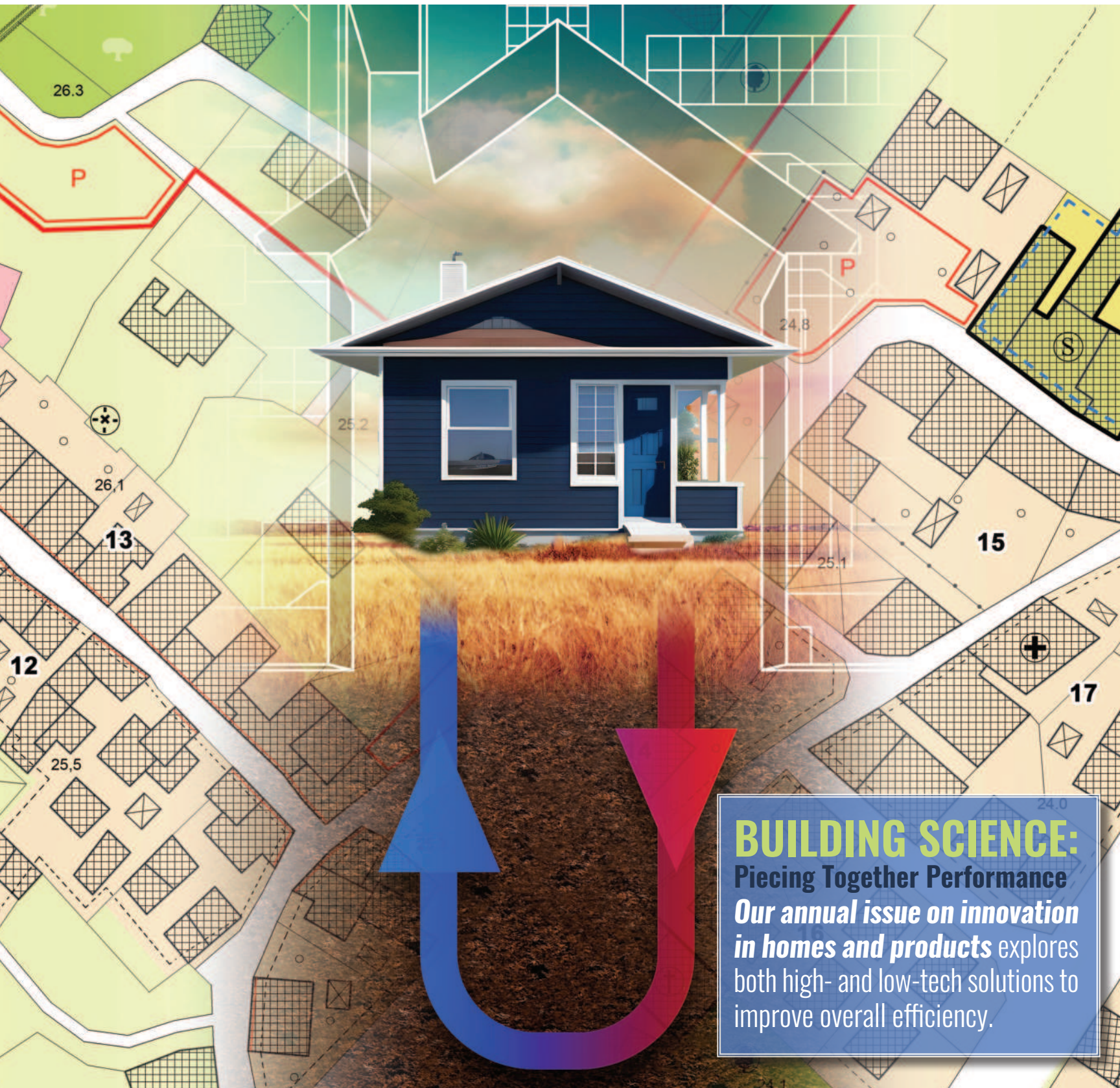


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THE BEST NEW IDEA ON THE BLOCK

We can all take inspiration from this tale of a humble inventor who harnessed the Sargassum seaweed crisis to create a **cheap, low-tech housing material.**



CREDIT: SARGABLOCK

I love success stories, particularly when the individuals rise from humble roots. One of my favorites in was that of the musician named Sixto Rodriguez, emotionally captured in the documentary, “Searching for Sugarman.” He was presumed dead, only to be discovered and “resurrected” to receive the acclaim (in South Africa) that he never got in this country back in the 1970s.

The story of **Omar Vázquez Sánchez** of Mexico has a similar arc, in that man involved is born into a humble lifestyle, and spends much of his life doing the kind of persistent hard labor that most of us would find deeply exhausting.

One of Sánchez’ small business efforts involved the thankless removal of tons of nasty smelling Sargassum seaweed from resorts and tourist beaches frequented by well-to-do tourists. This tangle of seaweed and current-borne detritus has washed ashore with increasing volume over recent years from Mexico to Florida beaches, and the sheer volume of organic yuck has overwhelmed local communities.

But Sanchez saw potential in the Sargassum: a virtually limitless source of “free” fiber, which, when mixed with the natural clay soil of his region, could form strong and durable “bricks.”

He began by gathering the seaweed, grinding it up and testing it with soil and other low-cost aggregates to find the right ratios for the blocks, the same way a multi-national R&D facility would, but without the HR department and big paychecks. And he and his local helpers did it all by hand. He built the **first block home**

for his mother, modeled after the modest dwelling where he spent his childhood.

Now his operation, which he calls **Sargablock**, has legs. The blocks have already been used to construct 13 homes for low-income families in Quintana Roo, Mexico. Sanchez is getting inquiries from people in other countries, including the U.S.

What’s important about this story is the concept of finding opportunity in obstacles. Think of all the other crises that seem existential. For example, could extreme outdoor heat be used to fire up energy devices to cool buildings? What about using thermoelectric generators or Sterling Engines? Can methane be burned in a cleaner way that destroys it and produces energy but minimizes pollution? What about plastics? Is there a way to extract the microscopic particles in our environment and reconstitute them into 3D-printed houses or furniture? Can we make plastics “permanent” so they don’t break down and pollute our world? Or do we need to release plastic-eating bacteria on the whole mess and find a better building block?

These are challenges that need to be solved by engineers and building scientists. If they approach problems with the same open mind as Omar Vázquez Sánchez, they might find a silver lining, and also buy time for the transition away from fossil fuels. **GB**



Matt Power
Editor-in-Chief

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Youths Win Montana Climate Change Lawsuit

A first-ever ruling reaffirms the constitutional right to clear air.

In the nation's first constitutional climate change trial, a Montana district judge has ruled that two statutes promoting use of fossil fuels and ignoring their impacts on the environment violated the constitutional rights of youth by depriving them of a "clean and healthy environment." The ruling was the result of a lawsuit filed by 16 under-age plaintiffs. It effectively means that Montana, which gets one-third of its energy by burning coal, must consider climate change when deciding to approve or renew fossil fuel projects.

According to Judge Kathy Seeley, the plaintiffs had provided ample evidence to prove, among other things, that Montana is responsible for as much carbon dioxide as produced by Argentina, the Netherlands or Pakistan.

"As youth, we are exposed to a lot of knowledge about climate change," said Rikki Held, the suit's lead plaintiff, in a report in *The Flathead Beacon* before the trial. "In some ways, our generation feels a lot of pressure to



Trailblazers. These teens were among the 16 that successfully sued the state of Montana for violating their right to a healthy environment.

CREDIT: YOUTH V. GOV/ROBIN LOZNAK

make something happen, because it's our lives that are at risk."

The Montana attorney general's (AG) office argued that the climate crisis is a global problem, and that if Montana is contributing to it, plaintiffs should work to change that through the legislature. The AG plans to appeal. **GB**

The Passive House is Still a Rare House

But if it is Passive, it's likely to be an affordable multifamily type.

A new report finds that constructing new buildings to all-electric Passive House standards can help protect residents from the devastating impacts of climate change and be built at the same cost or close to the same cost as conventionally designed buildings. But policy changes are required to overcome inertia in the building sector and ensure the benefits of Passive housing reach more Americans.

The report by The Passive House Network (PHN), "[Safe at home](#)," notes that Passive House buildings have surged since 2018, thanks to growing recognition of and demand for their widespread benefits. But Passive House still accounts for less than 1 percent of all multifamily construction in the U.S. over the past decade. Of that total, nearly half of all Passive House projects were of the affordable housing variety, illustrating the cost-effectiveness of green building design.

"We have the blueprint for coast-to-coast adoption of all-electric,



Option for construction. Multifamily Passive House projects continue to be a sustainable option for builders, but they're still only a fraction of the overall number of structures built in 2023. CREDIT: FLICKR/SUSANA SECRETARIAT

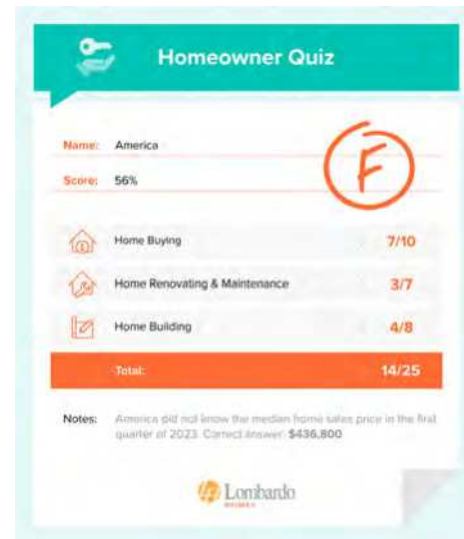
multi-family Passive House buildings," said Bronwyn Barry, PHN founding board member. "Everyone should get to experience the comfort—and we have the policy tools and professional know-how to ensure every new multi-family housing project in America is built this way." **GB**

Survey: Americans Lack a Basic Understanding of Home Systems

Like having children, no competency test is required to buy a home.

Although homeownership is a dream of U.S. homebuyers, many Americans lack sufficient knowledge of how to maintain those homes. According to a test-style survey by Michigan-based developer Lombardo Homes, buyers overall received an “F” grade when it came to the logistics of homeownership. Each of the four primary generations—baby boomers, Generation X, millennials and Gen Z—received “D” or “F” letter grades, the study notes.

Respondents scored worst on questions regarding home renovation and maintenance. They know what HOA stands for (Homeowners Association), and the average lifespan of a standard asphalt shingle roof (20 years), but they’re in the dark when it comes to how long a traditional tank-type water



Not making the grade. How to buy a house is fairly common knowledge for people of all ages and generations. But knowing how to maintain one or have one built is another matter.

SOURCE: LOMBARDO HOMES

heater should last (8-12 years), or the name of the material typically installed directly over the exterior wall framing of a house (sheathing).

More technical details about homebuilding also elude buyers. They don’t know the minimum clearance between a kitchen countertop and overhead cabinets (18 inches), and they underestimate the average cost to build a new home in 2023 (\$446,000, without the cost of land).

According to the survey, the results show that “America’s collective knowledge of homeownership has room for improvement,” and “reveal the need for accessible and comprehensive education” to help people become homeowners. **GB**

World Faces Extreme H₂O Shortage by 2050

U.S. states will not escape the squeeze, and housing will be on the front lines.

A growing population and rising temperatures will strain the world’s freshwater supplies over the next 30 years, jeopardizing available water for drinking, bathing and growing food, according to new research from the World Resources Institute (WRI). Such a shortage will also make it difficult to build new homes.

WRI’s **Aqueduct Water Risk Atlas** projects that by 2050, an additional 1 billion people will be living in regions with high water stress, where at least 40 percent of the renewable water supply is consumed each year. Two-fifths of the world’s population—3.3 billion people—currently live in such areas.

In the U.S., Arizona, New Mexico, Colorado, Nebraska, California and Idaho are using more water than they receive each year, depleting groundwater reserves to support farming and industrial use. Don’t expect anything better unless drastic action is taken, according to Heather Cooley, director of



Grim outlook. Drought and extremely dry weather will be commonplace for more than 4 billion people globally by 2050, if climate change isn’t slowed down.

CREDIT: ISTOCK/HUSEVIN BOSTANCI

research for the Pacific Institute.

With climate change, “water challenges are only going to become more frequent and more intense,” Cooley says. “That needs to motivate us to begin preparing and implementing projects.” **GB**

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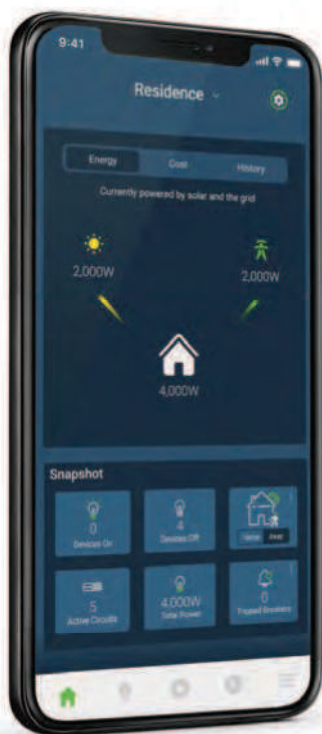
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1. Requires Leviton 2nd Gen Smart Circuit Breakers
2. Requires LWHEM-2; additional pairs of LSMMA (CTs) may be purchased to monitor multiple energy sources

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From the Ground Up

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"To me, if a person is old school, they are old fashioned enough that they don't fit in with new school society, they work hard and don't complain, they handle business and live honorably." **PAGE 64**

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TOP PRIORITIES

Annual Building Science Roundup 2023

SUSTAINABILITY TAKES CENTER STAGE ONCE AGAIN, AS BUILDERS SHOWCASE THE MERITS OF GREEN CONSTRUCTION.

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



CREDIT: ISTOCK/MAKSHOT

With the pandemic in the rear-view mirror, the U.S. Department of Energy (DOE)'s Zero Energy Ready Home (ZERH) Housing Innovation Award winners are back in the business of highlighting the ways their projects promote use of clean energy and a sustainable lifestyle.

It's no easy feat. Meeting the requirements of the DOE ZERH means that the home has been certified to the criteria of ENERGY STAR Certified Homes Version 3.0, 3.1, or 3.2,

and the U.S. Environmental Protection Agency (EPA)'s Indoor airPLUS program.

Builders must also meet other efficiency requirements, such as those of EPA's WaterSense program toward hot water distribution; the International Energy Conservation Code (IECC)'s insulation mandates; HVAC and water heating efficiencies; third-party verified air sealing targets; installation of Energy Star appliances, windows, and lighting; and ducts in conditioned space. In addition, homes are required to have solar electric panels installed or have the conduit and electrical panel space in place for it.



The price is right. The solar-powered DESEU State Fair House boasts energy costs as low as \$0—a key factor in helping low-income families purchase their first homes.



PHOTOS COURTESY OF ENERGIZE DELAWARE'S ZEMOD PROGRAM AND BERACAH HOMES

Project Info

PROJECT NAME: DESEU State Fair House, Lincoln, Delaware

BUILDERS: Beracah Homes, Greenwood, Del., BeracahHomes.com; Energize Delaware's ZeMod Program, ZeModDelaware.com

COMPLETED: July 2021



Price Point

An affordable housing program gives first-time buyers a chance to own a home—and save money on energy bills.

The lower the cost, the greater the chance of homeownership for low-income buyers.

That's the philosophy behind the **Energize Delaware ZeMod** program, which combines up to \$25,000 in payment assistance, and energy costs as low as \$0 monthly. According to Russ Huxtable, vice president and CEO of Milford Housing Development Corp. (MHDC), it's a winning combination of savings.

MHDC collaborated with the Delaware Sustainable Energy Utility (DESEU), Greenwood, Del.-based homebuilder Bera- cah Homes, Inc., and Vermont Energy Investment Corp. (VEIC) to bring zero energy modular homes to Delaware's low-income homebuyers.

Through the ZeMod program, home- ownership is made affordable in part through renewable energy and net meter- ing. The highly efficient modular homes also scored a win for the collaborative, earning a Housing Innovation Grand Award from the U.S. Department of Energy (DOE)'s Zero Energy Ready Home (ZERH) program in 2022.

All homes offered through the ZeMod Delaware program are certified as DOE ZERHs.

"Our mission is to provide decent, safe, affordable housing solutions to people of modest means," says Huxtable. "Meeting the high-performance home criteria of the DOE's [ZERH] program helps ensure we meet these goals."

EXTERIOR DESIGN 101

The first ZeMod home constructed is a 1,209-square-foot, two-bedroom, two- bath, single-story home at Knoll Acres in Lincoln, Del. Lincoln is a neighborhood of small lots with larger shared open spaces under development by MHDC, with sites qualified for low-interest financing through the U.S. Department of Agriculture (DOA) mortgage program.

With its 5.12-kilowatt (kW) of photovol- taic (PV) panels installed on the roof, the award-winning home—also known as the DESEU Star Fair House—achieved a Home Energy Rating System (HERS) score of 1. Even without PV panels, it would achieve a HERS score of 40, well below the HERS 80 to 90 of new homes built to just meet code.

The home was assembled over a vented, uninsulated crawl space. Framed assem- blies were constructed off-site in a factory. Walls are double 2-by-4 framing with a 1-inch gap to create an 8-inch insulation cavity, which is filled with blown fiberglass in the factory. Floors are insulated and sheathed in the modular factory. Windows, siding, and interior finishes are installed in the factory.

The roof comes to the site in two halves, with asphalt shingle roofing and solar pan- els already factory installed. Roof trusses create a 10-inch raised heel, allowing full R-50 cellulose insulation at the exterior wall top plates. The simple gable roof design is oriented with one side facing south at an optimal angle for solar exposure.

"Constructing the home modules in a factory ensures a controlled environment, which helps us to control costs, reduce waste, improve quality, ensure consistency, avoid labor and scheduling constraints, and minimize exposure to poor weather conditions for both the materials and the crews," says Huxtable.

The modular construction also helps to avoid ad hoc design improvisation in the field, which can sometimes result in quality and performance compromises. "Quality management is built into the modular process," Huxtable adds. "No design-build decisions are made during construction. All construction details are designed and documented before the build begins."

TEMPERATURE CONTROLLED

The double-pane windows have a U factor of 0.25 and a solar heat gain coefficient of 0.20. The vinyl-framed casement style windows have an argon gas fill between the two glass panes, both of which have a low-emissivity coating to minimize heat transfer. Quality control in the factory helped to ensure an airtight envelope and the home was tested after assembly at just 1.5 air changes per hour at 50 Pascals of pressure.

Fresh air is provided using a ventilator equipped with a heat pump to precondi- tion outdoor air. The ventilator provides MERV 13-filtered fresh air to each room. Demand controls respond to measure- ments of temperature, relative humidity,

Annual Energy
Costs

\$700
(without PV)

\$200
(with PV)

Annual Energy
Cost Savings*

\$1,050
(without PV)

\$1,550
(with PV)

Annual Energy
Savings

7,450 kWh
(without PV)

14,350 kWh
(with PV)

Savings in the
First 30 Years

\$42,050
(without PV)

\$63,850
(with PV)

* vs typical new homes

Key Features

AIR SEALING: 1.5 ACH50; modular components are sealed together on site.

APPLIANCES: ENERGY STAR refrigerator, dishwasher, clothes washer, clothes dryer.

ATTIC: Vented. R-50 of 7.25 inches of dense-pack fiberglass and 7.75 inches of loose-fill fiberglass; 10-inch raised heel energy trusses.

ENERGY MANAGEMENT SYSTEM: Rooftop photovoltaic solar panels. Energy production and usage at specific end uses are monitored.

FOUNDATION: Vented crawl space: Concrete masonry unit (CMU) walls. R-30 fiberglass batts in 2-by-10 floor joists.

HVAC: Ductless heat pump, 11 HSPF, 26 SEER, variable-speed compressor.

HOT WATER: Heat pump water heater, 50 gallon, 2.78 EF.

LIGHTING: 100 percent LED lighting, large windows.

ROOF: Gabled rafter roof, 2-by-8 ceiling joists, coated oriented strand board (OSB) with taped seams, asphalt shingles.

SOLAR: 5.12-kW rooftop panels.

VENTILATION: Ducted conditioning energy recovery ventilation (ERV) with MERV 13 filters; 2.6 CFM/watt. Controls based on temperature, relative humidity, CO₂, and volatile organic compounds (VOC) sensors. Continuous or timer-based settings.

WALLS: Double wall, R-33.5 total: two 2-by-4 walls, 1 inch apart, dense-packed fiberglass; coated OSB; vinyl siding. Wall panels and house sections constructed in factory.

WATER CONSERVATION: EPA WaterSense-labeled fixtures.

WINDOWS: Double-pane, argon-filled, low-e, vinyl-framed, U=0.250, SHGC=0.18.

OTHER: Low-emission cabinets, flooring, paint, counter tops, doors; hard floors that minimize particulates. Modular construction.

Small and sensible. The home's design and layout is compact and simple to minimize details, help control costs and take best advantage of the benefits of modular construction.



carbon dioxide, and VOCs within the home. Controls also allow continuous or timed ventilation. In favorable conditions, the ventilator brings in outdoor air to provide free cooling. A recirculation mode provides mixing and filtering of indoor air.

The home's single ductless mini split heat pump provides efficient heating and cooling in all weather conditions. Distribution and mixing of the heated or cooled air is assisted by the ventilator's fresh air ducts and recirculation mode.

APPLIANCE POWER

Water heating in the all-electric home is provided by a 50-gallon heat pump water heater with a coefficient of performance

(COP) of 3.45. The water heater is in a utility room within the home, where it derives heat from the condensing clothes dryer also located in the utility room. In addition, the room is supplied with conditioned air by the ducted ERV.

The home is equipped with high-efficiency, all-LED lighting and ENERGY STAR refrigerator, dishwasher, clothes washer, and clothes dryer. Several of the home's plumbing fixtures are EPA WaterSense rated for water efficiency. The electric panel has room to add an electric vehicle (EV) charger if desired by the homeowners in the future.

As an EPA Indoor airPLUS certified home, all cabinets, flooring, paints,



ENERGY EFFICIENCY.

The home is equipped with all-LED lighting and ENERGY STAR-rated fixtures, including the refrigerator, dishwasher, clothes washer and dryer.

HEAT SHIELD.

Double-paned, vinyl-framed casement style windows have an argon gas fill between the two glass panes to minimize heat transfer.

AIR QUALITY AWARE.

As an EPA Indoor air-PLUS-certified home, all cabinets, flooring, paints, countertops and doors are low-emission products.

SANDWICH SYSTEM. Floors are insulated and sheathed at a modular construction factory to help prevent quality and performance compromises that may occur during standard onsite construction.

countertops, and doors are low-emission products.

Energy metering was installed in the home to determine energy performance during occupancy. Circuits that are metered include the major appliances (the clothes washer, clothes dryer, and refrigerator), the HVAC, water heating, and bedroom plug loads. This energy usage data will be analyzed to identify opportunities for further savings and to support changes to the design of future ZeMod homes.

DESIGN PRIORITIES

According to Huxtable, the driving forces behind the design of a ZeMod home are

affordability, comfort, health, and zero energy. All are equally important.

“The design and layout of the house were meant to be compact and simple, to minimize details, to help control costs and take best advantage of the benefits of modular construction,” Huxtable says.

A simple form factor can help avoid costly problems associated with maintenance, he notes. For example, reducing the likelihood of water damage at roof valleys and around windows further supports affordability. “The size of the home is modest, again supporting the goal of affordable ownership,” Huxtable says.

This particular award-winning home was actually first assembled as a model

at the Delaware State Fair. But the ZeMod program has three standard designs to choose from: two different 2-bedroom, 2-bath models, and one 3-bedroom, 2-bath model. To be eligible to purchase a ZeMod home, the family must earn less than 120 percent of the median income. As of May 2022, four such homes have been purchased.

“We are hoping to attract those who likely did not think that homeownership, let alone ownership of a zero-energy home, was possible,” Huxtable says. “The success of the ZeMod program will be measured by the number of low-income families who can own and reside in a zero-energy home.”

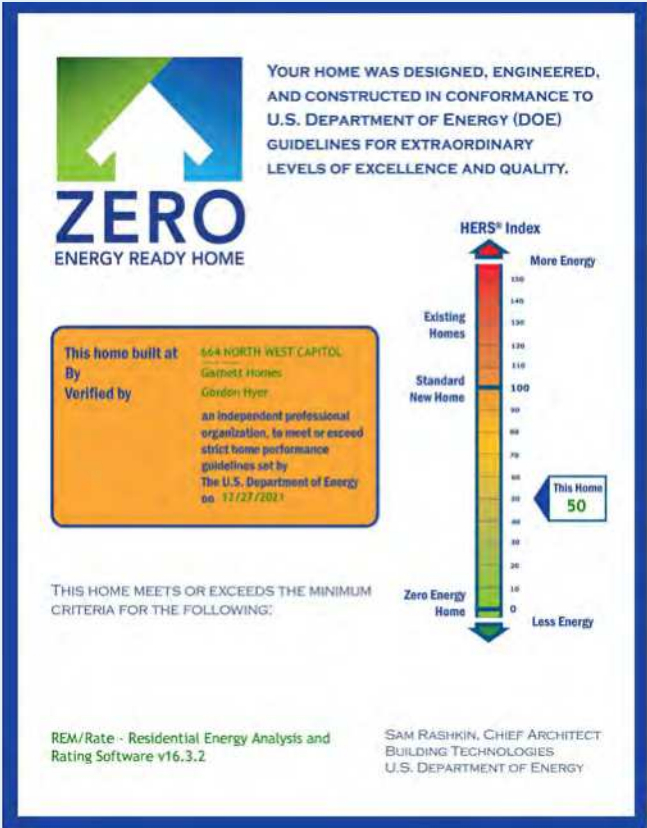


Sensible and stylish. A simple gable roof designed to withstand heavy snow loads gives the Sterling at Capitol Hill project a modern look while remaining practical. The roof's low pitch makes it appear to be flat from the front and rear street level.

PHOTOS COURTESY OF GARBETT CONSTRUCTION

Project Info

- PROJECT NAME:** Sterling at Capitol Hill, Salt Lake City
- BUILDER:** Garbett Homes, Salt Lake City, GarbettHomes.com
- COMPLETED:** December 2021



Package Deal

Buyers can't help but become 'attached' to these stylish award-winning homes.

It's been said that you can't have quick, cheap and quality at the same time. Don't say that to the team at Garbett Homes, which has mastered the ability to provide all three elements during its homebuilding efforts.

Panelized construction—which enables a home to be completed in as little as a few days, compared to several months or even years with other methods—is one way the Salt Lake City-based builder is able to cost-effectively produce high-performance homes that meet all requirements of the U.S. Department of Energy (DOE)'s Zero Energy Ready Home (ZERH) certification. Garbett's efforts helped the company to win its first Grand award in DOE's Housing Innovation Awards competition in 2022, in the Attached Homes category.

"Panelized walls are a great way to reduce construction waste and improve building timelines, and they can also improve the homes' energy efficiency," says Garbett Homes Land Acquisition and Energy Coordinator Damian Mora.

Garbett Homes is a production builder of single-family detached and multi-family homes for sale and for rent. Started by Bryson Garbett in 1983, the builder turned to higher efficiency homes in 2008 and committed to certifying all of its homes as DOE ZERHs in 2017.

Mora notes that Garbett is Utah's leading builder of DOE ZERHs, with almost 600 certified homes (the next-closest Utah builder has 12). "We like that the program sets a standard that is above and beyond local codes but is achievable for

any builder interested in achieving high performance," Mora says. "We like that it also goes beyond efficiency and includes comfort, durability, and indoor air quality. [And because it] is recognized locally by loan financing entities, that allows us to get great interest rates on long-term financing for rental projects."

PREPARATION AND PLANNING

The winning home is an attached home in a 10-lot infill development in Salt Lake City, down the street from the Utah State Capitol in the vibrant Capitol Hill neighborhood. The site was on a hillside requiring extensive excavation and the installation of massive retaining walls. The builder also had to plan for the Salt Lake area weather: Salt Lake City is located in the foothills of the Wasatch Mountains and gets 54 inches of snow annually, which influences materials, design, and site planning.

Garbett constructed its homes to be solar ready. All are pre-wired for solar and the roof is engineered to withstand future solar photovoltaics (PVs) on any portion of the roof regardless of floor plan. All Garbett Homes are now electric vehicle (EV)-ready, with a 220-volt outlet installed in the garage of every home. "Despite the infill location, the Sterling at Capitol Hill homes have great solar access," Mora says.

To ensure consistency and help control costs, the builder includes a comprehensive energy-efficiency package with insulation, air sealing, and indoor air quality measures that is implemented on all of

its homes to ensure they achieve ZERH standards.

Construction starts with site preparation. All homes come with a lot-specific grading and drainage plan to direct runoff away from the homes and protect them from the damaging effects of water. "We can have several feet of snow on the roof and perimeter of the home during the winter so a comprehensive drainage plan is critical to ensure the longevity of our homes," says Mora.

To meet the demands of the cold climate, Garbett packed R-23 of blown fiberglass into the 2-by-6 walls, which were built using advanced framing techniques such as 24-inch on-center stud spacing, 3-stud open corners, and open headers over windows and doors to maximize the room available for insulation. The walls of the attached homes were sheathed with 7/16-inch OSB sheathing and house wrap, then covered with 20-gauge stucco netting and 3/8-inch cement base coat stucco, brick, or fiber cement lap siding.

"Advanced framing is not widely used in Utah, so Garbett found that training our trade partners was essential," Mora says. "We train regularly to get new framers on board quickly. In a production home setting, it is important to have everyone familiar with the techniques to get the most consistent and highest performance out of our homes."

Garbett employed a vented attic with 15 inches (R-60) of blown fiberglass insulation on the attic floor. Over the 7/16-inch OSB sheathing, the builder installed two

Annual Energy Costs

\$774
(without PV)

* vs typical new homes

Annual Energy Cost Savings*

\$630
(without PV)

Annual Energy Savings

3,000 kWh
(without PV)

Key Features

AIR SEALING: 3.49 ACH 50. Taped house wrap; whole house aerosolized acrylic sealant.

APPLIANCES: ENERGY STAR refrigerator, dishwasher, clothes washer.

ATTIC: Vented attic; 16-inch R-60 blown fiberglass; 12-inch raised-heel energy trusses.

ENERGY MANAGEMENT SYSTEM: Programmable thermostat.

FOUNDATION: Slab-on-grade.

HOT WATER: Gas tankless, 96 percent EF. Push-button hot-water recirculation system.

HVAC: Gas furnace, 96.5 percent AFUE, ECM motor; air conditioner 15 SEER.

LIGHTING: 100 percent LED.

ROOF: Truss gabled and shed roofs: 16-inch R-60 blown fiberglass, 7/16-inch OSB, #15 felt, asphalt shingles.

SOLAR: PV ready, wiring in place, roof will support panels.

VENTILATION: ERV, 66 percent SRE; integrated with central air handler. MERV 8 filter in air handler, MERV 6 filter in ERV. Exhaust fan runs continuously at 50 CFM.

WALLS: 2-by-6, 24-inch o.c., panelized, R-23 total: advanced framed, 5.5-inch blown fiberglass in cavity, 7/16-inch OSB, house wrap, 20-gauge lath, 3/8-inch cement base coat stucco.

WATER CONSERVATION: EPA WaterSense push-button recirculation pump. "Localscaped" mix of patios, play areas, bark mulch, local plants, and grass.

WINDOWS: Double-pane, low-e, vinyl frame; single-hung and sliders. U=0.26, SHGC=0.31.

OTHER: Panelized walls. No/low-emission products.



layers of #15 roof felt and asphalt shingles. Garbett specified trusses with 12-inch raised heels to allow more insulation over the top plates. All of Garbett's house plans are designed with raised energy heels to maximize the insulation in the attic and above the exterior walls.

The project used a very simple roof design with one low gable running east-west at a 3/12 pitch for the full length of the building except for one small section of roof at a different height to separate the two units of this attached dwelling. A simple roof design provides many benefits in terms of cost and labor savings: fewer complicated details for water management and air sealing; simple installation of insulation, sheathing, and siding; more space for solar panels.

CONCRETE FORMULA

The attached homes also have a full daylight basement. The below-grade walls of the walk-out basement are waterproofed with a spray-on sealant. The builder installed R-10 of rigid foam insulation under the full slab. The concrete walls at the back of the basement were covered with framing. The above-grade walls at the front of the lowest level are also 2-by-6

framed walls at 24 inches on center. All framed wall cavities were filled with R-23 of blown fiberglass.

The double-pane, vinyl-framed windows have low-emissivity coatings to discourage heat transmission but no gas fill due to the altitude. They provide a U-factor of 0.27. Because Salt Lake County is a predominantly heating climate, the windows have a higher solar heat gain coefficient of 0.35 in strategic places so they can provide beneficial solar heat gain that offsets heating demand in the winter.

Garbett has recently shifted its air sealing strategy to include a whole-house technology that includes spraying an aerosolized acrylic into the home while it is pressurized. The tiny beads of acrylic adhere to the edges of cracks in the building envelope, accumulating to fill in and seal off air leaks during the 2-to-4 hour spraying process.

The aerosolized acrylic sealing process can be used on all cracks under 0.5 inch. Before applying the process, the builder's crew applies canned spray foam and dry-wall gasket around all penetrations in the building envelope.

Correctly installed house wrap with all seams and edges taped is also a critical air



Clean living. Garbett Homes meets the requirements of the EPA Indoor airPLUS program by including low- or no-VOC emitting paints and finishes, carpet, carpet pad and adhesives, and cabinetry.



sealing measure. “Before, we relied more on spray foam in the rim joists and attic for our air sealing, but we have reduced our use of it because of some issues we had with cracking and ineffective application,” Mora says. “However, we will still use spray foam if a portion of the house will be covered before the aerosolized acrylic is applied.”

To provide fresh air to the home, Garbett installed an Energy Recovery Ventilator (ERV). The ERV has separate ducts to bring in fresh air and exhaust stale air. The ducts pass in a heat exchanger, where heat from the warmer duct is passed to the cooler duct, helping to warm up incoming air in winter and cool incoming air in summer. In addition to the ERV, an exhaust fan in the hall bathroom is set for continuous operation.

Garbett installed a high-efficiency, high-capacity tankless gas water heater in the multifamily unit, with an energy efficiency factor of 96 percent. The water heater is equipped with a button-activated recirculation pump to speed hot water to taps that are further from the water heater. Garbett also installed low-flow U.S.

Environmental Protection Agency (EPA) WaterSense-labeled plumbing fixtures and ENERGY STAR-certified appliances to reduce water usage in the house.

QUALITY STANDARDS

To meet DOE ZERH specifications, Garbett focuses on construction quality. The construction team meets weekly to discuss quality control measures and also has pre-construction meetings with homeowners. Site managers are required to perform quality checks at various stages of construction, request fixes if needed, and report on the progress and quality of each home. The sales and construction teams meet periodically to do frame and insulation walks to find any potential problems with processes and plans and to identify ways to improve on them.

“We work closely with all trade partners and energy raters to ensure all aspects of our high-performance standards are met,” Mora says. “We have frequent trainings for our construction team and trade partners to keep up to date on all ENERGY STAR and [DOE ZERH] standards.”

Staff are required to attend local energy-efficiency trainings and workshops. “Having everyone educated to know what their part is in building a [ZERH] is crucial for maintaining quality construction and consistency,” Mora adds. “[And,] we recently worked with outside consultants to improve our processes, product and relationships with our buyers and trade partners.”

In addition to the DOE award, Garbett Homes was recognized for its efforts with a Bronze Award in the 2020 National Housing Quality Awards.

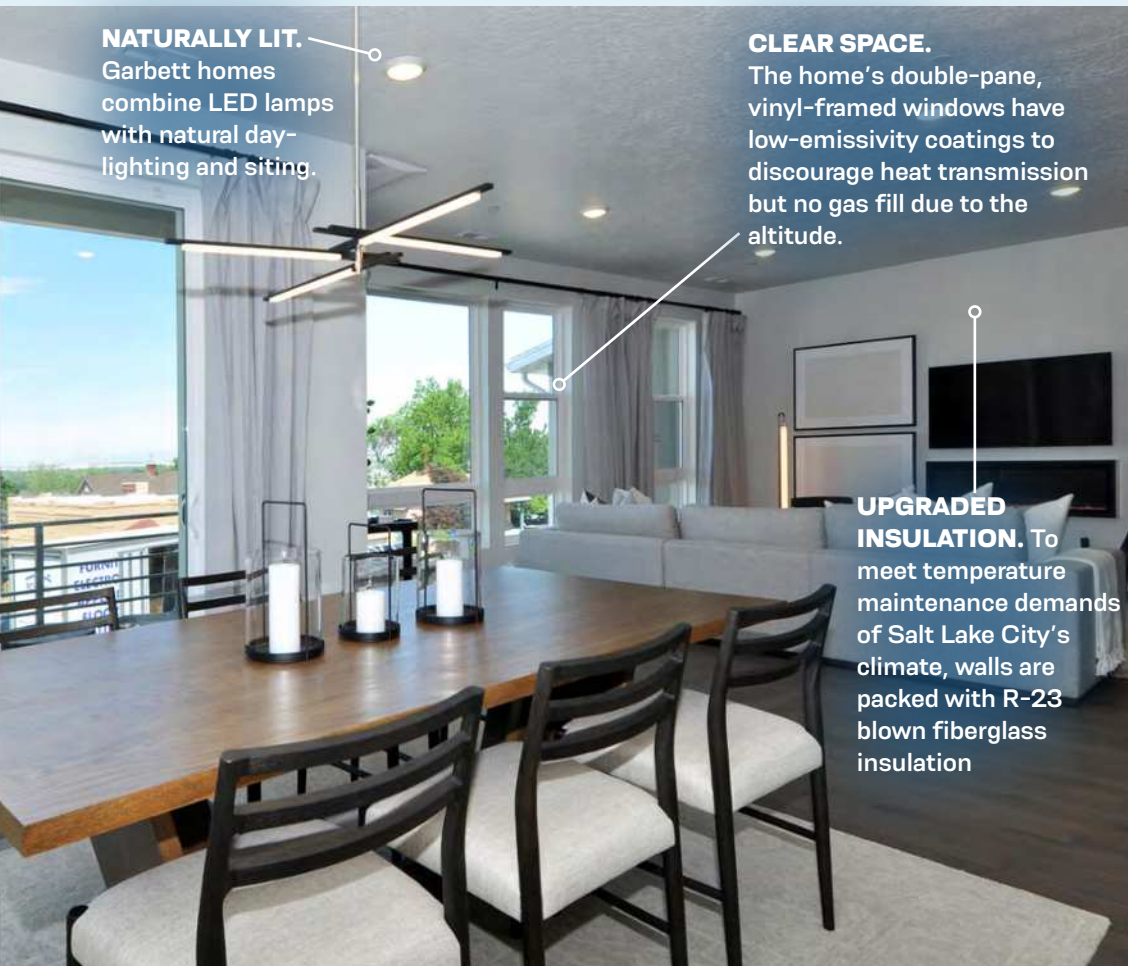
NATURALLY LIT. Garbett homes combine LED lamps with natural day-lighting and siting.

CLEAR SPACE.

The home’s double-pane, vinyl-framed windows have low-emissivity coatings to discourage heat transmission but no gas fill due to the altitude.

UPGRADED

INSULATION. To meet temperature maintenance demands of Salt Lake City’s climate, walls are packed with R-23 blown fiberglass insulation



Future plans. Mandalay Homes' all-electric Discovery Home is built around existing and optional sustainable products, such as a roof sized for solar panels, a nominal battery storage system, and an electric heat pump.



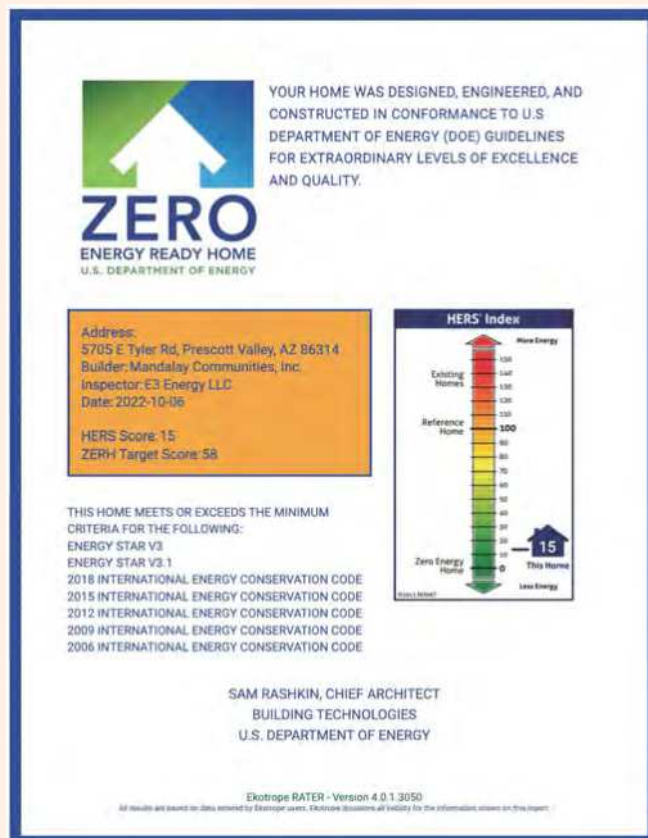
PHOTOS COURTESY OF MANDALAY HOMES

Project Info

PROJECT NAME: Discovery Home, Prescott, Arizona

BUILDER: Mandalay Homes, Prescott, Ariz., MandalayHomes.com

COMPLETED: May 2022



The Sky's No Limit

The road to all-electric housing starts with realistic solar and battery storage sizing.

When you live in a rugged place like Arizona, available energy at certain times of the year can be at a premium. That's why when building its homes, Mandalay Homes of Prescott capitalizes on one of the state's most notable and always-available natural resources: the sun.

Mandalay Homes has been offering solar panels on its homes since 2013, when the production homebuilder first committed to constructing all of its homes to the U.S. Department of Energy's Zero Energy Ready Home (ZERH) standard. Several recent advances in its product offerings helped the builder garner a Special Grand Award for Innovation in Advanced Home Concepts in DOE's 2022 Housing Innovation Awards competition, which recognizes exceptional builders in the ZERH Program.

"This year's 'Discovery Home' is the first to test a new energy storage algorithm we're developing in partnership with Sonnen and Mosaic Building group," says Mandalay Homes' president and founder Dave Everson.

Mandalay Homes offers 10-kilowatt (kW) batteries on many of its homes. "We're taking a different approach to managing the battery charge and discharge throughout the day to make use of cheaper grid power when needed to ensure sufficient energy to get through the evening," Everson says.

The new software is also designed to help prevent demand charges by mitigating electricity usage spikes during peak periods. "Our modeling has shown a 60 percent reduction in energy bills with

the new algorithm, without excess photovoltaic energy sold back to the utility," says Everson.

A POWERFUL PACKAGE

In 2022, Mandalay began offering all-electric homes at the [Jasper clean energy community](#) development in Prescott. Solar PV panels are a standard part of Mandalay's iONPlus Solar home package, which is available on 65 percent of the models sold by Mandalay. Mandalay offers an energy storage battery package on all of its solar panel-equipped homes.

Although Mandalay has been offering solar and batteries for several years, this year's Discovery Home is an all-electric model with both solar panels and the battery designed to manage the time-of-use (TOU) rate plans. With the battery storage, the home avoids the use of higher amounts of fossil fuel-driven power per kWh during peak periods. "We avoid dirty power and reduce the carbon footprint," says Everson.

This home has 3.74 kW of photovoltaic panels on the roof as well as a 10-kWh, 4.8-Watt nominal battery storage system. Mandalay is taking its commitment to solar one step further by preparing its homes at Jasper to serve as a community energy source. The installation of utilities at Jasper included a dedicated network of conduit for a "virtual power plant." This installed conduit will allow for future aggregation of power from individual homes to a central meter exiting the community. "The expectation is that one day the Jasper community will provide stored clean peak

power to the aging housing stock in the area," says Everson.

Mandalay's commitment to build to DOE ZERH standards has had an influence beyond the approximately 400 homes it builds. Although Mandalay is not the only builder at Jasper, the developer has mandated that all builders at Jasper construct their homes to meet the DOE Zero Energy Ready criteria.

"The success of the DOE Program and Mandalay was instrumental in this decision," says Everson.

NO MORE NATURAL GAS

Also, based on Mandalay's commitment to an all-electric home, the newest phase of Jasper was built with no gas installed. Lot plans were oriented predominantly north-south for the benefit of solar panel installation. Architectural guidelines for the development specified lower roof slopes, which optimizes the angle for solar production. Mandalay also ensures adequate roof area for solar panels by eliminating penetrations through the roof with the use of side venting and air admittance valves.

A key component of the all-electric home is the mechanical system. Mandalay switched from dual-fuel equipment to an electric heat pump. The heat pump's variable speed and pressure inverter technology helped the builder maintain high efficiency values during cold weather without the need for gas or heat strips. The cost of this new equipment was offset by eliminating the installation of gas.

Mandalay uses a building information

Annual Energy Costs

\$1,350
(without PV)

\$550
(with PV)

Annual Energy Cost Savings*

\$1,250
(without PV)

\$2,050
(with PV)

Annual Energy Savings

3,250 kWh
(without PV)

9,590 kWh
(with PV)

Savings in the First 30 Years

\$50,550
(without PV)

\$82,500
(with PV)

* vs typical new homes

Key Features

AIR SEALING: 0.66 ACH 50. Open-cell spray foam in walls and attic. Whole-house sealed with aerosolized acrylic air sealant.

APPLIANCES: ENERGY STAR refrigerator, dishwasher, ceiling fan, exhaust fans (5).

ATTIC: Unvented attic, vaulted ceilings, 10-inch R-33 open-cell spray foam on the underside of roof deck.

ENERGY MANAGEMENT SYSTEM: Smart water usage, leak detection, IAQ and RH monitors.

FOUNDATION: Slab on grade, insulated slab.

HOT WATER: Electric tankless water heater; smart recirculating pump.

HVAC: Central air-source heat pump, 12 HSPF, 18 SEER, 4-inch high-flow flex ducts.

LIGHTING: 100 percent LED, motion sensors, timers, lighting controls.

ROOF: Truss shed roof: OSB, underlayment, asphalt shingles; 4.625-inch raised heel energy trusses.

SOLAR: 3.74-kW rooftop panels, 10-kWh battery storage. Solar production tracking.

VENTILATION: ERV to central air handler; IAQ monitors in light switches in great room, kitchen, den, bedroom, and owner's suite. Humidity sensors in light switches for exhaust fans in baths and laundry.

WALLS: 2-by-6, 16-inch o.c., R-25 total: R-25 spray foam; OSB house wrap; stucco.

WATER CONSERVATION: Low-flow fixtures, PEX piping, drip irrigation.

WINDOWS: Double-pane, argon-filled, low-e, vinyl-framed, single-hung, U=0.29, SHGC=0.23.

OTHER: Low- or No-VOC products; air purification system; energy usage monitoring; EV charging station.

Perimeter Armor.. Mandalay Homes use a slab edge covered with closed-cell spray foam that adheres to the slab edge and the bottom edge of the overhanging bottom plate to form an airtight and watertight seal.



modeling software tool to draft all of its plans and options. As each home's options are selected, the turning on and off of layers assists the builder in creating a lot-specific plan even though it is operating in a production housing environment.

"Our intention is to continue to monitor the home once it is sold to collect data on the performance, systems, and customer experience. That information will be used to shape future innovation," Everson says. "Our goal is to continue to improve production efficiency, decrease build times, and dramatically reduce materials waste through advanced construction management technologies." Mandalay already employs several quality assurance steps. Every home design goes through an extensive review and departmental checks before being released for construction.

During construction, weekly meetings are held with the superintendents, customer care staff, and the sales team. In these meetings, the progress of the home and the satisfaction level of the customers are discussed. The sales team also takes weekly photos of the home throughout the build. The photos are used to keep the homeowner updated on progress and as an additional layer of quality control. Mandalay Homes employs a comprehensive in-house quality assurance program with inspections that are performed at pre-slab, pre-drywall, post insulation, upon completion, and in the warranty process. Mandalay also uses a web-based collaborative construction management system.

EFFICIENCY IS EVERYTHING

This home has a Home Energy Rating





System (HERS) score of 44, when the PV is not considered, or a HERS of 14 when the 3.74 kW of PV is included. The energy efficiency measures plus the solar system should save homeowners at least \$2,000 a year in energy costs compared to a home built to code. Savings are likely greater when the battery and the impact of the utility time-of-use rates are taken into account.

The 10-kW battery size is large enough to get most of Mandalay's homeowners through the daily late afternoon energy demand peak. Mandalay has found, for most homeowners, the battery covers about 8 hours of the homes' power needs each day. Some homeowners are able to run on their own stored power all night until the sun comes up the next day and the battery starts recharging.

The unvented attics and vaulted ceilings are insulated on the underside of the plywood roof deck, with 8 to 10 inches of open-cell spray foam for an insulation value of R-33. The roof is topped with ENERGY STAR Cool Roof certified asphalt shingles.

The exterior walls consist of 2-by-6 laminated strand lumber studs spaced 16 inches on center. The stud walls incorporate advanced framing techniques, such as three-stud insulated corners, open and

insulated headers, and ladder blocking at interior wall intersections to increase the amount of space in the walls for insulation. The wall cavities are filled with open-cell spray foam in the cavities, then wrapped with taped house wrap and covered with a continuous 0.5-inch-thick layer of rigid XPS foam for an R-25 total wall insulation value. The walls are covered with stucco cladding.

While the spray foam insulation in the attic and walls helps to air seal the building envelope, Mandalay takes the additional step of using a whole-house aerosolized sealant process to ensure even the smallest cracks are closed off, resulting in near Passive House airtightness levels. This home had air leakage of only 0.66 air changes per hour at 50 Pascals. An energy recovery ventilator (ERV) and timer- and moisture-controlled exhaust fans help remove contaminants from the tight home.

For heating and cooling, the home is equipped with a properly sized, two-stage, 18.2 SEER, 12.38 HSPF heat pump with a fully variable ECM motor and smart home connected user controls. The system uses 4-inch ducts installed in the sealed, conditioned attic.

A 95 percent efficient electric tankless water heater supplies hot water to the home. The water distribution system employs a central manifold with PEX piping, and distant hot water faucets use a smart programmable recirculating pump to reduce wasted water.

The piping includes an in-line water monitoring and leak detection system with automatic shutoff. All plumbing fixtures are EPA WaterSense labeled for energy and water savings. Outside the home, the builder implemented WaterSense guidelines for drought-resistant landscaping, drip irrigation, and smart irrigation.

Mandalay's home designs feature large windows and sliding doors. To keep them efficient, Mandalay uses ENERGY STAR rated, double-pane, vinyl-framed, argon filled windows with low-emissivity coatings and an insulation value of U-0.29 (R-3.45) and a solar heat gain coefficient of 0.23.

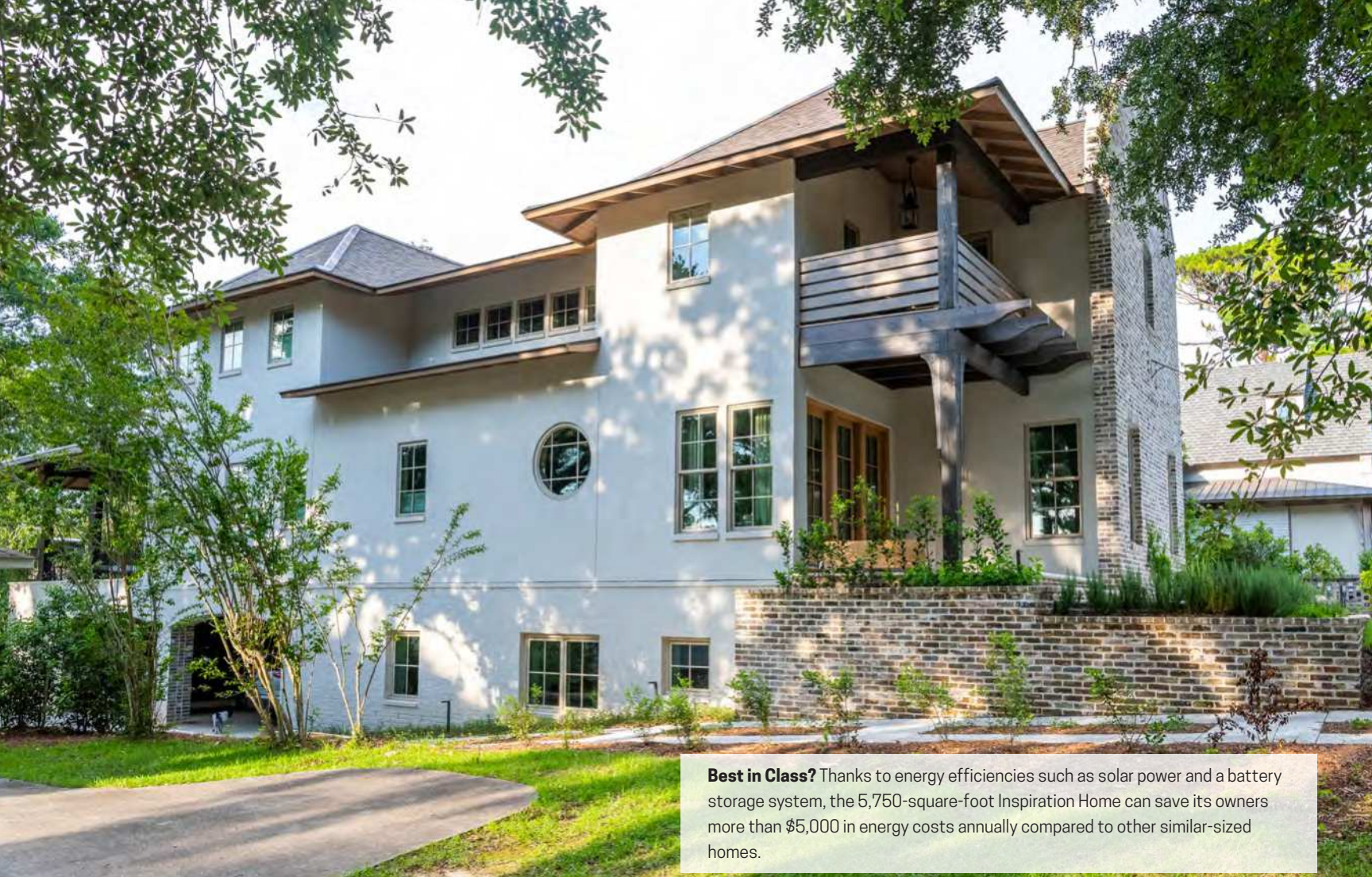


SMART LIGHTS. Light switches incorporate motion detectors and indoor air quality sensors.

JOINT EFFORT. The home has an in-duct, ozone-free air purification system that works in conjunction with the energy recovery ventilation (ERV) and HVAC units.

WATER SAVER. The water distribution system employs a central manifold with PEX piping, and distant hot water faucets use a smart programmable recirculating pump to reduce wasted water.

AIR CARE. To ensure good indoor air quality, Mandalay meets EPA Indoor airPLUS program requirements, including the use of low-VOC, low-formaldehyde products and finishes.



PHOTOS COURTESY OF SCC GROUP AND WATERSHED

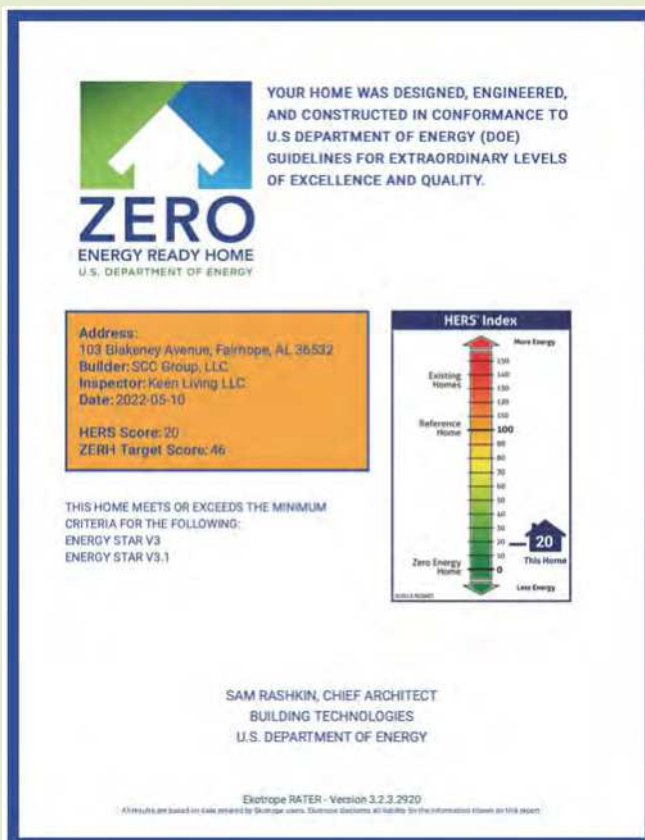
Project Info

PROJECT NAME: Mobile Bay Inspiration Home, Fairhope, Alabama

BUILDERS: SCC Group and Watershed, Fairhope, Ala., SCCGroupllc.com

COMPLETED: April 2022

Best in Class? Thanks to energy efficiencies such as solar power and a battery storage system, the 5,750-square-foot Inspiration Home can save its owners more than \$5,000 in energy costs annually compared to other similar-sized homes.





Crunching the Numbers

This large home uses about one-fifth the energy of others in its size range.

No home is too big to be energy efficient. Just ask Fairhope, Ala. architecture firm Watershed, which in 2022 completed a grand example of cost effectiveness.

The “Inspiration Home” is a four-bedroom, 5.5-bath, two-story single-family structure in Fairhope. According to Watershed architect and owner Rebecca Bryant, it is capable of saving its owners more than \$5,000 in energy costs compared to a similar-sized home built to the requirements of the 2018 International Energy Conservation Code (IECC).

In developing the home, Watershed partnered with builder SCC Group and energy rater Keene Living to win its first-ever Housing Innovation Award from the U.S. Department of Energy (DOE)’s Zero Energy Ready Home (ZERH) program in 2022. The judges were impressed enough to also give the builder-architect team a Grand Award in the Custom Spec category.

The 5,750-square-foot house was constructed for sale on spec, but Bryant decided to keep it as a personal residence and a showcase of high-performance features and DOE ZEHR construction.

Building such an energy-efficient structure might seem like a costly proposal. But Bryant noted that achieving ZEHR certification added less than 2 percent to the total construction costs, and that was primarily for the higher SEER HVAC, ventilating dehumidifiers, resealing of the HVAC ductwork, and energy rating.

CLEAN ENERGY ABOUNDS

Builders installed a 5.44-kilowatt (kW) solar panel array and a 10-kW battery. The photovoltaic (PV)-plus batteries cost \$31,250 after incentives. According to Bryant, the payback is 9 years for the PV alone and 6 years for the battery. The battery costs \$10,000, about the same as a whole-house backup gas generator, which has no payback.

The battery can serve as an emergency generator in the hurricane-prone region. The home’s solar array reports energy usage and consumption in real time to the homeowner and automatically switches into maximum battery charging mode when a storm is predicted. The battery is tied into the electric panel for the main floor and can power appliances, lighting, hot water ignition, and even HVAC when used non-simultaneously in emergency power mode.

“When people ask about our solar panels and we explain that our solar array is our backup generator, they get really excited,” Bryant says. “We’re in hurricane country. People here understand the need for backup power. That sometimes feels like a more pressing need than energy savings.”

The homeowners hope to expand the solar array to reach net zero in future years. With the current setup, the home achieves a Home Energy Rating System (HERS) score of 20 when counting the PV, or 39 if the solar is not included—far better than the HERS 80 to 90 of typical just-to-code homes.

To achieve this high performance, the builders constructed a highly insulated

shell that included 2-by-6 framed walls, with the studs spaced 16 inches on center. The wall cavities were densely packed with 5.5 inches of cellulose. The walls included an engineered wood sheathing, which was then covered with a liquid-applied weather-resistant barrier wrapped with a continuous 2-inch-thick layer of mineral wool insulation and synthetic stucco cladding. The mineral wool is part of the synthetic stucco product, which was actually less expensive than a non-insulated, traditional three-coat cementitious stucco.

SOMETHING IN THE AIR

To increase wind resistance, threaded rods are used in the exterior walls to tie the top plate of the second floor down to the top of the concrete basement walls. The stairway is wrapped in plywood sheathing and works with the elevator core inside the house to provide additional shear capacity to the entire home. Locally sourced southern yellow pine was specified for all framing.

The home’s truss roof uses a wind-resistant hip roof design. The unvented attic is insulated with 10.5 inches of open-cell spray foam sprayed to the underside of the engineered wood roof deck to achieve R-38. The spray foam covers the exterior wall top plates and completely encapsulates the roof trusses to minimize thermal bridging. A rubberized asphalt underlayment covers the entire roof deck, providing a continuous moisture barrier and “second roof” should any rain get past the asphalt shingle roofing and clay ridge

Annual Energy
Costs

\$2,100
(without PV)

\$950
(with PV)

Annual Energy
Cost Savings*

\$4,000
(without PV)

\$5,150
(with PV)

Annual Energy
Savings

171,560 kWh
(without PV)

24,600 kWh
(with PV)

Savings in the
First 30 Years

\$196,200
(without PV)

\$251,900
(with PV)

* vs typical new homes

Key Features

AIR SEALING: 1.5 ACH50; spray foam at top plates, band joists, all attic and floor penetrations; sill gasket under bottom plates. Ducts are sealed with aerosolized acrylic sealant.

APPLIANCES: ENERGY STAR clothes washer, dryer, freezer, refrigerator, ceiling fans.

ATTIC: Unvented attic, 10.5-inch R-38 open-cell spray-foam on underside of roof deck.

ENERGY MANAGEMENT SYSTEM: PV app measures usage and production; charges battery if a storm is predicted. Smart thermostats. Leak detection on plumbing.

FOUNDATION: Insulated basement: concrete walls covered with liquid-applied bituminous waterproofing, 1.5-inch mineral wool insulation, 1-inch grout, brick.

HOT WATER: Tankless gas water heaters, 0.95 UEF; central manifold, PEX pipes.

HVAC: Two heat pumps, 9 HSPF, 17.5 SEER; one mini-split (19.7 SEER).

LIGHTING: 100 percent LED, warm dimming in evening. Skylight in stairwell.

ROOF: Truss hip roof: 0.75-inch engineered plywood, rubberized asphalt underlayment; asphalt shingles with clay ridge tiles. All vents through walls.

SOLAR: 5.44-kW rooftop panels, 10-kW battery.

VENTILATION: Supply only; ventilating dehumidifiers to HVAC ducts. MERV 13 filters.

WALLS: 2-by-6, 16-inch o.c., R-28 total: advanced framed, dense-packed cellulose, engineered plywood, liquid-applied weather barrier, 2-inch rigid mineral wool; stucco.

WATER CONSERVATION: EPA WaterSense-rated fixtures. Rain garden for storm runoff.

WINDOWS: Double-pane, argon-filled, fiberglass-framed, low-e, U=0.3, SHGC=0.19.

OTHER: Low-emission products. Recycled-content concrete, countertops, mineral wool, roofing, cellulose insulation. Electric vehicle charging station installed.



tiles. Plumbing vents and outside air intakes exit through the top of the wall between the rafters to limit roof penetrations, and reduce the likelihood of leaks.

Meanwhile, there are roof shingles made with a polymer-modified asphalt that utilizes recycled plastic from rubber tires and plastic bags. The shingles use smog-reducing granules that chemically react with the air to reduce smog. The air-purifying performance of each roof with these shingles is estimated to be equivalent to two trees.

AT GROUND LEVEL

The home's lowest level is part carport, part enclosed basement. The basement level consists of 12-inch cast-in-place concrete walls with a 40 percent fly-ash mix. The exterior of the walls was covered with a liquid-applied bituminous waterproofing membrane and 1.5 inches of mineral wool board insulation within the brick cavity and a brick veneer. A 1-inch air gap behind the brick face prevents vapor drive into the walls.

The ENERGY STAR windows are double-pane, argon-filled, fiberglass-framed windows with low-emissivity coatings, a U-factor of 0.3, and a Solar Heat Gain Coefficient (SHGC) of 0.19. All windows have pultruded fiberglass exterior frames and sealed wood (pine) interior frames. The windows and exterior doors are impact rated for the high wind zone locale.

The large home was blower door tested and achieved a whole home air leakage of only 1.5 air changes per hour at 50 Pascals (ACH 50). This was accomplished by using spray foam at the roofline and band joists, as well as canned spray foam around the windows and at all building penetrations. Sill gasket was installed under the bottom plates. All joints and penetrations in the sheathing were completely sealed with a liquid-applied weather-resistant membrane.

After duct leakage was discovered inside inaccessible floor ceiling assemblies, the duct work was sealed with an aerosolized acrylic sealant procedure.

Two gas tankless water heaters provide hot water through insulated PEX piping that uses a central manifold for faster distribution. A leak detection system monitors water use in real time and will automatically shut off the water supply if a leak is detected.

A central air-source heat pump with a variable speed compressor provides heating with a heating efficiency of 9 HSPF and cooling with an efficiency of 17.5 SEER for the two upper floors. The central systems use hard piped, rigid metal ducts for the trunk lines with flex duct to each register. A mini-split heat pump with a 19.7 SEER services the partial basement. Ventilating dehumidifiers were integrated with the heating and cooling ductwork to bring in fresh air and dehumidify it and to manage moisture when there is no cooling load.



(Mostly) electric. All appliances except the tankless water heaters and fireplace are electric, including the induction cook top. The home is also equipped with an electric vehicle charging station.



MAKING WATERSENSE

The whole house is certified to the EPA's WaterSense program, which specifies the use of low-flow fixtures, and moisture-sensing and drip irrigation. To accommodate heavy rainfalls, the backyard is dedicated to a rain garden that captures runoff from the yard, downspouts, and foundation drains, and can percolate runoff from a 6-inch rainstorm in less than 12 hours.

The gardens are planted with fruit and nut trees and edible plants, and the yard is a National Wildlife Federation Certified Backyard Wildlife Habitat, a place that provides food, resources, and shelter for the animals and insects that live in the area.

Natural lighting and views were a priority for this project. All rooms have daylight from at least two sides, except for one windowless bathroom on the basement level. At night, dimming is provided on all lights, so homeowners only use the amount they need. LED lighting with a "warm dim" function was used throughout the first floor, where all primary living spaces are located. These

support healthy circadian rhythms by mimicking the color of sunlight at dusk and dawn.

Bryant said the home's design is inspired by the Arts and Crafts movement and incorporates elements of Cape Dutch and French Colonial traditional styles adapted to a hot-humid climate. The home also includes many aging-in-place and multi-generation options, including a ground-floor flex space and second-floor second master suite that could accommodate aging parents or returning adult children.

So far, the Inspiration Home has lived up to its name. In the past year, more than 1,500 potential homebuyers visited the home. Another 1,100 have visited the website, 17,300 have viewed social media posts, and the home has been the subject of local news articles reaching thousands more. Watershed and the energy rater Keene Living are monitoring the home's energy usage, which they will share via the website. They hope to continue to use the home as a location for training activities for homeowners and contractors.



WIND PROTECTION. Windows and exterior doors are impact rated to withstand the high wind zone locale.

TOP QUALITY. Asphalt roof shingles made from recycled rubber tires and plastic bags also chemically react with the air to reduce smog.

GENERATIONAL PLANNING. The home includes a second-floor master suite with aging-in-place and multigeneration options to accommodate aging parents or returning adult children.

NATURAL RESILIENCE. Backyard gardens are planted with fruit and nut trees and edible plants, helping to create a habitat for animals and insects that live in the area.

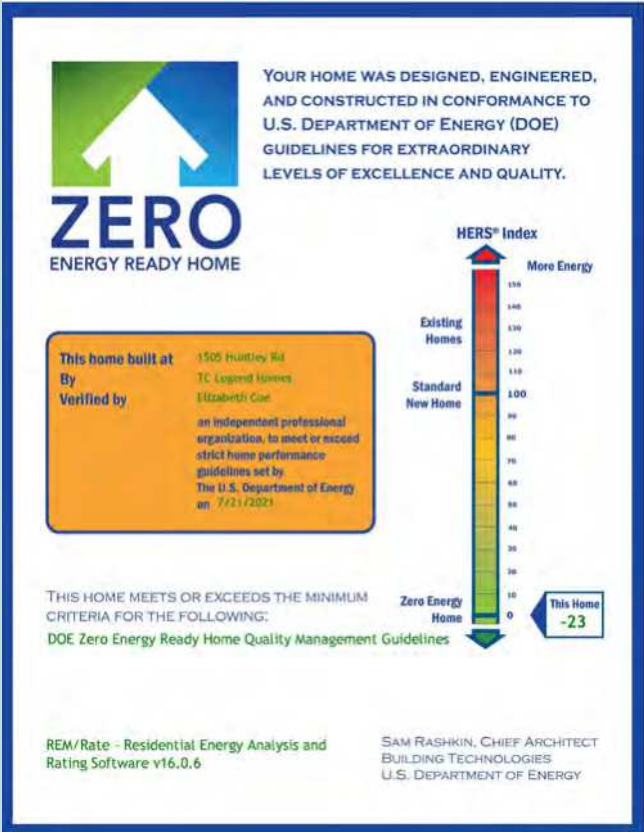
Power package. "The House in the Hollow" led to the builder's third grand award from the DOE's Zero Energy Ready Home (ZERH) program for its energy-saving efforts. The home achieves a Home Energy Rating System (HERS) Index as long as minus 23.



PHOTOS COURTESY OF TC LEGEND HOMES

Project Info

- PROJECT NAME:** House in the Hollow, Bellingham, Washington
- BUILDER:** TC Legend Homes, Bellingham, Wash., [TCLighthouse.com](https://www.tclighthouse.com)
- COMPLETED:** July 2021





'Hollow' Victory

Three-time ZERH winner TC Legend keeps efficiently lighting things up with its latest energy-saving home.

Builder TC Legend Homes of Bellingham, Wash., aims for quality and sustainability in every home it constructs. Company founder Ted Clifton Jr. has found the U.S. Department of Energy (DOE)'s Zero Energy Ready Home (ZERH) program an ideal way to achieve that goal.

"The DOE [ZERH] program is a great benchmark not only for ourselves, but for all those looking to build or purchase a home that is eco-friendly," Clifton says. "Since the program incorporates ENERGY STAR and Indoor airPLUS, holds high standards for energy efficiency, and is nationwide, it is an easy way to compare homes across the board and that reduces confusion for purchasers."

It's also great that the DOE program has a very low-cost barrier, Clifton adds. "There are many other certification programs that charge large fees, making it difficult for small builders to participate," he says. "Or, the cost of the fees gets passed along in higher home prices, increasing the barrier to purchase for many people."

Since 2015, TC Legend Homes has built all of its homes to the DOE program criteria. The builder typically constructs one spec home and five or six custom homes for buyers each year. It currently has nine homes under construction. In 2022, the builder was recognized by DOE for its efforts with a Housing Innovation Grand Award in the category "Custom for Buyer under 2,500 square feet."

That custom home, known as "The House in the Hollow," became the builder's third grand award from the ZERH program. The

2022 grand award winner is a 1,935-square-foot, two-story home in Bellingham, Wash. The home achieves a Home Energy Rating System (HERS) index of minus 23 when the solar photovoltaic panels are included. TC Legend's homes routinely achieve HERS scores of 10 to 20 below net zero. These "positive energy" homes realize enough energy savings and photovoltaic (PV) power production to run the home, as well as an electric car or two, with zero power bills.

BUSINESS AS USUAL— ONLY BETTER

Like all TC Legend homes, the all-electric Hollow model is constructed with structural insulated panels (SIPs) with insulated concrete form (ICF) foundation walls, slab-on-grade floors, triple-pane windows, HRV fresh air systems, air-to-water heat pumps, and solar panels.

To reduce heating and cooling loads, TC Legend Homes relies on its tried-and-true base design: A four-inch slab is poured over four inches of R-20 high-density foam insulation. The stem walls around the slab are made of insulated concrete form (ICF) blocks consisting of a six-inch reinforced concrete core wrapped with 2.625 inches of rigid foam on the interior and exterior for an R-23.6 total stem wall. The ICF stem walls reduce heat loss through the edges of the slab, and also reduce the labor costs involved in forming the stem walls since the easily assembled foam blocks create a stay-in-place form for the concrete.

TC Legend often stains and seals the concrete slab to serve as the finished floor

of the home because the exposed concrete readily absorbs passive solar heat and also easily transfers warmth from the radiant floor loops.

The home's above-grade walls consist of 6.5-inch R-29 structural insulated panels (SIPs) that use a graphite-enhanced expanded polystyrene core wrapped with oriented strand board (OSB). The walls are finished with house wrap and fiber cement siding.

All seams are sealed with SIP tape and any exposed ICF foam is covered with metal flashing. The bi-level roof is constructed of graphite-enhanced SIPs, using 10.25-inch R-49 SIPs for the north-facing roof and 12.25-inch R-59 SIPs for the longer south-facing roof. The SIP roof panels are topped with underlayment and lifetime-warrantied asphalt shingles.

In place of solid wood splines, foam inter-panel connection splines were used in the north roof and I-splines were used in the south roof to support the longer span of the south-facing roof. SIP construction offers seismic category D resistance; the SIPs are rated to last 100 years.

"SIPs also create less framing construction waste than traditional stick framing and are generally stronger than stick framing," Clifton says. "On top of that, SIPs are super quick and easy to install, making the labor much cheaper than traditional stick framing and therefore helping keep our houses more affordable."

The TC Legend team has the installation down "like a well-oiled machine," and can install the SIPs on an entire two-story house

Annual Energy Costs

\$600
(without PV)

\$-280
(with PV)

Annual Energy Cost Savings*

\$1,200
(without PV)

\$2,150
(with PV)

Annual Energy Savings

8,400kWh
(without PV)

20,350kWh
(with PV)

Savings in the First 30 Years

\$48,930
(without PV)

\$86,550
(with PV)

* vs typical new homes

Key Features

AIR SEALING: 0.54 ACH50, all SIP joints sealed with double beads of mastic and tape. Windows have a double gasket. Whole-house aerosolized acrylic sealant.

APPLIANCES: ENERGY STAR washing machine, dishwasher, refrigerator, exhaust fan.

ATTIC: No attic; vaulted ceilings.

ENERGY MANAGEMENT SYSTEM: CO₂ sensors; programmable HVAC system.

FOUNDATION: Slab on grade: 4-inch R-20 EPS under slab; ICF stem walls 11.25-inch R-23.6.

HOT WATER: Combination air-to-water heat pump for space and water heating, 50-gallon, 3.92 COP; electric tankless backup water heater.

HVAC: Air-to-water heat pump with 50 percent central air handler, 50 percent radiant, 6.75 COP for cooling, 3.92 COP for heating. Passive heating design with exposed concrete floors.

LIGHTING: 100 percent LED, passive and shaded vertical glazing.

ROOF: SIP gable and shed roof: 10.25-inch R-49 (north) and 12.25-inch R-59 (south) graphite EPS SIPs, asphalt underlayment and asphalt composite roofing.

SOLAR: 10.56-kilowatt (kW), 33 rooftop panels, microinverters.

VENTILATION: HRV to HVAC; timer, CO₂ and humidity sensors for boost setting.

WALLS: SIPs, R-29: 6.5-inch graphite EPS SIPs; house wrap; fiber cement lap siding.

WATER CONSERVATION: EPA WaterSense rated fixtures; central manifold with PEX piping.

WINDOWS: Triple-pane, argon-filled, low-e3, vinyl, U=0.15-0.18, SHGC=0.46-0.34.

OTHER: Low-VOC and recycled-content products. Aging-in-place design. EV charger installed.

Solid as glass. Windows are triple-pane glass with three low-emissivity coatings and argon gas fill that reduce heat transfer.



in just eight days, Clifton adds. “ICFs are also quick and easy to install,” he says. “They create less material waste and require less concrete, which helps to reduce the home’s embodied carbon totals.”

ABCS OF SIPS

SIPs make for a very airtight structure with almost no thermal bridging. The home is slab on grade, so there is no air leakage from the floor. All SIP panel joints are double-bead mastic sealed. Windows are foamed-in and sill plates are sealed with SIP mastic.

After the mechanical trades have completed their work and all windows and doors are sealed, the builder uses a proprietary aerosolized acrylic product that is distributed throughout the home while it is pressurized, with a blower door fan to seal any remaining cracks in the building envelope. The final blower door test on this home was 0.54 ACH50.

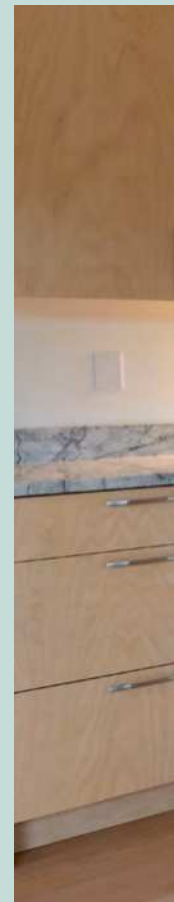
To provide mechanical ventilation for their super-tight homes, TC Legend installs heat recovery ventilators (HRV) as the standard ventilation system in all of their homes. An HRV brings in outdoor air that is tempered with outgoing stale air in a heat

exchanger to warm incoming air in winter and cool incoming air in the summer.

They added a MERV 17 HEPA filter unit to the fresh air intake of the HRV that includes an inline fan to pull in air that passes through the HEPA filter, which filters out 99.97 percent of particles down to 0.3 microns. The fan-powered filter unit is operated by the same variable-speed switch that controls the home’s powerful range hood fan, so when the range hood fan is on, just the right amount of makeup air is brought in through the HEPA filter.

The incoming air is tempered through the heat exchanger on the HRV to minimize blasts of cold or hot air. The main house ventilation is always on. It can be boosted to a pre-programmed setting of 10, 30 or 60 minutes by timers in the bathrooms. There is a sensor in the main living area that will boost the system as needed to keep CO₂ below 1,200 parts per million. There are also humidity sensors in the bathrooms.

TC Legend uses an air-to-water heat pump for efficient space and domestic water heating at a coefficient of performance (COP) of 3.92 (i.e., the heat pump is 3.92 times as efficient at making heat or hot





water as an electric-resistance furnace or water heater). According to Clifton, “This is much more efficient than a heat pump water heater and, because the compressor and fan are outside, it is not scavenging heat from the house or adding noise inside.” Space heating is delivered via radiant floor loops downstairs in the exposed concrete floor slab and via a fan coil unit upstairs, as well as via a heating unit in the supply side of the HRV. The heat pump also provides cooling with a COP of 6.75.

SUPER WINDOWS.

The home is designed to take advantage of passive solar heating and shading with a floor plan that is longer in the east-west direction and puts most of the windows on the south side of the house. The windows and doors are triple-pane glass with three low-emissivity coatings and argon gas fill that reduce heat transfer. The windows include fixed-glass windows with a U value of 0.15 and a solar heat gain coefficient (SHGC) of 0.46, and casement windows with a U value of 0.18 and a SHGC of 0.34.

The home has only two west-facing windows and five east-facing windows, and these windows have a lower SHGC, thus allowing in less solar heat gain than the

north- and south-facing glass. Roof overhangs protect south-facing clerestory and first-story windows from summer sun, while existing deciduous trees help shade east- and west-facing glass.

Recognizing the need to maximize any daylight available in the cloudy Pacific Northwest, TC Legend often incorporates shaded south-facing clerestory windows into its designs. Clifton noted the visible light transmittance of their windows is 0.59 on fixed windows and 0.43 on casement windows. “This is almost double the light transfer of some other triple-pane windows,” Clifton says. The home’s interiors are painted white to maximize daylight and when the sun goes down, 100 percent LED light fixtures illuminate the interior.

Clifton notes that TC Legend “really lives by the statement, ‘If you’re not actively trying to improve the world around you, then what are you doing?’” He adds that the company “believes in leaving the world a better place than we found it.”

One goal of the company is to start building larger developments of 25 or more homes that are affordable and just as eco-friendly as their current homes. “Owning a (Zero Energy Ready) house should be available to everyone, not just the wealthy,” Clifton says.



IAQ IMPERATIVE. TC Legend built the home to the standard of the EPA Indoor airPLUS program, which helps ensure good indoor air quality with top-notch ventilation and low VOC-emitting finishes and cabinetry.

INNER STRENGTH. The home’s above-grade walls consist of 6.5-inch R-29 structural insulated panels that use a graphite-enhanced expanded polystyrene core wrapped with oriented strand board.

HIGH-CLASS H₂O. Efficient ENERGY STAR appliances, low-flow plumbing fixtures, and a central manifold plumbing distribution with PEX piping combine to reduce water and energy usage.

AIRTIGHT ENVELOPE. Windows are foamed-in and sill plates are sealed with SIP mastic to prevent air leakage.

Highly efficient HERS. ZeroNetNow's Cooper Street Residence achieved a Home Energy Rating System (HERS) Index score of 26 without photovoltaics (PV) and minus 13 when the home's 13.74 kilowatts of solar panels are added.



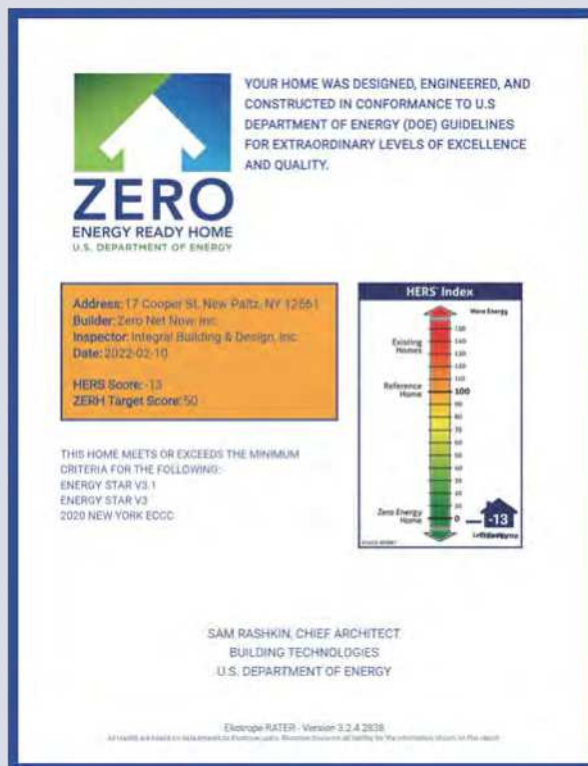
PHOTOS COURTESY OF ZERONETNOW

Project Info

PROJECT NAME: Cooper Street Residence, New Paltz, New York

BUILDER: Zero Net Now, Esopus, N.Y., www.ZeroNetNow.com

COMPLETED: February 2022



Cooper in Control

Zero Net Now's ICF-based project keeps its cool whenever it needs to.

Builder Anthony Aebi has been building homes from insulated concrete forms (ICFs) for more than a decade because of their energy efficiency and disaster resistance. Until this year, affordability was not considered one of their strong suits. But, with pandemic-related shortages driving up the cost of lumber, ICF construction has become more cost-effective. Owners of "The Cooper Street Residence," a stylish 3,718-square-foot home in New Paltz, N.Y., will get a house with highly thermally resistant ICF walls at a cost of \$7,500 less than a similar-sized conventional stick-framed enclosure built to the minimum energy code, according to the builder.

Aebi's company Zero Net Now, formerly known as Greenhill Contracting of Esopus, N.Y., constructed its first zero energy home in 2007 and has built 39 zero energy custom homes to date. The company has been a partner in the U.S. Department of Energy (DOE)'s Zero Energy Ready Home (ZERH) program since 2013 and has committed to certifying all of its homes to the DOE Zero-Energy Home label. ZeroNetNow routinely achieves among the lowest Home Energy Rating System (HERS) scores in the country.

On the HERS Index, a new home built to code would typically achieve a score of 80 to 100. A net zero energy house would score under 10, which is made possible by building a very efficient model and then adding solar panels that produce as much energy as the home uses over the course of

a year. Zero Net Now's homes often score below 40 before including the photovoltaic (PV) panels. Zero Net Now's home this year achieved a HERS score of 26 without PV and minus 13 when the 13.74 kilowatts (kW) of solar panels are added.

BLOCKING BASICS

The homes start with the highly insulating properties of the ICFs, which are hollow foam blocks that stack like Legos to form a wall reinforced with steel rebar, then filled with concrete. This home was constructed on 11.25-inch-wide ICF blocks consisting of a 6-inch concrete core with about 2.6 inches of rigid EPS on each side, for a total wall insulation value of R-22.

The solid walls are airtight and the continuous foam layers on either side limit thermal bridging or heat transfer through the walls. The ICF blocks were used for the below-grade basement walls and the above-grade walls, providing a continuous thermal barrier from the footing to the roof line. They also provide R-22 of slab-edge insulation around the basement floor slab.

Before pouring the floor slab, the builder applied 4.5 inches (R-29) of closed-cell spray foam directly onto the gravel base, where the foam serves as a vapor barrier and under-slab insulation. ICF construction eliminates framing and sheathing at exterior walls. The ICF blocks have integrated plastic splines, which allow for direct fastening of the exterior cladding without the need for furring strips or nailers.

Aebi uses the ICF blocks for the entire wall up to the eaves and to the roof line on the gable ends. Along the eaves, he installs pieces of 1.5-inch insulated coated oriented strand board (OSB) sheathing between the rafters at the roof-to-wall interface to serve as a backer board for the attic spray foam insulation while providing a complete R-6 thermal break to the roof truss framing.

The ICF blocks are sealed at the seams to provide a continuous air barrier. They also serve as the drainage plane on the exterior side of the walls, so no house wrap is needed. To protect the framing where windows or doors will be installed, an elastomeric waterproofing compound is applied with a caulk gun and putty knife to provide a seamless, jointless flashing layer around the openings. Composite wood clapboard siding is used for the exterior cladding.

Aebi constructed a sealed, unvented attic that is insulated on the underside of the roof deck with two types of spray foam. He sprays 10 inches (R-44) of open-cell spray foam followed by 2.5 inches (R-18) of closed-cell foam insulation which completely covers the open-cell spray foam, providing a total attic insulation value of R-62. The closed-cell spray foam also serves as a Class II vapor retarder. Above the roof deck, a self-adhered bitumen membrane is installed at the roof edges and valleys to provide additional moisture protection.

Annual Energy Costs

\$2,000
(without PV)

\$-250
(with PV)

Annual Energy Cost Savings*

\$4,500
(without PV)

\$6,250
(with PV)

Annual Energy Savings

25,250kWh
(without PV)

40,100kWh
(with PV)

Savings in the First 30 Years

\$182,950
(without PV)

\$254,100
(with PV)

* vs typical new homes

Key Features

AIR SEALING: ACH50 = 1.48 CFM50. Spray foam under slab and on attic walls and ceiling; ICF walls with liquid-applied flashings at all rough openings and penetrations.

APPLIANCES: ENERGY STAR refrigerator, dishwasher, clothes washer and dryer.

ATTIC: Unvented attic, vaulted ceilings: 10-inch R-44 medium-density spray foam topped by 2.5-inch R-18 high-density spray foam.

ENERGY MANAGEMENT SYSTEM: CO₂ sensors in master bedroom, return duct, and kitchen trigger boost setting on the ERV. Wi-Fi monitoring of energy production and end uses.

FOUNDATION: Insulated basement: ICF blocks R-22, 11.25 inches wide.

HOT WATER: Ground-source heat pump water heater, 80-gal, 2.66 EF.

HVAC: Heat pump, ground-loop configuration, 5.1 COP, variable-speed compressor, 34 EER.

LIGHTING: 100 percent LED, motion sensors, large windows.

ROOF: Gable truss roof, coated OSB sheathing, 1-by-3-inch furring strips, self-adhered membrane, solar PV shingles. Solar: 13,74-kW roof shingles.

VENTILATION: ERV with MERV 11 and 6 filters, demand-controlled ventilation, CO₂ sensors.

WALLS: ICF walls, R-22 total: 11.25-inch ICF blocks, engineered wood siding.

WATER CONSERVATION: EPA WaterSense fixtures; central manifold, PEX piping.

WINDOWS: Triple-pane, argon and krypton filled, low-e, vinyl; U=0.17-0.20, SHGC=0.21-0.25.

OTHER: Low-VOC products. ICF thermal mass holds temp through power outages. EV ready.

'STAR' struck. Additional energy savings come from the home's 100 percent LED lighting and ENERGY STAR-rated appliances.



LEAK-FREE ENVIRONMENT

The Cooper Street Residence was designed with large windows on all sides to maximize views and daylighting of the interior. To allow for an abundance of natural light without sacrificing too much in thermal performance, the builder opted for high-performance triple-pane windows. The windows are argon and krypton-filled, vinyl-framed, fixed, casement, and sliding style windows with an insulation value of U-0.17 and a solar heat gain coefficient (SHGC) of 0.21. Even the sliding doors are triple paned. They have an insulation value of U-0.20 and an SHGC of 0.25.

The home is so airtight that a blower door test of whole-house air leakage showed a leakage of only 0.23 air changes per hour at 50 Pascals pressure difference (ACH 50). That level of airtightness (which is typical of Aebi's homes) is far below the 3 ACH 50 required by the 2015 International Energy Conservation Code and below the 0.60 ACH 50 required in the Passive House U.S. standard.

To provide fresh air for the home, an energy recovery ventilator (ERV) runs 24/7 at low speed to exhaust air from the

bathrooms, kitchen, laundry, and attic. The ERV is equipped with sensors that will trigger higher levels of ventilation when CO₂ levels exceed 1,000 ppm. The main controller for the HVAC system allows occupants to increase (or decrease) ventilation as desired. Boost-speed controllers are also located in each bathroom and the kitchen for higher-speed exhaust when desired.

Fresh air brought into the home through the supply duct is filtered by a MERV 6 filter as it enters the ERV heat exchanger. Then, it is ducted into the return trunk of the air handling unit, where it is filtered again via a set of electro-static and MERV 11 media air filters. The redundant air filters, zero-VOC paints, and non-combustion HVAC all contribute to indoor air quality.

The home is equipped with a highly efficient ground-source heat pump with one 3-ton central air-handler unit, ground-loop configuration with a rated efficiency of 5.1 coefficient of performance. The air handling unit is fitted with an electrical heating coil for emergency backup only.

The duct system is made from rigid





metal and is all located in conditioned space. The properly sized HVAC equipment includes an air handler with a variable-speed compressor and high efficiency ratings. Variable speed compressors modulate the fan speed and produce the output needed based more precisely on the demands of the thermostat, which allows the equipment to run longer and more efficiently and to increase the lifespan on the system as it doesn't need to turn off and on as much.

Hot water for the all-electric home is provided by the water-to-water ground-source heat pump with an 80-gallon storage water tank to provide 100 percent of the domestic hot water for the home. The storage tank is fitted with an electrical element for emergency backup only, should the heat pump fail (e.g., due to an electrical surge).

The heat pump is in a mechanical room within the conditioned basement. The heat pump has a coefficient of performance of 3.10 and then is de-rated for the thermal standby loss of 0.63 person in the storage tank, resulting in a system energy factor rating of 2.66, per the EF calculator of the supplemental energy modeling toolkit.

Low-flow EPA WaterSense-labeled plumbing fixtures reduce water and water heating demand. This home is a part of a development that was designed to handle the storm water from multiple lots. Therefore, 100 percent of storm water runoff is managed onsite through design.

OTHER WAYS TO SAVE

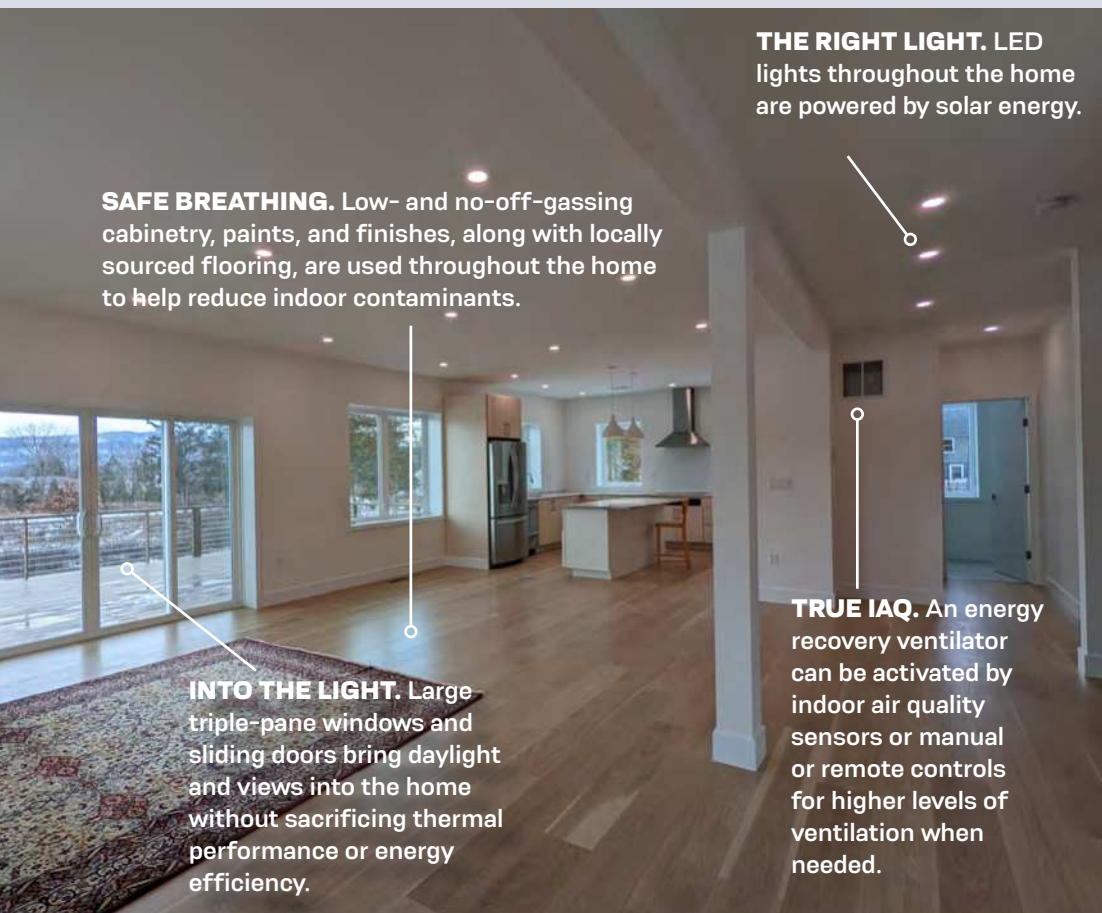
Additional energy savings come from the 100 percent LED lighting and ENERGY STAR-rated appliances. The builder specified a ventless heat pump clothes dryer, in part for efficiency but primarily because the home is so airtight that a standard vented clothes dryer would have depressurized the house too much.

Another feature of this home is the innovative solar shingles that were installed on the roof. This solar roof system was the second installation of its kind in New York state. Engineers from the product manufacturer were required to come to the site to train the crew on how to properly install the solar shingles. Despite the initial cost to invest in this solar array, the engineers claim that the roof lasts up to 200 years and that the durability of the solar PV shingles is three times stronger than asphalt shingles, which need to be replaced every 15 to 20 years.

"The best kilowatt of energy is the kilowatt not used," says Aebi. "It's critical that builders focus on constructing more-robust thermal enclosures and optimally efficient mechanical systems."

With ZeroNetNow's highly efficient ICF building envelope and high-performance HVAC, he is practicing what he preaches. But Aebi goes beyond construction with continued monitoring, because "our job doesn't end when the homeowners receive their keys."

The builder installs energy and climate monitoring systems on each home to track energy use and production, operation of the mechanicals, and indoor air quality measures. "We can monitor, identify, and troubleshoot equipment in a quick and efficient manner and assess whether or not homes are performing as expected," Aebi says. "Based on those assessments, corrective action can be taken to prevent challenges that a homeowner may face. The data collected is proof of what works and what doesn't." **GB**



SAFE BREATHING. Low- and no-off-gassing cabinetry, paints, and finishes, along with locally sourced flooring, are used throughout the home to help reduce indoor contaminants.

THE RIGHT LIGHT. LED lights throughout the home are powered by solar energy.

INTO THE LIGHT. Large triple-pane windows and sliding doors bring daylight and views into the home without sacrificing thermal performance or energy efficiency.

TRUE IAQ. An energy recovery ventilator can be activated by indoor air quality sensors or manual or remote controls for higher levels of ventilation when needed.

FOR A GREATER



Shades of green. As Millennials age into their homebuying years, builders must convey concern about environmental and health issues. CREDIT: ISTOCK/ANNIKA MCFARLANE

GOOD

The Digital Generation is ready to use technology to lead people into a fossil fuel-free era.

BY MICHELE LERNER

Tech-savvy millennials who rely on smart home automation and electric transportation modes are also among the most environmentally concerned generations. Generation Z (a.k.a. Gen Z, born in 1997 or later) may have an even greater claim to the term “digital native,” but millennials also grew up with technology. After all, the internet became available to the public in 1993, when the oldest millennials were tweens, and the first iPhone was introduced in 2007, when they were twenty-somethings. But right now, millennials are the prime marketing group. Born roughly

between 1981 to 1996, the oldest are in their early 40s, while the youngest are leaving college in their rear-view mirrors. Though the market is heavily stacked against them, they’re ready to spend; homebuying is a big part of their future hopes and aspirations.

So how can builders build them optimal homes? And how can we educate and entice them?

SMART IS COOL

Millennial homebuyers want high-speed, streamlined internet connectivity throughout their homes, according to COGNITION Smart Data



Unique effort. Inclusion of environmentally friendly features, such as solar power, all-electric appliances, heat pump technology for heating and cooling, and smart electrical panels that monitor energy use, turned a century-old “clone home” into a structure that stands out from its neighbors.

COURTESY OF TEASS/WARREN ARCHITECTS

market insights from Green Builder Media. Most millennials (more than 80 percent) consider a connected household to be an “important” or “very important” aspect.

For example, millennials want homes with video doorbells, remote-controlled locks and garage doors connected with whole-house intercom systems.

Environmental responsibility is key. Millennial survey respondents say their No. 1 global risk concern is the failure to mitigate climate change. Nearly 50 percent consider a company’s sustainability, environmental, social, and corporate governance (ESG) commitments, and carbon footprints as top priorities when they choose products. And, while 64 percent of people under age 40 say they feel guilty about their negative impact on the environment, just 45 percent of those over 40 feel similar guilt.

Between their comfort level with technology and their commitment to the environment, it might seem that millennials are ready for the great conversion to all-electric homes. But millennials actually lag behind their Gen Z cohorts when it comes to embracing the concept. The majority of millennials (63 percent) say they would go an all-electric with their next home, but among Gen Z, 100 percent are ready to do so.

SEDUCTIVE SOLAR POWER

Access to solar power is considered a bragging right by millennials, as it is a valuable way to reduce a home’s carbon footprint, decrease energy bills and increase an owner’s self sufficiency, according to COGNITION.

For Will Teass, co-founder and managing principal of **Teass/Warren Architects** in Washington, D.C., the transformation of a nearly 100-year-old rowhouse on Capitol Hill to a net zero house for his family started with solar power.



Photovoltaic positives. Millennial homebuyers place top emphasis on the use of solar power, primarily for its capacity to lower a home’s carbon footprint, decrease energy bills and increase owners’ self sufficiency.

CREDIT: ISTOCK/ANDREY POPOV



All-electric homesteads. Housing at KB Home's *Oak Shade at Shadow Mountain* subdivision is clean energy powered and includes solar power storage batteries, apps for real-time energy monitoring and electric vehicle (EV) chargers. COURTESY OF KB HOME

"As architects, we consider ourselves agents of change, and we need to personally practice what we professionally preach," Teass says. "We retained the front façade and porch of our rowhouse to preserve the character of the street, then planned to add solar panels. Our consultant suggested we eliminate all the gas radiators, which we worried at first might impact our thermal comfort, but then we embraced the idea of decarbonizing the home and severing the fossil fuel umbilical cord."

In addition to choosing all-electric appliances and heat pump technology for hot water and heating and cooling, Teass installed smart electrical panels that monitor all energy use, with detailed data for every plug, light and appliance. "We get an alert if a circuit or a device is using more electricity than usual," Teass says.

Clients in all generations ask for smart tech and solar panels, but they rarely ask about the potential to achieve net zero status, he adds.

"If their customers aren't ready or can't afford some green features, builders can plan for the physical aspects of solar power and build in capacity for an electric vehicle (EV) charger," Teass says. "They also need to pay attention to the electrical panels, because a more efficient, all-electric home is likely to need a 200-amp panel instead of a 100- or 150-amp."

Solar power, which is mandatory on most new homes in California, is just one piece of the high-performance models being built at KB Home's microgrid communities, *Oak Shade* and *Durango*. Located within the *Shadow Mountain* planned community in Menifee, Calif., each home will have solar power storage batteries. In addition, the community's solar powered microgrid will have battery storage. Each dwelling will be connected to apps that provide real-time energy monitoring.

"Buyers are empowered with digital energy to make economic and environmental decisions for themselves and their community," says Jacob Atalla, vice president of sustainability and innovation for **KB Home**, headquartered in Los Angeles. "Energy used to be all about the local utility. But now, we have storage systems to store energy and apps to monitor use. We can decide things such as when it's the best time to charge an EV to use the least amount of carbon."

GAMIFICATION AND THE CONNECTED HOME

Millennials' comfort level with apps and video games entices them to use smart tech to operate their homes for security, comfort and energy efficiency, says Cynthia Adams, CEO of Charlottesville, Va.-based **Pearl Certification**, an energy efficiency certification program for homes.

Optimizing Rentals with SMART TECH

Whether you're building multifamily units or single-family rentals, smart tech can provide a streamlined experience for landlords and residents. According to [Rent.com](https://www.rent.com), tenants prioritize a smart thermostat, keyless entry, smart appliances and smart lights. Online rent payment systems are also popular.

- **Smart thermostats.** Landlords can use these thermostats to set baseline scheduling for climate control yet allow some flexibility for tenants. Landlords can also monitor the systems for freezing temperatures or high humidity that could indicate a problem in the home. Residents can reduce their utility bills with careful programming.
- **Leak detection.** The damage caused by water, especially in a multistory building, can be costly. Leak detection systems help landlords and tenants avoid the damage of a major leak, along with water waste and higher bills from slow leaks. Some connected appliances include built-in leak detection.
- **IAQ.** Range hoods, bathroom fans and ventilation systems that work automatically provide better indoor air quality for



residents, and reduce damage to units from grease, smoke and humidity.

- **Security.** Smart locks, cameras, occupancy sensors and window and door sensors can provide a sense of security for residents, and allow landlords to more easily monitor their properties. While most tenants like the simplicity of smart locks, some security tech tools may feel invasive, so landlords need to communicate how the tools and data are used and use them responsibly.
- **Remote-controlled appliances.** Smart appliances come with a variety of features, but what most tenants want the most is the ability to operate their appliances even when they're not home, according to [Rent.com](https://www.rent.com).

A Smart Tech Path to Great Conversion



CREDIT: ISTOCK/CHRIS HERBURN

Some of the features that builders can offer to nudge consumers into reducing their carbon footprints include:

- **Solar prewiring.** This makes it less costly to add solar if buyers can't afford it when they first buy a home.
- **Smart appliances.** Tech-enabled appliances encourage buyers to choose energy-saving options.
- **Air and water monitoring.** Leak detection sensors can reduce water usage. Indoor air quality sensors can work with automated ventilation systems.
- **Electric vehicle (EV) charger prewiring.** While 8.5 percent of new car sales are EVs, 38 percent of Americans says they'll seriously consider buying one, according to [Pew](#). Having the capacity for an EV charger at home makes it easier to consider one.
- **Energy use monitors and smart plugs.** Monitors that provide instant feedback are more likely to change behavior around energy use.

The [Green Door app](#), available on newly built and existing homes from Pearl Certification, provides homeowners with information about how to maintain and improve the energy efficiency of their homes, and about tax credits and rebates available for green improvements. If they have a newly built home with prewiring for solar panels or an EV charger, for example, they can find information within the app about contractors to install more equipment and financing options.

"Smart thermostats provide an easy entry point for millennials around sustainability, and most millennials are comfortable with smart speakers and cameras," says Adams. "Millennials are also more comfortable with a one-stop shop to manage smart home features. We use gamification to motivate them, so they can get points for different improvements to their home to help them achieve different levels of Pearl Certification."

Samsung's [SmartThings](#), a smart home app that allows users to manage everything from air purifiers and thermostats to their blinds, lights and speakers. It can also be accessed on a Samsung [Galaxy Watch](#). Users can even swipe right or left on the app and livestream their security cameras from their wrist.

The smart home devices millennials want to buy now include smart doorbells, energy monitoring systems, smart doors and windows, and EV chargers, according to COGNITION data.

To get millennials to embrace other high-performance features, builders, salespeople and real estate agents need to proactively explain the benefits of various systems, building techniques and appliances, Adams says.

"Millennials want good indoor air quality, to maximize sustainability and to minimize their carbon footprint, but builders shouldn't assume they understand how to get those things," Adams says. "Buyers can make smarter decisions if they're provided with information on things like the benefits of induction cooking for their health. Builders should start at the model home and design center by demonstrating what different features can do for homeowners and the environment."



'Door' to smart sustainability. Pearl Certification's Green Door app provides homeowners with information about how to maintain and improve the energy efficiency of their homes, and about tax credits and rebates available for green improvements. COURTESY OF PEARL CERTIFICATION

NET ZERO ENERGY INVESTMENTS

KB Home's new microgrid communities, which have achieved numerous certifications—including Zero Energy Ready status from the U.S. Department of Energy—serve as models and research sites for high-performance homes, says Dan Bridleman, senior vice president of sustainability for KB Home.

"We started building these homes with the 'reduce before you produce' mindset," Bridleman says. "Each home has a tight envelope to run as efficiently as possible, so they're ready to be net zero homes. Then, we add state-of-the-art electric water heaters and air conditioning systems. We've reduced the energy use of each home by 40 percent, so it functions better even before the solar power starts producing energy."

KB Home and its research and manufacturing partners are working to develop new innovations and to improve affordability for these high-performance homes.

"We've partnered with Kia to experiment in some of the homes with bidirectional battery sharing," Bridleman says. "A lot of people assume that you can not only charge your EV from your house, but that you could use your EV's battery to provide electricity for your home. But most of the time, these systems aren't bidirectional. A typical EV battery has 70 to 120 kilowatts stored, which could be another power source in case of an outage."

KB includes a baseline of tech in each home, such as smart thermostats and smart locks. Buyers can layer in the features they want, Bridleman notes. "They can add lighting controls and theme music, and they



Multipurpose technology. Samsung's *SmartThings* smart home app allows homeowners to manage everything from air purifiers and thermostats to their blinds, lights and speakers. COURTESY OF SAMSUNG

can geo synchronize their car and driveway to automatically open their garage door when they come home," he says. "Millennials understand this technology and it's really infinite what some of them may want. They're interested in green features and technology, so we just need to educate them about energy monitoring and other innovations that can help them reduce their water and energy use." **GB**

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Complete package. With VISION House Sussex, the construction process is all about the details, from excavation efforts to a pre-possession walkthrough.

COURTESY OF TIM O'BRIEN HOMES

VISION House Sussex: From the Ground Up

There are many facets to constructing a new, sustainable home. Tim O'Brien is working his way toward completing all of them.

BY MARC HUMINILOWYCZ

When it comes to building a new home, there's a lot more than meets the eye. From the ground up, the construction process is all about the details. This principle applies to every Tim O'Brien home, and especially VISION House Sussex, where each stage is carefully executed by trusted tradespeople and inspected every step of the way.

Excavation for the VISION House Sussex model home began last winter, with careful consideration of frost in the footings and the foundation before pouring the foundation walls. "Because freezing and thawing of the soil shifts the ground, we have two seasons here in Wisconsin: winter and road construction," jokes Tim O'Brien Homes owner Tim O'Brien. "New homes built in Wisconsin have basements not because we're packrats, but because we must provide a solid base below the frost line."



Rock solid. Eight-inch-thick concrete slabs distribute the weight of the home and prevent water seepage. COURTESY OF TIM O'BRIEN HOMES

According to O'Brien, the frost line where VISION House Sussex is located is about four to six feet deep. "At this depth, the soil and groundwater no longer freeze in the winter," he explains. A GPS system was used to dig the hole, set up to follow a detailed plan including elevations. The next day, a foundation crew prepared the hole for footings: 8-inch-thick concrete slabs sitting below the foundation walls that distribute the immense weight of the home to keep it from sinking and prevent water from seeping into the foundation walls.

Next, builders installed *Form-a-Drain* rectangular tubing, a 3-in-1 product that acts as a form for the footings, a drainage system and a vessel to remove sub-soil gas (specifically radon). The work was thoroughly examined by a building inspector. This was the first of 10 inspections conducted at various stages in the construction process. Pouring concrete into the forms came next, followed a few days later by the application of the *Delta-MS* waterproofing membrane, which ensures a dry, comfortable and healthy basement.

GOOD BONES: FRAMING

Once the footing concrete was cured (10 days after pouring), the home was connected to municipal water and sewer mains, the foundation walls were back-filled, and everything was inspected. At the same time, the lumber arrived onsite and the framers began their work. First to be installed was

the sill plate and sill sealer, the bottommost components of framing. Tim O'Brien Homes uses 2-by-6 rot-resistant Southern yellow pine, pressure-treated to withstand water and prevent moisture from travelling from the foundation wall to the wood. "Since this section is vulnerable to heat loss, we spray-foam the basement box sills, which are the top of the foundation walls where the floor joists rest," says O'Brien. "This increases energy efficiency and shields the home from the outdoors."

Next came the floor joists on the first floor. "For hundreds of years, solid wood was used to support the central, suspended weight of buildings," says O'Brien. "About 50 years ago, 'I-joists' took over the role. They are used in most home construction today."

Stronger, stiffer and longer than conventional lumber, I-joists reduce floor squeaks and the amount of material required to build a home and improve the efficiency of installation. They carry the weight of the home down onto laminate veneer lumber (LVL) beams. And, unlike the Canadian lumber that makes up most of the project's framing, these "spray-tanned bodybuilder versions of lumber" are manufactured in Oregon, O'Brien says.

Building onto the floor joists, framers next assembled the first floor walls. Once complete, they installed a high-performance wall system unique to Tim O'Brien Homes. "We are one of few builders on the market to double-sheath



CLOCKWISE FROM LEFT:

Waterproofing ensured. The Delta-MS waterproofing system provides a 10-year dry basement wall guarantee.

Powerful framing: I-joists carry the immense weight of the home down onto Oregon-made laminate veneer lumber (LVL) beams.

Wall system. Exterior wall treatment allows for 2-by-4 vs. 2-by-6 wall studs to save costs and increase floor space. ALL PHOTOS COURTESY OF TIM O'BRIEN HOMES

our exterior walls, meaning two layers of 7/16-inch sheathing instead of one," explains O'Brien. "Over this, we apply one-inch rigid foam insulation. This prevents 'thermal bridging' where framing studs act as superhighways for the transfer of heat and cold. The exterior foam acts as a warm coat that significantly minimizes this effect."

Completing the wall system is a unique framing stud treatment. According to O'Brien, many builders frame 2-by-6 walls and pack them with standard batt insulation. In Tim O'Brien Homes, rigid foam on the outside combined with blown-in batt insulation in the wall cavities allows for a well-insulated 2-by-4 wall. "Without sacrificing structural integrity, the reduction in lumber size saves on costs and increases floor space," he says. "Using this wall system, we differentiate ourselves from other

builders not because it's trendy, but because it's value-driven."

After installing prefabricated roof trusses and creating the attic space, the framing crew created energy-efficient raised heel trusses. "A good chunk of heat loss in the home occurs in the attic," O'Brien explains. "Conventional trusses have sharp angles at their ends, which cause attic insulation to compress. Raising the heels of the truss allows for deeper insulation at the perimeter of the attic, which minimizes cold spots and moisture accumulation and increasing air flow, reducing the likelihood of ice dams."

IT'S A WRAP!

Following the completion of mechanical cut-ins, the roof of the home was immediately protected from the elements with a

WATER WORKS



COURTESY OF PHYN

As one of its many sustainability features, VISION House Sussex will be fitted with a *Phyn Plus* smart water assistant. According to the company's website, the average home in America leaks 10,000 gallons of water per year. *Phyn Plus* protects a house from leaks, conserves water and saves homeowners money by accurately detecting leaks across multiple flow sources in the home. The device measures microscopic water changes 240 times per second to recognize the unique "voice" of every water fixture. When a faucet runs, Phyn the device knows it's a faucet. If the faucet leaks, an alert is issued.

Phyn Plus shows homeowners how they are using and wasting water and provides them with tools to address these issues. It alerts homeowners to all types of leaks—from pinholes in pipes to frozen bursts—and stops them before they become expensive problems.

ABOVE:

Inspection time. A municipal building inspector checks mechanical rough-ins, plumbing and electrical systems.

Wrapped up. Certified Tyvek installers protect the home from the elements with a water-resistant barrier. ALL PHOTOS COURTESY OF TIM O'BRIEN HOMES

roofing underlayment and Owens Corning 30-year shingles. Certified Tyvek installers carefully shielded the exterior walls from the elements with a Tyvek weather-resistant barrier. This prevents water from seeping into the home, stops air from moving into the exterior wall and quickly removes water vapor, should it enter the wall system. The final phase of closing in the home involved the installation of high-performance ENERGY STAR windows by Tim O'Brien Homes certified installers.

The interior of the home was a hub of construction activity, with heating, ventilation and air conditioning (HVAC) systems roughed in, and plumbing and electrical trades installing the home's wiring, plumbing and drain systems. Once complete, the municipal building inspector returned to thoroughly inspect the home for compliance with the building code.

“Work with the same trusted tradespeople that you’ve established a long relationship with—especially mechanical contractors. They will call each other, work together and respect one another.”—**Tim O’Brien, president, Tim O’Brien Homes**

VISION House Sussex was now ready for insulation. Before this the model, like every Tim O’Brien home, underwent an additional step in the building process—a pre-drywall orientation with the homeowner. “During this walk-through meeting at the homesite, we introduced the homeowner to the value-driven features of their high-performance home before the walls were covered with drywall, as well as discussing our warranty and delivery processes,” says O’Brien.

A number of enhanced steps were taken to create a high-performance building envelope. Large seams in exterior walls were caulked; a vapor barrier was installed; dense spray foam was applied to basement box sills; a thick blanket of insulation was blown into the attic; and every square inch of exterior wall cavities was insulated using Tim O’Brien Homes’ advanced “blow-in blanket system.” Before drywall, all insulation and the vapor barrier were inspected by O’Brien’s third-party energy rater and the building inspector.

THE FINISHING TOUCHES

The next weeks in the building process involved numerous trades putting the finishing touches on VISION House Sussex: drywall, lighting and plumbing fixtures, cabinetry and countertops, doors and trim, flooring and tile, painting and the installation of the exterior finish component of the project: James Hardie’s *HardiePlank* lap siding, a product composed of cement reinforced with sand and cellulosic fibers from trees that will protect the home from wind, rain and snow and Wisconsin’s northern weather extremes.

Perhaps the most-critical element in an airtight high-performance home involved the installation of the mechanical

systems. These included: *Carrier Dual Fuel Performance Multi-Zone Heat Pump and Gas Furnace*; *RHEEM ProTerra Hybrid Water Heater*; *RenewAire* energy recovery ventilator (ERV); an active sub-soil venting system for radon mitigation; *Aeroseal* duct air-sealing technology; and *JinkoSolar* panels and solar storage.

Building a home is a complicated process, and many things can go wrong along the way. “You’ve got about 40 to 50 different entities—such as suppliers, companies, installers and laborers—including 200 people working on the house,” says O’Brien. “That’s why we utilize a ‘punch list’ to ensure adherence to quality standards and scope of work.”

As an example in the finishing stage, builders do a walk-around “punch” and a “manager quality walk” for a different set of eyes once the flooring and carpeting are in (to schedule last-minute paint touch-ups and cleaning), before the customer comes in for a walk-through seven days before possession.

When complete, VISION House Sussex will show builders and consumers in the Greater Milwaukee area how to improve a home’s energy efficiency, durability, health, and comfort—at an attainable price.

For other builders wishing to aspire to high-performance housing, O’Brien offers the following tips: “Work with the same trusted tradespeople that you’ve established a long relationship with—especially mechanical contractors,” he says. “They will call each other, work together and respect one another. We’ve had strong relationships with the same HVAC technicians, framers, plumbers, roofers, insulators and electricians for the past 16 years. And, employ a good energy consultant. With all this in place on a project, it’s amazing how much gets done without you!” **GB**

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HOUSING 2.0

DISRUPTIVE INNOVATION, PART 1: 'WHY' HOUSING DISRUPTION (OH, THE PAIN)

Here are five crises that are preventing builders from **making transformational change.**

BY SAM RASHKIN

This is Sam Rashkin's latest in a series of articles based on his second book, "Housing 2.0: A Disruption Survival Guide." It is intended as a roadmap for high-performance builders to become the most successful in the industry.

According to one expert, we're living in an unprecedented age of acceleration defined by two key realities. First, "if it can be done, it will be done," and second, "if you don't do it, someone else will." Let me interpret. Any market-ready innovation that can cost-effectively improve user experience (UX) is a sure thing, and if you ignore this opportunity, it is also a sure thing that someone else will not...eventually.

Another more common way of framing this reality is, "adapt or be left behind." The data bears this out. Two separate studies show companies that leverage innovations to optimize UX become industry leaders. Specifically, UX leaders compared to laggards provide three times greater financial return to investors and are three times more resilient during recessionary periods with shallower troughs and quicker recovery.

Yet, decades of personal experience suggest the housing industry is a huge innovation lagger. I'm not talking about incremental innovation; there's plenty of that. I'm talking about transformational innovation, such as personal transportation disrupting overnight from the horse and buggy to the internal combustion engine automobile at the turn of the 20th century, and once again 100 years later from the internal combustion engine to the electric vehicle. Or, seeing personal communication in recent decades disrupting from landline phones to cell phones, and then to smart phones.

Now it's housing's turn. Finally. My next series of articles lay out the "Why," "What" and "How" behind the disruptive innovation looming ahead. In this one, the basis for "Why" disruption is the convergence of five crises that are increasingly exceeding the builder pain threshold required to drive transformational change.

I've always been impressed with the ability of home builders to navigate the most difficult of all businesses. Ongoing challenges include the availability and cost of land, the availability and cost of critical trades, inflating material costs, supply chain vulnerabilities, rising interest rates, volatile design preferences, constantly changing codes, costly new regulations, and cyclical consumer confidence tied to our national economy. I could go on, but you get the point: builders are always in pain.

CRISIS #1: LACK OF USER EXPERIENCE READINESS

UX matters in all products. It really matters in housing. After all, housing is the ultimate consumer product. Nothing comes close to it in size, cost, emotion, risk, and transaction complexity. Meanwhile, the amount of information available to homebuyers is increasing exponentially. As a result, they expect so much more. It is critical every homebuilder is ready to meet these growing UX expectations.

However, personal experience visiting tens of thousands of homes in my role leading national high-performance housing programs suggests the housing industry is not ready. This assessment is supported by tabulated five-star ratings for more than 120 production builders featured in a leading independent peer review program.

The results were scary, with an average score below two stars for more than 75 percent of the builders. This is a crisis, as the average star rating for a consumer to consider engaging with a business is 3.4. I'll submit that this average threshold is way too low for the ultimate consumer product, housing. When my wife and I travel, we routinely screen out any restaurant or hotel with less than a four-star review for just a \$100 meal or \$200 lodging. What is the chance that much more informed buyers, increasingly aware of builder peer reviews, would spend hundreds of thousands or more than \$1 million for a home from a builder with less than a four-star rating?

Meanwhile, there is a huge opportunity to leverage impressive opportunities for transforming UX that are being left on the table.

CRISIS #2: LACK OF AFFORDABILITY

While the median home price has been increasing exponentially for the past half century, median household income has remained relatively flat (see Figure 1). This means the gap between home prices and household income is also increasing exponentially. That is not sustainable. The economic analysis can get very complicated, so I'll keep it simple: If the cost of a product blows way past the consumer's ability to pay for it, eventually things don't go well. The recently low mortgage interest rates—which were sure to increase to control inflation and inventory shortages—can only get you so far. In 2021, when mortgage interest rates were still approximately 3 percent, the \$144,000 average income needed to afford a home was two times the \$70,000 median household income. The recently low mortgage interest rates—which were sure to increase to control inflation and inventory shortages—can only get you so far.

Consider a recent news story about a professional couple in California making more than \$200,000 combined income that quotes them saying, "it's hilarious to think they could afford a home in Los Angeles." You know you have a problem when a couple in the 95th percentile of household income can no longer purchase a basic home in a state with an outbound move rate that rose to nearly 60 percent in 2021. But it's not just high-cost markets. Population centers across the country are struggling with the dangerous disconnect between housing prices and household incomes. We're reminded of this housing affordability crisis on a regular basis with never-ending news reports and no substantial solutions waiting in the wings.

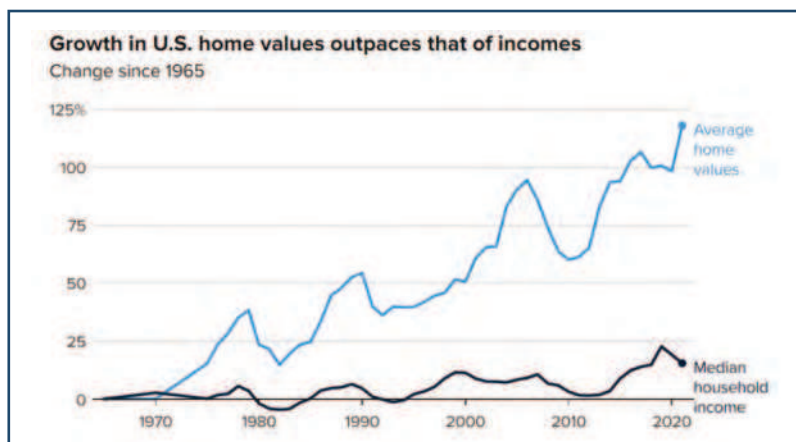


Figure 1: Average home price and median household income have gone separate ways since 2020.

CRISIS #3: LACK OF TRADES

Another housing crisis constantly in the news is the lack of trades. We're experiencing a tsunami of retiring older workers with a meager pipeline of younger workers to replace them. This is exacerbated by a national immigration crisis that has significantly reduced the entry of construction workers from our southern border. As a result, trades are consistently cited as the most significant problem confronting builders (see Figure 2). This includes a recent National Association of Home Builders (NAHB) survey where 85 percent of builders expected cost and availability of labor to be significant problems.

Results from a more-recent survey indicated more than 90 percent of builders reported framing crew and carpenter shortages in 2022. Recent analyses indicate this crisis is only going to get worse, with 2.2 million net new hires needed in the construction industry from 2022 to 2024. If you're a builder who is not figuring out how to manage growing strains on trades, significantly greater pain lies ahead.

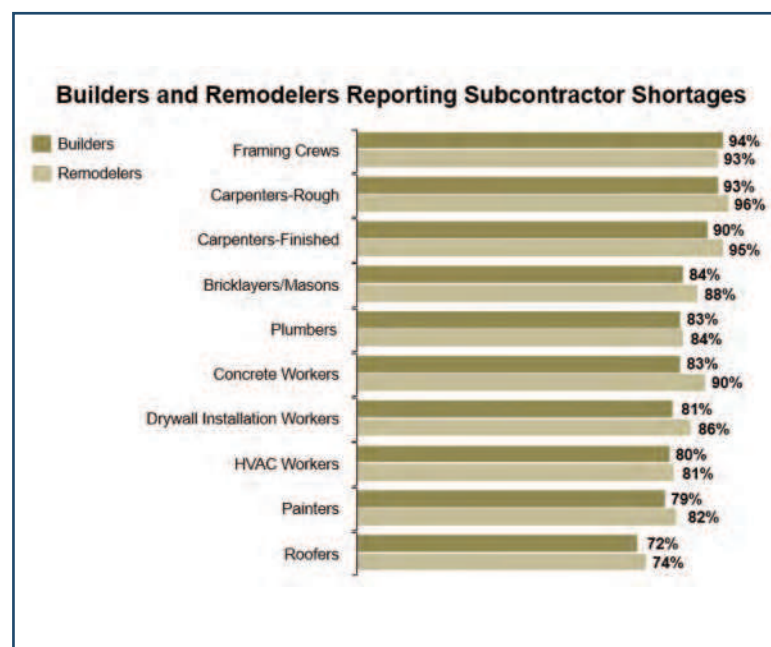


Figure 2: Builders and remodelers are nearly equal in their struggles with a housing trade shortage.

CRISIS #4: LACK OF PRODUCTIVITY

It probably comes as no surprise to casual observers of the housing industry that it has a profound productivity issue. Detailed industry studies make it clear that it is a crisis. A famous McKinsey & Company evaluation of the construction industry concluded that construction productivity has remained flat over the past 30 years, while manufacturing has nearly doubled (see Figure 3). This is further corroborated by separate findings that production resources add more than six times greater value in manufacturing than housing. In a more recent report, a \$200 billion cost was calculated for this labor productivity gap across the U.S. construction industry, and that it could be closed by adopting 21st century manufacturing methods such as prefabrication, robotic automation, and additive manufacturing.

Overview of Productivity Improvement Over Time

Productivity (value added per worker), real, \$2005

\$ Thousands per Worker



Figure 3: Construction productivity has remained flat over the past 30 years, while manufacturing has nearly doubled.

CRISIS #5: LACK OF DIGITIZATION

Virtually every industry is vastly more digitized than housing. This was the finding in one study that ranked housing as the least digitized industry except for agriculture and hunting. This represents a crisis because digitization exploits data, software, and technology to deliver a better UX at lower cost. To the degree that some architects and builders are utilizing building information modeling (BIM), that's a good start. But only a start. There is a severe shortage of true power users that can leverage the faster, better, cheaper benefits from fully digitizing housing including reduced cycle time, automated bill of materials, enhanced quality, comprehensive system integration, enabled machine learning, increased production efficiency, minimized waste, and substantially reduced rework. All these benefits are too vital to be missing from the housing industry. **GB**

Sam Rashkin's two-decade career as a licensed architect includes serving on national steering committees for the U.S. Green Building Council (USGBC)'s LEED for Homes, Green Builder Media's Green Builder Guidelines, the Environmental Protection Agency (EPA)'s WaterSense label, and EPA's Indoor airPLUS label. He has partnered with Green Builder Media to develop the **Housing 2.0 program**, which empowers building professionals to design and construct higher-performance, healthier and more-sustainable homes at a fraction of the cost.

The Housing 2.0 program is sponsored by JinkoSolar, LP Building Solutions, Mitsubishi Electric, Panasonic Healthy Indoor Solutions, Schneider Electric, and Sunnova.

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Mother Nature's landscaping. Arizona's "Sustainable Desert Development Policy" calls for planting of drought-tolerant and native plants, outdoor irrigation standards, enhanced standards for swimming pools, and more. CREDIT: ISTOCK/ADAMKAZ



Law and (Sustainable) Order

Clean energy, water conservation and carbon emission reduction efforts continue to be at the top of lawmakers' minds.

BY MIKE COLLIGNON

It was a very busy second quarter of 2023 in terms of state legislation related to sustainability in construction. As we headed into the third quarter, cities and states nationwide await the impacts of decisions reached over the summer.

Florida: Statute 403.892 offers density incentives to developers and homebuilders who use residential greywater technologies. The statute offers a 25 percent density bonus to developers or homebuilders if at least 75 percent of a proposed or existing development will have a greywater system installed, or a 35 percent bonus if 100 percent of a proposed or existing development will have a greywater system installed.

To qualify, the following five conditions must be met:

- The proposed or existing development must have at least 25 detached single-family residential homes or 25 multifamily

dwelling units, which may include apartments;

- Each single-family residence will have its own residential greywater system dedicated for its use. Each residence forming part of a multifamily project will be serviced by its own residential greywater system dedicated for its use, or by a master greywater collection and reuse system for the entire project;
- The developer or homebuilder has submitted a manufacturer's warranty or data providing reasonable assurance that the residential greywater system will function as designed and includes an estimate of anticipated potable water savings for each system;
- The developer or homebuilder has submitted a manufacturer's warranty or data providing reasonable assurance that the residential greywater system will function as designed and includes an estimate of anticipated potable water savings for each system;

- An operation and maintenance manual for the greywater system will be supplied to the initial homeowner of each home, including a method of contacting the installer or manufacturer and shall include directions to the residential homeowner that the manual shall remain with the residence throughout the life cycle of the system.

Greywater system proof of purchase must be provided within 180 days after the issuance of a certificate of occupancy for single-family residential homes that are either detached or multifamily projects. However, multifamily projects more than five stories in height are not eligible for this incentive.



A 'grey' day. Outdoor watering restrictions have led to the use of greywater for irrigation purposes in cities and new subdivisions nationwide.

CREDIT: ISTOCK/OLGA KORICA

Illinois: The **Electric Vehicle Charging Act** was recently signed by Gov. Jay Robert "J. B." Pritzker, creating minimum requirements for newly constructed single-family and small multifamily residences (2-4 units) to be equipped with at least one electric vehicle (EV)-capable parking space for each residential unit that has dedicated parking.

The effective date of the bill is Jan. 1, 2024. However, affordable housing units have a 2-year waiver from their requirement of a minimum of 40 percent of their parking slots EV-capable, with the minimum space requirement increasing to 50 percent after 5 years and 70 percent after 10 years of the bill's passage. For a new, large multifamily residential building or a large multifamily residential building being renovated by a developer converting the property to an association, those property types will be required to have 100 percent of their total parking spaces EV-capable starting with permits issued on or around April 1, 2024. For property conversions, "no EV-capable or EV-ready mandate shall apply if it would necessitate the developer having to excavate an existing surface lot or other parking facility in order to retrofit the parking lot or facility with the necessary conduit and wiring."

Colorado: The most recent legislative session saw a number of bills passed that will improve sustainability in the state:

- **HB23-1272** increases and extends state tax credits into 2024 for the installation of efficient home heating, cooling (\$1,500; or \$3,000 for a ground-source model), and hot water systems (heat pump \$500).
- **HB23-1161** cuts energy and water waste, reduces toxic mercury pollution, reduces smog-forming pollution by setting tougher emission standards for new gas furnaces and water heaters, phases out the sale of mercury-containing fluorescent light bulbs, and sets new energy- and water-saving standards for common appliances sold in the state.
- **HB23-1233** accelerates the implementation of new EV-ready building requirements currently being finalized by the state Energy Codes Board; increases the availability of EV charging options, particularly at multifamily apartment buildings and condos; and standardizes the definition of "Disproportionately Impacted Community" to help guide the state's efforts in targeting programs to the areas where they are needed most.
- **HB23-1134** requires a home warranty service contract to allow a homeowner to replace gas-fueled equipment, like furnaces, with electric alternatives such as heat pumps, synergizing with the tax incentives in HB 1272 (above) and federal incentives.

Phoenix: In mid-June, the City Council approved a "Sustainable Desert Development Policy." The new conservation guidelines apply to properties applying for rezoning. The stipulations include regulations on non-functional turf, a mandate to meet EPA WaterSense for Homes 2.0 or similar certification, planting of drought-tolerant and native plants, outdoor irrigation standards, enhanced standards for swimming pools, and more. The City's Planning and Development Department is now tasked with rolling out these draft stipulations and collaborating with applicants about how, when, and where they should be utilized.

The new policy was based on the city's work with the Verdin development, a residential neighborhood in North Phoenix that incorporated water conservation measures to the tune of 55 million fewer gallons of water annually (compared to a standard subdivision). The new regulations are also a natural outcome of the City Council's decision to leave up to 50,000 acre-feet of water in Lake Mead annually for a 3-year-period. To make that a reality, officials had to do something to conserve water. The City is also investing in a direct potable reuse plant, which is aiming to recycle almost 60 million gallons of water each day.

Finally, the City is also developing a strategy to stabilize and address its water challenges in the short and long-term. It wisely recognizes that the Colorado River is a "declining river system" and that "the long-term outlook for Colorado River supplies for Phoenix is still not stable."

Oak Park, Ill.: The Village of Oak Park has become the first municipality in the Midwest to pass an electrification ordinance for all new construction. New residential buildings shall be designed and constructed as follows:

- The source of energy for the building shall be all electric and the source of energy shall not be fossil fuels. Energy from

Clean living. The Village of Oak Park, Ill., is the first municipality in the Midwest to require new residential buildings to be all electric, with energy derived from non-fossil fuel sources. CREDIT: ISTOCK/NAITRASS



fossil fuels may be provided by generators for emergency backup power.

- All heating and air conditioning shall be provided by cold climate air source or ground source heat pumps.
- A building shall contain an energy recovery ventilation system.
- A building design shall include Manuals J and S calculations, or an equivalent design, by a licensed design professional.
- All refrigerators, dishwashers and clothes washers shall be Energy Star certified.
- Energy for any clothes dryer shall be provided by an electric heat pump.
- A building shall contain at least one level 2 electric vehicle charging station at one parking location if a building contains a parking space/garage.
- Directly piped exterior gas fire pits and gas cooking grills whose source of energy are fossil fuels are prohibited.

The Village Board also passed an ordinance approving the unamended 2021 IECC, and expressed an interest in adopting the Illinois Stretch Energy Code once it is finalized. This is part of its Climate Ready Oak Park initiative, with a goal to achieve community-wide net zero greenhouse gas emissions by 2050.

Both ordinances go into effect Jan. 1, 2024.

Alabama: SB 40 was introduced in early March, and it is quite an interesting attempt to prohibit electrification steps. It aims to prohibit a city, county or agency from requiring the installation of “latent, non-operable features in a residential structure.” This encompasses “any technology, appliance, electrical circuit, wiring, plumbing, gas tubing, framing, or other item, installed



Power sharing plan. Illinois’ forthcoming Electric Vehicle Charging Act requires newly constructed single-family and small multifamily residences to be equipped with at least one electric vehicle-capable parking space per dedicated unit.

CREDIT: ISTOCK/PHONLOMAIPHOTO

in or connected to a residential structure, that will not be placed in a state of active operation or that will not be utilized by the homeowner at the time of the residential structure’s completion.”

There are many witty and/or sarcastic things that could be written about this effort to fight against the tidal wave that is renewable energy, but instead it seems most apropos to link to this evisceration of the bill and the Homebuilders Association of Alabama from the Executive Director of Energy Alabama.

Ironically, this bill passed the House and the Senate two days before Earth Day. The Governor would later sign the bill into law. **GB**

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



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Memorable 'Meadows'. The Mariposa Meadows website is an example of how builders can post information about ongoing and completed projects, as they work with existing and potential clients. CREDIT: GREEN BUILDER MEDIA/SAMANTHA CARLIN

An Evolving Green Building Community

The idea of 'Green Building' has become an area of interest that is local, national and international in scope. Here's why.

BY TERRY BEAUBOIS

If you are reading this article, you are already part of the green builder community. This is an unofficial group of people united by a belief in the mission and purpose of green building. Green Builder Media and magazine have been at the center of this movement since Ron Jones and Sara Gutterman founded Green Builder Media in 2005. Green Builder has persisted, prevailed and accomplished much, operating with continued optimism that there is "more to accomplish!"

I recently talked with company president Ron Jones about the current state of Green Builder Media and its future. Ron discussed

how the company is building on its past, but not resting on its laurels. Ron's philosophy, which he presents in his editorials in the magazine, is one of being a "provocateur"—someone who challenges people and companies to think about how each person and company can contribute to and benefit from Green Builder—both how and why. He also adds an additional element to his approach: humility. This combination of factors keeps GB as a leading proponent of green building.

PRACTICING WHAT THEY PREACH

A recent project in Colorado clearly shows that Green Builder "practices what it preaches" and sets an example of how to feature



Inside information. Green Builder Magazine offers its readers ideas, concepts and products that help builders construct homes in a sustainable manner.

the “green” aspects of projects. (See “VISION House at Mariposa Meadows: Elevated Elegance” in the [September/October 2022 issue](#).) Many of the ideas, concepts and products that GB magazine articles feature are included in this project. This also shows how each of us can be more proactive in encouraging more sustainable, green ideas and products in our building projects and feature them prominently in an article or a page on your own website.

GB set up the [VISION House Mariposa Meadows website](#) as a good example of how you can post your ongoing and completed projects as a way to highlight your work with existing and potential clients. We can use our own websites to showcase our work and explain our commitment to green building, and also feature the green aspects of your projects.

HOW WE CAN LEVERAGE GREEN BUILDER FOR OUR BENEFIT

I mention this because I recently asked a fellow architect friend how often his homeowner/clients request their homes to be “green buildings.” He replied, “rarely.” He also mentioned that he didn’t post information about green building on his website. I encouraged him to reconsider that thought. I told him that this is an opportunity for us to provide more information to our clients about the benefits of green building. We can send our clients and potential clients a URL of an article in the online version of Green Builder that is appropriate to that client’s project interests.

This is a simple example of how each of us can be more proactive and provocative in our own practices, using the resources that Green Builder Media and magazine provide. (Here is another example of an article from the GB website that a client may find of interest: “[Colorado Home is a Lesson in Humanity](#).”)

GB WEBINARS: FREE ADVICE

Another great example of how Green Builder Media provides value to us, beyond reading the magazine, is through its webinars. These online mini-conferences have become “a business imperative to minimize risk, enhance long-term performance, and improve resiliency against market volatility and idiosyncratic events.” Past seminar topics include addressing the interests of the different generations now in the market for green buildings—from baby boomers, to Generation X, millennials and Gen Z; and successful environmental, social, and corporate governance (ESG) strategies. The webinars are posted on the [GB website](#) for readers to view at their convenience.



Online learning. Green Builder Media's webinars offer free advice on business-improving topics such as millennial marketing and ESG strategies.

HOUSING 2.0

Another area of benefit to readers of GB is the [Housing 2.0 program](#). This program is now free to participants. In the past, I attended a seminar given by Sam Rashkin in Portola Valley, Calif., when he was chief architect at the U.S. Department of Energy. I found Sam to be one of the most informed and knowledgeable professionals in the building industry. I still remember the comments and recommendation that Sam made during his presentation. His awareness, organization and presentation of information is of great value to builders and architects with an interest in green building.

In addition to national issues, Sam is well versed in local issues. If everyone in California had implemented his recommendations when he was observing and commenting on existing site conditions, the recent wildfires in that state and others would have resulted in far less devastation than was experienced.



Generational education. Stanford University's Doerr School of Sustainability encourages its students to work together to increase awareness and interest in green construction and design. CREDIT: ISTOCK/SPVVK

Sometimes, it takes an outside perspective to be objective. Sometimes, it gives local practitioners the perspective of professionals such as Sam to help us present information of benefit to our clients and be viewed as credible, additional, valuable sources of information.

Green Builder Media has joined forces with Sam to offer Housing 2.0, a pioneering training and education program focused on improvements in the housing industry for each of us to consider and share with our clients.

The curriculum has also been “designed to teach building professionals how to implement 30 to 70 percent cost savings for every new home built, and how to navigate the intense challenges that are plaguing our sector (including labor shortages, material shortages, and skyrocketing material costs).” These are issues of significant value to all Green Builder readers and our clients.

ENVIRONMENTAL/SUSTAINABILITY IN ACADEMIA

Colleges and universities are also becoming more aware of the scope of the green building industry. One example is the new [Stanford Doerr School of Sustainability](#), an academic community placing greater emphasis on the combined efforts of many related academic majors, recipients of which go on to participate in the building industry. This is encouraging students to work together to increase awareness and foster interdisciplinary collaboration about environmental/sustainability during education.

There are even classes within the school that collaborate with Stanford's business and real estate programs. Many other schools have and will be addressing the academic benefits of pursuing careers in the AEC and connecting with students pursuing careers in other areas of the greater building industry, including environmental sciences, and the Center for Integrated Facilities Engineering (CIFE). This increases the opportunities for improving interaction and interoperability among professionals across the building industry.

Doing so under the banner of the “Sustainability of People and the Planet” makes it even more in line with green building.

“GREEN AND SUSTAINABLE” IS A GLOBAL ISSUE

“Green” and “sustainable” are two words related to the same general concept. Internationally, the United Nations identifies the building and construction sector as “one of the most important areas of intervention,” and provides opportunities to limit negative environmental impact, as well as contribute to the achievement of the UN's sustainable development goals.

The United Nations Environment Program (UNEP) launched the [Sustainable Buildings and Climate Initiative](#) (SBCI) to address this. The UNEP promotes and supports sustainable building practices on a global scale with a focus on energy efficiency and greenhouse gas emission reduction.

Let's each do our part in representing and promoting green building, and benefiting from the resources of Green Builder Media. Let's follow Ron Jones' example of “being provocative while being humble” about how this is for the “greater good of People and the Planet,” one project at a time, for all building types, in all locations.

We can—and should—continue to be humble about our work, but should also be a little more “provocateur” in helping others, including our clients, to think about their own role in sustainable, green building in America. **GB**

Terry Beaubois is the CEO of [BKS: Building Knowledge Systems](#). He has presented on the topics of “The Future of Architecture” and “The Future of the Building Industry” for decades. He has taught at several universities, and presented at conferences and conventions nationally and internationally. He has written articles for Green Builder for 5 years.



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The State of Green Building 2024

Homebuying trends, market shifts and data-based forecasts are the focus in Green Builder's annual look at the health of the construction industry.

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OLD SCHOOL TRIFECTA

Perhaps Richard Parker, a self-described “Repairman of Mechanical and Simple Electronic Items,” said it best: “To me, if a person is old school, they are old fashioned enough that they don’t fit in with new school society, they work hard and don’t complain, they handle business and live honorably. If something is old school, it is of a style or design from times past.”

Much has changed in the shelter industries since I last built for clients in 2005. Soaring prices for materials and services, a steeply declining and aging workforce, unprecedented supply chain disruptions, and the seemingly exponential increase in natural and manmade disasters of all kinds have combined to remove whatever certainty building professionals traditionally relied upon.

When we add in the recent pandemic, a perpetual economic rollercoaster ride and the endless political turmoil that permeates every aspect of daily life, it’s a wonder anybody can feel optimistic about achieving reasonable stability in our industries, let alone realizing success.

What troubles me the most is the erosion of professional courtesy and integrity that I’ve witnessed over the past couple of decades. I’m not sure how much the challenges I listed above have contributed to the situation (although there must be some cumulative effect from them), or how much communication technology in the current forms has fostered the breakdown, but I’m certain that it’s not just my imagination or some delusional image of “the good old days.”

One thing specifically troubling is the lack of response that has become such a common occurrence. There was a time when you could expect people to get back to you if they said they would. Not anymore. Somewhere along the way, it became a norm to simply put people off and then not follow up as promised.

On occasions when I’ve been asked how success in the building industry is possible, I have had a simple reply: Do what you say you’re going to do, when you say you will do it. It seems easy enough, but in this era of voice mail, call screening and mailboxes that are full, we seem to have cultivated a culture of wiggle room.

Now, having said all that, I was recently amazed when I encountered three building professionals who share the ethic that I hold so dear.

First, I had the very good fortune of finding a concrete contractor who exhibits a commitment to customer service that I haven’t experienced in years. He goes out of his way to keep me informed and works hard to find ways to ensure a dependable schedule and quality work.

Then, after more than two years of struggling to secure the services of a qualified installer for pumps on two water wells, a young man was recommended by an equipment supplier and he turned out to be the kind of serious, skilled, reliable professional that I thought had become extinct. It was refreshing to know that I could depend on someone’s word, not just hope things would work out.

Finally, in need of an extra concrete finisher to help with some complicated flat work, I reached out to a semi-retired gentleman who had worked with my wife and me a few years back to see if he was willing to join in. At first, he was a little reluctant, but when I explained that we needed the level of skills that he had exhibited last time, he said sure, he would be happy to help out.

We agreed on the day and time, and I offered to make sure he had my number in case something came up. He replied that it wasn’t necessary because, as he put it, “I’m like you. When I say I’ll be there, I will.” I can’t express how humbling and gratifying it was to hear him say that.

It feels good to know there is still some “old school” out there. **GB**

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