Environmental Building News™
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Solar Thermal Hot Water, Heating, and Cooling

By creating heat instead of electricity, solar thermal achieves three times the efficiency of photovoltaics at a lower price.

by Brent Ehrlich

BACK IN THE 1960S, THE CARETAKER at a summer lodge that was in our family rigged a makeshift solar water heater: he laid a black sheet of plastic against the hillside next to the pool, hooked up a small pump, and attached a hose that directed the water down the plastic, where it was warmed by the summer sun before it flowed back to the pool. While not particularly attractive, his invention worked very effectively to provide low-cost hot water in the mountains of Colorado, where nighttime July temperatures often dipped below freezing.

Heating pools is still the most common use of solar thermal, or solar water heating (SWH): systems designed for domestic use have never fully caught on in the U.S., even as more complicated, more expensive, and less efficient photovoltaic (PV) modules have become more common. Why hasn't solar water heating become more mainstream? When is it worth considering, and what does it take to pay for it? Before we explore these questions, let's review the current technologies and applications.

Solar Thermal Basics

Many different types of solar thermal systems are available in a variety of configurations.

Direct vs. indirect systems

In *direct*, or *open*, solar thermal systems, potable water flows from an insulated tank directly through a collector designed to soak up the sun's heat. Direct systems are simple, inexpensive, and ideal for warmer climates. The water absorbs and holds the heat very efficiently; but with no protection against freezing, which would damage the collector and pipes, most direct systems are not appropriate for cold climates.

Indirect, or *closed*, systems run a heat-transfer fluid, usually propylene glycol (antifreeze), through the collector. The fluid then runs through a heat exchanger, located in the storage tank,

(continued on p. 9)

Photo: Ritter Gruppe

This 36,597 ft² Ritter XL solar thermal system installed on an exhibition hall in Wels, Austria went online in May 2011, providing almost 7 million Btu/hr of supplemental hot water for district heating.

Celebrating Our 20th Year

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Quote of the month:

"There are no zero-energy houses, only zero-energy families."

– Andy Sharpiro, energy consultant

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From the Editors

EBN Resources to Support the Classroom and the Syllabus

While we were researching *EBN*'s August 2011 feature story on green business strategies for surviving the recession, two things became increasingly obvious. First, we cannot grow our way out of an economic crisis that resulted from unsustainable growth. Second, sustainable building and development are a big part of the "new normal," and the next generation of designers, engineers, and builders needs to be ready to lead the way.

EBN and *BuildingGreen Suite* are already part of the curricula at more than a hundred colleges and universities, and professors tell us they are invaluable for lecture prep, class discussion, and students' independent research. In response to their feedback, we are offering the following new resources.

- We've posted a sample syllabus to highlight how readily our materials fit into a typical sustainable design course. This includes weekly units with our most popular articles on topics ranging from energy to water to thinking beyond the building. BuildingGreen.com/syllabus
- Classroom or homework discussion questions are included with the online version of each *EBN* feature article we have posted in 2011, and we'll continue to add these.
- In addition, we continue to receive continuing education (CE) approval from AIA and USGBC for our new feature articles and other content. CE certificates for dozens of articles are available at BuildingGreen.com/learn.

We hope you'll find these resources useful.

Finally, if your university isn't already using *BuildingGreen Suite*, we invite you to learn more at BuildingGreen.com/landing/campus.

– The Editors

Interface Chairman Ray Anderson Remembered

Inspiring. Gracious. Inviting. Each time we met Ray Anderson and heard him speak, we were impressed again and again by how fully he manifested those qualities. The green building world lost one of its biggest heroes and certainly its evangelist on August 8, 2011 with the loss of Ray Anderson, founder and chairman of carpet maker Interface, Inc., to cancer.

We first got to know Ray in 1994 when the two of us were in Atlanta for a charrette about greening Habitat for Humanity home designs. On the evening before that event, we invited participants and a few others to join us in a conversation about the publication we had just launched two years earlier, *Environmental Building News*, and what it should become. Ray showed up and introduced himself in a very humble way; it wasn't until the next day that we learned he ran a billion-dollar corporation!

Ray established and followed a vision for Interface. He challenged his team to learn the science behind his quest to scale "Mount Sustainability" and follow that science, even when it put him at odds with some of his friends and advisors in the green building industry.

Visit BuildingGreen.com/Ray for Alex and Nadav's complete remembrance of Ray.

What's Happening

Composting Is Winner in Food Waste Disposal Study

Forty percent of the food produced in the U.S. is wasted; that's about 1,400 calories per person per day, according to *Next Generation Food*. Most of this trashed food goes straight to landfills, where it releases huge quantities of methane, a potent greenhouse gas, into the atmosphere. A new study finds several environmentally preferable alternatives, including advanced composting, waste-to-energy, and some wastewater treatment options that may be used after food waste is ground in home garbage disposals.

The analysis, commissioned by the manufacturer of InSinkErator food disposal systems and performed by independent research group PE International, looked at 12 common ways that municipalities deal with food waste and compared their environmental impacts, including global warming potential (GWP), energy use, and likely effects on soil, water, and air quality. The study takes into account the cradle-to-grave life cycle of associated equipment (trash cans and bags, garbage disposals, etc.) but does not appear to consider water use—an apparent oversight, considering that garbage disposals require running water before, during, and after use.

Although several water treatment options require more energy than landfills (see "The Water-Energy Connection," *EBN* Oct. 2010), garbage disposals come out looking quite good compared with landfills in terms of GWP and direct effects on soil, water, and air quality. Even the most energy-intensive methods of wastewater treatment weigh in at half the GWP of landfilling (see chart). One method, extended aeration of biosolids, requires the use of blowers and was estimated to require three times as much energy as a landfill, but even when the solids from this wastewater treatment method were landfilled, the GWP was less than half that of putting food waste in the garbage.

However, composting—not the backyard scrap pile, but centrally located "advanced" composting—and waste-to-energy had miniscule energy and GWP impacts compared with most wastewater treatment options. With one exception (in which gases are used for combined-heat-and-power generation and solids are used as fertilizer), common wastewater treatment methods have considerably greater environmental impacts than composting and waste-to-energy. Composting is not without issues, however, including the second-highest smog potential among the 12 methods considered.

Based on this study's findings, a garbage disposal is not necessarily the most environmentally friendly way to deal with wasted food, even as InSinkErator often argues for its benefits. However, the study indicates that if your only two options are the trash can or a garbage disposal, the garbage disposal is a safer bet in terms of greenhouse gases and most other environmental impacts, despite its greater energy use.

In the longer term, wasting less food and working locally to find more sustainable ways to deal with municipal food waste—including composting, waste-to-energy, and water treatment methods that put waste products to good use—are likely to be far better options than washing wasted food down the drain without a second thought.

– Paula Melton

For more information:

InSinkErator
www.insinkerator.com

Global Warming Potential of Food Waste Scenarios

per 100 kg waste (annual household average)

Scenario	Global Warming Potential (kg of CO_2 equivalent)
Municipal Composting	2.1
Waste-to-Energy	3.6
Wastewater Treatment—Conventional Sludge	
Cogeneration+fertilizer	–0.16
Biogas in boilers	6.4
Biogas flaring	9.8
Lime stabilization	14
Biosolid incineration	14
Wastewater Treatment—Extended Aeration	
Lime stabilization	29
Biosolids landfilled	37
No other treatment	43
Landfill	
Biogas flaring	81
Biogas power generation	84

Source: PE International

What's the greenest way to deal with food waste? It all depends on what your municipality does with its wastewater—something most residents probably don't know. The global warming potential (GWP) of most common landfill options is quite high, making the landfill universally undesirable, while some wastewater treatment options are far better than others. One method, which puts both gaseous and solid waste to good use, actually results in negative GWP. Composting and waste-to-energy are far better than most wastewater options, though—making generalizations about garbage disposals being green difficult to justify.

PROJECT FOCUS

Want a Net-Zero Home? Be a Net-Zero Family

On June 1, 2010, eight families moved into nearly identical, superinsulated homes on Martha's Vineyard in Massachusetts. South Mountain Company designed and built the LEED Platinum homes for the Island Housing Trust with the goal of allowing the residents to operate them at net-zero energy, using the 5 kW photovoltaic (PV) arrays on the roofs for power. In case the energy cost savings didn't provide enough incentive, South Mountain offered a reward to any household that came in at net-zero energy for the first year. Two families achieved this goal, and won their choice of a $400 dollar gift certificate at a local fish market or a one-year membership at the local CSA.

South Mountain installed equipment to allow submetering of all the major energy systems in the homes, providing an unprecedented window into exactly how the families use energy. A report by South Mountain engineer Marc Rosenbaum, P.E. highlights key insights from this experiment—among them the importance of collecting data monthly. Though variations from the estimated energy use will be greater on a monthly basis than on an annual basis, it allows users to catch meaningful anomalies more quickly. In the case of one family, the data helped discover that a child had turned off an exterior AC disconnect from the PV system during the first month, allowing that family to generate only 279 kWh instead of the 630 kWh that the other seven homes averaged.

In a testament to the efficient construction, water-heating energy exceeded space-heating energy in all but one of the homes. Rosenbaum suggests that a good further investment would be for solar hot water or heat-pump water heaters. The submetering also showed that the biggest loads were the two uses of electric resistance heat: the radiant ceiling panels and the water heaters.

In the end, two families were able to operate below net-zero energy, while two others were close. One family used a measured 11,635 kWh in one year, nearly 170% of the average 6,873 kWh provided by the solar panels. In all cases, lights and plug loads accounted for about half of total energy use. With that in mind, the report quotes energy consultant Andy Shapiro: "There are no zero-energy houses, only zero-energy families."

– Martin Solomon and Nadav Malin

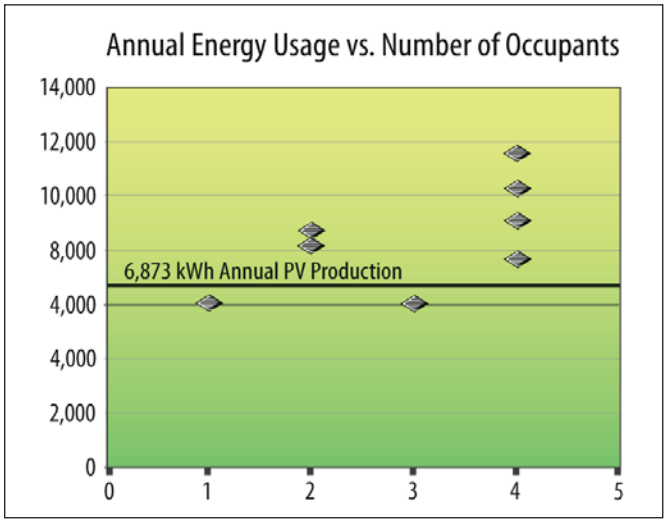
Photo: Derrill Bazzy

Each of the eight houses in the Eliakim's Way project on Martha's Vineyard sports a 5 kW PV array, which provides most or all of the home's energy.

For more information:

The complete report is available at www.southmountain.com

Eliakim's Way House Specifications	
Element	**Specs**
Envelope R-values	Walls: 31; Roof: 50; Foundation walls: 20; Underslab: 20
Heating and cooling	Daikin single-zone mini-split heat pump (RXS24 DVJU)
Supplemental heating	Enerjoy radiant ceiling panels
Water heating	50-gallon Marathon electric water heater
Heat recovery ventilation	Fantech 704 heat recovery ventilator
Windows	Triple-glazed Thermotech with two layers low-e and argon fill; Solar heat gain coefficients: 0.62 on South, 0.48 elsewhere
Photovoltaics	5.04 kW Sunpower array



Newsbriefs

International Passive House Institute Drops U.S. Affiliate—Accusations flew as the international Passive House Institute (PHI) officially severed its ties with the Passive House Institute U.S. (PHIUS). The separation was made public in an open letter from PHI's Wolgang Feist on August 17, in which he alleges that PHIUS improperly certified projects and infringed on the copyright of proprietary PHI software and states that PHIUS will no longer be licensed to certify buildings, administer exams to designers, or sell PHI's software tool. The details behind the discord remain unclear, and both sides are blaming the other for damaging the Passive House standard. This has been an especially unsettling development for PHIUS-certified designers in the U.S., as the future of their credentials in North America—without PHI's blessing—is unclear. PHIUS has promised to continue certifying buildings to its standard, saying in a statement, "Legitimacy is performance. Legitimacy doesn't live in Darmstadt[, Germany]"—the headquarters of PHI. For more detailed information, analysis, and updates, see BuildingGreen.com/news.

Photo: Joshua Barash

This electronics recycling drive sponsored by the City of West Hollywood netted old and broken consumer electronics. A new federal interagency task force has several goals aimed at safely dealing with e-waste, including increasing consumer access to certified recycling centers.

Judge Dismisses Gifford Case Against USGBC, LEED—In a strongly worded ruling issued August 16, the federal judge hearing Henry Gifford's complaint against the U.S. Green Building Council (USGBC) threw out the lawsuit. Gifford, a mechanical systems consultant, and the other plaintiffs had filed suit in October 2010 (see "USGBC, LEED Targeted by Class-Action Suit," *EBN* Oct. 2010) alleging that USGBC and LEED falsely advertise energy savings in LEED-certified buildings. The plaintiffs claim that this false advertising has caused them to lose customers to LEED Accredited Professionals (LEED APs). Judge Leonard Sand found that the plaintiffs did not adequately demonstrate that they had lost customers to LEED APs or been harmed in any way by USGBC. Further, he found that it was not clear that the plaintiffs were even competing with LEED APs for clients. Sand also dismissed the false advertising claim as "too speculative." Gifford has hinted to *EBN* that he may consider appealing, although he acknowledges that the legal fight has been trying. For more details and ongoing coverage of the Gifford case, visit BuildingGreen.com/news.

Evergreen Solar Files for Bankruptcy—In a major blow to U.S. solar innovation, Evergreen Solar, creator of low-cost ribbon technology for photovoltaic (PV) cells, has declared Chapter 11 bankruptcy. Evergreen was the only company using the proprietary ribbon technology, which involves drawing a wire through molten silicon to pull out polycrystalline ribbons; the cells have approximately 13% conversion efficiency—comparable to the efficiency of other polycrystalline technologies but with far less silicon. The price of silicon has dropped dramatically since the ribbon technology was created, reducing Evergreen's advantage. Demand also crashed after the global economic collapse, glutting the market with cheap PV from overseas manufacturers and further damaging Evergreen's chances. The company, which closed its large manufacturing plant in Devens, Massachusetts in January 2011 and moved its operations to China, will lay off 65 workers from a plant in Michigan. Manufacturing and research will continue as the company restructures and attempts to sell its assets.

New Energy Star Standards for Dishwashers and Furnaces—The U.S. Environmental Protection Agency (EPA) has announced revisions to Energy Star requirements for residential dishwashers and furnaces. Effective January 20, 2012, Energy Star dishwashers will be 8% more efficient than previous Energy Star models and 10%–30% more efficient than conventional models. Standard Energy Star dishwashers will consume no more than 4.25 gallons per cycle and 295 kWh per year, down from 5.8 gallons per cycle and 324 kWh per year for 2009–2011 Energy Star models. For furnaces, the rules become effective February 1,

2012 and will be regional for the first time, mirroring the U.S. Department of Energy's new minimum HVAC efficiency standards announced in July 2011 (see "New HVAC Standards Will Be Regional," *EBN* July 2011). Energy Star furnaces must now be 12% more efficient than the baseline in the South and 16% more efficient in the North. Energy Star furnaces in the South will have a special label that lists the states in which the certification is valid. In addition to the introduction of its Most Efficient label (see "Energy Star to Label 'Most Efficient' Appliances," *EBN* Aug. 2011), EPA has promised revisions to 20 Energy Star product requirements in 2011.

Photo: West Village Community Partnership, LLC

Common areas in the West Village at University of California–Davis, which aims to be the largest net-zero community in the U.S., include this 15,000 ft² recreation center.

Obama Administration Plans for Greener Electronics—With millions of tons of used electronics going to landfills every year, electronic waste, or "e-waste," is the fastest-growing waste stream in the U.S. When disposed of improperly, it is far more hazardous than most other trash, with toxic heavy metals and flame retardants that can leach into groundwater. A federal interagency task force is attempting to address these issues with a strategy designed to increase the environmental sustainability of the entire life cycle of electronic devices. Key recommendations of the "National Strategy for Electronics Stewardship," released in July 2011, include offering incentive programs for the development of more efficient electronic products; instructing government agencies to buy, use, reuse, and recycle electronics responsibly; and creating more recycling options for consumers. The strategy also recommends an increase in stewardship in developing countries, where many used electronic devices are sold cheaply. These electronics are often recycled by people living in or near dumps and working as scavengers, collecting and breaking down electronics into recyclable components. According to the interagency task force, the strategy will not only protect public health and the environment but will also create new jobs in electronics recycling. For more information, see www.epa.gov/electronicsstrategy.

Climate Change Could Double Need for Flood Insurance—A long-delayed Federal Emergency Management Agency (FEMA) report warns that rising sea levels and extreme weather caused by climate change may cause a 40%–45% increase within the next 90 years of U.S. land area vulnerable to flooding. Expanding floodplains will endanger millions of existing properties not formerly vulnerable to flooding and increase pressure on FEMA's National Flood Insurance Program (NFIP), which already holds 5.6 million policies protecting property worth $1.2 trillion. The report, which is to be released later in 2011 but has already received coverage in the *New York Times*, warns that flood insurance premiums could rise by as much as 70% by 2100 and that further new development in coastal cities is extremely risky. Insurance companies have long understood that rising population in flood-prone areas increases the cost of damage caused by floods. According to this report, insurers will now have to contend with both continued population increases in floodplains and the expansion of floodplains to encompass greater populations.

Students Move into "Largest Net-Zero Community" in U.S.—The University of California–Davis has opened its West Village development, which aims to be the largest net-zero-energy community in the country. The project will eventually cover 200 acres and include apartments for 850 students, 343 single-family homes for faculty and staff, and retail, recreation, and education centers. A 4 MW photovoltaic system, including rooftop installations and canopies over parking areas, will power the apartments and retail centers. Single-family homes will be available for purchase starting in 2012. The homes are expected to be popular; the university views them as a recruiting and retention tool for full-time faculty and staff, according to a spokeswoman. Publicity for the West Village development has downplayed LEED certification, but the spokeswoman told *EBN* the West Village was pursuing LEED Platinum certification for its buildings in addition to the development-wide net-zero goal.

Product News & Reviews

The World's Most Efficient Solar Thermal Collector?

Ritter XL Solar combines three unique technologies—advanced evacuated tubes, compound parabolic reflectors, and water as a heat-transfer fluid—to create large-scale compound parabolic concentrating (CPC) solar thermal systems for use in commercial, multifamily, and other applications that have high hot water demand. Distributed in the U.S. by Regasol USA, a subsidiary of the German company Ritter Gruppe, these complex systems require precise engineering and controls but can provide supplemental solar hot water even in cold climates.

The heart of the Ritter XL system is the company's evacuated tube. While similar to evacuated tubes made by other companies, the tubes used in the XL system are a larger diameter and are made specifically for large-scale use. Ritter increases their performance further by using a unique heat-transfer plate that works in tandem with a parabolic mirror behind the tube to capture sunlight and focus it back onto the collectors at a perpendicular angle—simulating mid-day conditions.

The tubes come preassembled into panels (most evacuated tubes are shipped separately) that put out an impressive Solar Rating and Certification Corporation (SRCC) OG-100-rated 55,000 Btu per day. These panels are modular, so they can be installed in a series of five before going parallel. According to Michael DiPaolo, president of Regasol USA, the company's real-world collector efficiency should be even higher when compared to other collectors, since SRCC collector testing is done with water and not propylene glycol. Yet in the real world, other large-scale collectors most often use glycol and not water.

Ritter XL is the only large-scale system that uses water as a heat-transfer fluid, and this is one of the keys to its performance. Propylene glycol protects a solar thermal system against freezing, but water has several performance advantages: water is more efficient at storing and transferring heat; it is less viscous and easier to pump; and it doesn't break down at high temperatures like glycol does. Using water can also reduce maintenance time, require smaller heat exchangers, use less piping and equipment, and cost less, according to the company. In most cases, the solar thermal loop is closed and separate from the domestic hot water loop, but it can be plumbed directly into the boiler if the system is supplying water for space heating.

The Ritter XL system eliminates freezing via a controller, precise engineering, and a small amount of stored hot water. According to DiPaolo, "Our controller monitors pressure, temperature, time of operation, flow direction, and about ten other parameters." When it gets close to freezing, every 15 minutes the controller triggers the pump and pushes water through the system for 5–15 seconds. It continues to analyze the data to determine the minimal amount of water necessary to keep the system clear. There isn't any water flowing into the insulated glass tubes, and all pipes on the roof are fully insulated. The company claims the freeze protection uses about 2%–4% of the annual solar heat gain.

Overheating can be just as much of a problem as freezing. Glycol breaks down and becomes acidic at temperatures around 250°F (121°C); if not managed, the acidic solution can damage copper collectors and pipes. There are additives and design options that help minimize this risk, but the Ritter XL system doesn't need overheating protection. The controller simply shuts down the pump, the collectors heat up until they generate steam, and the steam pushes the water out of the collectors and pipes into an expansion tank. When the system cools off again, it restarts.

The Ritter XL is not without its quirks. The system requires an uninterruptible power supply in case the power goes out, and the water has to meet specifications for pH, dissolved solids, and chlorine. If the local water does not meet the stan-

Photo: Ritter Gruppe

The Ritter XL solar thermal system at the New York City subway maintenance plant uses 48 compound parabolic concentrating (CPC) collectors to supply almost 2,000 gallons of hot water a day for washing the city's subway cars.

dard, treated water has to be used; but DiPaolo said that because it is a closed system, the water should last a long time.

The company has installed more than 50,000 residential and commercial systems in Europe, including the world's largest district heating installation in Wels, Austria, at 36,597 square feet (3,400 m^2), and the New York City subway maintenance plant on Coney Island. The price of these systems is difficult to compare with other solar thermal because Ritter is "vertically integrated," but DiPaolo claims they are very cost-competitive, noting that the company won the subway maintenance contract on an open bid. As one of the world's largest suppliers of evacuated tubes, Ritter keeps its costs down and quality high by supplying the equipment and incorporating all of the engineering into the price of each system.

Vanir Construction Management is using Ritter panels on six YMCA buildings in Winston-Salem, North Carolina. Donald Haase, senior project manager at Vanir, said five of the buildings have 50 panels and around 600 gallons of storage, and the sixth has 210 panels. "They are challenging because they are very dynamic systems, and the demand for hot water varies depending on site, day, and clientele," he said. "On a typical day we see 25 therms a day coming out of these systems, and we are still fine-tuning them." According to Haase, initial results from one site indicate approximately 51% savings in natural gas consumption over the previous year.

Regasol is awaiting SRCC-OG-300 certification for its residential systems and is hoping to have them available by the end of 2011.

– Brent Ehrlich

For more information:

Regasol USA
Stroudsburg, PA
570-517-5380
www.ritter-xl-solar.com

Porous Plus: Eco-Tek Pavers Include Regional Slag

Porous paving systems help manage stormwater, but most are made of concrete—one of the most environmentally intensive building materials. It's great, then, to find a manufacturer reducing the environmental impact of its systems. R.I. Lampus Company, a concrete manufacturer in the Pittsburgh area, has started offering its Eco-Tek interlocking porous pavers with up to 30% regional blast furnace slag in place of portland cement, the ingredient in concrete most responsible for its carbon emissions.

The pavers can be tinted with EnvironOxide pigment, an iron-oxide-based byproduct of soil remediation in areas with excessive runoff from abandoned coal mines. According to Lampus's vice president for marketing, Bob Welling, "We also have the ability to use some percentage of recycled materials as an aggregate constituent, in place of sand and gravel." Welling said that standard concrete pavers cost about \$4/ft^2; including blast-furnace slag in the mix could add roughly 10%–20%. Including slag and custom-ordered recycled content might add as much as 30% to the cost, but it varies.

The custom recycled- and regional-content offerings have been popular enough that Lampus has extended them to other products as well, including its newer Versa-Green retaining wall blocks and even its standard concrete backup blocks. Next year, Lampus will introduce a new permeable paver that has all the same green attributes but can be machine-laid, saving on labor costs, Welling told *EBN*.

For very large projects, that could help a little to boost interest in a product that can often be a tough sell, according to Jim Nesbit, owner of Nesbit's Landscaping Supply in Western Pennsylvania. Nesbit told *EBN* that while the Eco-Tek pavers perform well and aren't much more expensive than standard pavers, a whole porous paving *system* requires extra labor, excavation, and custom engineering, adding 50%–60% to upfront costs. "There are a few green projects out there, but for the most part it's because they're being forced to do it, not because they want to do it," he said.

Photo: R.I. Lampus Company

Eco-Tek porous pavers not only help manage stormwater but can also include regional and recycled materials to reduce the environmental impact of the concrete.

Welling says it's neither fuel-efficient nor cost-effective to ship such heavy stuff beyond the company's current distribution area in Pennsylvania, Ohio, West Virginia, and neighboring states; and even though the company might be willing, the concrete would no longer be a regional material. However, concrete manufacturers in other areas of the country could, in theory, offer a similar product line—if contractors started asking them to. We like the direction Lampus is going with its pavers and other concrete products, and hope to see more innovations like this in other regions as the need for thoughtful water management becomes ever more important.

– Paula Melton

For more information:

R.I. Lampus Company
www.lampus.com

Lightweight Drywall: More from Less

New lightweight drywall products have become widely available in the U.S. and Canada in the last year as major drywall manufacturers have entered the market. These products weigh 1.2–1.4 pounds per inch for ½" panels—a 25%–30% weight reduction from standard drywall.

The weight reduction is a significant advance for drywall installers, allowing for easier installation and less fatigue. Manufacturers have also been hinting that the product, which typically sells at a 5%–10% retail premium, is greener due to reduced transportation energy. According to the U.S. Geological Survey, the average American home contains eight tons of drywall. Assuming for the sake of illustration that the drywall for an average home travels 500 miles by truck, a 30% reduction in drywall weight—2.4 tons— would avoid the release of 424 pounds of carbon per home—the equivalent of burning 21 gallons of gasoline. That could start to add up if more of the 15 million tons of drywall produced and shipped every year in the U.S. switches to lightweight.

Manufacturers were reticent about the processes that allow for the weight savings. A representative from National Gypsum told *EBN* that weight reductions in Gold Bond High Strength Lite drywall are achieved through "bubble technology," a process in which air bubbles are evenly distributed throughout the gypsum core during manufacture.

Lightweight drywall shares a number of key features across manufacturers. It has increased sag resistance, allowing for ½" panels to be used in ceiling applications that would otherwise require ⅝" panels. It scores and snaps more cleanly than standard drywalls while meeting applicable drywall standards. Four of the five lightweight drywalls on the market are also certified as low-emitting under Greenguard for Children & Schools, Greenguard Indoor Air Quality, or both. It is available in 4' and 54" widths, and lengths from 8' to 14'. Lightweight drywall is all ½", with the exception of two ⅝" products from USG Corporation that are designed for fire-resistant applications.

One potential downside to the lightweight panels is a reduction in sound-dampening capacity. A representative from American Gypsum told *EBN* that the panels scored slightly lower on sound performance tests due to decreased density.

Lighter drywall is a welcome development for both drywall professionals and do-it-yourselfers, with a 4' x 8' x ½" panel weighing in at roughly 40 pounds compared to 55 pounds for regular gypsum board. Myron Ferguson, a drywall contractor in Galway, New York shared his experience using USG's Sheetrock Ultralight Panels with *EBN*. "The lightweight drywall is great—30% lighter is big. I also like the fact that it is more resistant to sagging. This makes it even easier to handle while hanging." Lightweight panels may eventually replace standard panels. An American Gypsum representative told *EBN*, "We would certainly rather have fewer products than more on the market, and this one performs really well."

– Evan Dick

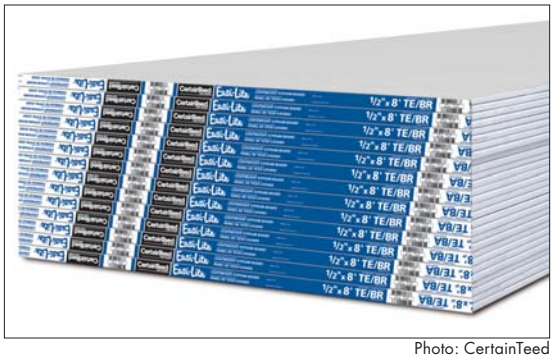


Photo: CertainTeed

Lightweight drywalls, like Easi-Lite from CertainTeed, are 25%–30% lighter than standard drywalls.

Solar Thermal Hot Water, Heating, and Cooling *(from page 1)*

that warms the potable water. Indirect systems can be used in all but the coldest climates, but they require more maintenance. If the glycol solution gets too hot, it becomes acidic and loses its ability to protect the system's components, so temperatures have to be regulated, and the glycol must be regularly monitored and maintained.

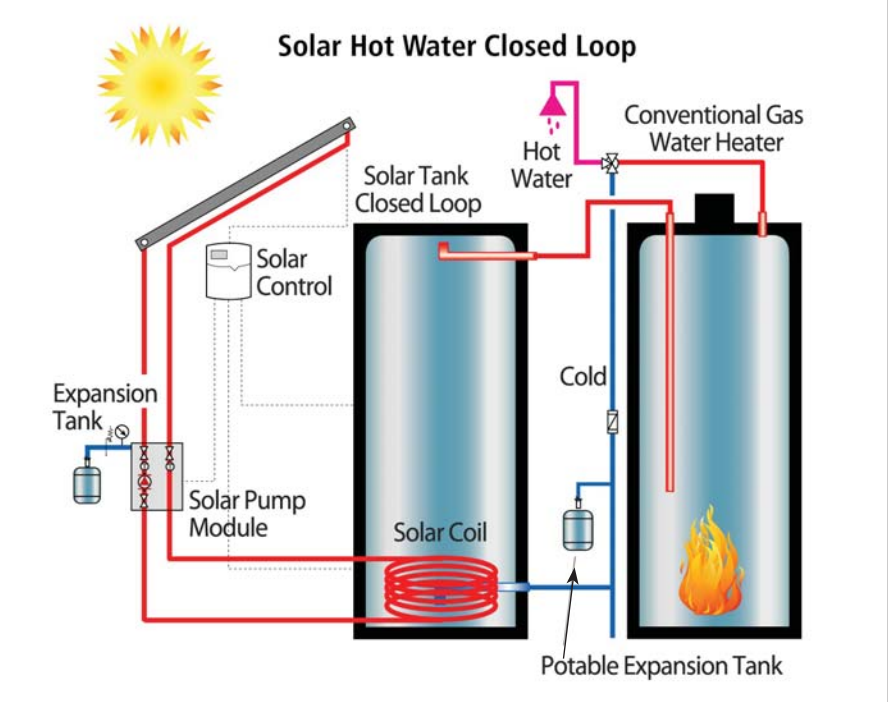
John Harrison, senior research analyst at the Florida Solar Energy Center (FSEC), recommends indirect glycol systems in the North due to freezing conditions, but in the South, direct systems can work fine. Harrison recently recommended 800 direct systems for low-income housing in Florida. "There are no pumps or controllers," he said. "There is little that can go wrong [for owners who] don't have the money for repairs."

Bill Guiney, director of the solar thermal business at Johnson Controls, which integrates solar thermal and PV for commercial, higher education, prisons, and other markets, said, "We only use indirect systems because of the freeze damage we've seen across the country in the past few years."

Active vs. passive

The heat-transfer fluids in solar thermal systems circulate either *passively*, allowing the system's water pressure or temperature differences to provide circulation, or *actively*, using circulation pumps and controllers to regulate the water temperature. Using pumps provides more control and improves thermal efficiency but adds some electrical load. Some systems use small PV panels to power DC pumps, reducing pumping energy significantly. Most systems sold in North America today are indirect, active systems that pump propylene glycol through flat-plate collectors.

In *drainback* systems—an active, indirect system that typically uses



Schematic: JTG/Muir

In a dual-tank, closed-loop solar thermal system, a glycol solution flows in a loop between the solar collectors and heat exchanger to warm domestic hot water in the storage tank. A standard water heater supplies any additional hot water.

water as the heat-transfer fluid—the pump to the collector shuts off once a specified temperature is reached; the heat-transfer fluid then flows down into a resevoir in the solar loop instead of overheating or freezing in the collector.

In direct, passive *thermosiphon* systems, the storage tank is located above the collector, so the hot water rises and the cooler water settles back through the collector. The tank and collector can be separate but are most often attached. These are very simple systems and are the most common in the world. Solahart offers both direct and indirect thermosiphon systems for use in hot and cold climates, respectively.

Low-, medium-, and high-temperature systems

We also categorize solar thermal systems by the temperature of the water they produce. Applications that don't require much hot water, such as pool heating, can use low-temperature solar thermal systems that produce water less than 110°F (43°C).

Medium-temperature systems deliver water at 110°F–180°F (43°C–82°C) for domestic or commercial use, with either glazed flat-plate or evacuated-tube collectors. High-temperature (>180°F/82°C) systems are always indirect and include evacuated-tube and concentrating solar collectors that produce water at temperatures that can generate electricity, provide hot water or space heating, or be used as an energy source to drive absorption chillers (more on that later).

Types of Collectors

At the heart of any solar water-heating system is the collector, where the sun actually heats the water (or the glycol). The three most common types are integral collector-storage systems, flat-plate collectors, and evacuated-tube collectors. All of these systems offer advantages.

Integral collector-storage

Integral collector-storage (ICS) is the simplest type of solar thermal system. Also known as a "batch" system, an ICS system includes a tank or a series of pipes inside a glass-covered, insulated box with a black or reflective interior. The box is pointed at the sun, and as the glass box receives and traps solar heat, the water sitting in the tank or tubes is warmed. The tank or pipes in the box serve as both the absorber and the storage tank, so the water needs to bask in the sun for a good portion of the day before it reaches a suitable temperature.

When ICS systems use metal tubes, there is more surface area to capture heat, but that surface area also allows heat to escape more quickly when the sun goes down. Either way, it's best to use the hot water by evening, before it cools overnight. ICS is common in warmer climates with plenty of sun and a lack of cold temperatures that would freeze the system or steal its heat. These systems are typically quite small, with a capacity of about 50 gallons (200 l), and they are heavy, so a roof holding them may need reinforcement. They can also leak and are not very attractive, though some can be integrated into the roof and are less noticeable.

Flat-plate collectors

Flat-plate collectors are the most common solar thermal system in the U.S. They look like oversized skylights, with cases about 4' x 8' x 4" that contain a dark-colored absorber housed directly beneath low-iron, tempered glazing.

Copper tubing, or "risers," installed on the absorber's surface have fins that increase heat transfer to the fluid—either water or a water-glycol mix (in cold climates)—that flows through the pipes. The risers connect to input and output manifolds at the top and bottom so additional collectors can be added in series. These collectors can be set up as either active or passive systems.

When water is used in these systems, it flows directly to an insulated tank for storage. If propylene glycol is used, then it runs through a heat

exchanger to heat water stored in the tank before being pumped back through the collector. Glazed systems have a cover of low-iron glass that allows the light through and traps the heat.

Glazed collectors are more efficient, but unglazed systems are common for lower-temperature applications, such as pool heaters. One company, Fafco, also makes an unglazed system that generates medium-temperature water for residential and commercial hot water.

Evacuated-tube collectors

Evacuated-tube collectors use a series of glass tubes with the air removed from them to create a vacuum, just like an insulated travel mug. Inside each tube is a specially coated copper or aluminum fin that absorbs the sun's heat and transfers it to pipes containing the water or glycol. Each pipe connects to a manifold at the top of the collector. Because the vacuum insulates these tubes so well, there is little heat loss from convection or conduction. Evacuated-tube collectors can be very efficient and can heat water to high temperatures, making them appropriate for some commercial applications, such as restaurants or laundromats.

There are two types of evacuated-tube collectors: direct-flow and heat-pipe. Direct-flow collectors contain two pipes in each glass tube, with cold inlet water circulating through one pipe and warm outlet water through the other. If a glass tube breaks and the copper pipe cracks, the fluid leaks out and the entire system shuts down until repaired.

Heat-pipe evacuated tubes have a sealed length of copper pipe inside that contains purified water, alcohol, or other fluids. Because the internal heat pipe is also in a vacuum, the liquid inside vaporizes at low temperatures—around 90°F (32°C) rather than 212°F (100°C). As sunlight hits the absorber, the liquid vaporizes and rises to the top of the heat pipe, where the absorber attaches to the manifold. A heat-transfer fluid running through a small heat exchanger in the manifold captures the heat from that vapor in the pipe, causing the vapor to cool, condense, and flow back down the tube to repeat the process. These collectors have to be mounted at a steep angle in order for the liquid to flow back down from the manifold, but they do not leak fluids, and if one tube breaks or stops working, it can be easily replaced while the rest of the system continues to operate.

Evacuated-tube collectors work well in colder, cloudier climates—but because they are so well insulated and do not leak heat, snow can accumulate on and between the tubes, significantly reducing performance. The borosilicate glass is somewhat fragile, so you have to be careful as you clean off the snow, and falling objects can be a hazard. Mounting an evacuated collector at ground level can make snow removal easier, and if they are installed at a steep angle, snow sloughs off relatively well.

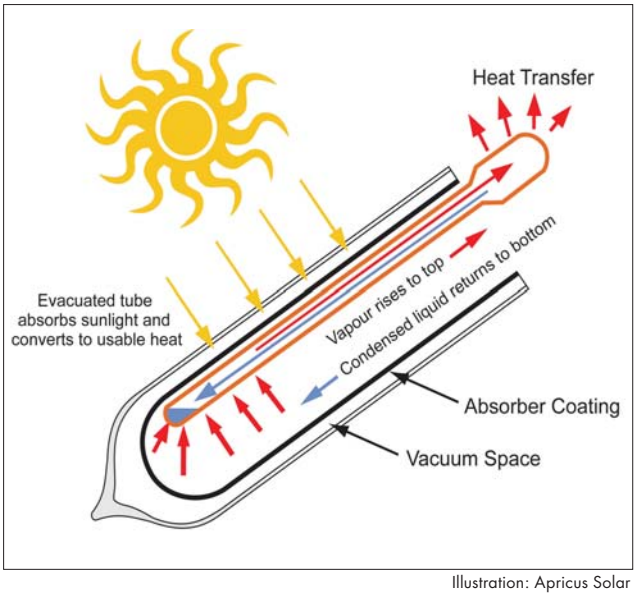


Illustration: Apricus Solar

Evacuated tubes contain a vacuum that helps transfer heat and insulate the pipes against heat loss, making them more efficient than flat-plate collectors in cloudy or cold conditions.

Packaged Systems: Plug and Play

Solar thermal systems used to have to be custom-designed by an engineer, parts had to be gathered and assembled, and plumbers had to spend hours piecing it all together. Today, solar thermal systems are more like appliances, with most systems sold as kits that include all necessary components. The distribution and marketing of these packaged systems is more complex than that of a dishwasher, however, and calculating accurate loads and installing them is beyond most do-it-yourselfers. While solar thermal systems are a bargain compared to PV, to the average customer they still seem expensive.

To bring costs down, companies are streamlining production and delivery and simplifying components. Integrated systems are less expensive to purchase, easier to install, and have more predictable performance. Large companies, such as Rheem and A.O. Smith, now offer complete systems, as do smaller, regional manufacturers like Sunward in Vermont.

Sunward's system includes two flat-panel collectors designed to work with an 80-gallon storage tank; a heat exchanger that sits outside the tank; a custom manifold; a PV-powered pump; controls; and flexible, pre-insulated copper pipe. "We package residential systems and ship everything a customer needs for installation," said Tom Hughes, sales director. The system is slightly less efficient because the heat exchanger is outside the tank, but, according to Hughes, "Over the lifetime of the system, you save money not having to replace the tank" when the heat exchanger fails. Sunward systems are SRCC

OG-300 certified (see page 13), and while installation can be a do-it-yourself project, the company recommends using a licensed plumber.

Commercial buildings usually have unique hot water needs that make packaging these systems difficult, but this is exactly the model Johnson Controls is pursuing. "We're packaging pre-engineered commercial systems, which makes it easier and less costly to develop a project," said Guiney. "It's basically like a residential packaged system, only we're doing it on a commercial scale in 400-, 1,500-, 2,000-gallon systems," he said.

Johnson Controls incorporated solar thermal at its LEED Platinum corporate headquarters in Milwaukee, using 1,088 ft^2 of SunEarth flat-plate collectors and 4,000 gallons of storage to supply 30% of the hot water for the company's 160,000 ft^2 of office space. Guiney says Johnson Controls uses modeling software and a rigorous vendor selection process to ensure the systems perform as intended.

Solar Thermal Heating

Using solar energy to heat water for domestic use is fairly straightforward, but space heating is another matter. While you need to size the collectors large enough to provide sufficient energy for both space and water heating, that sizing often results in too much capacity for summer use or in warmer climates. Any excess heat generated by the system must either be dumped (i.e., released into the atmosphere to protect the equipment), used for another application (such as heating a pool or hot tub), or stored for later use in large-capacity tanks. Excess heat generated in the summer can also be stored in a large, insulated heat sink such as a sand bed and used for wintertime heating load, although such systems are expensive and experimental, with inconclusive performance data.

Providing all a building's space heating needs using solar thermal is usually impractical, but offsetting a portion is realistic. J. Craig Robertson, president of the design-build firm Heliocentrix, builds superinsulated homes and acknowledges that using solar thermal for space heating requires complicated calculations to design; requires a significant amount of pumping energy, creating an added electrical load; and is only part of a solution. However, he has used both sand beds and tanks, including a 1,000-gallon storage tank in the Northeast that helped heat a basement through the coldest part of winter while providing dehumidification in the summer. "Relatively speaking, solar thermal is a costly way to obtain your heat," said Robertson, but "it's the only feasible carbon-free way to get it unless you build a windmill."

In multifamily and commercial buildings, thermal solar systems are used to preheat hot water typically supplied by boilers, and that heated water can be used for space heating, provided the building uses a hydronic heating system. Multifamily and commercial space heating can make more sense than a residential system because the solar thermal systems can be sized large enough to meet a significant amount of the demand while the excess can be stored in large tanks and be used for other building needs, such as heating pools or to provide cooling.

Solar Thermal Cooling

Though it seems counterintuitive, heated water generated by solar thermal collectors can also provide cooling by supplying the energy needed to power commercial absorption and adsorption chillers. *Absorption* chillers use heat and vacuums to evaporate and condense water in a loop that contains lithium bromide. The heat energy released by the process is removed, cooling the water to around 40°F–60°F (4°C–15°C). *Adsorption* chillers use several vacuum chambers and a desiccant, usually silica gel or zeolite, that is alternately heated and cooled. Water from solar thermal can be used for the heating portion; the water adheres to and releases from the surface of the desiccant, getting chilled in the process.

Mechanical chillers are smaller and more efficient and provide the majority of the cooling in the U.S., but where heat energy is readily available, absorption and adsorption chillers have some environmental advantages: they do not consume as much electricity, they're quiet, and they use water in place of fluorocarbon-based refrigerants that can have high global warming or ozone-depletion potential. Adsorption chillers have the added advantage of not having to use lithium bromide and requiring less maintenance. Both of these chillers are used to supplement a standard compressor-driven system, and because they are powered by heat, they can take advantage of solar thermal systems in the summer, when demand for hot water might otherwise be low. In the right applications, making use of this heat can turn a solar thermal system into a year-round asset.

Absorption chillers are available from most major HVAC manufacturers and can be found in single- and double-stage systems. A double-stage system will provide more cooling but also requires hotter incoming temperatures, so the system would

Average Thermal Performance Rating of Solar Thermal Collectors by Type Shipped in 2009

ICS/Thermosiphon	Flat-plate (active)	Evacuated-tube	Concentrator
913 Btu/ft^2/day	981 Btu/ft^2/day	973 Btu/ft^2/day	2,196 Btu/ft^2/day

Source: U.S. Energy Information Administration

require a large concentrating solar array, but a single-stage absorption chiller, such as those from Broad, York, and Yazaki, might only require temperatures around 190°F, which can be provided by standard evacuated tubes. Adsorption chillers are available through Mayekawa and HIJC USA.

Rating Solar Thermal Systems

Given the many types of solar thermal systems available, and offerings from over 160 manufacturers, Solar Rating and Certification Corporation (SRCC) data is indispensable when it comes to system selection.

Begun in 1975 as a way to test solar thermal systems in the U.S., SRCC certifies individual collectors and complete residential systems under its OG-100 and OG-300 standards, respectively. Individual collectors—including flat-plate, evacuated-tube, ICS, non-separable thermosiphon, and concentrating solar collectors—are tested under laboratory conditions to determine OG-100 compliance, and test results from individual collectors are fed into TRNSYS software from the University of Wisconsin to model performance of an entire system to determine OG-300 compliance. According to Jim Huggins, technical director of SRCC, "OG-300 is a residential water-heating program for pre-engineered systems designed to be installed many, many times." The OG-300 covers the following:

1. Collectors, which need to be certified under OG-100
2. Storage tanks
3. Pumps, controls, valves, pipes, and pipe insulation
4. A backup water heater with hot water output equivalent to that of the solar water heater (the rating will be affected by type of backup system: electric, gas, tankless, or boiler)

Photo: SunQuest Energy

This modular York absorption chiller and storage tank used by Johnson Controls at Ft. Bliss, Texas can use hot water from solar thermal systems for commercial cooling, making solar thermal a viable technology year round in hot climates.

The system also has to be designed and installed according to local codes.

Each SRCC-rated system comes with data, including solar energy factor, annual savings, and annual solar fraction (the amount of a home's hot water that is supplied by the system), and allows an apples-to-apples comparison of systems using different technologies and configurations.

Energy Star has certified residential solar water heaters since 2008 and requires certification of the system to SRCC OG-300. As part of the certification, Energy Star requires a solar fraction—the total amount of the hot water load supplied by solar thermal—of 0.50 on a scale of 0.0 to 1.0 (most solar thermal systems are between 0.5 and 0.75). Required warranties include ten years on the collector, six years on the tank, two years for the controls, and one year on other parts.

Cost, Payback, and Incentives

If initial loads are carefully calculated, solar thermal systems can provide low-cost, energy-efficient hot water and provide some protection against rising energy costs. These systems are expensive, however, and low coal and natural gas prices can make it difficult for them to compete financially. They are often installed anyway to lower the project's carbon footprint or as a learning tool, such as in schools. As with any onsite renewable energy system, it is critical to implement other, less expensive energy- and water-saving measures, such as using low-flow fixtures, before investing in solar thermal.

A robust solar thermal system can provide 50%–80% of a household's hot water needs, although the cost of these systems can vary widely from state to state and even within states. While the installed cost of various systems in the pilot program that preceded California's Solar Initiative (CSI)Thermal Program, for example, averaged around $6,700, they can cost as much as $12,000 in the Midwest and Northeast due to the basements and high-pitched roofs.

Most manufacturers claim a "payback" period of seven or so years, which is based on the cost of the system divided by annual savings, but there are a number of assumptions that dramatically impact payback. Most importantly, "Simple payback doesn't account for fuel cost escalation," said Everett Barber, Jr.,

a solar consultant with more than 30 years' experience. For example, a 2005 study by Steven Winter Associates measured solar thermal performance on a Massachusetts home with an efficient boiler and estimated a 47-year simple payback. However, the price of oil in 2005 was only $1.85 per gallon; using today's energy prices and incentives, the payback is only 18 years.

According to Barber, a more robust metric, such as the *internal rate of return* (IRR) or *break-even time*, will provide better data. IRR is the annual profit as a percentage that you earn on a solar thermal system. It's similar to the interest you receive from the bank and can be adjusted for rising fuel costs and other factors. Break-even is the amount of time it takes for the system to pay for itself—what people assume "payback" is. IRR and break-even calculations can be complicated, but there are tools available (such as solar-estimate.org) that help. Running the original Massachusetts study data through this spreadsheet provides a break-even time of less than four years and an IRR of over 32%, which is a pretty good investment.

Comparison of Solar Water Heating & Solar Electric Systems

Data comparing PV panels and solar thermal collectors show that PV requires almost six times as much area to produce the equivalent power.

	SOLAR HEATING	PV
Manufacturer	SunEarth	Shell Solar
Model	EP-40	SQ165-PC
Number of units	2	32
Output/unit peak	40,000 Btu/day each	165 Watts each
Output/unit	38,745 Btu/day each	120 Watts each
Total output/day	77,490 Btu/day each	22,272 Watt-hours each
Total output/day	22.7 kWhr	22.3 kWhr
Area	80 ft^2	456 ft^2
Energy/ft^2/day	0.28 kWhr	0.05 kWhr
Peak Power	5.0 kW	5.3 kW
Gross installed cost	$7,200	$31,680
Gross installed cost	$1.44/Watt	$6.00/Watt
Installed cost/ft^2	$90	$69

Source: Ron Richmond at SunEarth

Note: Data comparing rooftop solar thermal and PV at the SunEarth solar heating collector manufacturing plant in Ontario, Canada, was adjusted for present-day economics by Ron Richmond.

Federal and state programs

There are a number of federal and state incentive programs that can offset part of the cost of solar thermal systems. Federal incentives include a 30% personal tax credit for residential customers through the Residential Renewable Energy Tax Credit, and a 30% corporate tax credit through the Business Investment Tax Credit for commercial customers. Instead of the tax credit, businesses can opt to receive a grant from the U.S. Treasury Department, but this program is winding down.

At the state level, programs can be administered through the state or through utilities, and vary considerably. For more information on specific state incentives, check the U.S. Department of Energy's Database of State Incentives for Renewables & Efficiency (DSIRE) at dsireusa.org.

California offers the most well funded state incentive programs in the U.S. Its CSI-Thermal Program offers rebates of up to $1,875 for solar thermal systems on single-family homes and up to $500,000 for multifamily and commercial properties. Typical single-family rebates average about $1,500 for systems displacing natural gas water heaters and $1,000 for those replacing electric. The program has a goal of providing 200,000 rebates in ten years, but according to Les Nelson, a director of the California Solar Energy Industries Association, only 275 rebates have been awarded since May 2010, and $200 million in incentives remain available.

Bureaucracy and contractor costs have played a role in the program's small enrollment, says Barry Butler, Ph.D., owner of Butler Sun Solutions and current chair of the Thermal Division of the American Solar Energy Society. "You're supposed to get between $1,000 and $1,500 per system, but the California rebate is subtracted from the system cost before the federal tax credit, so the real value is only $700 to $1,050." He continued, "Program paperwork, local inspection costs, and waiting for both state and local inspectors to show up can cost a contractor $500–$700."

What's New in Solar Thermal

Most of today's solar thermal collectors use technologies that have been around for years. Though the systems are already reliable, a technology breakthrough would help bring costs down and improve performance. Fafco, the largest and oldest manufacturer of solar thermal systems in the U.S., is approaching innovation from the cost side. The company became famous in 1969 for introducing low-cost, unglazed solar pool-heating systems that are now the industry standard. Fafco partnered with the U.S. Department of Energy to develop similar technology for solar thermal.

The company now manufactures unglazed residential and commer-

Solar thermal or PV?

Mike Healey, partner at Skyline Innovations, which finances and develops commercial PV and solar thermal systems, offers this general rule of thumb: solar thermal provides three times the energy per square foot as PV. If you have limited space on your roof, install enough collectors to supply hot water needs first; then consider PV. However, grid-tied PV has its own advantage: there is little waste. Power generated by the system in summer is used or sold back to the grid, whereas solar thermal systems may need to "dump" heat in the summer to keep from overheating. In the end, choosing PV or solar thermal may depend on whether your electricity or hot water demands are larger.

cial collectors molded entirely from a rigid, proprietary UV-resistant polymer. There are no copper or aluminum, no complicated technology, and no assembly, so manufacturing costs are significantly lower than flat-plate or evacuated tubes. The tradeoff? The efficiency of Fafco's collectors is lower than that of flat-plate or evacuated tubes, so it could take more panels to provide the same output. But lower costs might tip the scales in Fafco's favor. Fafco offers these collectors in its SRCC OG-300-certified 200 series, a lower-cost drainback system; its 500 series, an indirect glycol system with optional PV; and standalone collectors for commercial use.

Combined PV and solar water systems are becoming a reality in commercial and industrial process applications and are now offered by companies like Solimpeks, which is manufactured in Turkey, and the U.S.-based Cogenra. PV performance drops as temperatures rise, so these companies use fins and heat exchangers to capture the heat off the PV surface, cooling the photovoltaics while also producing hot water. Solimpek's PowerVolt collector produces 175 watts peak via PV and 1,570 Btu/hr thermal, and its PowerTherm produces 160 watts peak and 2,080 Btu/hr thermal. According to the company, it would take 269 ft^2 (25 m^2) of standard monocrystalline PV and solar thermal collectors to equal the production of 172 ft^2 (16 m^2) of PowerVolt collectors.

When higher-temperature water is required, there are several innovative systems now available, such as Solargenix's Winston Series CPC compound parabolic concentrating (CPC) collectors. These contain a parabolic mirrored surface that concentrates the solar energy onto non-evacuated tubes filled with heat transfer fluid (see "BuildingGreen Announces 2004 Top-10 Products," *EBN* Dec. 2004, for our review and Top-10 product award). Solargenix is in the process of updating its technology, and those systems are undergoing testing by the SRCC. The company expects to have them on the market by the end of 2011.

The German company Ritter Gruppe offers its Ritter XL concentrating systems through its North American subsidiary Regasol. The company's large-scale commercial and multifamily systems use an innovative CPC system and water as a heat-transfer fluid. In these systems, the CPC reflector sits behind the evacuated tubes and focuses the sunlight onto the absorber. It has some of the performance advantages of concentrating solar without requiring a mechanical tracking system. Ritter claims that its AquaSystem transfers heat more efficiently than glycol, increasing the overall performance while minimizing the maintenance required with glycol systems. The company manages freezing via sophisticated controls and engineering. Currently, only commercial products are available in North America, but residential products should be available in late 2011.

Chromasun offers another high-temperature solar thermal option. Made for commercial and industrial use, particularly cooling, the company's MCT uses 25x Fresnel concentrating reflectors and an enclosed tracking system to focus the sun onto pipes that can carry a variety of heat-transfer fluids. This roof-mounted system can provide water temperatures as high as 448°F (220°C), in an area the size of a flat-plate collector, according to the company.

What's New in Solar Thermal

Concept	Company	Technology	End Use
Low-cost, unglazed flat- plate collectors	Fafco	Low-cost, corrosion-resistant, rigid flat-plate collectors made from UV-resistant polymer	Residential and commercial hot water
Combined PV and solar thermal collectors	Solimpek Cogenra	Solar thermal collector pulls heat off PV cells, improving PV efficiency while generating hot water	Residential and commercial hot water and power
Rooftop concentrating collectors	Chromasun	Fresnel reflectors and internal tracking mechanism focus light onto pipes carrying heat-transfer fluid	Commercial high-temperature hot water that can be used for absorption chillers
Compound parabolic concentrating (CPC) collectors	Ritter XL Solargenix	Mirrored surface reflects sunlight onto evacuated (Ritter) or non-evacuated tubes (Solargenix)	Commercial hot water, including absorption chillers

Focusing Our Energies

Solar thermal technologies have not changed all that much in the past 30 years, but the world around us has. Oil supplies are less stable, and though natural gas prices are at historic lows, concerns over hydraulic fracturing, or fracking, make its future uncertain. As energy prices inevitably rise, solar thermal has an opportunity to provide a plentiful, stable source of hot water and energy at costs that are becoming increasingly competitive and with a very small carbon footprint.

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BackPage Primer

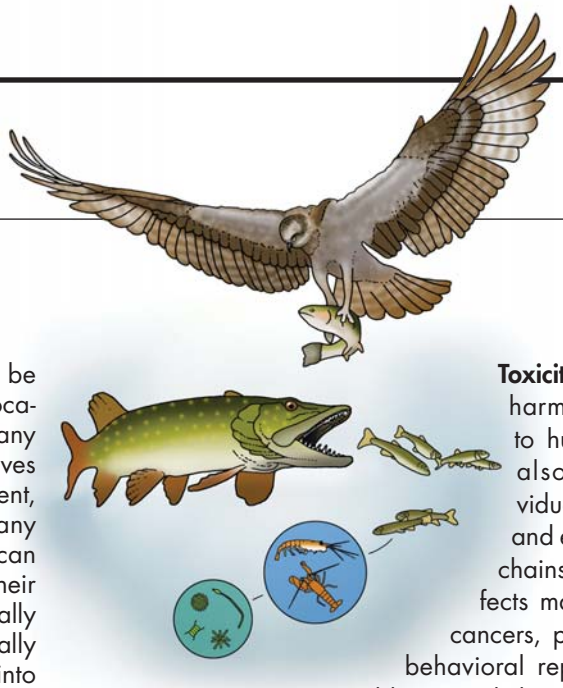

Illustration: Peter Harris

PBT Chemicals—Persistent, Bioaccumulative, Toxic

How can pesticides no one has used for decades be found in birds and fish in some of the most remote locations of the globe? These chemicals—along with many carpet treatments, flame retardants, and other additives still commonly found in building products—are persistent, bioaccumulative toxic chemicals (PBTs). While many toxic substances become less potent over time, PBTs can become more harmful the longer they persist due to their activity in ecosystems. Some, like arsenic, are naturally occurring, but many are human-made. Other naturally occurring ones, like mercury and lead, are released into the environment in greater concentrations due to human activities like burning coal.

Persistence means a chemical does not readily break down in the environment. PBTs can be transported long distances through air and ocean currents and the atmosphere. They can remain in soil and silt for decades, being absorbed by plants and microorganisms. The persistence threshold for testing and potential regulation by the U.S. Environmental Protection Agency (EPA) is a half-life longer than two months.

Bioaccumulation is the buildup of a substance in an individual organism. If a PBT remains in silt, bottom feeders take in small quantities, which accumulate in fatty tissue more quickly than they can be metabolized. Predatory fish then eat bottom feeders, storing larger quantities at higher concentrations in their own fat. The higher an animal is on the food chain, the more of the PBT the animal is likely to store and the more harm it may cause. *Bioconcentration factor* (BCF)—the ratio of a substance's concentration in an organism to its concentration in surrounding water—is a common measure of bioaccumulation; EPA's threshold for concern is a BCF of 1,000.

Toxicity includes harm not only to humans but also to individual animals and entire food chains. Toxic effects may include cancers, physical or behavioral reproductive problems, and damage to endocrine and nervous systems. PBTs known as persistent organic pollutants (POPs) include chemicals used in polystyrene insulation, interior fabrics, paint, carpets, and a multitude of materials containing plasticizers. Polyvinyl chloride (PVC), one of the most common building materials, releases many toxic substances during its manufacture and when it is burned; among these are dioxins—potent, carcinogenic POPs with other far-reaching effects on the immune, nervous, and endocrine systems.

Most signatories to the Stockholm Convention on Persistent Organic Pollutants, including the U.S. and Canada, have discontinued use of nine of the most potent PBTs, and the treaty limits use of three others, including the infamous pesticide DDT. Signed in 2001, the Stockholm Convention added nine new chemicals in 2009, a list that included perfluorooctanesulfonate (PFOS), formerly the main ingredient in Scotchgard stain repellent. Hexabromocyclododecane (HBCD), a flame retardant used in polystyrene insulation, is currently under review by the Stockholm Convention.