Environmental Building News™
The Leading Newsletter on Environmentally Responsible Design & Construction
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# Porous Pavement: A Win-Win Stormwater Strategy

THERE'S A LOT OF PAVEMENT IN THE United States—nearly 38,000 square miles (9.9 million ha) or an area about the size of Indiana, according to calculations *EBN* has done (Vol. 5, No. 1). The vast majority of this is impermeable surface that contributes to stormwater runoff. In certain applications, that pavement can be made porous so that the rainwater falling on it can soak into the ground instead of contributing to stormwater runoff.

Using porous paving is a relatively new practice, going back just a few decades, and there are significant limitations and challenges. But there are also huge opportunities. This article takes a look at porous pavement, examining various products and addressing strategies for making it work. The article will be relevant to anyone involved with projects that include parking lots, driveways, roadways, sidewalks, courtyards, or patios.

## Why Do We Care About Impervious Surfaces?

In urban areas, impervious surfaces can cover 75% or more of all surface area. Figure 1 (on page 11) shows the relative amount of impervious surfaces in different land-use categories. Shopping centers are typically the worst when it comes to

*(continued on page 11)*

*This walkway at the Pier A Park in Hoboken, New Jersey is made with concrete pavers from Capitol Concrete. The ¼" (6 mm) joints are filled with uniform-size angular aggregate.* Photo: Bruce Ferguson

## In This Issue



*Quote of the month:*

**"It's cost-competitive with copper, it's much easier to work with, and it takes about half the time to install."**

Contractor Ray Antonelli on the new Aquatherm polypropylene piping system

(page 10)

## Environmental Building News

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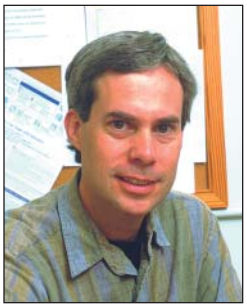
# From the Editors

## Thoughts on the Oil Bubble

The debate about whether—and how quickly—we are running out of oil has long fascinated me. A few thoughts: First of all, we aren't going to run out of oil; it just won't happen. As the easily extracted oil supplies are depleted, the cost of extracting the remaining oil will increase, so it won't be cost-effective for as many uses and we'll use less. Second, there is going to be a tipping point when the rate of world oil extraction (euphemistically referred to by economists as "production") reaches a peak and begins to decline. The extraction of a finite resource, such as oil, follows a mathematical curve—starting out slowly, speeding up as demand grows and we become more efficient at extracting it, gradually reaching a plateau as the discovery of new supplies slows, finally peaking, and then beginning the inevitable decline as it becomes more difficult and expensive to extract the remaining supplies. This mathematical curve for oil resources has come to be known as a Hubbert Curve, after the late petroleum geologist M. King Hubbert, who predicted, accurately, in the 1950s that U.S. oil production would peak around 1970.



*Alex Wilson*

A great deal of significance is placed on just when this peak in world oil production will occur, because that is believed to be the point at which significant price escalation will occur. That's when worldwide demand for oil will exceed available supply. We get caught up in arguments about whether this peak in world oil production will occur in a matter of decades or years—or whether it has already occurred.

No matter when that peak occurs, though, the indisputable fact is that a few generations of humans—particularly we Americans—will have squandered a geological resource that took several hundred million years to accumulate. And in the process of burning that petroleum resource we are releasing the vast majority of the stored carbon as carbon dioxide—the primary causative agent of global warming.

Let me put this into a personal perspective: Of all the oil that has been consumed since the dawn of the Petroleum Age, roughly 91% has been consumed since I was born not quite 50 years ago (in 1955). If I live to the current age of my father, now in his 84th year (highly doubtful, if I keep worrying about this stuff!), the world will have consumed during my lifetime between one-half and three-quarters of all of the oil that will ever be consumed—both past and future. Think about that. In the lifespan of one person—a mere heartbeat in the geological time scale—the human race will have consumed as much as three quarters of this resource.

What does this mean? It means that soon—very soon—we will enter a period of significant change. Perhaps, as economist Vijay Vaitheeswaran argues in *Power to the People* (see page 19), the coming shift to other energy resources will be relatively smooth, driven by market forces. Rising oil prices will make other energy sources more economically attractive; we'll increasingly shift to those, and the Petroleum Age will fizzle out—not for lack of oil but because of new and better energy resources. That sort of transition would be good.

The other possibility is not nearly so rosy. Richard Heinberg argues in *The Party's Over* (also reviewed on page 19) that the transition to the post-petroleum era is likely to be anything but smooth or comfortable. Our society has become so dependent on petroleum and has for so long ignored the need to develop alternatives that there will be massive dislocation as the inevitable crash arrives.

For building owners and those involved in the design and construction of buildings, the impacts of this coming transition—whichever scenario wins out—are likely to be dramatic. Well within the lifespan of most buildings being built today, we will have to retrofit those buildings either to use other forms of energy or to drastically reduce their consumption of conventional fuels. Buildings that cannot be so modified will be uneconomical to operate; they will be harder to sell and harder to lease.

Any building designed today that does not use dramatically less energy than conventional practice will be obsolete long before its useful life should end. If one believes the more dire predictions of Heinberg, such a building—constructed to today's codes—could become obsolete before the end of this decade.

All this points out how woefully inadequate our country's energy planning has been for the past several decades. Astoundingly, even as we close in on the tipping point of peak oil production and the inexorably higher costs that will face us thereafter, our political leaders continue to emphasize an energy future built almost solely on the past, rather than embracing a sustainable future of renewable energy and dramatic, tenfold efficiency improvements. For what we are spending on the war in Iraq, we could be investing in a politically stable, environmentally safe, and economically strong future built upon such energy sources as wind, solar, biomass, geothermal, and efficiency. – *Alex Wilson*

# What's Happening

## Eight States Call Climate Change a Public Nuisance

Ills caused by global climate change range from increased frequency of asthma and heat stroke to more intense storms and species extinction. While environmentalists go far past calling the phenomenon a "nuisance," they are applauding eight states and one city for doing just that. The attorneys general of California, Connecticut, Iowa, New Jersey, New York, Rhode Island, Vermont, and Wisconsin, along with the counsel of New York City, caused a stir in July when they sued five energy companies for contributing to climate change.

The companies—American Electric Power, Cinergy, the Southern Company, Xcel Energy, and the Tennessee Valley Authority—collectively operate 174 power plants in 20 states, releasing 650 million tons of the greenhouse gas carbon dioxide each year. They are responsible for 10% of the nation's carbon dioxide emissions and about 2.5% of all global emissions.

The lawsuit was filed in New York's federal district court under public nuisance law, which allows states to sue for pollution emanating from sources in other states. While nuisance law is frequently used in environmental cases, this is the first time it has been invoked to limit climate change. It is also the first time government officials have sued private companies for their contribution to climate change. "We're here because the federal government has abdicated its responsibilities," said Connecticut Attorney General Richard Blumenthal. The lawsuit is being compared to the tobacco lawsuits of the 1990s, in which the top five tobacco companies settled with all 50 states. "Think tobacco without the money," said Blumenthal. "All we're asking is to curb the pollution," he said. "Time is not on our side." – *JB*

## WHO Labels Formaldehyde a Carcinogen, EPA Allows Polluting Plywood Plants

Formaldehyde is a human carcinogen, according to a new report from the World Health Organization (WHO) International Agency for Research on Cancer. The agency upgraded its evaluation of formaldehyde from a probable carcinogen to a known one after the release of new evidence that formaldehyde causes nasopharyngeal cancer in humans. Based on studies disclosed by the National Cancer Institute (NCI) and the National Institute of Occupational Safety and Health in late 2003, the WHO panel also found a "strong" link between formaldehyde and leukemia but stopped short of calling it a direct causal relationship. Formaldehyde is commonly used in adhesives and binders in wood and paper products.

Meanwhile, according to a report by the Washington-based nonprofit Environmental Integrity Project (EIP), the Bush Administration ignored these findings when it drafted rules exempting industrial boilers and plywood manufacturing plants from Clean Air Act regulations—formaldehyde is controlled under the Clean Air Act's Maximum Achievable Control Technology (MACT) standard for hazardous air pollutants. The U.S. Environmental Protection Agency (EPA) estimates that 147 of the nation's 223 plywood plants will fall into what EPA has called the "low-risk subcategory" exemptions. EPA's exemptions, finalized in February, are based largely on a

risk model developed by the Chemical Industry Institute of Toxicology (CIIT) and do not take NCI's findings into consideration. According to EIP, NCI's study found a cancer risk 10,000 times higher than that predicted by the CIIT model as well as other health risks.

Applying cost-benefit models approved by the White House, EIP estimates that health costs could exceed $300 million per year as a result of air pollution from the plywood plant exemption alone. The same exemption is expected to save industry only $66 million each year. Although EPA still classifies formaldehyde as a "probable human carcinogen," it is performing its own evaluation of the new studies. If necessary, EPA will reconsider the exemptions, a process that would likely take several years.

EIP's report is posted on their Web site, along with a number of relevant documents. EIP was founded by Eric Schaeffer, former director of EPA's Office of Regulatory Enforcement who resigned in 2002 in frustration over Bush Administration efforts to weaken the Clean Air Act and other environmental laws. Visit EIP online at www.environmentalintegrity.org. – *JB*

## Cement Industry Launches Sustainability Initiative

At the June 2004 American Institute of Architects (AIA) national convention in Chicago, the Portland Cement Association (PCA) rolled out a sustainability initiative, "Concrete Thinking for a Sustainable World." Part of PCA's Cement Manufacturing Sustainability Program, the initiative will help the industry develop sustainability guidelines, educate architects and designers about the benefits of concrete in green building, and encourage more environmentally friendly cement manufacturing practices. In July, PCA's executive committee strengthened their commitment to sustainability, setting a goal for cement plants to implement "auditable and verifiable" environmental management systems. PCA plans for 40% of U.S. plants to meet the goal by the end of 2006, 75% by the end of 2010, and 90% by the end of 2020.

The cement industry has increased its energy efficiency by 33% since the mid-1970s and in February 2003 pledged to reduce its carbon dioxide emissions *per unit of product* by 10% below 1990 baseline levels by 2020. The industry is also pursuing other resource-saving opportunities, such as substituting crushed limestone and flyash for a portion of the cement in concrete mixtures. – *AW & JB*

**For more information:**

Portland Cement Association
Skokie, IL
847-966-6200
www.cement.org

Source: Lawrence Berkeley National Laboratory

*Developed by Michael Siminovitch and Erik Page, the Berkeley Lamp is dimmable and can be directed up, down, or in both directions. It includes a built-in outlet and data-link connection for use in hotels and offices.*

## UC Davis Opens Lighting Lab

The University of California at Davis has opened the California Lighting Technology Center (CLTC) as part of the school's Design Program. With a mission to "foster the application of energy-efficient lighting by facilitating technology demonstrations, development, outreach, and educational activities, in partnership with the lighting industry, lighting professionals, and the electric utility community," CLTC is the result of collaboration between the California Energy Commission and UC Davis, with support from the U.S. Department of Energy and the National Electrical Manufacturers Association. Initial funding for the project came from the Energy Commission's Public Interest Energy Research Program and UC Davis.

Michael Siminovitch, Ph.D., and Kosta Papamichael, Ph.D., both with doctorates in architecture and both coming from Lawrence Berkeley National Laboratory, have been hired to head CLTC. Electrical engineer Erik Page is also moving from Lawrence Berkeley. The new 7,500 ft$^2$ (700 m$^2$), multimillion-dollar facility includes full-scale laboratories for testing daylighting strategies and emerging electrical lighting technologies as well as meeting space to accommodate conferences about energy efficiency and lighting.

CLTC will work independently and in collaboration to develop energy-efficient lighting products that are also market-friendly. "Your 'better light bulb' must be designed for widespread use and acceptance; otherwise it is merely a theoretical better light bulb," said vice chancellor for research Barry Klein. Current

projects include the development of CFL downlights, hotel room lighting, exterior LED fixtures, and portable luminaires, and the demonstration of Berkeley Lamps, which were developed by Siminovitch and Page and are approximately 75% more efficient than their conventional counterparts (see photos, p. 4). – *JB*

**For more information:**

California Lighting Technology Center
www.cltc.ucdavis.edu/cltc/

Michael Siminovitch
530-757-3444
mjsiminovitch@ucdavis.edu

## Organic Valley Opens New Headquarters

The Organic Valley® Family of Farms celebrated the grand opening of its new headquarters building in July during the first annual Kickapoo County Fair in the Village of LaFarge, Wisconsin. The $5.9 million, 49,000 ft² (4,500 m²) facility was designed to reduce energy consumption and rejuvenate the surrounding farmland community while keeping its 250 employees happy and healthy. Morton Buildings, Inc. of Morton, Illinois, with the support of Wisconsin's Focus on Energy Program, designed the building to use 30% less energy than the minimum required by codes and to achieve LEED® Certification.

The building includes heat-recovery ventilation, extensive daylighting, and solar-powered parking-lot lights, and the design team selected salvaged, recycled, and locally manufactured materials when feasible. A locker room and showers encourage employees to bike or run to work and to explore the mile-long (1.6 km) nature path encircling the 36-acre (14.5 ha) site. Organic Valley also encourages employees to borrow company-owned bikes, and the cafeteria serves only organic food.

With 633 organic-farmer members in 16 states, Organic Valley is the only national organic brand that is entirely owned by farmers. Sales in 2003 totaled $156 million, 25% more than in 2002. Employees will move into the new headquarters in September 2004. Details are online at www.organicvalley.coop. – *JB*

Photo: Organic Valley Family of Farms

*Organic Valley's new headquarters building in the Village of LaFarge, Wisconsin is oriented along an east-west axis to maximize daylighting potential. It opens in September 2004.*

## Potential Water Shortages Halt Construction in Middletown, Maryland

On July 8, 2004, the Maryland Department of the Environment (MDE) imposed a moratorium on the issuance of building permits in Middletown, a community of 3,000 just west of Frederick. The cause of this action was concern that the town's water supply is inadequate to satisfy both existing and proposed development.

This is the second time in three years that such a ban has been imposed in Maryland; the first time was during one of the worst droughts in state history, when Frederick imposed its own ban, according to a July 10, 2004 article in the *Washington Post*. This time the state has taken action, even though the region is no longer in drought conditions. The state's concern has to do with susceptibility to future droughts, given the rapid pace of development. "Although rainfall has returned to above-normal levels and water is abundant right now, the 2002 drought reminded us of the importance of a reliable water supply," said Kendl Philbrick, secretary of MDE. "This temporary halt in construction will allow MDE and Middletown to review the situation carefully to ensure that Middletown residents have enough water in future droughts."

According to an MDE press release, the department's analysis of data submitted by the town indicates that Middletown has overcommitted its available water supply. The town's permitted water capacity is 290,000 gallons per day (gpd) (1.1 million liters). But the 1,297 residential units currently served by the water system require 324,250 gpd (1.2 million l)—a 34,250 gpd (130,000 l) deficit—and the 44 building permits recently issued by the town will further increase both demand and the town's water deficit. Under Maryland law, building permits may not be issued unless the water supply is adequate to serve the proposed construction.

Middletown officials have reacted strongly to the building moratorium, especially since they were not notified that this action would be taken. In the *Washington Post* article, Middletown burgess John Miller expressed disgust with the state, arguing that the town is operating within its permit for water usage. According to the article, other Maryland towns may face similar actions soon. – *AW*

**For more information:**

Maryland Dept. of the Environment
410-537-3000
www.mde.state.md.us

## Newsbriefs

Several regions of the country are experiencing a **shortage of portland cement**, the key ingredient in concrete. According to the Portland

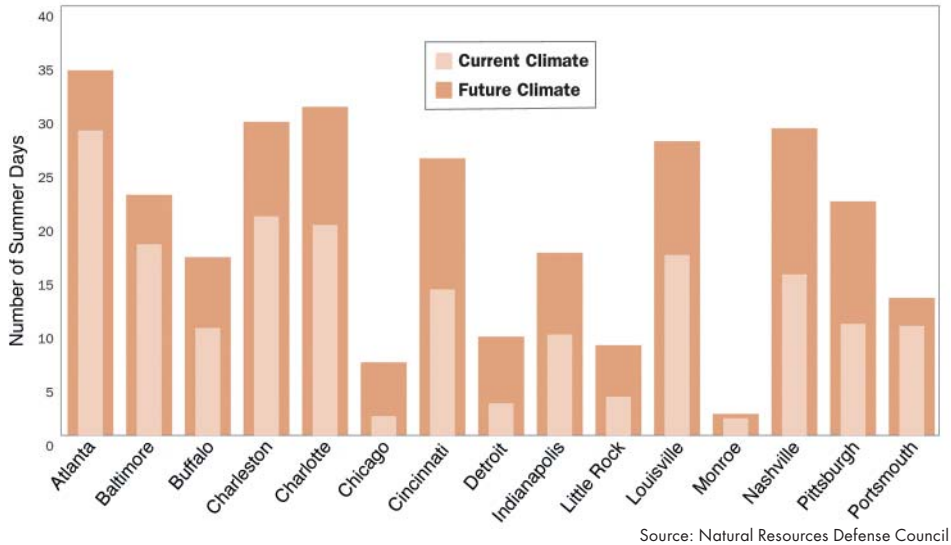
Cement Association (PCA), among the chief causes for this shortage are increased demand in the residential sector and limited availability of ships to carry imported cement, which in turn is blamed largely on booming Asian economies. Cement companies are expanding production to meet demand, but PCA says that "the short-term solution is to import more cement." Others see a solution in the replacement of portland cement with flyash, a byproduct of coal-fired power plants (see *EBN* Vol. 8, No. 6). According to Keith Bargaheiser, marketing manager for the American Coal Ash Association, in *Waste News* (August 2), flyash demand has risen 15–20% in the past year. Replacing each ton of portland cement prevents emission of approximately one ton of greenhouse gas.

By mid-century, climate change will increase by 60% the number of days when **ozone levels in the eastern half of the U.S.** exceed air quality standards set by the U.S. Environmental Protection Agency (EPA), predicts a report published by the Natural Resources Defense Council (NRDC). The study, *Heat Advisory: How Global Warming Causes More Bad Air Days*, was prepared by researchers at Johns Hopkins and Columbia Universities, in collaboration with Yale University, the University at Albany SUNY, and the University of Wisconsin at Madison. The study also predicts a 20% drop in the number of summer days with "good" air quality and a doubling of "red alert" air quality days, as defined by EPA. The complete report is posted online at www.nrdc.org.

Source: The Historic Chicago Bungalow Initiative

*This classic bungalow in Chicago has been greened through a unique partnership program in the city.*

One of every three single-family homes in the Windy City is a **Chicago Bungalow**, constructed by the tens of thousands in the early 1900s to house the city's working class. Bungalow owners can now take advantage of matching grants from the Chicago Department of Environment for up to $2,000 toward improvements in windows, doors, and insulation, and for water-efficient fixtures and appliances. Additionally, $1,000 vouchers are available for energy-efficient appliances. Bungalow owners can also tap into a $3.5 million grant from the Illinois Clean Energy Community Foundation to purchase or upgrade efficient furnaces, air-conditioners, water heaters, and solar technologies. Mayor Daley launched the Historic Chicago Bungalow Association in 2000 to promote the purchase and restoration of these homes. "Now these homeowners have new resources to make their homes more energy- and water-efficient, saving themselves money in the long run and helping further improve Chicago's environment," he said. To qualify for these incentives, homes must be certified by the Historic Chicago Bungalow Association, online at www.chicagobungalow.org.




Source: Natural Resources Defense Council

*A new study projects dramatically increasing smog in eastern U.S. cities by mid-century.*

The day-long seminar "Educating the Educators: A Crash Course on Eco Design™" is intended to quickly **bring design educators up-to-speed on green design**. David Bergman, architect and teacher at Parsons School of Design, and Erika Doering, interior designer and teacher at Parsons and Pratt Institute, developed the program with the recognition that green design's short history means that many educators were never trained in it. "Our goal is not to facilitate ecodesign courses," said Bergman and Doering. "It is to ... have ecodesign become an integral part of design education, to break down the separa-

tion and 'niche-ing' of ecodesign." More information is online at www.eco4edu.net.

**Old plaster may contain arsenic**, warns an article in the July 2004 issue of the *Journal of Light Construction (JLC)*. According to Kevin Hansen, who recently investigated abandoned tannery sites in the Wilmington, Delaware region for Tetra Tech, Inc., the leather-making industry used to soak animal hides in a slurry of lime and arsenic to soften them and remove hair. The waste product was then sold for use in rat poison or as filler in plaster. "I can't say that the presence of hair means that there is arsenic," Hansen told *JLC*. "But one has to wonder, where did that hair come from?" Industrial labs will measure arsenic levels in plaster samples for around $50 each, he says. The Tetra Tech report on tannery locations is online at www.tetratech-de.com/tanneries/.

The Aamjiwnaang First Nation near Sarnia, Ontario is experiencing an increasingly **skewed ratio of female to male births**, according to a July 31 article in the *Globe and Mail*. Until recently, the community tracked normally, but in 1994, the ratio suddenly shifted and has been heavily skewed toward females ever since. In 2003, the tribe welcomed 19 new girls, but only 9 boys—a nearly two-to-one ratio. Aamjiwnaang women have also been experiencing elevated rates of miscarriage, and more and more children show signs of developmental problems. Although the cause is uncertain, many suspect the oil refineries and chemical plants that ring the reservation. A number of chemicals, including PCBs and hexachlorobenzene, have been linked to high female births rates; these and other chemicals have been found at elevated levels in a creek running through the community. Sarnia's so-called "chemical valley" is home to 20% of Canada's refineries and produces about 40% of its petrochemicals, according to the article.

Seattle's **Environmental Home Center** (EHC), profiled in "Getting the 'Right Stuff': A Guide to Green Building Materials Retailers" (*EBN* Vol. 10, No. 4), lost its main warehouse, showroom, and offices to a fire on August 11, 2004. Two warehouses remain standing, however, and the company has laid out an aggressive recovery plan in a bid "not to make *our* problems our customers' problems," according to its Web site. Even while the fire burned, the EHC team began searching for temporary office space, and the company hopes to retain all of its employees. EHC is accepting help "because it gives others a way to contribute to our success, and because we need it." Contact EHC at 800-281-9785 or customer service@environmentalhomecenter.com. The recovery process is being documented at www.environmentalhomecenter.com/fire.shtml.

## Awards & Competitions

The Slag Cement Association has recognized two projects for replacing energy-intensive portland cement with blast-furnace-slag cement, an industrial waste byproduct from the reduction of iron ore to iron (see *EBN* Vol. 8, No. 6). **Clearview Elementary School** in Hanover, Pennsylvania (see *EBN* Vol. 11, No. 11 or BuildingGreen's Case Studies Database) won *Best Use of Slag Cement for Sustainable Development*. A LEED® Gold building, Clearview was built with insulating concrete forms (ICFs) containing concrete with up to 60% slag. **AirTrain JFK**, a new transit system linking New York City's Kennedy International Airport to city train, bus, and subway lines, won *Most Innovative Use of Slag Cement in Concrete*. AirTrain JFK includes 482 cast-in-place columns with 20–30% slag replacement and 5,000 precast, post-tensioned segments with 40% replacement.

Savings By Design has recognized three California buildings in its *2004 Energy Efficiency Integration Awards*: the **Cesar E. Chavez Education Center** in Oakland, the **Challengers Tennis Club for Boys and Girls** in Los Angeles, and **Lake View Terrace Branch Library** in Los Angeles (the latter two of which are profiled in BuildingGreen's Case Studies Database). Savings By Design was started in 1999 by Pacific Gas & Electric, San Diego Gas & Electric, and Southern California Edison to encourage high-performance nonresidential building design and construction within California (see *EBN* Vol. 8, No. 10). Details are online at www.savingsbydesign.com.

*Daylighting, natural ventilation, and other green features in the Los Angeles Challengers Tennis Club result in 60% energy savings compared to Title 24. PV panels generate 100% of the annual electricity consumption.* Source: Savings by Design

Photo: Dow BioProducts

*The GreenInteriors Student Design Competition winning entry is "Sweet Wheat," an integrated bed and shelving system made from straw-based particleboard.*

**David Butterfield**, president of the nonprofit Trust for Sustainable Development and founder of the Villages of Loreto Bay in Baja California Sur, has been given the *Good Neighbor Award* by the U.S.-Mexico Chamber of Commerce, a nonprofit bilateral coalition of businesspeople working to promote trade, investment, and joint ventures on both sides of the border. The $2.2 billion, 8,000-acre (3,200 ha) Loreto Bay development is planned to be a showcase for sustainable development and has the aggressive goal of harvesting more potable water and energy than it uses. More information is online at www.loretobay.com. The Trust for Sustainable Development, which also had a hand in Arizona's Civano development (see *EBN* Vol. 9, No. 7), is online at www.tsd.ca. The U.S.-Mexico Chamber of Commerce is at www.usmcoc.org.

University of Manitoba interior design students **Tamara Nyysola** and **Corina Penner** have won the first-ever *GreenInteriors Student Design Competition*. Dow BioProducts, Inc. and *Interior Design* magazine sponsored the first annual competition, which drew 55 entries from 14 design schools across North America. The winning entry, called "Sweet Wheat," is an integrated bed and shelving system made of WOODSTALK™ Gold MR straw-based particleboard. Although Dow BioProducts was a sponsor, the use of that company's product was not a requirement (*EBN*'s editorial policy does not include coverage of competitions created to promote a proprietary product). Details are online at www.greeninteriorsdesign.com.

The Natural Resources Defense Council **Robert Redford Building** in Santa Monica, California has won a *Charter Award* from the Congress for the New Urbanism (CNU). The building, designed by Moule & Polyzoides Architects and Urbanists, simultaneously addresses green building and New Urbanist concerns (see *EBN* Vol. 13, No. 2 or BuildingGreen's Case Studies Database). The project was announced as a LEED® Platinum building at its ribbon-cutting and its platinum status is not in question, but it has yet to be formally certified pending a final ruling on additional points it is pursuing. Details about all of the winners are online at www.cnu.org.

The **Nicola Valley Institute of Technology** in Merritt, British Columbia has won a *Governor General's Medal for Architecture*, jointly administered by the Royal Architectural Institute of Canada and the Canada Council for the Arts. Shared by the Nicola Valley Institute of Technology and the University College of the Cariboo, this 48,600 ft² (4,500 m²) facility was designed to celebrate First Nations values and beliefs. Tensioned fabric, referencing traditional stretched skins, was used as a shading device. The building's wood-column structural system represents poles used in traditional pithouse construction. The curved, three-story structure is built into the sloped site, and part of the roof is planted, lending the project a sense of continuity with its site. Other green strategies, including a glazed ventilation stack with operable windows and the use of locally manufactured materials, were implemented throughout the project: "This commitment to the 'new technology' of environmental sustainability is in clear alignment with the historical Aboriginal structures of the area," according to designers Busby Perkins+Will (BPW), formerly Busby + Associates. All of BPW's design associates are LEED-accredited professionals. The firm is online at www.busby.ca.

Photo: Nic Lehoux/Courtesy of Busby Perkins+Will

*The award-winning Nicola Valley Institute of Technology is remarkable on many fronts—aesthetically, socially, culturally, and environmentally.*

# Product News & Reviews

## Fusiotherm Polypropylene Piping From Aquatherm

There's a new option for potable-water, hydronic-heating, and other pressurized piping applications: polypropylene from the German company Aquatherm, GmbH. Aquatherm has been producing high-quality Fusiotherm® polypropylene (PP) piping for 30 years with tremendous success—never having paid a claim for damage due to failure of the piping, despite a well-financed guarantee. Now this piping is available in the U.S. from Aquatherm Piping Systems, LLC, the product's exclusive importer and distributor.

Source: Aquatherm Piping Systems, LLC

*Fusiotherm polypropylene pipe connections are heat-fused, resulting in joints that become monolithic—the pipe and fitting become one piece of plastic.*

What is immediately apparent when looking at Fusiotherm pipe is the wall thickness. It is thicker than copper and most plastic piping products available here, including cross-linked polyethylene (PEX) and polyvinyl chloride (PVC). This gives it tremendous strength and durability, but also makes it less flexible than most PEX piping. The other big difference is the system for fusing joints and connections. A fusing gun, available from Aquatherm, is used to heat both the end of a pipe and the fitting into which it will be secured. After heating for about 10 seconds, the pipe is secured into the fitting, and within about 30 seconds the joint becomes one piece of monolithic polymer. After ten minutes the pipe can be fully pressurized. "You can't screw it up," an Aquatherm representative told *EBN*.

Technically, the plastic used in making Fusiotherm is a *polypropylene random structure* (PP-R) polymer. From an environmental standpoint, polypropylene is one of the cleanest plastics (see *EBN* Vol. 10, No. 7/8), because it is made entirely of carbon and hydrogen atoms, with no halogens, such as chlorine or bromine, or aromatic (cyclic) rings, which are more likely to be toxic. Of great significance in Europe and the northeastern U.S., where a high percentage of solid waste is incinerated, combustion products released during incineration of PP are considered safer than those released from other plastics, including PVC. Unlike PEX piping, polypropylene is fully recyclable. (The crosslinking of the polyethylene molecules in PEX piping hampers its recyclability.) However, the polypropylene cannot be turned into new Fusiotherm pipe; use of recycled stock would compromise performance or durability, according to the company. Some refer to recycling of a material into a lower-grade product as *downcycling*.

These environmental characteristics have earned Fusiotherm formal approval by Greenpeace in Europe. The environmental organization carried out a detailed assessment and recognized that Fusiotherm satisfies maximum ecological standards and is a "future-compatible" product that is durable, recyclable, and free of PVC, heavy metals, and flame retardants (see *EBN* Vol. 13, No. 6 for more on flame retardants).

The polypropylene polymer and wall thickness give Fusiotherm piping much lower thermal conductivity than copper. This saves some energy by reducing heat loss from hot-water pipes (see *EBN* Vol. 11, No. 10). It also prevents condensation on cold-water pipes. According to James Brock, a partner in Aquatherm Piping Systems, even the thinnest-walled Fusiotherm pipe has low enough thermal conductivity that cold-water pipes rarely need to be wrapped with insulation to prevent condensation. (Hopefully this won't prevent builders from insulating *hot*-water pipes to save energy!) Another advantage, says Brock, is that water flow through Fusiotherm pipe "is quiet, and water hammer is non-existent."

The company makes pipe in a wide range of diameters, from 16 to 150 mm (0.63" to 5.9") outer diameter, plus over 400 termination fittings. Pipes are available in three wall thicknesses, or SDR (standard dimensional ratio) classifications, which refer to the ratio of the outer diameter of the pipe to the wall thickness—SDR 6 (the thickest, relative to pipe diameter), SDR 7.4, and SDR 11. Fusiotherm is rated at 180°F (82°C) at 100 psi (6.8 bar) water pressure, but expected life is dependent on temperature and pressure. At 122°F (60°C) and 94 psi (6.4 bar), SDR-11 pipe—the most common for houses—should last 50 years. Where higher temperatures or pressures will be experienced, or where longer life is required, thicker-walled pipe should be specified.

According to Paul Warren, the other partner of Aquatherm Piping Systems, Fusiotherm withstands freeze-thaw cycles, resists acids and most chemicals, and is FDA-approved for uses with foods. The smooth inner wall gives the pipe a very low coefficient of friction compared with copper, which allows smaller-diameter pipe to be used for some ap-

plications. Using pipe with a smaller inner diameter leads to significant energy savings because less water stands in the pipes between uses. If a pipe is punctured (by drilling into it through a wall, for example), the hole can be fully repaired with a heat-fusing plug, using a specialized tool available from the company. For plumbers used to working with copper pipe and soldered connections, Fusiotherm is a less radical change than PEX systems installed in "home-run" configurations (see *EBN* Vol. 11, No. 10). The big difference compared with copper is in how the joints and connections are made.

For tight bends in residential radiant-floor systems, the company also produces a more flexible polybutylene (PB) piping (brand name Aquatherm®). While some American PB systems experienced problems with cracked fittings in the 1980s, Aquatherm uses a very different approach, according to Brock. Aquatherm's PB piping has a very good track record in Europe, where it has been used for 20 years. PB pipe connections use special fittings rather than heat-fusing.

Fusiotherm is available in 57 countries and was recently introduced to the U.S. Use of polypropylene for pressurized-pipe applications in the U.S. will remain limited, however, until code listings are completed. "We had to write an ASTM standard for polypropylene pressure pipe that was just accepted: ASTM F2389-4," according to Brock. He told *EBN* that NSF International (previously the National Sanitary Foundation) just certified the pipe to that ASTM standard. "Now we can petition ICC [the International Code Council] and IAPMO [the International Association of Plumbing and Mechanical Officials] for code listings and product approval." Just before EBN went to press, Brock reported that the ICC will complete the listing of Fusiotherm by the end of October 2004. Brock expects that within another year there will be significant markets for their PP pipe in the U.S.

Currently, Fusiotherm is cheaper than copper pipe, but that is a temporary anomaly due to unusually high copper prices. Usually, Fusiotherm is slightly more expensive. However, labor costs—once plumbers become familiar with installation—are lower with Fusiotherm than with copper, according to Warren. Aquatherm's insurer carries a liability policy that protects users for ten years against property damage.

Source: Aquatherm Piping Systems, LLC

*A wide range of Fusiotherm pipes and fittings is available to satisfy most pressurized plumbing needs.*

Warren told *EBN* that while the product is new in the U.S., it is generating a lot of excitement. "It was a hit" at the 2004 NAHB International Builders' Show, he said. Ray Antonelli, president of Focused Resources, Inc. in Highland Heights, Ohio, first noticed Fusiotherm at that convention and now uses it for potable-water piping in home renovations. Although the size of the fusing gun makes it difficult to maneuver in cramped spaces, Antonelli told *EBN*, the absence of an open flame more than makes up for it. "It's safer to use around wood," he said. "Especially in reconstruction, you never know what you're going to find in the wall of a home." Once Fusiotherm gains code approval, Antonelli plans to use it routinely: "It's cost-competitive with copper, it's much easier to work with, and it takes about half the time to install." – *AW*

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## U.S. Plastic Lumber Files for Reorganization

U.S. Plastic Lumber (USPL) filed voluntary petitions for bankruptcy in late July 2004. The company is seeking debtor-in-possession financing, available only to companies in Chapter 11, to support its current operations and has hired Triax Capital Advisors to direct its reorganization. "Our filing provides U.S. Plastic Lumber with the opportunity to position itself for a viable future," said Michael Schmidt, USPL's chief financial officer. "With the hard work and dedication of our employees and the support of our customers and suppliers, we are confident that the business will emerge from this process a stronger company," he said. USPL is the world's leading manufacturer of plastic lumber and offers recycled-HDPE plastic lumber, composite wood-and-plastic lumber, and structural HDPE lumber for a variety of landscaping applications (see *EBN* Vol. 9, No. 2). Although at press time their Web site made no mention of the bankruptcy, USPL is online at www.usplasticlumber.com.

## Porous Pavement *(continued from page 1)*

impervious area, with about 95% coverage—two-thirds of which is pavement and one-third roofs.

Environmental problems from impervious land cover and the resultant stormwater runoff are well known. Surface waters are polluted by stormwater runoff; temperatures of those receiving waters are raised by the runoff; flooding and erosion occur downstream; aquifers are not recharged; and trees do not receive adequate moisture. Regulations to minimize or clean up stormwater have recently become much stricter with the implementation of the National Pollution Discharge Elimination System (NPDES) Phase II standards in 1999 (see *EBN* Vol. 11, No. 2). This regulation mandates Best Management Practices (BMPs) for stormwater in many more situations than did Phase I.

Porous pavement offers significant opportunity for improvement with all of these problems—and it can sometimes help the environment even while reducing construction costs.

### What is Porous Pavement?

First of all, *pavement* is the layered structure that forms the surface of a parking lot, path, road, highway, or aircraft runway. There are many types of pavement, including asphalt, concrete, compacted gravel, cobblestone, etc. *Porous* pavement is a special type of pavement that allows rainwater or snowmelt to percolate through. Several synonymous terms, including porous, pervious, and permeable, are used to describe such pavement, but we will generally stick with the term "porous" in this article.

Pavements that allow water to infiltrate have been around for thousands of years: pebble or crushed-stone pathways, stone walkways laid in gravel, and certain cobblestone installations, for example. But designing pavements specifically to allow infiltration, especially pavements that carry vehicles, is much more recent.

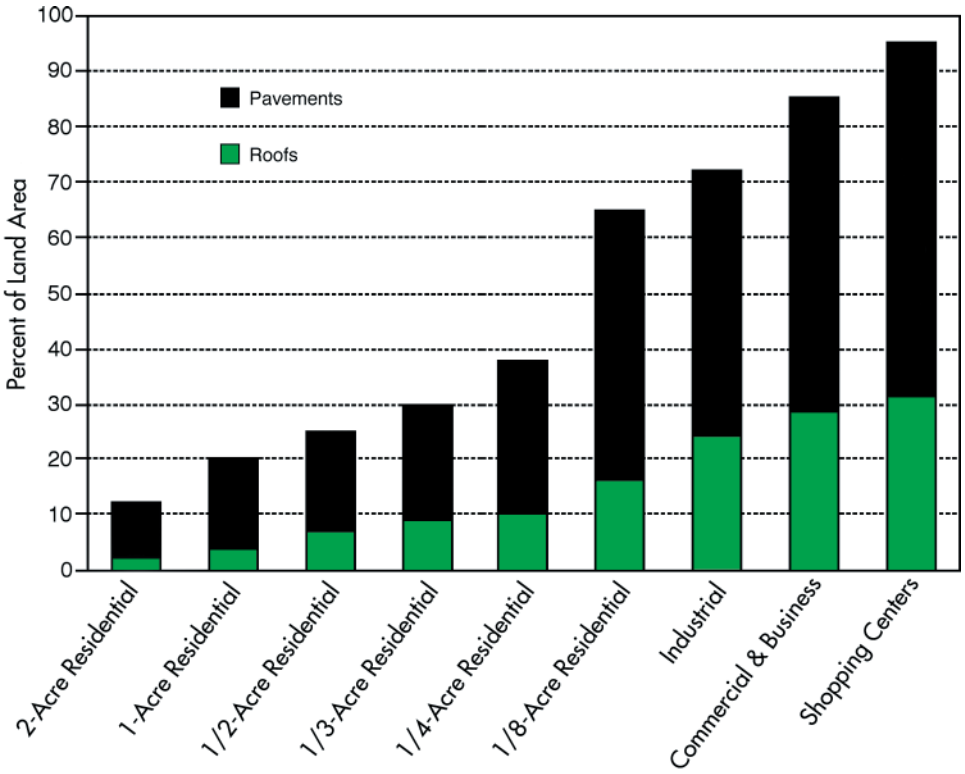
Specialized concrete grid pavers designed to support cars and allow water to percolate through them were first used in 1961, according to the Interlocking Concrete Pavement Institute, to handle overflow parking at a major cultural center near Stuttgart, Germany. In the U.S. these interlocking pavers were first used for erosion control along lake and stream banks and for lining ditches; they were gradually adapted for use in driveways, crossover medians along roadways, fire lanes, and overflow parking areas.

Porous concrete, according to the Florida Concrete & Products Association (FCPA), was first tried as a paving material in England in the mid-1960s, though a type of pervious concrete had been used in constructing breathable walls for buildings as far back as the 1850s (this construction material was widely used in Europe after World War II). In the U.S., porous concrete (often referred to as pervious concrete) was introduced in Florida in the early 1970s. Porous *asphalt* was first developed in 1972 by researchers at the Franklin Institute in Philadelphia.

### An Overview of Porous Pavement Systems

When we think of porous pavement, we typically focus on the top layer that we drive or walk on. But a porous pavement *system* includes more than the top layer; it is a fairly sophisticated, engineered system

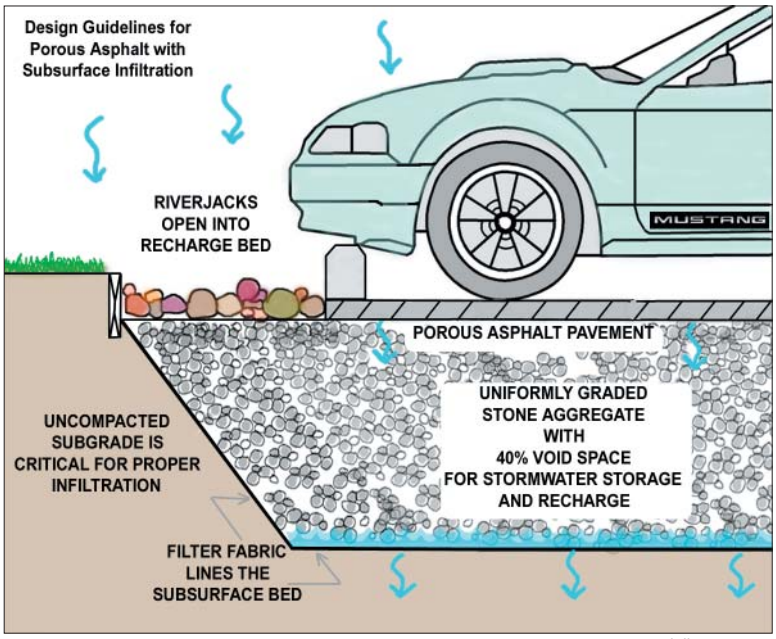
**Figure 1. Impervious Cover of Various Land Uses**




Source: Bruce Ferguson, from his forthcoming book *Porous Pavements* (CRC Press, 2005)

with multiple layers that allows rainwater to percolate through, stores rain from a large storm event, allows that stored water to gradually infiltrate the underlying soil, and is designed, constructed, and maintained to provide for overflow and prevent clogging. An example of a porous pavement system is shown in Figure 2. Starting at the bottom, this system includes the following components:

- **Level sub-base**—This should be underlying soil that can support the expected pavement loading and allow infiltration. A level sub-base is important so that water can infiltrate evenly across its surface.
- **Filter fabric**—A geotextile filter fabric is often placed on top of the leveled and graded sub-base to prevent soil from migrating up into the reservoir and clogging the system. A filter fabric is also placed along the perimeter of the porous pavement reservoir to prevent silt intrusion.
- **Reservoir**—The reservoir is a layer of crushed stone or river-run pebbles that are uniform in size—typically 1.5" to 2.5" (40 to 64 mm) and washed free of silt. The voids between these stones (typically about 40%) provide the reservoir capacity for rainwater. The depth of the reservoir layer depends on the design capacity of the porous pavement system, the infiltration rate into the soil beneath, and the local frost depth. In systems designed by Tom Cahill, P.E., of Cahill Associates in West Chester, Pennsylvania, this reservoir is typically 18" to 36" (45 to 90 cm) deep and designed to collect rainwater from an area four to five times that of the porous pavement surface. Cahill often designs these systems to also infiltrate water from roofs and adjacent nonporous pavement.




Source: Cahill Associates

*Figure 2. Engineering firm Cahill Associates has designed dozens of porous pavement systems since the early 1980s, most relying on this basic design.*

- **Porous surface layer**—The top layer of a porous pavement system is the layer on which we walk or drive. Many different types of material are available to fit site-specific requirements for traffic, cost, appearance, and accessibility. Depending on the material and the load requirements, it may be 2" to 12" (50 to 300 mm) thick. (Some systems also include a filter layer of finer aggregate, such as ½" (12 mm) washed, crushed stone, between the reservoir and surface layers.

Porous pavement top layers can be organized into several categories, described below. Representative products, as well as relevant trade associations, are listed in the table on pages 16–17.

## Porous concrete

Porous concrete is perhaps the best-known porous pavement system in use today, at least in the southern U.S. It is similar to conventional concrete, except that most or all of the fine aggregate, including sand, is left out of the concrete mix. Portland cement binds together uniform-sized, usually ⅜" to ¾" (9 to 19 mm), aggregate. Most porous concrete mixes are 18–21% portland cement, by cured weight. The waste products fly ash and blast furnace slag can substitute for some of the portland cement in porous pavement, offering resource efficiency benefits. According to FCPA's "Recommended Specifications for Portland Cement Pervious Pavement," fly ash conforming to ASTM C618 may be used in amounts up to 20% by weight of the total cementitious material, and ground iron-ore blast furnace slag conforming to ASTM C989 may be used in amounts up to 50%. Special additives, or admixtures, may be used to enhance handling or setting properties. Cured porous concrete has a density of 105 to 125 lb/ft$^3$ (1,700–2,000 kg/m$^3$) and a void space of 15–21%.

The porous concrete mix is cast in place at the thickness specified to carry the design loads—typically 4" to 12" (100–300 mm). Contractor experience with porous concrete is of key importance during installation. Moisture content needs to be fairly low, and spreading, striking (leveling), and compacting must be done quickly to ensure proper performance—admixtures can extend the working time. Too much moisture can result in ponding at the top of the slab, which creates impervious areas on the pavement surface.

### Porous asphalt

Porous asphalt, like porous concrete, is made by using only larger aggregate in the mix and eliminating the *fines*. Bituminous asphalt binds these particles together, leaving a void space of 16% to over 20%, compared with 2–6% for conventional asphalt. The thickness of porous asphalt pavements designed by Cahill is typically about 2 ½" (65 mm). He prefers a mix with 5.75–6.0% asphalt by weight. The finished asphalt surface looks very similar to conventional, nonporous asphalt. Because of the deeper base layer (reservoir), Cahill has found porous asphalt parking lots to outlast those made from conventional asphalt. He estimates the cost of porous asphalt pavement systems, including the underlying reservoir, overflow drainage, etc., to be between $2,000 and $2,500 per parking space. Significantly, this is one-quarter to one-third the cost of porous concrete, according to Cahill. Because asphalt never truly solidifies, however, there is concern that as it cycles through daily heating and cooling, flowing asphalt may clog the pores. Cahill does not share this concern; some of his porous asphalt applications have been working successfully for over 20 years.

### Unit pavers

Numerous concrete, brick, stone, and even plastic-composite unit pavers on the market are either designed to be porous or can be installed for porous paving applications. Solid blocks of concrete, brick, or stone can be laid with open joints to provide drainage between the pavers into the reservoir below. Also available are *open-celled* concrete and brick unit pavers (see photo) that can be filled with either loose, uniform-sized aggregate or porous planting media and turf. These open-celled unit pavers carry the load of vehicles while preventing the aggregate from being displaced or the soil and turf from being compacted by vehicles. As with porous concrete and porous asphalt pavements, unit pavers are laid on top of an engineered reservoir. They are more expensive to install than either porous asphalt or porous concrete but offer tremendous design opportunities.

### Plastic geocell unit pavers

Similar in some ways to the open-celled concrete unit pavers described above, plastic geocell unit pavers have thinner cell walls and are designed not so much to carry the load of vehicles as to retain the aggregate or soil that carries the load and prevent soil compaction (important if the pavers are planted with turf). Because the geocell walls are thin, they are almost invisible, and a pavement produced with these systems looks like turf or crushed stone. The flexibility of most plastic geocells allows movement with freeze-thaw or wetting cycles. Some of these products are made from recycled plastic. Unlike soil-stabilizing plastic mesh products, these geocell mats are removable, so need not permanently mix nonbiodegradable polymers with natural soils.

Source: Hanover® Architectural Products

*The square voids in these EcoGrid™ open-cell concrete pavers are filled with uniform-sized aggregate to provide drainage into the underlying reservoir and soil. This type of porous surface can support a moderate level of traffic.*

### Loose aggregate and soft-material pavement

Open-graded (uniform-sized) aggregate materials—for example, crushed stone or decomposed granite—provide 30–40% void space and can be used as porous paving in the right applications. For pathways, "soft" materials, such as chipped bark, nut hulls, and crushed seashells, may be used as porous pavement. Avoiding stormwater runoff was a high priority on Dewees Island in South Carolina (see *EBN* Vol. 6, No. 2), where only electric vehicles are permitted, and all roadways are made from crushed shells, sand, or wood chips. The challenge with these materials is keeping them in place with vehicle traffic and preventing clogging from decomposing leaves and particulates falling out of the air. Note that most gravel and dirt roads are not made with open-graded aggregate; they have a full range of aggregate size and very low permeability. From a stormwater runoff standpoint, a rural dirt road is little different from a road paved with standard asphalt.

## *Win-Win Solutions with Porous Pavement*

While still little-used, porous pavement has a great deal going for it. The primary environmental, safety, aesthetic, and economic benefits of porous pavement are described below.

### Aquifer recharge

Perhaps the most obvious benefit of porous pavement is its ability to recharge underground aquifers. Rainwater and snowmelt percolating through the pavement and reservoir slowly infiltrates the underlying soil, where it can recharge the aquifer. In urban areas, with pavement and rooftops often making up over 75% of the land coverage, very little rainwater typically reaches the underlying aqui-

fers—which in turn reduces stream flows. In coastal areas, depleted aquifers often suffer from saltwater intrusion, providing another strong incentive to increase aquifer recharge rates.

## Flood control

To the extent that porous pavement reduces stormwater runoff, it also reduces downstream flooding. The more urbanized an area, the higher the storm flows of streams and the lower the non-storm flows. This is because natural streams are primarily fed by groundwater seepage and springs. If we reduce the amount of rainwater getting into the ground, we reduce the amount seeping into streams. Instead, urban streams are fed primarily by surface runoff, which results in dramatic fluctuations in peak flows—and flooding. Serious flooding can cause tremendous environmental and economic damage, which is one reason state and local agencies are very interested in strategies to allow stormwater to infiltrate where it falls.

Source: Invisible Structures, Inc.

*GrassPave™ has a grid of recycled-HDPE plastic geocells that can be filled with porous soil and planted with turf. The system spreads out and carries vehicle loads while preventing soil compaction. The system is recommended for parking areas with intermittent usage, because the grass needs sunlight to remain healthy.*

## Pollutant removal

Stormwater carries pollutants that were carried out of the atmosphere in the falling rain or that were deposited on impervious surfaces into nearby surface waters. Stormwater is now the single largest source of water pollution in the U.S. In urban watersheds, according to Bruce Ferguson, FASLA, a landscape architect and author of a forthcoming book on porous pavement, impervious pavements are responsible for two-thirds of excess runoff in urban watersheds and nearly all of the hydrocarbon pollutants. With porous pavement, rainwater is treated where it falls. Microorganisms living in porous pavement and underlying soil biodegrade nutrients, hydrocarbons, and other contaminants. Surfaces of the aggregate or underlying soil adsorb metals from the infiltrating water. (See *EBN* Vol. 11, No. 2 for more information on pollutant removal from stormwater.)

Source: EP Henry Corporation

*These ECO™ I concrete pavers have wide joints filled with uniform-sized aggregate to provide free drainage into the crushed-stone reservoir and subsoil below.*

## Tree survival in urban areas

In our cities, trees offer numerous environmental benefits: reducing the urban heat-island effect, shading buildings and reducing cooling loads, shading parked cars and reducing air-conditioner use after start-up, absorbing carbon dioxide and producing oxygen, offering habitat for birds and other wildlife, and producing pleasant, pedestrian-friendly spaces. More than a half-million trees are planted annually in the U.S., and all too often they die young or fail to grow as they should because of inadequate rooting space and/or soil moisture. Allowing air and rainwater to percolate through pavement can significantly improve the health of trees along roadways and in parking lot islands.

## Control of urban heat islands

Urban heat islands increase cooling loads in cities and contribute to smog production (see *EBN* Vol. 10, No. 11). Porous pavement can reduce the urban heat-island effect in two ways: First, turf-based porous pavements cool the air through evapotranspiration. Second, because urban trees shade paved areas, reducing heat buildup, porous pavement reduces urban heat islands by improving the longevity of those trees. The differences in solar reflectivity of porous and impervious pavement is usually fairly minimal, though light-colored aggregate can increase reflectivity

slightly with either porous or nonporous pavement.

### Cooler surface waters

Thermal pollution in streams and rivers can be a significant problem in and around urban areas, and stormwater runoff can be a significant contributor. As temperature increases, a body of water holds less dissolved oxygen, so aquatic organisms suffer. Also, cold-water fish, such as trout, may disappear. During a rain event, the first stormwater runoff is warmed by the pavement surfaces over which it flows. By allowing rainwater to infiltrate where it falls, warmed runoff is not introduced to nearby streams or rivers, avoiding thermal pollution.

### Safer driving

Porous asphalt and concrete surfaces on roadways improve driving safety by eliminating the pooled water that can cause hydroplaning. Due to this benefit, some state highway departments, including Oregon and Georgia, specify a porous asphalt topcoat or *overlay* on highways. This overlay doesn't offer the infiltration benefit of a full porous pavement system, but it does reduce the pooling of water on the road surface. Porous pavement also increases visibility by eliminating or greatly reducing the spray from vehicle wheels and, at night, by reducing reflection off the surface film of water. Finally, in cold climates, porous pavement reduces the likelihood of black ice formation.

### Noise control

Porous asphalt and concrete surfaces are quieter than nonporous asphalt and concrete. Road noise comes both from vehicle drive trains (engines, exhaust systems, etc.) and from the rubber tires on the pavement. Tire noise results, in part, from tiny pockets of air trapped between the tire tread and the road surface being pumped out through the tread. Porous pavement is quieter because the pores in the pavement prevent these pressure pockets from forming. According to Ferguson, several recent studies have found a noise reduction of 3 decibels (dBA) or more by substituting porous for conventional asphalt. In wet conditions, the effect of porous pavement is even greater because the sound of tires forcing water across an impervious surface is louder still.

### Improved aesthetics

There is little difference in appearance between porous and nonporous asphalt and concrete, but there is a huge difference between conventional pavement and turf-paved surfaces. Neighborhood opposition to development may drop considerably if turf pavement is proposed over conventional asphalt for overflow parking areas.

### Accelerated permitting

Related to aesthetic issues and stormwater management, use of porous pavement for a development project may speed up permit approvals. This was the case at the Westfarms Mall in West Hartford, Connecticut. When the developer proposed the use of GravelPave™ and GrassPave™ (see illustration on page 14) for additional overflow parking required with the mall expansion, opposition dissi-

### Villanova University's Trials and Tribulations with Porous Concrete

In 2002 Villanova University, outside Philadelphia, set out to demonstrate the benefits of porous pavement through a highly visible 50,000 ft² (4,650 m²) courtyard and walkway in the center of campus. Cahill Associates designed the system, which also captures rainwater from dorm roofs and feeds it into the reservoir beneath the porous concrete pavement. Against Cahill's recommendations, the University decided to work with a little-tested admixture for porous concrete, made by the Mexican company Ecocreto.

Due to the combination of very hot weather (95–100°F, 35–38°C), poor communication with the ready-mix concrete supplier, improper washing of the aggregate (which contained too high a proportion of fines), a 45-minute (variable) delivery time from the ready-mix concrete plant, an admixture that didn't do what was expected, and the installers' inexperience with porous concrete, the August 2002 installation was a miserable failure. The concrete began setting up in the hot weather before proper screeding and tamping could be completed. The truckloads of concrete also varied in consistency, and the poorly secured plastic sheeting, which was supposed to cover the concrete to retard curing and improve hydration, blew off.

Fortunately, the university took all this in stride—as an experiment in innovative stormwater management. After visiting a number of successful installations in the Mid-Atlantic states, they used the lessons learned and started over in the spring of 2003. This time, the weather was much cooler, smaller loads of concrete were delivered, water was not added to the dry mix until the truck arrived at the site, and the proportions of the Ecocreto admixture were carefully controlled by the onsite Ecocreto technician. The amount of water added varied from 9 to 11 gal/yd of concrete (45 to 55 l/m³), depending on the weather. Even with more rapid mixing, working with the concrete became quite difficult by the end of the load, as the concrete hydrated. Compacting was done with rollers rather than vibrating screeds, and the paved areas were securely covered with plastic after compaction.

While the porous concrete pavement is handling the rainwater very well, according to Dr. Robert Traver of the Engineering Department at Villanova, they are not completely satisfied with the project. "We have had some surface spalling over the winter," he told *EBN*. "I put it down to experiences with a new technology." Tom Cahill is not so generous and blames the problems on the Ecocreto admixture. "As far as I'm concerned, it's Mexican pixie dust," he told *EBN*. "It doesn't work, it screws up the water-cement ratio, and, as far as I can see, it isn't worth the powder to blow it to Hell," he said. (*EBN* understands that some Ecocreto installations in northerm climates are working well.)

Villanova's experiences illustrate the challenges involved with porous concrete—and the importance of sticking with experienced contractors and tried-and-true products.

pated and the permitting process sped up.

### Cost savings

Porous pavement systems generally cost more than the conventional, nonporous pavement they are replacing. Much of the additional cost, according to Cahill, is due not to the actual pavement but to the reservoir, overflow piping, geotextile, etc. that are used to create the entire system. However, when considered as part of an entire development project, porous pavement can significantly *reduce* overall project cost. In the overflow parking project described above at Westfarms Mall, porous pavement not only sped up the permitting process but also obviated the need for a stormwater detention pond that had been priced out at $1 million (see *EBN* Vol. 3, No. 5). With more stringent regulations now in place that require best management practices for stormwater management (NPDES II), the financial benefits of porous pavement may be even greater—because pollutants can be "treated" at their place of origin rather than being concentrated in runoff that has to be cleaned.

## *Success with Porous Pavement*

Porous pavement, especially that relying on porous concrete and porous asphalt, is relatively new, and we are still climbing the learning curve. Along with plenty of success stories are some failures, which give pause to those interested in specifying porous pavement (see sidebar, p. 15). "Correct installation of porous pavements is not difficult," says Ferguson, "but it is different from that of conventional dense pavements." To succeed, he believes, a porous paving installation "must be selected appropriately for its setting, designed right, and installed right." Failures have resulted from inadequate information and inexperienced contractors, notes Ferguson, who visited more than 250 porous pavement installations in the research for his forthcoming book. "It is important to use design consultants and contractors who are knowledgeable and experienced in the distinctive requirements of this specific new technology," he says.

### Where *not* to install porous pavement

It is important to understand exactly where porous pavement makes sense—and where it doesn't. Porous pavement is not recommended for every application. Understanding these limitations is necessary to prevent failures or unsatisfactory performance. Below are some situations where porous pavement usually is not the best choice:

- On highways where heavy vehicles or high-speed travel is expected. Porous pavement may work fine for these applications, but there is little experience in the U.S. to date, except as an overlay (some testing is being done in Europe).
- On steep slopes. With asphalt, Cahill recommends against installing porous pavement systems on grades above 5%.

## A Panoply of Porous Pavement Products & Resources

| **POROUS CONCRETE** | ***No-fines concrete, typically contracted to local installers*** |
|---|---|
| Florida Concrete & Products Association<br>407-895-9333, www.fcpa.org | Trade association, introduced porous concrete in the U.S., publishes Portland Cement Pervious Pavement Manual |
| Bomanite (CA)<br>559-673-2411, www.bomanite.com | **Grasscrete®** – similar to open-celled concrete pavers but monolithic, cast-in-place, then planted with turf |
| Ecocreto of Texas, Inc. (TX)<br>512-312-5901, www.ecocreto.com | **Ecocreto** – specialized admixture for porous concrete; recent problems with installation in Pennsylvania |
| Stoney Creek Materials, LLC (TX)<br>512-261-0821, www.stoneycreekmaterials.com | **StoneyCrete™** – porous concrete produced with proprietary admixture |
| **POROUS ASPHALT** | ***"Open-graded," no-fines asphalt with less tar; normally contracted to local installers*** |
| National Asphalt Pavement Association (MD)<br>888-468-6499, www.hotmix.org | Trade association, offers information about porous asphalt |
| **OPEN-JOINTED CONCRETE PAVERS** | ***Pavers with inherent voids between blocks*** |
| Interlocking Concrete Paver Institute® (DC)<br>202-712-9036, www.icpi.org | Trade association, offers information for design professionals, contractors, and homeowners |
| Advanced Pavement Technology (IL)<br>877-551-4200, www.advancedpavement.com | **Bio-Aquifer Storm System** – engineered system of Z-pattern, square, or X-shaped pavers over well-prepared base |
| Air Vol Block, Inc. (CA)<br>805-543-1314, www.airvolblock.com | **Eco-Perm Pavers** – square interlocking pavers; different installation patterns achieve different void percentages |
| Capitol Ornamental Concrete Specialties, Inc. (NJ)<br>732-727-5460, www.capitolconcrete.com | **Ecologic™ Pavers** – wide range of concrete pavers that can be installed in porous applications |
| EP Henry Corporation (NJ)<br>800-444-3679, www.ephenry.com | **ECO™ I Pavers** have a brick look; **Monoslabs** have a raised "waffle" pattern |
| Pave Tech, Inc. (MN)<br>800-728-3832, www.pavetech.com | **Enviropave Spacers** – polyethylene and polypropylene pipe-style spacers for use with almost any paving block |
| SF Concrete Technology, Inc. (ON)<br>905-828-2868, www.sfconcrete.com | **SF Rima™** are square pavers; **SF Matoro®-Drain** is a two-dimensional, T-pattern, interlocking system for heavier loads |
| UNI-Group U.S.A. (FL)<br>800-872-1864, www.uni-groupusa.org | **UNI Eco-Stone®** – high-load interlocking pavers with diamond-shaped corner voids |
| Unilock, Ltd. (IL)<br>800-864-5625, www.unilock.com | **Aquaterra™** – Z-pattern pavers for driveable surfaces |
| **OPEN-CELLED CONCRETE PAVERS** | ***Pavers with integral voids for grass or drainage material*** |
| D'Hanis (TX)<br>800-299-9399, www.dhanisbricktile.com | **Grass Paver** – made from clay (not concrete); square, 5-hole pavers for use in dry and moderate climates |
| EP Henry Corporation (NJ)<br>800-444-3679, www.ephenry.com | **Turf Pavers** – lattice-style grid in a large paver format |
| Hanover Architectural Products (PA)<br>800-426-4242, www.hanoverpavers.com | **EcoGrid™ Pavers** – square pavers with four square voids, appropriate for moderate vehicle traffic |

- Where excessive sedimentation may occur. Where erosion from adjacent slopes cannot be avoided, the risk of clogging porous pavement is too great.
- Where extensive wintertime sanding is likely. Winter-use sand can clog the pores in porous pavement. In northern climates, porous pavements should be limited to fairly level parking lots and driveways, where traction in snow and ice will be less of a problem. Plowing crews should be instructed in appropriate maintenance practices.
- When underlying soils do not drain (assuming the objective is stormwater infiltration, Cahill prefers to use porous pavement only when it can be a minimum of 3 feet (1 meter) above the high water table and 2 feet (0.5 m) above bedrock. Porous pavement with a reservoir can be used with very poorly draining soils, but special measures may need to be taken. Ferguson notes that even with impervious soils, porous pavement can be used to meet nonrecharge objectives, such as tree rooting and water quality.
- On most brownfield sites where the soil is contaminated. Where heavily contaminated soils are present, rainwater should not be filtered through the ground because the infiltrating water can carry contaminants from the soil into the underlying aquifer. Nonporous pavement is usually preferable in such situations.
- On sites where spills are likely. Do not use porous pavement at truck stops, fuel filling areas, industrial sites where chemicals are unloaded, etc. (See *EBN* Vol. 11, No. 2 for more information on pollutant removal from stormwater.)

| | |
|---|---|
| Hastings Pavement Company, LLC (NY)<br>800-669-9294, www.hastingspavers.com | **Checker Block®** – steel-reinforced, 2-foot-square (0.2 $m^2$) waffle-type tiles |
| Nicolock (NY)<br>800-669-9294, www.nicolock.com | **Turfstone™** – lattice-style containment for turf or aggregate |
| Pavestone (TX)<br>800-580-7283, www.pavestone.com | **Grasstone™** – Z-shaped, 8-void containment block for turf or aggregate |
| **PLASTIC GEOCELLS HDPE PANELS** | ***Typically interlocking, with high-profile open cells; generally for embedded containment*** |
| Invisible Structures, Inc. (CO)<br>800-233-1510, www.invisiblestructures.com | **Grasspave²** and **Gravelpave²** – tubular cells with typically 100% post-consumer recycled content; Gravelpave² has a geotextile backing made with remnant fabric |
| Netlon Turf Systems (UK)<br>www.netlon.co.uk (look for US distributors) | Square cells with squiggly interstitials – **Netpave® 50** for embedment in turf or gravel; **Netpave® 25** for use on top of existing turf surfaces |
| NDS, Inc. (CA)<br>800-726-1994, www.ndspro.com | **TuffTrack, GrassRoad Pavers8 Plus** – interlocking honeycomb-void panels (minimum 25% post-consumer recycled content) |
| PermaTurf Co., Inc. (NH)<br>800-498-4116, www.permaturf.com | **PermaTurf®** – interlocking honeycomb-void panels, sold as a DIY product (100% recycled content, unspecified source) |
| Presto Products Company (WI)<br>800-548-3424, www.prestogeo.com | **Geoblock®** – interlocking square-celled panels (minimum 10% post-consumer recycled content) |
| RK Manufacturing, Inc. (MS)<br>800-957-5575, www.rkmfg.com | **Grassy™ Pavers** – honeycomb-shaped voids (minimum 97% post-consumer recycled content) |
| Grid Technologies, Inc. (RI)<br>800-959-7920, www.gridtech.com | **GridTech Hex Panel** – reusable, interlocking hexagonal panels, approximately 3 $ft^2$ (0.3 $m^2$) each, particularly good for sand; also available in aluminum (100% recycled HDPE, unspecified source) |
| **RUBBER PAVEMENT AND PAVERS** | ***Flexible (cushioned pavement surfaces, often made from recycled tires*** |
| Dinoflex Manufacturing, Ltd. (BC)<br>877-713-1899, www.dinoflex.com | **PlayTiles®** – interlocking porous tiles made with recycled rubber, sold as playground surfacing (up to 90% post-consumer recycled material) |
| KB Industries, Inc. (FL)<br>727-647-2307 | **Flexi-Pave™** and **Flex-Path™** – site-installed porous urethane-bonded crumb rubber pavement (rubber from used auto tires) |
| Hellas Construction Inc. (TX)<br>512-250-2910, www.hellasconstruction.com | **Sport Track™** – site-installed poly-bonded rubber and EPDM granules, sold as running track sufacing |
| Mat Factory, Inc. (CA)<br>800-628-7626, www.matfactoryinc.com | **Safety Deck II®** – interlocking high-void tiles of recycled rubber and PVC; sold as trail and playground surfacing. |
| Surface America, Inc. (NY)<br>800-999-0555, www.surfaceamerica.com | **DuraPaver™** and **PlayBound™ Tile** – recycled-rubber/polyurethane pavers and tiles for walkways and playgrounds |
| **OPEN-GRADED AGGREGATE** | ***Unbound "no-fines" aggregate*** |
| National Stone, Sand & Gravel Assoc. (VA)<br>703-525-8788, www.nssga.org | Trade association offering software for Stormwater Infiltration Structure Design |

## What it takes to do it right

One key to a successful porous pavement project is to consider the porous pavement as a system—not just the surface layer. This means that at least the larger systems should be designed by an engineer or landscape architect with knowledge in hydrology, soils, and stormwater. Well-designed porous pavement has a porous top layer, a reservoir of uniform stone, a geotextile filter fabric to keep silt from clogging the system, a level base to allow distributed infiltration into the ground, and a system to provide for overflow. At the edges of a porous pavement, the ground should slope away from the pavement so that sediment is not carried in.

Cahill, who has been designing successful porous asphalt systems in the Mid-Atlantic states since 1983, generally provides built-in redundancy. His company takes what he calls a "belt and suspenders" approach with all of their systems. "If the pavement were to be paved over, forgotten, or clogged, stormwater still must reach the stone bed below the pavement," his colleague Michele Adams, P.E. wrote in the May/June 2003 issue of *Stormwater* magazine. Around the perimeter of porous pavements they typically provide an unpaved stone edge; on large parking lots they may also provide surface drains or

catch basins that drain to perforated pipes laid in the reservoir. And they typically provide an overflow, which would carry stormwater away in the event that the bottom of the reservoir clogs or a very large storm event exceeds the reservoir's capacity—the water in the reservoir must never be allowed to saturate the pavement, they argue.

Another key to success with either porous concrete or porous asphalt is to work with an experienced contractor. Porous paving is still a new practice and as much an art as a science. With concrete, for example, many variables must be considered—weather, moisture content of the mix, effect of admixtures, how much the concrete has to be shifted before compacting, and so forth. It is very important to work with people who have worked with porous pavement long enough to understand these variables and be able to respond to them in the field.

Source: Cahill Associates

*This porous-asphalt parking lot at the Cumby Development Corporation in Springfield, Pennsylvania was completed in 2003. Cahill Associates has designed dozens of systems like this in the Mid-Atlantic states since the early 1980s. The dividing line between the porous and nonporous portions of the lot can easily be seen in this photo, taken in the rain.*

### Maintenance is key

As with many aspects of green building, simply building it right is not enough. Porous pavement systems have to be properly maintained to continue to function well over time. Recommended maintenance depends on the type of porous pavement used; a few important guidelines are provided below:

- Avoid sand and salt applications during winter maintenance.
- Use care when snowplowing. Porous concrete and asphalt can be plowed for snow removal, but grid pavers and turf-pave systems require a special skid-plate on snowplows to keep the blades slightly above the pavement surface.
- Keep sediment resulting from erosion or nearby construction off porous pavement. To keep construction vehicles from tracking dirt onto a porous parking lot or roadway, it may be necessary to require vehicles to access the site from a different side.
- Never apply a *sealant coat*, as it will clog porous pavement.
- Vacuum sweep porous pavement several times a year to remove particulates that find their way onto the pavement. Interestingly, Ferguson's investigations of 280 porous pavement installations suggest that vacuum sweeping may be less important than is generally assumed. Where problems have occurred, vacuum sweeping would not have solved those problems, he told *EBN*.
- Provide signage to identify porous pavement areas and remind maintenance crews about special maintenance provisions.
- Provide operating instructions. The property owner or property manager should be provided with specifications on the property maintenance of a porous pavement system, including the schedule for vacuum-sweeping.

## Final Thoughts

Porous pavement isn't for every application, but particularly as more concrete and asphalt paving companies gain experience with it, this is an option that should be considered by designers, builders, and building owners interested in greening their projects. While porous unit pavers can be used for walkway and patio installations in virtually any geographic region, lower-cost porous concrete and porous asphalt suitable for larger parking lots and driveways may be limited by winter treatment requirements, topography, and the availability of installers who have experience with the respective materials and installation practices. Growing demand will increasingly make porous concrete and asphalt a viable option—even in more northern climates where wintertime surface treatments can be adapted to porous pavement.

*– Alex Wilson*

*Special thanks to Bruce Ferguson, whose draft book,* Porous Pavements *(scheduled for release in 2005 by CRC Press), provided a great deal of background for this article; watch for a review of this book in an upcoming issue of* EBN.

### For more information:

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www.sed.uga.edu

*Stormwater* Magazine
Santa Barbara, CA
805-682-1300
www.forester.net/sw.html

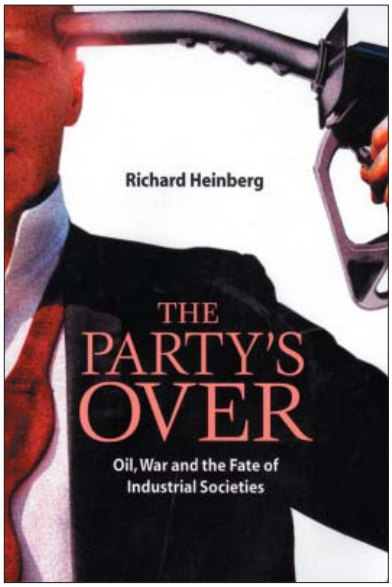
# From the Library

## Two Perspectives on Our Oil Future

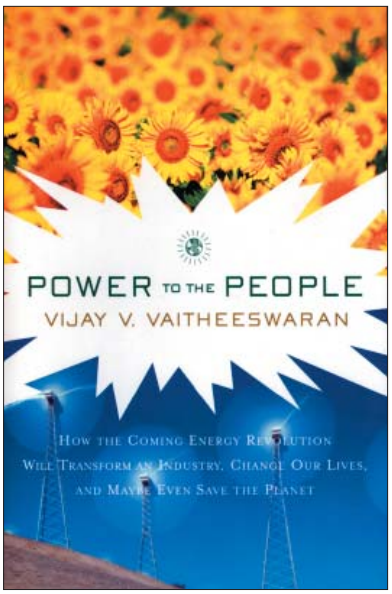
**The Party's Over: Oil, War, and the Fate of Industrial Societies**
by Richard Heinberg; New Society Publishers, Gabriola Island, British Columbia, 2003; 286 pages, softcover, $17.95

**Power to the People: How the Coming Energy Revolution Will Transform an Industry, Change Our Lives, and Maybe Even Save the Planet**
by Vijay Vaitheeswaran; Farrar, Straus and Giroux, New York, 2003; 358 pages, hardcover, $25.00

These two books couldn't be more different, yet some of their conclusions are remarkably similar. *The Party's Over* by Richard Heinberg is a treatise about our running out of oil and the impacts this will have on societies worldwide. Much of the book is depressing and leaves readers with a helpless feeling that our failures to recognize the limits to petroleum (and other resources) will almost certainly have dire consequences: collapsing economies, failing transportation systems, food shortages, inadequate energy for heating and cooling, environmental damage from desperate efforts to make up for petroleum shortages (even though pollution and carbon dioxide emissions from oil consumption may drop), public health crises, and political upheaval.




Heinberg has done exhaustive research into patterns of resource consumption, drawing heavily from the M. King Hubbert school of thought. (Hubbert was the geologist who predicted—heretically—in 1953 that U.S. oil extraction would peak less than 20 years later—in 1970. He was dead-on in that prediction.) Heinberg concludes that the peak in global oil extraction "will probably be reached between 2006 and 2015." A very telling chart shows the historical or projected peak oil extraction in several dozen other countries. The date of peak oil extraction is significant because that is the year in which demand begins exceeding supply and prices begin escalating rapidly.




*Power to the People* offers a very different perspective. Author/economist Vijay Vaitheeswaran, who writes for *The Economist* magazine, is an avowed free-market proponent. He believes that oil will never "run out," nor will its limits constrain economic development to any significant extent; rather, we will shift to alternatives, such as hydrogen produced from renewables. Vaitheeswaran argues that the market should be allowed to guide our decision-making. But he veers sharply from many free-market zealots, including those in the Bush administration, by arguing that the down-side impacts and societal costs of fossil and nuclear fuels (pollution, health problems, and global warming in the case of fossil fuels; long-term storage and security in the case of nuclear) should be factored into the prices of those fuels.

*Power to the People* quotes heavily from well-known green advocates such as Amory Lovins (he's called the "Sage of Snowmass" in this book) and Natural Resource Defense Council environmentalists who are trying to create market drivers for sustainable practices. While arguing that technological improvements will enable us to extract ever-more oil from reserves, he pushes for a carbon tax as one strategy to get us away from the environmental impacts of fossil fuel consumption and on track for a future powered by renewables.

Remarkably, though these two books come from almost opposite ends of the spectrum of economic philosophy, they achieve significant convergence regarding certain actions—including the need for a rapid transition to renewable energy sources. By reading both books, one hears both the doom-and-gloom perspective as well as the more optimistic view that we will shift away from the petroleum age before any crisis hits—a view articulated by the oft-repeated comment that the Stone Age didn't die out for lack of stones.

Which book will prove more accurate? We'll likely know within the next decade or so. In the meantime, I'm going to keep an eye out for a debate between these two very bright writers. And I'm going to keep up with my own efforts to live a more sustainable lifestyle. *– AW*

# Calendar

## SEPTEMBER

**17 • San Diego Green '04**, San Diego, CA. *Sponsor:* SDG&E, AIA-San Diego, USGBC-San Diego. *Info:* 619-252-2312; www.sdgreen.org.

**26-29 • Profitable Sustainability: The Future of Business**, Seattle, WA. *Sponsor:* Network for Business Innovation and Sustainability NW. *Info:* 425-828-0982; www.nbis.org/conference/register/.

**27-30 • Creating Partnerships, Building Bridges: Annual Meeting & Exposition**, Las Vegas, NV. *Sponsor:* Indoor Air Quality Association, National Air Filtration Association. *Information:* 301-231-8388 x13; www.iaqa.org.

**29-Oct. 1 • Mid-Atlantic Sustainability Conference**, Trenton, NJ. *Sponsor:* NESEA, NJ Dept. of Environment, USGBC-NJ. *Information:* 413-774-6051; www.nesea.org.

**30-Oct. 1 • Sustainable Communities: Learning from the Dutch Experience**, Chicago, IL. *Sponsor:* AIA, Illinois Institute of Technology, City of Chicago, et al. *Info:* 312-856-0110 x543; www.DutchSustainableCommunities.com.

## OCTOBER

**1-2 • Green Building/Hybrid Source Expo & Workshop**, San Antonio, TX. *Sponsor:* City Public Service, AIA-San Antonio. *Info:* 210-212-8031; www.greenconnexion.com/expo/default.htm.

**2 • National Solar Tour**, around the U.S. *Sponsor:* American Solar Energy Society *Info:* www.ases.org and www.nesea.org.

**4-6 • Wood-Frame Housing Durability and Disaster Issues**, Las Vegas, NV. *Sponsor:* Forest Products Society, USDA Forest Products Lab, and Forintek Canada. *Info:* 608-231-1361 x208; www.forestprod.org.

**5-6 • Affordable Comfort for New England**, Westford, MA. *Sponsor*: Affordable Comfort. *Information:* 800-344-4866 x10; www.affordablecomfort.org.

**5-7 • Labs21 Annual Conference**, St. Louis, MO. *Sponsor:* U.S. EPA and U.S. DOE. *Info:* labs21@erg.com (e-mail); www.labs21century.gov/conf/index.htm.

**10-12 • SE2 (Sustainability & Energy Efficiency) Leadership Conference**, Oconomowoc, WI. *Sponsor:* Wisconsin Green Building Alliance and The Energy Center of Wisconsin. *Information:* 414-224-9422; www.wgba.org.

**12-13 • Empire Energy & Environmental Exposition**, Saratoga Springs, NY. *Sponsor:* Environmental Business Association of New York State. *Info:* 518-432-6400 x224; www.eba-nys.org.

**20-23 • EEBA Building Solutions Conference & Exposition/Sunbelt Builders Show**, Dallas, TX. *Sponsor:* EEBA, Texas Association of Builders. *Info:* 952-881-1098; www.eeba.org/conference/.

**29 • Visions of Sustainability: 5th Annual Regional Development Forum**, Cambridge, MA. *Sponsor*: New Ecology, Inc., Mass. Assoc. of Community Development Corporations, MIT. *Information:* 617-354-4099 x25; forum@newecology.org (e-mail).

**29-Nov. 2 • ASLA Annual Meeting & Expo**, Salt Lake City, UT. *Sponsor:* American Society of Landscape Architects. *Info:* 202-363-4666; www.asla.org/meetings/am2004/saltlake.html.

## NOVEMBER

**10-12 • Greenbuild International Conference & Expo**, Portland, OR. *Sponsor:* U.S. Green Building Council. *Information:* 202-828-7422; www.usgbc.org.

## DECEMBER

**5-10 • Performance of Exterior Envelopes of Whole Buildings IX: Integration of Building Envelopes**, Clearwater Beach, FL. Sponsor: Oak Ridge National Lab. Info: 865-574-7267; www.ornl.gov/buildings/.

## 2005

**Feb. 16-17 • The Midwest Building & Design Exchange**, Chicago, IL. *Sponsor:* ABCA. *Information:* 888-821-0767; www.abcaevents.org.

**Feb. 23-24 • Affordable Comfort Northwest**, Portland, OR *Sponsor*: Affordable Comfort. *Information:* 800-344-4866 x10; www.affordablecomfort.org.

**Apr. 10-12 • Engineering Sustainability**, Pittsburgh, PA. *Sponsor*: School of Engineering at University of Pittsburgh. *Information:* 412-624-9698; www.engr.pitt.edu/msi/conference.html.

**Apr. 27-May 1 • EDRA 36**, Vancouver, BC. *Sponsor*: Environmental Design Research Association. *Information:* 405-330-4863; www.edra.org.

**Aug. 8-12 • ISES 2005: Solar World Congress**, Orlando, FL. *Sponsor*: ISES, ASES, et al. *Information:* www.swc2005.org.

**Sep. 27-29 • World Sustainable Building Conference: Action for Sustainability**, Tokyo, Japan. *Sponsor*: CIB, iiSBE. *Information:* www.sb05.com.

**More complete info and additional listings are online at: www.BuildingGreen.com**

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