically, and fiscally sound, integrated, continuously improving, efficient, and sustainable manner," President George W. Bush signed an executive order titled "Strengthening Federal Environmental, Energy, and Transportation Management" (EO 13423) in January 2007. In early April, the White House's Council on Environmental Quality issued instructions that explain the implementation requirements for federal agencies.

The order both consolidates and expands the federal government's internal environmental policies, said Alison Kinn Bennett, co-chair of the U.S. Environmental Protection Agency's Green Building Workshop.

The order introduces some substantive changes. Notably, it increases the goal of reducing energy use in federal facilities from 2% per year to 3% per year through fiscal year 2015, or 30% total by the end of fiscal year 2015 relative to a 2003 baseline. It requires federal agencies to reduce their water consumption by 2% per year through fiscal year 2015, or 16% total by the end of fiscal year 2015 relative to a 2007 baseline. It also ensures that new construction and major renovations comply with the principles established by the 2006 "Federal Leadership in High Performance and Sustainable Buildings" memorandum of understanding.

Executive Order 13423 also addresses transportation, requiring agencies with vehicle fleets to reduce petroleum fuel consumption with several strictures.

While many environmentalists praised the new executive order, some criticized it. According to the Alliance to Save Energy (ASE), the new goals "overlook the largest single source of federal petroleum use and greenhouse gas emissions, which is not from fixed facilities or fleet vehicles but from petroleum use by vehicles, aircraft, and ships—mainly those used by the military."

ASE also complains that the order is weaker than the Energy Policy Act of 2005 requirements for buildings (see *EBN* Vol. 14, No. 9). "Further policy guidance to federal agencies … must make it clear that the broader environmental management directives in this executive order do not override or weaken the more specific, statutory provisions for federal energy management in the Energy Policy Act of 2005," said ASE, in a prepared statement.

– Jessica Boehland

For more information:

Instructions for Implementing
Executive Order 13423
Council on Environmental Quality
www.ofee.gov/whats/eo13423.pdf

Home Depot Rolls Out Green Labeling

The building-products retailing giant Home Depot launched a labeling initiative in April 2007, called EcoOptions, to identity environmentally preferable products in all of its U.S. stores. The program identifies more than 2,500 products as having better environmental performance than other products in their class. Large signs in store aisles point the way to these products, which are marked with tags describing their environmental benefits in one of five categories: sustainable forestry, energy efficiency, healthy home, clean air, and water conservation. To qualify for the EcoOptions label, a product must meet recognized labeling standards, such as by those Energy Star or the Forest Stewardship Council (FSC), or it must go through an examination of its environmental claims by Scientific Certification Systems (SCS).

According to Chet Chaffee, vice president of environmental programs at SCS, his company has been working with Home Depot since 1992 to verify environmental claims, starting with certified wood (see *EBN* Vol. 2, No. 4). "It's not like they come new to this," he said. "They've just been doing most of it internally. [Now] they're externalizing all that work of the last 15 years." Chaffee said that SCS's role in the new program expands on its previous technical advisory work: "They send us vendors that don't fit the five categories or where the claims don't fit into accepted standards," he told *EBN*. According to Chaffee, SCS will investigate manufacturers' environmental claims to recommend whether a product is suitable for the EcoOptions label; Home Depot will make the final decision.

EcoLogo products are being prominently displayed at the ends of aisles in Home Depot stores; signs throughout the store point customers towards environmentally preferable products. Photo: Home Depot

Tony Wilbert, public relations manager for environmental programs at Home Depot, said that the company is also working with manufacturers directly to encourage more environmentally friendly products: "We've told them that if there are two manufacturers, and one is green, and the price is pretty similar, we'll choose the green product," he said. According to Wilbert, Home Depot is already the largest purchaser of FSC-certified wood in the U.S. and hopes to use its purchasing power in other areas as well, with plans to include at least 6,000 products in EcoOptions, accounting for $2.7 billion in sales, about 3% of the store's annual sales of $90.8 billion.

Wilbert admits that getting consumers to buy EcoOptions products may be a challenge. Citing compact fluorescent lamps (CFLs) as an example, he said that "price is the first hurdle" when customers are used to paying much less for an incandescent lamp. Home Depot now lists the potential lifetime savings on the packages of its own brand of CFLs, N:Vision. Wilbert noted that the primary goal of the EcoOptions program is to educate consumers about their choices. "We want the consumer to be able to walk in the door and have options for saving energy" and make other environmentally conscious choices, he said.

– Allyson Wendt

For more information:

The Home Depot
Vinings, Georgia
www.homedepot.com/ecooptions/

Appraising Green in Vancouver

Efforts to include green building features in a project are often hampered by a lack of support from lenders, particularly due to poor understanding of how to appraise those features. The Vancouver Valuation Accord, a memorandum signed in March 2007 at the Vancouver Valuation Summit in Vancouver, B.C., may bring change to green building by integrating environmental awareness into the standards governing real estate appraisal (called *property valuation* in the U.K. and Canada).

Photo : GLOBE Foundation

Sandy Wiggins, chair of the U.S. Green Building Council, speaks at the Vancouver Valuation Summit.

Real estate appraisal standards are governed in the U.S. by the Appraisal Foundation; worldwide, the U.K.'s Royal Institution of Chartered Surveyors (RICS) is the most prominent organization. Both organizations support the accord. "To the extent that sustainability is either legislated or used in the market or is part of everyday life, it gets captured" in existing standards governed by those groups, according to Chris Corps, president of Asset Strategics, of Victoria, B.C., and past chair of RICS. The Vancouver initiative will look more thoroughly at more innovative green building practices, said Corps, where "translation to value is unclear."

Discussing a green roof as an example, Corps said, "How valuable is it? There are extra costs up front but a longer life cycle. Better thermal properties, but it requires more maintenance." Corps noted that while capital expenditures affect one set of accounts, maintenance and operations typically affect a different set of accounts. The green roof also affects the saleability and hence the value of a building. For example, some companies won't insure buildings with green roofs, presenting a major obstacle to property transfer and hence value.

Kevin Hydes, P.E., former chair of the U.S. Green Building Council (USGBC) and a signatory to the accord as chair-elect of the World Green Building Council, told *EBN*, "This is about two similar buildings standing side by side. One's green, one's not, and right now those buildings are valued at the same price." Hydes argued that "the owner-occupant can find ways to benefit from green investments" by making capital investments that reduce operating costs. But for investors to adopt green building strategies, there must be increased recognition of the value of those capital investments, so that they can sell and earn a return.

By establishing more complete standards, Corps said, "the banks, the investors, and the entrepreneurs are armed with the information they need. You are enabling sustainability to expand because the incentive is clearer." However, the accord will take a neutral stance toward environmental responsibility. "This is not about an advocacy position—this is about a neutral and dispassionate review of sustainability and the linkage back to value," Corps told *EBN*. He added, "I expect that by being neutral we'll find that a lot of sustainability is actually extremely financially sensible."

Supporters included British Columbia Premier Gordon Campbell; the

Appraisal Institute, the most prominent U.S. membership organization of appraisers; the Globe Foundation of Canada; the Canada Green Building Council; and USGBC. Representatives from 20 countries attended. Although the Vancouver Accord set the policy course for the group, "we're now defining what its work program will be," said Corps. Participating groups will likely undertake a variety of tasks, he added, including examining and publishing case studies, writing white papers, and building networks to spread knowledge. The signatories of the accord will work on the initial program through 2010, when a progress report is planned.

"Sustainability has grown partly because of altruism and partly because it's effective," Corps told *EBN*. "This is moving it into possibly a new phase. Knowledge of the financial implications will arm people to actually do it."

– Tristan Roberts

For more information:

Vancouver Valuation Summit
The Globe Foundation of Canada
Vancouver, British Columbia
604-775-7300, 800-274-6097
www.vancouveraccord.org

3M Guarantees Product Won't be Banned

3M, the diversified technology company, recently announced a warranty for its Novec 1230 Fire Protection Fluid that appears to be a first for the industry. 3M's 20-year Blue Sky Warranty guarantees that if use of Novec 1230 is banned or restricted due to ozone-depletion or global-warming potential, 3M will refund the purchase price.

Fire protection systems made by companies like Tyco, Siemens, and United Technologies often use "clean agents" like Novec 1230. The chemical is liquid at room temperature, but those systems expel it as a gas, and it disperses into the atmosphere instead of reconstituting as a liquid. Controlled environments such as rooms with high-value electronics, ships, generator rooms, pump rooms, paint lockers, and museums often use these systems rather than sprinklers. 3M markets Novec 1230, a fluoroketone, as an environmentally preferable choice over halons, production of which is banned due to ozone-depletion potential, and hydrofluorocarbons, or HFCs, which have a high global-warming potential (GWP). GWP measures the estimated potential of a greenhouse gas to contribute to global warming, compared with carbon dioxide. According to 3M, Novec 1230 has zero ozone-depletion potential, a GWP value of one (equal to that of carbon dioxide), and an atmospheric lifetime of five days, as having low acute and chronic toxicity.

Joe Koch, 3M's business manager for Novec fluids, said that consumers of fire protection fluid have been bounced from halons to HCFCs and HFCs, and environmental concerns now are arising with those chemicals. "Novec 1230 has been on the market for a few years now," said Koch, "and we look at it as a sustainable product in the long-term." The 20-year warranty term is somewhat arbitrary, Koch told *EBN*, although, since the average system life is shorter than that, it is "long enough to be meaningful," he noted.

"I don't think they're taking much risk with the guarantee," said Mark Trexler, Ph.D., director of EcoSecurities Global Consulting Services and an expert in corporate planning for climate change mandates. "The fact that the compound was engineered so that it didn't pose GWP or ozone depletion issues is very interesting," he said, but "it doesn't look like there is any risk of regulation of that particular compound."

Whether or not 3M is taking any risk with its warranty, it has been ahead of the curve previously on environmental issues like the human health problems with the chemical it previously used to make its popular Scotchgard products. Even if it is little more than an innovative marketing ploy, this approach suggests an interesting model for producer responsibility in general.

– Tristan Roberts

For more information:

3M
St. Paul, Minnesota
888-364-3577, 651-737-6501
www.3M.com/novec1230fluid/

A fire protection system releases 3M's Novec 1230 fluid, which 3M warranties against environmental regulation. Photo: 3M

Cradle to Cradle Recognized in LEED

Products earning Cradle to Cradle (C2C) certification, a multifaceted program run by McDonough Braungart Design Chemistry (MBDC), are now recognized in the LEED Rating System, following an April 2007 ruling by the U.S. Green Building Council (USGBC). The new "administrative credit interpretation ruling" allows projects to earn a LEED credit if at least 2.5% of the building's materials, by cost, are C2C-certified.

The stated purpose of the ruling, which was posted on USGBC's website for LEED users, is to "stimulate the development of environmentally focused product evaluation and certification tools for use by building professionals." The 2.5% threshold incorporates some adjustments to the calculation to account for different C2C certification levels. The cost of products certified at the lower levels—as Silver or as technical or biological nutrients—is discounted by half. The cost of products at the middle level, Gold, is not adjusted, while the cost of Platinum products, C2C's highest and so far unattained level, is doubled for the calculation (see *EBN* Vol. 16, No. 2 for more on C2C).

USGBC's decision was made as an approval of an innovation credit, avoiding the more extensive review and balloting required for a new credit. No registered LEED projects appear to be pursuing the credit yet. The ruling was reviewed by USGBC's Materials & Resources Technical Advisory Group (MR TAG; *EBN* editor Nadav Malin is chair). Despite the ruling's affirmation of C2C, it includes several caveats, notably that "TAG has concerns about the lack of transparency in the C2C certification process."

For Tom Hicks, who oversees LEED, the C2C ruling is an example of USGBC's focus on continuous improvement. "In the past, if a good idea came about, we were looking at the next iteration of the rating system," which could take years. "We're looking for ways to make the system more nimble," he told *EBN*, noting the potential for other programs to follow in C2C's footsteps. Referring to USGBC's intent to integrate life-cycle assessment (LCA) into LEED, Hicks added, "We are also interested in addressing health and other impacts [of products] not directly addressed in LCA work." C2C evaluates products in five areas, taking in an array of environmental and human health factors.

The decision appears to represent a continued strengthening of ties between MBDC cofounder William McDonough, FAIA, and USGBC, following his keynote address at the 2006 Greenbuild conference. Neither McDonough nor MBDC chose to comment for this article, pending an official announcement.

– Tristan Roberts

Newsbriefs

Firms Accredited to Perform SFI Certification Audits—The Sustainable Forestry Initiative (SFI) announced in March 2007 that four firms have achieved accreditation by the American National Standards Institute (ANSI) to perform chain-of-custody certification audits for SFI and the Programme for the Endorsement of Forest Certification (PEFC) sustainable forestry certification systems. PEFC is an international certification group, with SFI as its designated U.S. affiliate. The four accredited firms are Bureau Veritas Certification North America, KPMG Performance Registrar, NSF International, and the Quality Management Institute. By separating its standards-writing body from the certification process, SFI, which has been closely linked with the forest products industry, has added a new facet of independence. SFI's website is at www.sfiprogram.org.

Insurance Company Recognizes Solar Power Backup System—Fireman's Fund, a major national insurance company, has announced that it will give the same policy discount to homes with a solar-powered backup power system as it gives to homes with backup generators. The company's 2% policy credit for conventional backup power systems will apply to homes using the GridPoint Connect Series from GridPoint, Inc. The GridPoint system uses photovoltaic panels to generate grid-tied electricity while also using batteries to store energy for power outages. Fireman's Fund customers can also earn a 20% discount on GridPoint systems—similar to discounts offered for conventional fossil-fuel systems. The program is currently available to customers in twelve states. Fireman's Fund also plans to announce a similar program for homeowners who install leak-detection systems—another product that combines reduced risk for claims with environmental benefits.

Photo: GridPoint

The GridPoint Connect Series uses PV power as a backup power source in homes.

Energy Star to Stop Certifying Programmable Thermostats—Energy Star, the federal energy efficiency program, has announced that it will no longer certify programmable thermostats. According to Energy Star spokesperson Jill Abelson, the thermostats have the potential to save homes $150 or more yearly when used properly, but in practice, homes with programmable thermostats don't consume less energy compared with homes without them. Presence of the thermostats has even been associated with higher energy use in some studies. "Consumer confusion persists around whether programmable thermostats inherently save money or whether proper use is a factor," said Abelson. She said that Energy Star would transition during 2007 to an "educational partnership" with manufacturers and retailers, which may allow products to carry a modified Energy Star label, rather than to a performance-based specification program. More information is at www.energystar.gov/index.cfm?c=revisions.thermostats_spec/.

New Mexico Governor Signs Green Home Tax Incentive—New Mexico building owners can now earn an income tax credit for building or renovating a green building. Tax credits for residential buildings range from $4.50–$9.00 per square foot ($50–$100 per m^2) for the first 2,000 ft^2 (186 m^2) depending on the rating a building receives through the U. S. Green Building Council's LEED Rating System or through the Green Building Initiative's Build Green New Mexico rating system. Commercial buildings are assessed using LEED only, and the rates per square foot are priced differently. Although other tax incentives have targeted green buildings, this is among the first in the country to target individual homeowners as well as businesses. The credit, which is in effect through 2013 and is retroactive to January 2007, was part of a renewable energy bill signed by Governor Bill Richardson on April 3, 2007.

California Design Firm Heads for Zero Energy—Integrated Design Associates (IDA), a lighting design and electrical engineering firm in Santa Clara, California, is renovating a former bank in San Jose to house its new headquarters. IDA hopes that the formerly windowless concrete building will be the first commercial building to provide for all of its own energy needs through an onsite photovoltaic (PV) array, which will power all systems in the building, including heating. The grid-connected building has a 30-kilowatt array on its rooftop and is expected to use 56,000 kilowatt-hours of electricity annually. Designed by EHDD Architecture, the renovated building will feature skylights for interior daylighting, windows for occupant views, and outdoor patios for informal gatherings. Currently in the final stages of renovation, with the PV array installed, the building should be completed by June 2007. More information is available at www.ideasi.com.

For its new office space, Innovative Design Associates is renovating a former bank—a windowless concrete building—and installing a photovoltaic array on the roof to provide for all of the building's energy needs. Photo: EHDD Architecture

Greenguard Meets CHPS Standards—The Collaborative for High Performance Schools (CHPS) has recognized the Greenguard Children and Schools product certification program from the Greenguard Environmental Institute (GEI) as a means of improving indoor air quality in school buildings. GEI's product certification program complies with California's Department of Health Services Standard Practice for testing chemical emissions from products and therefore meets the requirements set out in the CHPS best practices manuals. The Greenguard Children and Schools program, started in 2005, tests products against emissions criteria that were created with the needs of children in mind. For more on both programs, visit www.chps.net and www.greenguard.org.

NYC Green Schools Guide Released—The New York City (NYC) Department of Education and the NYC Construction Authority have announced the release of the NYC Green Schools Guide and rating system, designed to bring new school construction projects into compliance with Local Law 86, which sets green building requirements for all public buildings in the city. The new rating system combines elements from both LEED for Schools and the Collaborative for High Performance Schools (CHPS) with some new aspects. Certain credits in the new system are required for all projects, while others are required if feasible (design teams must provide reasons acceptable to the certifying body to avoid fulfilling these credits). For example, credits pertaining to low-emitting materials are required of all projects, while credits pertaining to daylighting and views are required if feasible. The Green Schools Guide is

available online at http://schools.nyc.gov/offices/sca/doingbusiness/.

U.N. Report Connects Buildings and Climate Change—A report from the United Nations Environment Programme, titled "Buildings and Climate Change: Status, Challenges, and Opportunities," details connections between the building industry and efforts to curb greenhouse gas emissions. According to the report, which focuses primarily on Europe, more rigorous energy efficiency standards there could result in a reduction of one-fifth of the continent's energy use and 50 million tons (45 million tonnes) of carbon dioxide by 2010. The report emphasizes policy, regulation, and education as the primary means of pursuing green building efforts and recommends a global benchmark that could be used to develop national and regional green building standards. The report is available for download at www.unepsbci.org.

Washington Bans PDBEs—A bill passed by the Washington State Legislature places a limited ban on the use and sale of all polybrominated diphenyl ether (PBDE) flame retardants. The legislation includes a widespread ban, effective January 1, 2008, on the octa and penta forms of PBDE, which were voluntarily discontinued by the sole manufacturer, Great Lakes Chemical Corporation, in 2005 (see *EBN* Vol. 14, No. 2). The bill also includes a more limited ban on the deca form of PBDE, prohibiting its use in mattresses, residential upholstered furniture, and televisions and computers; another deca ban, passed in Europe in 2006, is limited to electronics. The deca ban, however, is subject to the findings of the Department of Health and a fire-safety committee, both of which will search for an alternative flame retardant that meets fire-safety standards. If an alternative is found by December 2008, the ban will go into effect in 2011; if not, the flame retardant will be allowed in the state until an alternative is discovered. For more on flame retardants, including PBDEs, see *EBN* Vol. 13, No. 6.

Public Transit Gaining Ground—According to the American Public Transportation Association (APTA), Americans took more than 10 billion trips on local public transportation in 2006, reaching the highest level since 1957. Ridership was up 3% between the end of 2005 and the end of 2006, and up 28% in the decade since 1996. Over the last decade, the growth rate of public transit ridership outpaced that of both U.S. population and vehicle miles traveled on U.S. highways. The full report is online at www.apta.com.

RMI Announces New CEO—Michael Potts has replaced Amory Lovins as CEO of the Rocky Mountain Institute (RMI), the Colorado-based nonprofit and self-described "think and do tank." Potts has been a member of RMI's board of trustees since 2005. He previously served as CEO of software design company American Fundware, and, most recently, as a managing partner at Galway Investments. RMI cofounder Lovins relinquished his position to become chairman and chief scientist of the 25-year-old organization, which promotes environmental responsibility through energy policy, technology research, and education.

Awards & Competitions

AIA Announces Top Ten —Plus Four—Green Projects for 2007

The American Institute of Architects (AIA) Committee on the Environment has selected ten winners and four honorable mentions in its 2007 Top Ten Green Projects competition. Full project descriptions are online at www.aiatopten.org and in *BuildingGreen Suite*.

The Top Ten

• **EpiCenter, Artists for Humanity** (Boston; Arrowstreet, Inc.)—This 23,500 ft^2 (2,180 m^2) LEED Platinum gallery and studio space has a 49-kilowatt grid-connected rooftop photovoltaic array that provides for all of the building's electrical needs. Young employees at Artists for Humanity encouraged the organization to build a green building; the site was chosen in part to help revitalize an urban neighborhood. Daylight reaches deep into gallery and studio spaces, and natural ventilation helps ensure good indoor air quality.

• **Heifer International Headquarters** (Little Rock, Arkansas; Polk Stanley Rowland Curzon Porter Architects)—Part of a four-phase master plan to revitalize a brownfield site, the 94,000 ft^2 (8,700 m^2) headquarters is surrounded by a constructed wetland. Harvested rainwater is stored in a 42,000-gallon (160,000-l) storage tank situated in the middle of

Photo: Timothy Hursley

Heifer International Headquarters

a fire stair, making the water collection highly visible. Daylight features prominently in the narrow building, with low interior partitions bringing it deep into the interior.

• **Global Ecology Research Center** (Stanford, California; EHDD Architects)—Housing the Carnegie Institution, this 10,800 ft² (1,000 m²) laboratory and office building features extensive daylighting, shading, and natural ventilation, as well as night-sky radiant cooling. These and other energy-efficiency measures reduce the carbon dioxide emissions associated with building operations by 72%, compared with a conventional building. Salvaged and recycled materials, including redwood siding from wine vats, were used extensively throughout.

• **Hawaii Gateway Energy Center** (Kailua-Kona, Hawaii; Ferraro Choi and Associates)—The first building of a research campus for the Natural Energy Laboratory of Hawaii, this 3,600 ft² (330 m²) LEED Platinum visitor center was designed as a thermal chimney, moving air through the building at 10 to 15 air changes per hour without a mechanical system. Incoming air passes over a coil filled with water drawn from deep in the ocean, providing space cooling and dehumidification. A 20-kilowatt photovoltaic system generates all of the electricity used by the facility.

• **Government Canyon Visitor Center** (Helotes, Texas; Lake Flato Architects)—Situated at the entrance to an 8,600-acre (3,500-ha) protected aquifer recharge area, this 4,250 ft² (395 m²) education center features water conservation in its architecture with an extensive rainwater harvesting system. The main exhibit hall opens to the outdoors to limit the amount of conditioned space; rolling screens and overhangs protect visitors from rain and sun.

• **Sidwell Friends Middle School** (Washington, D.C.; KieranTimberlake Associates)—The goal for the 39,000 ft² (3,600 m²) LEED Platinum addition to, and renovation of, this school, originally built in 1950, was to teach environmental responsibility by example. A green roof reduces stormwater runoff; excess water flows into a biology pond on site. Building orientation and screens limit solar heat gain while allowing daylight into classrooms. A constructed wetland processes wastewater, which is used in toilets and cooling towers.

Photo: Chris Cooper

The Government Canyon Visitor Center

• **Wayne L. Morse U.S. Courthouse** (Eugene, Oregon; Morphosis and DLR Group)—The designers of this 267,000 ft² (24,800 m²) LEED Gold courthouse had to balance environmental goals with security requirements, resulting in creative uses of space indoors and landscaping outdoors. Parking was placed underground, creating space for barriers between the road and the building, which contain native plantings. Indoor spaces take full advantage of daylighting; even courtrooms, normally surrounded by offices and cut off from views, are lit naturally.

•**Whitney Water Purification Facility** (New Haven, Connecticut; Steven Holl Architects)—This 140,000 ft² (13,000 m²) facility houses offices aboveground with water purification facilities below, maintaining as much open space as possible on the site and allowing gardens and a restored wetland to filter stormwater. A ground-source heat pump provides heating and cooling for the building, and the water-processing facility's gravity-fed processing lowers energy needs.

• **Z6 House** (Santa Monica, California; Ray Kappe and LivingHomes)—This 2,480 ft² (230 m²) modular home features natural ventilation, a photovoltaic array, a green roof, and rainwater harvesting. Sliding panels indoors allow rooms to be connected to or separated from central common spaces, creating a flexible living space that can change with occupants' needs. Recycled and rapidly renewable materials were used extensively, and the modular design (with construction in a factory) reduced construction waste. (See *EBN* Vol. 15, No. 10 for more details.)

• **Willingboro Master Plan and Public Library** (Willingboro, New Jersey; Croxton Collaborative Architects)—Part of a larger plan to revitalize an abandoned strip mall, this 48,700 ft² (4,530 m²) library reused the structural steel frame of a Woolworth's store. In addition to creating an open, daylit interior, the project team replaced portions of the asphalt parking lot with trees and vegetated swales, reducing stormwater runoff.

Honorable Mentions

- **Gerding Theater at the Armory**—Portland, Oregon; GBD Architects
- **Provincetown Art Association and Museum**—Provincetown, Massachusetts; Machado and Silvetti Associates
- **Stillwell Avenue Terminal Train Shed**—New York City; Kiss + Cathcart Architects
- **William J. Clinton Presidential Center**—Little Rock, Arkansas; Polshek Partnership Architects

Product News & Reviews

Measuring Solar Access with the Solmetric SunEye

Assessing solar access is a critical step in designing installations of solar water heating panels and photovoltaic (PV) modules, and in siting passive solar buildings. Until recently, we've had only manual tools to support that assessment, most notably the industry standard Solar Pathfinder (www.solarpathfinder.com). With Solar Pathfinder, a user looks down at a transparent, plastic, fisheye globe (mounted on a tripod and leveled) that allows the user to see through and trace the reflected horizon or any solar obstructions on latitude-specific template papers placed under the globe.

Now, Solmetric Corporation has digitalized this process with its SunEye—a sophisticated, easy-to-use tool for measuring solar shading and calculating monthly and annual solar access. The SunEye includes a built-in digital camera with a fisheye lens. A user holds the SunEye or mounts it on a tripod, keeping it level using a built-in bubble-level and orienting it to the south using the built-in compass, then clicks to take a photo. The heart of the system is a Hewlett-Packard iPAQ processor that captures and computes the digital image data.

A straightforward interface allows the user to calculate the percentage of solar access, graphically showing the obstructions by time of day and month, and to simulate removal of the solar obstructions by erasing those areas on the digital image—to show the effect of cutting down a tree, for example. Digital files can be processed in the field or uploaded to a Windows computer (Macintosh interface not yet available) for review and printing.

SunEye users expressed enthusiasm to *EBN*. "We're really happy with it," said Jeremy Smithson of Puget Sound Solar in Seattle. Smithson has been using the SunEye since October 2006 and told *EBN* that it cuts about an hour from a typical site investigation. With an average of four site assessments per week, the SunEye's $1,355 price was not a problem. "For me, it paid for itself pretty quickly," Smithson said. He installed over 60 PV and solar hot water systems last year and expects to put in 80–100 this year.

The SunEye uses digital camera technology and a sophisticated processor with computer interface to assess solar access quickly and easily. Photo: Solmetric

Richard O'Connell, of O'Connell Solar Company in Rohnert Park, California, purchased the very first production model SunEye in August 2006 as soon as he heard about it. He'd been using the Solar Pathfinder for six years and had wondered when someone would come up with a digital version that was easier to use. "It's an invaluable tool for solar installers and designers here in California," he said, because of the specific calculations that are required for participation in the California Solar Initiative (see *EBN* Vol. 15, No. 2). "The SunEye takes the guess work out of those calculations and provides a hard copy of the actual site survey," he told *EBN*. Also, California law protects solar access (preventing someone from building a shed or planting a tree that will block access), and he thinks the SunEye "will undoubtedly stand up in a court of law should that be an issue in the future." Like Smithson, he had no problem with the cost. "I didn't think twice about purchasing this unit," he said.

Jonathan Cohen of Imagine Energy, a solar design, engineering, and installation firm in Wilsonville, Oregon, called the SunEye "a great sales tool to show potential customers the effect of shading elements in full color." It doesn't hurt that the product looks cool during site visits! None of the users *EBN* spoke with have had any problems with the SunEye, and they spoke highly of Solmetric. The company has also provided regular software upgrades at no cost. "The support staff is great," said Cohen.

The SunEye was invented by Solmetric president Willard MacDonald, an electrical engineer who worked previously as a senior design engineer for the test and measurement company Agilent Technologies (a Hewlett-Packard spin-off), where he helped to develop precision electronic measurement devices. In addition to the SunEye's performance features, the manufacturing is remarkably green. It makes extensive use of recycled materials and components, including the unit's main processor, according to director of marketing Daniel Weinreb, who demonstrated the product for *EBN* staff. To date, the young company has sold about 150 units, with interest growing quickly.

– Alex Wilson

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Clean Concrete—and Air—with TX Active

The remarkable ability of titanium dioxide (TiO_2) to refract, or bend, light makes the substance suitable for myriad applications, including pigment in paint, paper, plastics, cosmetics, and food; a light-blocking ingredient in sunscreen; and a UV-reflector in applications including ceramics and glass. In addition, some TiO_2 molecules in a material release an electrical charge at the material's surface upon absorbing sunlight. That charge forms highly reactive radicals that oxidize nearby compounds, including organic and some inorganic substances. This photocatalytic reaction occurs without degrading or "using up" the TiO_2.

TX Active, a line of concrete products from Essroc, harnesses both TiO_2's pigmentation and photocatalytic properties. TX Arca is Essroc's "architectural line" of cement products, offering a bright white, self-cleaning surface. TX Aria, the "environmental line," is specially formulated to remove pollution from the surrounding air in addition to offering a white surface. Both are available in a variety of products, including precast architectural panels, pavers, and cementitious plaster.

The Jubilee Church in Rome uses TX Active precast concrete panels, which integrate titanium dioxide for a bright white, self-cleaning surface. Photo: Italecementi Group

"This technology can be used anywhere a cementitious product appears," said Dan Schaffer, product manager for TX Active, but "it's not cost-effective to use it in a whole homogeneous product," such as a structural cement pour. Precast panels using TX Active, for example, use 6 inches (15 cm) of conventional concrete, covered with a 2-inch (5 cm) surface layer incorporating TX Active. Six-inch concrete pavers use a 0.3-inch (8 mm) surface coating of TX Active concrete. Precast panels made with TX Active usually come with a 10%–15% cost premium, said Schaffer. They are manufactured in Front Royal, Virginia, with the TiO_2 coming from France, and can be shipped throughout North America, said Schaffer, although for now, shipping to the Northeast is most affordable.

TX Active has been available in Europe for years—Essroc is owned by Italecementi, an Italian company—and a number of buildings have used it there, including the Jubilee Church in Rome, designed by Richard Meier, FAIA, and known for its brilliant precast panels. It is just starting to appear in North America, according to Schaffer. Neils Valentiner at VBCO Architects in Salt Lake City has specified it for the renovation of a religious complex in Mexico City. According to Valentiner, air pollution and regular power-washing have exacerbated installation defects, leading to deterioration of existing precast panels. "We have specified the TiO_2 primarily for the self-washing capabilities," said Valentiner, who expects a 12-year payback from the panels when power-washing expenses are considered.

The most exciting aspect of the TX Active line, however may be the TX Aria products, which Essroc claims improve surrounding air quality. "TX Aria will clean itself and mitigate many compounds found in the air," said Schaffer. Essroc backs that claim with several studies, including the 3.4 million euro ($4.6 million) PICADA (Photocatalytic Innovative Covering Applications for De-Pollution Assessment) project, a four-year research program supported by the European Commission and a group of universities and companies, including Essroc. Most of these studies have focused on the effect of photocatalytic cement or coatings on nitrogen oxide (NO_X) pollution produced by vehicle traffic. In some cases, the cement has demonstrated a greater than 50% reduction in surrounding NO_X pollution. Said Schaffer, "Our owners did some calculations and figured that if we covered 15% of the [exterior] surfaces in Milan, it would reduce pollution in that city by 50%."

However, there is no standard test or measurement for defining the depolluting efficacy of a photocatalytic concrete surface. The effect varies with light levels and air movement, and so changes significantly with daily and

seasonal patterns. Roger Atkinson, Ph.D., a professor at the University of California–Riverside and an air pollution researcher, told *EBN* that he was not familiar with TX Active but that "it will have some effect on the chemicals in the layer of air just above the surface. It's going to depend on stability of the air as to whether it's of any significance or not," with greater air movement increasing exposure of particles to the cement.

Essroc could not provide any peer-reviewed studies of the depolluting effectiveness of TX Active. However, the self-cleaning product can be judged with a visual inspection, and it appears to perform well. According to Schaffer, the mortar used in the Jubilee Church between the precast panels does not contain TiO_2, and it has darkened compared with the panels. David Shepherd, AIA, director of sustainability for the Portland Cement Association, told *EBN* that he considered the product interesting because "no maintenance is needed on a concrete structure, but it still gets dirty." Shepherd added, "We're looking for applications in the U.S. that can corroborate what they've seen in Europe."

To increase durability and reduce maintenance needs for concrete products, TX Arca is an intriguing new solution. In its capacity to reduce surrounding pollution, TX Aria is even more intriguing—but more experience and study are needed to assess whether it is worthwhile. At a broad level, reducing pollution at its source remains a more immediate and cost-effective solution, but TX Aria may be useful in applications where architects want an additional option to protect building occupants and surrounding residents from air pollution.

– Tristan Roberts

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Building Information Modeling *(from page 1)*

A Brief History of Digital Design

In the early 1980s, technologically savvy architecture firms were replacing their drafting tables and pencils with workstations running computer-aided design (CAD) software. By the end of that decade, firms that hadn't made that transition were in trouble. Through the 1990s, two-dimensional CAD drawings gave way to tools that could create three-dimensional views of a design, and more advanced tools enabled architects to design directly in three dimensions using virtual models. "Working with a model of a building is actually very natural, because it's what we architects carry around in our heads anyway," said Mario Guttman, AIA, vice president and CAD director at HOK. Structural engineers working on complex buildings have been among the early adopters of 3D CAD tools, but architects and other engineers now commonly use these tools as well.

Building information modeling (BIM) adds additional "dimensions" onto those 3D CAD models by attaching information to elements in the virtual building. Early uses of BIM have advanced beyond collision detection to focus on specific functions, such as real-time cost estimating. Autodesk's Revit, for example, is linked to cost data from RSMeans, so a project's budget can be tracked as the design evolves. Sophisticated contractors are using tools such as Constructor from Vico Software (recently spun off from Graphisoft) to create cost estimates based on their own cost databases and also to model and optimize construction sequencing.

What is Building Information Modeling?

"BIM is not just software but a methodology of practice," said Huw Roberts, Bentley Systems' global marketing director, suggesting that "an architect or engineer would decide to practice BIM and use a bunch of tools to do that." Adam Rendek, of Anshen + Allen Architects in San Francisco, added, "We are taking advantage of the intelligence that is embedded in the model. That's what makes BIM different from 3D CAD."

The move towards BIM is driven in part by large building owners, including the U.S. General Services Administration (GSA), which, as of 2007, accepts delivery of designs for major projects only as interoperable models. Owners like GSA have documented the wastefulness of the conventional paper-based building delivery process and are dictating a more integrated approach. A handful of BIM-related organizations and

Acronym List and Glossary

AEC: Architecture/Engineering/Construction

BIM: Building Information Model—a digital representation of physical and functional characteristics of a facility that serves as a shared knowledge resource forming a reliable basis for design decisions throughout its life cycle.

CAD: Computer-Aided Design

XML: Xtensible Markup Language—a protocol for tagging text to give it a structure and semantics that both computers and humans can understand.

gbXML: an implementation of XML that organizes information about a facility for energy simulation purposes.

IFC: Industry Foundation Classes—a data structure for organizing and sharing information about facilities throughout their life cycle, promulgated by the International Alliance for Interoperability.

DOE-2: U.S. industry standard simulation engine, does the calculations behind the scenes in popular tools such as eQuest and PowerDOE. EnergyPlus is gradually replacing DOE-2 as the preferred engine.

MEP: Mechanical/Electrical/Plumbing—engineering disciplines, often combined under a single contract.

initiatives joined forces under the umbrella of the National Institute of Building Sciences (NIBS) buildingSMART Alliance and, in February 2007, released the first part of a national BIM standard for industry review.

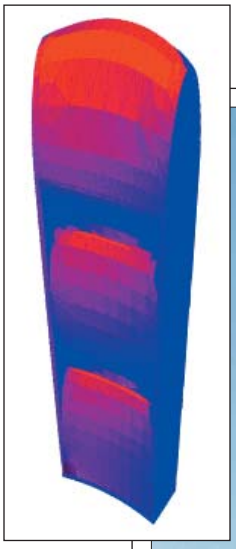
Autodesk, the 800-pound gorilla in the CAD software jungle, has incrementally added data-linking capabilities to its flagship Architectural Desktop software package. In 2002, the company made a major commitment to BIM with its acquisition of Revit, a database-driven design software package. Autodesk is now actively seeking to migrate its longtime CAD customers into the Revit product line. Currently there are 200,000 licensed Revit users worldwide—doubled from last year, according to Jay Bhatt, vice president for AEC at Autodesk. Other major players in this market include ArchiCAD from Graphisoft (a Hungarian company acquired in 2006 by the German firm Nemetschek), and the Microstation suite of software tools from Bentley Systems. Bhatt estimates that between 5% and 10% of CAD users worldwide use BIM software from one of these companies.

Streamlining Building-Performance Simulations

As the number of designers working in BIM grows, so does the opportunity for using those virtual models to do more than just estimate costs. Working in two-dimensional, basic CAD drawings, "you had to do all this heroic behavior to create an environmentally sensitive design," noted Bhatt. With the advent of BIM, however, "technology is facilitating a much bigger movement around sustainability in the buildings space," Bhatt added. Vincent Murray, business development manager in the Boston office of simulation software company IES, agrees: "BIM opens up building-performance modeling to the entire building construction community," he said.

Energy modelers use specialized software to create a virtual model of a building. They then subject that model to the building's anticipated weather and usage patterns to predict its heating and cooling loads and energy use. Until now, setting up an energy model took many hours, even for a relatively simple building, so iterations through various design alternatives were slow and expensive. "Now, since the model is available as a given, representing the actual current state of the design, we can shorten this amount of time dramatically," said Rendek.

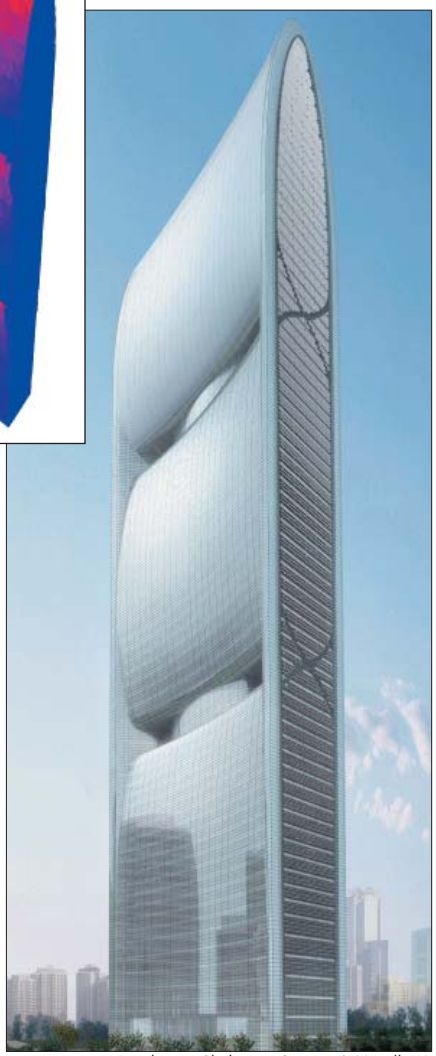
Energy feedback during conceptual design



One of the ironies of energy modeling and other simulations used in the design process is that they tend to require a fairly complete model of the building, which means that by the time the modeling is done, the design is fully developed and only minor changes can be entertained. BIM mitigates this problem to some extent because the integrated 3D design model makes it relatively easy to make changes, even late in the process, by eliminating the need to coordinate changes across multiple drawings. But early-stage simulations from preliminary 3D and BIM models offer the greatest potential benefits. Green Building Studio and (soon) SketchUp are optimized for use in those early stages—specifics on each follow.

Green Building Studio. Green Building Studio (GBS) is a pioneer in the field of easy, basic energy simulation from design models. As both a company and a Web-based service of the same name, GBS includes a protocol for translating information from CAD software into the industry-standard DOE-2 energy simulation engine. Because an energy model requires data that isn't typically defined even in BIM files, much less conventional 3D CAD, GBS fills in the gaps with many default assumptions. "Most of the tools that are moving forward are still engineering tools," said John Kennedy, president of the company, referring to their intended use for analyses of fully developed designs by trained engineers. He added, "The whole point of this tool is early-stage modeling."

Kennedy has created plug-ins for Revit and ArchiCAD that assist users in defining HVAC zones and validating the BIM model to increase the chances that



Rendering: Skidmore, Owings & Merrill, LLP

The Pearl River Tower designed by SOM for construction in Guangzhou, China, includes integrated wind turbines and photovoltaic panels to offset its energy use. Inset is an Ecotect model showing the amount of solar radiation on the tower's various surfaces.

The Georgia State Parks Headquarters in Stockbridge, Georgia, was designed to be environmentally responsible using building information modeling services provided by the independent BIM consultants RCMS Group of Atlanta. Credit: Gerding Collaborative

the energy simulation will provide useful results. The plug-in software generates a file in gbXML format (an information exchange protocol developed by GBS) that the software uploads to GBS's server for analysis. Minutes later, the designer can download the results of the model. GBS allows users five free runs; more runs are available for a nominal fee. GBS recently introduced a "design advisor" service that automatically generates proposed modifications to the design and allows users to experiment with a small number of alternatives. GBS also makes its DOE-2 input file available for download, offering engineers a shortcut for running their own early-stage energy models.

Development of the software was funded largely by the California Energy Commission and Pacific Gas & Electric, but for ongoing support GBS is looking to other sources, including manufacturers that appreciate the potential for highly targeted product placement. On that basis, PPG's SolarBan 70 glazing is one of the design alternatives from which users can choose. GBS has also developed a tool for Owens Corning that identifies what a building would need to implement to qualify for the Energy Policy Act of 2005 tax credit (see *EBN* Vol. 14, No. 9).

SketchUp and EnergyPlus. While it is a far cry from the full-fledged BIM tools, Google SketchUp offers a 3D modeling interface and the ability to assign characteristics to objects in the design. "A lot of designers prefer SketchUp early on because it's such a facile tool," noted Chris Leary, AIA, of KlingStubbins. Most mainstream design tools now have at least some capability to import models from SketchUp and to export simplified models out to it. That capability will soon carry more significance for green projects because by June 2007 the U.S. Department of Energy (DOE) expects to release a SketchUp plug-in for the powerful EnergyPlus modeling engine.

DOE intends for EnergyPlus, which was released in version 2.0 in April 2007, to supersede the venerable DOE-2. While EnergyPlus is widely regarded as a more powerful and flexible simulation engine, its use has been limited by its lack of a user-friendly front end. "I could imagine that SketchUp would be a pretty good interface for making an EnergyPlus model," said Kevin Pratt, director of research at KieranTimberlake. The plug-in, which will be available for both the free and the full versions of SketchUp, will help users define HVAC zones and assign thermal characteristics to elements in their models. It will then export an EnergyPlus input file for a user to run separately—although, according to Drury Crawley, AIA, Technology Development Manager at the U.S. Department of Energy, future versions of the plug-in should be able to run the simulation entirely within SketchUp.

Tools like SketchUp are especially useful for early design studies. "A smart team working on sustainable design will start looking at energy models before even designing the building," noted Guttman, adding, "They may do a lot of analysis on preliminary, pre-architectural models."

Analysis during design development

More detailed energy analyses during design development, or verifying a building's performance from the construction documents, is the traditional purview of mechanical engineers who specialize in energy modeling. Simply by translating building geometry automatically from a design model, 3D CAD and BIM tools have the potential to dramatically reduce the amount of time and effort required to set up those energy models. As noted above, that translation can be done from Revit and ArchiCAD. A more generic approach, developed by the Industry Alliance for Interoperability, uses a data structure termed Industry Foundation Classes (IFC), although support of the IFC standard has been spotty and the IFC definitions don't cover all building data exchange requirements. Finally, there are several efforts at direct bilateral connections between BIM tools and performance modeling platforms. The following sections describe how the major BIM software tools support this type of analysis.

Revit MEP Links to IES. In February 2007, Autodesk and simulation developer IES Limited announced a collaboration linking their tools. This collaboration began bearing fruit in April, when an incremental version upgrade to the mechanical engineers' Revit product (Revit MEP) gained the ability to calculate heating and cooling loads directly using an IES engine.

IES's Virtual Environment is an integrated performance modeling package that models energy use, daylighting, computational fluid dynamics (CFD), and other attributes based on a single shared model of the building. Beyond the load calculation tool that is now provided with Revit MEP, users can purchase the Virtual Environment Toolkit, which includes the ability to do more sophisticated analyses. IES also sells individual modules separately that step up the modeling potential even further. The primary modeling engines within IES are collectively called Apache (unrelated to the Web server software). "Apache is being continuously updated by a team of leading experts," claimed Murray.

KlingStubbins has been an early adopter of both Revit and performance modeling tools. "We're software junkies—we buy everything," admitted Leary. "We had IES sitting around, but no one could find the time to use it. Now that we're not having to recreate the data, it's getting used." Leary has seen results from the integration of these tools. In one case, the results of an IES simulation led Leary's team to narrow a building to allow better daylight penetration. KlingStubbins is now engaged in a firm-wide evaluation of the tools, with engineers in the Philadelphia office comparing the results from IES with those from other modeling tools, and a team in Washington, D.C., examining the CFD analysis. "Who ever thought an architecture and engineering firm would be doing its own CFD modeling?" Leary asked.

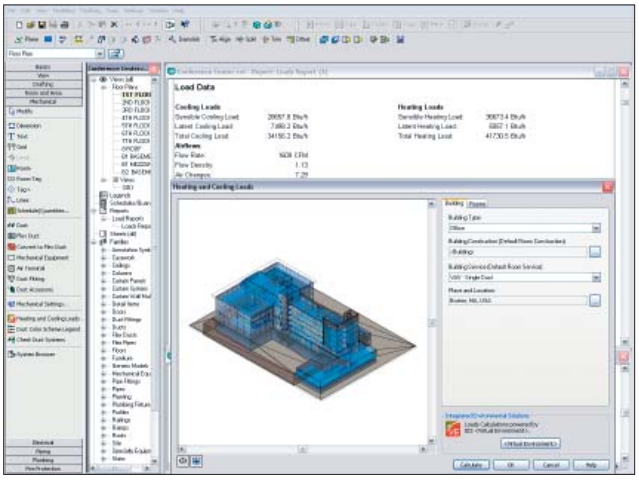
The fact that IES is tied only to Revit MEP and not to Revit Architectural presents an obstacle in the path towards energy modeling that is fully integrated into the design process, especially since Revit MEP is not as mature as the other Revit tools and some engineers are hesitant to commit to it. Autodesk and IES don't see the dependence on the MEP module as a limitation, however—they believe the shared model can enhance communication and collaboration across disciplines. "We would hope that the integrated model with Revit would become the catalyst for integrated design," said Murray. Involving experts in the energy modeling process, even if it is largely automated, is also a good idea in terms of interpreting the results. "If you don't understand what's happening behind the scenes, you can get some really misleading data out of the software," warned Pratt.

ArchiCAD and Ecotect. Graphisoft is pursuing a path similar to Autodesk's by establishing ties with another integrated performance modeling package, Ecotect. Ecotect is used extensively in academic settings and is popular in many firms for early design studies. Architects rave over its intuitive graphic interface. "The advantage of Ecotect is that you can have very visual models showing the results of different scenarios," said Patrick Mays, AIA, vice president of Graphisoft North America.

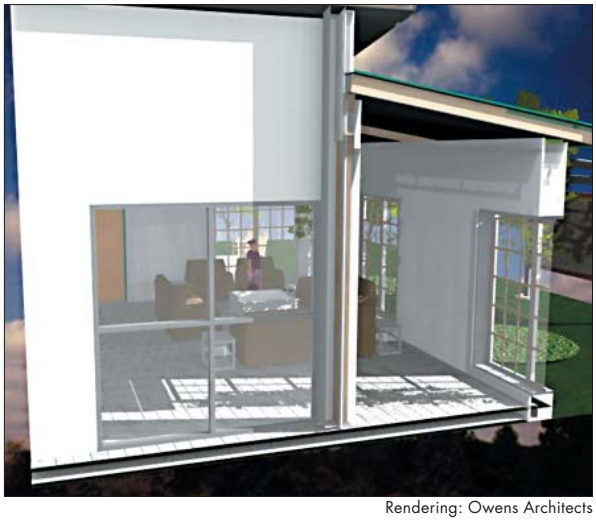
Ecotect was created by Andrew Marsh, Ph.D., who is originally from Australia but currently resides in the U.K. Marsh and a tiny staff handle all development and maintenance, so keeping up with the demand for features and fixes has challenged them, especially as demand for the tool has mushroomed. Ecotect remains a valuable player in the industry, however, largely because of its connection to open-source tools, such as Radiance for daylight modeling and EnergyPlus for energy, in which Ecotect users can perform more robust simulations that are beyond the scope of its internal code.

Graphisoft has enhanced ArchiCAD's gbXML plug-in from Green Building Studio to serve as a translator to Ecotect. "We have the capability to map zones and export data, so properties of walls, windows, doors, are all tracked," noted Mays. Right now the export to Ecotect is one-way, but users will soon be able to move Ecotect models back into ArchiCAD, according to Mays: "In two months you will see documentation and process for how stuff will work back and forth," he said.

If Revit and IES are becoming an industry standard for mainstream, production-oriented architects, ArchiCAD and Ecotect are the darlings of those who prefer an alternative approach, in terms of both catchy graphics and, for the technically inclined, ability to be customized and extended. "ArchiCAD handles things more openly, which offers an advantage in terms of interoperability with a variety of modeling tools,"



This screen capture from Revit MEP shows the heating and cooling load calculator from IES Virtual Environment running within the Revit application. Image courtesy Autodesk



Rendering: Owens Architects

BIM tools can support some analyses internally, such as this daylighting study of a residence, extracted from an animation created by Jeff Owens of Owens Architects in Lawrenceburg, Kentucky, using Bentley's Triforma software. The full animation is viewable online at www.owensarchitects.com.

said Anshen + Allen's Rendek, adding that "Revit is more of a closed system. It works well with other tools that are written to work with that system." Along similar lines, users cannot easily extend or modify the library of predefined building assemblies in IES. After comparing Revit and ArchiCAD for building-performance modeling, Rendek found "no clear answer as to which is better. Both are good, and both have advantages and disadvantages."

Bentley's BIM Solutions. Rather than linking directly to any specific building-performance package, Bentley Systems instead touts its flexible data structure as an ideal solution because it allows users to store any type of data and migrate that data into third-party tools for specialized analyses.

Bentley's primary vehicle for these translations is the IFC framework, which is finally gaining widespread support, according to Roberts. Roberts says that a unique strength of Bentley's software is its ability to exchange data back and forth with other tools, including an option to selectively re-import modifications to a model. "The majority of the analysis tools aren't as smart as BIM," noted Roberts, "but they have all the processes for dealing with the information they care about—other than the geometry—internal to themselves." Rather than managing all that additional information in one BIM software package, Roberts suggested that a more effective solution would be to allow the tools to pass back and forth the parts of the model that they do share while allowing any of them to modify the design.

While Bentley's tools have the potential to be a strong, open platform from which to develop energy-efficient design solutions, the company does not appear to have progressed as far as its competitors in supporting or promoting those capabilities. This two-way sharing of data, for example, is already working in the area of structural analysis but not yet in the areas of building performance most closely associated with green design.

Reality Check

While the ability to go directly from a design model to an energy simulation is tantalizing, and the capabilities are improving, we still have a ways to go. "It's not as simple as pushing a button and getting an energy number. Analysis requires a lot of simplifying assumptions, and understanding what is really important and what isn't," HOK's Guttman told *EBN*.

Perhaps the most fundamental challenge is that energy analysis requires a range of inputs, only a few of which are included in a typical building-information model. The physical layout—what software engineers call "building geometry"—is a basic element in all 3D CAD models. Information on how the various elements are constructed and on their thermal performance may be included in a BIM model. But an energy model also needs location information—which it uses to track sun angles and apply appropriate climate data—schedules of operation, and a mapping of HVAC zones.

Typcially, most of these additional elements don't exist in an architectural BIM model, so they must be created either before or after the model moves to an energy simulation environment. Similarly, daylight modeling tools require information about the reflectivity of surfaces, and those that model airflow need to factor in friction coefficients. In this sense, although both conventional design and performance simulations are working from a virtual model of the same building, they need to know different things about that building, making their models quite different. As a result, it will never be possible to take a model that was built just as a visual representation and run a meaningful energy simulation: "I'm a little skeptical that you will actually be able to push a button and get a thermal model," said Pratt.

To get even rudimentary simulation results architects have to learn to create models with the necessary information, and for more sophisticated results, there will likely always be a need for specialists. "There is a lot of art to the science of energy modeling. You can't just take an architectural model and run a thermal analysis on it," noted Pratt, adding, "The real question is, do you understand what the results mean?"

It's not only the lack of necessary information that represents a problem; unnecessary information can slow even the most capable simulation engine to a crawl. "BIM gives you the ability to bring over much more detail than you would normally put into an energy simulation," said Crawly, "but that also has a downside—you can bring over too much data and make the model overly

complicated to run." For example, he noted, including every closet in the model of a large building increases computer processing time without significantly affecting results.

Companies, including Burt Hill and SOM, are addressing this issue through the formulation of teams that are expert in energy modeling and other building-performance analyses. These groups are engaged early in the conceptual design process working directly with the architectural design team. This integrated approach provides the design team with expertise in using analytical applications and ensures that Building Information Models contain the appropriate level of information to perform the simulations that can support important decisions. "Our Energy Modeling Team is also engaged later in design to perform more detailed simulations, but it is the early involvement that is important to set the strategies for the building," noted Mark Dietrick, AIA, chief information officer at Burt Hill.

The Materials Promise

While they may not be ideal for thermal simulations, BIM models are well suited to tracking the materials used in a design. If the model is set up properly, the tedious and error-prone task of measuring each surface and volume to estimate material quantities is eliminated. "The only way to take off quantities accurately is out of a model," said Bhatt.

Accurate take-offs reduce waste, which is beneficial in itself. But in addition to providing an accurate measure of how much concrete to order, for example, a model can also track specific attributes of materials. When constructing a BIM model, designers can select building elements from a library of generic assemblies, or they can create their own libraries. Most models already link to cost information for those assemblies. In theory, they could just as easily store information such as quantities of recycled content or even environmental impact scores from life-cycle assessments of those assemblies. Any information that is available for the individual assemblies can instantly be aggregated for the entire model. "We'd like to make a change and be able to understand, in real time, the carbon impact of the change in terms of embodied energy of the materials," said Mara Baum of Anshen + Allen.

The challenge in practical terms is getting accurate information—a problem that is not unique to BIM applications. "It is very hard to get life-cycle data on most products," noted Pratt. BIM offers one potential solution: to develop channels by which that information is streamed directly from building product manufacturers into the model. Just as many manufacturers now provide CAD representations of their products so designers can drop them right into a design, in the future they will likely publish BIM-friendly models of those same products, incorporating data about their properties. "Our end goal is that the building-product manufacturer publishes all the data," said Noah Cole of Autodesk, adding that some companies, such as Trane, have already started down that path. Other software companies are also on board; according to

Rendering & Photo: Gerding Collaborative

Sweetwater Creek State Park Visitor Center near Atlanta, Georgia, is the first building in the southeast to earn LEED Platinum certification. Dan Gerding, AIA, managing principal of Gerding Collaborative, credits their implementation of building information modeling using ArchiCAD with aligning the client and design team around this ambitious goal.

Roberts, "Bentley is working with McGraw-Hill's Sweets to help the manufacturers figure out how to store that stuff."

But that proprietary-product-based solution "is very tricky in an architectural context because we try to use generic specifications," noted Pratt. The fact that the design model is usually generic presents problems when it comes to getting parts from the manufacturer, agreed Roberts. "That's been tried a few times but has never gained traction," he noted, suggesting that those product libraries are more valuable when a building model is used during construction.

Using information models to manage the construction process offers compelling advantages, many of which also have environmental implications. Software now available allows contractors to scan items for inventory management as they arrive on the construction site, and link them directly to their place in the building model. Eventually, electronic tags might allow contractors to track the location of each item and ensure that it is installed in the right place. Such tools could reduce errors and waste while streamlining the commissioning process.

Automated Documentation

The use of BIM raises a host of issues around liability and intellectual property and is forcing the industry to rethink the concept of contract documents. "We're talking about new contracts, new relationships between architects and contractors and owners," said Guttman. Currently, he said, the transition to construction is "usually done in a traditional contract arrangement—two-dimensional documents are the contract. But the model is shared in information meetings so everybody in the room is better informed."

Some building owners, including GSA, are demanding ownership of the virtual model, however—which concerns architects, who have traditionally retained copyright on their designs. Legal issues aside, the ability to share a virtual model through the construction process, and even as support for building operations, should improve actual building performance. "We can input information on the fly, as we are creating the model, that can be used directly for facility management," said Rendek, and "that could bring a huge benefit to the client for little additional work."

Implications for LEED

The ability of BIM tools to aggregate materials information and analyze other building information also has intriguing implications for the documentation requirements of rating systems such as the U.S. Green Building Council's (USGBC's) LEED. Noting that Adobe System's Acrobat technology is the platform for LEED Online, "Anshen + Allen wants to work with them on streamlining the information uptake from the model into the LEED docs," said Rendek. The Portable Document Format (PDF) created by Adobe provides portability and security for sharing BIM information, and Adobe is moving aggressively to enhance the ability to link data to individual elements in a 3D Acrobat file.

While PDFs are valuable for sharing information among users before submitting it for LEED verification,

How BIM Tools and Analysis Tool Interact

	Autodesk Revit	Graphisoft ArchiCAD	Bentley Microstation	SketchUp
Integrated modeling tools				
IES Virtual Environment	Revit MEP runs heating and cooling load tool directly; exports to IES via gbXML and native graphic file format for more sophisticated analyses.	ArchiCAD exports gbXML, which can be run in IES Virtual Environments.	Models can be transferred using graphic exchange format and traced, or using IFCs.	
Ecotect	Revit exports gbXML, which can be run in Ecotect.	ArchiCAD gbXML exports can run in Ecotect. Building geometry can also be converted using graphic file formats.	Models can be transferred using graphic exchange format and traced.	
Energy-only modeling tools				
Green Building Studio (DOE-2)	Revit's gbXML plug-in cleans up and exports the model to GBS.	ArchiCAD's gbXML plug-in cleans up and exports the model to GBS.	Not supported.	
EnergyPlus	Not supported directly.	ArchiCAD utility makes it easy to combine rooms into HVAC zones for export to EnergyPlus.	Models can be transferred using IFCs.	Direct plug-in announced for release in spring of 2007.

in the future the actual submission won't necessarily require a PDF file at all, notes Max Zahniser, USGBC's certification manager for LEED for New Construction. "LEED Online was originally built on XML technology, so our templates are submitting XML packets into our database. We went that route so that we could eventually capitalize on the ability for other tools to submit those packets, without users having to go through LEED Online themselves." Zahniser added that the next major enhancement to LEED Online, as it evolves to support a new underlying structure for LEED, will have more direct data-flow capability.

That ability to deliver documentation seamlessly into LEED Online has obvious value for third-party LEED project-management tools, such as Johnson Controls' Leedspeed, but in theory that information could come directly from the BIM software. Such an arrangement is not unlikely, given the partnership between USGBC and Autodesk that was announced at Greenbuild in November 2006 (see *EBN* Vol. 15, No. 12).

While for now the dataflow into LEED Online still requires that a user log into the website, the information needs are already being streamlined. In particular, the latest release of Revit has a built-in capability to perform LEED's daylight calculation and report what percentage of the occupied space achieves the required 2% daylight factor. Users running Revit MEP with IES Virtual Environment also have the option to report those results based on IES's daylight simulation, and the results of either calculation could be used to demonstrate that a project meets the criteria for LEED's daylighting credit. As capabilities of this type are expanded and the calculations verified, documentation coming from Revit and other tools may increase the confidence of design teams that they are submitting documentation LEED will accept, and may even streamline USGBC's verification process.

Transforming an Industry

While the software can't take all the credit, BIM tools are a key element of a broader trend in design towards integration of design disciplines and knowledge-based decision making. "For us BIM is the technology that supports integrated practice. Without the rich exchange of digital data, we'd be in bad shape," said Volker Mueller, design technology manager at NBBJ.

Leary of KlingStubbins points to the power of BIM and analysis tools for putting numbers on information that was previously more subjective. "When you're in front of a certain kind of client, things that have numbers related to them are valued as decision-making points, whereas things that are qualitative are not," he told *EBN*. Using Revit, Leary was able to quickly measure how many occupants would have direct views of a window: "When considering a shift to interior offices and external workstations, thanks to the Revit model we had a quantified way to drive the decision."

Real-time performance feedback during design can not only improve the building but also educate designers. "You see the changes and understand what's going on. It's not just spitting out numbers—the process of using an iterative tool is educational for us," Leary reported. Similarly, Kennedy sees his Green Building Studio as a response to the "massive education problem" of getting architects up to speed quickly so they can begin designing buildings with the potential of becoming carbon-neutral.

Given the speed at which technology changes, choosing modeling tools is like hitting a moving target. "It's important to stay open and flexible rather than just following what the software vendors dictate," suggested Rendek. The fact that only a small subset of designers is currently using BIM tools represents both a challenge and an opportunity. As designers move from conventional CAD to BIM they need training, and younger architects who never worked in older systems may have an advantage. With both green design and building information modeling on geometric growth curves, their marriage is mutually supportive. That's a good thing, given the demands on the industry to learn quickly how to create buildings that make sense for our times.

–Nadav Malin

For more information:

buildingSMART Alliance
National Institute of Building Sciences
Washington, D.C.
202-289-7800
www.iai-na.org/bsmart/

Revit Architecture
Autodesk, Inc.
San Rafael, California
800-578-3375
http://usa.autodesk.com

ArchiCAD
GraphiSoft U.S., Inc.
Newton, Massachusetts
617-485-4203
www.graphisoft.com/products/archicad/ac10/

MicroStation product line
Bentley Systems, Inc.
Exton, Pennsylvania
800-236-8539
www.bentley.com/en-us/products/microstation/

Virtual Environment
IES Limited
Cambridge, Massachusetts
617-621-1689
www.iesve.com

Green Building Studio
Santa Rosa, California
707-569-7373
www.greenbuildingstudio.com

EnergyPlus simulation software
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
Washington, D.C.
877-337-3463
www.eere.energy.gov/buildings/energyplus/

EcoTect (and the Weather Tool and the Solar Tool)
Square One, Ltd.
Joondalup, Washington
347-408-0704
www.squ1.com/products/

BackPage Primer

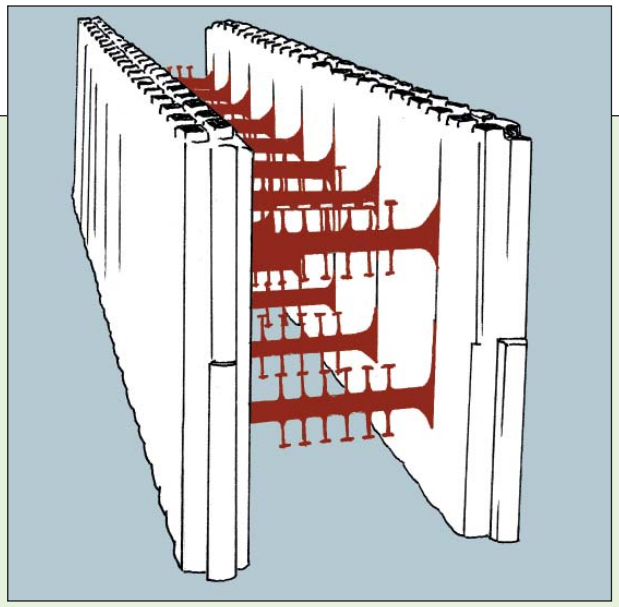
Insulated Concrete Forms

Insulated concrete forms (ICFs) are permanent forms for poured-concrete walls; the forms are typically stacked without mortar before concrete is poured, providing insulation and often reducing the amount of concrete needed for the resulting wall.

The insulation material varies from system to system, with the most common being high-density expanded polystyrene (EPS) foam, which, unlike extruded polystyrene (XPS), is produced with a non-ozone-depleting blowing agent. Some include recycled EPS foam, waste wood fibers, or a combination of EPS beads and portland cement.

Many manufacturers add borates, which are considered benign to humans and the environment, to the EPS foam to protect against wood-boring insects. However, most EPS foam also contains a brominated flame retardant, which has come under increased scrutiny because of environmental and health concerns (see *EBN* Vol. 13, No. 6). Some manufacturers recommend gluing seams between forms; the glues recommended may have high levels of volatile organic compounds.

The primary environmental benefit of ICF walls is their insulating performance; most have tested R-values around R-20, with some as high as R-25. The most reliable information for comparison is the "steady-state" R-value, which is calculated by keeping one side of a material at a constant temperature and measuring how much energy is required to keep the other side of the material at a different temperature.



When manufacturers refer to "effective" or "mass-enhanced" R-values, they are referring to the fact that high-mass materials that store heat can achieve better energy performance if outdoor temperatures fluctuate above and below the desired indoor temperature. Although Oak Ridge National Laboratory has developed a test to measure mass-enhanced R-value, testing procedures vary among ICF manufacturers and the ability to benefit from this higher R-value is highly dependent on climate, so listed effective R-values might be inaccurate or irrelevant.

For More Information:

"Thermal Mass and R-value: Making Sense of a Confusing Issue," *EBN* Vol. 7, No. 4

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www.buildinggreen.com
(Click on "CSI divisions," then on "Concrete," then on "Insulating Concrete Forming.")

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