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Driving to Green Buildings
The Transportation Energy Intensity of Buildings

AS THE WORLD'S FIRST LEED Platinum building, the Chesapeake Bay Foundation's Philip Merrill Environmental Center is loaded with green features: photovoltaic panels, rainwater harvesting, composting toilets, and bamboo flooring, to mention just a few. However, moving the organization's staff of around 100 into the new building meant that many employees who had been able to walk to work in the older downtown facility now have to drive roughly ten miles (16 km) to get there. To their credit, the organization spent two years looking for a downtown building to house their growing staff, and they tried to mitigate the increased use of cars in the new building with bicycle and kayak racks, showers, and loaner vehicles for non-automobile commuters, among other strategies. The fact remains, however, that the additional energy use from more employees driving to work may well exceed the energy savings realized by the green building.

Designers and builders expend significant effort to ensure that our buildings use as little energy as possible. This is a good thing—and very obvious to anyone who has been involved with green building for any length of time. What is not so obvious is that many buildings are responsible for much more energy use getting people to and from those buildings. That's right—for an average office building in the United States, calculations done by *Environmental Building News* (*EBN*) show that commuting by office workers accounts for 30% more energy than the building itself uses.

(continued on p. 11)

Photo: Reconnecting America

Since the late 1990s, Portland's Pearl District has been transformed from a largely abandoned industrial area into a bustling mixed-use neighborhood. Local developers actively promote alternative forms of transportation, evident in the giant neon "Go By Streetcar" sign atop this multi-use complex.

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Quote of the month:

"I think you should lose your [architecture] license for laying out sprawl."

Doug Farr, AIA, on auto-dependent development

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From the Editors

Use Performance-Based Transportation Credits in LEED

Back in August 1999, I participated in a U.S. Green Building Council (USGBC) charrette to craft the LEED 2.0 Rating System from the original LEED 1.0 pilot. The small workgroup focused on site and ecosystem issues, in which I participated, sought to remove any bias that encouraged building on previously undeveloped sites. We ended up with five credits that provide points for development density, access to public transit, bicycle storage and changing rooms, infrastructure for low-emitting vehicles, and limitations in parking capacity. While some have poked fun at credits for bicycle racks and vehicle charging stations, these five credits have brought the important issues of location and transportation to design teams.

Our research on "transportation energy intensity" (see page 1) has helped me appreciate just how important site selection and transportation are. We found that an average commercial office building in the U.S. built to ASHRAE 90.1-2004 energy standards is responsible for more than twice as much energy *in getting workers to and from work* as the building itself uses in its operation. If the average commute distance is greater than the national average (12 miles one-way) the transportation fraction of a building's energy use may be even greater. As covered in the accompanying feature article, a wide range of strategies—most having to do with land-use planning—can significantly reduce this transportation energy intensity of a building.

While the prescriptive approach in LEED to site and transportation issues has served an important role, it's time to provide a more rigorous basis for these credits. Specifically, I believe that the points addressing transportation should be changed from a prescriptive basis (provide bicycle racks, limit parking, etc.) to a performance basis. To do this, USGBC should champion research to develop building-specific metrics for measuring the transportation energy intensity of new and existing buildings. A huge body of research has already addressed these issues, but that research has been done largely on a community scale. To be used in LEED for New Construction and other building-specific LEED rating systems, we need building-specific metrics. (This research need is included in the National Green Building Research Agenda being developed by the USGBC Research Committee, on which I sit [see *EBN* Vol. 16, No. 6].)

USGBC should articulate the specific needs for such performance-based metrics and assemble a team of the leading experts in transportation and land-use planning to develop those metrics. The end product might be a "transportation energy intensity" spreadsheet that would be used for a building going through LEED certification. A dozen or so factors would be entered for such attributes as distance to public transit, neighborhood density, limitations on parking, access to bicycle and pedestrian pathways, and streetscape design amenities like traffic calming that encourage pedestrian use.

By filling in the submission form, the user would end up with a weighted adjustment factor that could be used to calculate performance-based LEED points. As actual performance measurements are taken of the transportation energy intensity of completed LEED buildings, USGBC could improve these formulas, making LEED more scientifically rigorous and improving the environmental performance of future LEED buildings.

– Alex Wilson

What's Happening

FEMA Investigates Trailer Air Quality

The Federal Emergency Management Agency (FEMA) announced in August 2007 that it had suspended the installation, sale, transfer, and donation of emergency-housing trailers until concerns over high levels of formaldehyde can be investigated. A common ingredient in pressed-wood products, including particleboard, formaldehyde can cause eye, nose, and throat irritation; wheezing and coughing; fatigue; skin rashes; headaches; nosebleeds; and severe allergic reactions. The U.S. Environmental Protection Agency considers formaldehyde a probable human carcinogen, and the International Agency for Research on Cancer calls it a known human carcinogen.

In addition to halting future uses of the trailers, FEMA has also agreed to find alternate housing for any trailer occupant who requests it and, for those who have purchased trailers from FEMA in the past year, to refund those purchases. The agency will also pay to relocate those who can't find alternative housing in their immediate areas to anywhere in the continental U.S. About 56,000 families currently live in FEMA trailers—mostly in areas affected by the September 2005 hurricanes Katrina and Rita.

Health and environmental experts from the Centers for Disease Control and Prevention (CDC) and the U.S. Department of Homeland Security are now testing the air quality in FEMA trailers throughout Louisiana and Mississippi, FEMA reported. The agency noted in an August 1 statement that "formaldehyde is commonly used in building materials and is prevalent in the environment," and said it made the decision to suspend use of the trailers "out of an abundance of caution."

FEMA has also asked experts to identify an acceptable air quality level for formaldehyde in trailers. While the construction of mobile homes and other manufactured housing is subject to regulations—including formaldehyde limits—from the Department of Housing and Urban Development (HUD), FEMA trailers fall under recreational vehicle classification because they are designed for temporary habitation, not long-term housing, according to FEMA, and therefore are not regulated by HUD.

The Agency for Toxic Substances and Disease Registry, a sister agency to CDC, has set minimum risk levels for exposure to formaldehyde below which a person would be unlikely to experience any ill effects. The minimum risk level is 0.04 parts per million (ppm) for one to 14 days of continuous exposure, 0.03 ppm for up to one year of continuous exposure, and 0.008 ppm for exposure that exceeds one year. Formaldehyde levels of more than 1 ppm (25 times the highest risk level) have been measured in some FEMA trailers, and some have been almost continuously occupied for nearly two years.

Photo: John Fleck, FEMA

These FEMA trailers in Biloxi, Mississippi, are some of the roughly 56,000 currently housing American families.

In related news, more than 500 South Louisiana residents have filed a lawsuit against 14 manufacturers who sold trailers to FEMA in the aftermath of the 2005 hurricanes. The lawsuit, which does not list FEMA as a defendant, accuses the manufacturers of exposing the plaintiffs to dangerous levels of formaldehyde and requests that they remove from the trailers any materials containing formaldehyde and pay for medical monitoring to determine whether the formaldehyde has caused health problems for the plaintiffs.

One study published in the *Annals of Emergency Medicine* in May 2007, although not establishing a link to formaldehyde, suggests that the health problems of trailer occupants are dire. The study reports that, among people living in FEMA trailer parks in Louisiana and Mississippi, half meet the criteria for major depression, which studies have shown can be caused by exposure to the levels of formaldehyde often found in mobile homes. Respondents were also 14 times more likely than normal to contemplate suicide and 78 times more likely to attempt it.

– Jessica Boehland

For more information:

Federal Emergency Management Agency
Washington, D.C.
800-621-3362
www.fema.gov

Integrated Design Process Standard Approved

In July 2007 the Whole Systems Integrated Process Guide (WSIP) 2007 for Sustainable Buildings & Communities, ANSI/MTS Standard WSIP 2007, was approved by public ballot. "Everybody is coming to the realization that there is a pattern of practicing an integrated design process for

buildings," said Bill Reed, AIA, chair of the committee that developed the standard under the auspices of the Institute for Market Transformation to Sustainability (MTS). The document, which has the blessing of the American National Standards Institute (ANSI), codifies that pattern in the form of a specific integrated design process.

The process of getting the standard approved was smooth, according to Mike Italiano, head of MTS. The only objections came from respondents who didn't understand that, as a guide, this is more qualitative than other standards, he reports. While the document has been approved and will soon be available for purchase from ANSI, according to Italiano, it is still rough. The practice it claims to define, for example, is labeled variously as "integration process," "integrated process," and "integrative process." Reed and committee vice chair John Boecker, AIA, are producing a cleaner version, which should eventually replace the current document. Changes will not be substantive, according to Reed, so it shouldn't require any additional balloting.

The committee was interested in going beyond a dry checklist of steps, Reed reports, by including enough introductory information to explain why this practice is important. Following that introduction, the standard describes how an integrated process differs from a more conventional, linear process, then lists suggested measures for each phase in a hypothetical design-construction-occupancy process.

Now that the standard is approved, Reed has turned his attention to bridging the gap between the practice of integrated design as it is understood in green building circles and the "integrated practice" model promoted by The American Institute of Architects and others, which has been targeted at improving timeliness and quality in project delivery. Meanwhile, authors of draft LEED rating systems, including LEED for Healthcare and LEED for Homes, that have attempted to define an integrated design process in their credit requirements may choose to reference this ANSI-approved standard instead.

– Nadav Malin

For more information:

American National Standards Institute
Washington, D.C.
202-293-8020
www.ansi.org

New Standard Puts Air Barriers to the Test

"Build tight and ventilate right" is a favorite motto of building scientists concerned with good indoor air quality and low energy use. A new test method from ASTM International—ASTM E2357, "Standard Test Method for Determining Air Leakage of Air Barrier Assemblies"—offers them help in living up to their motto.

The method provides the first uniform way to evaluate leakage through an air barrier as part of an actual wall assembly. According to Lance Robeson, AIA, president of Building Envelope Technologies, a founder of the American Air Barrier Association, and the principal author of the standard, before this standard existed, the only way to evaluate the performance of an air barrier was to evaluate the performance of the constituent materials. "This standard is designed to test a number of materials combined into a system," Robeson said.

The test simulates real-world conditions by calling for the assembly of an 8′ x 8′ (2.4m x 2.4m) mockup of an exterior wall. The mockup includes a tie-in to a foundation wall, a tie-in to a roof, duct and pipe penetrations, outlet penetrations, a window, and brick ties, all of which must be addressed by the air-barrier system. The assembly is tested before and after exposure to sustained wind and wind gusts, which are adjusted to exert both positive and negative pressure on the assembly.

Grace Construction Products recently became the first manufacturer to use the standard, announcing in July 2007 that its Perm-A-Barrier air barriers—including wall membrane, fluid-applied, and vapor-permeable products—had passed laboratory tests with leakage of less than 0.0008 cubic feet per minute per square foot (0.004 $l/s \cdot m^2$). Robeson said he expected other manufacturers to follow suit but argued that the standard's greatest use will be in testing

Perm-A-Barrier VP from Grace Construction Products, shown here partially applied to a new building, was among the first products to pass a new ASTM test for air leakage as part of a wall assembly. Photo: Grace Construction Products

onsite mockups of wall assemblies for high-performance commercial building projects, where materials as well as construction methods need to be evaluated. Robeson also noted that several additional air-barrier standards are in the works, including one testing multiple assemblies at once—essentially simulating the performance of whole buildings.

– Tristan Roberts

For more information:

Air Barrier Association of America
Walpole, Massachusetts
866-956-5888
www.airbarrier.org

ASTM International
West Conshohocken, Pennsylvania
610-832-9585
www.astm.org

President Bush Authorizes Energy Research But May Not Fund It

In August 2007, President George W. Bush signed the "America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act," or the "America COMPETES" act. The bill authorizes funding for an array of programs in the U.S. Department of Energy (DOE), the National Science Foundation (NSF), and a number of other agencies.

According to a summary published by the U.S. House of Representatives Committee on Science and Technology, the bill is intended to improve the quality of science and math education, to invest in science and engineering research, to offer incentives for students and researchers in science, and to offer tax incentives and other benefits to support scientific innovation in the private sector.

The bill authorizes the creation of the Advanced Research Projects Agency for Energy (ARPA-E) at DOE to support research in energy technologies including renewable energy, carbon sequestration, nuclear energy, and energy efficiency. According to the bill's summary, "ARPA-E will address long-term and high-risk technological barriers in energy through collaborative research and development that private industry or the DOE are not likely to undertake alone." To fund ARPA-E, the bill authorizes $300 million in fiscal year 2008; funding for DOE programs in the bill totals $17 billion in fiscal years 2008–2010.

However, the programs authorized by the America COMPETES bill may not ever gain funding, as Congress and President Bush must pass a budget appropriating those funds, and, in signing the bill, the president warned of roadblocks: "I will not propose excessive or duplicative funding based on authorizations in this bill," he said. Among the projects Bush considers "excessive" is ARPA-E, as it focuses on research and development that he argues is "more appropriately left to the private sector."

– Allyson Wendt

For more information:

U.S. House of Representatives
Committee on Science and Technology
www.science.house.gov

Newsbriefs

Grocery Store Earns LEED Gold—The Redmond, Washington, branch of Seattle-based PCC Natural Markets became the first grocery store to achieve a Gold certification in any of the U.S. Green Building Council's LEED rating systems. The store, certified under LEED for Commercial Interiors, features 28 skylights that bring daylight into the store and reduce general lighting electricity use to an anticipated 0.21 watts/ft^2 (2.25 W/m^2), an 86% reduction compared with a base case building in minimal compliance with Washington State code requirements; electricity use for accent lighting is expected to be 37% lower than code. Waste heat from the refrigerators is used for space and water heating, and overall energy savings are expected to be 50% compared with a code-compliant store. Recycled-content materials were used throughout, as were finishes with low levels of volatile organic compounds. More information is available at www.pccnaturalmarkets.com/locations/rd.html.

Photo: PCC Natural Foods

Clerestory windows and skylights bring daylight into this LEED Gold grocery store in Redmond, Washington, lessening the need for artificial light and saving energy.

National Green Building Program from NAHB—The National Association of Home Builders (NAHB) has announced the creation of the National Green Building Program, which will be launched in February 2008. The first iteration of the program will be based on the Green Home Building Guidelines written by NAHB (see *EBN* Vol. 16, No. 2); the National Green Building Standard being developed by NAHB with the International Code Council (see *EBN* Vol. 16, No. 3) will be incorporated into the program when it is available. The national building program will allow builders to submit their projects for certification and have them verified by a third party. In addition, local building certification programs whose criteria meet or exceed those of the NAHB program will be able

to use the national program to certify projects. More information is available at www.nahb.org/greenbuildingprogram.

BOMA Announces Energy Savings Plan for Existing Buildings—At its annual conference in New York in July 2007, the Building Owners and Managers Association (BOMA) announced a seven-point energy savings challenge for its more than 16,500 members. The challenge calls for BOMA members to decrease energy consumption in existing buildings by 30% across their portfolios by 2012 and benchmark every building's energy performance and water usage at least once a year using the Energy Star benchmarking tool. BOMA features education for maintenance personnel, energy audits, and improved building maintenance as chief strategies in the plan. More information is available at www.boma.org.

Armstrong Headquarters Achieves Platinum—The corporate headquarters for Armstrong World Industries, a flooring, ceiling, and cabinet manufacturer based in Lancaster, Pennsylvania, has earned a Platinum certification through LEED for Existing Buildings. The nine-year-old building, which achieved 64 points out of a possible 85, features onsite renewable power generation, waterless urinals, extensive daylighting, and native landscaping. The project earned an innovation point for the acoustical quality of its open-plan office spaces, which achieved an *articulation class*—a measurement of reflected speech noise from one partitioned workspace to another—of 200 using Armstrong's own Optima ceiling panels. The average articulation class for open-plan offices is 150–180, according to the company, and the best possible score is 250.

Long Island Town Requires LEED Certification—Developers and builders in Babylon, New York, are preparing to register their buildings for LEED certification to comply with a 2006 local law that goes into effect in December 2007. The law requires all new commercial buildings larger than 4,000 ft^2 (400 m^2) to achieve at least a LEED Certified rating. In addition, projects applying for building permits must pay three cents per square foot (32 cents/m^2), up to $15,000, to a town fund used to support and promote green building; if the building achieves LEED certification, the fee is refunded. If the building fails to achieve certification, the fee is forfeited and serves as the penalty for noncompliance with the law. According to Peter Cardona, past chair of Long Island's USGBC chapter, the law has been well received by townspeople and developers alike. Cardona noted that the neighboring town of Islip is considering a similar law.

New Energy Star Specifications for Commercial Dishwashers and Ice Machines—The U.S. Environmental Protection Agency (EPA) has finalized new Energy Star specifications for commercial dishwashers and ice machines. Starting on October 11, 2007, manufacturers will be able to qualify their dishwashers for the Energy Star label; the specification for ice machines will not take effect until January 1, 2008. According to Gwen Dobbs with ICF International, a contractor working with EPA on the specifications, about 25% of models currently on the market should qualify for the Energy Star label. More information is at www.energystar.gov; search for "commercial dishwashers" or "ice machines."

Organizations Developing Measurement Tools for Buildings—The American Society of Heating, Air-Conditioning, and Refrigerating Engineers (ASHRAE), the U.S. Green Building Council, and the U.K.-based Chartered Institute of Building Services Engineers are working together to provide guidance for measuring and reporting building performance. After a literature review, due out on September 1, 2007, the group will create baseline criteria for energy use, water use, air quality, thermal comfort, and acoustics. According to ASHRAE, the final report will be completed no sooner than the group's annual winter meeting in January 2008.

Photo: Armstrong World Industries, Inc.

More than 50% of interior spaces in the Armstrong headquarters are daylit. Integrated lighting control systems react to sunlight and adjust artificial light levels.

Federal Report Finds Health Risks from Polycarbonate Chemical—In the first official federal statement about the chemical's risks, a panel of scientists for the Center for Evaluation of Risks to Human Reproduction, part of the National Institutes of Health, concluded in August 2007 that bisphenol-A poses "some concern" for human health. After looking at more than 500 animal studies of the chemical, used to make the hard plastic polycarbonate found in water bottles, translucent building panels, and high-impact glazing, the panel agreed that there is a risk that it causes neural and behavioral effects in fetuses, infants, and children. The panel expressed "minimal" and "negligible" concerns about various reproductive effects of the chemical, which mimics estrogen. These findings will be forwarded to the National Toxicology Council, which will determine whether bisphenol-A should be considered toxic to humans and issue a report with its recommendations for regulation of the chemical. More information is available at http://cerhr.niehs.nih.gov/chemicals/index.html.

Energy Star Facilitates Bulk Purchasing—The U.S. Department of Energy (DOE) has created a new website, Energy Star Quantity Quotes, to help those wishing to purchase Energy Star appliances and equipment in bulk. After registering with the website, purchasers can request price quotes from Energy Star partner companies; the website currently has supplier listings for light bulbs, lighting fixtures, and appliances such as clothes washers, refrigerators, and room air-conditioners. The U.S. Environmental Protection Agency, which collaborates with DOE on the Energy Star program, hopes to add more categories of products, such as windows, doors, and skylights, although there is currently no timeline for this expansion. Quantity Quotes is online at www.quantityquotes.com.

Then & Now: 1997-2007

Newer Fluorescents Have Less Mercury, But Recycling Continues to Lag

When Philips Lighting Company first introduced its Alto technology in 1995, the average amount of mercury in a four-foot (1.2 m) T-8 Alto fluorescent lamp was 14 mg. By encapsulating the mercury and creating a chemical barrier coating to prevent absorption of the mercury by the phosphor coating, Philips was able to lower the amount of mercury in its Alto lamps to 3.5 milligrams (mg). In 2007, Philips introduced the Alto II line with 1.7 mg of mercury per four-foot lamp (see product brief, page 11).

All fluorescent lamps contain mercury, as they work by passing an arc of electricity through mercury vapor, which gives off ultraviolet light, exciting a phosphor coating inside the lamp that in turn produces visible light. That mercury poses a disposal problem, however, as it is a powerful neurotoxin and can escape from a broken lamp or leach into groundwater from landfilled lamps. Since we published a feature article on fluorescent lamp disposal ten years ago, the industry has taken great strides to reduce the amount of mercury in fluorescent lamps (see *EBN* Vol. 6, No. 9). However, recycling rates continue to lag, despite efforts to increase them.

The lower amount of mercury in Philips' lamps caused a few problems at first: according to Jennifer Dolin, environmental marketing manager at another low-mercury lamp manufacturer, Osram Sylvania, lamps were subject to "premature end-life blackening," when most of the mercury was absorbed before the end of the lamp's life, creating pink light. In a 2002 *EBN* article, some experts were still reporting shortened life in low-mercury lamps, but an investigation by an environmental group found no evidence of the phenomenon (see *EBN* Vol. 11, No. 6).

Despite the early difficulties, other companies soon followed Philips' lead. "There are benefits to having another company go first," said Dolin, "because they get all the kinks worked out." Osram Sylvania introduced an environmental label for its lamps, EcoLogic, in 2006, and lowered the mercury in its Octron T-8 lamps to 3.5 mg. A third major manufacturer, GE Lighting, also worked to lower mercury in its lamps. According to environmental marketing manager Joe Howley, the company's Ecolux T-8 lamps are "under the industry average" of 8.3 mg of mercury per lamp. This number comes from a 2001 survey performed by the National Electrical Manufacturers Association; since Osram Sylvania introduced their low-mercury lamps in 2006, however, the industry average may have dropped. "You have to balance the performance needs of the lamp with the needs of the environment," Howley said of efforts to lower mercury content, apparently justifying higher mercury levels than those achieved by Philips and Osram Sylvania.

Both Dolin and Howley told *EBN* that their companies are working to lower the mercury content of fluorescent lamps; according to Dolin, 1.7 mg per lamp is believed to be the lowest amount of mercury technically feasible.

While manufacturers have worked to lower the mercury content of fluorescent lamps, they and other industry groups have been working to raise recycling rates, which hover around 25% despite regulations requiring recycling from the U.S. Environmental Protection Agency (EPA). According to Paul Abernathy, executive director of the Association of Lighting and Mercury Recyclers (ALMR), this low

rate is due to several loopholes in recycling regulations. One loophole, Abernathy told *EBN*, is that lamps passing the EPA's Toxicity Characteristic Leaching Procedure (TCLP) are not considered hazardous waste and therefore do not need to be recycled; all three manufacturers' low-mercury lines pass this test. The second loophole is that any company, including small businesses of all sorts, producing less than 220 pounds (100 kg) of hazardous waste per month (equivalent to several hundred fluorescent lamps) are not required to recycle their lamps. Homeowners are also exempt from recycling fluorescent lamps. ALMR is working with several legislators to close these loopholes, said Abernathy.

Meanwhile, the Product Stewardship Institute (PSI) is working with manufacturers, retailers, and government agencies to create a pilot recycling program for fluorescent lamps, including compact fluorescent lamps, and thermostats. Aimed primarily at consumers and small business owners, the program will begin in October 2007 at 25 retail locations in Colorado, Montana, North Dakota, and Utah. Although hopeful about the results of the program, Scott Cassel, executive director of PSI, agreed with Abernathy that regulations are needed to increase recycling rates. "There need to be disposal bans," he said, "and enforcement of those bans." One such ban exists in California, where all fluorescent lamps are considered hazardous waste and must be recycled.

– Allyson Wendt

For more information:

Philips Lighting Company
www.lighting.philips.com

Osram Sylvania
www.sylvania.com

GE Lighting
www.gelighting.com

Association of Lighting and Mercury Recyclers
www.almr.org

Product Stewardship Institute
www.productstewardship.us

Product News & Reviews

Agrifiber-Plastic Composite Privacy Fencing Introduced

Heartland BioComposites, of Torrington, Wyoming, has commercialized a new breed of composite wood using annually renewable wheat straw rather than wood flour, and has introduced its first product, a privacy fence. The company purchases regional wheat straw and compounds it with post-consumer high-density polyethylene (HDPE). The raw materials, which include 50–60% straw, 35–45% plastic, and less than 5% proprietary additives (described by the company as "non-hazardous and organic"), are mixed, heated, extruded, and cut to length.

The usual attributes of composite wood apply: durability; low maintenance; lack of splinters; little appeal to insects; and good fastener retention. The composite mimics the appearance and use of natural wood, is available in four low-fading integral colors, and carries a 20-year residential warranty (five years commercial). Heartland BioComposites touts the line as more cost-effective than wood, vinyl, and the leading wood-plastic composites.

The PrairieFence wheat-straw/plastic composite privacy fencing system provides a durable alternative to vinyl and wood-plastic composites. Photo: Heartland BioComposites

The material, in development since the mid-1990s, has been the work of Heath Van Eaton—himself a product of a Kansas wheat-farming background. Growing up, he saw "a high level of underutilization of wheat straw. Then, in the early '90s, I learned about Trex [wood-plastic composite lumber], and that intrigued me beyond belief." Van Eaton began research on straw-plastic composites while studying at the University of Wyoming, and in 1999 founded Heartland BioComposites to further develop and market the material. The company has blossomed into a $10 million manufacturing startup.

Mike Fauth is the PrairieFence product manager for Empire Building Materials in Billings, Montana, a wholesaler that has been carrying the line since early 2007. "We looked for many years for a composite fencing product, but the composite decking people just weren't going there," he said. According to Fauth, the retail lumber yards Empire supplies have so far been selling it mainly to homeowners.

Houlihan Fence by Design, in St. Louis, began installing the PrairieFence system during summer 2007. Houlihan's Morvie Boyd said that customers find it an attractive option. "We're pricing it between wood and vinyl," she told *EBN*, "and not filling up the landfills with plastic."

Jares Fence Company, also in Billings, installed 350 feet (107 m) of PrairieFence in 12 hours when the television show "Extreme Makeover: Home Edition" came to town. Justin Jares, vice president, noted that the product's density provides impressive strength but also makes it fairly heavy: "We went to six-foot centers and used brackets," he said. "With cedar, we can just toenail." Each 72" (183 cm) PrairiePicket weighs 5.4 pounds (2.4 kg). With the recommended 1/16"

(0.16 cm) spacing, an eight-foot (2.4 m) run of pickets weighs about 100 pounds (45 kg).

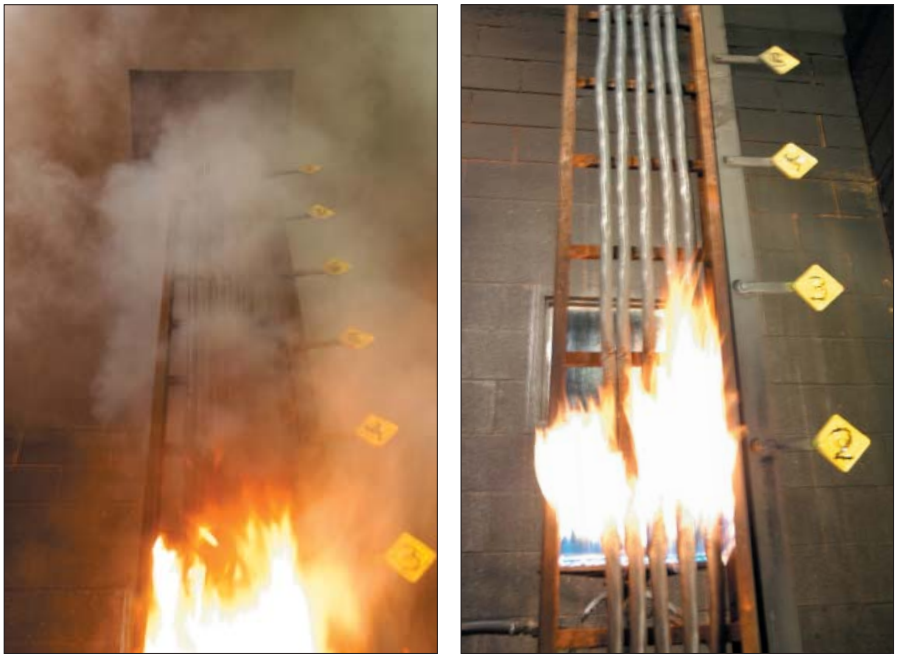
Other components of the system include PrairiePost, a hollow 4x4 extrusion with ⅝"-thick (1.6 cm) walls in 8' (1.2 m) lengths; PrairieRail, a solid 2x4 used for the support rails, compatible with most fence brackets, in 12' (3.7 m) lengths (16' and 20' [4.9 m and 6.1 m] available by special order); and PrairieDeck, a ¼" x 6" (1.3 cm x 15 cm) board used as a finishing element at the fence top, in the same lengths as PrairieRail. So far most distribution of PrairieFence has been in the western U.S.

Additional products are under development, says Van Eaton. "We've got properties that exceed most of the composite products out there, but we haven't completed all of the ASTM testing yet." Tweaks in process and formulation could yield an array of building materials, including decking, dimensional lumber, sheet materials, and roofing shingles.

– Mark Piepkorn

For more information:

Heartland BioComposites
Torrington, Wyoming
866-997-7637
www.heartlandbio.com



The LifeGuard low-smoke nonhalogenated electrical cables from Houston Wire & Cable Company release water vapor on combustion, shown at right, rather than toxic gases that can form during combustion of halogenated cables, shown at left. Photo: Houston Wire & Cable Company

Search for Green Wiring Gets a LifeGuard

Green building advocates (among them the editors of *EBN* and the *GreenSpec Directory*, both published by BuildingGreen) have long sought an electrical cable product that meets their standards. According to *GreenSpec*, the product should be free of heavy metals and halogens (including chlorinated, brominated, or fluorinated substances), and compliant with RoHS, the European Union's Restriction of Hazardous Substances in Electrical and Electronic Equipment regulation. The product should also perform up to relevant flame retardancy standards.

A product meeting this description has been absent from the building wire market, leaving PVC-sheathed cable as the main option. Meanwhile, since 2003, Houston Wire & Cable Company (HWC) has sold the LifeGuard line of nonhalogenated cable meeting all of those ideals and more. There are two catches: HWC hasn't yet sold building wire for commercial or residential projects, and LifeGuard sells for a 30% premium over conventional wire in a cost-competitive product category with low visibility.

HWC sells LifeGuard primarily for applications where it is valued for its resistance to corrosion and its low smoke emissions, and where reliability is at a premium, driving buyers to higher-end products. In these specialized applications, which include power plants, wastewater treatment facilities, marine vessels, and populated, confined areas such as transit corridors, LifeGuard is cost-competitive. At high temperatures PVC cable releases hydrogen chloride gas. The gas deprives a fire of oxygen, but it combines with moisture to form corrosive hydrochloric acid, which is damaging to people and equipment in buildings. In contrast, LifeGuard has a nonhalogenated polyolefin sheathing that uses aluminum- or magnesium-based metal hydrides as flame retardants, according to Jim Pokluda, vice-president for marketing at HWC. At high temperatures, the plastic releases steam, which inhibits flames.

HWC offers several products in the LifeGuard line, including armored cable and power transmission cable for up to 15,000 volts. The HW010 and HW020 lines of 600V power cable could be used in non-plenum wiring for lighting, outlets, and appliances. While suitable for commercial and residential buildings, Pokluda said that HWC has not sold wiring for those purposes. HWC has instead sold this building wire to utilities such as operating plants using only high-reliability, nonhalogenated wiring. While those facilities need to power lights and electrical services just as any conventional building does, they use the higher-end LifeGuard for those applications to

match the LifeGuard wiring they use for high-voltage applications.

Pokluda said that there isn't a lack of interest in LifeGuard from green builders. "I get calls from green organizations where they may be building a prototypical green home," but, he said, "we haven't sold any. People like to think about it, but it's just not price competitive for them." Gail Vittori, co-director of the Center for Maximum Potential Building Systems, said that she hasn't yet been able to get LifeGuard into green projects despite "valiant effort," but not because of cost. "What stopped it was reticence by the engineers to use a product that in their minds posed uncertainty in terms of performance," she told *EBN*. "They're reluctant to make a change." Although recognizing its higher cost, Vittori noted that early adopters of LifeGuard or other similar products could be rewarded by preferential pricing by manufacturers looking to advertise successful case studies.

Nonhalogenated wiring like LifeGuard is flourishing as a niche product where engineers have sought it out for its reduced risk to people and property. It may not outgrow that niche, however, without stronger interest from building professionals and consumers, pursuit of the market by manufacturers, and perhaps regulatory help.

– Tristan Roberts

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Phoenix Solar Tank Does it All—Efficiently

The basic Phoenix water heater from Heat Transfer Products (HTP) combines multiple features—including the integration of space and water heating—in one efficient package. The unit's modulating burner and condensing flue provide residential hot water with an impressive 97% thermal efficiency using natural gas or liquid propane. Auxiliary hookups for a heating coil can be used in forced-air or radiant heating systems. The new Phoenix Solar has a second heat-exchange coil inside the tank for fluid from solar thermal panels. This feature means that one tank can serve as both the primary and the backup storage tank for a solar hot water system.

Phoenix Solar, a modified version of the Phoenix super-efficient, high-capacity gas water heater, includes a second heat exchanger at the bottom of its tank to store heat from solar collectors. Photo: Heat Transfer Products, Inc.

Storing both solar-heated water and gas-heated backup water in the same tank simplifies installations dramatically, but it could compromise the efficiency of the system. If the fluid loop serving the solar collectors encounters water in the tank that is kept warm by the gas backup system, it would force the solar collectors to operate at a higher temperature, reducing their efficiency. HTP has mitigated this problem, however, by placing the solar loop at the bottom of the tank and the gas burner halfway up. In this configuration, the water stratifies in the tank, so the bottom remains cold. "We've measured and found cold water at the bottom of the tank, even with water at 115°F (46°C) at the top," claims David Davis, president of HTP. Any loss in efficiency may also be offset by the increase in the amount of solar energy provided to the system from the larger tank, compared with a dedicated solar tank. In addition to solar panels, fluid from a heat exchanger connected to a wood-burning stove or other heat source can also be used to preheat water in the tank.

Phoenix Solar is available in 80-gallon (300 l) and 119-gallon (450 l) sizes. It has two inches (50 mm) of foam insulation, and can be installed with zero clearance to combustibles. The auxiliary connections for a heating coil are especially useful for low-temperature heating applications, such as a radiant slab. If higher temperatures are required, a mixing valve would be needed to reduce the temperature for sinks and showers. The system can be configured with an outdoor temperature sensor to boost the water temperature only during the heating season, according to Davis.

"I really like the auxiliary connection ports—it's something I often struggle with, so it's nice to see they thought of it," said Marc Rosenbaum, P.E., of Energysmiths in Meriden, New Hampshire. While the unit is too new to have much field experience, it's based on the well-established Phoenix water heater, so chances are it will be a winner.

– Nadav Malin

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www.htproducts.com

Product Briefs

Philips Introduces Lower Mercury Fluorescent Lamp—Philips Lighting Company has announced a new line of T-8 fluorescent lamps using the company's Alto II technology to replace its ten-year-old Alto technology. Each new lamp contains 1.7 mg of mercury, compared to 3.5 milligrams (mg) in each original Alto lamp. "Through some innovative approaches to mercury doses and retention in the lamp technology, we were able to take this next step," said Susan Bloom, director of communications for Philips Lighting. The new technology improves upon Philips' encapsulation of mercury and its chemical barriers that prevent the phosphor coating inside the lamp from absorbing the mercury. Philips will be incorporating the new technology into all of its T-8 lamps by the end of 2008; the company's T-5 lamps already have very low mercury levels, containing 1.4 mg each. More information is available at www.nam.lighting.philips.com/us/newproducts/alto-ii/.

MetroPaint Earns Green Seal Certification—MetroPaint, a 100% recycled-content latex paint produced in Portland, Oregon, has become the first paint to be certified under Green Seal's recycled-content paint standard (see *EBN* Vol. 15, No. 12). The paint is produced by Metro, a regional council that collects unused paint as part of its waste management programs. To achieve certification, the paint had to meet standards for recycled-content levels, quality of filtration, paint performance, and volatile organic compound levels. The paint was also certified through the Master Painters Institute, which tests recycled-content paint using the same standards as virgin paint. MetroPaint is available in Portland and at several retailers throughout Oregon; more information is at www.metro-region.org (search for "recycled paint").

Driving to Green Buildings *(from page 1)*

For an average *new* office building built to code, transportation accounts for more than *twice* as much energy use as building operation.

This article takes a look at the "transportation energy intensity" of buildings and the influence of location and various land-use features on this measure of energy use. While the focus will be primarily on energy (and the associated environmental impacts of energy use, such as pollution), we will see that measures to reduce transportation energy use can have very significant ancillary benefits relating to water runoff, urban heat island mitigation, and habitat protection, while creating more vibrant, livable communities.

Transportation Energy Intensity as a Building Performance Metric

"Transportation energy intensity" is a metric that has long been used to measure such things as how efficiently freight is transported. We're proposing it here as a metric of *building* performance. The transportation energy intensity of a building is the amount of energy associated with getting people to and from that building, whether they are commuters, shoppers, vendors, or homeowners. The transportation energy intensity of buildings has a lot to do with location. An urban office building that workers can reach by public transit or a hardware store in

Comparing Transportation and Operating Energy Use for an Office Building

	U.S. UNITS	METRIC UNITS
Average U.S. commute distance – one way[1]	12.2 mi	19.6 km
U.S. average vehicle fuel economy – 2006[2]	21.0 mi/gal	8.9 km/liter
Work days	235 days/yr	
Annual fuel consumption	273 gal/year	1,030 liters/yr
Annual fuel consumption per automobile commuter[3]	33,900 kBtu/yr	9,890 kWh/yr
Transportation energy use per employee[4]	27,700 kBtu/yr	8,100 kWh/yr
Average office building occupancy[5]	230 ft^2/person	21.3 m^2/person
Transportation energy use for average office building	121 kBtu/ft^2	381 kWh/m^2
Operating energy use for average office building[6]	92.9 kBtu/ft^2-yr	293 kWh/m^2-yr
Operating energy use for code-compliant office building[7]	51.0 kBtu/ft^2-yr	161 kWh/m^2-yr
Percent transportation energy use exceeds operation energy use for an average office building	30.2%	
Percent transportation energy use exceeds operation energy use for an office building built to ASHRAE 90.1-2004 code	137%	

1. U.S. Department of Transportation, *Transportation Energy Data Book 26th Edition*, 2007, Table 8.6
2. U.S. EPA Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2006
3. Assumes 124,000 Btu/gallon of gasoline, DOE Energy Information Administration data
4. Assumes 76.3% commute in single-occupancy vehicle, 11.2% carpool (2 per car) and no other energy use (commuting transportation modes from U.S. DOT *Transportation Energy Data Book 26th Edition*, 2007, Table 8.14.
5. U.S. General Services Administration
6. This includes site energy only, not source energy. U.S. DOE Energy Information Administration Commercial Building Energy Consumption Survey (CBECS) data for 2003, published June 2006.
7. Bruce Hunn, ASHRAE, personal communication

a dense town center will likely have a significantly lower transportation energy intensity than a suburban office park or a retail establishment in a suburban strip mall.

In the table on page 11, we compare the transportation energy intensity of an average commercial office building with the building operation energy intensity of such a building. We use average figures for commute distance, fuel economy, work days per year, gross square footage per employee, and commuting transportation mode to calculate the average transportation energy use per square foot of building floor area. For that average building, the transportation energy use exceeds the building energy use by 30%. When compared with a new, more energy-efficient building built to ASHRAE 90.1-2004 energy code, the transportation energy use exceeds the building energy use by nearly 140%. (Note that this analysis examines only *site energy*; if it compared *primary energy* or *source energy*, the differences would be smaller—largely due to the significant electricity use in commercial buildings and the inefficiency of electricity generation.)

We will see in this article that about eight factors, largely controlled by planners, designers, developers, and regulators, dramatically affect the transportation energy intensity of buildings. While far from a comprehensive treatise on the topic, this article introduces these issues and makes the case that, first, we need to pay far more attention to location and land-use planning as a part of green development, and, second, that this is an area deserving a great deal more research attention.

Environmental Impacts of Automobile Travel

Transportation energy use and the environmental impacts associated with that energy use are huge. In 2006, transportation in the U.S. consumed 28.5 quads of energy (84 trillion kWh), or 28.5% of total national energy use, according to the Energy Information Administration of the U.S. Department of Energy. Both the total energy and the percentage of transportation energy use have been rising in recent years, while industrial energy use (currently the largest share at 32.1%) has been dropping. The transportation share of carbon dioxide emissions is slightly greater at 32.9% (2005 data) and higher than that of industrial, commercial, and residential sectors, with the share rising slightly since 1990.

Environmental impacts of transportation are not limited to energy and greenhouse gas emissions. The table below shows transportation's share of certain criteria pollutants.

In addition to these direct emissions from transportation, there are many other environmental impacts associated with the infrastructure needed to support transportation and with development patterns. Our roadways create impervious surfaces that result in significant pollutant runoff into waterways—in fact, non-point source water pollution from stormwater runoff is now the nation's leading source of water pollution to estuaries and the third largest to lakes. Highways fragment ecosystems and wildlife habitat. Paved areas, including roadways and parking lots, absorb solar energy, contributing to localized heat islands that exacerbate smog and increase air-conditioning requirements in urbanized areas. And stormwater runoff from these surfaces creates thermal pollution that makes many waterways unsuitable for trout and other cold-water fish.

Land development is occurring at a far higher rate than population growth, resulting in sprawl. In the nation's 34 metropolitan areas with populations greater than one million people, between 1950 and 1990 the population increased 92.4%, according to the U.S. Environmental Protection Agency (EPA) report *Our Built and Natural Environments: A Technical Review of the Interactions Between Land Use, Transportation, and Environmental Quality*, while the urbanized land area grew by 245%, or 2.65 times the population growth rate. In Atlanta, the developed land area grew almost tenfold during this period, while the population grew a little over threefold.

As our urban and suburban areas spread out, vehicle travel increases. Transportation planners use *vehicle miles traveled* (VMT) to measure automobile use. In the U.S., VMT per household has increased from 12,400 miles (20,000 km) per year in 1969 to 21,200 miles (34,000 km) per year in 2001, a 70% increase. During the same period, VMT for commuting to work increased from 4,180 miles to 5,720 miles (6,730 km to 9,200 km), or 37%.

Transportation Share of U.S. Criteria Air Pollutant Emissions (2002)

Criteria air pollutant	Transportation share	Highway vehicle share
Carbon monoxide (CO)	77.3%	55.5%
Nitrous oxide (NOx)	54.3%	34.9%
Volatile organic compounds (VOCs)	43.7%	27.5%
Particulates – 10 micron (PM-10)	2.3%	0.9%
Particulates – 2.5 micron (PM-2.5)	6.5%	2.2%
Sulfur dioxide (SO_2)	4.5%	1.8%
Ammonia (NH_3)	8.8%	8.0%

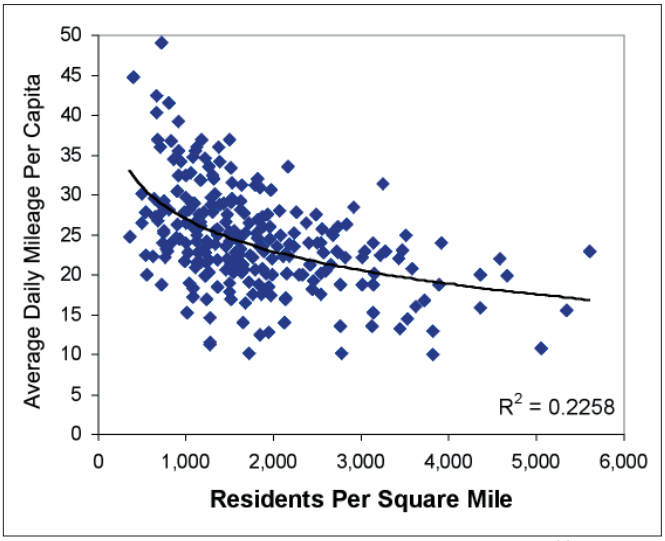
Source: U.S. Department of Transportation, *Transportation Energy Data Book: 26th Edition* (2007)

Reducing the Transportation Energy Intensity of Buildings

While most measures to reduce *building* energy use relate just to that particular building, most measures to reduce the *transportation* energy

use of buildings relate to the broader land-use context. They help to achieve what is often called transit-oriented development (TOD) or smart growth. (The terms new urbanism and neo-traditional development are also used, though with slightly different connotations.) Among the goals of these development paradigms are communities, towns, or urban areas that are pedestrian-friendly and accessible with minimal use of the automobile.

Density vs. Vehicle Travel for U.S.



Source: Todd Litman, VTPI

Per capita vehicle travel tends to decrease with increases in density.

Features used to achieve this sort of development are typically beyond the control of building designers and, to some extent, even building owners. Location is critical. "The transportation performance of buildings is all about location," says Doug Farr, AIA, of Chicago, author of the forthcoming book *Sustainable Urbanism: Urban Design With Nature* (John Wiley & Sons, 2008).

We'll now explore eight key factors that can reduce the transportation energy intensity of buildings, primarily by reducing VMT. Transportation and land-use planners often talk about the "D-factors," including density, distance to transit, diversity of uses, and design of streetscapes; we'll look at these and others.

Density

Most experts put density at or near the top of the list of measures for reducing vehicle use. Hank Dittmar, executive director of the Prince's Foundation for the Built Environment and chair of the Congress for the New Urbanism, points to density as the first priority in achieving location efficiency. Research he conducted with the Natural Resources Defense Council (NRDC) and the Center for Neighborhood Technology (CNT) in the 1990s "showed a fairly dramatic reduction in VMT as you moved from seven to 10–12 units to the acre," he told *EBN*. The reduction curve begins to flatten out at 40–50 units per acre; the benefits of mixed use remain, Dittmar explains, but the residents of those units may still have to travel for work and other trips throughout the region, which density does not affect. This correlation between density and VMT is shown in the graph above.

Reid Ewing, Ph.D, a widely published author on transportation planning and traffic calming and director of the National Center for Smart Growth Research at the University of Maryland, says that in the most compact, densely populated places like Chicago, VMT can be as much as 90% less than in sprawling suburbs. Among the innovative strategies for encouraging density are density transfer mechanisms, which enable planners to manage development rights by trading them from environmentally sensitive areas to areas that can be developed. This mechanism is being used in Montgomery County, Maryland; Sarasota, Florida; and Chapel Hill, North Carolina.

Transit availability and access

Everyone agrees that the availability of rail and bus transit is a key requirement for getting people out of cars. Distance to transit addresses how far someone must walk to get to a bus stop, light rail or trolley stop, or train station. "The first problem is that it isn't there for most people," says Dittmar. When public transit isn't available, or convenient, or comfortable enough to be used, some companies are taking it upon themselves to satisfy the need. Information technology giant Google maintains a fleet of alternative-fuel buses that it uses to shuttle employees from many locations throughout the San Francisco Bay area to its office park; the company encourages ridership by offering such amenities as comfortable seats and wireless access.

To be effective, transit stops have to be close to where people live. "Generally speaking," according to John Thomas, Ph.D., of the Development, Community & Environment Division at EPA, "one-quarter to one-half-mile range is the distance people will walk to transit." People can be expected to walk further to reach rail transit stops compared with bus stops, but rarely will people walk more than a half-mile.

While transit is the key word in transit-oriented development, it's really more about walking. "I think of transit as connecting walkable districts," says Ellen Greenberg, a coauthor of *The New Transit Town* (Island Press, 2004) and the past director of policy and research at the Congress for the New Urbanism. "Everyone winds up being a pedestrian somewhere in the travel day," she told *EBN*. Even people who commute by car walk to and from their cars, she points out, "but transit riders are on foot a bigger part of their day, so transit-

oriented developments have, by their very nature, a bigger component of the walking trips than conventional development."

In a discussion of transit, it's worth noting that some forms of transit are no more energy efficient than private automobile commuting (see chart below). On a Btu per passenger-mile basis, buses actually use more energy per passenger mile than cars, assuming average occupancy of both, while all forms of rail use less and vanpools use a lot less. The number of passengers makes a huge difference in the energy intensity (Btu per passenger mile). For example, by increasing the assumed ridership of a transit bus to 40 people, the energy intensity drops to less than 1,000 Btu per passenger mile. Note that even though buses with average ridership may use more energy per passenger mile than cars, bus transit is still beneficial as a public service, because it can make urban areas more walkable.

Mixed uses and access to services

Diversity has to do with the mix of residential, commercial, and retail land uses and whether key services can be met within easy walking distance of residences and workplaces. In the LEED for New Construction rating system, one of the considerations for awarding a credit is whether a residential area is within a half-mile of at least ten out of 22 listed services, including banks, convenience grocery stores, daycare, restaurants, pharmacies, laundry, schools, libraries, and parks. Farr calls this area a "pedestrian shed"—a play on the term "watershed"—referring to a surrounding area in which everyday needs can be met on foot.

This diversity also affects the success of transit. "It's very important for people who ride transit to be able to accomplish multiple things on foot once they arrive at their destination," notes Greenberg. "You need to have a mix of uses to satisfy people's needs," she told *EBN*.

In addition to having a diversity of services and land-use types in a community, it is beneficial to have a diversity of housing to serve all socioeconomic groups. According to Ewing's book *Best Development Practices* (American Planning Association, 1996), "promoting affordable housing serves transportation as well as social purposes." He notes that low-skill-level workers tend to be concentrated in cities, while low-skill-level jobs are concentrated in wealthier suburbs. This mismatch results in a lot of commuting by those who have the hardest time affording it.

The Energy Intensity of Different Forms of Travel

Vehicle Type	Load Factor (persons/vehicle)	Energy Use (Btu/vehicle-mile)	Energy Intensity (Btu/pass-mile)
Cars	1.6	5,489	3,496
Personal trucks	1.7	7,447	4,329
Taxi & van (demand response)	1.0	14,952	14,301
Vanpool	6.4	8,226	1,294
Bus – Transit	8.7	38,275	4,318
Airline	90.4	358,000	3,959
Rail – Intercity (Amtrak)	17.9	51,948	2,760
Rail – light & heavy	22.4	70,170	2,750
Rail – commuter	32.9	91,525	2,569

Source: U.S. Department of Transportation – *Transportation Energy Data Book, 26th Edition*, 2007, Table 2.12 (data from 2004)

Parking management

For transit-oriented development to succeed, many experts call for good parking management. Todd Litman, executive director of the Victoria Transport Policy Institute, calls parking management the top priority in reducing VMT. "Once you build generous parking," Litman told *EBN*, "you have very little incentive to provide alternatives." Brett Van Akkeren, a smart growth analyst at EPA, told *EBN* that in suburbs there are nine parking spots for every car.

Greenberg agrees, saying that the first priority "is definitely constrained or expensive parking supply. It has been shown that expensive parking acts as a deterrent to commuters." In the book *Parking Management Best Practices* (Planners Press, 2006) and in a summary paper, "Parking Management: Strategies, Evaluation and Planning" (Victoria Transport Policy Institute), Litman lays out more than 20 strategies that can be used alone or in combination to reduce parking by 20% to 40%.

As with many of these strategies for encouraging transit-oriented development, parking affects more than just VMT. "Not only will more parking encourage more driving," says John Holtzclaw, a widely published transportation researcher in San Francisco and chair of the transportation committee for the Sierra Club, "but curb cuts along sidewalks make walking less interesting and less safe and make buildings less interesting." Surface parking also takes up a lot of space, forcing pedestrians to walk further to get where they want to go. Where you do have parking, suggests Holtzclaw, "have it underground. Don't take up the first two floors with parking; that just deadens the neighborhood."

Walkability, traffic calming, and site design

As noted earlier, walkability is key to the success of transit-oriented development. "Walkability and public

transit go hand-in-hand," argues Holtzclaw. He suggests that planners place themselves as pedestrians: "Think about how it feels to walk. Are there places to walk to? How are the streets laid out? Are there sidewalks on both sides of the street? Is the traffic calmed? Are the buildings close to the sidewalk, or do you have to walk through a parking lot to get inside?"

Hank Dittmar notes that while transit is a key aspect of smart growth and transit-oriented development, not all communities are there yet. For communities without transit, measures can be taken to prepare for a transit future. "They ought to be getting those neighborhoods ready," he said. "At the core must be a connected, strong network that works for pedestrians."

Traffic calming is another aspect of walkable communities. "By slowing traffic, you create a nicer pedestrian environment," notes Reid Ewing, whose book *Traffic Calming: State of the Practice* (Institute of Traffic Engineers, 1999) remains the authority on the topic. "Also, when you slow down traffic, you make trips shorter, which reduces VMT," he told *EBN*. (For more on traffic calming, see *EBN* Vol. 12, No. 3.)

Along with traffic calming, it helps to create streetscapes that are comfortable, safe, relaxing, and enjoyable to spend time in. Good lighting, park benches, outdoor tables at cafés, shade tree plantings, pedestrian courts that are closed off to automobiles, and public wireless access can all help to create vibrant, pedestrian-friendly outdoor spaces where people will be glad to walk a few blocks from a transit stop to get to their workplaces, and glad to walk to a restaurant for lunch, thus helping to reduce VMT.

Connectivity

Connectivity is about designing—or redesigning—communities so that pedestrian connections are better. It can mean breaking up "superblocks" into smaller, more walkable blocks, and replacing connector streets and cul-de-sacs with a network of interconnected streets that spread out traffic flow, slow down vehicles, and make walking more pleasant.

"The smaller the block dimension, the more people will walk," notes Farr. Ewing agrees that limiting block size favors pedestrians. "You ever walk on a super block? They're endless," he says. "With small blocks, it's much easier to walk." To evaluate the connectivity of a community, Ewing created a "connectivity index," which is determined by dividing the number of roadway links (street segments between intersections) by the number of roadway nodes (intersections). The higher the connectivity index, the greater the route choices and the better the pedestrian access. Using this formula, a minimum connectivity index of 1.4 is considered necessary for a walkable community.

Connectivity can also be achieved for pedestrians by creating pathways that cut between cul-de-sacs or that bisect long blocks. Such connections don't spread out vehicle traffic, but they improve walkability. Providing appropriate lighting and attractive landscaping along those pathways can increase usage.

In Copenhagen, Denmark, more than 30% of workers commute by bicycle. Since the 1970s, planners, traffic engineers, and politicians have worked hard to keep road infrastructures from growing, which has reduced VMT by 10%. Photo: Dan Burden, Walkable Communities, Inc.

Bicycle accessibility

While a much smaller percentage of Americans bicycle than walk, bicycle access is an important strategy in achieving the kind of communities envisioned with transit-oriented development. While walking is limited to sidewalks and pedestrian pathways, a significant portion of bicycling occurs on roadways, where it competes with motor vehicles.

There are areas in Europe, particularly The Netherlands, Denmark, and Sweden, where bicycling accounts for up to 40% of all trips, and in the U.S., bicycling is widely used on many campuses and in a some urban areas. A big limitation to greater bicycle usage in the U.S. appears to be that our streets and communities are not

bicycle friendly. According to the 2004 publication *Getting to Smart Growth II* by the Smart Growth Network, a 2003 poll by the American League of Bicyclists found that over half of the respondents would like to bike more often, and three-quarters of them would increase their biking with safer bike paths and other amenities.

The most important strategies for increasing bicycle use relate to where people bike: bicycling lanes and designated bicycle paths and trails. But some bicycle-access measures relate more to buildings. Covered bicycle storage allows people to bike to work and not worry about their bicycles getting wet. Changing and shower facilities at workplaces are essential for bicycling to be realistic as a commuting option.

Improved efficiency of transportation options

The strategies addressed here focus primarily on land-use and transportation planning issues. The transportation energy intensity of buildings can also be reduced by making our motorized means of transportation more energy efficient. Natural-gas-fueled and hybrid diesel-electric buses are increasingly appearing in cities around North America, offering both improvements in fuel economy and reductions in pollution emissions. New, more efficient light-rail and heavy-rail train cars are improving the energy efficiency of rail travel; most of those serving as commuter transit are now electric, so they have very low emissions (at the place of use).

With both bus and rail transit, the best way to improve the energy efficiency of operation is to increase ridership. While a packed train, subway, or bus may be somewhat less pleasant for riders, it's far better from the standpoint of energy use and pollution emissions per passenger-mile.

With private automobiles, the same arguments apply—for both energy efficiency and ridership. Hybrids and biodiesel-burning cars are generally better than conventional gasoline-powered cars, but even the lowest fuel-economy SUV carrying four carpool riders to work will use less energy and emit less pollution per passenger-mile than a hybrid Prius carrying only a driver.

Portland planners predicted in 2001 that the new streetcars would serve about 3,500 riders a week, but 9,000 people now ride them daily. Over half of the city's development in the last decade has occurred within one block of the streetcar route, and property values within a block of the route are 35–40% higher than those just two blocks away. Photo: Reconnecting America

Developing Building-Specific Metrics for Transportation Efficiency

One reason that location efficiency or transit-oriented development isn't more front-and-center in the design community is that it's too easy to consider it someone else's problem. The common sentiment is that it's a land-use issue that's beyond the scope of a particular building project. Specific metrics that measure the transportation energy intensity of a building would help change that perception. "What's needed is to develop a set of adjustment factors that a planner or designer could apply that indicate the reduction of vehicle travel," Litman told *EBN*. From these, one could calculate the reduction in energy consumption associated with those factors, he suggests.

For example, if one could define the baseline transportation energy intensity for a building type and attach a number to that, it should be possible to modify that value by a series of adjustment factors—much as is done with energy performance ratings of buildings. These adjustment factors would be based on the measures covered in this article: distance to transit, presence of bicycle pathways, traffic calming, etc. In such adjustment factors would be implicit weightings: distance to transit might be worth more than existence of bicycle racks, but both could be applied numerically.

One could argue that the transportation energy use of a building is too dependent on occupant behavior to warrant this sort of treatment (that even if the building is located right next to a light-rail station, there is nothing to stop workers from driving to work anyway). This is a reasonable concern that needs to be addressed, but the same concern exists with building energy use—albeit to a lesser degree. We are learning that the modeled energy use of buildings

Select Strategies for Achieving Transportation-Efficient Communities

MUNICIPAL PLANNING	
Support transit-oriented development (TOD).	Develop in clusters with highest density near transit stations, commercial centers, and parks; direct development toward existing communities; develop TOD features in building design; create walkable communities; incorporate density transfer mechanisms when managing development rights.
Encourage mixed use.	Redevelop single-use areas into mixed use; place services and stores in residential neighborhoods; combine ground-floor retail with upper-floor residential whenever possible; accommodate adaptive reuse of obsolete buildings.
Encourage alternative means of transportation.	Provide a variety of high-quality transportation options; provide right-of-way to rapid buses; develop bicycle and pedestrian networks that are as good as (or better than) those for motorists; liberally employ traffic calming methods; keep streets narrow (no more than four lanes wide); keep speeds as low as 20 mph on local streets and 35 mph on arterials and collectors; create comprehensive transit-rider programs; provide preferential parking for car-share vehicles; refrain from expanding roadway capacity, which has been shown to induce traffic.
MUNICIPAL ZONING	
Increase Density.	Mandate density minimums and eliminate lot-size minimums; density near transit should meet or exceed density in surrounding areas; consider a "density average" for an area combined with a "density gradient" that adjusts depending on site's distance to transit station; develop density requirements in conjunction with open space requirements and urban growth boundaries.
Eliminate parking minimums.	Establish maximum rather than minimum parking requirements, particularly in areas with high-quality transit, or establish parking requirements that suit each site's actual needs rather than relying on "one size fits all" standards; allow building owners to assign "parking share zones" rather than individual spaces for multifamily housing; allow businesses the flexibility to trade or share parking capacity.
Change height and floor area ratio (FAR) limits.	More compact development can occur as height and FAR limits increase; this is especially important near transit stations.
PUBLIC INCENTIVES	
Municipal	Charge motorists for street parking costs to reduce demand for parking; provide property tax exemptions and revolving loan funds for TOD features; institute road pricing strategies such as road tolls, congestion pricing using fixed or dynamic schedules, and area tolls in places like city centers.
State	Change state insurance policies to encourage pay-as-you-drive insurance; institute road pricing strategies such as HOT (high-occupancy toll) lanes for which low-occupancy vehicles pay to use, distance-based charges such as mileage fees (in addition to, or in place of, vehicle registration fees and fuel taxes), and provide funding for bicycle and pedestrian access.
Federal	Increase transit's share of overall federal funding to at least $1 for every $3 currently spent on highways; make location-efficient mortgages more available to buyers of transportation-efficient housing; develop stronger tax incentive programs for adaptive reuse, mixed-use and TOD projects; remove tax loopholes that allow drivers to use pre-tax wages to pay for parking at work.
PRIVATE INCENTIVES	
Building Designers and Developers	Provide all the necessary amenities (e.g., showers/lockers) to accommodate pedestrians and cyclists; create clear pedestrian connections between buildings and sidewalks; ensure that primary entrances face street; place windows at ground level; avoid blank walls on pedestrian streets.
Employers and Commercial Building Owners	Locate business near transit, preferably in mixed-use areas; unbundle parking from employment contracts and sell or rent parking to employees instead; in places where free parking acts as a subsidy for motorists, provide equivalent cash-outs to non-motorists; provide free transit passes; provide loaner vehicles to transit commuters for daytime business; provide preferential parking for carpool vehicles.
Landlords and Residential Building Owners	Locate residential buildings in mixed-use areas, preferably near transit; assign parking zones to groups of residents rather than individual parking spaces to individuals; provide preferential parking for car-share vehicles.
Community Groups	Encourage community members to participate in planning charrettes early in the development of transit policy; they can help advance transit alternatives by demanding relief from automobile pollution, etc.

Todd Litman, Victoria Transport Policy Institute, provided input for this checklist.

often varies considerably from the *actual* energy use—because doors are left open, workers use electric resistance heaters at their workstations and leave their computers on 24/7, or the facility managers use more air conditioning than predicted. Despite the reality that user behavior influences the actual transportation energy intensity of a building, such modeled transportation energy intensity would provide a good means of comparing one building to another in terms of expected performance.

Conventional wisdom has it that the U.S. population is expected to increase by forty million people over the next two decades, 80% of whom will settle in developments like this car-dependant Denver suburb. More and more communities are recognizing that transit-oriented development offers a better option, particularly among an aging population. Photo: Airphoto-Jim Wark

Such metrics could be used in energy and environmental rating approaches for buildings, from Energy Star to LEED—permitting such certification programs to become more performance-based. Clearly, there would be a lot of details to work out, but the opportunities for providing metrics that help us reduce the environmental impacts of buildings are huge.

Final Thoughts

The green building movement is making tremendous strides at improving the environmental performance of buildings. Pushed by building codes and pulled by voluntary programs like LEED, buildings are getting better and better. But, as this article shows, if we want to continue reducing the ecological footprint of buildings, we need to focus much more actively on the transportation impacts that are associated with our buildings. With average new code-compliant office buildings "using" twice as much energy getting occupants to and from the buildings as the buildings themselves use for heating, cooling, lighting, and other energy needs, the green building community needs to focus greater attention on the transportation dependency of our buildings.

Farr takes these ideas one step further: "It's unconscionable to do any new development that's auto-dependent," he told *EBN*, suggesting that the architects' oath should address these location issues in some way. "I think you should lose your license for laying out sprawl," he said, only half in jest.

Increasingly, a key driver of such changes is likely to be demographics. According to Sam Zimmerman-Bergman at Reconnecting America, a national organization providing resources on transit-oriented development, by 2030 there will be "demand for 10 million more housing units for people who want to live near transit." When you add in such factors as a possible increase in transportation fuel cost, demand could be even greater.

"What we're talking about is a fundamental paradigm shift," according to Todd Litman of the Victoria Transport Policy Institute. The benefits of reduced VMT would extend well beyond energy savings. "If we get people to drive less through building location and building management strategies," says Litman, "there's a huge range of benefits beyond energy conservation and pollution reduction. Until we develop a more holistic model that takes [these added benefits] into account, we'll undervalue transit demand management."

It's time for the green building community to embrace the transportation energy intensity of our buildings much more directly. Where we build should be given greater attention, and our tools for evaluating building performance should include metrics that relate to transportation.

– Alex Wilson with Rachel Navaro

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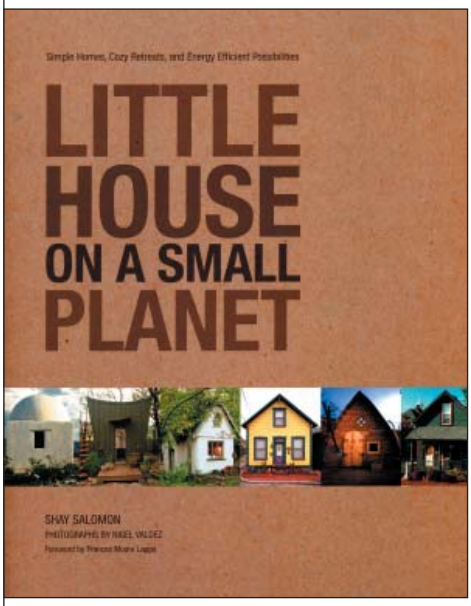
From the Library

Briefly Noted

Little House on a Small Planet: Simple Homes, Cozy Retreats, and Energy Efficient Possibilities (Shay Salomon; The Lyons Press, 2006; 240 pages, $20)—Shay Salomon visited



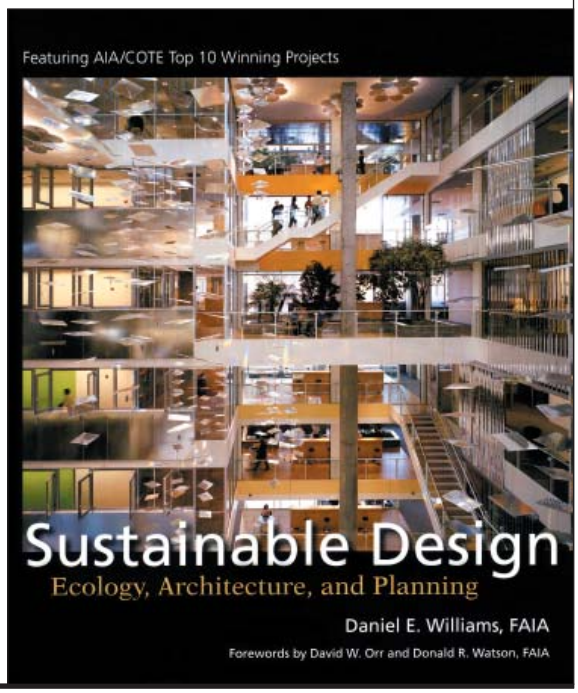
over 100 tiny houses in preparation for writing this book, which presents the floor plans of, photographs of, and stories about many of the homes. She profiles various individuals and families that use their small spaces efficiently, eliminating the need for larger homes. Ideas for nooks, lofts, and storage spaces are plentiful in the book, as are plans for outdoor rooms and multiuse and flexible spaces. Written primarily for homeowners and those looking for small living spaces, the book has a wealth of inspiration for all readers.

ASTM Standards on Indoor Air Quality, 3rd Edition (Niren Nagda, Ph.D. and Andrew Persily, Ph.D., editors; ASTM International, 2007; 300 pages, $165)—This new edition presents 55 standards relating to indoor air quality, most of which are new or revised. The standards define methods for sampling and analyzing indoor air for a variety of harmful substances, including volatile organic compounds. While each of these standards is available individually from ASTM International, they refer often to each other, and having the collection makes for easier cross-referencing. This collection is also available as a CD-ROM.

Unbuilding: Salvaging the Architectural Treasures of Unwanted Houses (Bob Falk and Brad Guy; The Taunton Press, 2007; 256 pages, $30)—In this practical, step-by-step guide to deconstruction, Falk and Guy explore one of the options available at the end of a building's useful life. They cover the basics of deconstruction, from how to estimate the yield of useful material in an old building to how to organize a deconstruction site. Lots of photographs provide guidance. The authors also present profiles of "unbuilders" from lifelong deconstruction experts to the owners of salvaged-building-supply stores.

Sustainable Design: Ecology, Architecture, and Planning (Daniel Williams, FAIA; John Wiley & Sons, Inc., 2007; 304 pages, $75)—Williams challenges architects and designers to move beyond green design into sustainable design. To do so, Williams argues, designers must begin thinking about buildings as part of a system, using ecological systems as models. Starting with the premise that everything in an ecological system is related to everything else, Williams explores how buildings, towns, and regions can become regenerative systems of energy and waste as well as parts of social and economic systems. He ends with case studies pulled from 10 years of The American Institute of Architects Committee on the Environment Top Ten Green Projects competition.

The Encyclopedia of Grasses for Livable Landscapes (Rick Darke; Timber Press, 2007; 484 pages, $60)—In addition to the photographic encyclopedia of over 400 grass species, this book offers a thoughtful examination of the use of grasses in landscapes. Grasses can grow well with little or no irrigation and can serve as anchors for other landscape features. Although emphasis is often placed on the use of native species in environmentally friendly gardens, Darke finds that hardy nonnative (and noninvasive) species often do well in challenging environments such as brownfields or urban gardens. A large, well-designed, and beautifully illustrated volume, this book is a good fit for landscape architects, particularly those involved with the design of public spaces.



BackPage Primer

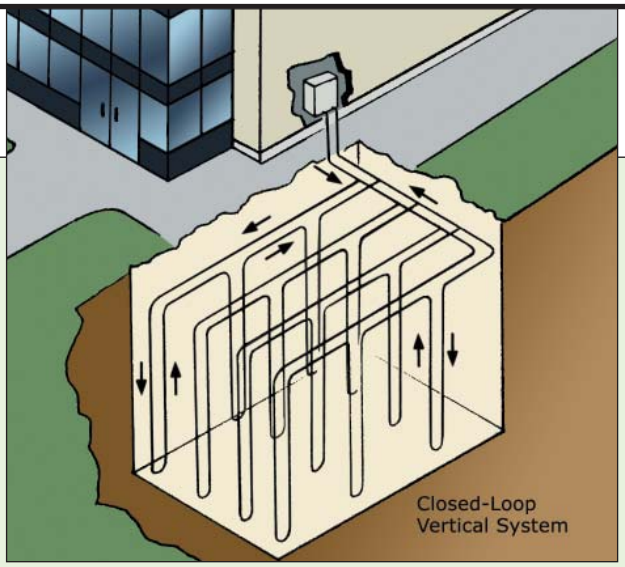
Ground-Source Heat Pumps:
Tapping the Earth's Mass

Ground-source heat pumps (GSHPs), often called "geothermal heat pumps," exploit the relatively stable temperatures found just 5 feet (12 m) or more below the surface, either depositing or extracting low-intensity heat. Heat pumps—whether ground-source or air-source—are basically air conditioners that can be run in reverse to provide heating as well as cooling.

Air conditioners (and refrigerators) make a relatively cool place cooler by extracting heat from it and releasing the heat in a warmer place. The key to this magic is the refrigerant, a fluid that changes from a liquid to a gas at ambient temperatures. After absorbing heat, the gas moves through a mechanical compressor that squeezes the heat back out, not unlike squeezing water out of a sponge. By releasing this heat to the temperate earth rather than into hot outdoor air, GSHPs cool more efficiently than air conditioners or air-source heat pumps. They provide heat by using the same principle in reverse—drawing heat from the relatively warm earth rather than from cold outdoor air.

GSHPs should not be confused with geothermal heat, which lurks roughly six miles below the surface, where the earth's crust gives way to a layer of molten rock. This geothermal energy occasionally explodes to the surface as a volcano, creates natural geysers and hot springs, and, in places like Iceland, it is tapped to produce electricity.

There are many variations on the ground-source theme. In some installations, especially those for residential or small commercial buildings, the connection to the earth is through pipes laid in horizontal trenches. Larger systems typically use drilled wells that may descend over 1,000 feet (300 m), using groundwater as the primary source of stable temperatures.



Some GSHP configurations come with ecological burdens. Groundwater may be extracted and dumped, or it may be contaminated by pollutants leaking in through the wells. The refrigerants used in some systems contribute to ozone depletion (although not as much as the older generation, which has been phased out of use). Finally, a poorly engineered system can change the temperature underground, with potential ecological implications, not to mention a loss in energy efficiency. Even with these caveats, their advantages in energy efficiency make GSHPs worth considering for projects that have significant heating and cooling loads in roughly equal proportions—although for homes, it's still better to make them small and efficient enough that it simply isn't worth investing in such a complex heating and cooling system.

For more information:

Ground-Source Heat Pumps: Are They Green? *EBN* Vol. 9, No. 7

The Refrigerant Revolution: Cooling Buildings ... But Warming the Earth? *EBN* Vol. 6, No. 2

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