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EDITOR'S NOTE

The Inside Scoop

By Matt Power
Editor-in-Chief

Building Science: The Pathway to Resilience

Preparing future homes to survive climate-induced shocks begins now.

BUILDERS FACE TOUGH TIMES. Each year brings more restrictive land use, rising material costs, stricter building codes (in some areas) and the ever-looming threat of litigation. Of course, sometimes the industry backs outdated ways of building (opposition to low-flow toilets a few years ago was not a high mark). But builder groups in California were right to resist a new bill that holds them responsible for the unpaid wages of their subcontractors' employees. We need our best and brightest focused on what really matters—building high-performance housing—not fighting legal battles.

Good building science is in every builder's



interest. The better a unit of housing performs, the greater its energy efficiency and ability to withstand nature's fury, the more likely it will get built, stay intact and serve as a calling card with municipalities for future permitting and planning.

In coming months, we'll be doubling down on our commitment to the need for more resilient housing. It's a natural fit with our sustainability mission. Resilient homes naturally waste less energy than their built-to-code-minimum counterparts. Keeping additional CO₂ out of Earth's atmosphere clearly serves dual purposes. It will help dampen global warming—and make homes safer and more durable.

So we're keeping our eye on the ball with this month's topics. HVAC is the biggest energy user in a modern home; let's start there. Keeping airflow balanced, optimized and efficient makes the most of conditioned air. But we're also aware that you need to sell homes. And clients are trending toward concern with "wellness." Their biggest concerns (and selling points) may include indoor air quality and comfort. There's no reason building science can't address these issues simultaneously, helping you sell homes while you make them more efficient.

In the wake of the extreme drubbing given to Houston, Key West, Puerto Rico and the Virgin Islands this fall, no other issue outweighs the need for more resilient housing. The solution is not hand wringing, finger pointing or worse—abandoning the places and people who need the construction industry most. Let's approach this from a calm, focused perspective. Assess what happened. Figure out how to build in a way that it won't happen again. And get to work. **GB**



Coincidence? The science of building tough, resilient housing has taken on new urgency, as climate change demonstrates the cost of procrastination.

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Green Building NEWS

The Latest on Sustainability and Renewable Energy

Busy Building Year Ahead in East, Midwest

Consumers' No. 1 planned upgrade is their kitchen.

NEARLY 1 IN 6 AMERICANS plan to renovate their homes within the next year, and the most likely candidates are those living along the East Coast or Midwest, according to the 2017 Home Hearth Renovation Survey. One in three of the respondents who lived in Hawaii and Kansas plan such upgrades, as do 1 in 4 of those survey participants in Montana, Rhode Island, New Hampshire and Utah.

Michigan, Connecticut, Missouri and Maine rounded out the top 10 states, with each recording resident renovation plans of more than 20 percent.

The phone survey of 2,000 homeowners also found that, if money were no option, the kitchen would be the thing most likely to be renovated (38 percent), more than twice as likely as the bathroom (15 percent) and three times more than the living room (12 percent).

Credit cards are a popular way to pay for renovations, preferred



CREDIT: JEREMY LEVINE/FICKR

Changes on tap. When it comes to renovations, consumers have their sights set on their kitchens above anywhere else in their homes, according to a new homeowners' survey.

by 1 in 3 survey respondents in Alaska and Delaware, and 1 in 4 in New Jersey, Rhode Island and New York, according to the survey.

The full survey can be accessed at www.gethearth.com. **GB**

Earth's First Really Green City Takes Hold in China

THE AIR-CLEANSING 'FOREST CITY' COULD BE THE FIRST OF MANY WORLDWIDE.

THE GOVERNMENT OF CHINA has broken ground on a new city that will literally be green. When completed in 2020, Forest City near Liuzhou in Northern China will be home to 30,000 people, with all buildings covered by nearly 1 million plants of more than 100 species. The greenery will be capable each year of absorbing nearly 10,000 tons of CO₂ and 57,000 tons of pollutants, and producing 900 tons of oxygen, according to Italian architect Stefano Boeri.

Boeri, whose firm designed the development, says Forest City will help decrease the area's average air temperature, improve local air quality and biodiversity, create noise barriers, and generate numerous natural habitats. The 175-hectare (0.67-square-mile) city along the Lijiang River will "have all the characteristics of an energy self-sufficient urban establishment," such as geothermal energy for interior air conditioning and solar panels over the roofs for collecting renewable energy," according to Boeri.

The city will be entirely Wi-Fi enabled and will include commercial zones, residential areas, recreational spaces, a hospital and two schools. Residents may travel from Forest City to Liuzhou by a fast rail line for electric cars.

Boeri notes that if the project meets all expectations, it will "set



CREDIT: STEFANO BOERI ARCHITETTI

Taking root. Liuzhou, the world's first "green city" with almost 1 million plants, offers a new approach to resilience.

an example for green city design elsewhere in the country and around the world." The architect should know: His 2014 project, the Vertical Forest in Milan—two residential towers that featured as many trees as could be planted in a hectare of land—is being replicated in cities such as Sydney, Seoul, Sao Paulo, Nanjing, Shanghai and Shenzhen. **GB**

Contractors Get a Way to Keep Things 'Clean'

Now, builders don't have to go far for green products.

A NEW TOOL FROM the BlueGreen Alliance Foundation is offering everyone from building professionals to consumers a way to find energy-efficient housing products that are healthy and made locally. Building Clean—found at www.buildingclean.org—provides an easy-to-use interface to access its unique database. Products and manufacturers of products available on the database include appliances, heating and air-conditioning equipment, insulation, lighting, plumbing, roofing, sealants and water filtration.

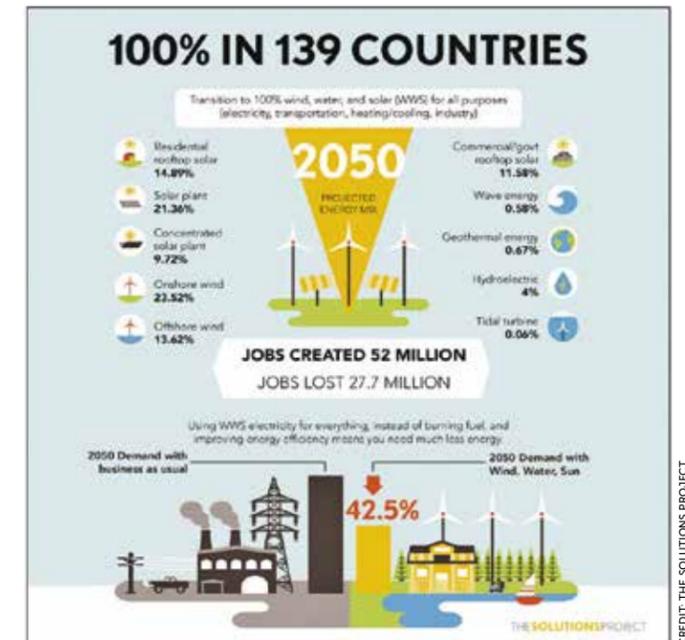
According to Kim Glas, president of the BlueGreen Alliance Foundation, the site allows searches for products and manufacturers in energy-efficient building sectors and includes information about toxic chemicals commonly found in some product categories. In addition, you can search for products certified with third-party health certifications and that promote transparency by listing the chemicals they contain.

The site can also be a resource for businesses looking to break into the energy-efficient product supply chain. "We wanted to make sure we were making it easy for manufacturers looking to grow their businesses to find and get into contact with other business with needs they can fulfill, providing an opportunity to grow their market and business," Glas says. **GB**



CREDIT: BLUEGREEN ALLIANCE FOUNDATION

Market value. The Building Clean search tool gives manufacturers and builders a chance to buy their housing products from local providers.



CREDIT: THE SOLUTIONS PROJECT

Renewed potential. A variety of green power options could lead to the end of fossil fuel use by at least 139 nations by mid-century.

Fossil Fuels Could Be All but Extinct to Phased Out

Stanford study shows that most nations can be powered entirely by renewables.

BY 2050, AT LEAST 139 COUNTRIES could be powered entirely by wind, water and solar by making only a few infrastructure changes, according to a study by Stanford University researchers.

All 139 nations profiled in the study were members of the Paris Climate Agreement as of 2015, including the United States. These nations account for 99 percent of all fossil fuel-derived carbon dioxide, according to lead researcher Mark Jacobson.

The study notes that clean energy practices required by the surveyed countries would also prevent up to 7 million deaths annually from air pollution, and create 24 million long-term, full-time jobs. It would also result in stable energy prices, because fuel would arrive for free.

It won't be an easy transition for everyone, Jacobson says. Nations with larger geographic areas and smaller populations—such as the United States and European Union countries—will have an easier time giving up fossil fuels than more densely packed ones like Singapore. Each nation's governmental views will also play a role.

"Policymakers don't usually want to commit to doing something unless there is some reasonable science that can show it is possible, and that is what we are trying to do," Jacobson says. "There are other scenarios. We are not saying that there is only one way we can do this, but having a scenario gives people direction." **GB**



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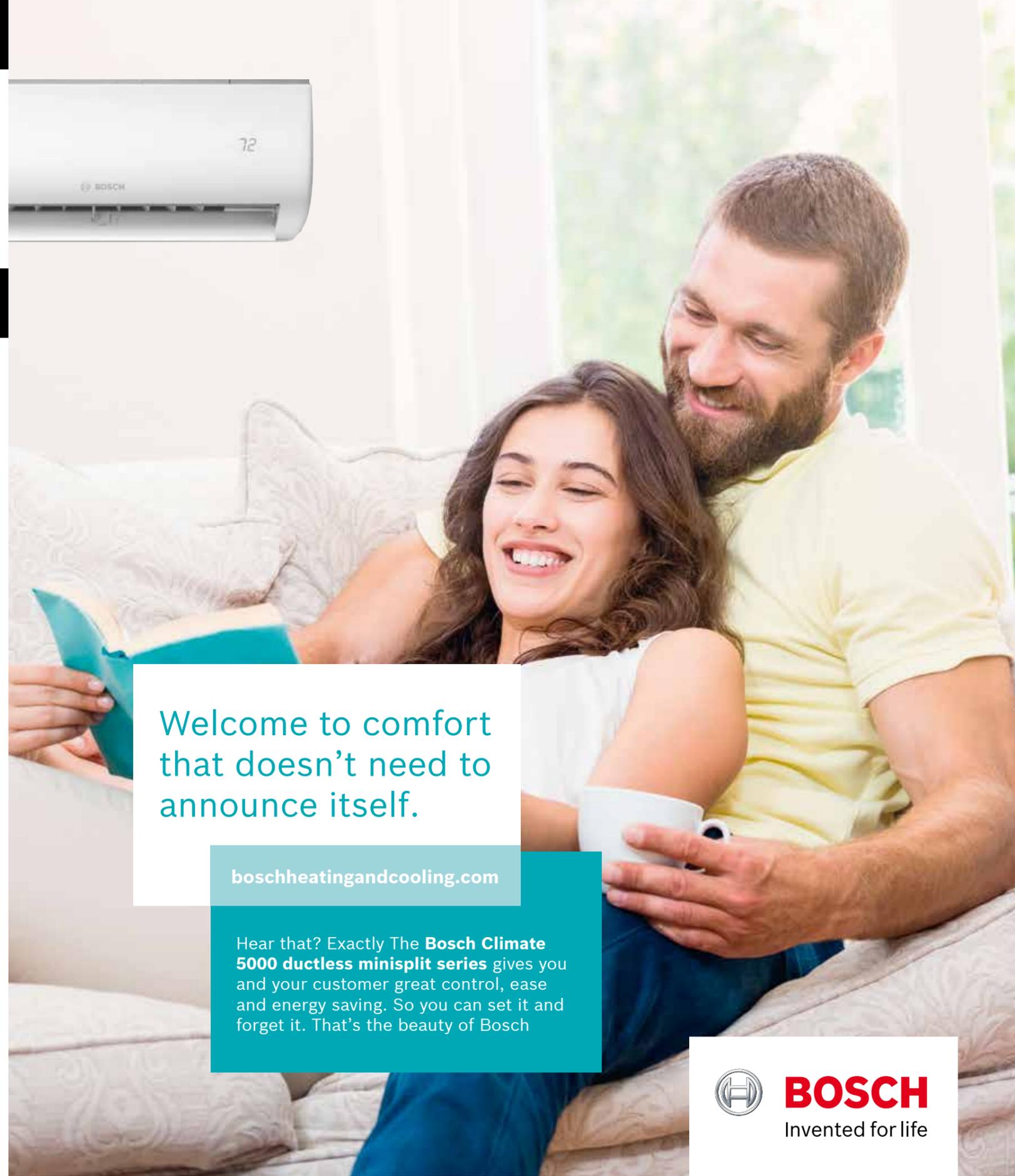
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HERE'S A SAMPLE OF WHAT'S INSIDE

“There is a perception that ‘green’ or high-performance homes are something that only the wealthy can afford. We wanted to design a house that would shatter that perception.”
(p.24)

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Normalizing Net Zero

WHAT DOES IT TAKE TO BE A TRULY GREEN HOME? For builders, it's attention to detail: what types of materials are used, how those items were made, how they are assembled or installed, and how well they perform when it comes to meeting the standards required to be considered energy efficient or environmentally friendly.

It's a scenario that the U.S. Department of Energy knows well, with its Zero Energy Ready Home (ZERH) program. ZERH participants must be certified to Energy Star Certified Homes Version 3.0 and the U.S. Environmental Protection Agency's Indoor airPLUS Program, meet the EPA WaterSense program's hot water distribution requirements and match or exceed insulation requirements of the 2012 International Energy Conservation Code. Homes must also have solar electric panels installed, or have the conduit and electrical panel space in place for it.

Many of this year's ZERH homes are DOE Innovation Award winners. Here's a look at the what we hope is the next evolution of "conventional" housing.



Simple science. Habitat for Humanity of South Sarasota County constructed a modest, energy-efficient 1,200-square-foot home tailored to moderate-income families that is attractive, durable and affordable.

Air and Space

Green home affordability starts within the walls of this H for H award winner.

BY GREEN BUILDER STAFF/DOE

LOW-INCOME AMERICANS FACE a disproportionate energy burden, spending 17 percent to 50 percent of their incomes on heating and cooling bills, while other U.S. households spend an average of just 4 percent of their income on energy. “These families are the ones who would benefit the most from home energy upgrades but they are the least able to afford them,” says Michael Sollitto, Habitat for Humanity South Sarasota County’s director of construction. This is one of the primary reasons that the Venice, Fla.-based Habitat affiliate is now constructing all of its homes to the high energy efficiency and durability levels of the U.S. Department of Energy’s Zero Energy Ready Home (ZERH) program. The Habitat for Humanity affiliate has constructed 21 DOE Zero Energy Ready-labeled homes to date, including one, the Saragossa Innovation Home in Venice, which won a 2016 DOE Housing Innovation Award. “In the beginning, I thought it would be hard to comply with the requirements,” Sollitto says. “Now it’s just second nature to do what needs to be done to comply.”

SMALL STATURE, BIG GREEN STATUS

The simple, one-level, three-bedroom, two-bath, 1,200-square-foot

homes are true to Habitat’s mission to provide safe, decent and affordable homes to those in need. But they go even further by providing homeowners with low energy bills for the long term. The award-winning home is expected to cost its owners about \$838 annually in energy bills, or roughly \$70 per month.

“Our affiliate has totally embraced the concept of building homes better than code and employing energy-efficient and green building techniques,” Sollitto says. Among them: The home has an uninsulated slab-on-grade foundation with proper grading of the site to allow for drainage away from the structure. The concrete slab is raised 8 inches above grade per local code requirements, while gutters, downspouts and rain barrels keep rainwater from pooling around the foundation.

WALL OF WONDER

The Habitat affiliate chose a common Central Florida construction type: concrete masonry block walls. To increase the insulation value of the walls, the hollow cores are filled with a two-part foam product that hardens as it dries to provide insulation and sound proofing.

On the interior side of the walls, the affiliate installs a 0.75-inch layer of rigid expanded polystyrene (EPS) foam board. On the inside-facing side of the foam board, they install 0.75-inch furring strips. This provides an air space between the concrete block walls and the foil-faced insulation. This is a rolled-sheet vapor retarder product combining layers of perforated foil and kraft paper that is nailed



CREDIT: HABITAT FOR HUMANITY SOUTH SARASOTA COUNTY

Bug proof. All Habitat for Humanity South Sarasota County homes are built with borate-treated wood framing to discourage termites and other pests from compromising the building structure.

directly to the furring strips with the paper side facing the drywall, which is installed next. The wall has a total insulation R-value of 17.5. The walls’ exterior surface is covered with stucco.

The roof framing and trusses are made of borate-treated lumber for protection against termites. The soffit is also treated for termite and mold resistance. A self-adhering underlayment covers the entire plywood roof deck. The roof is topped with Energy Star-rated reflective shingles in a light gray color to reduce solar heat gain in the attic. The attic is unvented, sealed and conditioned to provide a protected space for the home’s HVAC equipment and ducts. A 5.5-inch-thick layer of open-cell polyurethane spray foam coats the underside of the roof deck, providing an R-20 insulated, cool, conditioned attic space.

The affiliate installs locally made double-paned single-hung impact-rated windows with thermally insulated vinyl frames. The windows have a low-emissivity coating to reduce heat transfer and are Energy Star rated with an insulation U-factor of 0.33 and a solar heat gain coefficient of 0.19.

“There are two major factors that need to be addressed when building a home in our part of the country—high winds and moisture,” Sollitto says. In the latter case, the affiliate employs moisture-resistant practices including slab-on-grade construction with a raised slab, concrete block walls, borate-treated trusses and framing, a secondary

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**BUILDING
SCIENCE**

water barrier on the roof, and sealed exterior soffits to prevent moisture, dust and insects from entering the home.

In addition, the structures are built to withstand winds up to 130 mph, with concrete block walls and metal tie downs that provide a continuous connection from the footers to the truss straps. The closed-cell spray foam insulation that covers the underside of the roof decking also has a gluing effect, helping to hold the roof pieces together. A special nailing pattern is used on the roof sheathing and shingles with an increased number of fasteners. Impact-resistant windows and doors are installed. The walls are clad with fire-resistant stucco and fiber cement.

The sealed soffits help to keep out sparks as well as wind-driven rain. Studs and trusses are treated with borate for termite resistance. Inside the home, the rigid foam and tile flooring provide more moisture resistance

than fibrous insulation and carpet or wood floor coverings. “Our homes meet the Habitat for Humanity ‘Habitat Strong’ program requirements for durability,” Sollitto says.

DRY AIR IS GOOD AIR

Comprehensive air sealing helps to keep humidity, pollen and dust out of the home. Like all DOE Zero Energy Ready-certified homes,



CREDIT: HABITAT FOR HUMANITY SOUTH SARASOTA COUNTY

Tough stuff. To increase the insulation value of the walls, hollow cores are filled with a thick layer of rigid expanded polystyrene foam board. In addition, comprehensive air sealing helps keep humidity, pollen and dust out of the home.



Mass effect. Traditional concrete masonry block walls and a stucco exterior moderate the home temperature fluctuations.

the home was tested for air tightness and showed an air leakage rate of 2.8 air changes per hour at 50 Pascals (meeting the air tightness limits required by the 2015 International Energy Conservation Code of 3 ACH 50 for homes in climate zones 1 and 2).

To remove moisture produced in the home (for example, from showering and cooking), the home is equipped with a run-time ventilation system that uses electronic controllers to operate the bathroom exhaust fans in coordination with the home's central HVAC fan. A fresh air intake brings in outside air through a dampered duct and filter. The controller is set for an hourly run time and will turn the air handler fan on for several minutes every hour to cycle fresh air through the home even if the thermostat does not call for heating and cooling.

The bath fans and range hood fan vent outside. The garage is also equipped with an exhaust fan with an occupancy sensor to pull car exhaust and other pollutants out of the garage.

The home is outfitted with a high-efficiency 1.2-ton ducted, mini-split air source heat pump with a cooling efficiency of SEER 15. The heat pump and ducts are located in the conditioned attic.

Sarasota Habitat homes are all built to the Florida Water Star guidelines, which are similar to the WaterSense program and require 1.28-gallon-per-flush toilets, low-flow shower heads and faucets. Hot water is provided by a 50-gallon air-source heat-pump hot water heater with a 3.25 energy factor. The refrigerator and dishwasher are Energy Star labeled. Irrigation is not installed and



Happy homeowners. The South Sarasota Habitat for Humanity affiliate has constructed nearly two dozen DOE Zero Energy Ready-labeled homes thus far, an effort construction director Michael Sollitto says has "taken us to a new level of efficiency, quality and commitment to our families."



Team effort. All volunteers and staff go through intensive training on the safety, techniques and products used in the homes.

To help its homeowners get the most benefit from these high-performance homes, the South Sarasota Habitat offers intensive training sessions for new homeowners. The training includes information on operation and maintenance of the systems in their homes.

Sollitto says the DOE (ZERH) program has "taken us to a new level of efficiency, quality and commitment to our families." Habitat's affiliate has totally embraced the concept of building homes better than code and employing energy-efficient and green building techniques in them, he adds.

"Our homes now offer a high-performance, affordable option for low-income families who are seeking an alternative to poorly constructed homes with high rent and outrageous energy bills," Sollitto says. "We

want to ensure that our families have a safe, decent and affordable place to live for many years to come." **GB**

the home is landscaped with plants and drought-resistant turf rated as "Florida-Friendly" by the University of Florida Institute of Food and Agricultural Sciences Extension. All of the home's lighting is energy efficient. About half of the fixtures are ultra-efficient LED-based lights, while the other half of the fixtures use compact fluorescent light sources. The home has five Energy Star-rated ceiling fans that are equipped with compact florescent lamps (CFLs), which save energy and don't heat up like older bulbs. The cooling effect of the fans' air flow allows homeowners to set the thermostat higher for additional energy savings.

WEEKLY CHECKUPS

To ensure quality construction, Habitat for Humanity projects are implemented with Team Leaders and Crew Leaders that manage the jobsites. "Each week we meet to discuss the progress of the jobs, the schedule and materials, and any difficulties or issues that need to be resolved," Sollitto says. "Each member of our team has totally embraced our goal to build affordable, durable, sustainable and efficient homes within our limited budget."

He add that quality control comes from the commitment of Habitat for Humanity's volunteers and staff to provide the best built home within the project's budget. "Our volunteers and staff go through intensive training on the safety, techniques and products that are used in our homes," Sollitto notes. "From the first shovel of dirt to the last stroke of a brush, we are committed to providing our first-time homebuyers a truly once-in-a-lifetime experience!"

All of these measures helped the home achieve a Home Energy Rating System (HERS) score of 51. A typical new homes built to code would score about 80 to 100. No solar panels are included as part of the construction, but each home built by the Habitat affiliate is equipped to be "solar ready," with conduit and electrical panel space installed for future solar panel installation as required by the DOE (ZERH) program.

want to ensure that our families have a safe, decent and affordable place to live for many years to come." **GB**

Saragossa Innovation Home

KEY FEATURES

- DOE ZERO ENERGY READY HOME PATH:** Performance
- WALLS:** R-17.5 total wall R: concrete block filled with foam; on interior: 0.75-inch EPS, 0.75-inch furring strips, perforated foil insulation sheet, 0.5-inch gypsum board
- ROOF:** 0.625-inch sheathing, fiberglass-reinforced asphalt self-adhering underlayment, Energy Star light asphalt shingles
- ATTIC:** Unvented, insulated under roof deck with 5.5-inch R-20 polyurethane spray foam; borate-treated trusses
- FOUNDATION:** Uninsulated raised slab on grade
- WINDOWS:** Vinyl-framed, impact-rated double-paned, low-e, U=0.33, SHGC=0.19
- AIR SEALING:** 2.8 ACH 50
- VENTILATION:** Timer-controlled fresh air intake tied to bath fan
- HVAC:** Ducted mini-split heat pump in conditioned attic, 15.5 SEER
- HOT WATER:** 50-gallon heat pump water heater, 3.25 energy factor
- LIGHTING:** 50 percent LED, 50 percent CFL, Energy Star ceiling fans
- APPLIANCES:** Energy Star refrigerator, dishwasher
- SOLAR:** N/A
- WATER CONSERVATION FEATURES:** Florida Water Star compliant; low-flow fixtures
- ENERGY MANAGEMENT SYSTEM:** N/A
- OTHER:** No-VOC paint, drought-resistant plants



Don't be square. A simple rectangular shape is key to Greenfill's space-conserving but extremely roomy 4,600-square-foot design, which includes two stories above ground and a full finished basement.

Rapid Payback

For this cost-competitive green home, it's the little things that make it an airtight bargain.

BY GREEN BUILDER STAFF/DOE

ATENTION TO DETAIL has helped BrightLeaf Homes turn standard building materials and a straightforward design into an extremely high-performing home at a remarkably competitive price.

The LaGrange, Ill., home is BrightLeaf's second straight Housing Innovation Award winner from the U.S. Department of Energy. The DOE Zero Energy Ready-certified house earned a Home Energy Rating System (HERS) score of 36. A typical new home built to code would score a HERS 80 to 100.

They're cost effective, too. BrightLeaf's high-performance homes cost about \$280 per square foot (not counting land), while older homes around Chicago cost about \$270 per square foot. When electricity production from the 2.8-kW roof-mounted solar photovoltaic system is included in the analysis, the HERS score drops to 26, even closer to the coveted net zero score. For homeowners, this translates into calculated monthly energy bills of \$110 per month and energy cost savings of \$2,900 per year compared to a typical new home in Illinois.

It's a clear process and logical approach to building, according to Scott Sanders, a partner at BrightLeaf Homes. "We're building homes this way because we believe it is the right thing to do," he says.

A WINNING RECIPE

To achieve exceptional performance, BrightLeaf followed the same DOE Zero Energy Ready Home (ZERH) recipe it has followed on five previous certified homes (see box on ZERH requirements).

BrightLeaf packed five bedrooms, three-and-a-half bathrooms and 4,608 square feet of living space into a 1,536-square-foot footprint on a 55-by-130-foot lot, thanks to a simple rectangular shape that includes two stories above ground plus a full finished basement.

The company used a wood-framed wall with 2-by-6 top and bottom plates, with 2-by-4 studs installed every 12 inches but staggered so that alternating studs align with the inside or outside edge of the plates. This allows the dense-packed cellulose insulation to fill the spaces between the studs as well as wrapping around the edges of the studs to stop thermal bridging through the wall, to provide an effective R value of R-25. The interior is surfaced with 0.625-inch drywall that is made airtight by applying sealant at the top and

bottom plates and around all openings.

The exterior is covered with 0.5-inch engineered sheathing with a plastic coating on the exterior side. The sheathing was not taped at the seams, but it was covered with a house wrap that was very carefully air sealed at the edges and seams to provide a continuous weather-resistant barrier under the fiber cement lapped siding.

The company tested several rain screen options before deciding on the coated, untaped sheathing and sealed house wrap. "We concluded that we can achieve remarkable levels of airtightness at a fraction of the cost with common house wrap and careful attention to detail," Sanders says. "This is an assembly that almost every contractor could build, but very few can or will do it with the attention to detail that we have."



Solid state. The home's exterior is covered with 0.5-inch engineered sheathing with a plastic coating on the exterior side. Similar sheathing on the roof offers an ideal backing for photovoltaic panels.

SEALING THE DEAL

Window and door openings and utility penetrations were carefully and properly flashed, primarily using a butyl tape sealant for the top and sides and a flexible waterproof fabric flashing for the sills. All openings were oversized by 0.5 inches and a piece of cedar bevel siding was placed on the bottom sill under the flashing to create a positive slope away from the interior of the house.

The simple gable roof has an untaped 0.5-inch coated sheathing, 30-pound roofing felt, ice-and-water shield at the eaves, Energy Star-certified shingles, raised-heel trusses, 24-inch overhangs, and ridge and soffit vents. To make room on the south-facing roof for PV, there are only six roof penetrations (a plumbing stack, a radon vent, two exhaust fan vents and two solar tubes), all on the north side.

The second-story drywall ceiling serves as the primary air barrier in the vented attic. Before installing the 16 inches of R-60 blown



A wall for weather. House wrap is carefully taped and sealed at the edges to provide a continuous weather-resistant barrier under the fiber cement lapped siding.

cellulose attic insulation, BrightLeaf sealed the drywall to the top plates, spray foamed the interior drywall-to-top plate seams, taped and foamed any ceiling fixture electric boxes, and avoided holes by installing lights and smoke detectors on walls instead of ceilings wherever possible.

A STRONG FOUNDATION

The house has a full basement with 8-inch-thick poured concrete foundation walls. The basement was positioned with 4 feet below ground and 4 feet above ground to allow for significant amounts of daylight through the 36-inch-tall basement windows. A strip of 10-mil polyethylene sheeting provides an inexpensive vapor barrier between the keyed concrete footing and the foundation wall to prevent moisture transfer from the footing up into the foundation wall.

The foundation walls are fully insulated on the exterior, with 3 inches of rigid extruded polystyrene (XPS) insulation installed in two 1.5-inch-thick layers. The panels have staggered seams for extra protection against water infiltration to the foundation wall. Before pouring the 4-inch-thick concrete basement slab, the builder laid down a base of crushed gravel to promote drainage, then topped this with a 2-inch-thick layer of rigid XPS insulation, which extends out over the tops of the footing and has taped seams.

On top of the foam insulation is a single continuous sheet of 10-mil polyethylene vapor barrier. Sanders notes that the Chicago area has a variable climate with temperatures that can get extremely hot and extremely cold. By completely insulating the basement along the exterior, the basement can be thermally connected to the interior of



CREDIT: BRIGHTLEAF HOMES

Best face forward. Careful siting of the home optimizes solar gain, and overhangs reduce excess heat in warm months.

the home and the thermal mass of the concrete floor and walls can act as a large, thermal heat sink, helping to balance daily swings in outdoor temperature from day to night.

THREE LAYERS OF GLASS

BrightLeaf found affordable triple-pane low-air-infiltration, highly insulated windows made by a European company in Bristol, Pa. The windows have foam-insulated vinyl frames, an argon gas fill, and a low-emissivity coating to minimize heat transfer, providing a U-factor of 0.22 for the double-hung units and 0.18 for the fixed-pane styles.

Window sizes are standardized as much as possible, with most fitting exactly into rough openings framed to 3-by-5 feet or 2-by-3 feet. "This allows our carpenters to frame more quickly and minimizes mistakes for rough opening sizes, since they are whole numbers and not something like '35-3/16 inches,'" Sanders says. The home was designed with the bedrooms and living spaces along the south side of the house, where most of the windows are for beneficial day light and solar heat gain, he adds.

To provide balanced whole-house ventilation to the tight home, BrightLeaf employs a cost-effective strategy using an electronically controlled, dampered fresh air intake interlocked with a high-performance exhaust fan on the second floor.

The air-cycler controller is integrated with the variable-speed



CREDIT: BRIGHTLEAF HOMES

Rain guard. Plastic drain mats protect basement walls from water infiltration.



CREDIT: BRIGHTLEAF HOMES

Work in progress. Within a few weeks, carefully planned walls, windows, ventilation and flooring will help give this home a HERs score of 36.

furnace motor to provide fresh air as needed based on the occupant load, total conditioned space, and run time of the HVAC system. When the controller opens the fresh air damper, outside air is pulled into the return side of the plenum and the multi-speed exhaust fan on the second floor is automatically turned on. The fresh air damper is also tied into the 400-CFM range hood so that when the range hood turns on, the damper is automatically opened to allow pressure relief.

Bathroom spot ventilation is provided in each of the three full bathrooms, with exhaust fans connected to 6-inch exhaust ducts going directly out the roof or an exterior wall. The ventilation is

“We’re building homes this way because we feel it’s the right thing to do.”

—Scott Sanders

controlled manually by a standard switch but is set to continue for 6 minutes after the switch in the room is turned off.

The HVAC system is a conventional, sealed-combustion, 96 percent AFUE gas furnace paired with a 14 SEER air conditioning condenser and coil. The furnace is rated at 60,000 BTU. The dual-stage gas valve and variable-speed ECM motor allow the furnace to run at partial capacity to minimize short cycling.

All ductwork is un-insulated and located completely within the conditioned envelope through the use of open-web floor trusses. Even though there would be no leakage to the outside, all joints were completely sealed with both mastic on the exterior and a spray sealant on the interior of the ducts after the return plenum was installed.

MAKING A TRADE

BrightLeaf Homes firmly believes in the motto, “Proper planning prevents poor performance.” According to Sanders, the company

Eco 3 Greenfill

KEY FEATURES

DOE ZERO ENERGY READY HOME PATH: Performance

WALLS: Staggered 2-by-4s 12-inch o.c. on 2-by-6 plates, 2-stud corners, ladder blocking at wall intersections, right-sized insulated headers, window and door framing aligned with 12-inch o.c. wall studs, R-25 dense-packed cellulose, 0.5-inch coated OSB sheathing, air-sealed house wrap, fiber cement. Window and door openings get flexible flashing and beveled sills

ROOF: Coated OSB sheathing, 13-inch raised heel trusses, 24-inch overhangs, 30-pound felt, ice-and-water shield at eaves. Energy Star light asphalt shingles

ATTIC: Vented: all top plates foamed, 16-inch R-60 blown cellulose, few penetrations

FOUNDATION: Basement only 4 feet deep for daylight, insulated on exterior with 3-inch rigid XPS, 2-inch XPS beneath slab, drain mat over exterior insulation.

WINDOWS: Vinyl-frame triple-pane, low-e, U=0.22-0.18, SHGC=0.24

AIR SEALING: 0.98 ACH 50

VENTILATION: Air-cycler-controlled fresh air intake balanced to timered exhaust fans

HVAC: 96 percent AFUE gas furnace, 14 SEER AC. Ducts un-insulated, in conditioned space

HOT WATER: Tankless gas EF 97

LIGHTING: 95 percent LED

APPLIANCES: Energy Star dishwasher, clothes washer

RENEWABLES: 2.8-kW PV

WATER CONSERVATION: 100 percent WaterSense fixtures

ENERGY MANAGEMENT SYSTEM: None

OTHER: No-/low-VOC primer, paint, cabinets, flooring. Pre-wired for electric car charger

starts each home with a complete set of architectural plans “that is continuously improved with every iteration of the homes we build,” and fully detailed project and phase-specific specifications.

Preconstruction and on-site meetings are held with trade partners whose work overlaps with each other. The site supervisor is required to be on site for the first day of work for each major trade to review details, changes and those “things that BrightLeaf does that they probably didn’t do on the last job they worked on for another builder,” Sanders says.

Trade partners are required to complete jobsite readiness checklists that confirm their phase of work is completely done, and that the site is 100 percent ready for the next trade partner. “Our site supervisor does occasional double-checks on these completed checklists to verify that no upcoming trade partner is delayed or has to come back another day because the prior trade didn’t finish his job,” Sanders says. “Most of our trade partners and crews have worked on our homes before and, since all of our homes are built to the Energy Star and DOE ZERH specifications, they are familiar with the specific ‘quirks’ and attention to detail that we require.” **GB**

Power Surplus

This net-zero-plus design can spare some solar for the electric car.

BY GREEN BUILDER STAFF/DOE

FOCUSING ON TOTAL COST of ownership helped builder David Jones earn his first-ever Housing Innovation Award from the U.S. Department of Energy for a home he constructed in Litchfield, Conn. The 1,380-square-foot home—the Perkins Road House—was Jones’ first to be certified to the DOE Zero Energy Ready Home (ZERH) program. And it was the first home that could be classified as “affordable” for the

west Connecticut custom home builder whose company, Revival Homes, has built a solid reputation over 30 years of constructing high-efficiency luxury custom and antique reproduction homes.

“There is a perception that ‘green’ or high-performance homes are something that only the wealthy can afford,” Jones says. “We wanted to design a house that would shatter that perception, both when considering the initial cost of construction and even more importantly when considering the total cost of ownership, which we defined as initial construction costs plus energy costs plus maintenance costs.”



Bargain shopping. Revival Homes’ builder David Jones wanted to change the perception of green homes being only for the affluent by building the Perkins Road House, one that was affordable for the average resident.



Hard to hole. The home’s first-floor walls are made of precast structural concrete wall panels, consisting of R-12.5 of rigid XPS foam—adhered to a 2.5-inch layer of concrete.

Revival Homes chose to build the house to the criteria of the DOE Zero Energy Ready Home program (see box on ZERH requirements).

Jones joined forces with architect Kate Briggs Johnson of Responsive Designs and the DOE Building America research team led by Steven Winter Associates to come up with an affordable high-efficiency design for the Connecticut climate that met the DOE program requirements. Homeowners were enthusiastic about the approach, as the builders’ primary design goal was to minimize the total cost of ownership.

Jones and his team were so successful with the home’s compact design and highly efficient shell that, with the addition of a 7.6-kW solar photovoltaic system, the home achieved a Home Energy Rating System (HERS) score of -12. In other words, the home will produce more power than it uses in a year. The homeowners should have \$0 electric utility bills and should also have enough surplus to power an electric car.

Even without PV, the home would achieve a HERS score of 41, well below the 80 to 100 typical of new code-built construction. Jones achieved all of this at a cost of about \$135 per square foot, including the PV.

BEYOND THE BOX

The resulting design was a two-story, Cape Cod-style three-bedroom, two-bath home with a simple floorplan and a small footprint. The home’s concrete slab floor was poured and finished before any interior walls were added. The house is only 26 feet at its widest point, allowing the second-floor joists to be clear-spanning, open-web trusses that don’t require interior supports. These two features allow interior walls to be moved easily in the future if uses for the rooms change over time.

Spare conduits were also installed to accommodate electrical and

plumbing for a solar thermal water heating system if one is desired in the future. Jones notes this adaptability is important for a home he expects to last several hundred years.

To achieve the very efficient building enclosure at a low cost, Jones asked his design team to “think outside the box.”

For the first-floor walls, they chose precast structural concrete wall panels, which are usually used for basement walls. The panels are factory-made, with an R-12.5 layer of rigid XPS foam insulation adhered to the 2.5-inch-thick layer of concrete and EPS foam wrapping the concrete studs, which are set at 20 inches on center and faced with a steel surface to nail drywall to. The wall cavities are filled with R-23 mineral wool batts, then covered with 0.625-inch fire-code drywall and plaster. The unfaced mineral wool batt is fire-, moisture- and pest-resistant and dense

enough to be cut with a saw for a precise fit with RESNET Grade 1 installation quality. All of these components together provide thermal mass walls with an insulation value of R-35.5.

The second floor has walls on the gable ends only. These walls are made with structural insulated panels (SIPs), which consist of two sheets of OSB sandwiching a layer of expanded polystyrene (EPS) rigid foam. The SIPs used on these walls were 10.5 inches thick, providing an R-39 insulation value. A 0.625-inch fire-code drywall was installed over the SIPs and covered with 0.125-inch natural



Slab palette. Perkins Road’s concrete slab floor, poured and finished before any interior walls were added, and clear-spanning joists on the second floor allow easy relocation of interior walls in the future.

plaster to serve as the inside wall surface while providing additional thermal mass. On the exterior, a dimpled house wrap product covers the SIPs, providing a rainscreen and weather-resistant barrier behind the vinyl shingle siding.

The roof is also made of 12.25-inch-thick SIPs that provide R-45 of insulation. The relatively narrow roof needed no ridge beam or rafters; the SIPs themselves provide all of the structural support, simplifying air sealing and reducing labor and material costs. The entire roof is covered with self-adhered membrane, which provides air sealing as well as a leak barrier should the 130-mph-rated shingles ever blow off in a storm.

Jones used large SIP panels (8 feet by 22 feet), which enabled quicker assembly with fewer seams to seal. All SIP joints were sealed with a two-part spray foam injected under pressure to fill the entire joint. Seams were also sealed on the interior side of the house with a very tenacious air sealing tape.

These air sealing measures plus the solid panel construction reduced air leakage in the home to 0.76 air changes per hour at 50 Pascals pressure difference, well below the 3 ACH 50 required by the 2015 International Energy Conservation Code.

One of the most unusual features of the home is its foundation,



Double duty. A ductless mini-split pump with one inside air handler provides all of the home's heating and cooling.

CREDIT: REVIVAL HOMES

or lack thereof. The concrete first-floor wall panels sit at grade on crushed stone. Before pouring the floor slab, the builder graded the site level, dug 32-inch-deep trenches for the building's perimeter, filled them with crushed stone and continued with 10 inches of crushed stone extending across the entire house site. The concrete walls were then set in place over the trenches.

Then, three layers of 1-inch rigid XPS were set down within the perimeter of the walls with seams staggered and taped. The builder then stacked 8 inches (R-40) of EPS rigid foam inside the base of the

The primary goals were to minimize the total cost of ownership and to encourage others to follow a similar path.

wall cavities to insulate the edges of the 5-inch concrete floor slab. Before pouring the slab, he laid down a thick polyethylene vapor barrier, then loops of PEX tubing that could be used for in-floor radiant heat at some future point. But at this point, they are being used to pre-warm well water, as much as 10 to 15 degrees according to Jones, before it reaches the hot water tank. The concrete slab was sealed and stained to provide the finished flooring for the first floor of the home.

NATURAL CIRCULATION

A mini-split heat pump provides heating and cooling. Although the heat pump has only one air handler, located on the first floor, Jones monitored room temperatures over the winter and found



Tight space. The home's narrow roof allows easy install of insulation and sealing agents to prevent moisture and retain temperature-correct air.

CREDIT: REVIVAL HOMES

temperatures varied less than 4 degrees from the warmest room to the coldest. The home's passive solar orientation with large south-facing windows contributes to beneficial passive solar heat gain, while the home's significant thermal mass and extensive insulation provide a buffer against temperature swings during the day and even over several days. The heating system was turned off for several weeks during the winter and Jones found the house never dropped below 50 degrees Fahrenheit.

The home's heat pump hot water heater is located next to the bathrooms and laundry, which helps reduce wait times at the tap. The kitchen sink is equipped with an on-demand electric hot water heater; this provides nearly instant hot water at the kitchen sink, where hot water is often used in short intervals, without the complications and energy requirements of a recirculation system.

INTEGRAL DURABILITY

At the homeowners' request, Jones added aging-in-place features like a first-floor laundry, master bedroom and full bath with a curbless shower. The first floor is only 6 inches above grade, so it is wheelchair accessible with a low ramp.

Jones felt he was also successful in meeting the clients' primary goals: to minimize the total cost of ownership (energy cost plus maintenance cost plus construction cost) and to encourage others to follow a similar path. "When total cost of ownership is considered, this house is incredibly inexpensive," he says.

Simple finishes, factory-built components, minimal mechanical equipment, and a small footprint helped Jones achieve the low construction costs of \$135 per square foot (including the solar PV system, but excluding the site, well and septic).

Perkins Road House

KEY FEATURES

DOE ZERO ENERGY READY HOME PATH: Performance

WALLS: First floor R-35.5; precast concrete wall panels with continuous R-12.5 rigid foam plus steel stud interior wall 24-inch o.c. with R-23 mineral wool cavity insulation. Second floor R-10.5 structural insulated panels (SIPs), draining house wrap, vinyl shingle siding

ROOF: Full self-adhered membrane, architectural shingles

ATTIC: R-45 12.25-inch SIPs

FOUNDATION: Concrete slab has 8-inch R-40 rigid foam at perimeter and R-15 rigid foam under the floor, pre-cast concrete wall panels sit at grade on 3-foot-wide trenches filled with crushed stone and drained to daylight

WINDOWS: Triple-pane, vinyl-framed, argon-filled, low-E windows; south facing U=0.18, SHGC=0.39, others U=0.17, SHGC=0.2

AIR SEALING: 0.76 ACH 50

VENTILATION: Continuous exhaust fans, auto-open skylights

HVAC: 18,000-BTU ductless SEER 21, HSPF 12 air source mini-split heat pump with single inside air handler

HOT WATER: Heat pump hot water heater, electric on-demand water heater at kitchen sink

LIGHTING: 100 percent LED. Exterior lights on motion and daylight sensors

APPLIANCES: Heat pump clothes dryer, Energy Star refrigerator, dishwasher, bath fans

SOLAR: 7.6-kW PV

WATER CONSERVATION: EPA WaterSense-certified fixtures

ENERGY MANAGEMENT SYSTEM: Programmable thermostat. Programmable skylights

OTHER: Electric car charging station, passive solar water preheating through concrete slab. No-VOC interior paints and finishes. Passive heating and cooling with thermal mass concrete walls and slab and 0.75-inch drywall. All construction debris recycled. Disaster-resistant concrete and SIP construction

"It has zero energy costs and it has extremely low anticipated maintenance costs (over the next 30 years) compared to typical homes and especially most high-performance homes," Jones says. "The ductless mini-split system is far simpler than many heating and cooling systems; it is less likely to fail. But if it were to fail, it is easier and less costly to replace than other systems."

The use of concrete offers even more energy efficiency benefits, Jones adds. The concrete walls can't burn, rot or support mold, and they never need painting. They will withstand bumps from lawn mowers and storm damage far better than stick-built homes covered in traditional siding. All exterior trim is PVC, which won't rot. The concrete floor never needs replacement. The PEX plumbing tubes won't corrode and are unlikely to freeze in the winter. And, home temperature is consistent: Jones notes that the house goes for weeks without the heat on in winter and does not drop below 50 degrees Fahrenheit. **GB**



Foot warmers. A polyethylene vapor barrier and loops of PEX tubing are being used to pre-warm well water by as much as 10 to 15 degrees before it reaches the hot water tank.

CREDIT: REVIVAL HOMES



Triple threat. Trailside Community in Greenville, S.C., is Addison Homes' third project to receive a Department of Energy Housing Innovation Award.

First-Class Performance

Insulation and sealants push this conventional-looking home beyond net zero.

BY GREEN BUILDER STAFF/DOE

MINIMIZING ENVIRONMENTAL IMPACT while maximizing homeowner value" is one way Addison Homes sums up its construction philosophy. That attitude underscores construction practices at the builder's Trailside Community in Greenville, S.C., where this home won a 2016 Housing Innovation Award from the U.S. Department of Energy.

The Emery Greenville home also earned a DOE Zero Energy Ready Home (ZERH) program label (see box with ZERH requirements).

Addison Homes went beyond these requirements to meet the

optional certifications of EPA WaterSense for all of the home's plumbing and irrigation and DOE's ZEHQ Quality Management Guidelines, as well as certification to Energy Star Version 3.1. Addison also installed solar photovoltaic shingles that generate more energy than the home uses annually. The home has also achieved an Active House certification (an international label focused on comfort, daylighting, air quality, energy efficiency and low impact on the environment).

HIGH PERFORMANCE, HEAVY INTEREST

The Trailside Community home was one of 16 to be built by Addison Homes, adjacent to the Greenville Health System Swamp Rabbit Trail, a popular walking and biking "rails to trails" project. While

the location is drawing visitors, the high-performance features of these homes are getting buyers.

Addison Homes constructed the 4,551-square-foot home as a one-floor plus walk-out basement home with wood-framed walls consisting of 2-by-4s set 16 inches on center with insulated headers and two-stud (rather than three- or four-stud) corners.

A variety of insulation and sealants wrap the home in a blanket of efficiency. The wall cavities were filled with R-13 unfaced fiberglass batt insulation and sheathed with OSB, then covered with 1-inch-thick (R-5) sheets of rigid foam insulation, providing a continuous thermal break to stop heat from transferring through the walls at the studs, resulting in a wall with a total insulation value of R-18.

All seams in the rigid foam were taped so the rigid foam can serve as an air barrier and drainage plane behind the vinyl siding. Flashing tape seals the seams around windows and doors to keep out moisture and air.

The vented attic was insulated with R-38 blown fiberglass. All



Laying it on. When it comes to insulation, there's no such thing as too thick within the Emery Greenville home.

penetrations and top plates were sealed. Skylight shafts were insulated on the attic side with R-10 rigid foam and R-19 unfaced fiberglass batts. The roof decking was covered with synthetic felt. Extra care was taken to prevent leaks with drip-edge flashing, vent gaskets on all vents, butyl tape at all penetrations, and ice-and-water shield in valleys and low roofs under the asphalt and PV shingles. Kick-out flashing helps to protect side walls from water entry.

The daylight basement was constructed of precast concrete walls insulated along the exterior with continuous rigid foam insulation resulting in an R-value of R-16. R-5 rigid foam was installed under the slab at the perimeter. The daylight wall of the basement has R-5 rigid foam over the OSB sheathing.

The home was tested per DOE ZERH requirements and showed air leakage of only 1.4 air changes per hour at 50 Pascals. That's more than twice as tight as required by the newest energy code. (The 2015 International Energy Conservation Code requires 3 ACH 50 or less.)

To promote healthier indoor air, the home's HVAC has a fresh air intake, MERV 16 filter, and PCO (photocatalytic oxidation) air purifier. Addison also implemented all of the requirements of the EPA Indoor airPLUS program including using low-VOC paints and finishes; no-added-formaldehyde insulation; GREENGUARD-certified hardwood flooring, carpet, and carpet pad; non-toxic termite treatment; and good moisture management details.

BRING THE HEAT

The home is equipped with a highly efficient central heat pump with a cooling efficiency of 20.5 SEER and a heating efficiency of 10.2 HSPF. The system maintains precise temperature and humidity throughout



Opening up. The vented attic was ultimately insulated with R-38 blown fiberglass. Skylight shafts were insulated on the attic side with R-10 rigid foam and R-19 unfaced fiberglass batts.



CREDIT: ADDISON HOMES

Locked in. Ductwork consists of insulated and air-sealed rigid trunk and flexible branch ducts for improved performance.

the house, as its variable capacity compressor automatically adjusts up or down as necessary, using only the amount of energy needed to meet the thermostat set point. Return registers are located in every room and balancing dampers are installed on every supply run.

Ductwork consists of insulated and air-sealed rigid trunk and flexible branch ducts. All ductwork was installed in the conditioned basement and sealed per Energy Star and DOE ZERH requirements for improved performance.

All of the home's windows are double pane with low-emissivity coatings that reduce heat transfer. These windows, together with sun tunnels and solar venting skylights, provide daylight to nearly every room in the house. Nearly all of the home's light fixtures are equipped with LED lighting.

An Energy Star-labeled tankless condensing gas water heater with a 0.95 energy factor provides efficient water heating with low NOx emissions. The home is piped with an insulated hot water recirculation loop that distributes hot water close to each hot water fixture in the home. The water heater includes a smart logic controller that "learns" the occupants' hot water usage patterns and circulates hot water through the insulated loop during times when the residents are most likely to use it. This eliminates the wait time for hot water at the fixtures while reducing the amount of cold water wasted. The home also has low-flow faucets and 1.28-gallon-per-flush toilets. Outside, the WaterSense irrigation system uses a weather station installed on the home's exterior to control watering periods and amounts based on the local weather conditions as well as plant type and topography. The sprinkler heads are designed to provide slower, more uniform and accurate delivery of water.

DESIGNED FOR A LIFETIME

Elements of universal design were incorporated throughout the home, including wide doorways, a zero-step garage entry and a curbless shower in the master bath. Addison also implemented

The tankless water heater's smart logic controller "learns" the occupants' water usage patterns and circulates hot water when residents are most likely to use it.

good stewardship practices including installing cabinetry labeled through the Kitchen Cabinet Manufacturer's Association's (KCMA) Environmental Stewardship Program (ESP). Laminated engineered beams, I-joint floors, engineered roof trusses, and finger-jointed trim were used because these reduce the use of large-dimensional lumber.

"We leave nothing to happenstance," says Addison Homes founder Todd Usher. "When it comes to quality, we want every 'T' crossed, every 'I' dotted. Our Quality Management System puts all requirements and expectations in writing to ensure each phase of the home building process is completed according to our established standards."

In addition, trade partner general agreements define Addison's expectations for every business relationship. By clearly outlining obligations, these agreements help eliminate the errors that can result from miscommunication. Job ready and quality checklists and scopes of work encourage best practices by trade partners, not only standardizing work requirements but also outlining job specifications, minimizing resources wasted on rework, according to Usher.

Project superintendents execute the job ready checklists in advance of specific construction activities to properly prepare for the next trade partner or phase and review the quality checklists as work is completed. They approve the job for prompt payment or refer it back



CREDIT: ADDISON HOMES

Smart plumbing. Now-standard power-saving devices include an Energy Star-labeled tankless condensing gas water heater with low NOx emissions and a smart controller that learns occupants' hot water usage patterns and circulates hot water when the residents are most likely to need it.

to the vendor or trade partner for correction.

"Our strategy for addressing performance is to adhere to nationally recognized standards and best practices based on years of proven building science and ongoing research, resulting in homes that meet the rigorous energy savings, comfort, health and durability standards of the [DOE ZERH] program," Usher says.

Addison has committed to building all of its future homes to ZERH program standards. "The U.S. Department of Energy has set a standard that is truly 'best in class' and is pulling our industry towards a quality revolution," Usher says.

AN EXEMPLARY TRACK RECORD

Winning awards is nothing new for Addison Homes and its forward-thinking team. The builder has won several awards, including a 2016 Pinnacle Award from the Home Builders Association of South Carolina, the U.S. Green Building Council-South Carolina Chapter's Leadership in Green Building Award, the National Association of Home Builders' Green Advocacy Award, EarthCraft House Regional Builder of the Year, the Greenville Home Builders Association Builder of the Year, the EarthCraft House Gold Project of the Year, and the

Emery Greenville

KEY FEATURES

DOE ZERO ENERGY READY HOME PATH: Performance

WALLS: 2-by-6 24-inch o.c. advanced framed with insulated headers and 2-stud corners, R-13 unfaced fiberglass batt, OSB, 1-inch R-5 taped, R-18 total. Vinyl siding

ROOF: Asphalt and PV shingles, ice-and-water shield in valleys and low roofs; kick-out flashing, synthetic felt, drip-edge flashing, vent gaskets, tape flashing

ATTIC: R-38 blown fiberglass. All penetrations and top plates sealed. Skylight shafts have R-10 XPS foam and R-19 unfaced fiberglass batts.

FOUNDATION: Daylight basement of precast concrete walls with R-16 XPS foam, R-5 XPS under slab perimeter. Daylight wall has R-5 XPS

WINDOWS: Double-pane low-e, U=0.30, SHGC=0.26. Solar tubes, venting skylights

AIR SEALING: 1.51 ACH 50

VENTILATION: Fresh air intake with ventilation controller and MERV 16 filter, spot exhaust

HVAC: Central heat pump 20.5 SEER, 10 HSPF, ducts inside. Insulated rigid trunk and flex branch. Return registers in every room, balancing dampers on every run

HOT WATER: Tankless gas water heater, 0.95 EF, with smart controller.

LIGHTING: 95 percent LED, 5 percent CFL, skylights, sun tubes, and roof windows

APPLIANCES: Energy Star clothes washer, refrigerator, dishwasher, ceiling fans, exhaust fans

SOLAR: 7.625-kW solar shingles, grid tied

WATER CONSERVATION: Low-flow fixtures and toilets. WaterSense irrigation controller

ENERGY MANAGEMENT SYSTEM: Smart HVAC, solar PV monitoring system

OTHER: No-/low-VOC paints, adhesives; GREENGUARD-certified hardwood flooring, carpet, pad; non-toxic pest control, KCMA ESP-labeled cabinets, no added formaldehyde insulation. Laminated beams, I-joint floors, finger-jointed trim and cabinets. Universal design. The home is flooded with natural daylight through skylights, sun tubes, and roof windows.

Southern Home & Garden Bridge Award for Green Building.

Usher was the first builder in the United States to earn the National Association of Home Builders' (NAHB) Master Certified Green Professional designation. Usher has held a variety of industry credentials including EarthCraft House Technical Advisor, Energy Star home energy rater, LEED Accredited Professional, LEED for Homes Green Rater, National Green Building Program Accredited Verifier for the NAHB Research Center, Certified Aging in Place Specialist, Graduate Master Builder, and South Carolina Certified Master Builder. Usher served as president of the Home Builders Association of Greenville in 2008 and is now an NAHB National Director and South Carolina HBA Education Chairman.

This is Addison Homes' third home to receive a DOE Housing Innovation Award. **GB**

Innovation Showcase

These housing design breakthroughs could be in all new homes in a few years.

BY U.S. DEPARTMENT OF ENERGY AND ALAN NADITZ

ONE OF THE MOST IMPORTANT QUESTIONS in construction is the open-ended, “Wouldn’t it be great if...?” This is usually followed by “That will never work” or “How could somebody actually make that happen?”

But ultimately, somebody does. Think of the modern HVAC system, lead-free paint, “smart” controls and even the net-zero home. Once upon a time...

Here are four game-changing products that developers are finding a way to make happen. Keep your eye on these items:

SMART RANGE HOOD

DEVELOPERS: Newport Partners and Broan-NuTone

CURRENT STATUS: Pre-prototype phase

EXPECTED COMPLETION DATE: September 2019

Kitchens are where some of a home’s most harmful pollutants originate. Kitchen range hoods can mitigate the impact of these pollutants, but they can also be ineffective at their capture. They are often not used because of noise

or because occupants are unaware of when ventilation is needed.

With funding from the U.S. Department of Energy, Newport Partners, in partnership with Broan-NuTone—the nation’s largest manufacturer of residential range hoods—plans to develop and validate a “smart” range hood that senses pollutants and automatically operates to remove the contaminants efficiently.

The proposed smart range hood, targeted for single- and multi-family residential units, will be quiet (less than 1 sone), five times more energy efficient than today’s Energy Star models, and will capture nearly 100 percent of pollutants. Ultimately, this will improve residential indoor air quality (IAQ), extend the lives of residents, and save billions of dollars in health-related costs annually.

The goal is also to create a smart range hood that is at a target price point competitive with the intermediate market for standard kitchen range hoods. The target completion date is fall of 2019, if not sooner.

The Newport Partners/Broan-NuTone report may be found at <http://bit.ly/2wx2xXp>.



CREDIT: IBACOS/DEPARTMENT OF ENERGY

Special delivery. IBACOS is finalizing technology to simplify duct system design and eliminate many installation errors for residential air delivery systems.

‘PLUG AND PLAY’ AIR DELIVERY SYSTEM FOR LOW-LOAD HOMES

DEVELOPERS: IBACOS Inc. and Housing Innovation Alliance

CURRENT STATUS: Under peer review

Current tools and practices require trade contractors to design air delivery systems that are often complex, difficult to install and integrate into the framing and structural components of the home, and not optimized for newer space-conditioning equipment or for the comfort needs of more energy-efficient homes. This complex process can be a burden to an already-strained construction labor pool; and it has been shown to lead to comfort problems in homes, negatively impacting the homeowner, trade contractor, manufacturer of the equipment, and builder.

IBACOS Inc., in partnership with the Housing Innovation Alliance, is finalizing technology that promises to simplify duct system design and eliminate many sources of installation error for residential air delivery systems.

Energy-efficient homes have significantly lower heating and cooling load requirements to maintain comfort. IBACOS research indicated that some amount of conditioned air should be delivered directly to each zone or room in the home to maintain thermal uniformity throughout the home when a centrally located thermostat is used. To deliver this air, IBACOS tested use of small-diameter ducts coupled with a variable-capacity heat pump. This equipment provided a more effective mixing of the conditioned air in the zone than a control system using traditionally sized ducts. But, the duct system still required careful design and installation using conventional methods—a practice that is not uniform among installers.

A manufacturer that embraces this “plug and play” technology could earn a significant share of the \$1.2 billion residential ductwork market. The technique is expected to have 10 percent penetration within the new construction market within 5 years, and 25 percent within 10. And as production costs decrease, market penetration will rise further.

The IBACOS/HIA report can be found at <http://bit.ly/2xeXivk>.



CREDIT: MONOPATH LLC

Outside looking in. A long-ignored construction method in which insulation and water protectant are placed on the exterior of a home could popularity thanks to new cost-cutting efforts by builder MonoPath LLC.

AFFORDABLE SOLID-PANEL “PERFECT WALL” SYSTEM

DEVELOPERS: University of Minnesota, MonoPath LLC, Building Knowledge Inc., Huber Engineered Woods, Unico

CURRENT STATUS: Prototypes under development

EXPECTED COMPLETION DATE: June 2019

The concept of a “perfect wall” in housing is not new—researchers at the University of Minnesota (UMN) have been studying the idea since the late 1990s. But the design, which calls for placing the building’s insulation and water barrier on the outside instead of inside the structure’s wall cavity may finally catch on with contractors.

UMN researchers compare the perfect wall’s exterior insulation to “wrapping the whole house in a blanket.” The concept has proven far more expensive than traditional insulating, holding back its acceptance by builders. But MonoPath LLC, which has been testing the method for several years, has found ways to cut down construction costs.

MonoPath’s homes require only a few skilled workers and subcontractors, and have fewer home designs. There is an emphasis on interior systems—such as smaller furnaces and air conditioners—which helps with energy efficiency. And, they’re built differently: Standard houses are constructed with hundreds of relatively small wooden panels that are assembled piece by piece. MonoPath homes use large 8-by-24-foot panels that get hoisted by a crane and are nailed into place in a single day.

The lower construction costs also mean a more affordable price for buyers, which should boost their popularity. The MonoPath building system works in all climate zones, meaning the approach can be easily taken into other national affordable housing markets.

The UMN/MonoPath report may be found at <http://bit.ly/2hKaGp8>.

VENTILATION INTEGRATED COMFORT SYSTEM (VICS)

DEVELOPERS: Steven Winters Associates Inc., Mitsubishi Electric, dPoint Technologies

CURRENT STATUS: First prototype under development

EXPECTED COMPLETION DATE: July 2019

Balanced, heat recovery ventilation (H/ERV) is becoming a more obvious choice in very tight, energy-efficient homes. But the installation process remains very expensive—about \$3,000 per home—and can be challenging to integrate effectively. Many current H/ERV installations have poor integration, inconsistent controls, questionable delivery of outdoor air, and high energy use.

Steven Winters Associates Inc. has taken on the task of creating a way to enable heating, cooling, and whole building ventilation in a single-duct system. The goal is to help airtight homes achieve 40 percent to 60 percent energy savings by reducing thermal ventilation loads, without loss of indoor air quality. The Ventilation Integrated Comfort System (VICS), which will feature variable speed fans to enable low-energy operation and precise control, providing balanced, distributed ventilation with heat recovery, should also cut costs by 30 percent to 50 percent versus separate HRV/ERV systems.

CREDIT: MITSUBISHI ELECTRIC COOLING AND HEATING



All in one. An upcoming Ventilation Integrated Comfort System will help cut installation costs, improve indoor temperature control and lower energy bills for many new single- and multi-family homes.

The VICS target market is homes with design loads of less than 10-12 kBtu/h (multiple systems for higher loads). This would include thousands of single-family homes (including those part of the DOE Zero Energy Ready Home and Passive House programs), as well as most new multi-family apartments built after 2016.

Initial interest has been positive among builders and developers surveyed about the product. ERV/HRVs were not standard for those surveyed, but those who had used the system considered the experience “a nightmare.” When it came to the VICS concept, the response was more enthusiastic: “When can we get one?”

With the product still under research and development, it will be some time. A fully functional prototype should be completed in spring 2018, with installation into an occupied home expected by next summer. Projected completion date is summer of 2019. **GB**

The VICS report may be found at <http://bit.ly/2xTVABu>.

Multi-purpose planning in Tennessee.

The green|spaces net-zero-energy home includes Greenguard-certified open-cell spray foam for insulation, and a standing steel metal roof for durability and easy solar panel install.



Sealed in Bliss

green|spaces' mostly airtight home pays its own way in energy use.

BY ASHLEY CABRERA

IN CHATTANOOGA, TENN., a small nonprofit asked a simple question: "Why aren't zero-energy healthy homes the norm for new homes in our market?" The answer from builders: "Because people aren't asking for them." The answer from buyers: "Because builders aren't building them, or I can't afford the upgrades."

Sustainable living advocate green|spaces sought to solve this problem by designing, developing and ultimately selling a series of spec-built net-zero-energy homes. In the process, the nonprofit educated the entire market, including designers, builders, real estate agents, appraisers, buyers, lenders, students and teachers. With simple, off-the-shelf features, the design team delivered a home that can produce as much energy as it consumes, protects and promotes the health of its occupants, and uses water and materials responsibly—all at a conventional price point for the neighborhood in which it is located.

green|spaces began its net-zero-energy homes project in 2014, with a list of what it wanted to achieve with the homes. They needed to be visible from afar, located on a steep site, and able to be built and sold at a reasonable rate. To ensure these components were possible, the group looked at other net-zero energy case studies. These helped it decide which products and techniques were best to achieve net-zero energy, as well as to build an affordable house.

The nonprofit held a design competition featuring 11 teams, each with a builder, designer and engineer, to design the home with components that green|spaces wanted to include. Each team had to demonstrate that its design could realistically be built net-zero energy. The final project team included green|spaces, Workshop Architecture, WM Whitaker Landscape Architects and Collier Construction. Their consultants were Conditionaire, SK Collaborative and Vandemusser Design.



CREDIT: KAREN CULP PHOTOGRAPHY AND DESIGN

Air apparent. Casement windows, thermally broken frames and multi-point lock doors, which provide better air tightness, were installed to improve energy efficiency.

A PASSIVE DESIGN

Energy costs can be reduced by simply taking advantage of the movement of the sun. For the Chattanooga area, it is best to shade any south-facing windows to eliminate direct sunlight in the summer, but allow for heat in the winter. Providing overhangs and vertical shading elements helps to improve energy performance. On the homes, the windows at the top of the house have an overhang, which allows the solar panels to pick up the sunlight, conserve energy, and reduce excess heat, glare and ultraviolet radiation.

A BUILDING ENVELOPE: WALLS, ROOF AND FOUNDATION

The design of the walls, roof and foundation can help achieve a high-performance home.

VaproShield, a vapor permeable air barrier, was used on the walls to keep the wood dry. This secures a long life for the wood in the home.

Greenguard-certified open-cell spray foam was used to insulate the walls. The crawlspace was sealed, insulated and conditioned with a 10-mil vapor barrier and closed-cell spray foam.

The roofing material required something that would work well with the solar panels, so green|spaces used a standing steel metal roof. The solar racking can be clamped to the seams, with open-cell spray foam between the rafters, instead of having to penetrate like a regular roof. Also, it is one of the longest-lasting roof materials—one that will outlast the solar panels—so it prevents the owner from having to remove the solar to replace a shingle roof and then reinstall the solar.

IN THE AIR: HEATING, AIR CONDITIONING AND VENTILATION

The passive design also plays a role in keeping the house well ventilated. Natural ventilation with high exhaust windows pulls air up through the house during months when active heating and air conditioning is not necessary.

For heating and cooling, green|spaces installed two Mitsubishi *Hyper-Heat* ductless mini split systems, one upstairs and one

downstairs. These eliminate the use of ductwork, increasing efficiency. The units have the ability to vary capacity, which saves energy. It can run a little, when just a little is needed—which is most of the time—in a well-sealed, well-insulated home. Another feature of this system is that it can still work effectively at temperatures as low as -13 degrees. A Schneider Electric *Wiser Air* thermostat was installed and works as a control panel for the home. It has intuitive scheduling and learning algorithms, which help to conserve energy in the home, and also has live weather alerts.

green|spaces wanted to seal house as tightly as possible, while also making sure the home has enough fresh air. They used an energy recovery ventilator, which takes the air from outside and brings it inside, then sucks it back out through the kitchen and bathroom. The system pre-heats and pre-cools the fresh air that is brought in from outside.

After installing the system, a blower door test showed a 1.67 air changes per hour (ACH) rating in the home. The required Energy Star rating is 4 ACH; the nonprofit is anticipating that number to be lower in the next three homes.

BETTER WINDOWS AND DOORS

green|spaces found that using Energy Star-qualified windows and doors allowed for greater efficiency. They meet standards for the insulating value of glass, which is a U-factor less than 0.30, and standards for the amount of heat the window allows to enter the home from direct sunlight, which is a solar heat gain coefficient of less than 0.40.

With that in mind, casement windows, thermally broken frames and multi-point lock doors were installed to improve performance further, through better tightness of the building envelope. Unlike double-hung windows, which are pressurized at the top and bottom, casement windows are pressurized on all sides, resulting in a tighter seal and less cool and warm air entering the home. To ensure optimal tightness around the window, minimal expanding foam was applied to the window frame.



CREDIT: KAREN CULP PHOTOGRAPHY AND DESIGN

Bill busters. Energy Star-certified appliances, along with LED lighting, help cut electric costs by several hundred dollars per year.

A HEAT PUMP-DRIVEN WATER HEATER

To determine the most efficient system for heating the home's water, green|spaces referred to a study from Tennessee Valley Authority's Campbell Creek Research Homes. The nonprofit decided to use a heat pump water heater in the home, instead of the typical electric or gas water heater.

A heat pump hot water heater uses the same compression cycle as a refrigerator to do the opposite job. It squeezes heat and humidity out of the ambient air and puts it in the water. In the process, it gives off slightly cooler, slightly dryer air.

Not only is the water heater more efficient, but in the Southeast, where there is often humid air, it assists the mechanical system to save even more energy than gas, electric or solar thermal.

FOR SAVINGS, THINK LED LIGHTING AND ENERGY STAR APPLIANCES

LED was the obvious choice for lighting in the home. As LEDs have become more popular, they have also become more affordable. Using LEDs throughout the net-zero home allows for a monthly energy savings of \$12, or about \$152 per year, when compared to an average new home of the same size.

Energy Star-certified appliances, including the refrigerator, washer and dishwasher, were installed to save an average of \$8.33 a month and \$100 a year. The dishwasher also conserves water by using only 2.5 gallons to completely wash, dry and sanitize really dirty dishes. The range installed in the home is a double oven induction unit that is 75 percent more energy efficient than conventional electric.

Another important appliance feature is a heat pump dryer, which is an Energy Star appliance as well. This dryer uses the heat from the home to dry the clothes in the dryer, and since there is no hole that has to be made for a dryer vent, it keeps the house as tight as possible.



CREDIT: KAREN CULP PHOTOGRAPHY AND DESIGN

The new norm? Hoping to draw more attention to net-zero homes as a low-cost housing option, green|spaces built the home at about the same price point as others in the neighborhood.

Products used in the green|spaces Net Zero-Energy Homes Project:

Tennessee Solar Solutions 4.65-kw solar array with AXITEC solar panels and Enphase microinverters

Schneider Electric *Wiser Air* thermostat, electric vehicle charger, and home electric load center

SunClad wood windows and doors

Siano Appliance Distributors Energy Star-qualified double oven range and dishwasher, and hybrid heat pump dryer

Mitsubishi Electric cooling and heating *Hyper-Heat* technology; ductless mini-split systems

VaproShield, *WrapShield IT*

SESCO Electric Supply Co. LED light fixtures and smart home controls from Lutron Caseta

Titebond subfloor adhesive

AFM *Safecoat DuroStain* and *Polyureseal*

Executive Cabinetry eco-friendly cabinetry

ABOVE ALL, IT'S SOLAR

Solar was the final piece of the equation to get the home to net-zero energy. Based on the energy that would be produced from the homes, with the above techniques and appliances, green|spaces installed a 4.65-kw array. This will generate approximately 6410 kWh each year, and offset demand and selling excess to generate \$641 per year. This value is expected to increase as electric rates rise over time. Even on a cloudy day, this array has proven to produce more energy than the home consumes.

The first of the four homes was completed in December 2016 and recently sold for \$366,000. Land is currently being cleared for the other three homes, which will sit alongside the first model. **GB**

Ashley Cabrera is creative services coordinator at the Tennessee Department of Energy and Conservation's Office of Sustainable Practices.



CREDIT: BRECHER

WATER MISER

The Flex House demonstrates how to live right with less water.

BY JULIET GRABLE

The Flex House was designed and built in California, a state that has just recovered from the worst drought in recorded history. With its large population and dependence on agriculture, the Golden State is—by necessity—leading efforts to reduce water use across the board.

With emphasis on right-sized living, Shelter Dynamics and Green Builder® Media set out to demonstrate strategies in The Flex House that reduce potable water use while meeting or exceeding California's stringent standards.

Green Builder® Media presents **FLEX HOUSE** by Shelter Dynamics

Reducing Demand

Just as a high-performance home reduces energy demand before adding solar panels, The Flex House shrinks its water footprint by first reducing demand with efficient faucets and fixtures provided by American Standard.

Both the toilet and lavatory faucet are certified by the EPA WaterSense program. By definition, WaterSense-labeled products use 20 percent less water than their conventional counterparts, but these products go even further. The contemporary-style faucet uses 1.2 gallons per minute (gpm), while the toilet uses 1.1 gallons per flush (gpf), exceeding the WaterSense standards of 1.5 gpm and 1.28 gpf, respectively.

In the kitchen, the sleek *Beale* pull-down "touchless" faucet enables hands-free operation and can be turned on or off by waving a hand in front of the sensor; sliding the door over the sensor enables manual mode. The faucet's maximum flow is 1.5 gpm, below the maximum threshold of 1.8 gpm for kitchen faucets set by the stringent Cal-



CREDIT: AMERICAN STANDARD

Wise idea. The *FloWise* three-function showerhead from American Standard automatically reverts to the 1.5-gpm water-saving mode. www.americanstandard-us.com

Green program. (At present, the WaterSense program does not certify kitchen faucets.) The company is maintaining performance with these lower flows through technological innovations and high-quality manufacturing. "Performance with conservation—that's what I like to tell people," says James Walsh, vice president of product management at LIXIL Americas, the business unit under which American Standard operates. He cites products such as the *FloWise* three-function showerhead as an example of a product that combines performance with water savings. The showerhead includes a 1.5-gpm water-saving mode that uses a turbine to rotate the head, providing the user with a full, satisfying spray. The *Greentherm* condensing gas tankless water heater from Bosch also helps save water. Models in the *Greentherm 9000* series include a built-in recirculation pump and require no dedicated return line. This drastically reduces the time spent waiting for hot water at the tap, and the company claims this feature can save an estimated 11,000 gallons a year per household. The compact appliance is also a good fit for this smaller-footprint home.



CREDIT: BOSCH USA

Numbers (not) up. Lack of a dedicated return line and inclusion of a recirculation pump helps the Bosch *Greentherm 9000* series tankless water heater save 11,000 gallons a year per household. www.bosch-home.com/us/

The Scoop on NSF 350

NSF/ANSI 350 and 350-1 establish material, design, construction and performance requirements for onsite residential and commercial water reuse treatment systems and set water quality requirements for the reduction of chemical and microbiological contaminants for non-potable water use. Treated wastewater can be used for restricted indoor water use, such as toilet and urinal flushing, (and in California, for laundry washing) and unrestricted outdoor water use, including lawn irrigation and vehicle washing. Several codes, including the International Residential Code (IRC) and Universal Plumbing Code (UPC) recognized NSF 350 in the 2015 code cycle.

Using Water Twice

The Flex House also demonstrates a graywater system from Nexus eWater, consisting of a *NEXtreater* graywater treatment unit and a *Recycle Ready Assembly*, a pre-assembled graywater collection system. Such systems typically capture two out of every three gallons of indoor water for reuse in landscaping and for toilet flushing.

The appliance-like *NEXtreater* uses floatation, physical and carbon filtration and UV disinfection to treat graywater to NSF 350 standards. Developed by NSF International, this standard establishes requirements and water quality standards for onsite reuse systems. California adopted NSF 350 into the California Plumbing Code in 2013, which opened up opportunities for mainstreaming graywater reuse throughout the state. The *NEXtreater* was the first graywater product to receive this certification and remains the only one widely available in California. With its products, Nexus eWater has positioned itself to provide market-ready and code-compliant systems to builders, developers and homeowners across California. "We've taken a productized, modular approach to onsite graywater recycling," explains Tom Wood, CEO for Nexus eWater. "The *Recycle Ready Assembly* makes installation simple for builders and contractors—there are just five connections—and the *NEXtreater* was designed to be as simple to use as an air conditioner."



CREDIT: NEXUS

Ready to Go. The *Recycle Ready Assembly* from Nexus eWater includes a 75-gallon holding tank and a 200-gallon reservoir for treated graywater. www.nexusewater.com

The *Recycle Ready Assembly* includes a holding tank for untreated graywater and a larger reservoir for treated graywater. The company is advocating that new construction with dual plumbing go a step further and add a *Recycle Ready Assembly*.

Dual plumbing keeps graywater from showers, sinks and washing machines separate from the wastewater from dishwashing and



In the Zone. The Rachio smart controller offers “set it and forget it” intelligence that can compensate for weather, season and the unique characteristics of irrigation zones. www.rachio.com



The Full Treatment. With a 200-gallon daily capacity, the NEXtreater from Nexus eWater filters and disinfects water to NSF 350 standards. Treated graywater can be stored and used to irrigate landscaping and to flush toilets. www.nexusewater.com

homeowners can actually do something with it,” says Josh Fuller, director of marketing and sales for Nexus eWater. “The builders are coming around because they feel like they are giving the homeowner something of value.” The NEXtreater, which is the most expensive part of the system, can easily be plugged in later.

toilets. If the home does not include a graywater treatment system, the two wastewater streams combine into a single pipe outside of the house, and all of the wastewater flows to the sanitary sewer system. In California, municipalities with water recycling in place require dual plumbing in new construction; municipalities without water recycling may still elect to mandate it.

“The logic was, some municipalities are already requiring dual plumbing; let’s give them an option so

Taking It Outside

The Flex House takes water conservation outside the home by demonstrating efficient irrigation with the Rachio *Smart Irrigation Controller*. This controller communicates with local weather stations and incorporates information about each watering zone to create watering schedules that guarantee plants only receive water when they need it.

According to the EPA, Americans spend 9 billion gallons of water on landscaping, and the agency estimates that up to 50 percent of that water may be wasted by inefficient systems. Recognizing the huge potential savings, the EPA began certifying smart controllers through its WaterSense program starting in 2011.

“[Conventional] irrigation controllers were as smart as they were going to get the day they were placed on the wall; the intelligence was confined to the device itself,” says Ric Miles, VP of Business Development at Rachio. “There was no insight into seasonality or meteorological events, because they were not connected.”

In contrast, a smart irrigation controller can track local weather and soil moisture and match that information with detailed information about planting zones, including soil type, slope, sun exposure and plant species to create customized watering schedules for each zone. These controllers can make decisions based on forecasts; for example, if it’s predicted to rain tomorrow, the



controller might suspend the irrigation program today.

“[We spend] thousands of gallons of water on landscaping and irrigation; it accounts for over 50 percent of the water consumption in many homes,” says Miles. “If you can skip weather events, or if it’s overcast and cool; if you can take advantage of the different characteristics of different zones, you can save an average of 30 percent and even up to 60 percent.”

The controller also automatically compensates for seasonal fluctuations. Most schedules are created around peak need—usually mid-to-late summer, when solar radiation is most intense. However, water needs are typically lower in the “shoulder seasons” of spring and fall.

The EPA estimates that replacing a standard clock timer with a WaterSense-labeled irrigation controller save an average home nearly 8,800 gallons of water annually. Rachio’s was the first controller to be certified by the WaterSense program, in 2014. It can be controlled through an app from anywhere, and users can share access.

Putting It All Together

We use water to produce energy, and we use energy to treat, transport and heat water. Consequently, reducing potable water use almost certainly also cuts energy use, even if it’s not necessarily reflected in a utility bill.

There is a growing awareness of the “water-energy” nexus—the complex interdependencies between energy use and water. In our next article on The Flex House, we’ll explore how envelope construction, efficient HVAC and appliances and renewable energy come together to make The Flex House a net-zero home. **GB**

“Giving homeowners the ability to reuse onsite water resources is the single most-effective way to reduce the environmental impact of new and remodeled homes. Water recycling allows architects and builders to offer clients the landscapes they want, and protect those landscapes against future drought restrictions.”

—Tom Wood, CEO, Nexus eWater

Shrinking Usage, Expanding Possibilities

Graywater reuse and smart irrigation can help projects earn permits and stretch tight water budgets further.



CREDIT: BLUBHIL75

ONE OF THE BIGGEST BENEFITS of graywater reuse, according to Josh Fuller, Sales and Marketing, Nexus eWater, is that it enables more possibilities when it comes to outdoor water use, especially in places with tough water ordinances.

“Using the system allows most people to expand their proposed landscaping, or add a pool or spa,” says Fuller. “It helps ease the project through permitting, because you can prove that you’re not using any extra potable water.”

This is certainly true in California. As per Governor Jerry Brown’s 2015 Executive Order, part of emergency measures targeting the drought, California updated its Model Water Efficient Landscaping Ordinance, or MWELo. This ordinance applies to all new construction and sets standards for plantings, irrigation equipment and allowable percentage of turf, among other things. Cities may adopt their own ordinances, so long as they are at least as strict as the state-wide MWELo. The updated MWELo incentivizes graywater reuse, along with rainwater collection and stormwater management. Landscapes under 2,500 square feet that are irrigated exclusively with graywater

or captured rainwater are not subject to the full ordinance, but instead must comply with a simple irrigation checklist.

The Nexus eWater team has been cultivating a network of California architects, builders and developers over the years, in preparation for their first full production run this summer. One of these partners is Gary McDonald Homes, which is installing either a full system or the *Recycle Ready Assembly* in every new home in Copper Hills Estates, a development in Fresno.

Features such as graywater systems can help builders distinguish their homes, especially in areas where sustainable housing is in demand. Still, despite its benefits, the Nexus eWater graywater system still costs around \$10,000, and builders must show the value of this added cost. During the last code cycle, NSF 350 was expanded to include commercial and multi-family projects, opening up new opportunities for graywater reuse. Nexus eWater is starting to explore those opportunities.

“In this new world of MWELo, we are seeing that even for regular home buyers the price tag is worth it if it allows them to have larger pools or greener landscaping,” says Fuller. “But there’s a real opportunity to split use and costs between two or three units in multi-family developments, which is really exciting for us.”



CREDIT: RACHIO

Data Collector. The Rachio Wi-Fi Smart Sprinkler Controller can be controlled by a smartphone or PC, and it will track water use over time.



Experience The Flex House

Shelter Dynamics and Green Builder® Media will exhibit The Flex House in Las Vegas early next year. The third of three planned exhibitions.

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Stretching the Water Budget

Ordinances such as MWELo also mandate the use of “weather-based” irrigation controllers such as the WaterSense smart controllers offered by Rachio. These controllers can significantly reduce irrigation water use and can help ensure landscaping projects are approved. But they may also offer a revolutionary way to manage development in areas with limited water infrastructure.

Much like the energy grid, the capacity of water infrastructure must be built around peak demand. Last year, Rachio participated in a study in collaboration with the Alliance for Water Efficiency, New Jersey American Water and WaterDM to learn how suspending irrigation on the hottest, driest days could “shave” the peak of this demand.

“This has profound implications on required water supply for a given municipality, and reduces the cost of infrastructure,” explains Rachio Vice President Ric Miles.

Rachio is unique among smart controller manufacturers in that access to the controllers can be shared, and Rachio can access

its customers’ accounts and watering schedules. The ability to control many schedules at once holds the potential for reducing peak water demand.

For this study, 15 homeowners were provided with Rachio smart controllers, and the homeowners agreed to have their irrigation schedules remotely interrupted for two days in August of 2016. Based on water use history for these properties, the interruption saved 84 kilogallons (84,000 gallons) during each of the two days. Scaling this strategy up to include hundreds of homeowners could cut millions of gallons from peak demand.

For now, the Rachio real-time reporting provides a valuable source of data on outdoor water use. The app allows landscaping contractors to control many customers’ controllers at once, but it offers another benefit, too. Landscaping contractors are typically held liable for new landscaping for up to a year after it is installed, even if homeowners skimp on watering and the plants suffer.

“With this shared intelligence, you get a notification that something has changed—it creates a virtual ‘paper trail,’” says Miles. **GB**

High Performance with Low Flows

THERE'S NO DENYING “low-flow” toilets and faucets save water. But for customers to embrace these products, they must guarantee performance at these lower flows. For showerheads, this means creating adequate pressure and coverage with less volume. For toilets, this means ensuring the toilet does its job of removing solid waste while adequately cleaning the rim. American Standard's high-efficiency, low-flow toilets receive the highest ratings for flushing solid waste, according to Maximum Performance (MaP) testing, an independent evaluation of flushing performance.

American Standard was recognized with the WaterSense Excellence in Innovation and Research award in 2016, in part for its research on high-efficiency toilets and “drain line carry.” Conducted in collaboration with the Plumbing Efficiency Research Coalition (PERC), the study looked at how toilet paper, slope of plumbing lines and the flushing characteristics of the toilets themselves affected the ability of toilets to successfully “kick waste to the curb,” as described by James Walsh, vice president of product management for American Standard, part of LIXIL.

“In homes, drain line carry is not as much of an issue, because there are multiple sources of water to push toilet paper and waste through the pipes,” explains Walsh. In homes, showers, dishwashers and washing machines all contribute to the flow through the drains, but in commercial buildings, toilets and sink faucets typically provide the only water that can facilitate the removal of paper and waste through drain lines.

“In homes, drain line carry is not as much of an issue, because there are multiple sources of water to push toilet paper and waste through the pipes.”

— James Walsh, American Standard



A New Standard. The ultra-high-efficiency H2Optimum toilet by American Standard, featured in The Flex House, uses just 1.1 gallons of water per flush, exceeding WaterSense standards.

CREDIT: AMERICAN STANDARD

“That’s why our testing with PERC is so important, to ensure that commercial low-flow toilets can attain the same high performance as their residential counterparts,” says Walsh.

The WaterSense threshold for toilets is 1.28 gpf, which is 20 percent lower than the current standard of 1.6 gpf. Aggressive green building standards such as California’s CalGreen program are using or exceeding WaterSense standards. Manufacturers are responding.

“We have a hydraulic platform that does an outstanding job with both drain line carry and rim wash,” says Walsh. This VorMax technology primes the bowl using two flush valves and a single, powerful jet of water, rather than shooting water through multiple holes to clean the rim.

“We’ve now taken this technology and developed an even more water-conserving VorMax toilet that uses only one gallon of water to flush 1,000 grams (2.2 pounds) of solid waste—the highest MaP rating,” says Walsh. **GB**

Learn more about MaP testing at www.map-testing.com



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Smaller is better. Homes in the Villages of Seven Lakes in Nova Scotia might never have been built, without the hidden infrastructure that kept blackwater manageable.

CREDIT: SEVEN LAKES COMMUNITY/THE PENNEY GROUP

Subterranean Secrets

BY JOSEPH HARMES

To keep home prices affordable, excavation minimal, and sewage manageable, the developer used “grind and pump” technology.



A broad plan. The Penney Group's goal is simple: creating an open-space conservation community of 634 moderately sized and priced residences, while leaving 60 percent of the 11-mile-long parcel undisturbed.
CREDIT: SEVEN LAKES COMMUNITY/ THE PENNEY GROUP

AFTER SPENDING ALMOST SIX YEARS consolidating separate parcels into a contiguous 634-acre tract of mature forest touching seven different lakes—and another four years negotiating a development agreement with the regional Canadian government—the Penney Group embarked on a unique challenge: creating an open-space conservation community restricted to only 634 moderately sized and priced residences, while leaving 60 percent of the pristine landscape undisturbed. It also needed to implement a septic system for the homes without risk of contaminating the lakes.

That effort—the Villages of Seven Lakes—broke ground in 2014 next to the small town of Porters Lake (pop. 3,200), an exurb of Halifax, the capital of Nova Scotia in eastern Canada. A long-time dream envisioned by Penney Group President Gail Penney, the residential development detours from the 21st-century approach of big profits derived from over-sized homes on tiny



Repeat performance. Massive storage tanks store wastewater until it can be biologically broken down and used to recharge groundwater.

lots, to a quality-of-life philosophy straight out of the Urban Land Institute's (ULI) playbook advocating “land use policies and design practices that respect the uniqueness of both the built and natural environments.”

A blank slate this large could easily accommodate many more homes, but the creation of a scaled-down community the scope of Seven Lakes is actually more difficult. A narrow target like this requires “insightful planning and design,” ULI says, because “the elements of a thriving community don't come together randomly.”

According to Brad Harnett, a certified civil engineering technologist and project manager of the Villages of Seven Lakes, the developer has to think outside the box, then fit all of the pieces back into the box or various boxes of differing shapes. “Classic open-space development leaves a minimum of 60 percent of the area undisturbed,” he says. “This means that placement of all roads, services, infrastructure, wells, wastewater systems, driveways, houses and lawns has to be carefully thought out.”

Penney, a school teacher for 18 years before joining the 40-year-old family business of automobiles, heavy construction, energy services and real estate, admits this strategy is an expensive, detailed process. But it also “provides us the opportunity to be creative. If you want to innovate, you really just need to listen to what people are telling you and ‘use what you have’ to help find solutions.”

AFFORDABLE, SUN-POWERED AND SEPTIC FRIENDLY

The Villages of Seven Lakes' inventory is a new interpretation of the Craftsman and Colonial-style houses found throughout Nova Scotia. The sustainable, low-impact homes average 900 to 1,300 square feet, with a \$300,000 CAD (approximately \$240,000 USD) starting price. Among their amenities: homes are situated to maximize passive solar energy.

Houses at Seven Lakes are clustered together in “little villages” surrounding nature preserves, with each home site measuring one-quarter to three-quarters of an acre. Eventually, seven clusters (totaling 634 residences worth about \$160 million CAD, or \$128 million USD) of single-family homes, duplexes and four-plexes will be linked by trails for walking, hiking and biking. A single 4.2-mile trail mirroring the road between the development and Porters Lake will cost Penney Group \$700,000 CAD (\$560,000 USD).

“We learned [from focus groups] that while many people currently living in the urban center [a 25-minute commute between Seven Lakes and downtown Halifax on the Atlantic shore] want to live rurally, several things are stopping them from doing that,” says Penney. “They want to stay connected to their neighbors and they don't want to have to drive their kids to their neighbors' homes. They don't want to spend all weekend gardening nor too much upkeep. They want trees and the space to recreate in.”

Rural homeowners also do not want to worry about having to maintain a septic system. Many prospective buyers are nervous at the prospect, according to Penney. “Many homebuyers have had no prior experience with individual

septic systems and do not understand or trust them,” says Randall Arendt, an author, designer, consultant and pioneer of conservation planning whose work influenced Penney's concept of Seven Lakes. “They prefer central systems, and most are probably not much concerned as to whether it is a conventional one that discharges treated effluent into rivers and lakes, or one that recharges aquifers with more progressive approaches.”

Infrastructure for stormwater or wastewater can degrade the environment or play a beneficial role, Arendt says. “Wastewater infrastructure rarely registers as a consideration among homebuyers, except perhaps as a very minor one,” he says. “[And even then,] only when innovative wastewater solutions are highlighted as part of the marketing.”

INAPPROPRIATE INFRASTRUCTURE'S ENVIRONMENTAL RISK

The developer's tenet of environmental integrity commences with the water quality of the lakes (Bell, Canoe, Thief, Porters, Conrod, Fiddle and Thompson). It extends to Seven Lakes' riparian buffers,

The main reason [gravity sewers] were invented several millennia ago was because the Romans could no longer tolerate the smell.

—Halifax Regional Municipality



CREDIT: SEVEN LAKES COMMUNITY/THE PENNEY GROUP

The nature of things. Gravity-driven sewer systems get a thumbs-down from Seven Lakes developers, because they require removal of a large amount of vegetation from homesites.

wetlands, vernal pools and flood plains. Although the popular area provides numerous access points for boating, swimming, fishing and other activities, Penney says they decided not to locate homes around the lake front. Besides guaranteeing everyone full access, the policy protects the lakes from at least some human footprint.

Septic systems could have been risky. For example, a typical 1,000-gallon tank used by a family of four would require pumping every three to five years. If homeowners lapse into a flush-and-forget mentality, the tanks and leach fields could deteriorate within decades and put everything in jeopardy.

“Septic wasn’t the choice for us because it is too limiting,” Penney says. “For buyers, the environment and for developers. In the long term, it presents too much risk for the environment and ultimately the development overall.”

Modern septic systems are widely accepted by the Halifax Regional Municipality (HRM). In some cases, HRM considers them superior to traditional gravity sewers which will, it asserted in a report, “invariably begin to leak and become conduits for surface and groundwater to enter and dilute sewage in the collection system.”

CAVEATS OF GRAVITY SEWER DESIGN

HRM’s report contends that gravity sewers “have never been more than a means of relocating a problem in a manner that is convenient to us.” The main reason they were invented several millennia ago, it adds, was because “the Romans decided they could no longer tolerate the smell.”

The HRM does not recommend gravity sewers in the area because of the proximity of bedrock and vulnerability to frost heave. Unsaid was the environmental disruption necessary for a gravity sewer’s large-diameter, deeply excavated mains.

“The (Seven Lakes) terrain is quite challenging, and a gravity

system would have required many manholes and several pump stations,” Harnett says. “Some homes would still require pumps to get up to the sewer main. Septic tanks at each home would require them to be monitored and pumped at an unknown potentially high cost, and there would always be the fear of contamination from leaks.”

Gravity sewers likely would have required removing acres of trees, which the developers were committed to preserving. “There is no clear cutting of lots at Seven Lakes, and we retain as many trees as possible when we are clearing for a home,” says Nicole Perchard, Seven Lakes’ community communications manager.

THE ATS SOLUTION

The Villages of Seven Lakes retained engineering firm WSP (WSP/Parsons Brinckerhoff) for a state-of-the-art solution. WSP endorsed innovative ALL-TERRAIN SEWER (ATS) products for pressure sewer systems manufactured by Environment One (E/One) Corp. in Niskayuna, N.Y.

Coincidentally, the HRM report noted that constraints associated with conventional gravity sewers, given typical geological and climatic conditions, “suggest the need to investigate alternatives.” Pressure sewers, it stated, “represent a revolution of these traditional techniques.”

Seven Lakes’ sewer system is a low-pressure unit that uses two- to four-inch small-diameter pipes and E/One grinder pumps (a component of the ATS system), which are installed at each home, according to Harnett. The grinder pump station collects all of the wastewater from the home and grinds it into slurry. The wastewater is then pumped directly to the development’s wastewater treatment plant, he explains.

“It was either a (developer-financed onsite) wastewater treatment plant or individual on-site septic disposal systems,” Harnett says.

“[ATS] allows us to place homes anywhere on our site whether it be at the top or bottom of a hill and anywhere in between.”

Besides water features, the topographical challenges include slopes exceeding 30 percent, rock outcroppings and potential archeological sites.

“Traditional septic systems result in expansive lawns, and large spaces between home sites. Our design addresses these issues. We can design our lots to suit the land and the needs of homebuyers first and foremost,” says Penney. “We do not need to plan the homes around the soil conditions required for septic design.”



CREDIT: SEVEN LAKES COMMUNITY/THE PENNEY GROUP

It’s a grind. E/One grinder pump station can propel wastewater for more than two miles—even uphill—and help re-invent the terrain.

The E/One grinder pump station begins with a tank about the size of a dishwasher that is buried in the ground, its lid easily camouflaged with minor landscaping. Components include a 1-hp, semi-positive displacement pump whose robust torque can propel wastewater through small-diameter, inflow-and-infiltration-free pressurized pipe for a distance of more than two miles—or even uphill—to a force main or treatment plant. As in the case of Seven Lakes, it can help re-invent the terrain.

This technique performs well in harsh, frozen climates, Harnett says. “Frost does not normally penetrate deeper than [5.5 feet], and our sewer lines are installed at least that deep,” he notes. “If rock is an issue and we cannot achieve that depth, we can insulate the pipe.”

INNOVATIVE, MODERN WASTEWATER DISPOSAL DESIGN

Harnett estimates that each home will produce approximately 1,000 liters (264 gallons) of wastewater daily. “In a community of 103 homes (the initial phase under construction) that is a lot of water,” he says. Each home’s E/One grinder pump requires zero preventive maintenance to “move wastewater quickly and efficiently away from the home and transport it through the closed ATS system to our

wastewater treatment facility,” Harnett adds.

When the wastewater reaches the facility, it meanders through five 25,000-gallon tanks, where it is separated into scum, effluent and sludge. The effluent’s nutrients are broken down in a biological process before passing through ultraviolet light for tertiary treatment and pumped uphill to a subsurface dispersal system (drip irrigation), which delivers the cleaned water back into the ground to help recharge groundwater.

Seven Lakes developers have approval for a total of 634 homes. Each dwelling has its own E/One unit regardless whether it is detached, semi-detached or a townhouse, according to Harnett. For him, it’s not a first-time scenario. “I was introduced to E/One’s ATS when I worked for a local firm that engineered a subdivision where they are in use,” he says. “We are the first on this scale.”

The Seven Lakes wastewater configuration includes a cost-per-home of around \$6,500 CAD (\$5,300 USD), depending on the exchange rate, Harnett says. The cost includes supply, pump startup and homeowner education on its use and operation.

Each E/One grinder pump is owned by the homeowner. “This puts the responsibility for proper use and care on the homeowner, who is more likely not to abuse the system if they are responsible for repairing or replacing it,” Harnett says.

A local plumbing company is trained in pump replacement and if service is required, the pumps will be sent to the regional supplier for repair. The pump is easily swapped out of the tank by removing bolts in the lid and unlatching the pump from the tank’s accessway.

“Our homeowners so far love the fact that they do not have to deal with a septic tank or disposal field on their property,” says Harnett, “and that the system is monitored by a qualified professional, a retired municipality treatment plant operator licensed by the provincial department of the environment.”

NO SUCH THING AS A “CONVENTIONAL” SUSTAINABLE ALTERNATIVE

Seven Lakes’ sewer system wasn’t just a revelation to its new homeowners. WSP’s forward-thinking proposal is almost unique among its peers, Arendt observes. In his book *Rural by Design*, he lamented that normally “many engineering consulting firms, whose core expertise lies in designing larger conventional systems, are biased against these alternative systems.”

“It sounds like the (Seven Lakes) system is designed to do everything in the most-environmental manner, from start to finish,” says Arendt. “I like small-diameter pressurized systems. They make a great deal of sense.”

According to Harnett, “This may sound like a lot of trouble to develop a single project, but in the end you are left with a unique, environmentally friendly, sustainable community.” **GB**

SUSTAINABILITY SYMPOSIUM

The Renewable Energy Internet

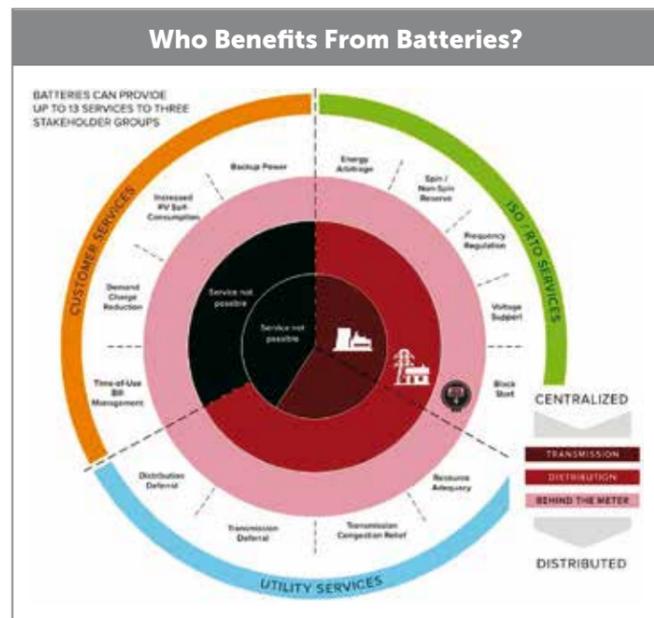
It won't be long before green power is the No. 1 source for all homes.

BY JEREMY RIFKIN

Note: This article is an excerpt from *The Third Industrial Revolution Final Report RNE*, a combination of narratives and proposals on technology and its use toward green business collaborations.

THE BULK OF THE ENERGY we use to heat our homes and run our appliances, power our businesses, drive our vehicles, and operate every part of the global economy will soon be generated at near-zero marginal cost and be nearly free in the coming decades. That is already the case for several million early adopters in the European Union who have transformed their homes and businesses into micro-power plants to harvest renewable energy onsite. Currently, 32 percent of the electricity powering Germany comes from solar, wind and other renewable energies. By 2030, a minimum of 50 percent of the electricity powering Germany will be generated by renewable energies.

The quickening pace of renewable energy deployment is due, in large part, to the plunging cost of solar and wind energy harvesting technologies. The reduction in fixed costs of solar and wind technologies have been on exponential curves for more than 20 years, as shown in Figure 1. In 1977, the cost of generating a single

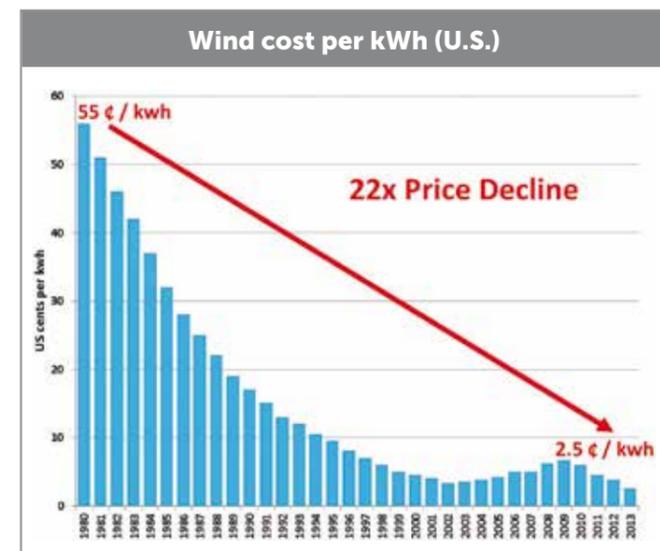


Powered up. Batteries offer a dependable backup for more than a dozen groups during times of high energy demand.

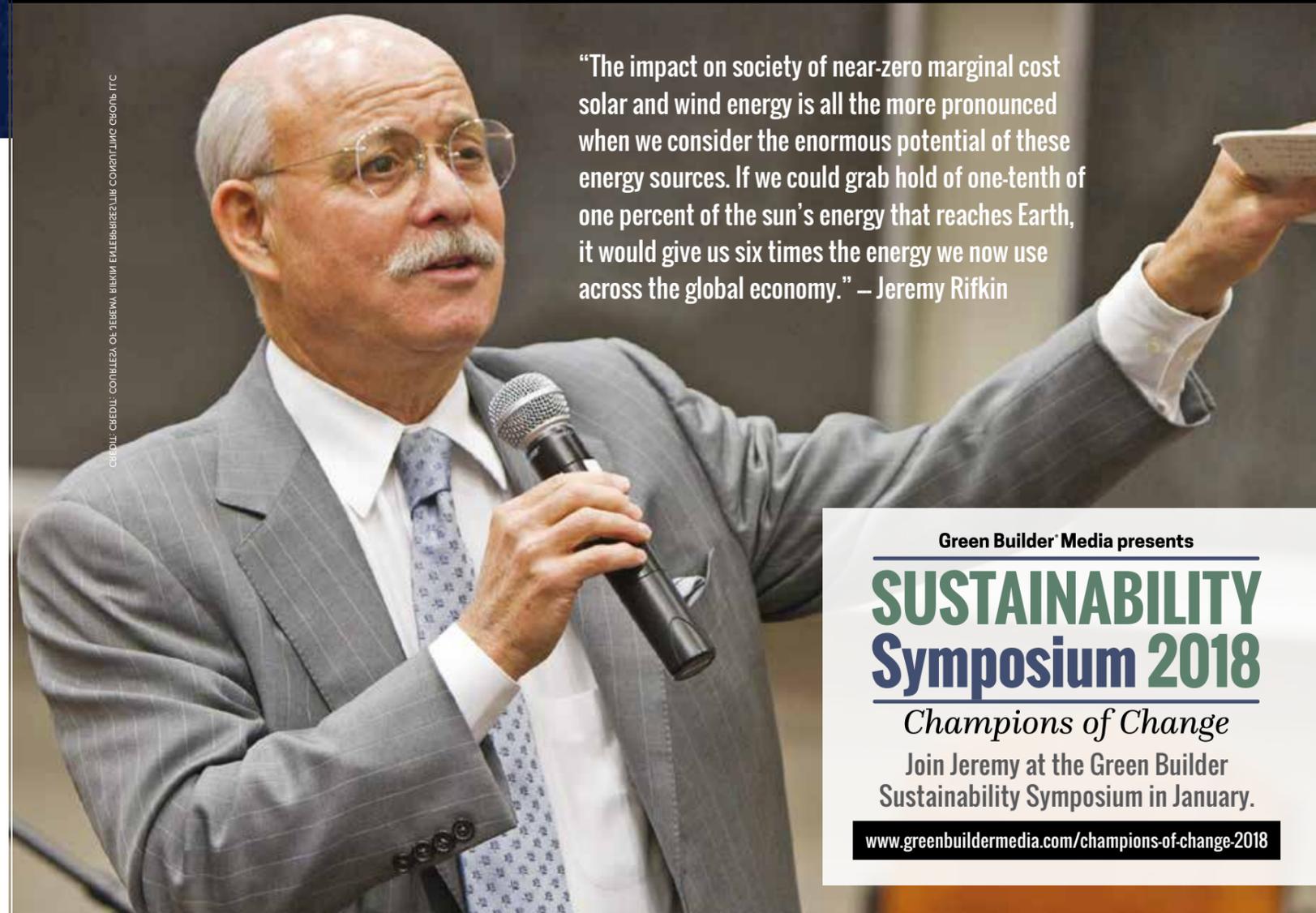
watt of solar electricity was \$76, and by 2017 the cost is about \$0.55 per watt. After the fixed costs for the installation of solar and wind are paid back—often in as little as two to eight years—the marginal cost of the harvested energy is nearly free. Unlike fossil fuels and uranium for nuclear power, in which the commodity itself always costs something, the sun and the wind are free.

The impact on society of near-zero marginal cost solar and wind energy is all the more pronounced when we consider the enormous potential of these energy sources. If we could grab hold of one-tenth of one percent of the sun's energy that reaches Earth, it would give us six times the energy we now use across the global economy. Like solar radiation, wind is ubiquitous and blows everywhere in the world—although its strength and frequency varies. A Stanford University study on global wind capacity concluded that if 20 percent of the world's available wind was harvested, it would generate seven times more electricity than we currently use to run the entire global economy.

At present, the Netherlands is still heavily reliant on conventional fossil fuel energies, particularly natural gas. In fact, in 2012, the Netherlands was the largest natural gas producer in the European Union, producing 43.2 percent of all the natural gas production.



Winding down. Over the past three decades, renewable energy deployment has sped up while the cost of solar and wind energy harvesting technologies had dropped.



“The impact on society of near-zero marginal cost solar and wind energy is all the more pronounced when we consider the enormous potential of these energy sources. If we could grab hold of one-tenth of one percent of the sun’s energy that reaches Earth, it would give us six times the energy we now use across the global economy.” – Jeremy Rifkin

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The country ranks low among the Western European nations in renewable energy generation. In 2012, renewable energy accounted for only 4.3 percent of total energy consumed in the Netherlands, and renewable energy in 2011 made up only 10.9 percent of the energy used in power generation. In fact, the Netherlands is among the EU countries that are woefully behind in reaching its renewable energy targets and is only halfway toward achieving its global greenhouse gas (GHG) emissions goals in the non-EU Emissions Trading System (ETS) sectors.

However, the Netherlands has begun to embrace far more ambitious renewable energy targets in the past year. Solar panel sales alone increased in the first half of 2015 between 70 and 100 percent compared to the same period a year before, with the installation of more than 2 million panels. While only 0.2 percent of the electricity generated in the Netherlands is produced by solar, the new data points to a potential leap forward in adoption of solar technology and other underutilized renewable energies. A summary of renewable energy opportunities for the MRDH Roadmap Next Economy can be found in Figure 2.

The Energy Internet is comprised of four foundational pillars, all of which have to be phased-in simultaneously in the Metropolitan Region of Rotterdam and The Hague for the system to operate efficiently.

- First, buildings and other infrastructure will need to be refurbished and retrofitted to make them more energy efficient so that renewable energy technologies can be installed to generate power for immediate use or for delivery back to the electricity grid for compensation.
- Second, ambitious targets must be set to replace fossil fuels and nuclear power with renewable energy sources. To achieve this goal, various government incentives need to be introduced to encourage early adopters to transform buildings and property sites into micro-power generation facilities.
- Third, storage technologies including hydrogen fuel cells, batteries, water pumping, etc., will need to be embedded at local generation sites and across the electricity grid to manage both the flow of intermittent green electricity and the stabilization of peak and base loads.



Renewables in the Netherlands

%	ENERGY SOURCE	TECHNICAL POTENTIAL	NAMEPLATE CAPACITY	SOURCE OF ENERGY	AVERAGE CAPACITY FACTOR	FOOTPRINT AREA (km ²)	2050 LCOE (levelized cost of electricity)
60%	Offshore Wind Power	31%	80 GW	16,000 turbines, each 5 MW rated power	45%	10,700	€.11/kWh
5%	Onshore Wind Power	17%	8 GW	1,600 installed turbines, each 5 MW rated power	38%	722 (2.2% land area)	€.7/kWh
31.4%	Utility-Scale Solar PV	73%	137 GW	2,740 solar farms, each 50 MW rated power	14%	1,228 (3.64% land area)	€.10/kWh
3.2%	Residential & Commercial Rooftop Solar PV	27%	15.1 GW	76,280 commercial rooftop systems, each 100 kW rated power and 1.5 million residential rooftops systems, each 5 kW rated power	13%	73.7 (0.2% land area)	€.13/kWh

CREDIT: COURTESY OF JEREMY RIFKIN ENTERPRISES/TIR CONSULTING GROUP LLC

Renewable opportunities. Renewable energy targets are becoming more common, such as in the Netherlands, where offshore wind power is the top prospect.

▪ Fourth, advanced metering infrastructures and other digital technologies like energy management systems will need to be installed in every building, transforming the energy grid into a fully digitized bidirectional system in order to manage multiple sources of energy flowing to the grid from local generators (smart grid implementation).

The Dutch utility companies have announced the nationwide installation of smart electricity meters with the goal of 100 percent deployment between 2016 and 2020. This will enable passive consumers of energy in the Metropolitan Region of Rotterdam and The Hague to become active prosumers of their own green energy, which they can then use off-grid to manage their facilities or sell back to the Energy Internet.

[In addition], every parking space will need to be equipped with a charging station to allow electric and fuel cell vehicles to secure power from the Energy Internet, as well as sell power back to the electricity grid. Electric and fuel cell vehicles connected to the Energy Internet also provide a massive backup storage system that can send electricity to the grid during peak demand, when the price of electricity has spiked, allowing vehicle owners to be appropriately compensated for contributing their electricity to the network. Figure 3 provides representative battery energy storage applications for further clarity.

The phase-in and the integration of these foundational pillars will transform the electricity grid of the Metropolitan Region of Rotterdam and The Hague from a centralized to a distributed energy system, and from fossil fuel and nuclear generation to renewable energy. In the new system, every business, neighborhood and homeowner becomes the producer of electricity, sharing their surplus with others on a smart Energy Internet that is beginning to stretch across national and continental landmasses.

This massive shift has started to appear in Germany with the establishment of electricity cooperatives. Most of these cooperatives were successful in securing low interest loans from banks to install solar, wind and other renewable energies on site. The banks were more than happy to provide the loans, assured that the funds would be paid back by the premium price the cooperatives would receive—via feed-in-tariffs—from selling the new green electricity back to the grid.

The rise of electric cooperatives has forced electricity companies to rethink their business practices. A decade ago, four giant vertically integrated electricity generating companies—E.ON, RWE, EnBW, and Vattenfall—were producing much of the electricity powering Germany. Today, they are producing less than 7 percent of the new green electricity that’s taking Germany into a Third Industrial Revolution.

Peter Terium, CEO of RWE, the German-based energy company, acknowledges the massive shift taking place in Germany from centralized to distributed power, and says that the bigger power and utility companies “have to adjust to the fact that, in the longer term, earning capacity in conventional electricity generation will be markedly below what we’ve seen in recent years.” **GB**

Jeremy Rifkin is an American economist and author whose best-selling Third Industrial Revolution served as a blueprint for Germany's transition to a low-carbon economy, and China's strategic acceptance of climate policy. He is also president of TIR Consulting Group, a coalition of companies and consulting organizations in the fields of energy efficiency, renewable energy technologies, construction, advanced fabrication manufacturing, engineering, urban planning, architecture, real estate, information and communication technologies, power and utilities, and transport and logistics. He may be contacted at jrifkin@foet.org.

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SMART CITIES

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'Smart Communities thinking' helps you on multiple levels.

BY TERRY BEAUBOIS

This is the second in a series of articles about the increasing interest in—and necessity for—smart homes, villages, cities and communities globally, and how they relate to green building in the U.S.

WITH MY BACKGROUND in architecture, NASA, a smart house project, researching small towns in Montana, and now teaching the Smart Villages module in a Smart Communities class at Stanford, I have become fully aware that multi-disciplinary knowledge and collaboration are the best way forward in building smart, sustainable communities. I've also discovered that green builders can take a leading role.

Looking at communities through a "smart" lens helps us understand the reality of the world around us. In my experience, most people do not want to be in an isolated house, isolated town or an isolated city. Smart communities need to be connected regionally and globally. The Internet allows us to do this, but we should have the ability to "opt in" to the aspects of the Internet we want, and stay safe and secure from what we don't.

HOW CAN "SMART COMMUNITIES THINKING" HELP YOU?

If you are a designer, builder or a homeowner, you know your local area and its requirements. If you're a big builder with a number of different regional markets, then you're taking each of those local markets into consideration. It is our goal to learn from local requirements and to "think globally, act locally." There will never be a "one size fits all" solution, but there will be common elements.

These elements not only need to provide their inhabitants with smart community benefits, they need members of the building industry to be knowledgeable about them, and to participate in the planning and creation of smart communities.

This is not always easy. Local government reviews, approvals and regulatory requirements determine what one can, can't and must do. The local weather determines how the buildings should be designed. The local market determines what price ranges are reasonable for the finished products.

So how does smart community design factor into our individual approaches to a building industry that is extremely complex and vast? One goal is increasing the choices that homeowners and builders have, while also providing the information about how to evaluate what is right for any particular project.



IT TAKES A VILLAGE TO BUILD SMART COMMUNITIES

Any building or community today involves a wide variety of organizations and disciplines—developers, governments, architects, academia, contractors, subcontractors, materials and product manufacturers, consumers, financing and real estate. Stakeholders that make up the building industry make their own decisions about how much or how little they want to be involved in the options available to them for building smarter, more sustainable, greener buildings in the 21st century.

Homeowners and builders are faced with an overwhelming set of choices and decisions to make. How can we make these decisions in an environment prioritizing sustainable, "green" features and advancing, competing Internet of Things options? This is where knowledge, experience and communication of what is working and what is not, plays a vital role. This can best be done by collecting information from a variety of sources and combining that information into an organized "dashboard" format of searchable information and making that information available at the highest level to each individual. The ultimate goal: to connect the power of people with the power of information.

GOVERNMENTS CAN LEAD THE WAY

You may or may not be surprised to learn that, in my experience, one of the projects that is most advanced in exploring the development and implementation of digital dashboards to collect and make smart communities data available is in India.



By a Whisper. Whisper Valley, a smart community under development in Austin, will feature homes by Pacesetter (left) and M-AVI (right).

Every time I visit India, I learn something about the United States. On one trip to India, there were floods in some areas of the country. I returned to the U.S., where there was flooding in West Virginia, Maryland, Louisiana and California. Water management, water quality, water availability—these are all important and basic issues with people living anywhere on Earth.

During a meeting in December 2015, in the Indian state of Andhra Pradesh, Chief Minister N. Chandrababu Naidu noted that rather than working on smart cities in India, he needed us to work on smart villages in Andhra Pradesh. "There are 1.3 billion people in India and 70 percent of them live in villages. If they all move to the cities, it will collapse my cities and collapse the villages," he says. "We need smart villages along with our smart cities, so that people have options to stay in the villages if they want to and still get the benefits of new 'smart' concepts being developed. We need ideas that increase their quality of life, provide economic opportunities, and give them more access to education."

Chief Minister Naidu wants a series of dashboards in his state that can allow everyone to post and view what is going on in their village, their district, the entire state, so the government and individuals can all benefit from viewing the same information. I revisited India for the fourth time in the last two years at the end of August 2017 and will include even more information about this major project in our next article.

EDUCATION CAN LEAD THE WAY

There are many people engaged in smart communities globally. My involvement with India smart communities began with meeting Prof. Solomon Darwin, at an IBM Watson conference. This is where I learned of his work with Henry Chesbrough, author of *Open Innovation*, at University of California, Berkeley's Haas School of Business, and how Prof. Darwin was applying it in India.

Another example in academia is a Smart Communities course at Stanford University where Rich Lechner and Peter Williams have been teaching about smart communities and providing an overview of the enablers, smarter systems and services, and risks and challenges globally. I teach the Smart Villages module in this course and am amazed at the amount of valuable information available from projects that can help raise the awareness of what is currently underway in smart communities globally. The students this year had a project evaluating a variety of cities globally, including Singapore; Songdo, Korea; Amsterdam; Columbus, Ohio; San Francisco; Nairobi; Barcelona; and Rio de Janeiro.

BUSINESSES CAN LEAD THE WAY

In Silicon Valley, businesses are also involved. Facebook is planning a new Menlo Park, Calif., smart village/campus for its employees and local residents. Google is also working in downtown San Jose, Calif., to build a smart community.

In Austin, Texas, Taurus Development, Bosch, Rehau and others have organized to create Whisper Valley, a 7,000-home new smart community currently under construction. In Canton, Ohio, Johnson Controls is engaged in creating the first-ever sports and entertainment "smart city." In West London, Ontario, Canada, the West 5 project is Ontario's first sustainable, net-zero community planned urban development.

COLLABORATIVE EFFORTS

Cities are collaborating with universities, too. In 2015, the Mayor of San Diego and U.C. San Diego Chancellor announced their participation as founding members of the MetroLab Network, with specific emphasis on infrastructure, city services and civic engagement.

Paul Hawken has dedicated his life to environmental sustainability and changing the relationship between business and the environment. He is currently on a book tour for his latest book, *Drawdown*. It is a worthy read, because it is not alarmist, but instead assembles the thoughts of more than 120 contributors to address a number of the most important issues today—many of which give hope and real solutions that the building industry can address directly.

In each of these venues, builders can play a key role in bringing smart communities into existence. The essential element is knowledge. People either know what to do, or they don't. I see this in the classroom, in the field and in government. It is clear what is needed—multidisciplinary collaboration and the "just in time" delivery of knowledge in government, business, education and technology related to the building industry. **GB**

Terry Beaubois, a designer and architect, is founding director of the Creative Research Lab at Montana State University, and was the MSU project director of the REHAU-MONTANA ecoSMART House Project. The project was awarded the Montana USGBC Honor Award Project of the Year in January 2016, as well as a Green Builder® House of the Year Award. He is currently CEO of the internet startup BKS (Building Knowledge Systems LLC) and is an adjunct lecturer at Stanford University.

Saving Water

Tips, Technology and Common Sense Solutions for a Thirsty World

An Underutilized Resource

Sometimes scarce, rainwater could be—and should be—managed more efficiently.

BY ELIZABETH HEIDER

WHEN IT RAINS, our natural instinct is to take cover. We find a place to shield ourselves from getting wet, or if we planned ahead, we pull out an umbrella and keep moving ahead to get to our destination. It's in our nature to avoid the rain, when really we should be seeking measures to capture it.

We take for granted the free resource that is rainwater, which at times in the U.S. is scarce, and around the world is rapidly becoming a scarcity crisis.

If you live in California, Nevada or Oregon, for example, you know drought all too well. Even water-surrounded Florida has suffered from drought in the last decade. Here and in developed nations abroad, as the world population charges toward 9 billion, water represents a significant problem because of supply shortages, poor quality, or inadequate distribution and disposal systems.

Rainwater is a valuable resource that we should be trying to not only harvest, but seek to manage during times of heavy rainfall. Using strategies such as incorporating cisterns and bioswales into projects from the onset is environmentally responsible and can lead to cost savings if used in a holistic approach in building a sustainable structure.

THE CISTERN: A WATER STEWARD

You have probably seen these barrels connected to downspouts in residential backyards. They collect rainwater runoff from the roof, which channels into the barrel and is stored for future use to water lawns and gardens, clean off gardening tools and wash cars. Cisterns help lower water bills, particularly in the summer months, by collecting a free resource. They are also important for our environment, helping to reduce water pollution by decreasing the amount of runoff contaminated by fertilizer and other surface chemicals that wash into streams and rivers. It's a small and simple way to make a big impact for the environment and for cost savings. Using cisterns is a great way to become a good steward of your local community.

Rain cisterns are becoming more prevalent on construction jobsites too, and for various uses. For example, it is good conservation practice, and saves cost to use water runoff to clean equipment. Systems can be designed to capture rainwater for use in nearly any



Showing (bio)diversity. The Expo Line Phase 2 project's landscaping design uses native drought-tolerant plant species and recycled water supplemented for irrigation to conserve potable water consumption, reduce stormwater runoff and promote a more natural state of biodiversity.

non-potable need within a building, ranging from the water to flush toilets to providing HVAC systems with water for cooling towers.

At the leading edge, district-scale solutions mean the water collected by a group of buildings can be redistributed throughout a community, and even treated locally. An elegant example of this is the Omega Center for Sustainable Living in Rhinebeck, N.Y. Moreover, every gallon of rainwater collected and put to use is one less hitting utility bills.

The construction industry has made great strides in building

sustainable structures. It is simply the smart thing to do, for the environment and permanency of the building, as well as delivering long-term cost savings to owners.

Incorporating a rain cistern often can help a project on its way to LEED certification. It's also an important strategy in the Living Building Challenge, the industry's most rigorous performance standard, which requires net-zero environmental impact.

Chesapeake Bay Foundation's Brock Environmental Center in Virginia Beach, Va., is one of the world's greenest buildings. The 10,500-square-foot building is Living Building and LEED platinum certified and features solar panels, wind turbines, geothermal wells, composting toilets and rain cisterns, which capture water that is then treated for all potable uses. It is the first and only Living Building to date that has been approved by governing health officials for drinking.

THE BIOSWALE: MORE IN THE TRENCHES

Bioswales, which are most often seen in large parking lots and major roadways, are designed to manage rainwater runoff. These linear trenches, which are vegetated with plants that can withstand heavy watering and drought, allow for the collection, filtration and infiltration of storm water. They also help prevent overwhelmed sewers from discharging waste into streets and waterways during storms.

In practice, these systems can be incorporated into building and infrastructure designs to lower the need for irrigation and, in rain-prone areas, potentially eliminate the need for irrigation systems. Of



We take for granted the free resource that is rainwater, which around the world is rapidly becoming a scarcity crisis.

— Elizabeth Heider

course, it comes with the added benefit of easing erosion and even property damage from flowing stormwater and flooding.

The Expo Line Phase 2 project in California, which is the extension of the light rail service from the current terminus in Culver City to Santa Monica, has incorporated a bio-filtration system, which has similarities to a bioswale. The landscaping design was installed along the alignment and adjacent to the Expo Line bike bath. The project, which received Envision Platinum certification from the Institute for Sustainable Infrastructure (ISI) and is the first transit project to receive the certification, had a calculated potable water savings of 27 percent below industry standard.

Rain gardens, a concept that is sometimes used interchangeably



All right as rain. Rain cisterns at Chesapeake Bay Foundation's Brock Environmental Center capture water that is then treated for all potable uses. It is the only building thus far approved by governing health officials for drinking.

with bioswales, are seen in urban and residential settings. These are similar, but smaller systems for intercepting storm water that would otherwise flow onto city streets, again managing and making use of a free resource.

In buildings, this can go beyond solutions on the ground level. Green roofs have a number of benefits, but one of the most obvious is catching and retaining rainwater like their bioswale counterparts, slowing discharge so that stormwater systems aren't overwhelmed during major storm events. In cities like Washington, D.C., that have combined storm and sewer systems, slowing down the flow keeps sewage from overflowing into waterways. As the built environment grows, permeable surfaces are needed to collect and manage rainwater. Green roofs are a great way to do just that.

These strategies to harvest and manage rainwater runoff share two common elements: They are cost effective and environmentally beneficial. Rainwater is a free resource that we take for granted, but that needs to change. We need to be advocates in our local communities. The buck stops here. **GB**

Elizabeth Heider is chief sustainability officer for Skanska, U.S.A. The company specializes in construction, civil infrastructure, public-private partnerships and commercial development initiatives.

CODE ARENA

The Latest Rules, Regulations and Codes Impacting Sustainable Construction

Flood Insurance's Muddy Waters

What's ahead for NFIP after Dec. 8? Time will tell

BY MIKE COLLIGNON

THE NATIONAL FLOOD INSURANCE PROGRAM (NFIP) was created in 1968 to provide gap coverage for risky properties in flood-prone areas. The federal government offered coverage on two conditions: that local communities would take appropriate measures to prevent development in risky low-lying areas; and that homeowners would pay actuarially sound premiums.

While it started with good intentions, the program gradually succumbed to real estate interests, with the result being that flood insurance enabled, rather than managed, development along coastlines and in other flood-prone areas, ultimately putting more people and property at risk than might otherwise have been the case. Also, well-to-do people benefit disproportionately from this program, as they are the ones who tend to build expensive houses on the beach. The NFIP has spent many millions of dollars to repair properties that have repeatedly flooded. The program has needed reform for quite some time. It's currently running a deficit approaching \$25 billion, it allows homes and buildings to be built in high-risk areas, and it doesn't adequately price premiums. There was a short-lived attempt at reform that passed in 2012, when the Biggert-Waters Flood Insurance Reform Act spurred much-needed rate increases. However, that caused some home prices across coastal regions to plummet, so the rate increases were undone by the Homeowner Flood Insurance Affordability Act of 2014.

The NFIP was set to expire at the end of September, but Congress passed a three-month extension, so the program will continue to flounder along until Dec. 8. This will almost assuredly pile more onto the program's deficit. Many Representatives, including some who are actively working on bills to reform the NFIP, were displeased with the month extension, because it will exacerbate the program's problems even more now that the U.S. has experienced two more major hurricanes since early September.

UPCOMING REFORM EFFORTS

Prior to the extension, there were already bills attracting attention in Congress that aim to reform and extend the NFIP. A bipartisan Senate bill from Mike Crapo (R-ID) and Sherrod Brown (D-OH) has minimal flood-mapping reforms in it, but "excludes privatization of flood insurance and makes no effort to limit federal coverage of properties that continually flood." Contrary to that Senate bill, private insurers believe they can adequately and cost-effectively cover the



Washout. Recent hurricanes have caused millions of dollars in property damage in cities like Houston, leading to constant rebuilding of homes and other structures.

flood insurance market.

In the House, two Louisiana Republicans, Clay Higgins and Mike Johnson, are working with their Senate counterparts on tougher reforms, including rate hikes up to 10 percent, and granting FEMA authority "to terminate contractors that have a track record of abuse."

Rep. Higgins also joined more than 25 Congressional members who sent a letter expressing their dissatisfaction with an existing package of flood insurance bills that have passed the House Financial Services Committee with the assistance of its Chair, Rep. Jeb

Hensarling (R-TX). That package, which would have continued to allow NFIP coverage of new homes constructed in the 100-year floodplain and further grandfathered policyholders even if their risk changed and limited annual rate increased to 6.5 percent, was heavily influenced and then lauded by the National Association of Home Builders (NAHB).

While this would normally be an important story, it has taken on a whole new level of importance after Hurricane Harvey soaked the Texas coastline with multiple feet of rain, Hurricane Irma devastated U.S. territories in the Caribbean and affected most of Florida and parts of Georgia and South Carolina, and Hurricane Maria compounded the Virgin Islands and Puerto Rico's storm damage problems. Rep. Hensarling may have characterized it best when he said, "Shame on Congress if we don't use the time afforded by this short-term extension to pass a long-term reauthorization that offers Americans something better." Whatever is decided in the coming weeks, many—possibly all—Americans will be affected by the outcome. **GB**

Mike Collignon is the executive director and co-founder of the Green Builder Coalition.

COURTESY OF The Green Builder Coalition

The Green Builder Coalition is a not-for-profit association dedicated to amplifying the voice of green builders and professionals, driving advocacy and education for more sustainable homebuilding practices.

For more information, visit GreenBuilderCoalition.org

For more information, contact Executive Director Mike Collignon at mcollignon@greenbuildercoalition.org.

Salt Lake City gears up for new carbon footprint plan

IN LATE AUGUST, the Salt Lake City Council voted in favor of the Energy Benchmarking & Transparency Ordinance. Proposed by Mayor Jackie Biskupski and the City's sustainability department, the ordinance looks to cut energy costs, improve local air quality, and reduce the city's carbon footprint.

This ordinance requires all commercial buildings above 25,000 square feet to benchmark and report their energy consumption to Salt Lake City on an annual basis using the free online Energy Star Portfolio Manager software (with automation services made possible through local utilities Rocky Mountain Power and Dominion Energy). To minimize the burden on buildings, the ordinance will roll out over a staggered timeline:

- Salt Lake City municipal buildings benchmark and report their Energy Star score in 2018. (The City has already started benchmarking.)
- Commercial buildings 50,000 square feet and larger benchmark and report in May 2019
- Commercial buildings 25,000 square feet and larger benchmark and report in May 2020

According to the Salt Lake Sustainability Department (SLSD), the ordinance will save local building owners \$15.8 million in annual energy costs and eliminate more than 29 tons of criteria pollutants from Salt Lake City's air annually.

MORE THAN MANDATORY BUILDING PRACTICES

The new requirement is also supported by incentives and technical assistance. Energy Star-certifiable buildings (those



A steady buildup. Salt Lake City lawmakers recently passed an energy consumption-based building ordinance to cut energy costs, improve air quality and reduce the city's carbon footprint.



A steady buildup. Salt Lake City lawmakers recently passed an energy consumption-based building ordinance to cut energy costs, improve air quality and reduce the city's carbon footprint.

with a score of 75 and higher) will automatically be a contender at the annual Skyline Challenge Awards in July 2018, an event that honors the top energy efficiency leaders in Utah.

In addition to the energy efficiency resources available from local utilities, the ordinance will also create a resource center, housed in the SLSD, to help building managers understand the range of tools and incentives available to voluntarily upgrade equipment to reduce costs and prevent pollution.

IT TOOK A WHILE, BUT...

The elongated time period for passage is due in part to push back from legislators, businesses and The Church of Jesus Christ of Latter-day Saints. The ordinance, as originally proposed, would have published the energy scores of all buildings. It also would have required improvements. Places of worship and tax-exempt buildings were also able to successfully lobby for exemption from the benchmarking requirement.

According to the *Salt Lake Tribune*, the Building Owners and Managers Association of Utah (BOMA) was involved with the legislative process but ultimately remained opposed to the ordinance, staying consistent with its nationwide opposition to such requirements. There is also some concern that the state legislature will nullify this ordinance.

Meanwhile, the City of Salt Lake is moving forward with this increasingly utilized measurement methodology. "This ordinance requires certain buildings to undertake mandatory measurement of their energy use and report it to the City," says SLSD Director Vicki Bennett. "That is all. It's then up to building owners and managers to decide if they want to make voluntary energy efficiency improvements that will save them money. We think they will after seeing the dollars and cents they'll save." **GB**

For more info on the ordinance, please visit www.slcgreen.com/elevatebuildings.

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Building your trust in solar. www.jinkosolar.com

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Panasonic

One Fan—Endless IAQ Solutions <http://us.panasonic.com/ventfans>

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Less Waste. More Hot Water. www.rheem.com/TanklessInnovation

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Schlage

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FROM THE TAILGATE

New Offerings for the Sustainable Minded

By Ron Jones

Time for all builders—and insurers—to embrace a higher standard

WE FIND OURSELVES in a most interesting time for homebuilders.

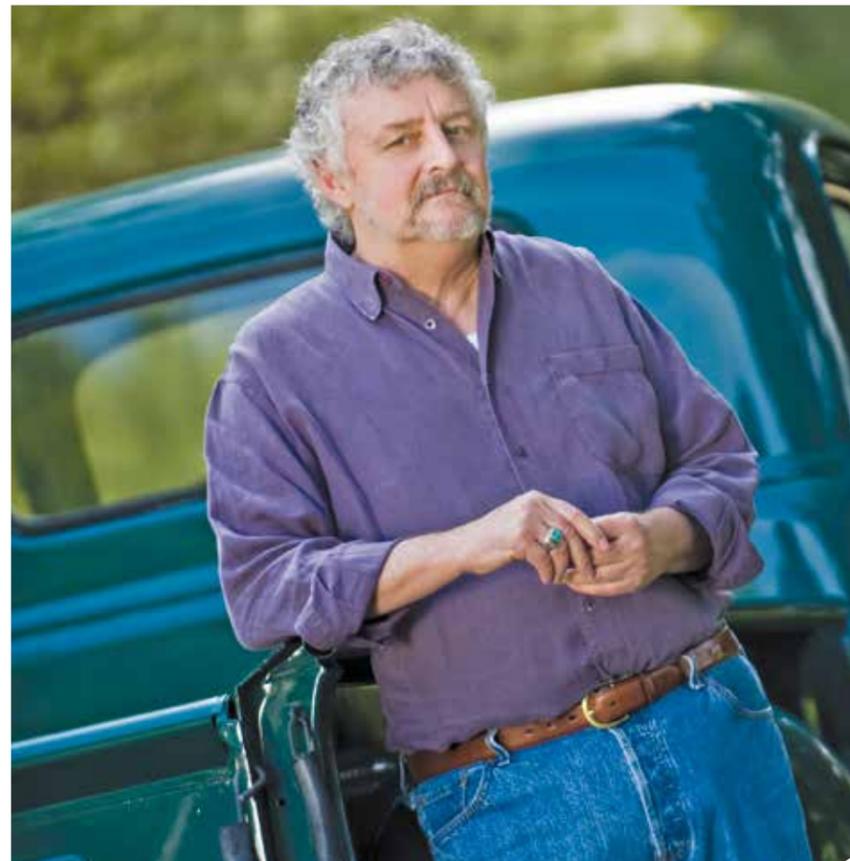
In addition to the persistent challenges surrounding labor scarcities, fluctuating material costs and availability, competition for raw land and finished lots, and regulatory issues that include everything from OSHA's new silica rules to the never-ending squabble over lumber imports, the recent plethora of extreme weather events (and devastating coastal flooding), merciless wildfires in the West that consumed entire communities, and increasing failures of outdated and fragile infrastructure have combined to stress the industry to perhaps unprecedented levels.

By the time this column reaches readers, we should be close to a decision on what the next version of the National Flood Insurance Program (NFIP) will look like and how it will affect the status of existing homes and proposed new construction in flood-prone areas—unless the decision makers back down from the issue and kick that can down the road once again. Additionally, efforts to roll back stricter building codes by some building organizations, especially in the most recently hard-hit regions, are sure to meet strong opposition from those advocating safer, more durable and resilient residential structures across the board.

The insurance and finance industries will surely be powerful players in the outcome of these ongoing struggles, wielding their tremendous influence, though often from behind the scenes. Public officials will continue to attempt to juggle the conflicting demands of multiple constituencies and balance the pressure of special interests with the common good and long-term goals of the residents of their communities.

It is not hard to understand why builders often feel like they are caught in the middle and have lost control of their industry and their own businesses. To some extent, that reaction is justifiable. There is no denying that challenges come from virtually every direction, making it hard to stay on a steady course and even harder to effectively plan ahead.

But there is a lot going for the builder who is up to the challenge as well. The past couple of decades have seen our knowledge of building science and technology matched only by the countless new product solutions and building systems we now have to select from. We are in a position to deliver the highest quality, best performing



housing in history and along with it, unprecedented comfort, safety and value to our customers. This is the one thing we do control, and perhaps it is the most important of all.

In spite of the outside influences and unpredictable hurdles that present themselves, what we have complete ownership of is not the externalities, not the complexities of a dynamic industry, but rather our own ethic. We get to choose for ourselves whether to embrace the highest standards of performance we're capable of. We get to decide how much of that advanced knowledge and improved understanding we're going to apply to our projects.

Often, it seems that many builders and the groups that advocate on their behalf resort to using the challenges and difficulties as alibis for mediocrity; for meeting the minimum requirement. But it doesn't have to be that way, and builders who hold themselves to a higher ethic deliver the proof every day. **GB**

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Team Leader
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