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GREEN BUILDER

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BUILDING SCIENCE UPDATE

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- Sustainable innovations that will transform the building industry
- Social justice issues as they pertain to the built environment on a local, national and global scale
- 2020 Sustainable Development Benchmarks: Where have we succeeded, where have we failed—and we go from here?
- The Built Environment Today: Are we designing and constructing properly for our changing climate and growing social and economic inequity issues?

SPEAKERS:

ANDREW WINSTON, globally recognized expert on how companies can navigate and profit from humanity's biggest challenges, and author of *Green to Gold*, *The Big Pivot*, and *Green Recovery*.

ED MAZRIA, founder of Architecture 2030 and internationally recognized architect, author, educator and visionary with a long and distinguished career.

GENE MYERS, CEO/founder of Thrive Home Builders, six-time winner of the Department of Energy's Grand Award for Innovation, and the first production builder to deliver "solar standard" homes, build net-zero communities, and use Colorado beetle-kill lumber in the construction of its homes.

JAVON JOHNSON, Ph.D. is an Assistant Professor and Director of African American & African Diaspora studies at the University of Nevada, Las Vegas.

KALPANA KOTAGAL is a Civil Rights & Employment Litigation Partner at Cohen Milstein. She is also the co-author of the "Inclusion Rider," and is a highly-accomplished and award-winning plaintiffs' lawyer.

HOME OF THE YEAR AWARDS DINNER : JANUARY 19

Green Builder® Media's annual Home of the Year Awards are recognized as one of the industry's most innovative and important programs that identify authentic, advanced, beautiful and sustainable projects and the professionals who design and construct them.

Green Builder® Media will celebrate our annual Home of the Year Awards winners at a special VIP dinner, held on January 19 at the elegant Zappos Bistro on Zappos Campus.

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EDITOR'S NOTE

The Inside Scoop

By Matt Power
Editor-in-Chief

The All-Electric Home Has Arrived

It's no coincidence that housing's transition from fossil fuel-based heating and appliances to all electric concurs with the dropping per-watt cost of renewable energy.

I READ RECENTLY THAT the city of San Luis Obispo, in Central California, is considering rewriting its building codes to support all-electric living. New homeowners will have to pay extra to install gas appliances, stoves, heater and dryers—and that money will be put toward carbon offsets. The goal is to help the city reach carbon neutrality by 2035.

Sure, it's California, which is always ahead of the curve on energy efficiency. But this shift is well underway across the United States. Why? Several technologies have converged with the need to halt CO_2 emissions. First, electric heat pumps offer a 3-to-1 efficiency upgrade over old, electric-resistance baseboards. Second, hybrid heat pump hot water heaters make electric water heating competitive with gas units. And let's not overlook the unsung hero of home cooking—electric induction tops—which offer many of the same perks once associated with gas. Combine all these efficient devices with the fact that solar panels have achieved price parity with natural gas, and the path of least resistance becomes clear: all-electric living, powered by non-polluting renewables.

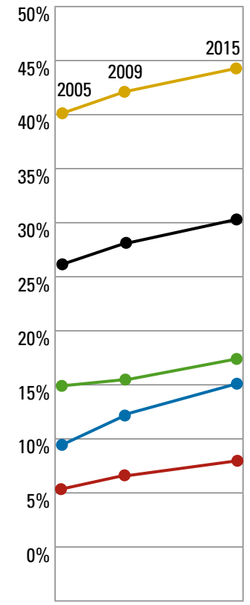
According to U.S. Energy Information Administration (EIA), "From 2005 to 2015, the share of American homes using electricity for their main heating equipment increased from 30 percent to 36 percent, with the share of heated homes using a heat pump increasing from eight percent to 12 percent. At the same time, the share of homes using electricity for their main water heater increased from 39 percent to 46 percent. That rapid adoption has only accelerated over the past couple of years, at least in the U.S.

Manufactured homes have actually outpaced site-built housing in moving toward all-electric living. It's easy to thumb our noses at the *Housing and Urban Development* (*HUD*)- and *American National Standards Institute (*ANSI)-code building sector with their lighter construction standards, but RVs and mobile homes have mastered the application of small, efficient appliances and heating systems. We could study them and learn a thing or two about how to live comfortably without gas heating and cooking.

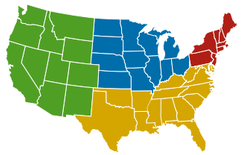
According to EIA, in 2015 single-family detached homes were the least likely to be all electric (18 percent), while mobile homes were the most likely (44 percent). Newer homes were also more likely to be all electric: 35 percent of homes built in 1980 or later used only electricity, compared with 17 percent of homes built earlier.

All-electric homes by census region (2005, 2009, 2015)

Share of all primary residences



SOURCE: U.S. ENERGY INFORMATION ADMINISTRATION



Rapid conversion. As the most recent Census data shows, U.S. homes, especially new ones, are moving rapidly toward all-electric equipment.

One of the holdouts in the single-family category has been gas cooking ranges. I can't tell you how many times I've heard buyers say, "I just like to cook on gas." Most, however, have not tried (or mastered) electric induction cooking. With precise control of heat and efficient (i.e., super-fast) pan heat up, induction also allows you to cook on cast iron again, something difficult on certain older types of electric cooktops.

For U.S. builders and developers, the shift to electric may seem like old news, but for the rest of the world, it's a trend that's just starting. According to the International Energy Agency (IEA), only three percent of the world's buildings have switched to heat pump heating. Perhaps our example of how rapidly a housing technology can shift will inspire and encourage the same fossil-free innovation around the globe. **GB**

Seattle Cascades

VISION House® by Green Builder® Media

Imagine what your house would look like if the greatest minds in sustainability, performance, and design came together to build it – with the goal of remaining within your design parameters and budget.

THE EXPERIENCED PROFESSIONALS at Green Builder Media have joined forces with internationally-acclaimed building scientist and production builder CR Herro (VP Innovation, Meritage Homes) and pioneering green architect Stace McGee (Founder, Environmental Dynamics Inc) to create the VISION House Seattle Cascades: The House the Experts Built.

Located in Enumclaw, WA (the gateway to Mount Rainier National Park) the VISION House Seattle Cascades features the most advanced products, systems, and technologies to achieve extraordinary performance results – all at a reasonable price point. The net-zero, solar powered, high performance, resilient, healthy, and intelligent home boasts stunning design details, an open floor plan, and innovative materials.

Through meticulous planning, space is optimized to significantly reduce material use, jobsite waste, and cost. By deploying advanced building science and superior construction techniques, the home will exemplify resource efficiency and promote occupant well-being.

The result: a simple, replicable template that homeowners and builders can follow, based on decades of experience in the fields of green building, sustainable design, and building science.

FOR MORE INFORMATION:

Look for ongoing editorial coverage about the VISION House Seattle Cascades from Green Builder Media in the coming months. In the meantime, be sure to check out the project microsite at www.greenbuildermedia.com/vision-house-cascades for updated articles, videos, and news about the project.

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Incandescent Bulb Ban Gets the Ax

The Trump Administration's reversal of an energy efficiency lighting requirement is expected to cost Americans $14 billion yearly.

THE TRUMP ADMINISTRATION IS ROLLING BACK energy efficiency standards for light bulbs that would have kept millions of tons of carbon dioxide out of the atmosphere, a move that will "ensure that the choice of how to light homes and businesses is left to the American people, not the federal government," according to U.S. Department of Energy (DOE) Press Secretary Shaylyn Hynes.

DOE's action reverses a requirement initiated in 2017 that three-way, recessed can, candle-shaped and round bulbs switch from incandescent and halogen bulbs be switched to more energy-efficient LED varieties. The requirement would have taken effect in January 2020 and would have impacted bulbs that fill 2.7 billion sockets, nearly half of all nationwide, according to the Natural Resources Defense Council (NRDC).

The DOE also will not update standards for bulbs such as the common pear-shaped variety still included in an efficiency regulation signed by President George W. Bush in 2007. Together, the two decisions will increase U.S. energy bills by $14 billion annually up through 2025 and consume at least 25 power plants worth of energy every year, the NRDC calculated.

NRDC alleges that the rollback is illegal because it violates an "anti-backsliding" provision in the original law that prevents the DOE from weakening standards once they are put in place. But Hynes says the 2007 regulation only mandated that the department issue standards when "economically justified." She maintains that the reversed standards are not.

CREDIT: MARCO VERCH/FLICKR

Executive pardon. Certain incandescent light bulbs, once scheduled to be on the way out by 2020, will instead remain in circulation following action by the Trump Administration.

Berkeley Bids Goodbye to Natural Gas

The city's requirement for all-electric new buildings kicks off in 2020.

BERKELEY, CALIF., has become the nation's first city to require every building built from Jan. 1, 2020 or thereafter to be all-electric. The new ordinance, passed unanimously by the Berkeley City Council, means no gas hookups will be installed in new houses, apartments and commercial buildings. Existing buildings are not affected.

According to a report by NRDC, the action is a major part of the city's effort to reduce reliance upon natural gas, a major pollutant that is currently used to heat 90 percent of the state's homes. Under the ordinance, natural gas may be allowed in new projects if an applicant can show that "it is not physically feasible to construct the building" without it. But the construction must be built so it can be converted to all-electric in the future, the council notes.

Berkeley is not alone in promoting electric homes. More than 50 other California cities, including Los Angeles, San Francisco, San Jose and Santa Monica, are exploring local building codes and ordinances to encourage or require all-electric new construction. This could pave the way for all of California and other states to follow suit, NRDC notes.

CREDIT: NEIL CONWAY/FLICKR

No more natural gas. As of Jan. 1, 2020, Berkeley will be no place for certain natural gas-powered products—the city has passed an ordinance banning gas hookups in all new homes and buildings

A New Type of Environmentally Friendly

'The Recycle House' shows a new way to build a prefab home that's good for nature. All you need is 612,000 plastic bottles.

A PAIR OF NOVA SCOTIAN builders have created a prefab home that resists mold and mildew, can withstand hurricane-force winds and gives a new use for an environmentally deadly product: plastic. Dubbed "The Recycle House," the structure consists of 612,000 recycled plastic bottles that were processed into gas-injected, hardened foam and sandwiched between fiberglass skins to create lightweight composite panels. It's the first such known use of PET foam, according to a report in *Dwell*.

COURTESY OF JD COMPOSITES

Plastic prefab? At first glance, you'd never realize that this prefab home is made of recycled plastic bottles.

Joel German, who with partner David Saulnier co-founded JD Composites to fund construction of the beach house, says they wanted a way to start a business and build responsibly. The Recycle House is also exceptionally strong, with its 8-foot-by-8-foot panels being tested to withstand 326 mph winds—forces twice as strong as that of a Category 5 hurricane. The home exterior is also clad with aluminum and vinyl siding for looks. "Our intent is to further develop the technology so it can be licensed and built all around the world, and we will continue to try different things to bring to various builders," German told *Dwell*. "Many hurricane-prone areas need this product, and we plan on delivering."

Don't expect to see homes of this type in North America soon, he adds. "The building codes [there] need to adapt. It will take some time for them to adjust and learn our technology through testing."

CREDIT: RICHARD ERIKSSON/FLICKR

Net-zero boom. Homes that produce as much energy as they consume continue to become more popular in North America.

Zero-energy residentials continue swift climb

The number of green homes in North America has risen 59 percent in one year.

THE MARKET FOR RESIDENTIAL ZERO-ENERGY BUILDINGS continues to show growth across the United States and Canada, with 59 percent more units in design, construction or operation in 2019 compared to the same period one year earlier. The 22,146 units include single-family and multifamily projects that are working to achieve zero-energy-using or zero-energy-ready performance, according to the *Zero Energy Residential Buildings Study* from Richmond, Calif.-based green construction activist Team Zero.

A zero-energy, or net zero energy building, produces as much renewable energy as it consumes over a year. A net zero-using building is one that will be net zero upon opening; a net zero-ready building can be converted to zero-energy when desired.

The report, produced by the group formerly known as the Net Zero Energy Coalition, also shows a 7.2 percent increase in the number of U.S. projects pursuing zero-energy-using vs. zero-energy-ready status, from 66.6 percent and 21.7 percent in 2017, to 73.8 percent and 29 percent now, respectively. In Canada, there was a 240 percent increase in the number of zero-energy units over 2017. And in that two-year-period, multifamily homes with green energy capabilities have risen to dominant shares in both countries: 67 percent in the United States and 90 percent in Canada. The study is available at https://teamzero.org.

Climate Change Viewed as Huge Problem by Apartment Dwellers

Millennials and Gen Z multifamily building residents show greatest concern over environmental issues.

APARTMENT RESIDENTS ARE INCREASINGLY interested in finding ways to combat climate change and other environmental issues, according to a report by sustainable multi-family properties developer AMLI Residential. The company's third annual Sustainable Living Index projects how apartment dwellers' opinions on environmentalism and green initiatives impact their choices on where to live.

The 2019 survey results revealed nearly 89 percent of AMLI residents are concerned about climate change. More than 70 percent said their desire to find solutions to environmental issues has increased over the last five years. More millennials reported feeling particularly concerned about climate change and expressed a heightened desire for solutions to environmental issues, followed by Gen X, Gen Z and lastly, Baby Boomers.

Millennials were the generation most inclined to pay more for green features, again followed by Gen X, Gen Z, then Baby Boomers. Overall, more than 61 percent of residents responded they would be willing to pay more to live in a sustainable community.

"This year's survey demonstrates that AMLI's residents are increasingly concerned about climate change and the long-term effects of environmental issues," says AMLI Residential President Phil Tague. "Our residents are conscious of how their lifestyle at our communities affects the environment and their health."

CREDIT: TAKVERI/FLICKR

Coming of age. The millennial generation has its eyes on the environment more than any other group—and it also has the loosest pockets when it comes to supporting green causes.

The survey was conducted in July at properties in AMLI's nine markets—Atlanta, Austin, Chicago, Dallas, Denver, Houston, Seattle, Southern California and Southeast Florida. More information can be found at www.amli.org.

LEED's Future Looks Bright

California, Texas lead nation in number of certified, energy-saving homes.

LEADERSHIP IN ENERGY and Environmental Design (LEED)-certified homes are at an all-time high, growing 19 percent since 2017 to reach nearly 500,000 single-family, multifamily and affordable housing units globally and more than 400,000 units in the U.S. The organization's new report, **LEED in Motion: Residential**, also outlines the top 10 states for LEED-certified homes in the U.S., with California at No. 1. The Golden State is home to nearly 40,000 certified residential units, followed by Texas, with more than 24,500, and New York, with nearly 10,900.

LEED, a product of the U.S. Green Building Council (USGBC), encourages design that maximizes indoor fresh air and uses materials that reduce exposure to toxins and pollutants connected to various respiratory issues. The U.S. Environmental Protection Agency (EPA) estimates Americans spend about 90 percent of their time indoors, where pollutants can be two to five times more concentrated than outdoors. There's also an energy-saving component: On average, LEED-certified homes use 20 percent to 30 percent less energy than a traditional home, with some homeowners reporting up to 60 percent savings annually.

COURTESY OF GRAND CANYON NATIONAL PARK

A 'Grand' certification. The Grand Canyon National Park apartment project is the National Park Service's first multi-family housing to receive platinum LEED certification, and the first in Arizona.

"It can be difficult to see why prioritizing a green home is important, but the environmental and personal health outcomes are very real," says USGBC President and CEO Mahesh Ramanujam. "By building and buying green homes, we make those actions easier to do, while also creating a healthier, more sustainable environment for ourselves and future generations."

CREDIT: MOONJAZZ/FLICKR

Blowing in the wind. Renewable energy investors have a long way to go to meet the Paris Agreement's goal of keeping global warming to less than 1.5 degrees by 2100.

Four Times is Not Enough for Renewable Energy

Huge growth in capacity since 2010 is still too little to prevent catastrophic climate change.

RENEWABLE ENERGY CAPACITY quadrupled worldwide over the past 10 years, with an estimated $2.6 trillion invested in its growth, according to a report from the United Nations Environment Programme. But the speed of that growth still falls far short of what researchers say is needed to keep global warming in check.

In 2017 the Paris Agreement set a goal of keeping global warming under 1.5 degrees Celsius by century's end. The Intergovernmental Panel on Climate Change notes that although progress has been made, but the world actually needs to invest an average of $3 trillion to $3.5 trillion annually through 2050. "There is certainly a global shift," says Kathy Hipple, an analyst with the Institute for Energy, Economics and Financial Analysis (IEEFA). "The question is, 'Is it moving fast enough from a climate perspective?' And arguably it's not."

But this finding and others outlined in the report, **Global Trends in Renewable Energy Investment 2019**, gives some hope that the climate can be salvaged, according to Richard Cleetus, policy director for the climate and energy program at the Union of Concerned Scientists. "There's lots to be optimistic about," he notes. "But at the same time we need more."

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ON THE COVER

BUILDING SCIENCE

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A GRAND SYNERGY

CONTENT BY THE U.S. DEPARTMENT OF ENERGY, EDITED BY GREEN BUILDER STAFF

Zero Energy Ready Home award winners succeed at the solo and group levels—a path everyone can follow.

THERE IS STRENGTH IN NUMBERS." It's an old phrase with a simple, logical definition: A group can accomplish more than one person alone. So it goes with the U.S. Department of Energy (DOE)'s Zero Energy Ready Home (ZERH) Housing Innovation Awards winners, selected on the basis of how well they can save energy, resources, time and money.

The winning homes showcased this year in *Green Builder* are all about going green through the power of teamwork. Whether it's a joint effort between contractor, architect and homeowner toward getting a dream house done right, or the combined performance of a subdivision in proving continued energy efficiency, or even how the presence of ZERHs can benefit the local community as a whole, there's a common mantra: One is good. More is better.

In the case of the innovation awards, some of that success is preordained. The ZERH program requires certification to Energy Star Certified Homes Version 3.0 and 3.1, the U.S. Environmental Protection Agency's Indoor airPLUS, the insulation mandates of the 2015 International Energy Conservation Code, and the hot water distribution totals set by EPA's WaterSense program.

Homes must also have solar electric panels installed or have the conduit and electrical panel space in place for future installation of solar panels. And, every home is performance tested by a third-party home energy rater to verify that the requirements have been met: A good number of must-haves for great construction.

Also, a solid blueprint for how others can and have been building their homes to DOE standards. Chad Adams, developer of the winning Revive Properties project in Fort Collins, Colo., sums it up accordingly: "If imitation is the best form of flattery, then I guess we should be proud."

Let's all take pride then, as we keep going green.

Sustainability sentinel. Mantell-Hecathorn Builders' project in Durango, Colo., is among the Grand Winner nominees at the U.S. Department of Energy's Zero Energy Ready Home Housing Innovation Awards ceremony in October.
CHRISTOPHER MARONA PHOTOGRAPHY

Harnessing nature. High Performance Homes' custom Zero Energy Ready Home (ZERH), Rose Acres, uses Mother Nature and Mother Earth to heat, cool and power the residence.
COURTESY OF HIGH PERFORMANCE HOMES

Double Duty

This Maryland project incorporates SIPs to achieve excellent efficiency in a house that also includes two home offices.

BY GREEN BUILDER STAFF

AN EMPTY NESTER COUPLE found everything they needed and more in this custom home built to the exacting standards of the U.S. Department of Energy (DOE)'s Zero Energy Ready Home (ZERH) program in Westminster, Md. The 2018 award-winning home, dubbed Rose Acres by its owners, Suzanne and Dan Swisher, provides 4,270 square feet of living space, including two bedrooms plus his-and-her offices for the work-from-home couple; a great room, breakfast room, dining room, kitchen and bathrooms on the main floor with full wheelchair accessibility; a second-story loft; a hot tub; a complete two-bedroom mother-in-law apartment in the daylight basement; and beautiful views of the surrounding countryside—all at energy bills of less than $50 per month.

"After having outrageously high energy costs over the past several years, we now look forward each month to seeing how small our utility bills are," say the homeowners.

The couple adds that it is enjoying various ZERH creature comforts, such as its geothermal heat pump, R-value, airtight Structural Insulated Panel (SIP) construction, and insulated concrete foundation walls. The home "effortlessly maintains even temperatures throughout, while delivering super clean air."

The homeowners also sing the praises of their builder, Kiere DeGrandchamp, who launched High Performance Homes in Gettysburg, Pa., in 2014. DeGrandchamp builds up to 10 custom or semi-custom homes per year, all of which are certified to the DOE ZERH program. "The program encapsulates everything we try to achieve—a quality built home that is livable, efficient, healthy and environmentally friendly," DeGrandchamp says.

PRECAST BELOW, SIPS ABOVE

Rose Acres is a one-and-a-half-story home with a walk-out basement. High Performance Homes constructed the below-grade walls of precast concrete panels with an integrated R-21 of rigid foam and integral metal-faced foam-insulated concrete studs. The panels were installed on site; then, two inches of rigid extruded polystyrene (XPS) foam was laid down to provide an R-10 insulation layer under the entire poured concrete basement slab.

The above-grade walls were constructed of 6.5-inch R-23 SIPs,

Lighting up. The home's open floorplan allows for extensive natural lighting through south-facing dual-pane windows.
COURTESY OF HIGH PERFORMANCE HOMES

> "There is an expected level of expertise to be a part of one of our projects."–Kiere DeGrandchamp, High Performance Homes

which provide an R-30 insulation value. The sturdy panels, which consist of two sheets of Oriented Strand Board (OSB) sandwiching a layer of rigid expanded polystyrene foam, come to the site pre-cut for fast assembly with no construction waste. The solid panels block air flow and resist movement in high winds, while the continuous layer of rigid foam stops heat transfer through the walls.

Around the perimeter of the first-floor bands, a 4.5-inch-thick SIP wall was installed to eliminate any thermal bridging and provide an R-15 insulation value. The bands were sealed with one inch of closed-cell spray foam and further insulated with an R-19 batt between the floor joists. The entire assembly nets an R value close to R-30. Every crack and joint was sealed using low-expansion foam and caulk. The SIP panels were covered with house wrap plus tar paper behind the diamond lath on any areas

to be clad with stone. The remainder of the house was clad with vinyl siding per manufacturer's instructions. At the wood-to-foundation transition, weep screed was installed to help ensure proper drainage.

COURTESY OF HIGH PERFORMANCE HOMES

Down sized. Energy-efficient appliances and fixtures throughout the house, such as the microwave, are at a height suitable for one of the home's owners, who is in a wheelchair.

TIGHT SHIP

Builder Kiere DeGrandchamp leaves little to chance when planning and organizing a project of this complexity

ON ALL OF HIS HOMES, to help ensure that the details specified in the plans get implemented during actual construction, Kiere DeGrandchamp holds individual meetings with all of the trade supervisors, as well as pre-construction meetings with teams that could include the excavator, framer, plumber, electrician and HVAC geothermal contractor. "By the time the framer arrives, the team already knows where all of the utilities will be located, which reduces confusion and duplication of efforts," says DeGrandchamp. "We work with the same crews consistently. There is an expected level of expertise to be a part of one of our projects."

By working with the same teams over and over, the company minimizes the need to retrain or to explain modifications from the typical building process, he adds.

According to DOE, to qualify a home to this program, the owner must be forward-thinking, creative, detailed, striving for improvement and "seeking repetitive, predicted performance results." The DOE ZERH program educates builders to improve their techniques to reach such standards, and the program creates the opportunity for participants to learn from each other.

The webinars, seminars, conferences, materials available online and supportive DOE staff have created an environment of learning, DeGrandchamp notes.

"We really like the fact that we can reach out to other builders in this program and discuss best practices or successes they have posted on their social media pages," he says. "We feel it is more of a community than a program."

OTHER INSULATING DETAILS

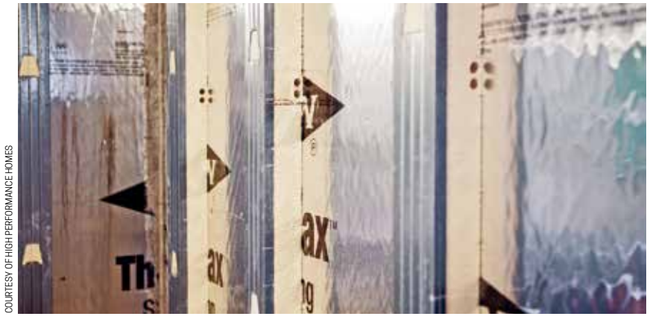
The vented attic was insulated and air sealed along the entire ceiling deck with one inch of closed-cell spray foam and R-49 blown fiberglass for a total insulation value of about R-53. The attic has full ridge and soffit vents. The lifetime-warrantied roofing shingles were applied over 15-pound felt. The eaves, valleys and gables all have ice-and-water shielding that extends 12 inches past the interior plane of the walls. The builder used kick-out flashing and five-inch sidewall flashing to help keep water out of the walls. All of the downspouts are connected to pipe to carry runoff 10 feet away from the foundation, with pop-ups for overflow.

High Performance Homes installed double-pane Energy Star®-rated windows with low-emissivity coatings, and an argon fill with an insulation U-factor of 0.25 and a solar heat gain coefficient (SHGC) of 0.29.

The tight home was tested per DOE ZERH requirements and showed air leakage of only 1.1 air changes per hour at 50 Pascals, which is more than twice as tight as required by the 2015 International Energy Conservation Code. To provide good ventilation for the home, DeGrandchamp installed a system that employs a fresh air intake, exhaust with timer and controlled smart switch venting that calculates the makeup air needed and opens the fresh air damper when needed to provide balanced fresh air.

GEOTHERMAL PERKS

The home is heated and cooled with an ultra-efficient ground-source heat pump. The closed-loop horizontal ground-source heat pump draws heat from the ground in the winter and sheds heat to the ground in the summer. The heat pump has a heating efficiency of 5.3 Coefficient of Performance (COP) and a cooling energy efficiency ratio (EER) of 24.4, or seasonal energy efficiency ratio (SEER) of 27.4. All of the ducts are located within the conditioned space of the home.



COURTESY OF HIGH PERFORMANCE HOMES

Heat shield. Airtight Structural Insulated Panel (SIP) construction, insulated concrete foundation walls and a continuous layer of rigid foam help bring the home's energy bill to a monthly average of a mere $49.

COURTESY OF HIGH PERFORMANCE HOMES

Top side. Highly efficient photovoltaic shingles blend in and help the home achieve a Home Energy Rating System (HERS) score of 35.

The ground-source heat pump also helps provide domestic hot water via a desuperheater. The unit supplies hot water to a 55-gallon storage tank plus a 0.91-energy-factor (EF) 55-gallon electric water heater. A push-button-activated hot water recirculation pump and low-flow fixtures help reduce hot water usage.

The highly efficient home achieves a Home Energy Rating System (HERS) score of 35, far below the 80 to 100 of typical code construction. With the addition of a 5.94-kW solar system, the HERS score drops to 14 and annual energy bills drop from an estimated $1,290 per year to $585 per year, or $49 per month. To minimize the visual impact of the roof-mounted photovoltaic (PV) array, the builder selected PV shingles rather than panels. The shingles are similar in dimension to roofing shingles and actually take the place of some of them, for a profile that blends in.

ADJUSTMENTS FOR AGING IN PLACE

One of the unique aspects of the project for DeGrandchamp was the design. The home owners, one of whom is a Realtor, wanted it to look good and be very energy efficient. It also needed to be handicapped accessible, as Dan is wheelchair bound. The homeowners already owned the land and had plans drawn by an architect when they contacted DeGrandchamp. "Once we were contracted to build the home, we made engineering changes to accommodate the [DOE Zero Energy Ready Home] principles, plus make the home accessible for the handicapped homeowner," DeGrandchamp says.

To facilitate the design process, DeGrandchamp set up three formal meetings with the homeowners, in addition to many informal meetings. "To improve accessibility and to keep the home as energy efficient as possible, we wanted to make sure we were not missing out on any detail that could improve the homeowner's ease and convenience when living and working in his home," he notes.

Among the changes DeGrandchamp made to improve accessibility were selecting and installing appliances that could be accessed from wheelchair height, designing the kitchen and master baths with roll-under sinks and counter tops, installing a wheelchair-friendly shower, adjusting the height of the electrical outlets and switches, relocating the electrical box from the basement to the main floor, and moving the solar inverters from the basement to the garage for accessibility. Other changes included designing zero-entry thresholds for the front door and garage entrance to the home, and installing a wheelchair-accessible path to the basement entrance.

To improve energy efficiency, DeGrandchamp re-engineered the wall system to accommodate SIPs and other insulation improvements, moved a set of outside stairs that led to a room above the garage into conditioned space, and added insulation under the basement slab. He also adjusted the home's orientation on the site to maximize beneficial solar gain through the oversized south-facing windows. The eaves were extended to minimize overheating from high summer sun. GB

KEY FEATURES

DOE ZERO ENERGY READY HOME PATH: Performance.

WALLS: 6.5-inch R-23 Structural Insulated Panels (SIPs); house wrap; stone and vinyl siding; 4.5-inch SIPs; one-inch closed-cell spray foam plus R-19 batt at rim joists. All joints caulked.

ROOF: Asphalt shingles, 15-pound felt; all eaves, gables and valleys have ice-and-water shield; kick-out flashing; five-inch sidewall flashing.

ATTIC: Vented attic, one-inch closed-cell foam sprayed on ceiling deck plus R-49 blown fiberglass equals R-56 total.

FOUNDATION: Basement of R-21.3 insulated concrete panel walls; R-10 under slab.

WINDOWS: Double-pane, single-hung, low-e, argon-filled, U equals 0.24, SHGC equals 0.17.

AIR SEALING: 1.1 ACH 50.

VENTILATION: Controlled smart switch venting system that calculates makeup air; fresh air intake; timered exhaust.

HVAC: Ground-source heat pump, 5.3 COP, 24.4 EER, 27.4 SEER; mastic-sealed ducts.

HOT WATER: 55-gallon desuperheater, +0.91 EF 55-gallon electric tank water heater. Push button recirculation pump.

LIGHTING: 100 percent LED or CFL; all Energy Star® fixtures.

APPLIANCES: All Energy Star®.

SOLAR: 5.94-kW PV system.

WATER CONSERVATION: Low-flow fixtures; recirculation pump. Native landscaping.

ENERGY MANAGEMENT SYSTEM: Energy management system.

OTHER: Low- or no-VOC products; motion-sensor garage exhaust fan; ADA accessible.

High expectations. A host of energy efficiency features ranging from solar panels to hygrothermic modeling help make Thrive Home Builders ZEN 2.0 Collection net zero, with Home Energy Rating System (HERS) ratings as low as 4.0.
COURTESY OF THRIVE HOME BUILDERS

The Zen Imperative

Thrive's latest collection of net-zero homes takes building science and planning to a new level.

BY GREEN BUILDER STAFF

THE 41 HOMES THAT MAKE UP Thrive Home Builders' ZEN 2.0 Collection at the redeveloped Stapleton Airport site in northeast Denver are all net-zero energy, thanks to the solar photovoltaic arrays on each home, and a host of energy efficiency and high performance home features.

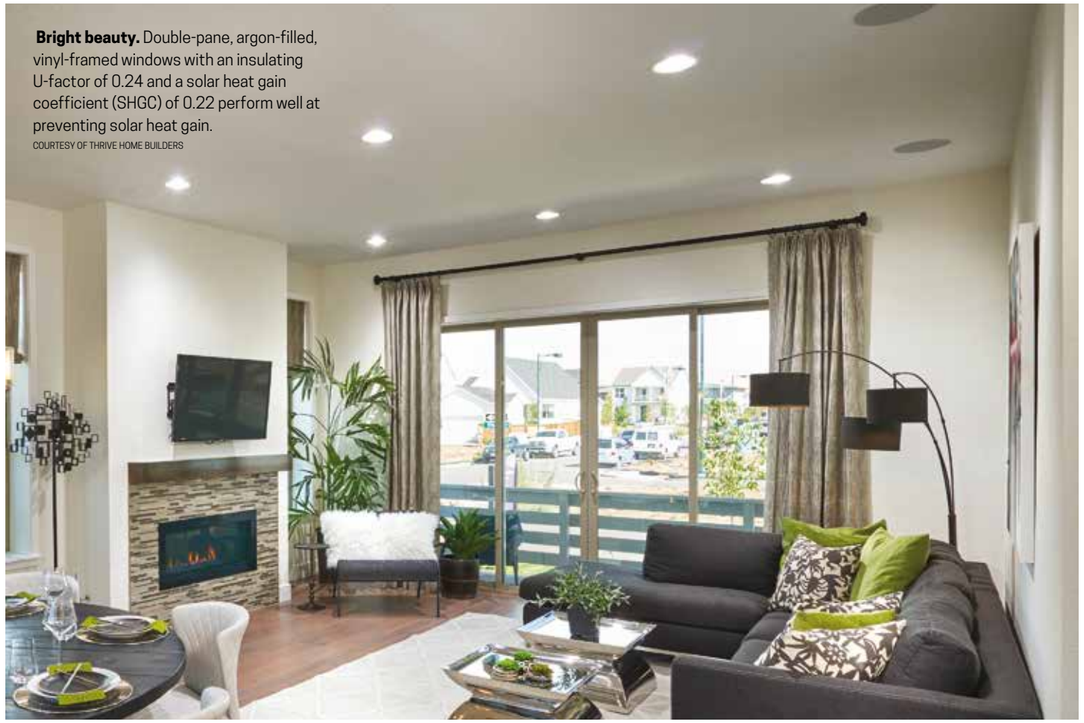
Like every home Thrive builds, these homes were constructed to the criteria of the ZERH program.

Thrive has taken the extra step of installing a 7.93-kW solar PV system, as well as an energy storage system. All of the ZEN 2.0 collection units come with enough solar panels to achieve a Home Energy Rating System (HERS) score of 15 or less (Thrive's winning home here has a calculated HERS score of 4). Even without the PV system, the energy-efficient home would achieve a HERS score of 38.

DOUBLE-WALL DESIGN

The traditional farmhouse style of the home with its simple gable roofs, front porches, and lap siding belies the sophisticated energy-efficiency technology inside. Thrive used WUFI® hygrothermic modeling to come up with a wall design that would provide walls with a total insulation value of R-40 with low risk of moisture accumulation. Thrive chose double-wall construction consisting of two 2-by-4, 24-inch on-center walls with staggered studs. The walls were spaced 2.5 inches apart to provide a 9.5-inch-deep wall cavity. After installing half-inch OSB sheathing, crews sealed all seams with a sprayer-applied sealant and sprayed sealant along the top and bottom plates, before attaching drywall to form airtight gaskets. Then, the wall cavities were filled with blown fiberglass. Textured house wrap provided a drainage plane behind the fiber cement and brick veneer siding.

The home's vented attic was constructed with 14-inch raised heel trusses to allow space for the full depth of insulation over the eaves. All of the top plates were air sealed with a sprayer-applied sealant before installing the R-50 of blown fiberglass. The roof was protected with ice-and-water shield at all valleys and from the eaves up 24 inches past the wall line. The deck was covered with a synthetic water-resistant underlayment and metal drip edge was installed under the asphalt shingles.



Bright beauty. Double-pane, argon-filled, vinyl-framed windows with an insulating U-factor of 0.24 and a solar heat gain coefficient (SHGC) of 0.22 perform well at preventing solar heat gain.
COURTESY OF THRIVE HOME BUILDERS

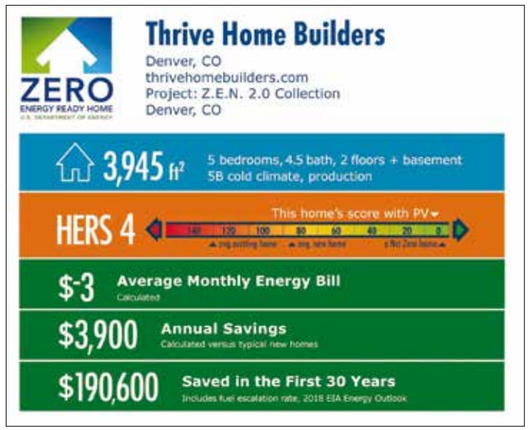
> "This information provides a better understanding of energy use and is a tool homeowners can use to track how behavioral changes can improve the home's overall efficiency while reducing energy costs."
> –Bill Rectanus, Thrive Home Builders

BELOW-GRADE BONUS SPACE

The homes in the community have basements with concrete slab floors and 8.75-foot-tall basement walls to accommodate optional or future basement finishing. Underneath the slab is a 6-mil vapor and radon barrier that is sealed to the foundation with polyurethane sealant. Beneath the barrier is a four-inch-thick layer of 0.75-inch rock over compacted soil.

As an added measure of protection, the builder installed an active radon venting system that consists of a four-inch perforated plastic pipe installed along the inside perimeter of the foundation walls to collect soil gases under the slab. These are vented through the roof by a four-inch stack pipe that is equipped with an inline exhaust fan.

Due to expansive soil requirements, the exterior basement walls are hung from the floor joists above. These walls have a minimum



three-inch gap from the slab and are anchored to pressure-treated lumber with six-inch nails to allow for expansion of the soil without affecting the structure. The walls are insulated with unfaced fiberglass batts providing an R-15 insulative barrier that protects the home from heat loss through the foundation.

THRIVE'S SECRET SAUCE

The widely respected building firm's comprehensive in-house quality management program includes an internal quality assurance department.

THRIVE HOME BUILDERS didn't stumble into success. The company works tirelessly to stay way ahead of the curve, including continuous improvement across all departments: construction, purchasing, architecture, warranty, vendor-partner relations and more. With its trade partners, Thrive uses highly detailed project specifications, scopes of work, a construction project management software to track costs and deadlines, checklists with numerous checkpoints embedded into the construction schedule, and an active feedback process to solicit feedback from trades.

Thrive also conducts frequent training sessions, including its monthly all-hands "Huddle" meetings and weekly "Building Science 101" classes covering construction details, safety and sales. Thrive often brings in vendors to conduct on-site training in new technologies.

The third-party evaluations that certification programs like DOE's ZERH program, Energy Star®, and EPA's Indoor airPLUS requirement are a further quality assurance check and validation of the homes' high performance.

Thrive also focuses on educating home buyers on the benefits of zero energy construction. Thrive has set up Building Science Centers at nearly every community, where it builds to explain the energy-efficiency and health benefits of its homes. The builder also offers "meet your neighbor" nights giving new home owners a chance to socialize and learn more about their high-performance homes.

Thrive Home Builders also provides home owners with a one-year limited warranty that includes a 90-day and 11-month warranty review and emergency care, as needed. Customer service coordinators follow up with the home buyers at 48 hours, two weeks, 90 days, and 11 months after closing to address any issues. Thrive implemented an online punch list manager program that provides buyers with an easy way to submit their warranty requests and for Thrive to reach out to homeowners with maintenance reminders.

FINE-TUNED HVAC AND HOT WATER

Most of the home's heating and cooling is provided by a very efficient heat pump with heating seasonal performance factor (HSPF) of 12.2 and a seasonal energy efficiency ratio (SEER) of 18.9. A highly efficient 97.4 AFUE gas furnace provides back-up heat. All of the mechanical equipment is located in the conditioned basement. A MERV 15 air purifier is included in every home for enhanced air filtration. This and other measures, such as a continually operating energy recovery ventilator (ERV) with a MERV 6 filter, low- and no-VOC paints and finishes, VOC-absorbing drywall, and moisture-resistant construction practices reduce the likelihood of mold formation and help maintain good indoor air quality in the home, which is certified to the EPA Indoor airPLUS criteria.

The HVAC system's metal supply and return ducts are located completely within the conditioned space of the home and are sealed with mastic. The ducts were tested for air tightness by a third-party energy rater as required by the DOE ZERH program and showed zero leakage to the outside. The tightly air sealed home was also tested for overall air leakage and had a leakage rating of only 1.77 air changes per hour at 50 Pascals pressure difference.

Continuous hot water is supplied to the home by a 0.97 efficiency factor (EF) tankless gas water heater. The water heater is plumbed with a recirculation loop, which uses "intelligent" technology that recognizes usage patterns to have hot water ready for delivery during high use periods, thus reducing wait times and wasted water. Thrive equipped all of the Z.E.N. 2.0 homes with EPA WaterSense-labeled plumbing fixtures for water savings inside while outside the homes are landscaped with drought-tolerant, climate-specific plants that are irrigated with ground-level drip irrigation to minimize evaporation and reduce overall water usage.

COURTESY OF THRIVE HOME BUILDERS

Solar ready. Every home in the ZEN 2.0 Collection comes with a high-efficiency solar energy system to offset electricity consumption and nearly eliminate electric bills.

COURTESY OF THRIVE HOME BUILDERS

Good housekeeping. Energy Star®-rated appliances and EPA WaterSense-labeled plumbing fixtures, from tankless water heaters to all-LED lighting, add to energy and water savings.

For additional energy savings, the home is equipped with Energy Star® double-pane, argon-filled, vinyl-framed windows with an insulating U-factor of 0.24 and a solar heat gain coefficient (SHGC) of 0.22, meaning the windows perform well at preventing solar heat gain. Energy Star® appliances and 100 percent LED lighting add to energy savings.

SMART FEATURES

Every Thrive home is provided with its own internet-based live monitoring system that tracks the home's solar system production and overall electric consumption. "This information provides a better understanding of energy use and is a tool homeowners can use to track how behavioral changes can improve the home's overall efficiency while reducing energy costs," says Bill Rectanus, vice president of operations for Thrive Home Builders. Rectanus also notes that every ZEN home is equipped with a Tesla *Powerwall* energy storage system that integrates with solar to power the home in the event of a power outage.

Rectanus points out that while nationwide in 2017 new homes averaged 62 on the HERS index, Thrive Home Builders' single-family homes averaged HERS 28, and its multifamily homes averaged HERS 48. "Thrive successfully differentiates ourselves from the competition with our Zero Energy Ready construction techniques," says Rectanus. The industry has recognized Thrive Home Builders' efforts in housing innovation and energy efficiency. Thrive also won a Green Home of the Year Award from *Green Builder* magazine in 2019.

Thrive Home Builders' consistently low HERS scores and high performance gave the builder the confidence to offer homeowners a two-year built-in savings guarantee. If the total energy costs exceed the predicted amount over a 12-month period, the difference will be refunded to the homeowner. "Energy bills are locked in at the original estimate, even if the cost of energy increases, college students return home, or there is an extremely hot or cold season," says Rectanus. GB

KEY FEATURES

DOE ZERO ENERGY READY HOME PATH: Performance.

WALLS: Double walls, staggered studs at 24 inches, 2.5-inch space between walls, two-stud open corners, right-sized window headers, open framed wall intersections; R-40.7 total wall, closed-cell spray foam, drywall, 0.5-inch OSB sheathing, house wrap, fiber cement siding.

ROOF: Ice-and-water shield; waterproof underlayment; metal drip edge; 30-year asphalt shingles.

ATTIC: Vented attic, R-50 blown-in fiberglass.

FOUNDATION: Unfinished basement with R-15 unfaced batts.

WINDOWS: Double-pane, argon-filled, vinyl frames, U=0.24, SHGC=0.22.

AIR SEALING: 2.29 ACH 50.

VENTILATION: ERV, balanced, meets ASHRAE 62.2, MERV 6 filter on ERV, MERV 15 filter on air purifier.

HVAC: Heat pump, SEER 18.9, 12.2 HSPF; 97.4 percent AFUE gas back-up furnace.

HOT WATER: Tankless gas water heater with smart recirculation pump, 0.97 EF.

LIGHTING: 100 percent LED.

APPLIANCES: Energy Star®-rated refrigerator, dishwasher and exhaust fans.

SOLAR: 7.93-kW PV system.

WATER CONSERVATION: WaterSense fixtures, drought-tolerant and climate-specific species, drip irrigation.

ENERGY MANAGEMENT SYSTEM: Battery storage.

OTHER: Low-VOC paints, low-formaldehyde wood, active radon mitigation, two electric vehicle charging stations.

Power miser. When it comes to energy use, all Revive Fort Collins homes are ultra efficient, earning Home Energy Rating System (HERS) ratings of 2 or less in 2018.
COURTESY OF REVIVE PROPERTIES

Energizing the Neighborhood

A carefully planned design means a real 'Revival' for this multifamily project.

BY GREEN BUILDER STAFF

HOMES BUILT TO the U.S. Department of Energy (DOE)'s Zero Energy Ready Home (ZERH) criteria can save energy and cut costs for homeowners. They've also been known to provide a more comfortable, quieter living experience. And, in Fort Collins, Colo., they may just be helping to spark a neighborhood revival.

Susan McFaddin, development consultant and broker for Revive Properties, LLC, certainly believes that's the case. She notes that a former assistant city manager who visited the Revive Fort Collins project praises Revive Properties and its development partner, Philgreen Construction, for the way the ZERH community has revitalized North College Avenue.

The two firms collaborated on Revive Fort Collins to construct 37 townhouses and 18 single-family homes with attached apartments on a 10-acre site on the north side of Fort Collins. The property is located in an urban renewal district just north of a trailer park. "The property was in an undesirable location, and the development had been unsuccessful under a previous developer," McFaddin says.

Now, there is a large grocery store and shopping area within a quarter mile. A new movie theatre and restaurant were recently built within a half mile, and other businesses and cultural centers are coming to this urban renewal district and revitalizing this part of town. "Revive is known as a catalyst for the revitalization," she notes.

BETTER BUILDINGS

What differentiates Revive from all other developers is the fact it only sells zero-energy homes, says McFaddin. All homes had Home Energy Rating System (HERS) ratings of 2 or less in 2018; the lowest was negative 11.

Solar is not optional. "We sell our solar to buyers at cost, which is about half of what most builders charge," McFaddin says. "Other builders make photovoltaic an option, and many home buyers choose to avoid the extra cost. [But] rather than incentivizing lots, finishes, etc., as some builders do, we incentivize the PV, which we believe to be the most beneficial to the buyer and society."

The DOE ZERH construction has attracted positive attention for the builder. In 2017 Revive was the Greenest Home award from

Sustainable fortune. Monthly electric bills drop from several hundred dollars to a mere $14 with the use of energy efficient appliances, lighting and other green tools.
COURTESY OF REVIVE PROPERTIES

> "Many of our home buyers regard these homes as the future of home building. They've told us the energy-efficient construction is an expression of their core beliefs."
> –Susan McFaddin, Revive Properties LLC

the Northern Colorado Home Builders Association (HBA) Parade of Homes. Several positive articles by local media also didn't hurt. "These helped create a very favorable public perception," says McFaddin. "The day after one such article, there was a stream of Priuses going down our back alley."

The development is used as a research project for several elements of the City of Fort Collins, including the Utilities Design Assistance Program and the Green Building Program. "Elected officials, including a former mayor, a city councilman and a member of the Colorado House of Representatives, have all inquired about living in our community," says McFaddin.

Success has proven contagious. "Two new zero energy home projects are planned in our city and both refer to our development as the catalyst for their developments going zero energy," says Chad Adams, Revive's owner and developer. "If imitation is the best form of flattery, then I guess we should be proud."

COURTESY OF REVIVE PROPERTIES

All-star appliances. Refrigerators and dishwashers are Energy Star® rated, while all lighting comes from LEDs and strategically placed windows.

balconies and vaulted ceilings on the third floors to maximize daylighting.

The home's concrete foundation slabs are left exposed and polished to serve as the flooring for the first floors. The slabs are insulated with R-10 of closed-cell spray foam under the slabs and R-10 of rigid polystyrene wrapping the slab edges.

The above-grade walls are constructed with 2-by-4s, staggered on 2-by-6 top and bottom plates, allowing the R-23 of blown-in fiberglass insulation to wrap around the sides of the studs to minimize thermal bridging (or heat transfer) through the walls. The party walls between units are insulated with blown-in cellulose for an R-value of 13. The rim joists are insulated with R-2 of open-cell spray foam.

The vaulted ceilings are filled with R-50 of open-cell spray foam. The roof decking of 7⁄16-inch Oriented Strand Board (OSB) is covered with ice-and-water shield. Drip-edge flashing is installed along the eaves and the roof is topped with Class 4 asphalt shingles.

EAGER BUYERS

According to McFaddin, Revive Fort Collins is highly desired due to the homes' efficiency, and for their beauty and comfort. All duplexes and entry-level townhomes are sold; four recently released townhomes went immediately under contract at the excavation phase. "Many of our home buyers regard these homes as the future of home building," McFaddin says. "They've told us the energy-efficient construction is an expression of their core beliefs. Our buyers are mainly environmentally conscious early adopters."

Revive also attracts many buyers who want control over their future energy bills and who care about the quality of construction, McFaddin adds. "Our energy bill data has, in fact, been the major selling point," she says. "Most people have never seen negative energy bills—a benefit a number of our residents enjoy because of net metering." Energy bills are expected to average about $4 per month for owners of the 1,533-square-foot townhomes.

In addition, ZERH program homes are required to have solar electric panels installed or have the conduit and electrical panel space in place for it. All Revive Fort Collins townhomes include installation of solar photovoltaic panels. A typical unit, which won a DOE Housing Innovation Award in 2018, had a 6.4-kW PV system installed on the roof.

COURTESY OF REVIVE PROPERTIES

Wet wisdom. Water conservation features such as dual-flush toilets reduce water use inside the home and for the Fort Collins community as a whole.

BEST PRACTICES: TOWNHOMES

The townhouse units are 1,533 square feet, and have two bedrooms, and two full and two half baths. All units are three stories, with patios,

COURTESY OF REVIVE PROPERTIES

Building blocks. Closed cell spray foam between joists and elsewhere is among the product used to control the flow of hot and cool temperatures through the walls and floors.

All windows are double-paned and vinyl framed with low-emissivity coatings to block heat transfer, and an insulating argon gas fill between the panes. The windows have an insulation U-factor of 0.29 and a solar heat gain coefficient of 0.22.

All homes in the DOE ZERH program are third-party tested. The Innovation Award winner was blower door tested and showed an airtightness of two air changes per hour at 50 Pascals pressure difference (ACH 50).

Units are heated and cooled with a ground-source heat pump with a heating coefficient of performance of 3.6 Coefficient of Performance (COP) and a cooling energy efficiency ratio (EER) of 18.

The refrigerators and dishwashers are Energy Star® rated, and Energy Star® ceiling fans are included in many of the rooms. All lighting is supplied by LEDs, and strategically placed windows provide daylighting even in closets, bathrooms and garages. Significant energy modeling was done to maximize daylighting while reducing heat loss and uncontrolled solar gain, according to Adams.

A heat pump water heater supplies the home's hot water with an efficiency of 3.42 EF. Water conservation features, such as dual-flush toilets and EPA WaterSense-compliant hot water distribution, including a recirculation pump to the top-floor bathrooms, reduce water use inside the home, while landscaping incorporates low-water-use plants outside.

All townhomes are sold with PV panels installed and the garages are pre-wired for electric car charging stations.

INHERITED SITING

The lots and streets had been plotted by a previous developer before Revive Fort Collins took over the site so the builder didn't have complete control over building orientation on the lots. Ultimately, they were still able to achieve considerable energy savings. "The greatest lesson we learned in this is that you don't need the optimum solar orientation to achieve net zero—just a combination of good windows, insulation, air sealing and solar," says McFaddin.

The winning home achieved a HERS index of 42 without PV, which is far better than the typical HERS score of 80 to 100 for new homes built to code across the country. When the solar energy production is included in the calculation, the townhome's HERS score drops to a negative 8. The winning unit had a calculated annual energy bill of $50 and estimated annual energy savings of $1,850, when compared to a home built to the state energy code equivalent, the 2012 IECC.

But energy savings aren't the only benefit to homeowners. "Home owners I talk to are very impressed with the comfort," says McFaddin. "They're very quiet houses. They work really well and I think it goes without saying that meeting EPA's Indoor airPLUS and WaterSense makes them healthy, too. Those things go hand in hand with energy efficiency." GB

KEY FEATURES

DOE ZERO ENERGY READY HOME PATH: Performance.

WALLS: 2-by-6 advanced framed, R-23 blown-in fiberglass in exterior walls; R-13 blown-in cellulose in party walls. R-20 open-cell spray foam in rim joists.

ROOF: 7⁄16-inch OSB sheathing, ice-and-water shield, drip edge, asphalt shingles.

ATTIC: R-50, open-cell spray foam on underside of roof deck, unvented.

FOUNDATION: R-10 EPS at slab edge, R-10 EPS under slab.

WINDOWS: Double-pane, vinyl-framed, low-e, argon-filled, U=0.29, SHGC=0.22.

AIR SEALING: 2.0 ACH 50.

VENTILATION: Exhaust fans, 92 cfm, 15 watts.

HVAC: Ground-source heat pump, 3.6 COP, 18.1 EER.

HOT WATER: Air-source heat pump 50-gallon water heater, 3.42 EF.

LIGHTING: 100 percent LED, two Energy Star®-rated ceiling fans.

APPLIANCES: Energy Star® refrigerator, dishwasher, clothes washer, and clothes dryer.

SOLAR: 6.4-kW PV system.

WATER CONSERVATION: Dual-flush toilets, recirculation pump.

ENERGY MANAGEMENT SYSTEM: Smart thermostat.

OTHER: Prewired for electric car charging stations. Low-VOC paint. Daylighting.

Power house. Thrive homes, constructed to the Department of Energy's Zero Energy Ready Home (ZERH) program criteria, are highly energy-efficient, solar-ready and well within insulation requirements of the 2015 International Energy Conservation Code.
COURTESY OF THRIVE HOME BUILDERS

Nothing Left to Chance

Every detail of this high-performance project demonstrates carefully planned and executed planning and product selection.

BY GREEN BUILDER STAFF

ZERO ENERGY CONSTRUCTION is front and center at the Lowry site in Denver, where Thrive Home Builders has constructed 34 single-family homes to the high energy-efficiency criteria of the U.S. Department of Energy (DOE)'s Zero Energy Ready Home (ZERH) program.

All 34 homes are expected to perform as zero energy homes—a home that makes as much energy as it uses—offering owners $0 in energy costs over the course of a year. DOE selected one of the 34 homes as a winner in its 2017 Housing Innovation Awards. The winning home achieved a calculated Home Energy Rating System (HERS) score of 4, with projected annual energy costs of negative $11 per year.

This home, like all 34 of the homes at Lowry, and like every home Thrive builds, is constructed to the DOE ZERH program criteria, providing a highly energy-efficient, solar-ready home.

The single-family detached homes at Lowry feature a modern style with large mono-truss or simple gable roofs to accommodate solar panels. The 40-foot lot widths in this urban Denver setting required some creativity to incorporate master bedrooms on the main floor along with a kitchen, dining and living area. Thrive came up with Z-shaped lots where homes touch lot lines and connect around courtyards. Tall ceilings add a feeling of spaciousness while finished basements increase square footage. This unit is 4,119 square feet, with four bedrooms, 4.5 baths and two floors above grade.

CLIMATE SPECIFIC DESIGN

To achieve the high energy-efficiency requirements in this cold climate location, Thrive used WUFI® hygrothermic modeling to come up with a wall design that provides a high wall insulation value of R-40 with a low risk of moisture accumulation. Thrive chose double-wall construction consisting of two 2-by-4, 24-inch on-center walls with staggered studs. The walls were spaced 2.5 inches apart to provide a 9.5-inch-deep wall cavity. Crews installed 0.5-inch sheathing and used a sprayer-applied sealant to seal all seams. The wall cavities were filled with blown fiberglass. Textured house wrap provided a drainage plane behind the fiber cement and brick veneer siding.

The home's vented attic was constructed with 14-inch raised-heel trusses to allow space for insulation at the eaves. All top plates were air sealed with a sprayer-applied sealant before installing the R-50 of blown fiberglass. The roof was protected with ice-and-water shield at all valleys and from the eaves up 24 inches past the wall line. After installing metal drip edge, the deck was covered with synthetic underlayment and asphalt shingles.

Lowry has an unfinished, conditioned basement with 8.75-foot ceilings. Underneath the slab is a 6-mil vapor and radon barrier that was sealed to the foundation with polyurethane sealant. Beneath the barrier is a four-inch-thick layer of 0.75-inch rock over compacted soil. The basement was insulated along the inside of the poured concrete foundation walls with R-19 perforated vinyl-faced drape insulation.

Head space. Energy Star® appliances, WaterSense fixtures, energy-efficient lighting and other green fixtures are displayed throughout these high-performance homes.
COURTESY OF THRIVE HOME BUILDERS

> "Creating awareness and understanding of the [Home Energy Rating System] score is essential to help our buyers appreciate just how much more efficient those homes are."
> –Bill Rectanus, Thrive Home Builders

COURTESY OF THRIVE HOME BUILDERS

EDUCATION MATTERS

THRIVE ALSO TEACHES buyers about the HERS score, how it's calculated, and how it translates into cost savings in operating their Thrive home. Thrive sees the HERS score's value as a third-party validated method customers can use to objectively compare Thrive homes to homes by other builders. Thrive tells home buyers, "Every home has a HERS Score. Don't buy a home until you know The Score!"

"Most of our competitors claim to build an energy-efficient home, so creating awareness and understanding of the HERS score is essential to help our buyers appreciate just how much more efficient our homes are," says Rectanus.

Thrive appreciates the third-party evaluation required by certification programs such as ZERH, Energy Star®, and EPA's Indoor airPLUS, and the consumer confidence they inspire. "We strongly believe in the power of the credible, third-party endorsements that these standards offer," says Rectanus.

In addition to all the other benefits, there are of course the utility bill savings. Thrive has a unique way of driving home the impact of those savings. A display in its Building Science Centers asks home buyers, "What will you do with the savings?" Play dollars are stacked up to represent 30-years' worth of energy savings. The display shows the energy savings can add up to real dollars that can really impact the homeowners' lives.

IAQ aware. The homes also meet the criteria of the EPA's Indoor airPLUS program, which promotes good indoor air quality with low- or no-VOC products and finishes; moisture management to reduce the likelihood of mold; and good ventilation practices.

The home is equipped with an active radon venting system. Soil gases are collected in a four-inch perforated plastic pipe installed along the inside perimeter of the foundation walls and vented through the roof via a four-inch solid plastic pipe with a fan. Thrive tests all homes for radon after construction; this home measured only 0.5 pCi/L.

OPTIMIZED HVAC

Most of the home's heating and cooling is provided by a very efficient heat pump with a heating seasonal performance factor (HSPF) of 12.2 and a seasonal energy efficiency ratio (SEER) of 18.9. A highly efficient 97.4 AFUE gas furnace provides backup heat for those rare very cold Colorado nights. All of the mechanical equipment is in the conditioned basement.

The HVAC system's mastic-sealed metal supply and return ducts are located completely within the conditioned space of the home. The tightly air sealed home was tested for overall air leakage and had an air leakage rating of only 1.77 air changes per hour at 50 Pascals pressure difference.

This home is supplied with continuous hot water with a 0.97 EF tankless gas water heater. Water conservation features include WaterSense plumbing fixtures and a hot water recirculation loop that minimizes wait times for hot water delivery. Outside, drip irrigation and drought-tolerant plants minimize water use.

Every home is equipped with an internet-based monitoring system to help homeowners track their electricity production and consumption.

Thrive also incorporated disaster-resistance features. This home includes shear walls and framing and roof reinforcement to accommodate 100 psf snow loads and wind resistance for 100 mph gusts. To reduce the risk of fire damage, Thrive specified fire-resistant siding and shingles.

PERFORMANCE THAT PAYS

In 2014 Thrive began building its homes to the high-performance criteria of the DOE ZERH program. "Homeowners have told us that Thrive's energy efficiency was the primary reason for seeking out and buying a Thrive home," says Bill Rectanus, vice president of operations for Thrive Home Builders.

Thrive's efforts have been rewarded with the second-highest sales price per square foot in the Denver metro area. "We have found great success in selling the additional benefits of a ZERH, including airtightness, high-performance windows and insulation, improved

COURTESY OF THRIVE HOME BUILDERS

Shock value. To reduce damage during disaster, Lowry homes include shear walls and framing, fire-resistant siding and shingles, and roof reinforcement to accommodate snow loads and heavy wind resistance.

comfort and health, disaster resilience, less dust indoors, and a quiet indoor environment," Rectanus notes.

Thrive Home Builders has been designing, building and selling high-performance homes for 25 years and is committed to continuous training of its staff, vendors, trades and even homeowners, according to Rectanus. Thrive recently began conducting weekly "Building Science 101" classes, which are taught by in-house staff and cover topics like energy efficiency, indoor air quality, construction best practices and details of the DOE ZERH program. The training classes are offered to all employees, and are required for the sales and construction departments.

Thrive spends even more time educating home buyers on the benefits of zero energy construction. Thrive has set up Building Science Centers at nearly every community where it builds. The centers are packed with educational displays on the benefits of owning a zero energy home. Thrive uses interactive displays and informative handouts like DOE's "A Symbol of Excellence" consumer brochure, the DOE ZERH Point of Sale display, the Energy Star® "Better is Better" brochure, the Indoor airPLUS "Breathe Easy" brochure, and information about the solar energy systems. Side-by-side displays compare Thrive's energy-efficient features with standard construction.

The education efforts are often the tipping point when it comes to a consumer's home choice, Rectanus notes. "We have received feedback from both buyers and realtors about how this demonstration was the deciding factor in the buying decision," he says.

"Our homes offer a potentially staggering amount of energy savings, especially for those moving from older, inefficient homes," Rectanus adds. "Whether it's saving for your children's college education, saving for retirement, or being able to afford a bigger home or special upgrades, it is important to characterize how those savings can be put to better use." GB

KEY FEATURES

DOE ZERO ENERGY READY HOME PATH: Performance.

WALLS: Double walls; 2-by-4, 24-inch o.c. advance framed; staggered with space for 9.5-inch R-41 blown fiberglass; sprayer applied sealant; 0.5 inch OSB sheathing; corrugated house wrap; fiber cement and synthetic stone siding.

ROOF: Ice-and-water shield at roof edge; waterproof underlayment; metal drip edge; 30-year asphalt shingles.

ATTIC: Vented attic; R-50 blown fiberglass, 14-inch raised heel trusses; sprayer-applied sealant at all top plates.

FOUNDATION: Basements with perforated vinyl-faced R-19 blanket insulation on interior of unfinished walls; 4-inch gravel and vapor barrier under slab.

WINDOWS: Energy Star® double-pane; argon-filled; vinyl-framed windows; U=0.25, SHGC=0.30.

AIR SEALING: 1.77 ACH 50.

VENTILATION: Continuous exhaust fans.

HVAC: Central air-source heat pump; HSPF 12.2, SEER 18.9; +97.4 AFUE backup gas furnace; ducts in conditioned space.

HOT WATER: 0.97 EF tankless gas water heater.

LIGHTING: 100 percent LED; daylighting.

APPLIANCES: Energy Star® refrigerator, dishwasher, exhaust fans, ceiling fans.

SOLAR: 8.68-kW PV.

WATER CONSERVATION: WaterSense fixtures; "smart" hot water recirc; drought-tolerant plants, drip irrigation.

ENERGY MANAGEMENT SYSTEM: Internet monitoring of PV production and energy use.

OTHER: EPA Indoor airPLUS, low-VOC paints, low-formaldehyde wood products. Active radon ventilation system; radon testing prior to closing. Ducts cleaned. Shear walls; reinforced framing and roof. Excavation to 30-foot depth to replace high-expansion soils.

Economic elegance. When it comes to electricity, solar panels are helping to make power more than plentiful for Depot Neighborhood's small, single-family homes.
COURTESY OF HABITAT FOR HUMANITY, GRAND TRAVERSE REGION

Absolute (Net) Zero

Habitat for Humanity's latest housing project brings green affordability to the Grand Traverse's Depot Neighborhood.

BY GREEN BUILDER STAFF

THE HABITAT FOR Humanity, Grand Traverse Region has an inspiring vision for its Depot Neighborhood begun in Traverse City, Mich., in May 2014: to build each of the community's 10 single-family homes to be truly affordable ones that harvest and produce all the energy they need over the course of a year, with the goal of eliminating homeowner energy bills forever. To meet this goal, the Habitat affiliate decided to certify all 10 of the homes to the strict energy performance requirements of the U.S. Department of Energy (DOE)'s Zero Energy Ready Home (ZERH) program.

For Depot Neighborhood, the Grand Traverse affiliate chose to install solar panels on the roofs at construction so that the homes could start performing as net-zero homes upon completion. A net-zero home produces as much energy as it uses over the course of the year. As a result, it is not uncommon for homeowners in the Depot Neighborhood to have negative energy bills in the spring and summer. This excess production shows up as credits on the utility bill, which can be applied to winter season bills when energy demands are higher in this heating-dominated climate.

The DOE ZERH Housing Innovation Award-winning unit at the Depot Neighborhood is a 1,352-square-foot, two-story home with 27 solar photovoltaic panels mounted on the roof. Each panel is rated at 275 watts, so the array provides a total installed capacity of 7.4 kilowatts. Like all Depot Neighborhood houses, the three-bedroom, two-bath Midwestern farmhouse-style home has the roof aligned for southern exposure to best accommodate the solar panels.

The solar panels cost about $17,000, but a 30 percent tax credit reduced this amount to about $12,000, yielding a project payback of about 13 years.

PERFORMANCE DETAILS

Solar panels alone are not what allows the home to achieve its zero energy status. Before the PV panels were installed, the home was designed and constructed with a high-performance building envelope and efficient equipment that meet the DOE ZERH program requirements. This results in a construction that significantly reduces

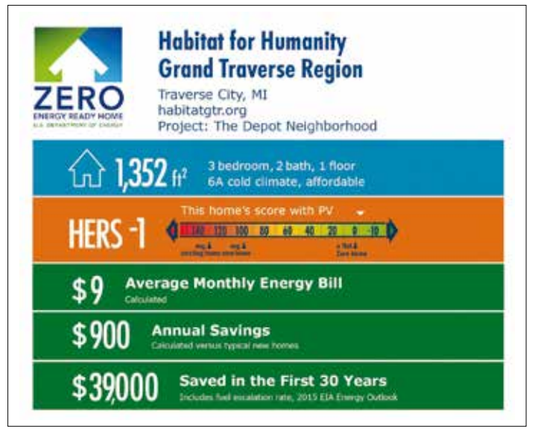
Sunlight makes right. LED-based lights and Energy Star®-rated appliances are among the items that optimize use of natural solar and limit the need for electric lights each day.
COURTESY OF HABITAT FOR HUMANITY, GRAND TRAVERSE REGION

> "Net zero is where it's at. This is the direction everyone should be going."–Ryan McCoon, Habitat for Humanity, Grand Traverse Region

energy use, compared to a standard home build that just meets the State energy code.

The Depot Neighborhood dwelling was constructed with 2-by-6, 24-inch on-center wood-framed walls. The wall cavities were filled with 5.5-inches of dense-packed, blown-in fiberglass insulation, which provides an R-23 cavity insulation value. The walls were wrapped with 0.5-inch sheathing plus a continuous layer of insulation consisting of a pair of two-inch-thick layers of rigid foam equaling R-20, for a total wall R-value of 43, well above Michigan's current code-required R-20 insulation level. Fiber cement lap siding was installed over 1-by-4 furring strips placed vertically over the foam board to create a 0.75-inch air gap between the foam board and siding that helps prevent moisture buildup.

But the builders kept solar panels in mind when designing the home. The home's south-facing roof was kept free of obstructions, with all vents, chimneys and other roof-mounted obstructions located



on the north-facing roof. The roof's 7⁄12 pitch is slightly steeper than would be ideal for solar gain but the angle is necessary to help shed snow more quickly.

Two-foot overhangs at the eaves and gable ends help protect the

A GRAND SYNERGY

walls from rain and snow. The attic was air sealed with closed-cell spray foam at eave-wall connections and at all ceiling penetrations. The roof has raised-heel trusses to allow space for 20 inches of blown-in cellulose insulation, which provides an attic insulation value of R-80—well above Michigan's required R-49.

GROUND CONTROL

To construct the home's slab foundation, the builder excavated nearly 60 inches to get below the Michigan frost line, poured concrete footings, then constructed 54-inch-high footing walls consisting of insulated concrete forms (ICFs). ICFs are hollow foam board blocks that are stacked like bricks, then filled with concrete and reinforced with steel rebar to form very sturdy walls. The foundation area between the ICF walls was then filled with dirt to within 12 inches of the top of the ICF wall.

The packed dirt was covered with three two-inch layers of rigid EPS foam board, providing R-30 of insulation under the four-inch concrete slab, while the ICFs provide R-20 of slab-edge insulation. The current code requires R-10 of foundation wall insulation and no insulation is required under the slab. The ICFs were topped with a butyl tape capillary break before constructing the above-grade wood-framed walls. The EPS was covered with a 6-mil vapor barrier of plastic sheeting.

AIRTIGHT TIMES THREE

The home's windows are all triple-pane, with low-emissivity coatings to reduce heat transfer and an argon gas fill between the panes to increase the insulation value. The windows have an insulation U-factor of 0.19—well below the current code requirement of U=0.35.

The home was tested for air tightness and had a whole-house air leakage rate of 0.88 air changes per hour at 50 Pascals pressure difference (ACH 50), which far exceeds the code requirement of 4 ACH 50.

HVAC is provided by a ductless mini-split heat pump, consisting of a single outdoor unit (compressor and condenser) with two indoor units (each having an evaporator and fan-coil). The inverter technology on the ductless mini-split heat pump allows the outdoor unit to vary its speed and output to match the comfort needs of the home's occupants.

COURTESY OF HABITAT FOR HUMANITY, GRAND TRAVERSE REGION

Running a temperature. Energy Star®-certified HVAC, combined with the home's ultra-efficient solar paneling, keep the home cool or warm without breaking the bank.

The heat pump has a cooling efficiency or Seasonal Energy Efficiency Ratio (SEER) of 18, a heating efficiency or Heating Season Performance Factor (HSPF) of 9.3, and a Coefficient of Performance (COP) of 3.44 (which exceeds the current Federal minimum efficiencies). A heat pump water heater with an energy factor (EF) of 2.75 provides domestic hot water to the home. An energy recovery ventilator (ERV) provides ventilation for the air-tight home.

OTHER COST CUTTERS

All lighting is provided by LED based and all appliances are Energy Star® rated. The home's design optimizes natural daylight to eliminate the need to use electric lights during the day.

The home is expected to cost its owners about $106 per year, or roughly $9 per month, in energy bills. The home achieved a Home Energy Rating System (HERS) score of 36 without factoring in the roof-mounted solar panels. With the panels, the home achieved a HERS score of -1. Over the course of a year, this net zero home can produce as much energy as it uses. For this home, this equates to about $900 in annual energy bill savings for the homeowners.

The home also includes water-saving features such as low-flow shower heads, toilets and plumbing fixtures, and an irrigation system that is LEED certified for maximum water efficiency.

"Net zero is where it's at," says Habitat board member Ryan McCoon, who served as project manager during the planning stages of the Depot Neighborhood project. "This is the direction everyone should be going. Low energy and water use mean this home will be inexpensive to live in for years to come."

COURTESY OF HABITAT FOR HUMANITY, GRAND TRAVERSE REGION

Airtight planning. Fiberglass and foam insulation, and cement lap siding give the home an R-value that is twice Michigan's required total (per code).

Habitat for Humanity, Grand Traverse Region engages in a variety of events designed to educate the community about the need for affordable housing, and the benefits of net-zero energy homes. Habitat home owners also learn about energy-efficient construction through the sweat equity hours they put into building their homes.

The Habitat affiliate also teaches homeowners how to keep the house running efficiently. They are shown how to change the filters in the mini-split air handlers and the energy recovery ventilation (ERV) system. They learn about habits that can increase or decrease their utility bills. Homeowners are given a comprehensive home operation binder that includes a sustainable energy manual, schedules for regular maintenance activities, and information on how to do a self-guided home inspection. The binder also contains manuals for all of the home's appliances and mechanical equipment as well as warranty information.

For Habitat homeowners, the economic impacts of energy-efficient housing have been life changing. "Previously if you took our gas bill and electric bill, it was over $300 a month," says one Depot Neighborhood homeowner. "Now, our electric bill is under $10 a month. I can actually afford to not only save for repairs and upkeep on the house, and make the payments on the house, but I can also save for our kids' future." **GB**

KEY FEATURES

DOE ZERO ENERGY READY HOME PATH: Performance.

WALLS: R-43: 2-by-6, 24-inch o.c. with 5.5-inch R-23 blown fiberglass in cavity, 0.5-inch OSB, two 2-inch layers XPS R-20 rigid foam on exterior, fiber cement lap siding over 1-by-4 battens.

ROOF: Raised heel trusses, 2-foot overhangs at eaves and gables, asphalt shingles.

ATTIC: Vented attic with 20-inch (R-80) blown cellulose insulation, plus closed-cell spray foam at eaves and penetrations.

FOUNDATION: R-22.5 ICF foundation walls, three 2-inch layers EPS under slab for R-30.

WINDOWS: Triple-pane low-e, argon-fill, U=0.19.

AIR SEALING: 0.88 ACH 50.

VENTILATION: ERV.

HVAC: Ductless mini-split heat pump, two indoor wall units, 18 SEER, 9.3 HSPF.

HOT WATER: Heat pump water heater, 2.75 EF.

LIGHTING: 100 percent LED.

APPLIANCES: All Energy Star®.

SOLAR: 7.43-kW PV.

WATER CONSERVATION: All fixtures low flow.

ENERGY MANAGEMENT SYSTEM: Energy monitoring of PV HVAC, appliances and plug load.

OTHER: No-/low-VOC paints.

Shape shifter. Ferrier Custom Homes' project in Mineral Wells, Texas is a winner in the "Innovation in Custom Homes" category.
COURTESY OF FERRIER CUSTOM HOMES

First Look

Here are the homes up for top honors at DOE's 2019 Housing Innovation Awards.

BY GREEN BUILDER STAFF

FOR SIX YEARS, the U.S. Department of Energy's annual Zero Energy Ready Home (ZERH) Housing Innovation Awards have honored the very best projects that are headed to net zero. The awards also recognize forward-thinking builders who are delivering a better experience to American homebuyers.

This year's awards ceremony will be held during the EEBA High Performance Home Summit in Denver, Oct. 1-3. Winners have been selected for each of five main award categories and one Grand Winner will be announced from each one.

Here are the categorical winners:

INNOVATION IN AFFORDABLE HOMES

- **Habitat for Humanity of Catawba Valley:** Hickory, N.C.
- **United Way of Long Island:** East Patchogue, N.Y.

INNOVATION IN CUSTOM HOMES (FOR SPECIFIC BUYER)

- **Amaris Homes:** Eden Prairie, Minn.
- **Bellingham Bay Builders:** Seattle, Wash.
- **Clifton View Homes:** Anacortes, Wash.
- **Deltec Homes:** Mills River, N.C.
- **Ferrier Custom Homes:** Mineral Wells, Texas
- **Greenhill Contracting:** Newburgh, N.Y.
- **Health E Community Enterprises of Virginia:** Hampton, Va.
- **High Performance Homes:** Easton, Md.
- **Imery Group:** Monroe, Ga.
- **Module Housing:** Pittsburgh, Pa.
- **Mantell-Hecathorn Builders:** Durango, Colo.
- **S.D. Jessup Construction:** Pinnacle, N.C.
- **TC Legend Homes:** Bellingham, Wash.
- **Tim O'Brien Homes:** New Berlin, Wisc.

INNOVATION IN CUSTOM HOMES (BUILT ON SPECULATION)

- **C&B Custom Homes:** Clarkdale, Ariz.
- **Charis Homes:** North Canton, Ohio
- **CVF Homes:** San Antonio, Texas
- **Gardner Custom Homes:** Prescott Valley, Ariz.
- **Sareth Builders:** Lorain, Ohio

INNOVATION IN MULTIFAMILY HOMES

- **Garbett Homes:** South Jordan, Utah
- **Revive Properties and Philgreen Construction:** Fort Collins, Colo.

INNOVATION IN PRODUCTION HOMES

- **Garbett Homes:** South Salt Lake, Utah
- **Insight Homes:** Millsboro, Del.
- **Mandalay Homes:** Prescott, Ariz.
- **Thrive Home Builders:** Denver, Colo.

HONORABLE MENTION

- **Lifestyle Homes:** Downers Grove, Ill.
- **Sustainable 9:** Edina, Minn.

More about these award-winning homes may be found at DOE's Tour of Zero site.

Eye in the sky. A drone's preconstruction surveying and mapping abilities quickly help building planners learn a site's topography.
COURTESY OF EQUIPMENT TRADER

CAN DRONES SERVE SUSTAINABILITY?

By improving site surveillance, worker safety and resource management, this flying robot technology could make construction greener and more efficient than ever.

BY ETHAN SMITH

DRONES, ONCE A HOBBY FOR a few enthusiasts, are now prominently featured across a number of professional fields. Today, delivery and cargo drones transport goods across increasing distances, military drones spy on enemy combatants, and ag-drones engage in precision farming.

More than any other industry, however, drones are being put to use on construction worksites, with their use surging by 239 percent from 2017 to 2018, according to drone software manufacturer DroneDeploy. Infrastructure work now makes up 35.5 percent of professional drone use, far ahead of the next two biggest drone-using industries, agriculture (25.5 percent) and transportation (10.2 percent).

Typically operated by project managers, technology managers and superintendents, construction drones have many functions, as they can be used in every phase of the project lifecycle. Equipped with GPS technology, as well as cameras and sensors that can capture images, video, thermal readings and infrared data, drones can help improve project conceptualization, planning, measurement, building, management, reporting, monitoring, inspection, safety, security and even marketing.

Drones are revolutionizing construction at a breakneck pace. Here are eight ways drones are changing construction:

1. PRECONSTRUCTION SURVEYING AND MAPPING: Drones have the ability to survey and map large geographic areas, quickly helping building planners get a sense of a site's topography. With high-resolution drone imaging, construction teams can develop 3D models to help them identify constructability challenges ahead of time, make accurate estimates, and sufficiently prepare for the job.

Drone mapping and modeling can also be conducted throughout a project and the data can be used by architects, engineers, and others in conjunction with leading construction software programs, including AutoCAD, Bluebeam, Civil 3D, BIM 360, Procore and others.

2. ON-SITE MEASUREMENTS: On a smaller scale, drones can additionally be used to make various measurements on a worksite, including measuring stockpiles of materials, such as piles of fill dirt, sand or gravel. Increasingly, builders are using drones in coordination with

COURTESY OF EQUIPMENT TRADER

Safety tool. Drones will enable construction companies to perform simple maintenance on structures like towers, roofs and scaffolding that can be more dangerous for human workers to reach.

ground control points (GCPs), which are ground markers equipped with GPS to calculate exact global positioning. This approach to making site measurements has skyrocketed in recent years, as it achieves up to 99 percent accuracy when measuring distance, area and volume.

3. PROGRESS REPORTS: A drone's ability to observe and record almost anything on a worksite makes it a valuable tool for keeping all relevant parties up-to-date with accurate information about the project's progress. Clients appreciate a high level of access and visibility that helps them feel assured of quality control, and everyone from owners to managers to laborers are able to stay updated, on the same page and able to identify anything that looks wrong or out of place.

4. WORKFORCE MONITORING: Many project managers have also turned to drones for the general supervision of their workers. Many places of employment record the day-to-day activities at their business, but mounted cameras don't always work on a construction site where structures, equipment and materials are frequently moved around and could impair visibility.

Drones may soon allow for the mobility necessary for supervisors to fully oversee the workforce, which is especially helpful if there are specific concerns that a particular person or group is not adhering to protocol. OSHA has not yet released official protocols for drone inspections; stay tuned.

5. STRUCTURAL AND EQUIPMENT INSPECTIONS: The maneuverability of drones, which can easily fly around project structures, makes them useful for examining and evaluating stability and repair needs. High-resolution images can provide finer visual details, measurements can determine if a structure is straight or leaning (and by how many degrees), and thermal sensors can identify heat leaks, cold spots and electrical malfunctions. Similarly, a drone may be able to quickly analyze a broken-down piece of machinery and send equipment data to the technician to begin their diagnosis before the equipment even reaches them.

6. SAFETY IMPROVEMENTS: Increasingly, drones are being used to make measurements and to even perform simple maintenance on structures like towers, roofs and scaffolding that can be more dangerous for human workers to reach. Regular worksite monitoring with drones can also help managers be on the lookout for on-site safety concerns, such as employees not following safety regulations or structures and equipment that may be loose or unstable. As an added bonus to protecting workers, construction companies that use drone inspections and patrols as preventative and responsive safety measures may be eligible for risk-mitigation insurance discounts, depending on the provider.

7. SECURING EQUIPMENT AND WORKSITES: The construction industry loses $1 billion every year due to equipment theft, and 83 percent of equipment owners have been the victim of theft, according to Equipment Trader. A flyover of the worksite is a fast and easy way for supervisors to ensure that machinery is secure and located where it is supposed to be.

Likewise, drones are able to be the eye-in-the-sky that can survey the site and check for unauthorized trespassers. Even the presence of patrolling drones may serve as an effective deterrent against thieves. As of now, drones cannot autonomously fly nighttime patrols on their own—they're currently limited by battery life, an inability to judge if they are sensing authorized or unauthorized personnel, and federal regulations about flying drones at night in certain areas—but the day is soon coming that self-flying drones will be able to survey and secure the worksite.

8. MARKETING AND PROMOTION: Drones are a great way to promote your business. Expert aerial photography can help you show off finished projects with captivating shots that enhance and elevate your company's portfolio and marketing materials. Drone images, as well as scale models and 3D rendering using data from drone surveys and mapping, can also help prospective clients visualize what you can offer them. And finally, simply the fact that your construction firm uses drones can attract customers who are interested in all the benefits we've described above, including receiving those dynamic progress reports, and want to contract a cutting-edge company that uses the latest technology. GB

Ethan Smith is a content curator for Trader Interactive, a comprehensive digital marketing corporation.

COURTESY OF EQUIPMENT TRADER

Stealthy surveyor. A drone's ability to observe and record a worksite can keep relevant parties up-to-date on a project's progress.

Finding the 'sweet spot'. There are a growing number of methods for managing moisture, driven by advances in material technology, evolving building codes, and a growing awareness among end users for mold prevention, indoor air quality and energy efficiency.
COURTESY OF TYPAR CONSTRUCTION PRODUCTS

Permeability Makes Perfect

Advances in technology and increased builder awareness are making the fight against water leakage more effective than ever.

BY BIJAN MANSOURI

IN THE BUILDING INDUSTRY'S ever-increasing pursuit of tighter and more waterproof structures, what are we at risk of losing? Is there a point at which we build a wall that is too tight? While a water-tight assembly is vitally important for controlling issues such as mold growth and protecting indoor air quality, some building practices may be inadvertently making it easier for moisture-related issues to fester. After all, no matter how tightly a wall is constructed, water is inevitably going to find its way in. There's no such thing as a "waterproof" wall, just one that is built so tightly it is almost guaranteed to get wet and stay wet.

The highest-performing wall assemblies are ones that have been designed to realistically manage moisture and dry out, not those designed with the unachievable goal of completely locking out all moisture. The good news is that there are a growing number of methods for managing moisture, driven by advances in material technology, evolving building codes, and a growing awareness among end users for mold prevention, indoor air quality and energy efficiency.

MANAGING WATER IN MANY FORMS

Water can find its way into a wall in numerous ways. High humidity and extreme temperatures can cause vapor diffusion when warm indoor air causes condensation on colder outside surfaces. Wind-driven rain can be forced into small openings in the exterior cladding at joints, laps and utility cutouts, and wind blowing around the building can create a negative pressure within the wall assembly which siphons water into the wall.

When reservoir claddings become wet from rainwater or condensation and are then warmed by the sun, the vapor pressure of the stored water increases, driving it inward and outward from the cladding material. Where that moisture goes from there—and how quickly it gets there—is largely a function of how permeable the adjacent building materials are within the assembly.

Permeability measures the amount of vapor transmission that a building material will allow over a period of time. ASTM E96, Standard Test Methods for Water Vapor Transmission of Materials, addresses two testing procedures for measuring permeability: the Desiccant Method and the Water Method.

In the Desiccant Method, the material to be tested is sealed to a test dish containing a desiccant, or drying agent, and the assembly is placed in a controlled atmosphere. Periodic weighing determines the rate at which water vapor has moved through the specimen into the desiccant. In the Water Method, the dish instead contains distilled water, and periodic weighing determines the rate of vapor movement through the specimen from the water.

In most wall assemblies, outwardly driven moisture won't cause many problems (unless you're dealing with a material like stucco that's been painted with a low-perm paint, in which case you would see bubbling and cracking). But the inwardly driven moisture presents a problem, especially in situations where conditioned indoor air is much cooler than the warm, moist exterior.

Typically, this inwardly driven moisture vapor is managed by separating the cladding from the rest of the assembly with a capillary break, which can be a gap or a sheathing material that sheds water or does not absorb or pass water. Impermeable sheathing, such as extruded polystyrene (XPS), is one option for halting inward vapor drive. In these types of assemblies, the inwardly driven moisture condenses on the surface of the XPS sheathing and drains downward.

But in situations where a reservoir cladding is paired with a highly permeable sheathing like gypsum board (which can be as high as 50 perms) or a moisture-retentive material like oriented strand board (OSB), an air gap may not be enough to slow down inward moisture intrusion. In these applications, an added weather resistant barrier (WRB)—commonly referred to as a building or house wrap—is needed to reduce unwanted moisture intrusion.

In the recent paper, "Inward Drive – Outward Drying," building scientist Joseph Lstiburek identifies the "sweet spot" for the permeance of this WRB layer as between 10 and 20 perms. Too high, he writes, and the moisture driven out of the back side of the reservoir cladding into the air space will blow through the layer, through the permeable sheathing and into the wall cavity. Too low, and the outward drying potential of the cavity is compromised. Thankfully, advances in building wrap technology are adapting to meet this need.

EVALUATING WRBS

Due to their durability and ease of installation, plastic building wraps made of polyethylene or polypropylene fabric have been a popular method of protecting against moisture intrusion since the 1970s. But as building assemblies have gotten tighter, building wraps have taken on a new function—helping to remove trapped water from the building enclosure. Their unique functionality enables them to block moisture from the outside while also allowing walls to "breathe" to prevent vapor buildup. And the very latest innovations in building wrap technology is also taking this moisture removal function one step further to incorporate drainage capabilities.

Bulk water defense. *Typar Drainable Wrap* features an additional layer of integrated polypropylene fibers that create a highly efficient gap for shedding excess water.
COURTESY OF TYPAR CONSTRUCTION

The 2018 International Building Code (IBC), Section 1402.2, Weather Protection, requires that exterior walls "provide the building with a weather-resistant exterior wall envelope… designed and constructed in such a manner as to prevent the accumulation of water within the wall assembly by providing a water-resistive barrier behind the exterior veneer…and a means for draining water that enters the assembly to the exterior." This water-resistive barrier, as defined by Section 1403.2, is comprised of at least "one layer of No. 15 asphalt felt, complying with ASTM D226 for Type 1 felt or other approved materials…attached to the studs or sheathing."

It is important to note the difference between a *weather* resistant barrier and a *water* resistant barrier, as they have distinct purposes yet are often confused with one another. The American Architectural Manufacturers Association (AAMA) defines weather-resistant

barriers as a surface or a wall responsible for preventing *air and water* infiltration to the building interior. The differentiating factor is that a weather-resistant barrier must also preventing air infiltration, while water-resistant barriers are only responsible for preventing water intrusion.

The International Code Council Evaluation Service (ICC-ES) evaluates the following key performance characteristics for building wrap, which provide a valuable starting point for deciding which product best suits your project.

WATER RESISTANCE

As its most basic function, a building wrap must hold out liquid water. A premium building wrap will be able to pass both "water ponding" tests, which measures a house wrap's resistance to a pond of one-inch water over two hours, and a more stringent hydrostatic pressure test where the wrap is subjected to a pressurized column of water for five hours.

AIR RESISTANCE

According to the Air Barrier Association of America (ABAA), an air barrier system is a system of building assemblies within the building enclosure—designed, installed and integrated in such a manner as to stop the uncontrolled flow of air into and out of the building enclosure. Because an air barrier isolates the indoor environment, it plays a major role in the overall energy efficiency, comfort and indoor air quality of a building. According to the U.S. Department of Energy, up to 40 percent of the energy used to heat and cool a building is due to uncontrolled air leakage. As such, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1 and the IECC both include air barrier requirements.

For an individual building material to be classified as an air barrier, its air permeance must be equal to or less than 0.02 L/(s-m2) @ 75 Pa when tested in accordance with ASTM E2178. However, this air permeance test only measures the amount of air that migrates through the material itself and not through holes or gaps in the larger assembly. Therefore, it is important to keep in mind that a material's effectiveness as an air barrier is largely dependent on proper installation and the use of compatible tapes, fasteners and sealants.

DURABILITY

The ICC-ES looks at the tear resistance and tensile strength as the best measure of a building wrap's durability, since it must be able to withstand the handling and application process without compromising its water resistance. UV and low temperature resistance are also important measures of durability because prolonged exposure to the elements can compromise the integrity of the product or cause it to crack.

VAPOR PERMEABILITY

For a product to be considered a building wrap and not a vapor retarder, ICC-ES mandates the permeance rating must be higher than 5 perms. But there are a variety of ways permeability is achieved, and as noted by Lstiburek, a higher perm rating doesn't always equal a better building wrap.

When selecting a building wrap, look for one that hits the "sweet spot" of 10 to 20 perms to achieve the desired balance of moisture protection and drying capacity. For example, some wraps have mechanical micro-perforations, which may allow the passage of more water vapor, but could also be more vulnerable to bulk water leakage. Generally, it's better to go with a higher quality, non-perforated or micro-porous product, which allows for sufficient vapor mitigation while providing excellent resistance to bulk water.

DRAINAGE

Drainage is widely accepted as one of the most effective measures for reducing moisture damage due to rain penetration. Drainage is a critical component in allowing a building wrap to do its job, particularly in keeping walls dry. Usually this involves the use of furring strips that separate the wrap from the structural sheathing and framing, but new technologies have emerged that are helping to simplify this process.

No matter how advanced a WRB material is, it alone cannot be counted on to protect a structure from unwanted air and moisture movement without taking the whole assembly into consideration. It is important to specify compatible materials to ensure all components work together.

Changing building codes and greater adoption of certain cladding materials have caused specifiers to take a closer look at how they manage moisture in the wall assembly—and that's a great thing. Advances in building wrap products have added a powerful tool to help achieve these goals. The smart way forward is to avoid waterproofing the wall to the detriment of breathability, but rather to take a holistic approach to designing a wall system that provides adequate protection against water yet can also dry out when it inevitably gets wet. **GB**

Inspection clause. Changing building codes and greater adoption of certain cladding materials have caused specifiers to take a closer look at how they manage moisture in the wall assembly.

Bijan Mansouri is technical manager at TYPAR Construction Products. He is responsible for building code requirements, designing and development of new construction products, training builders and architects on their application, and creating and teaching proper practice and installation of building envelopes.

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FIRST COST VS. FULL COST

The building industry practice of driving cost out of new home construction to the detriment of long-term durability and energy efficiency is the worst way to build a house. **VISION House® Seattle Cascades demonstrates a better way.**

Balancing act. Builders need to understand the net impact of operational costs before they can focus on the "first cost" of building a home—material and labor.

BY CATI O'KEEFE

C.R. HERRO is building a sustainable house. It isn't just his dream house; it is the culmination of all he has ever learned about home building in the 10 years he has served the residential home building industry. Currently the vice president of innovation for Meritage Homes, he knows firsthand the tradeoffs that happen between cost and value, how to educate buyers on the importance of incorporating sustainability as a system, and how total value represents a better business model.

Herro is eager to go through the home building process himself and come out the other side with a completed house that meets his needs while also providing a scalable, customizable "template" for homes to be conceived and built today.

A tall order, to be sure, but Herro is on a mission. He believes home building in its current state is overdue for disruption. "For the last 100 years, most people have focused on the first cost of building a home—the material and labor costs to produce a home," he explains. "And this is because there isn't an understanding of the net impact of operational costs or durability of the home."

Herro has spent the past decade challenging builders' assumptions that all they can do is control first costs. "That assumption is wrong," he says. "The full cost of a home is the mortgage, utilities and maintenance, and it is a part of the value equation for builders and buyers." Those last two terms—utilities and maintenance—are significant in the life of a 30-year loan. "The operation and durability of a home can be hundreds of thousands of dollars in benefit or cost, depending on the thoughtfulness of the

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COURTESY OF PHYN

Full house. In addition to the radiant floor heating, plumbing and fire sprinkler systems, Uponor has supplied its smart water leak detection product *Phyn Plus* to the VISION House® project.

upfront design and construction," Herro says. "Most consumers today do not understand the opportunity of spending an extra dollar to save two."

The general public is beginning to understand that products such as LED lights, efficient water heating and HVAC, low-e windows and better insulation are worth the upfront cost. "A house as a system works under the same principle," Herro explains. "A small investment in better materials and thoughtful design can drastically reduce operating and maintenance of homes, representing hundreds of thousands of dollars in value for those who own that home."

GOALS OF THE BUILD

The VISION House® Seattle Cascades presented by Green Builder Media is just out of the chute, with groundbreaking planned for fall 2019. This article was being reported as the home-performance hypotheses were being made and therefore it encapsulates the intentions of the build. Once the house is completed, Herro and his team will gather data for two years to validate building performance, which will be shared here in *Green Builder*.

Because the building envelope has the most impact on the home's performance, the VISION House® team allocated money to the envelope to eliminate mechanical heating and cooling demand, including using insulating concrete form (ICF) walls, structural insulated panel (SIP) roof structure, light-gauge steel interior framing and ultra-high-performance windows. Plus, the use of smart ventilation appliances that take advantage of temperature cycles ensures steady humidity and temperature control.

"The highly insulated envelope means the house needs very little heating and cooling during the season to make it operate properly," says Stace McGee, the project's architect and founder of Environmental

RESILIENT WATER

Climate change, extreme weather and an off-grid site prompts the VISION House® Seattle Cascades team to address water from many angles.

HERRO AND THE VISION HOUSE® TEAM wanted to address fire resistance, not just by using noncombustible materials in the house construction, but also by using a fire sprinkler system. Turns out, it was required anyway because the remote location and siting of the house makes fire department service difficult.

The house is not on public water, so the team put in a cistern that is filled by rainwater and water pulled from the air by an atmospheric generator. The generator runs off a three-panel photovoltaic (PV) system and can pump out up to 80 gallons of water a day.

"With climate changes we are going to see more-robust sprinklers become standard in homes," predicts McGee. "In addition to the interior sprinkler system, we are exploring installing sprinklers on the eaves of the house. If there is a fire and Herro isn't there, the sprinklers will turn on automatically or he can turn the sprinklers on with his smart phone. Herro can watch the level of water in the cistern to make sure it is used appropriately."

For the home's interior fire sprinklers, plumbing and radiant floor heating, Herro selected Uponor. "The *AquaSAFE* combined plumbing and fire sprinkler system is a smart choice for this house," notes Ingrid Mattsson, director of sustainable brand development, Uponor North America. "Having a combined system incorporates the fire sprinklers into the home's cold-water plumbing. This ensures fresh water is always available if it is ever needed in the event of a fire."

Mattsson notes that a combined plumbing and fire sprinkler system makes a lot of sense for builders. "With more jurisdictions across the country requiring fire sprinklers in homes, the *AquaSAFE* multipurpose system is a smart solution for builders. It can save on installation and materials costs compared to a separate plumbing and fire sprinkler system, and oftentimes the fire sprinklers can be installed by the builder's trusted plumber already on the job."

Mattsson says that it isn't just the changing climate and wildfires that are prompting people to use fire sprinklers. It is also important to have them because of the synthetics in today's home decor. Synthetics burn faster and hotter than natural materials. "Smoke detectors are important, but fires happen so quickly in homes," she notes. "Fires used to take about 15 minutes to flash over and now it's three minutes. Fire sprinklers save structures, yes, but more important, they give you time to exit the house."

When it comes to cost versus value, the fire sprinkler conversation often comes up, Mattsson says. "The reality is, fire sprinklers are like insurance: You don't know its value until you use it. You pay for it and hope to never have to use it." However, she notes, builders have an opportunity to differentiate their houses, particularly with the recent heavy press given to natural disasters: "They can say, 'My houses are beautiful, well built *and* safe.'"

Dynamics, Inc. "We also added mass materials in the home so it can hold internal temperatures as outside temperatures swing up or down—radiating heat or absorbing heat to maintain comfortable temperatures."

Even smaller details add to the performance of the building. The team will use a steel coating designed for thermal protection of steam pipes for the steel beams. "This coating goes on like paint but is layered in six coats and builds up 10 mils of thickness, making it R-5," explains VISION House® builder Ted Clifton of Clifton View Homes. "So by coating the steel penetrating enclosure from the inside and outside, with R-5 on each side, the steel beams go through an R-10 opening, which is better insulated than windows. These are the kinds of things that provide durability, protection against fire, and energy efficiency. So it may be $120 a gallon compared to $40

COURTESY OF NUDURA INSULATED CONCRETE FORMS

Staying power. NUDURA's advanced insulating concrete form (ICF) design combines two panels of *Expanded Polystyrene* (EPS) foam with the structural strength and thermal mass of concrete, for a house hurricane wind resistance up to 250 miles per hour and an energy-efficiency rating as high as R-50.

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COURTESY OF EQUITERRA

Showing their smarts. The VISION House® project team leaned on technologies such as insulating concrete form (ICF) walls, structural insulated panels (SIPs), high-performance windows and stone-coated steel roofing to get the job done.

a gallon, but it is key to the total cost story of this house."

And let's not forget the dollar savings this represents. As designed, the house is projected to operate using a quarter of average energy demand of an equivalent home built to contemporary standards while having no negative impact on comfort, convenience, or quality of life. "Reducing 75 percent of monthly operational cost of house is equivalent of adding $150,000 value to the house," says Herro. "In terms of environmental implications, the carbon footprint of the operating house would be 25 percent of the carbon footprint of conventional construction, and when you add renewables, we can get to carbon neutrality on this house."

BUILDING FOR THE UNKNOWN

According to McGee, the building industry and home buyers need to think even bigger than first cost versus total cost. "When looking at long-term costs there are variables, and the biggest are climate change and severe weather," he says. "The operations and maintenance point of view is peanuts in terms of challenges we will face 10 years from now."

McGee notes that while he and Herro were designing the VISION House®, California was having its first ballot over forest fires. The team decided that although the house is not located on the wildlife urban interface, it would be smart to make the home as fire proof as reasonable.

COURTESY OF BORAL INDUSTRIES

Metal (over)head. Owner C.R. Herro selected Boral *Steel-Stone Coated Roofing*, a product that comes in five profiles, including the enhanced high-definition, two-color blend *Cottage* shingle.

To address fire resistance, the team went through the design and decided that there would be no wood in the project (except for finished interior wood/cabinetry). The roof is a fire-resistant assembly, with Boral's stone-coated steel roofing. "We addressed the roof and how air moves through it," McGee says. "The assembly allows heat to go up and out, and stops heat conduction from the sun or fire. We have a good handle from the energy model how it will perform so that operations and maintenance costs won't be a wild card."

That's just one example, McGee continues. The entire house was looked at through numerous lenses: thermal bridging, fire resistance, water resistance. "The industry used to do what met building code and was cost effective," he says. "Then, when people added in energy efficiency, things like drainage planes and durability got the focus. Now, we are adding climate change and radical weather."

To further reduce the ongoing operating costs of the home, the team specified products that would hold up under the windy, wet conditions of the site—notably, products made from concrete and steel. "This house can last forever as opposed to conventional low-cost timber construction, which can degrade in this wet mountain climate," Herro notes.

The upshot is that building for climate change and severe weather adds a little bit of cost, McGee says. "But if you are super energy efficient you are choosing to buy materials not just based on aesthetics but also on climate change, energy efficiency and durability," he notes.

In the end, McGee believes that the insurance companies will have an impact on how we build, and smart builders will get out ahead of that. "Even if your house didn't burn in Northern California, you're going to get an insurance hike. Insurance companies are going to require things—have a real impact on what products can be used based on what certain climate zones are experiencing, like hail or fire."

McGee matches Herro when it comes to mission orientation. "What we do for a living just keeps getting more complicated, and because of that we need an overall conversation on the nitty gritty of long-term costs," he says. "Why are we doing what we are doing? What is the conversation we are trying to raise up? We need to help prioritize these issues for the industry."

COURTESY OF PREMIER BUILDING SYSTEMS

Productive paneling. The VISION House® uses Premier SIPs, which install 65 percent faster than traditional roofs, offer increased strength capacity of roof sections, and are super energy efficient.

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COURTESY OF: WESTERN WINDOW SYSTEMS

Super 'Series'. The VISION House® will use Western Window Systems' *Series 7000* aluminum windows, which offer U-value ratings as low as 0.19 and design pressure ratings above 50.

FROM UPHILL BATTLE TO NEW REALITY

Outside this VISION House® project, the battle to elevate the conversation around first-cost versus full-cost will continue, at least in the short term.

"It is basic to human nature to skip to the bottom line and just skim through the specifics," says Green Builder Media Founder and President Ron Jones, whose design/build firm produced award-winning, high-performance custom homes in the Southern Rockies for more than two decades. "So in home building, like any industry, it's difficult to be competitive but still take buyers one by one and walk them through all the elements that add up to that final number, especially when everyone is so focused on first cost."

Jones believes that many builders, as well as buyers, understand the concept that first cost is not the same as full cost; that better quality and higher performance are much more cost-effective in the long run. "But sometimes, it's impossible to embrace the reality that the long game is in everyone's best interest if they don't feel it's in their immediate interest," he says. "Even the builder with the best of intentions and highest standards often has to choose between delivering a truly superior product or watching a potential customer walk out the door in search of a 'better deal.'"

VISION House® Seattle Cascades aims to be a definitive proof point in this education process. "The VISION House® will show real people what they can really do," says Clifton. "If builders say, 'In my price range I can't do that,' then we have missed what we are trying to accomplish."

Herro is secure in his belief that this house will ultimately illustrate the value of looking long-term when designing and building homes. "As a builder, I am keenly aware that we can't do amazing building science if negative impacts are experienced by the homeowner," he says. "This home is designed so a 36-year-old mom would have no idea about the building science in it. It's crazy smart physics and building science, but the experience of living would just be easier, more comfortable...and cost a bunch less." GB

Nature's Freefall

As the world's water need grows, rainwater harvesting is gaining popularity.

BY MICHAEL TOBIAS

PUT SIMPLY, WATER IS LIFE—we simply cannot exist without it—which is why, after serious, sustained periods of drought in many regions, the concept of harvesting rainwater is gaining momentum worldwide.

While it certainly isn't a new idea (it's been used for millennia), rainwater harvesting hasn't been widely used in industrialized countries where centralized water distribution systems provide communities with all the water they need.

The fact is that rainwater is free and it provides an inexpensive supply of water that can be used for irrigation and non-potable uses indoors. With filtration and relatively minor treatment, it can also be used to augment drinking water supplies.

Additionally, harvested rainwater helps reduce storm water runoff, contamination and erosion that commonly occur in urban environments. It is particularly useful for fire protection, and some insurance companies offer discounts if water is stored on site for emergency use.

What's not to like?

CREDIT: MEG STEWART/FLICKR

Backup plan. Rainwater systems can hold thousands of gallons of water for later use, making them essential for drought-impacted areas.

THE RAIN GAME

Also known as rainwater recycling systems, rainwater harvesting can decrease demand on city water supplies and even reduce utility bill charges for water. In places where water is exceptionally scarce, systems can help reduce (not resolve) water shortage problems.

Rainwater harvesting systems may be as simple as a rain barrel with a downspout, to an arrangement of large cisterns or tanks connected via a series of pipes. Sometimes rooftop systems, including blue roofs and green roofs, are incorporated into systems used for harvesting rainwater.

In general terms, there are passive and active rainwater harvesting systems:

- Passive harvesting systems can be mere rain barrels that catch runoff from roofs, gutters and downspouts in relatively small volumes. They are great for smaller residential applications, but barrels and cisterns should always be made from opaque materials and they need to be located where sunlight doesn't encourage algae growth.
- Nevertheless, the water captured is considered non-potable and in most states, it can only be used outdoors. There are also regulations relating to drowning hazards as well as prevention methods to stop vectors from breeding in or around the barrels.
- Active rainwater harvesting systems, on the other hand, deal with much larger volumes (up to about 100,000 gallons) and rainwater is captured from all kinds of surfaces, including roofs. Because of this, there is a need for water quality treatment, as well as pumps that can supply water to a suitable distribution system.

Cisterns may be made from a variety of materials including concrete, metal, plastic, and even wood, and, like barrels used for passive systems, they should be constructed and placed to minimize penetration of light that would result in the growth of algae.

Water from active systems is commonly used outdoors for irrigation, and indoors for non-potable use including flushing of toilets, evaporative cooling, and so on. Intended use impacts directly on the way water is treated.

EVER-GREATER HARVESTS

Anyone planning to install a rainwater harvesting system will need to ascertain specific requirements, including whether the water will be stored for later use or used immediately. If it is going to be used for farming, to irrigate crops, the water treatment system will be a vital element of the system.

While homeowners who are harvesting rainwater will usually be quite happy with a simple rain barrel that captures more than enough water for their needs, companies offering rainwater harvesting services will likely want to explore the efficacy and profitability of different systems.

Many experimental rainwater harvesting (RWH) systems and studies provide valuable insight, such as "**Urban rainwater harvesting systems: Research, implementation and future perspectives**," written by a team of academics from the U.S., United Kingdom, Australia, South Africa, Israel, Italy, Brazil, Japan and South Korea, and published in 2017.

A major finding was that the selection of technologies used and the implementation of RWH systems are often influenced by local laws and regulations and economic constraints. Another was that design protocols tend to focus on water conservation, ignoring other potential benefits of rainwater harvesting. They found that while RWH systems in urban areas show a wide range of applications, many potential benefits tend to be controversial.

Conventional rainwater harvesting systems and innovative "new systems" are discussed, including modular systems, collapsible tanks, and high-level, low-energy systems, as well as more complex systems that incorporate infiltration systems, bio-retention cells, and even rain gardens. RWH systems with dual storage facilities are also considered.

It's a no-brainer that when it comes to quality, harvested rainwater relies on the materials used for RWH systems and is affected by runoff surfaces. Acid rain can be an issue in areas where there is a lot of vehicular traffic, industry and high-density housing or office development. Even agricultural bush-burning can be a problem, though this is normally restricted to rural areas and/or developing nations.

Contaminants also come from roofs and gutters, particularly when metal is part of the structure including zinc and aluminum gutters, and both galvanized iron and copper piping. The microbial quality of the water is another factor that must be taken into account, and depending on the end-use of the water, it may be necessary to incorporate filters and pumps in RWH systems.

CREDIT: WORLD HEALTH ORGANIZATION

Waste not, want less. Rainwater harvesting and recycling are considered key ways to meet the world's ever-growing water demands in the next several decades.

COURTESY OF INNOVATIVE WATER SOLUTIONS

Thinking bigger. It's free, it's natural and it's abundant—yet rainwater harvesting is only now starting to become a viable, logical option for thirsty nations.

H_2O-NO

In some parts of the world, the concept of rainwater harvesting takes on new importance when it comes to a basic function: flushing a toilet. The feeling tends to be one where drinking water is considered too valuable to be flushed down the drain. That philosophy is explored in a new European study.

"**An Analysis of the Effectiveness of Two Rainwater Harvesting Systems Located in Central Eastern Europe**," published in January 2019, examines two systems established for toilet flushing needs in Kosice, Slovakia and Rzeszów, Poland, where drinking water is in short supply, and where rainwater harvesting systems are rarely used because they are considered unprofitable. As such, the fact that there are no formal regulations or guidelines that encourage the use of RWH systems is considered a disadvantage.

Student dormitories in major urban areas were used for the study, and in both cases, there was a high and constant demand for water. Similar-sized underground tanks were used—100 cubic meters in the Nemcova dormitory in Kosice, and 90 cubic meters in the Ikar dormitory in Rzeszów—and water was discharged to both via a pipe system. The Kosice roof was sloping while the other was flat.

CREDIT: EDSEL LITTLEFLICKR

Taking up a collection. A rainwater collection system doesn't have to be high tech—it can be as simple as a barrel set up to capture downpours.

Precipitation from 2003 to 2012 was analyzed and found to be similar in both places.

Two financial ratios were used to determine profitability:

- Net present value (NPV) that shows projected earnings vs anticipated costs and cash flows and ultimately determines future profit.
- Discounted payback period (DPP) that indicates how long it will take to break even.

Strangely, while there was so much in common at the two dormitories, implementation of the two systems yielded very different results. The Polish RWH system was found to be completely unprofitable, with a DPP period that exceeded 30 years. The Slovakian RWH system, on the other hand, produced favorable NPV and DPP results.

Although the researchers concluded that it was possible to save around 18 percent and 29 percent water over a 10-year period for the two facilities respectively, the "slight water savings" at Ikar were found to be unprofitable.

It is accepted that volumes of precipitation, the demand for non-potable water, roof surfaces and tank capacity all affect the efficiency of RWH systems. But this study showed that there are a huge number of financial parameters that may potentially influence the efficiency of any RWH system.

Quite clearly, the financial viability of the two rainwater harvesting systems studied was impacted by their efficiency. For instance, during the wettest year (2010) when rainfall was higher, tests for tank capacity showed that 29 percent (at Nemcova) and 40 percent (at Ikar) more rainwater was taken. Even though the percentage of rainwater discharged into the sewer systems during the same year was very similar (85 percent at Nemcova and 87 percent at Ikar), water savings were 36 percent and 23 percent, respectively. In 2003, the driest year, the savings at Nemcova were 25 percent, which was even more than Ikar's savings in the wet year!

One factor the researchers highlighted was that while water-flushing demands were exactly the same, the water surface area from which the water was collected at Ikar was significantly lower than Nemcova. The slightly bigger tank size at Nemcova was found to be an advantage.

Other factors that impacted on the two rainwater management systems included operating costs. Also, capital expenditure at Ikar was unacceptably high.

The total period of analysis was 30 years, but the researchers agreed that a longer functioning period of 50 years for an RWH system, as suggested by previous research, would lead to a more favorable investment. Generally, plastics used to manufacture tanks suitable for RWH systems have a minimum life span of 50 years, so that wasn't an issue.

Ultimately, Stec and Zelenáková concluded that rainwater harvesting has many benefits for the sustainable development of cities and the environment. Furthermore, they can also be financially viable. But because of the influence of financial parameters on financial efficiency, it is vital to undertake full economic and technical analysis to ascertain whether the system will be profitable or not.

Of course, design engineers realize how important it is to determine volumes of water that can potentially be harvested. As the Stec/Zelenáková study shows, this can vary tremendously year-on-year. It's also recognized that because objectives relating to the primary purposes of RWH systems can conflict (for instance wishing to maximize water saving as well as empty tank volumes for control of runoff), systems do require customization to maximize ROI. **GB**

Michael Tobias is the founder and principal of New York Engineers, *an Inc 5000 Fastest Growing Company in America, with offices in New York and Chicago.*

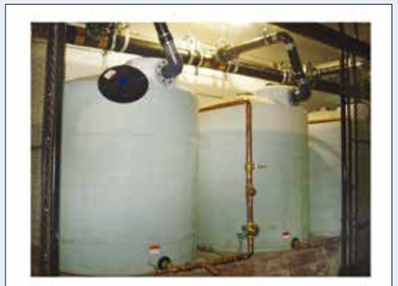
Harvesting know-how. Various government agencies, such as the U.S. Environmental Protection Agency, provide free guides and studies on rainwater harvesting.

CREDIT: U.S. ENVIRONMENTAL PROTECTION AGENCY

GUIDELINES FOR HARVESTING RAINWATER

IF RAINWATER IS GOING to be harvested on any scale, there is still a significant need for guidance. While no U.S. states prohibit the harvesting of rainwater, regulations (where there are any) are not consistent. For example:

- In California, where harvesting rainwater was illegal until 2012, harvesters must now comply with the requirements of the California State Water Resources Board.
- In Colorado, traditionally the most restrictive state in terms of harvesting rainwater, harvesting has been permitted since 2016, but only for non-potable purposes. Also, the quantity of rain that may be collected is limited.
- In Arkansas, a professional engineer licensed in the state must design the system.
- In Illinois, it is legislated in terms of water conservation and renewable energy. A Chicago engineering firm will need to make certain the system conforms in terms of water conservation, infrastructure, efficiency and management.
- In New York, rainwater harvesting is 100 percent legal and is encouraged.



More information on rainwater harvesting is available at various levels of government and private associations. They include:

- In 2013, the U.S. Environmental Protection Agency (EPA) published a comprehensive document on rainwater harvesting. It provides useful references that contain technical information as well as guidance manuals from Texas, Georgia and Virginia, and a series of interesting case studies.
- New York City (NYC) has specific acceptance and maintenance criteria for rainwater harvesting systems that were developed by the City's Department of Environmental Protection (DEP) in consultation with the NYC Department of Buildings (DOB).
- New York State has a more-specific *Rainwater Harvesting Guide*, published in 2015, which includes easy-to-follow, step-by-step instructions with appropriate references.
- The national Uniform Plumbing Code (UPC) and International Plumbing Code (IPC) has addressed the subject of harvesting rainwater since 2010. The same applies to other professional organizations, including the American Rainwater Catchment Systems Association (ARCSA).

Five Tech Items Builders Should Keep an Eye On

BY JASON KRANKOTA

CONSTRUCTION HAS BEEN one of the slowest industries to adopt technology. That's partly cultural—folks in the industry like to solve problems with their own ingenuity. Many firms are still family owned, and there's still a lot reverence for tradition. Finally, this is an industry with thin margins, where the first funding priorities are equipment and personnel.

But, it's also partly because there hasn't been a lot of technology built to meet the needs of the industry. Before smart phones, it was hard to bring technology to the field. Even then, you had to have a good Wi-Fi connection, which wasn't consistently available, or an expensive data plan. A lot of early field capture technology based on someone having to manually input data didn't really provide much in the way of productivity gains, and made for a lot of unhappy superintendents.

Now all of that is changing. Founders are aging out of the industry, creating an opportunity for younger generations to apply technology with less resistance. Project owners are requiring the use of different technologies as a condition of funding. And, there are an increasing number of great solutions specifically designed for the industry.

Here are some of the technology opportunities construction companies should have on their radar:

1. AR and VR

Whether it's on a computer screen or through a headset, augmented reality (AR) and virtual reality (VR) are taking the output of Building Information Modeling (BIM) software and creating virtual models of a structure subcontractors can walk through before it's even built, allowing them to collaborate and spot potential issues in a virtual environment.

For example, an electrical contractor could walk through the schematic of what the mechanical contractor would have built so they can say, "Okay, I see that there's going to be a standpipe here, so we'll run our conduit right next to it." That leads to less rework and fewer scheduling delays. AR can also be used to help train workers in a more effective and cost-efficient manner.

2. AI: Not yet

Artificial intelligence (AI) could potentially have a big impact on the industry, but probably not for quite a few years. One immediate application is job site safety. There are already rudimentary tools that can analyze video from job site cameras and spot hazards. They can also determine from workers' movements whether or not they're accessing a scaffold or carrying materials up a flight of stairs correctly.

Eventually AI could be used to help improve project scheduling by learning from data from past projects and flagging issues that could lead to delays. It could analyze the performance of buildings over time and offer materials recommendations. But AI needs relevant data to learn from, so the industry needs to digitize first.

3. Internet of Things

If you look at industries that are starting to see some success with AI, such as health care and manufacturing, everything is happening more or less in one place. That makes it easier to put sensors on a machine or robot and capture data. It's a bit more of a challenge when you have multiple job sites and a lot of movable equipment, so taking data capture out of the hands of individuals and automating it, and storing data in a centralized place where it can be managed is the frontier right now.

4. Back office efficiency

Most firms are using some sort of automated accounting platform. But there are still gaps that need to be filled.

Invoice routing and approval is a big one. People are literally having the back office scan invoices and then email out invoice images to the project superintendent. Invoice images are "digital paper," meaning they're not actual digital artifacts. Any data that's on them has to be manually entered, and the whole routing and approval process is manual as well.

Then there's the payment process itself. Solutions built to handle procure to pay actually only handle procure to invoice approval, so then you need a payments automation solution on top of that. The good news is that automating payments is pretty easy to do, and it doesn't depend on automating the invoice workflow, which is a much bigger project.

5. Business intelligence

Most enterprise resource planning (ERP) systems offer tons of reports, but people want to be able to look at the data three-dimensionally and be able to drill into it. ERP systems don't have that kind of capability, and as the amount of data companies have access to grows, so does the need to have a business intelligence platform to pull it together and generate analyses and models.

There are a lot of challenges to overcome before construction becomes a fully digitized industry. It's still hard to deploy technology organization wide when you have workers on multiple job sites. Do you pull everyone off the job to come in for training? Probably not. Adoption can move pretty slowly, with some workers using the technology and others holding to traditional practices, resulting in the industry overall heading in the right direction of the benefits, even if it's not happening at a rapid pace. **GB**

Jason Krankota is vice president of construction sales, West region, at Nvoicepay, a specialist in intelligent payment automation. His expertise in construction business technology includes corporate payments, accounts payable and expense management solutions.

A Very Big (Green Jobs) Deal

Maine lawmakers are taking huge steps toward ensuring a green future.

BY MIKE COLLIGNON

THE "PINE TREE State" has had many efforts underway to help keep the state green. Maine's most recent legislative session was rife with climate change bills. Here are the highlights:

- LD 1282 establishes a Green New Deal within the state. It is largely a jobs bill. Here are the specifics:
  i. Apprenticeships—This bill is looking to create a labor force skilled in the construction of electricity generation facilities. The start date on the construction of any new generation facilities will determine the minimum percentage of apprentices employed on that project.
     a. 10 percent apprentice requirement for projects started between 1/1/2021 and 12/31/2024
     b. 17.5 percent requirement for projects started between 1/1/2025 and 12/31/2026
     c. 25 percent apprentice requirement for projects that begin on or after 1/1/2027
  ii. Fines—Violations will be subject to a fine between $50 and $200 per incident.
  iii. Incentives—Incentives will be created for cost-effective electric and natural gas conservation projects tied to school construction.
  iv. Solar—All new schools will conduct a competitive solicitation for a power purchase agreement for solar to be installed on the property. The solar system may not exceed the estimated annual electricity consumption by the school or 100 kilowatts, whichever is less.

- LD 1679 creates the Maine Climate Council. The Council will develop the action plan and timetable to meet the state's greenhouse gas reduction goals, to promote jobs and economic benefits for Maine people in the transition to a lower carbon economy, and to support the climate resiliency of Maine's communities. The Climate Council will consist of several department commissioners, key state leaders, science and technical experts, business and non-profit leaders, municipal leaders, a tribal representative, and a representative of Maine youth. It will be charged with leading Maine's efforts to reduce Maine's Greenhouse Gas emissions by 45 percent by 2030 and at least 80 percent by 2050, and with achieving 80 percent renewable energy in Maine's electricity sector—specifically energy consumed in Maine—by 2030 and 100 percent by 2050.

CREDIT: BECKER1999/FLICKR

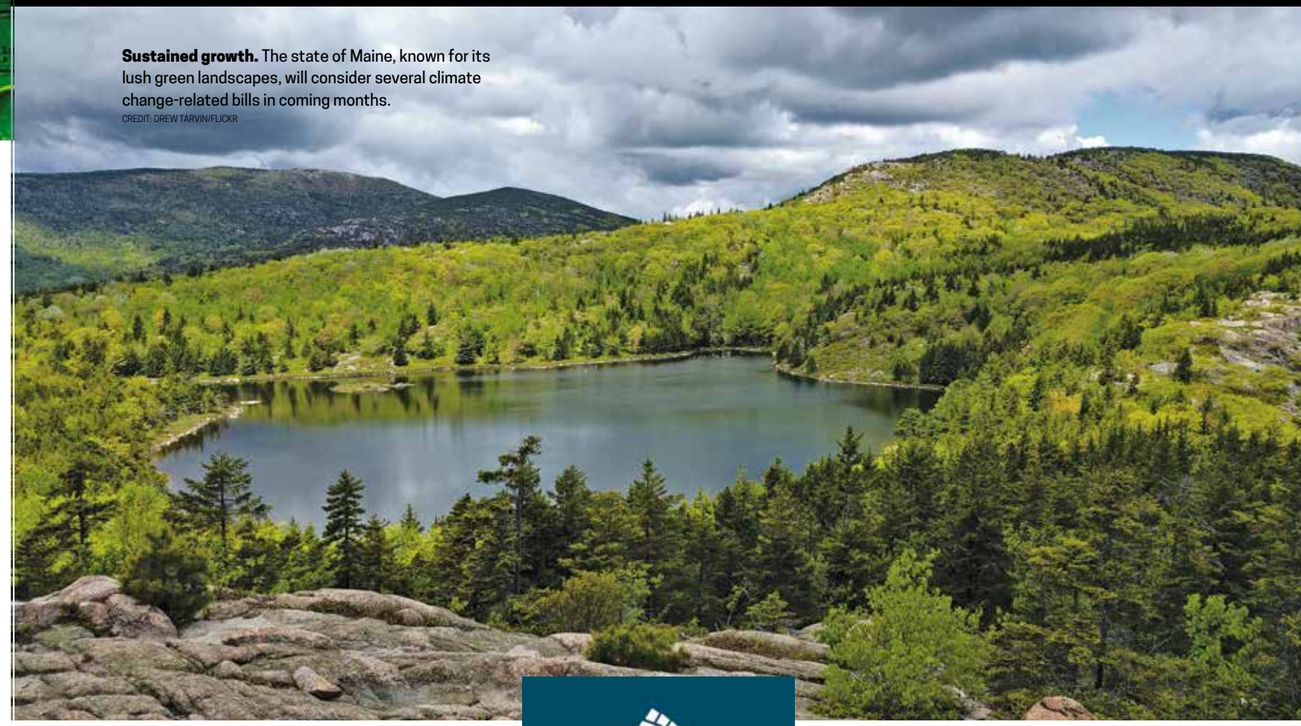
Going Green—finally. After months of debate among legislators and the populace, Maine's Green New Deal became law this summer.

The Climate Council will also convene several working groups from within its membership—including a Scientific and Technical Working Group, a Transportation Working Group, a Coastal and Marine Working Group, and others—to focus on how the state can tackle challenges within these specific areas. In addition to recommending new policy and innovative strategies to reach these emission and energy goals, the Council will update the Maine State Climate Plan every four years, and will solicit input from the public and report out progress on its goals every two years to the people of Maine.

The first Climate Action Plan is due to be submitted to the legislature by Dec. 1, 2020.

- LD 658 calls for the Governor's Office to develop a 10-year energy independence plan whereby the state "can become a net exporter of energy through the development and expansion of energy generating capacity within the boundaries of the state and its coastal waters, energy conservation and energy efficiency at levels sufficient to offset the total value of the State's domestic energy consumption across all sectors. This analysis must identify economic benefits to the State from becoming a net exporter and policies that would be necessary to achieve this outcome." The state better get moving on this plan, because (per the bill) a progress report is due by Dec. 31, 2019.

- LD 1494 passed in mid-June, this bill seems a bit redundant to LD 1679. It sets the requirement of electricity sales sources from renewable energy at 80 percent by 2030 and 100 percent by 2050.



Sustained growth. The state of Maine, known for its lush green landscapes, will consider several climate change-related bills in coming months.
CREDIT: DREW TARVIN/FLICKR

- LD 1614 simply calls for the creation of a 14-member commission to study the economic, environmental and energy benefits of energy storage to the Maine electricity industry. The commission will meet a minimum of four times, has a seven-point directive, and must submit a report to the Joint Standing Committee on Energy, Utilities and Technology by Dec. 4, 2019.

- LD 1509 slightly modifies the membership of the Technical Building Codes and Standards Board to include the Director of the Efficiency Maine Trust, who serves in an ex officio role and may not vote. The six-page bill also stipulates that the Maine Uniform Building and Energy Code consists of the IBC, IEBC, IRC, IECC, IMC, ASHRAE 62.1, ASHRAE 62.2, ASHRAE 90.1 and ASTM's Standard Practice for Radon Control Options for the Design and Construction of New Low-Rise Residential Buildings. Finally, it makes the state code mandatory for municipalities more than 4,000 residents. For municipalities with 4,000 residents or less, the enforcement of the code is optional, but the state code is the only code they can adopt and enforce should they choose to have a code.

- LD 1543 gives the legislative green light to municipalities that want to adopt a stretch code for energy efficiency by creating an appendix to the Maine Uniform Building and Energy Code. The appendix contains energy conservation and efficiency requirements that are based on established national voluntary efficiency standards that exceed the energy code requirements established in the state code. The stretch code will be available no later than July 1, 2020.

Governor Janet Mills and the Maine legislature is making a clear commitment to mitigate climate change and reduce its carbon footprint while simultaneously generating employment opportunities for its residents. This is what bold and decisive action looks like. **GB**

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

COURTESY OF
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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**

The Future of Green Buildings

Part I: The Top 5 Coming Challenges

This is the first in a series of articles about upcoming challenges and advancements in green city architecture, master planning and technology.

BY TERRY BEAUBOIS

GREEN BUILDING HAS A BRIGHT FUTURE. More people every day are becoming aware of the benefits of green building. What will also develop in the future, along with this increasing interest, is the growing need for up-to-date knowledge about how to best provide green homes and buildings, so that builders can benefit directly from the coming, greener environment.

The green building industry is not alone in facing future challenges. This year, I am involved in events, classes and articles related to the futures of architecture, green building, master planned communities, smart cities and technology transfer to the building industry. I am drawing from my work in all of these areas to derive what matters most and can benefit green builders.

Here are the top five issues to consider in green building, from my perspective:

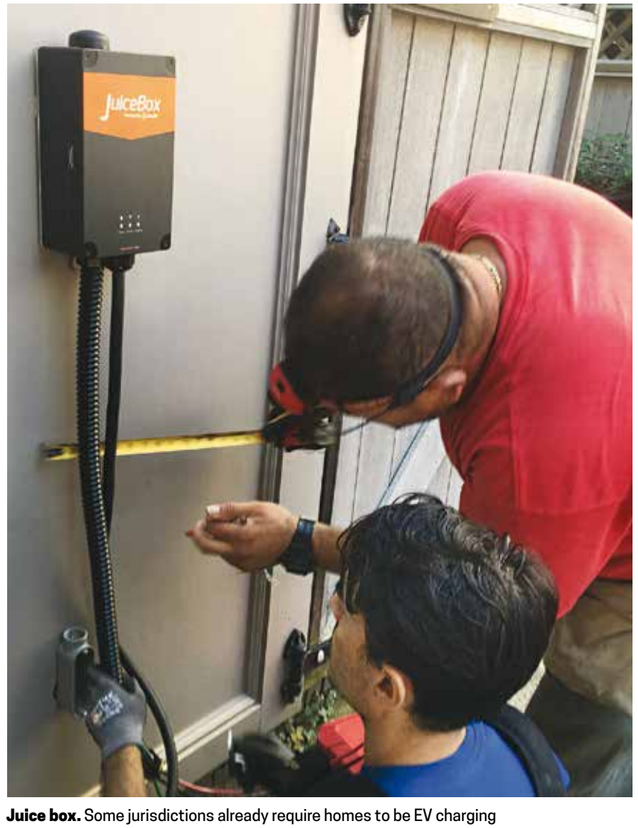
Human Health in Green Buildings and Related Requirements

Human health will become one of the main reasons that people will want green buildings in the near future. The health of their families and/or employees is of great importance to your clients. The reason that builders, homeowners and building owners will address this in new projects will include an increase in local and national codes that require it.

For your clients and building permit agencies, you will need to be able to show that you are aware of this and can provide a healthy home that is a green building. This includes air quality (indoor, outdoor, humidity), water quality, and how you will provide this with the design and construction of a green building.

Also included is how the products you use will meet these standards (safety, no outgassing, etc.), and how the mechanical equipment and plumbing products will meet coming newly required product and performance standards. These requirements will come from the Environmental Protection Agency (EPA), the Department of Energy (DoE) and other government agencies.

Another reason that this will be important is that these requirements may also become mandatory to sell a house or building in the future, in some locations. For example, some U.S. jurisdictions already require that new houses must be wired for charging units in the garage for electric cars, to pass final inspection and receive an occupancy permit or to sell the house. Anticipate that more local and national requirements will be developed.



CREDIT: EARTH AND MAN/FLICKR

Juice box. Some jurisdictions already require homes to be EV charging capable—a scenario the rest of the nation will eventually follow.

Evolving Technology and the IoT of Green Buildings

This category pertains to the Internet of Things (IoT), including connected appliances, smart thermostats, smart phones, voice control, video cameras, entertainment centers, various sensors and other security devices such as smart locks, that are increasing in popularity. It is expanding to include smart appliances, HVAC equipment, and other devices such as solar and geothermal equipment.

How to select and integrate these devices is no simple task. In many cases, the responsibility will fall to contractors. Specialty consulting businesses are already developing in this area. These specialists can be a good addition to your subcontractor team, when you have a client with high IoT interests.

Products and Materials

Matching homeowner desires with product manufacturers' information can be challenging. Your clients' need for assistance in selecting products and materials with the availability of appropriate current products can vary from project to project. Just as builders are updating their practices, product manufacturers are updating how they keep the outlets for their products—direct sales, showroom sales, and increasing online sales—supplied with current trends, innovations and brand sentiment, from sources such as Green Builder's COGNITION Smart Data.

They are also trying to market and sell their newer products, and transition from more-familiar products that they plan to retire and will be no longer be available. Coordinating products' features, available finishes and styles of products can be a complex and somewhat confusing world for new clients. Much of this information is available digitally and your own ability to manage this data efficiently will increasingly become part of your competitive advantage.

The old days of the "installation instructions with critical clearance dimensions being in the box when the product is delivered" are hopefully over. But the responsibilities of the general contractor to coordinate this information with subcontractors remain. In cases where products are "owner selected/purchased and contractor installed," the need and ability to effectively include the homeowner in this process is important.

CREDIT: NAVFAC/FLICKR

Field marshall. To remain competitive, general contractors will have increased responsibility to coordinate communication with their subcontractors and with the homeowner.

Project Management: From Bids to Job Site

The amount of data to be managed in a green building project is complex and extensive. Connecting to and easily exchanging data with your clients, consultants, subcontractors, product manufacturers, review agencies and building inspectors is critical. Project management software for teams will play an even greater role in everyone's work to successfully participate and compete in the business of green buildings. Builders who master project management software successfully, and who become more efficient and effective in their projects will be more successful in the financial and economic aspects of green building as well. GB

Terry Beaubois is CEO of Building Knowledge Systems (BKS) LLC in Palo Alto, Calif. For 40 years, he has been involved in research projects, articles, speaking engagements and guest lecturing in university classes related to the building industry, with a specialty in advancing technologies.

AD INDEX

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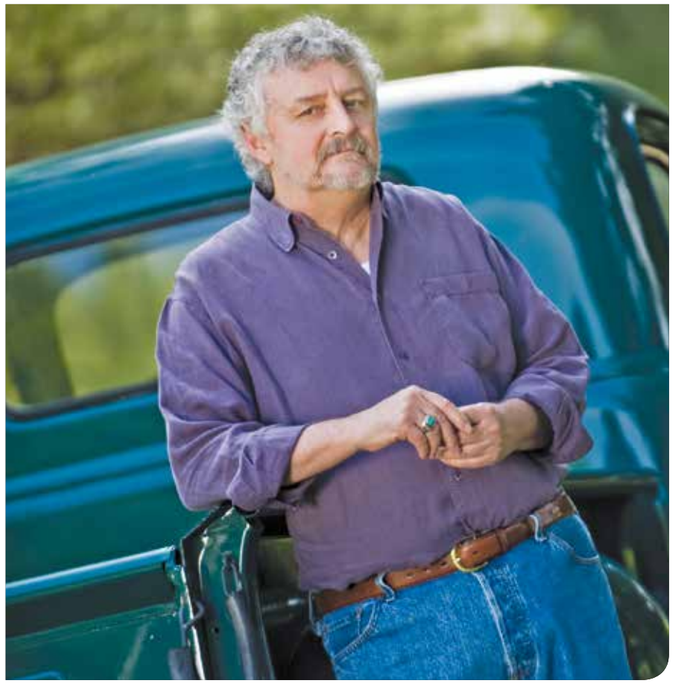
For more information about the Green Builder Sustainability Awards, contact Mike Collignon at mcollignon@greenbuildercoalition.org

FROM THE TAILGATE

New Offerings for the Sustainable Minded

By Ron Jones

Let's do what we say–and mean it when we do



IT IS NOT UNUSUAL NOWADAYS to read an opinion piece written by someone who is lamenting the loss of things we used to take for granted, such as courtesy, good manners, consideration or professional behavior. It would be easy to point to particular figures of prominence, politicians, professional athletes, celebrities and so on, and make them the targets of our dissatisfaction but that wouldn't be completely fair or honest.

There was a time, not that long ago, when you could count on most people in the building business to extend the expected level of professionalism in their dealings, when you could actually depend on them to do what they said they would do, when they said they would do it. Unfortunately, those expectations no longer seem realistic in many cases.

Recently, I met with a new masonry contractor who I had been trying to connect with for a couple of months. He had been recommended to me by several builders and I just wanted him to take a look at a project of mine to let me know if he was interested in the job. I had reached out by phone and email numerous times and was about to give up and move on when I finally got a response. He expressed interest and agreed to give me some lead time when he could connect with me.

Instead, I got a message late the night before from him saying he would be in my area the following day. I had out-of-town meetings scheduled and responded that he would need to let me know when he had another chance and suggested that a little more lead time would be helpful.

When we were finally able to connect, he was pleasant enough and followed me to the site of my project to have a look. He again expressed interest in the work and offered to prepare a proposal for me. He also asked when I wanted the work to take place, and I responded that I just needed it completed before we started getting freezing temperatures. He chuckled and said, "Yeah, that's what everybody is wanting now that summer is over."

I felt like reminding him that I had been trying to get him to look at the job for many weeks, long before the change of seasons became a concern, but I thought better of it and held my tongue. There was a time when I would have simply thanked him for coming and told him I would be looking elsewhere, but I have enough experience to know that I would probably just be teeing up a repeat with somebody new.

What's most frustrating is that the story I have just relayed seems to be the norm; business as usual these days. It seems that all the instant communication at our fingertips has resulted less in streamlining our interactions, and instead provides a platform for ignoring reasonable protocols and being less responsive than we really should be.

We're all participants at one time or another. More than once, my editor has had to coax me to deliver a column, so I suppose what goes around comes around, as they say. I'll try to give the masonry contractor the benefit of the doubt. Still, I don't have a lot of faith that the upcoming colder weather won't render the conversation moot. GB

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