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EDITOR'S NOTE

The Inside Scoop

By Matt Power
Editor-in-Chief

The 9-11 That Wobbled

Despite near-biblical storm events in Florida and Texas, few seem to take the warning signs seriously.

WHAT WOULD HAPPEN if a 16-foot storm surge hit the Tampa Bay, Fla., area? We almost found out on Sept. 11, just a few months ago. But by happenstance, luck or grace, the storm "wobbled" slightly to the east. The big surge never hit, and winds dropped to Category 1. Lives and property were spared.

What's the rational way to respond to this near miss? We could ask the residents of Puerto Rico or St. Thomas. They may never recover to their pre-Hurricane Irma standard of living. Or we could listen to real estate brokers and builder groups in Texas and Florida, who seem to see this year's unprecedented series of powerful storms as flukes that will barely interrupt the status quo homebuilding process.

In Florida, for example, real estate brokers expect demand for new homes to remain high, with buyers looking for few resilient "upgrades," including impact glass and "hurricane-related construction features." For their part, builders seem more concerned with finding qualified labor than what the new age of serial hurricanes means to their business.

Of course, many homes in Florida were spared Irma's muted wrath, thanks to better building codes passed following Hurricane Andrew in 1992. But the State's climate change skeptic-in-chief—Governor Rick Scott—recently weakened those rules. Builders now have a choice: Follow Scott's spiral into irrelevance or build homes that just might survive the coming deluge.

Let's flash back for a moment to the night Hurricane Irma made landfall in Southwest Florida. The storm's surge was expected to peak at 12 feet to 16 feet. According to Weather Underground, "a one-foot storm surge can sweep your car off the road." Imagine if that surge had hit at high tide, with 10-foot waves. Water would have reached 26 feet. The highest point in the Tampa Bay area is only 48 feet.

Folks, impact glass is not going to be enough.

What will matter, however, is every choice you, the builder, make: piling depth, rebar placement, tie-down systems, roofing fasteners, glass protection—all of it. Fortunately, we have a lot of hard experience to learn from. FEMA has documented the impacts of Katrina, Harvey and other major storms on conventional structures, and has much to say on the matter.

Can we build homes to withstand the worst nature can throw at us? Probably not. I've seen the aftermath of a Category V tornado. But as you'll learn in this month's series on resilient building, we have many tools and systems available. We're not helpless. We can build and strengthen homes so that they have a fighting chance when the next big one comes.

And it will come. Let's not bet life and limb on the next wobble. **GB**

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Fools rush in. When Hurricane Irma's storm surge sucked millions of gallons of water from Tampa Bay, Fla., local residents ran to take selfies in the bay.

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On behalf of the Panasonic Eco-Solutions Company of North America, I wanted to thank *Green Builder* for recognizing our continued leadership in protecting the environment through superior energy efficient products and long-term sustainability initiatives. Sustainability is at the core of our business model, and we continuously look for ways to exceed standards with virtually every product we introduce. Additionally, we take a great deal of pride in being recognized as an ENERGY STAR® Partner of the Year for Sustained Excellence for the eighth year in a row in 2017, further reflecting on our commitment to energy efficient ventilation and indoor air quality solutions. Working closely with organizations such as ENERGY STAR® and *Green Builder* help us achieve our shared goal of making the world a healthier place to live, one home at a time.

Panasonic is proud to offer high-performance ventilation and Indoor Air Quality solutions. Panasonic ventilation fans are ENERGY STAR® certified, and comply with stringent ventilation codes and green building standards. In fact, since 1999, Panasonic has been one of the few manufacturers to work closely with the United States Environmental Protection Agency (EPA) in developing guidelines for the ventilation category. We are continuously motivated by our builder and remodeler customers, who are exceedingly dedicated to building greener and more energy efficient homes.

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We are honored to be among the 2017 Green Builder Eco-leaders and look forward to continuing our green initiatives in years to come.

Sincerely,

Jim Shelton
Vice President, Panasonic Eco Solutions North America

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Environmental Lawyers Say Natural Land Has Rights, Too

Green activists believe natural entities like the Colorado River should be treated as persons instead of property.

THE STATE OF COLORADO and its Governor are being sued by the Colorado River. The lawsuit by Denver lawyer Jason Flores-Williams and environmental group Deep Green Resistance seeks personhood rights for the river, which Flores-Williams says is being "egregiously overused," as it supplies water to seven states. The suit also alleges the State "violated the river's right to flourish" by polluting and draining it, and threatening endangered species.

"If a corporation has rights, so too should an ancient waterway that has sustained human life for as long as it has existed in the Western United States," the suit states. An additional goal is to "force humans to take better care of natural resources by creating a legal consequence for inaction," Flores-Williams says.

The suit could practically rewrite environmental law, possibly allowing the redwood forests, the Rocky Mountains or the deserts of Nevada to sue individuals, corporations and governments over resource pollution or depletion. Future lawsuits might seek to block pipelines, golf courses or housing developments, Flores-Williams says.

CREDIT: JEFFREY BEALL/FLICKR

Natural wonder? Environmentalists say personhood rights must be established for the Colorado River to prevent its destruction—and serve as an example for future cases.

If successful, the suit would be a first in the United States, but not unprecedented. Several nations have endowed similar status on natural entities in an effort to preserve them, according to the *New York Times*. Many legal experts consider the suit "ridiculous," but Harvard Environmental Law Director Jody Freeman believes it "has some merit, but faces a very uphill battle."

EVs Slated for Huge Chunk of Auto Engine Market by 2030

Technology, changing costs and mandates are expected to permanently knock fossil fuel-powered vehicles off their perch.

HYBRID AND FULLY ELECTRIC VEHICLES (EVs) are expected to cut the global market share of pure internal combustion engines (ICEs) by about 50 percent by 2030, according to new research by Boston Consulting Group (BCG).

The report attributes the market change to new technology, regulatory mandates and consumer cost of ownership. BCG expects the transition to take place in three phases over the next dozen years.

"ICEs will continue to be the dominant powertrain for the next several years, at least through 2020, as the prices of EVs will remain high, even with incentives," the report states. "And, the payback period based on total cost of ownership for consumers will be too long to be attractive."

But as the industry moves into phase two, from approximately 2020 to 2025, EVs will increase their share of market as original equipment manufacturers meet tighter fleet-wide efficiency and emissions standards by incentivizing sales of non-ICEs.

CREDIT: WORKHORSE GROUP INC.

A future Workhorse. Electric trucks like the Workhorse *W-15* are rolling into the vehicular market and will be a common sight by 2030.

After 2025, falling battery prices and rising consumer demand will drive rapidly increasing sales of all EVs, the report notes. "[EVs'] higher mileage will result in more-rapid payback of the investment," study lead author Xavier Mosquet says. "We expect pure ICEs to decline in share from 96 percent globally today to about half of all vehicles around 2030."

BCG's report is available at **http://bit.ly/2AzLwC5**.

2017 Hurricane Season Deemed Second Worst Ever

Harvey, Irma and Maria were part of more than $202B in damage to the Southern United States and Caribbean.

IT'S OFFICIAL: HURRICANES HARVEY, IRMA AND MARIA were nightmares for the Southern United States and the Caribbean—and the 2017 hurricane season as a whole was one of the most expensive and destructive in modern history, according to the National Hurricane Center (NHC) and disaster modeler Enki Research.

The monster storm season, which ran from June 1 to Nov. 30, resulted in $202.6 billion in damage to the United States, second to $211.2 billion in 2005, NHC reports. But 2017 could surpass the Hurricane Katrina-era record holder once construction is complete, according to Enki.

Worldwide, damage totaled $369.6 billion, the second highest since 1960. There were 17 named storms in the Atlantic basin, 10 of which became hurricanes. Three storms—Harvey, Irma and Maria—were Category 4 when they hit U.S. shores, a first in recorded history, NHC notes.

Category 4 hurricanes, which have winds of 130 mph to 156 mph, are relatively rare in the U.S., according to The Weather Company. Only 27 have been recorded since 1851, with three eventually reaching Category 5 (157 mph-plus) at landfall.

The "Terrible Three," which hit the mainland U.S., U.S. territories or Caribbean from late August to mid-September, set dubious records. Harvey dumped 27 trillion gallons of water on Texas and Louisiana from Aug. 25 to Aug. 30, breaking the previous rainfall record by more than a foot, according Michael Bell, a professor of atmospheric science at Colorado State University in Fort Collins. On Sept. 6, Irma obliterated 95 percent of all structures on the Caribbean island of Barbuda, leading to a total evacuation and leaving the nation uninhabited for the first time in 300 years, according to U.S. Ambassador Ronald Sanders. The storm also set a record by maintaining Category 5 strength for 37 hours. And on Sept. 20, Maria destroyed Puerto Rico's power grid, resulting in an island-wide blackout for more than two weeks and an ongoing partial blackout. The Army Corps of Engineers hopes to restore 95 percent of power by February.

The hurricanes' destructive nature may lead to retirement of their names, according to the World Meteorological Association. Normally, storm names are reused every six years. Eighty-two monikers have been retired since 1950, including Andrew (1992), Charley (2004), Katrina (2005) and Sandy (2012).

Indoor Comfort Systems Market Tightens Up

Trane-CALMAC, Icynene-Lapolla mergers will broaden residential home environment options.

A PAIR OF MERGERS TAILORED to indoor insulation and temperature control are narrowing the home improvement field while offering builders and residents more flexibility in ways to go green.

Spray-foam polyurethane insulation product makers Icynene U.S. Holding Corp in Mississauga, Ontario, and Lapolla Industries Inc. in Houston have merged and will now operate as Icynene-Lapolla, company officials announced. The combined firm will manufacture and distribute SPF products from offices in Canada and the United States, according to Icynene-Lapolla media spokesperson Julie Fornaro.

Icynene's acquisition of Lapolla was first announced in October 2017. The all-cash transaction was valued at $160 million. Lapolla President and CEO Doug Kramer is Icynene-Lapolla's president, while Icynene CEO Mark Sarvary is Icynene-Lapolla's CEO. "We are excited about the completion of the merger," Sarvary says. "The two businesses have complementary SPF products and outstanding customer service, and both have a strong commitment to innovation."

Meanwhile, Ingersoll Rand subsidiary Trane, a global provider of indoor comfort systems and services, has acquired CALMAC Corporation, a privately held company specializing in cool energy technologies and storage tanks. Financial terms were not announced.

Currently, CALMAC's cooling storage is used by Trane in heating, venting and air-conditioning (HVAC) systems to "take pressure off of the energy grid," Trane said in a statement. CALMAC's cooling technology is used to reduce temperatures at times such as evening or afternoon peaks when the cost of electricity from the grid is high.

According to CALMAC CEO Mark MacCracken, support and investment from Trane and Ingersoll Rand could expand the availability and distribution of CALVAC's products. All employees will be retained to work for Trane, and MacCracken will continue as the company's president. CALMAC will remain headquartered in Fair Lawn, N.J.

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"Resilience means more than just picking yourself and your neighbor up off of the mat. It means adapting and changing in light of new realities." **(p.58)**

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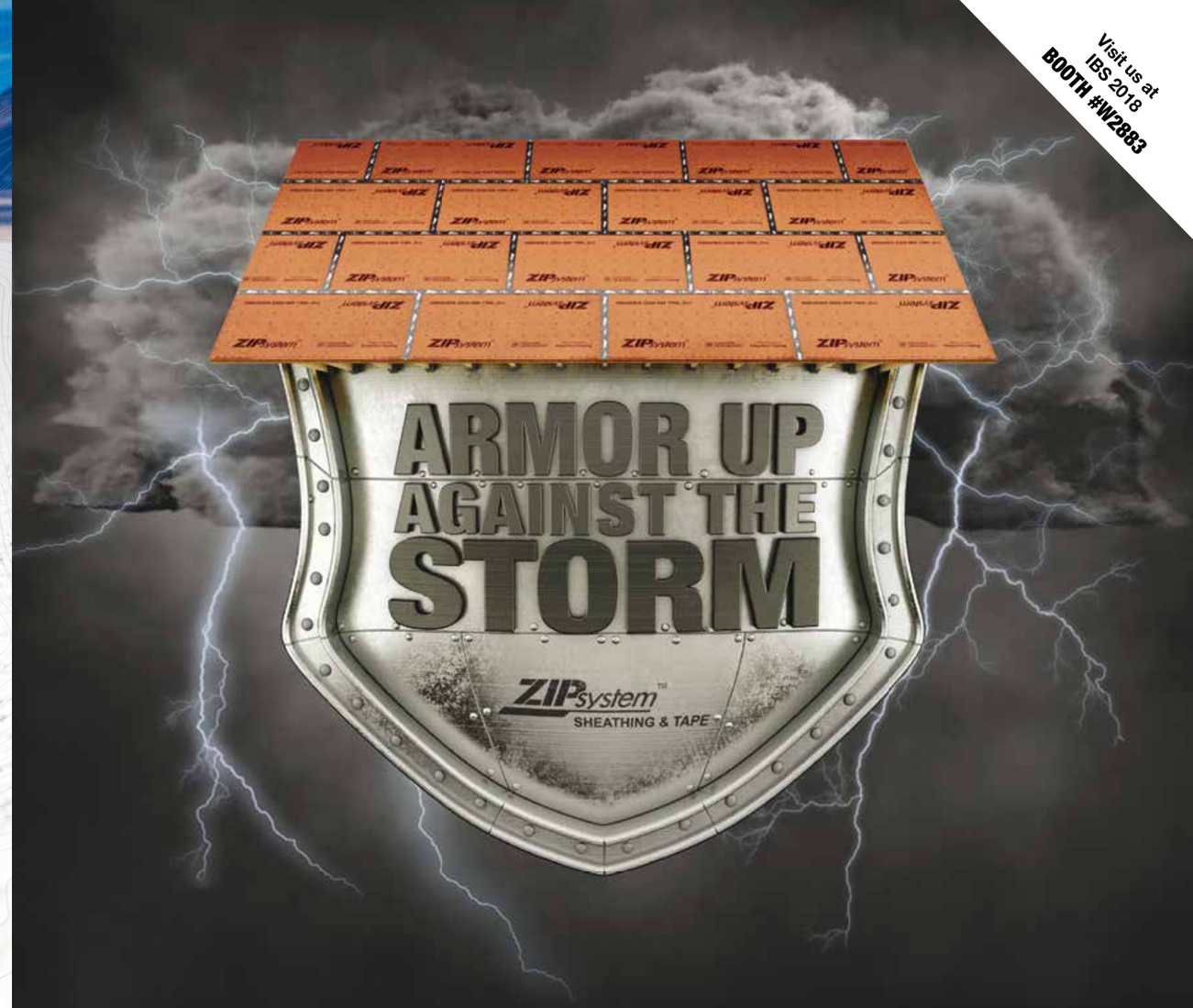

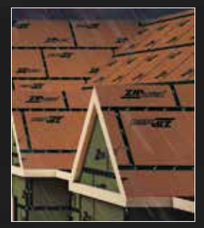

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A New Reality

The Next Big One

Faced with high probability of more Category IV and V storms, builders have voluntary and code-mandated ways to integrate the lessons of Katrina, Harvey, Charley, Sandy, Irma and Maria.

BY MATT POWER, EDITOR-IN-CHIEF

After watching and reading this fall's spectacularly inept news coverage of Hurricane Irma, you might come away with the perception that natural disasters are "sad" and infrequent events, and there's nothing any of us can [nor have any reason] to: a) mitigate them, or b) prepare for future extreme weather. **Neither perception is accurate.** Read on.

RIDING THE TEMPEST

We know how and where buildings fail in hurricanes. Now it's time to prepare for the worst.

BY MATT POWER, EDITOR-IN-CHIEF

AFTER HURRICANE KATRINA IN 2005, I visited New Orleans several times to explore and write about what survived—and what didn't. I also visited the site of the La Plata, Md., F4 tornado back in 2002, and wrote about what happened there—whole houses swept off their foundations, exploding roofs, chimney failures. Back then, those seemed like freak storms. Now, they feel like early warnings of what was to come.

We have entered a new age of weather extremes, at least part of it human induced. That's simply a scientific fact. This year's double whammy of Hurricane Harvey and Hurricane Irma was supercharged by higher-than-normal ocean temperatures. And those temperatures continue to rise each year. Given this situation, how are our Southern friends and families to cope? Will South Florida, Houston, Puerto Rico, the Virgin Islands and other points south simply become unlivable?

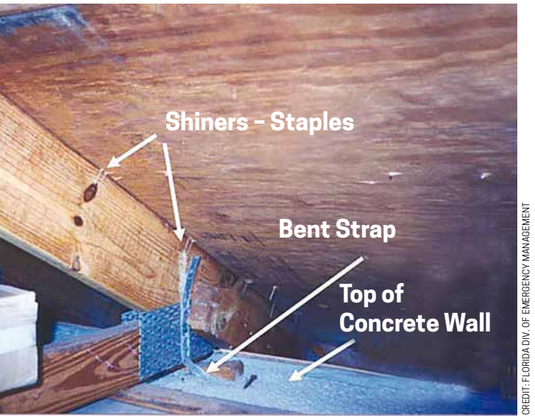
Let's hope not. But we need to take the threat seriously. Builders now have the knowledge AND the products to design and build more-resilient housing. Also, new coastal building codes have proven remarkably effective. After Hurricane Charley, FEMA found that *not one home* built to the 2001 Florida Building Code failed structurally.

FEMA also has done some first-rate research over the past decade. They have published several post-mortem reports on the aftermath of major hurricanes. Sifting through them, it becomes apparent that many aspects of modern homes and multi-family units could be further amended and fortified at a reasonable cost, particularly in the new construction phase.

A key takeaway is that both materials and process matter. If buildings are designed and assembled with extreme weather vulnerabilities in mind, they inevitably perform better when the crisis strikes.

For builders, architects and building designers, there's actually some good news buried in the post-mortem reports from FEMA: Many of the worst failures could have been prevented simply by strictly adhering to the building code.

They identified numerous "weak points" in the building process that were severely damaged by Charley. I would concur, based on personal observation of dozens of ruined homes. To keep this simple and digestible, I've pulled out nine of the most problematic building science flaws and offered solutions.



CREDIT: FLORIDA DIV. OF EMERGENCY MANAGEMENT

Weak link. This thin metal strap is not enough to hold a truss rafter to a masonry wall in a big storm.

1

Design wind loads used were too low, resulting in members and connections too weak for the winds encountered, and roof and framing damage.

THIS IS PRIMARILY A PROBLEM with older homes built before codes were improved, subject to the rigors of corrosion (see page 21]) or poor workmanship, especially in homes where two structural systems are combined. A common failure point in high winds, for example, has been the weak linkage between concrete masonry walls and engineered truss roof systems. As Florida's Division of Emergency Management notes, "the vast majority" of older CMU homes simply had a 2 x 8 plate attached to the top of the block, often with only a few widely spaced anchors. Rafters were then toenailed to this face plate. For new and retrofits, this plate must be attached by embedding anchor bolts of a half-inch or larger diameter, spaced no more than 48 inches. The bolt must be installed within a couple of inches of the end of any plate. Also, washers and nuts must fit without gouging out the wood. I would recommend stainless steel anchors (see item No. 6).

2

Degradation of building elements and connections due to material deterioration, insect infestation or lack of proper preventive maintenance resulted in premature building and envelope system failure.

I WOULD CLASSIFY THIS AS THE NO. 1 ISSUE of concern in hurricane-threatened regions. The *Insurance Journal* notes that the age of a home has a direct correspondence to the level of damage inflicted by a hurricane. Homes in Florida built between 1994 and the 2001 code upgrade, for example suffered much more than newer homes. But homes built prior to 1994 fared even more poorly. Hurricane Andrew in 1992 destroyed 125,000 Florida homes.

An important consideration for the future is the intermixing of new and older homes. A 30-year-old property can literally blow to pieces in a storm, and all of its components, such as roof tiles, 2 x 4s and plywood, become airborne projectiles. And that's not even considering the force of a home carried off of its foundation by storm surge flooding. Some areas of Florida are designated as a windborne debris region, where new homes requiring impact glass and other features (see page 25).

Age matters. Older building materials and systems perform much more poorly in high wind than new products built to better codes.

The best defense is to build the home as we've suggested here, with corrosion-resistant materials, sufficient high-quality fasteners and straps, with the goal to make future homes much more able to maintain their hurricane resistance than their predecessors.

CREDIT: FEMA

Frame failure. If fasteners are inadequate, sliding glass doors can be blown completely out of their jambs.

3

Structural design that did not account for unprotected glazing, leading to structural failures due to increased internal pressures.

GLAZINGS IN LARGER WINDOWS have been known to blow completely out of their frames, even if the glazing is laminated or otherwise protected. This negates the advantages of impact glass or applied impact window films. However, the solution may be simple: Increase the number of fasteners holding the frame in place. It's too easy to cut corners and apply fewer fasteners than recommended by the manufacturer.

4

Corrosion of anchors or connectors that attach the building to the foundations or tie structural elements together resulted in structural collapse in some instances.

AGAIN, THIS IS a relatively easy issue to address. Assume the worst, when it comes to corrosion. Keep in mind that most concrete at the top of a concrete slab or foundation wall can only dry to about the same level of moisture as the ambient air. So in the Southeast, it will remain wetter than out west. Also, if the concrete was installed without vapor barriers underneath it, its moisture level will follow the ups and downs of the adjacent soil. Metal fasteners will be constantly exposed.

Fortunately, corrosion-resistant versions of foundation anchors are now widely available. For example, Simpson sells 25 stainless steel, half-inch concrete anchors (5-½-inch length) for about $70. That's about twice the cost of galvanized versions, but your clients will probably understand why it's important. Be sure to have an engineer recommend the best size/thickness.

Made to last. Stainless concrete anchors like this one from Simpson Strong-Tie mitigate the problem of corrosion at a home's base.

Danger zone. Rusty anchor bolts of mild steel are almost inevitable in damp soils, and frequently fail under stress.

5

Corrosion of ties or fasteners used to attach siding to the wall structure led to loss of wall cladding and water intrusion.

THIS MAY BE one of the easiest resiliency improvements: upgrading to a better-quality sheathing fastener. The corrosion of fasteners has been heavily researched. We know that galvanized fasteners hold up better than mild steel, and the treated wood accelerates fastener corrosion. But we have to be realistic: Most builders today use nailguns, not hammers, to attach sheathing and roof decking. Fortunately, you can find plenty of corrosion-resistant products, such as type 316 stainless steel fasteners. Here's one online source: **http://bit.ly/2iHpvJ0**

Incidentally, the increasingly popular Huber *Zip System R-Sheathing* can be used in coastal zones where basic wind speed is 100 mph, but must be designed by a professional as a shear wall. I would also recommend selecting a siding system with good impact resistance, such as LP SmartSide engineered lumber, solid-sawn wood or some brands of fiber cement. FEMA's analysis **(http://bit.ly/2icj9y9)** of post-Katrina damage found that homes with the siding through-nailed directly into wood studs performed best, and that nailing should not exceed a 24-inch gap.

Metal matters. Research (**http://bit.ly/2icPjti**) has shown that traditional mild steel fasteners can corrode quite rapidly in wood. This test include a one-year field exposure of nails in a) treated wood, b) untreated wood, c) galvanized in treated wood and d) galvanized in untreated wood.

CREDIT: ELSEVIER/CORROSION SCIENCE

Impact imperfect. Storm shutters can save windows where impact glass may fail, such as in coastal zones.

6

Unprotected glazing led to interior damage from wind and wind-driven rain.

PRESSURIZATION OF HOMES can literally blow the top off a structure. Impact glass tends to meet building code, but it's expensive and not always optimal. My recommendation would be to install impact glass even in high-risk areas such as Florida—whether code mandated or not—but use shutters in the coastal zone. Sure, the glass can slow depressurization. But multiple strikes by debris could compromise it, leading to failure. FEMA can offer examples of storm-shuttered houses that survived Category 4 destruction, located right next to unshuttered ones that did not.

CREDIT: NATIONAL GUARD

Preparing for the worst. Changing weather patterns are making scenes like this Hurricane Harvey-related one all-too-common nationwide. They're also a signal flare for builders, who need to prepare even more for natural disasters.

7

Improper elevation of habitable space and utilities relative to flood risks resulted in structural and contents damage.

ELEVATED HOMES TEND to survive flooding much better than those on low-lying foundations. Flood vents in elevated reinforced block or monolithic foundations can save a home, if flood levels adhere to "normal" levels. But let's assume future storm surges WILL exceed current height estimates—and focus on the use of pilings.

After Hurricane Fran in 1996, FEMA conducted a study of what happened to stilt homes. The agency found that:

"A significant reduction in building losses was observed in similarly sized oceanfront buildings constructed after the North Carolina Building Code was amended in 1986 to require a minimum embedment to 5 feet National Geodetic Vertical Datum (NGVD), or 16 feet below the original ground elevation, whichever is shallower, for pilings near the ocean."

Bottom line: The depth is key. It should be noted, however, that pilings do not guarantee an unscathed structure after a storm:

"A study of Topsail Island found that 98 percent of post-1986 oceanfront houses (200 of 205) remained after the hurricane. Ninety-two percent of the total displayed no significant damage to the integrity of the piling foundation. However, 5 percent were found to have leaning."

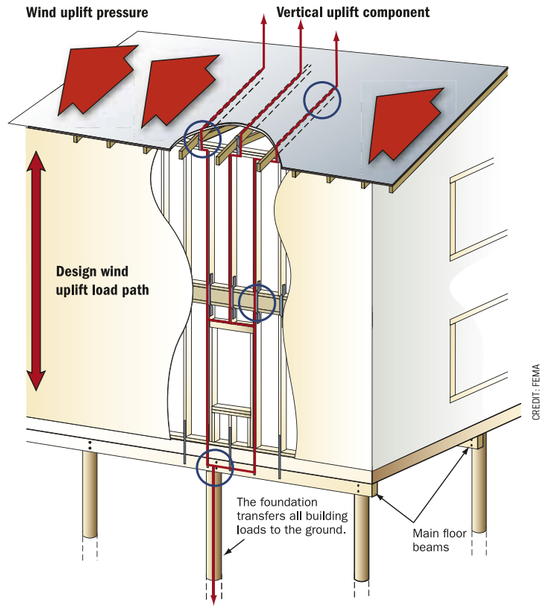
FEMA tested the leaning buildings to find out what happened. They discovered that among the leaning buildings, "none of the leaning pilings tested met the required piling embedment standard. Many were much shorter."

In other words, the contractors failed. Out of this research, the suggestion was made that pilings be embedded to a minimum depth of 10 feet NGVD, without exception.

8

Small or missing strapping to anchor the roof structure to the walls led to roof framing damage.

AGAIN, THIS PROBLEM applies primarily to older homes. But it's also an important reminder to contractors to check the workmanship of their framing crews. There's no room for skipping rafter straps to save time. Strap size and types should be evaluated with each new building design. Simpson Strong-Tie makes about 20 different types of straps, each designed for a certain uplift. Don't guess. Download the company's *High-Wind-Resistant Construction Application Guide* **(http://bit.ly/1r4DKa0)**, and make sure the straps you specify are right for worst-case wind uplift.



CREDIT: FEMA

Tied down. An integrated, consistent system of fasteners and tie-downs is arguably the best defense to keep the roof on a home in hurricane-force winds.

(Not quite) rock solid. Hurricanes can be just as dangerous as earthquakes if a masonry-supported house lacks proper reinforcement from a product such as rebar.

9

Unreinforced masonry walls lacked a continuous load path, resulting in wall damage and failure.

IT'S WELL KNOWN that unreinforced masonry can be extremely dangerous in an earthquake. But recent experience shows it also can't be trusted in hurricane winds, not to mention flood surges. The simplest takeaway for builders is: *Don't build masonry homes without rebar and other reinforcement, under ANY circumstances.* I would apply this rule of thumb even to homes that do not specifically lie in high-wind zones. Any home in Florida, frankly, should be built reinforced. Retrofitting existing buildings with reinforcement is also possible, but obviously quite costly and difficult.

And simply reinforcing the wall itself is not enough to head off cataclysmic damage from a storm. Other systems—windows, shutters, top plates—must be considered as well.

AREAS OF CONCERN

Here are a few other parts of existing homes that have been found to be especially vulnerable during hurricanes:

Vanishing soffits.

Unless they are special, hurricane-resistant types, they are often blown away, allowing water to enter buildings.

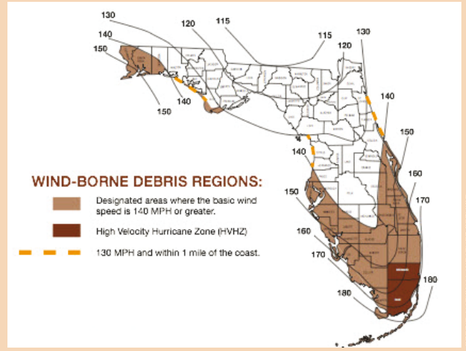
Flying vents.

Rooftop-mounted equipment can be blown off roofs or severely damaged.

CREDIT: CLOPAV

Crumpled garage doors.

Unreinforced doors can be penetrated and blown out or simply blown in. Either can cause significant structural damage to the garages.



CREDIT: NATIONAL WEATHER SERVICE

Airborne carports.

These, along with other accessory structures such as pool houses or screened lanais attached to manufactured homes are frequently blown off, creating additional debris.

A New Reality

Resilient Product Showcase

New products and systems that address flooding and wind provide ready-made solutions to design and engineering challenges.

BY GREEN BUILDER STAFF

CREDIT: GENEST/COMFORT BLOCK

Comfort Block

ONE OF THE MORE EXCITING product innovations at Greenbuild in Boston this fall was this concrete block wall system, designed by a couple of guys from Sanford, Maine. The *Comfort Block* masonry system is unique in several ways. First, it's assembled using a high-tech adhesive, not traditional mortar. Second, it shields the rigid foam insulation inside dual layers of concrete. The finished walls are 16 inches thick, R-30. But what builders may like most is that the system can be finished on the outside with a simple latex-based coating, with no drainage layer, no house wrap and no sheathing required. The same is true on the interior. You can apply plaster directly to the face of the concrete. Clever use of narrow chambers provides chase area for electrical and supply-side piping.

Tabuchi Electric *Solar* + Storage

UTILITY RULES IN MANY STATES dictate that solar inverters automatically shut down and stop backfeeding power to the grid. This has been a source of frustration to many solar owners system: in an outage, even on a sunny day, they can't use their systems. Tabuchi Electric, an innovative Japanese company, has solved the issue with a smarter inverter that redirects solar power to a small battery bank, essentially acting as an emergency generator. We especially like the fact that this solution precludes the need for a combustion-powered backup generator, so it's a "win-win" for sustainability. As this article is being written, the company is installing hundreds of units in Puerto Rico. A Tabuchi Electric system will be displayed in our Flex House project at the Consumer Electronics Show (CES) in Las Vegas in January.

CREDIT: TABUCHI AMERICA

extremegreen Wallboard

THIS INNOVATIVE WALLBOARD defies easy categorization. It's made with magnesium oxide with no organic fillers or resins, and comes in quarter-inch, half-inch and ⅝-inch thicknesses. The company also sells tile backer and other products of the same material.

We talked with extremegreen CEO Sam Catling at Greenbuild. He says the product is currently imported from China. GB: "Do you have plans to open a U.S. manufacturing plant?" Catling: "No comment." We're hoping that means we'll one day see U.S.-made versions of this product, which has a Class A1 fire rating, with zero flame spread and zero smoke developed rating.

After a flooding event, Catling says the product can just be washed off with a mild bleach solution and will continue to perform. Perhaps the best feature, however, is that the wallboard can be used in place of interior drywall. Seams would still need to be taped, of course, and this might require some clever product choices to keep up with the wall's strong performance in the face of mold, water and fire.

Another perk is that fixtures, art and other heavy objects can be hung directly from this material, without blocking. The product is more suited to nailing than screws when attaching to studs.

CREDIT: EXTREMEGREEN

CREDIT: 3M

3M Impact-Resistant Window Film

AS THE LAST HURRICANE SEASON demonstrated, it's not only homes in high-risk zones that can be damaged by hurricanes. One of the most-common causes of major damage to homes old and new is penetration, followed by "blowout." This can happen through a soffit, a vulnerable door or window. Like more expensive impact glass, impact film will not necessarily prevent all damage to a home in a major blow. But as an affordable—and surprisingly effective—method to strengthen glass, it could certainly be used as a retrofit glazing reinforcement for homes a little further from the coast, yet still at risk. The risks of airborne debris in older neighborhoods are very high. Impact film could mean the difference between a total loss, and a little water damage.

RESILIENT PRODUCT SHOWCASE
continued on page 26

continued from page 25

VersaDry Track System

NO HIGH-TECH BELLS AND WHISTLES here, just old-fashioned engineering. This system solves one of the most common problems with below-grade basement remodeling—mold and mildew growth at the base of drywall after even the mildest flooding.

The galvanized tracks simply create a space at floor level to keep drywall out of harm's way. And of course, they could also be used with other types of water-resistant sheeting, such as recycled plastic and magnesium oxide (see extremegreen, above).

VersaDry is available to accommodate drywall sizes up to ⅝ inches thick, and in a double-sided wall version. The wall can thus still achieve up to a two-hour fire rating. It offers numerous options for LEED v4 credits, including Eqp2—Enhanced Indoor Air Quality Strategies.

CREDIT: VERSADRY

CREDIT: CLOPAY

Clopay *WindCode* Garage Doors

WHEN HURRICANES THREATEN, one way to reinforce garage doors is to insert posts behind the door until after the storm has passed. But Clopay has developed some doors specifically with high winds and flying debris in mind. The company's *WindCode* line of garage doors are tested under ASTM E330 for uniform static air pressure. Doors are assigned to specific homes in different regions, based on the response to several questions. Clopay assigns a *WindCode* "W" rating to their doors, based on code requirements determined by wind speed in miles per hour (MPH), home exposure and home structural type. W1, for example is good for winds up to 85 mph, while W7 can handle 150 mph winds.

RESOURCES

- *Comfort Block*
  www.genest-concrete.com
- Tabuchi Electric *Solar* + Storage
  www.tabuchiamerica.com
- 3M Impact-Resistant Window Film
  http://bit.ly/2zLRefW
- extremegreen Wallboard
  www.extremegreenbp.com
- VersaDry Track System
  www.versadryllc.com
- Clopay *WindCode* Garage Doors
  http://bit.ly/2icanAq

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Survival and Sustainability

Here's what it took for homes to withstand storms and other disasters during last fall's hurricane season.

BY JOSHUA GASSMAN

THE 2017 ATLANTIC HURRICANE SEASON has drawn to a close, but we still remember related names—Harvey, Irma, Maria—which are now synonymous with devastation that upended millions of people's lives. It will take years of work and untold resources to ameliorate the damage. Additionally, memories still linger of Katrina, Hugo and Andrew from previous years. Increasing development in coastal cities combined with sea level rise make natural disaster mitigation and management ever more urgent.

It is no longer enough for architects to merely reduce the negative environmental impacts of building. We must begin to ask, "What does it take for our projects to survive the storm?" and more importantly, "How can the built environment contribute to the greater good after a disaster?"

The first step is designing projects that don't just survive storms but provide critical shelter and services in their wake. We must create buildings that are *passively survivable*. The concept of *Passive Survivability* was introduced by *Environmental Building News* (now *Building Green*) in a December 2005 article published shortly after Katrina struck the Gulf Coast.

The concept posits that buildings should be designed to meet some basic needs of occupants, such as light, drinking water and ventilation in the face of disaster-induced utility interruptions. At one point, more than 90 percent of the island of Puerto Rico was without power due to Hurricane Maria. Imagine what might have happened with a few construction modifications.

SERVICE WITH STYLE

Designers must find ways to make structures more habitable in the face of such interruptions. Many of the planning and design strategies that can make buildings passively survivable have been around for a long time, but we have ceased to incorporate them as we increasingly rely on air conditioning, artificial lighting and other active systems for human comfort.

CREDIT: JONATHAN HILLYER PHOTOGRAPHY

Flow on the go. Grand Bay Discovery Center's 12-foot-high trusses allow flood waters to move below unimpeded, reducing impact on the natural hydrology.

These strategies can include design for extensive daylighting to reduce the need for artificial lighting, operable windows to allow for natural ventilation, passive solar design to allow (or avoid) solar gain based on location and climate, orienting the building to take advantage of prevailing breezes—especially in coastal areas—and, finally, not building in flood-prone locations (while this may seem obvious, flooding in Houston after Harvey and in New Orleans after Katrina were exacerbated greatly due to building in low-lying areas).

One example that implemented many of these strategies is the Blue Ridge Parkway Visitor Center, located just outside of Asheville, N.C. In the Asheville climate, daylighting and natural ventilation are keys to creating a comfortable building in summer, but the winter conditions required a more complete passive solution.

As a result of climate analysis coupled with a study of the vernacular architecture of western North Carolina, the team designed a series of Trombe walls along the south façade to passively heat the building. A Trombe wall is a high-mass wall (typically concrete or stone) with a glass wall in front of it, creating an air space. The sun heats this gap like a greenhouse, and this energy is then transferred to the inside of the building through the mass wall, via venting, or both.

This strategy, in conjunction with others mentioned, yielded a building with energy performance nearly 80 percent better than a code-compliant building, while passively providing heat for an indefinite period of time without the use of any fossil fuels or power.

CREDIT: JLORD AECK SARGENT IN COLLABRATION WITH THE MILLER HULL PARTNERSHIP

Disaster safeguard. When construction is completed, Georgia Tech's Kendeda Building for Innovative Sustainable Design will include emergency potable water collection services, a backup battery system if the solar array is damaged, and an edible landscape in case of urgent food needs.

ADAPTIVE DESIGN

While passive survivability is increasingly relevant, we need to add more deliberate intent and action to the thought process to be truly holistic and helpful. Enter the idea of *Resilient Design:* "The capacity to adapt to changing conditions, and to maintain or regain functionality and vitality in the face of stress or disturbance. It is the capacity to bounce back after a disturbance or interruption."

At the Grand Bay Discovery Center in Moss Point, Miss., many passive survivability strategies come together to deliver a resilient project able to bounce back after interruptions in a remote, storm-prone region subject to frequent, extended power outages.

A marine research and education center, the project takes advantage of passive survivability strategies and creates resiliency for its occupants. It is elevated 12 feet on trusses that allow flood waters to move below unimpeded, reducing impact on the natural hydrology. The windows are hurricane impact resistant and oriented to optimize daylighting and reduce solar heat gain, as well as being operable with insect screens to allow for natural cross ventilation.

A research porch was designed to function in the event of a long disruption. Screened-in with large overhangs and emergency power for research refrigerators, the building helps prevent interruption of critical research activities. A large, elevated exterior gathering space can function as a classroom and public gathering space should the need arise. Providing living quarters for visiting scientists, the building can serve a safe harbor for those working or visiting. An off-grid toilet system was designed to use collected rainwater for flushing and treats all water on site with a biofiltration system for infiltration back into the ground.

BUILDING RESILIENCE

Grand Bay does create a community resource, but its impact is limited due to its remote location. Having greater social impact and serving non-direct occupants of the building can help create more-resilient communities—especially if these projects are in urban areas. Resilient projects can become refuge and community gathering spaces in the event of disasters, potentially exporting needed energy, water or other resources.

The Kendeda Building for Innovative Sustainable Design, currently in design in the heart of Atlanta on Georgia Tech's campus, is incorporating community resilience considerations in its design. Seeking full Living Building Certification, the project builds on passive survivability concepts to become nearly self-sufficient.

In addition to incorporating many of the passive design strategies highlighted previously, this project includes collection and provision of potable water, potentially offering a life-saving resource if the city source should go down. Power generation via solar panels will generate 105 percent of the project's projected power use, as well as a battery system for use at night or if the photovoltaic array is damaged.

The Kendeda Building also offers a possible food source in its edible landscape, which is fully accessible to the public. All of these features allow the building to survive, but more importantly, allow the community to recover more quickly in the event of disaster.

As we consider the future of survival and sustainability, let's continue to think of buildings as an opportunity to impact more than just that building's occupants. Buildings can give back in terms of environmental impact upon construction and resource use, but also withstand storms and other disruptions, and can provide shelter and safe harbor within their communities. **GB**

Joshua Gassman is a senior associate at Lord Aeck Sargent (http://lordaecksargent.com), with more than 15 years of experience in sustainable design and project management. He is a LEED-accredited professional and NCARB certificate holder, serves the AIA Atlanta Chapter on the Committee on the Environment and is a member of the Georgia Solar Energy Society.

Pillars of Society

Efforts like RMI's Islands Energy Program can turn nature's fury into tomorrow's powerhouse.

BY CHRISTOPHER BURGESS, STEPHEN DOIG AND JUSTIN LOCKE

MAJOR STORMS TAKE TERRIBLE personal and societal tolls on the small economies of the Caribbean, setting these countries back decades overnight. For example, Hurricane Ivan cost Grenada $900 million in 2004, more than twice the country's GDP. Last fall, Hurricane Irma caused an estimated $10 billion in damages to Barbuda, the British Virgin Islands, St. Bart's, Anguilla, Puerto Rico, Cuba, the Dominican Republic, Turks and Caicos, the Bahamas and the U.S. Virgin Islands, and overall economic losses could be tenfold higher.

Equally important, these disaster events highlight how vulnerable Caribbean countries are to disruption. Nowhere is this more evident than in their electricity grids, which are exposed, centralized and powered by fossil fuels. If a storm shuts down an island's power plant, the entire island goes dark. Damage to vulnerable seaports also cuts off the delivery of desperately needed fuel. And the many miles of power lines are highly vulnerable and expensive to rebuild.

Rebuilding for Resilience

The crucial first response to this latest disaster, of course, is tackling the humanitarian crisis. That means bringing in water, food and other essential supplies; ensuring the safety of residents; reestablishing basic services; and helping businesses get back on their feet. But even as we rally to help the region now, there is an opportunity to rebuild better, cleaner and stronger. Instead of reconstructing the existing 20th-century electricity grid, we can leapfrog ahead with 21st-century technologies that make the Caribbean far less vulnerable to future storms.

The key step is replacing or retrofitting the centralized electricity grid with decentralized resilient renewable power, combined with energy efficiency measures. This will bring many benefits. Thanks to plunging costs for solar, wind and battery storage, small distributed renewable energy systems and increased efficiency actually would lower the electricity costs on the islands, which now are some of the highest in the world at 20 to 50 cents/kWh.

They also would reduce the countries' vulnerability to major storms, because some individual microgrids are likely to continue functioning even if the grid or other microgrids are knocked out. Remarkably, the solar installation that powers the majority of Sir Richard Branson's Necker Island survived the brunt of Irma. And reports from Fortis TCI, the utility on Turks and Caicos, confirm the uninterrupted operation of its solar assets on the island of Providenciales after Irma whipped over 155 mph winds through the popular British Overseas Territory.

The islands are not the only places that decentralized, resilient and renewable grids are being targeted. In the U.S., the National Electrical Manufacturers Association (NEMA) envisions that a resilient and robust utility infrastructure of the future can be built out of interconnected microgrids at universities, hospitals, industrial parks and neighborhoods. Individual microgrids would be nominally connected to form a single utility grid, but could also isolate from the grid and operate independently in case of disruptions.

In addition to resiliency, renewables would insulate the islands from spikes in fossil fuel prices, which along with hurricanes have shocked the region's economies and put significant burdens on one of the most economically challenged parts of the world. More importantly, they would reduce dependence on fossil fuel imports, keeping millions of dollars at home instead of shipping them off island to buy foreign fuel—while also making it possible to slash those imports far more by switching to an electrified transportation system.

Seizing this opportunity to rebuild smarter would be eminently worth doing, even in a world without climate change. But with the certainty of rising seas and stronger and more-frequent storms, the task becomes even more vital. It offers the Caribbean islands their very best hope for surviving the next challenges while also cutting costs, boosting their economies and improving the entire region's competitiveness.

"Seizing this opportunity to rebuild smarter would be eminently worth doing, even in a world without climate change. But with the certainty of rising seas and stronger and more-frequent storms, the task becomes even more vital."

Pillars of Transformation

The approach to transforming the Caribbean builds on our experience from running the Islands Energy Program with the Clinton Climate Initiative (CCI) over the past few years. Specifically, the approach consists of three mutually reinforcing components.

The first step is rapid-integrated resource planning, a whole-systems approach that will create an integrated plan for the energy and transportation sector that reduces costs, catalyzes private-sector investment, improves reliability, increases resiliency (to extreme weather events and other disasters) and reduces emissions (ideally to net zero). The plan identifies the optimal projects for transforming the energy sector with high levels of renewable energy and energy efficiency and converting the transportation sector to electric vehicles. This process includes:

- Aligning stakeholders on a shared vision of what they want their society to look like;
- Forecasting the change in electricity demand and determining the need for new resources to meet that demand;
- Identifying the available resources such as solar, wind, hydro, biomass, geothermal, waste-to-energy (WTE), diesel and natural gas;
- Analyzing combinations of energy efficiency and centralized and distributed energy generation options and their impacts on the existing grid, along with their costs;
- Identifying existing vulnerabilities in the grid (from disasters, overloads or other issues), and the opportunities to strengthen the grid.

CREDIT: UK DEPARTMENT OF INTERNATIONAL DEVELOPMENT

Wipeout. Scenes like this on the Caribbean island of Jost Van Dyke northwest of Tortola were all too common following Hurricane Irma's passage in September 2017.

The second step is project identification and resilient development. Once the planning process identifies the possible investment projects, the next phase of the effort focuses on increasing the investment opportunity in targeted Caribbean islands by creating more-detailed plans and reducing the overall risks. The process includes:

- Identifying the mix of resources that will meet a specific island country's needs at least cost and determining the best place to install those resources;
- Performing a detailed financial and economic analysis;
- Preparing the sites for development and commercialization.

The third step is project financing and construction. Once resilient, renewable projects are developed and considered investment ready, affected countries need support in mobilizing concessionary and grant financing and private sector capital to turn those proposed projects into steel in the ground. They also need support in supervising construction to ensure safety and building standards are met. This support includes:

- Determining the right financial structures such as power purchase agreements (PPAs); build, own, operate, transfer (BOOT); public-private partnerships (PPPs); or typical capital improvement loans;
- Supporting the contract negotiation process;
- Supervising construction to ensure that best practices and safety standards are implemented;
- Commissioning the system with the local island utility, the contractor and a third-party engineer.

The efforts in all three components are mutually reinforcing. The rapid integrated resource planning work identifies optimal climate resilient projects to pursue. Project derisking ensures high quality and attractive investment-ready projects. Meanwhile, project financing and construction oversight support ensures the rapid quality deployment of these projects—enabling beneficiaries to see the myriad benefits, including lower costs and increased reliability and resiliency.

This, in turn, reinforces the value of the integrated plan and the iterative process continues. Moving forward with this process yields faster, higher-quality and lower-cost projects, making it possible to accelerate the transition to a stronger, cleaner, more sustainable future. **GB**

The Rocky Mountain Institute (RMI) engages businesses, communities, institutions and entrepreneurs to accelerate adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. Christopher Burgess is director of projects for RMI's Islands Energy Program (IEP). Justin Locke is the IEP's director. Stephen Doig is RMI's managing director.

CREDIT: TEXAS NATIONAL GUARD

Positive flow. Strange as it may seem, the Houston floods were not as bad as past years—at least, not in Caroline Kostak's neighborhood.

Thoughts From Ground Zero

Ten ways to make your home more resilient to disaster.

BY CAROLINE KOSTAK

After spending significant time last fall tearing out wet drywall and insulation in Houston, I have some thoughts on building homes with an eye toward resiliency:

1. Build homes higher. Elevate homes that are within the 500-year-flood plain, or at least the 100-year. The difference in our neighborhood between the elevated house, such as ours, and the non-elevated houses was "no problem" vs. "total loss." Some of this may be covered in local codes, but it is no joke—it's the best thing you can do to protect your home.

2. Find better drywall. There has got to be some material better for the bottom three feet of a house than drywall. Maybe beadboard or some other wood-based material? Just put it up a few feet, and then drywall to your heart's content. Or switch to a wallboard product like the one on page 25.

3. Rethink insulation for flood-prone areas. Both blown-in cellulose and fiberglass insulation get wet inside walls and are hard to dry out…Could these and other insulation systems be modified for flood zones, so that with removal of wallboard, they could be dried more efficiently?

4. Build escape hatches into attics. I'm not kidding. If it's a vented attic, make the vent removable. If it's an unvented attic, build in a removable door, especially in one-story homes. Or at least have an axe holder on the wall or ceiling, and include the axe.

5. Make pavers and driveways permeable. This would greatly increase a site's ability to absorb water. We've paved over a significant portion of the west side of Houston, and I think it's not a coincidence that we've had three major flood events since. What was prairie is now neighborhood. All that stormwater runs off into the Houston bayous, which flood Houston.

6. Expect more floods. Thank God for first responders and boats.

Washout. Hurricane Harvey's hammering of Houston left many residents' homes under water, and has builders wondering how to keep it from happening again.

Of course, if we take the above steps, there's also some psychology we need to employ:

1. Have less stuff. The people with the greatest need are the hoarders (or whatever nicer term you want to use for people with a lot of stuff). A house volumetrically full of stuff is WAY harder to clean up than a house with a reasonable amount of stuff. And it turns out there are a LOT of people with a LOT of stuff. Even nice people, like your friends.

2. Be educated ahead of time about what to do in case of a flood. Floods are going to be a reality for a lot of people in the coming years. Why not prepare ahead of time? Know what FEMA and your flood insurance policy recommend: Should we sort materials on the curb? How high up should we cut the drywall? These things are easy to figure out ahead of time, and save a lot of consternation and phone calls to your insurance agent in an emergency. They can also keep you from doing things wrong while in emergency mode.

3. Don't panic. It creates more waste. They're not thinking about things through clearly. They're throwing out some perfectly fine things—stuff that just needs some cleaning—simply because they got wet and people can't handle the emotional trauma of having wet stuff around them. This is becoming an opportunity to have your neighbors and friends clean out the craft drawers you haven't touched for years, even if they didn't get wet. Solid wood furniture isn't ruined if it gets wet.

4. Become resilient people. Be prepared to handle things when things go wrong (i.e., learn how to not freak out when things go wrong). Life throws us challenges sometimes. If we crumble, we won't be able to help ourselves or those around us. Toughness is a requirement in life, not an option.

Surviving this has been another amazing experience. Neighbors and friends coming together to help recovery; people from all over the country donating materials and money to get other people back on their feet…

Unfortunately, I said "another." Hurricane Ike was similar, except our neighborhood had far more damage. Really, despite having kayaked through the streets, there are not huge amounts of trash on the curb this time. After Ike, most of the houses in our neighborhood were raised if they weren't already elevated (anything built after 1977 had to be built on stilts). I think that made a huge difference. And maybe, just maybe, people learned the lesson from Ike that they shouldn't have so much stuff under their house.

And actually, I ask myself: Why wasn't the damage worse? I know there were a lot of displaced people. And I know there are a LOT of damaged houses. And there were some people who unfortunately perished in the water. But a lot of people didn't have damage, and a lot of people didn't drown. Why not?

If this happened in some other country, or maybe in another city, I think things could have been way worse. Fifty inches of rain is a LOT. I believe that the infrastructure improvements that we've made in the last eight years have significantly improved Houston's drainage. The bayou and reservoir systems work pretty well. Some improvements can be made, of course—especially in helping inland bayous drain toward the Gulf—but really it handled a huge test fairly well. There are a lot of people who do not have damage. **GB**

Caroline Kostak is a green building consultant with GreenHouse Integration LLC (www.greenhouseintegration.us) in Clear Lake Shores, Texas, and owner of RePurpose Depot (www.repurposedepot.org). She also chairs the U.S. Green Building Council's Green Homes and Green Schools committees.

Staying Power

Mother Nature is no match for this highly insulated home.

BY GREEN BUILDER STAFF

WHEN A RARE TORNADO touched down on Johns Island off the coast of South Carolina, all of the homes in its path sustained considerable damage except for one—a two-story, 3,756-square-foot custom home built by Insulsteel of South Carolina, LLC.

Insulsteel's founders, Tina and Steve Bostic of Charleston, S.C., constructed the home using their "EcoShell Building Enclosure" design with structural insulated panels (SIPs). This resulted in a draft-free, highly insulated structure so sturdy that it can reportedly withstand 200-mph winds. The home, built to the criteria of the U.S. Department of Energy's Zero Energy Ready Home (ZERH) program, was recognized by DOE with a 2016 Housing Innovation Award.

ZERH requires that every home be certified through Energy Star Certified Homes Version 3.0 and the U.S. Environmental Protection Agency's Indoor airPLUS program. Homes must meet the hot water distribution requirements of the EPA's WaterSense program and the insulation requirements of the 2012 International Energy Conservation Code.

In addition, the homes are required to have solar electric panels installed or have the conduit and electrical panel space in place for future photovoltaic panel installation. Insulsteel installed 6.8 kW of photovoltaic solar panels and solar thermal water heating panels on the roof of the 2016 home.

With these renewable energy features, the home achieved a Home Energy Rating System (HERS) score of 12. Energy costs were an estimated $643 per year or about $54 per month. Even without the solar PV and water heating, the home achieves a HERS score of 50; most code-built homes in the United States would score between 80 and 100.

CREDIT: INSULSTEEL OF SOUTH CAROLINA, LLC

A hard case to crack. Walls are constructed with 8-¾-inch-thick insulated R-33 panels of magnesium oxide (MgO) sides and a rigid foam core. Their durability is evidenced here by the minimal damage sustained during the storm.

MAGNESIUM OXIDE SIPS' MANTRA

To achieve this high level of performance, Bostic chose magnesium oxide (MgO) SIPs to construct the walls and roof deck. The panels consist of two 12-millimeter-thick layers of magnesium oxide sandwiching an 8-inch layer of expanded polystyrene (EPS) for an R-value of 33. The Bostics found that MgO panels have a superior fire rating to OSB or fiber cement panels, are highly resistant to moisture absorption, and do not support mold growth.

The SIP walls were covered on the inside with drywall and on the outside with house wrap and fiber cement cladding. The roof panels were covered with 30-pound felt and standing-seam metal roofing in a white color to minimize solar heat gain. The SIP roof panels provide cathedral ceilings and insulated attics with increased fire and storm resistance, as there are no soffit vents to provide entry for sparks or wind-driven rain.

Due to the coastal, hurricane-prone location, the builders used an elevated concrete block foundation as required by local code. The concrete walls were constructed with smart vents that allow water to flow through in the event of flooding. The first floor was insulated with 3 inches (R-19) of closed-cell spray foam that was sprayed on the underside of the subfloor to insulate and provide comprehensive air sealing protection from the garage below.

AN AIRTIGHT CASE

The SIP solid panel construction minimizes the opportunities for air leakage. The thick beads of construction adhesive used to glue the panels together and to the top and bottom plates also serve as

CREDIT: INSULSTEEL OF SOUTH CAROLINA, LLC

Built to last. Energy efficiency enhancements to the 3,700-square-foot Sonny Boy Lane House on Johns Island, S.C., save about $4,000 per year and an estimated $167,000 over a 30-year mortgage.

CREDIT: INSULSTEEL OF SOUTH CAROLINA, LLC

Weather warrior. The structurally fortress-like Amerisips home (center) on Sonny Boy Lane came away mostly unscathed from the tornado that hit Johns Island—unlike its unfortunate neighbors.

an air sealant. Roof panel seams were taped. Subfloor seams were caulked. Flashing was installed around all doors and windows. These air-sealing measures helped to provide for an airtight home.

The home was heated and cooled with an air-to-water heat pump. The system uses a variable-speed compressor that can adjust speed based on temperature and heating loads for greater efficiency. The heat pump pulls heat from or sheds heat to the outside air via a refrigerant loop that circulates refrigerant from the outside compressor to a hydrobox located in the conditioned attic. The hydrobox heats or cools water that circulates through coils in the air handling unit to heat or cool air blown through the unit. The base efficiency of the heat pump is an EER of 9.33 and a COP of 3.81.

The air handler distributes conditioned air throughout the home via small-diameter, high-velocity ducts. The main trunk lines for the system were located in the attic spaces, and the smaller ducts were run within the open-web floor joists between the floors. The ducts came pre-insulated at R-3.3 for branch lines and R-8 for trunk lines. All ducts were sealed with tape and mastic, or gaskets for branch lines, prior to insulating them.

For ventilation, fresh outside air is brought into the home via an outside air vent with an automatically controlled actuated damper. The outside air is brought into the return plenum of the air handler and travels through a MERV 13 filter, through an ultraviolet light filter, and across the cooling and heating coils of the air handler to be conditioned before it reaches the air supply of the home. The air handler is electronically controlled to operate with the outside air intake to meet ASHRAE 62.2 ventilation requirements, but excessive air handler run time can be minimized by choosing a setting that maximizes outdoor air damper opening periods within times when the system is operating for normal heating or cooling. Exhaust fans in the kitchen and bathrooms provide spot ventilation.

HERE'S TO SOLAR

The home's primary hot water source is a solar water heating system that uses solar thermal panels mounted on the roof to heat a water-glycol fluid, which heats an 80-gallon storage tank via a heat exchanger. The solar panel pump controller is interlocked with a supplemental solar pump for the air-to-water heat pump. When there is a temperature difference of less than 18 degrees Fahrenheit and the tank is not at maximum temperature, the solar pumps will run in unison with fractional horsepower pumps to

CREDIT: INSULSTEEL OF SOUTH CAROLINA, LLC

Let the sun shine. Solar panels are installed at the optimal angle for gathering light at this location. They have already survived a tornado without damage. The home also has two solar water heating panels.

Battling Burnout

After the California fires, how can we rebuild homes?

BY KARIN BURNS

MONTHS AFTER WILDFIRES TORE through California's North Bay in Napa and Sonoma, we are still grappling with the magnitude of loss and devastation. At least 42 people died and 8,900 structures were destroyed. Thousands of people were made homeless in a region that already had a housing shortage. At Build It Green, our staff in nearby Oakland expressed deep concern, and I'm proud that members of our team donated supplies or traveled north to assist in disaster relief efforts.

Yet in the aftermath of this tragedy, we're already seeing a resilient and resolute spirit take hold across the North Bay: People are vowing to rebuild their homes and restore their communities as quickly as possible. At the same time, an important conversation is emerging, as builders, developers and policymakers wrestle with *how* homes should be rebuilt.

I'd like to share some thoughts from Build It Green's perspective.

We need more resilient homes and communities. Resilience is defined as the ability to bounce back from challenges, and the climate change crisis has made it painfully clear that we need more resilient communities. In a hotter, drier California, heat waves, droughts, severe storms and wildfires will, unfortunately, become more common.

In the residential sector, we must strengthen the durability of newly built homes. That means revisiting building codes for flood and fire resistance, and building new homes with a keen awareness of each community's climate vulnerabilities.

CREDIT: CALIFORNIA NATIONAL GUARD/CAPT. WILLIAM MARTIN

Firestormed. Charred cars and homes covered the landscape after wildfires spread across Sonoma County, Calif., last October.

The speed of rebuilding efforts is the primary focus right now—and understandably so—as local governments look for ways to streamline permitting and construction processes. But rebuilding right doesn't necessarily need to slow down these efforts.

CREDIT: CALIFORNIA NATIONAL GUARD/CAPT. WILLIAM MARTIN

Luck of the draw. The nearly 9,000 structures destroyed in the Sonoma County wildfires included parts of this Santa Rose subdivision, where little remains of some homes, while others were virtually untouched.

Rebuild homes with health in focus. Millions of people in the greater Bay Area were exposed to dangerous air quality like never before. And after the fires, North Bay neighborhoods remain plagued by hazardous chemicals, ash and debris. Lead, asbestos and other toxins could leach into water supplies and soil. We must remember that these toxins were once inside people's homes!

At Build It Green, we are passionate believers that a green home is a healthy home. Across the North Bay, we must rebuild homes with health in focus; we must use more-sustainable and healthier materials without formaldehyde and other chemicals; we must air seal and smartly ventilate homes to keep out pollutants and minimize dust, allergens and mold. The fires taught us the destructive impact of poor outdoor air quality, and we also know that maintaining indoor air quality can have an incredible impact on health and quality of life. There are no expensive technologies required to achieve healthier homes—just smart building practices implemented by all builders and contractors.

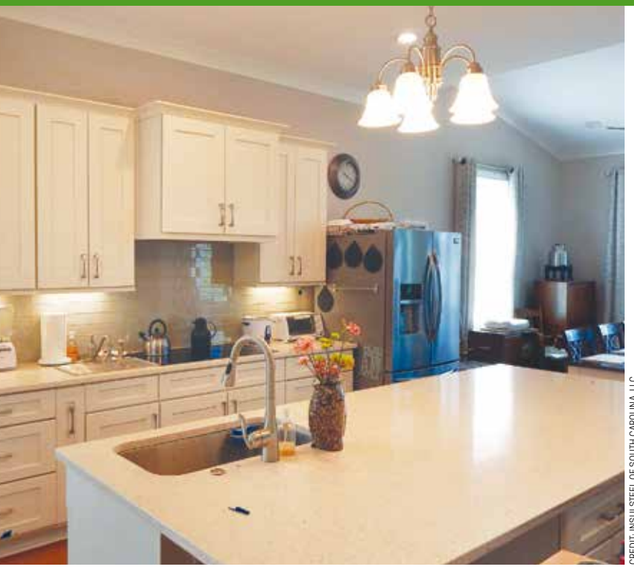
Invest in a new level of workforce development. When you realize the scale of rebuilding that must take place in the North Bay, it begs the question: Where will we find thousands of new construction professionals to swing hammers, screw in sheetrock and install HVAC systems? A dire shortage of skilled labor is looming ahead.

Existing workforce development programs must be expanded and fully funded. And, we must seize the opportunity to train and employ residents from our most disadvantaged communities, where skyrocketing housing costs have hit vulnerable people the hardest. Putting people to work with good-paying construction jobs can also help fight displacement and homelessness.

Leverage leadership. Across the North Bay, we're seeing elected officials and everyday community members step up to meet challenges that would have seemed unimaginable before October. It's also worth noting that this region—Sonoma County in particular—has long been a national green building leader. Local government staff, builders and contractors alike have helped pioneer practices and policies, and established the standards for what a green, healthy home looks like.

Now, as the region faces its greatest challenge ever, that green building leadership will pay dividends. Together, we can rebuild our communities to be healthier, more resilient and more sustainable. **GB**

Karin Burns is the executive director of Build It Green (***www.builditgreen.org***), a nonprofit with a mission to create a world of healthy and sustainable homes for all people.



CREDIT: INSULSTEEL OF SOUTH CAROLINA, LLC

Inside information. The refrigerator, dishwasher and ceiling fans are Energy Star certified. The quartz countertops are manufactured from recycled materials.

create hot water at a much better efficiency than gas, electrical or heat pump energy can produce.

The air-to-water heat pump serves as a secondary heat source for the 80-gallon tank using heat pulled from the outside air via the refrigerant loop. The tank also has an electrical element, in the unlikely event backup heat is needed.

Because the homeowners were also very interested in water collection for gardening, the builder installed roof gutters over the front of the home that route water run-off to a 1,335-gallon cistern, which is used for drip irrigation. Gutters on the back roof direct water to six rain barrels. From there, PVC pipes carry the water to backyard gardens. One more rain barrel is located below the air condenser and leads to gardens on the west side of the house. A rain garden and a French drain next to the driveway catch and disperse additional runoff.

On the roof top is 6.8 kW of solar photovoltaic panels. The 427-square-foot array is tilted at an optimal angle of 22 degrees south, and the panels operate at 96 percent efficiency. The system was set up to be grid tied; but it can also be switched to power a subpanel of critical backup circuits while lithium ion batteries provide 200 amps of standby power "off the grid" during emergencies.

STARTING OUT INSULSTEEL

The Bostics began building homes in the Charleston, S.C., area in 2011. Their desire to find a better way to build led them to MgO SIPs. After constructing two homes with MgO SIPs, including this 2016 award winner, they discovered insulated steel panels. These consist of solid panels of expanded polystyrene (EPS) with reinforcing steel C channel posts spaced at 16 inches on-center that serve as nailing surfaces for the panels, which are typically 4 feet by 12 feet and come in widths varying from 5.5 inches to 9.5 inches thick.

Because the steel strips are fused into the outer surface of the panels but do not extend through the panels, there is no thermal bridging through the panels. This means they can provide insulation values of up to R-40 to R-58. The Bostics were so certain of the product's potential that in 2015 they founded Insulsteel Building Enclosures and its parent company, Insulsteel of South Carolina, LLC, to manufacture the EPS and steel panels.

They have since designed 12 homes with the Insulsteel panels through their Amerisips Insulsteel Homes custom home construction company, including three homes that are or will be certified to ZERH specifications.

Insulsteel promotes the *EcoShell* system that is used in its own homes and can be used by other builders who buy Insulsteel panels. "We market the Insulsteel 'Free Energy Living' homebuilding process, which includes our systems, DOE and LEED certification, indoor air quality design for a healthy home indoor environment, and a homeowners' warranty program," says Steve Bostic. Insulsteel also uses its Free Energy Living mortgage estimator to show potential homebuyers how the energy savings they will reap can offset added costs to meet their monthly mortgage budget while yielding an exceptionally efficient home.

In addition to the high energy efficiency features, the system also incorporates building durability features like a design that can withstand 200-mph winds, water- and pest-resistant wall and roof panels with a two-hour fire rating, unvented attics, durable metal roofing, impact-resistant glass, elevated floors, solar water heating and solar PV that is wired with battery backup for stand-by power. All features add up to a home that can handle whatever weather hits the Southeastern seaboard, from high winds and hurricanes to coastal flooding—and even the occasional tornado. **GB**

CREDIT: INSULSTEEL OF SOUTH CAROLINA, LLC

Fluid performance. The home's primary hot water source is a solar water heating system that uses roof-mounted thermal panels to heat a water-glycol fluid. The fluid heats an 80-gallon storage tank via a heat exchanger.

The *New* New Normal

The 2017 wildfire season reshaped how we define and address the global wildfire problem. What's next?

BY LUCIAN DEATON

IN TRYING TO MAKE SENSE of the many dramatic wildfires that occurred this year, a few media outlets have described 2017 as the dawn of a "new normal" in terms of the scope and size of wildfires. While that label is open for debate, I do think 2017 was unique in revealing some important lessons and showing us the full cumulative impacts of a changing world on wildfire behavior.

The fire season kicked off in January when wildfires burned across Chile, charring entire towns and landscapes. In spring, a historically early batch of wildfires ignited in Florida and California, while grass fires burned hot and fast across Kansas and Oklahoma and near Cape Town, South Africa. This summer, 60 people died while fleeing a forest fire in Portugal; the U.S. wrestled with the costliest wildfire season on record; and large, menacing fires on the Mediterranean coasts of Europe sent tourists scurrying and made global headlines. In mid-October, one of the most destructive wildfires in U.S. history struck Northern California, killing at least 40 people and destroying thousands of homes. The year closed out with similarly destructive fires in Southern California.

CREDIT: FLICKR/GLENN BELTZ

A burning problem. Wildfires around the world in 2017 demonstrated the disastrous combined effects of increased wildland development, an aging rural population and a warming climate.

While certainly a challenge for residents and the fire service, did these events really mark a "new normal" as some would suggest, or just a more recent version of the old normal? It's a little of both. Many of the factors that made for a difficult fire season—increased development in the wildland/urban interface, an aging rural population and a warming climate—aren't new, but 2017 was perhaps the first time we clearly saw their combined effects. Taken as a whole, they have created a new fire environment that we have not prepared well for. When the three components of the wildfire triangle—fuel, topography and weather—become imbalanced, wildfire as we know it stops behaving in a roughly predictable way, and a "new normal" is the result.

The June wildfires in Portugal offer a good illustration of the potential outcome of this imbalance. While seeking answers about why the deadly wildfire in Portugal swept so quickly across the rural landscape, The *New York Times* described the problem in part like this: "hotter, drier summers are setting off more forest fires, which are accelerating a decades-old migration [among residents] from rural areas, leaving lands untended. That, in turn, helps fuel new and more-intense fires that spread and burn even faster."

The *Times* also explained that changes in land management helped fuel the flames in Portugal. Areas that were once open oak stands, farmers' fields and grazing pastures have been transformed into forest plantations of pine and eucalyptus to feed the global wood-pulp market. This new cash crop is highly combustible and is surrounded by small landowners who are often unable to properly manage fire on their own lands.

Similar changes are happening across the globe. In the U.S., rural populations are getting older, making it more difficult for some people to adequately maintain their properties against fire. Summers are getting hotter, and changes in how we use the land have put more people in places where fire has historically been an integral part of the landscape. The resulting buildup of dry overgrowth requires only a spark to become a devastating wildfire.

These shifting factors are the real "new normal." If we are to address them, fire departments, wildfire agencies and policymakers need to learn from the global wildfire experience of 2017. These lessons will help us figure out not only where wildfires might demand attention in the years to come, but what other steps we can take to mitigate their impact. **GB**

Lucian Deaton is project manager in the National Fire Protection Association (NFPA)'s Wildland Fire Operations Division. NFPA (www.nfpa.org) is a global nonprofit organization that strives to prevent death, injury, property and economic loss due to fire, electrical and related hazards.

Floods and Folly

Cities, such as Houston, must learn from natural disasters to prevent being hit even harder the next time.

BY DIANE TOOMEY

Note: This article originally appeared in *Yale Environment 360* (http://e360.yale.edu/), a publication of Yale School of Forestry & Environmental Studies and Yale University.

FOR DECADES, HOUSTON AND its surrounding region has been one of the fastest growing metropolitan centers in the United States, with the population of Harris County rising from 1.75 million in 1970 to more than 4.5 million today. But as population soared, developers in southeast Texas were allowed to build on whatever land they could find, including wide swaths of drained wetlands, with little thought of flood risk.

[Hurricane, later Tropical Storm] Harvey reclaimed much of that land, dumping more than 40 inches of rain in a matter of days and flooding as much as 30 percent of Harris County in August 2017. In the wake of the storm's catastrophic damage, flood expert Philip Bedient says business-as-usual building practices in the Houston area must change.

Bedient is a civil and environmental engineer at Rice University, where he directs the Severe Storm Prediction, Education and Evacuation from Disasters (SSPEED) Center. He has advised the city of Houston on low-impact development practices that help to mitigate flooding. In an interview with *Yale Environment 360*, he discusses southeast Texas' haphazard development boom, how communities should approach rebuilding after Harvey, and how the region needs a network of flood mitigation policies and technologies to protect it from future climate change-fueled storms.

***Yale Environment 360* (*e360*): Harris County, which includes the city of Houston, has experienced phenomenal population growth in the last few years. You've described the building practices in the area as "the Wild West." How so, and how did that contribute to the current disaster?**

Philip Bedient: Most of that Wild West [building] was years ago. We have a lot of legacy areas around that were built in the 1960s, '70s, and the '80s, in the fast boom-or-bust era. It was also a time where our flood control policies were not very strong at all. A lot of those areas were built with a lot of high density, with not a whole lot of green space, with not a whole lot of good practice. Very little attention went into it. That's all changed, but it didn't change until the '90s, and it was a day late and a dollar short, because so much of the area had already been developed.

CREDIT: WORDJUNKY/FLICKR

Rework-ready. Houston-area contractors and homeowners will be kept busy as they repair flood-caused damage from Harvey and future storms. The city is considering a variety of projects to protect against flooding.

***e360*: Are there zoning regulations now that, say, prohibit building in a 100-year flood plain?**

Bedient: No, they [local officials] still allow building in the flood plain, but I have a feeling that a lot of this is getting ready to go through a change. I do know that they're starting to think seriously about putting some additional [water] storage out on the west side, in the Katy Prairie area, and try to do a better job with the reservoirs that are out there now. But don't forget, we just had the largest flood in U.S. history spread out over an entire county. There's no way we could've come out of this without some flooding. But it would've been a lesser amount, if we had had some of these policies in place.

***e360*: Were there any surprises for you regarding the pattern of flooding in the Houston area?**

Bedient: No real surprises, other than it's the largest amount of rainfall to ever befall an urban area in the history of the United States. When you get 3 feet of rainfall, pretty much spread uniformly over a 1,700-square-mile area, it's pretty daunting.

***e360*: You've worked with the City of Houston to evaluate different types of low-impact development. What does this look like?**

CREDIT: DANIEL MARTINEZ/AIR NATIONAL GUARD

Flood watch. By the time Harvey had subsided, an estimated 30 percent of Harris County—about 444 square miles—was submerged.

Bedient: You can do everything from an individual green roof, or a small green area associated with a building, all the way to what I call green infrastructure, which would be using a greenway or green belt, and adding [water] retention wherever you can, and minimizing impervious surfaces. We've recommended that at all different levels.

When I came to Houston originally, I worked on the Woodlands, up on the Northside, which is one of the best-designed flood-protected communities anywhere. We did that in the '70s. There are other areas around Harris County, out in Fort Bend County and in the Sugar Land area, where these are practiced, and they actually worked well during this flood. But unfortunately, we need to do a lot more of that in Houston. I do think that they are going to begin to turn in that direction. This is the third year in a row of major flooding. They're really going to have no choice but to turn in that direction.

***e360*: You've also worked on flood resiliency with the Texas Medical Center, which fared pretty well during Harvey. Tell me about how you advised that facility.**

Bedient: We helped rebuild the Med Center and redesigned the whole infrastructure post-Allison. We have a flood warning system that they rely upon. All of that worked really, really well during this storm. This was the highest recorded levels ever on the bayou next to the Medical Center, by probably more than a couple of feet. The Med Center actually saw a little bit of flooding, but it was absolutely minor compared to everything else we're seeing in the city of Houston. The system worked perfectly.

***e360*: They've got submarine doors, I understand, in their underground tunnels.**

Bedient: They brought in shipbuilders from the Northeast the day after Allison, and they started designing these gates and doors to be completely waterproof. They work very well.

***e360*: There is an ongoing federal and county project known as Project Brays, which is trying to reduce the risk of flooding along the Brays Bayou with channel widening and storm water retention basins. Is this an effective approach? If so, is more of the same needed?**

Bedient: I would say that Project Brays is the only hope those people had, but we just saw about a 500-year flood, and that is far beyond anything that Project Brays was ever designed to do. It will still help the next time we get the 100-year [flood]. But those people in Meyerland have been flooded now three years in a row. I think we're going to probably end up looking at a massive buyout. There's going to have to be some sort of a major shift in policy. There's got to be an infusion of money to really make this happen and get those people out of harm's way.

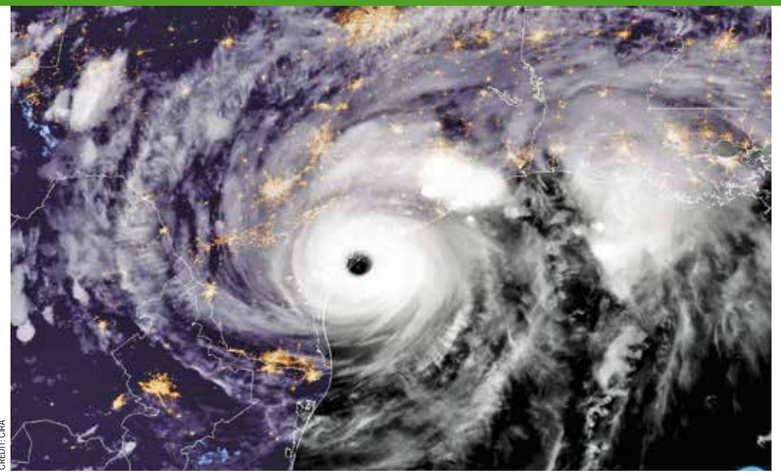
***e360*: If this is Houston's Katrina, is there receptivity now to major shifts in the way this region thinks about development?**

Bedient: I think if there weren't a major shift now, I would be very surprised. Unfortunately, there are a bunch of developers who just try

to meet the bare bones minimum, and we're going to have to turn that thinking around. We cannot continue to develop just for the bottom line. We're going to have to develop in smart, resilient ways. Otherwise, Houston is going to be forever known as the flood capital of the United States.

e360: Your center and Texas A&M at Galveston have put forth various proposals to protect the region from storm surge. The Texas state legislature and local officials are now supporting the so-called coastal spine, or "Ike Dike," a series of floodgates along the coast that can be closed when needed. In April, Texas land commissioner, George P. Bush, asked President Trump for $15 billion to build the project. If that money doesn't come through, then what?

Bedient: I hope it does. I hope that we begin to do something. It's been nine years since Ike. We'll see. But I'm also [not] going to be surprised to see... a competition for money for inland flood defense, which is what just happened here. This wasn't a surge event. We had no surge at all. It was all inland flooding. Monies are going to begin to flow, but the question is, what are they going to be used for? And what is their best purpose? I'm not in any position to try to make those political decisions, but hopefully, the right decisions get made about how to spread the money around appropriately to protect all of the critical facilities, all these neighborhoods, as well as the coastline.



CREDIT: CIRA

Eye of fury. When it hit land in late August 2017, Hurricane Harvey became the most destructive natural disaster in U.S. history, causing $199 billion in property damage.

e360: What does the SSPEED Center's modeling tell us about a worst-case scenario hurricane hitting the area?

Bedient: The SSPEED Center scenario says that even if a coastal spine [were built], you would really still need even some in-bay elements. We've advocated for the mid-bay solution, particularly to protect the Houston Ship Channel.

e360: That's the solution that your center has put forward. What does it entail?

Bedient: Our mid-bay is basically a dike that runs down alongside the Houston Ship Channel, all the way out toward Galveston Bay. But about midway down, it cuts over and connects with the existing Texas City dike. It protects a big bay area, including all of the Clear Lake area, and in particular, provides an extra level of protection for the Houston Ship Channel. It involves a coastal spine. We think that actually all of it, all the elements together, really need to be built—both a coastal spine, as well as mid-bay elements—because just the coastal spine will not be fully protective.

This storm hit Corpus. It hit Rockport. But it very easily could've come in and hit Houston. If it had come into Houston with a direct hit, we would've seen massive damage within the Houston Ship Channel area—spills, environmental impacts—because there's nothing out there to protect it right now. They're sitting ducks. You can't trust just a single line of defense.

e360: Given the reality of climate change, the Houston region will face even more powerful hurricanes, more heavy rain events, higher storm surges. Will a place like Houston even be habitable in a century?

Bedient: That's a really good question, but then we've learned to live with big storms over the years. If indeed they're going to start to get bigger and more intense—which I think they are—I think we're seeing it now, and I think we've seen it in the last three years. If that's going to happen, then we've got to take flood protection a lot more seriously than we have in the past. It needs to become No. 1 priority.

Houston helped put a man on the moon. Houston is the leader in the medical field. It could also begin to be a smart, resilient city if it puts its mind to it. That's all it's got to do. **GB**

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- Yale School of Forestry & Environmental Studies, **http://environment.yale.edu/**
- Rice University Severe Storm Prediction, Education and Evacuation from Disasters Center, **http://sspeed.rice.edu/sspeed/mission.html**
- Project Brays, **www.projectbrays.org**

The Foam Factor

After the big one hits, here's how to keep residential flood and water damage to a minimum.

ACROSS THE U.S.A. and Canada, heavy rainfall and flooding have caused millions of dollars in damage, lost revenue, damaged crops and homes. Hurricane Harvey ravaged southern Texas and the nation's fourth largest city, Houston, flooding vast areas of the region—and Hurricane Irma pounded Florida, Puerto Rico and much of the Caribbean with high winds and downpour. In British Columbia, a tough spell of raging wildfires over the summer made heavy rainfalls a greater threat in fall.

Water ingress resulting from storm surges, high rainfalls and flooding can cause massive damage to the typical home. When water ingress occurs from extreme weather events, it becomes necessary to assess extent of damage and contamination, debris removal requirements, and how to reconstruct or repair to reduce probability of similar damage in the future.

CREDIT: ICYNENE

The dry look. Closed-cell spray foam such as Icynene *ProSeal* can act as a water-resistant barrier and provide additional "racking" strength vs. high-powered winds.

Power cells

When seeking methods to reduce the risk of water ingress, spray foam insulation is often overlooked as a comprehensive solution that can help play a role to keep out moisture and deter flood damage. However, spray foam insulation can be a key component in the design of building assemblies against future disaster-driven damage. Both open-cell and closed-cell spray foam insulation can be used throughout a residential or commercial structure to manage and minimize moisture ingress.

When it comes to addressing moisture, open-cell foam is better suited for use against building materials that can be damaged by water buildup. When applied against these types of materials (e.g., exterior wood sheathing), particularly in hot or humid climates, insulation should allow just enough moisture diffusion to occur to let adjacent building materials breathe, preventing moisture entrapment. Open-cell foam delivers this "breathability" and allows building materials to dry, minimizing moisture buildup and related problems, such as mold.

For example, in scenarios where the foam is applied to the underside of a roof deck, in the event of a roof leak water drains straight through the insulation by gravity rather than being trapped against the roof sheathing where it could contribute to roof rot. Upon drying, some open-cell spray foam insulation products return to their original state without warping or distortion, and the effectiveness of the insulation is restored to its original performance potential.

The Federal Emergency Management Agency (FEMA) has identified closed-cell spray foam as a flood-resistant material due to its resilience and strength. According to the government agency, flood-resistant material is any building material capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage. Closed-cell spray foam, like Icynene *ProSeal*, can be used as a water-resistant barrier to help deflect moisture and provide additional "racking" strength to help resist the high winds of a storm or hurricane.

Dealing with flooding's aftermath

When assessing flood damage, one must almost always assume that the water contains contaminants, such as decaying organic matter and debris, raw sewage, fuel, solvents, microbes and mold. Through wicking, moisture and contaminants can be drawn into areas above the actual flood level. Even after cleanup, homeowners may still notice problems with housing elements, since mold and other contaminants can be present due to wicking and therefore may render homes unlivable.

CREDIT: BART EVERSON/FLICKR

Unpleasant surprise. Mold, which can take hold in as little as two days once a structure has become saturated, may appear in obvious places like ceilings, or, in this case, on a wall behind a hanging picture.

Cleaning up after a flood should involve an assessment of the extent of removals required, necessary cleaning, drying and disinfecting of surfaces by a qualified contractor. Some porous materials may take days or even weeks to carry out. Mold can begin to thrive in as little as 48 hours when contaminated water floods an assembly. This makes it likely that many porous materials will, in fact, require removal after an extreme weather event.

Repair work following water ingress or flooding will often involve raising older buildings and constructing new ones on piers or platforms above the Base Flood Elevation (BFE). Construction below the BFE must be done with flood-resistant materials. Closed-cell spray foam insulation is suitable for application below the BFE.

Above the BFE, both open-cell and closed-cell spray foams can be used, but consideration has to be given to avoiding other porous materials that can absorb contaminated water. The choice of materials should be made based on sound building science principles. For instance, in a floor above a damp crawlspace, it may be desirable to use closed-cell foam because of its vapor retarding, compressive strength and water-resistant characteristics. A qualified and experienced insulation contractor is able to help work through the best approach.

Most of all, building materials exposed to flooding must be resilient enough to sustain a certain amount of water exposure to avoid the need for complete replacement. A "repair and prepare" approach using spray foam insulation can help reduce risk of water ingress and damage, as weather patterns across North America continue to change and challenge our approach in designing and building sound, solid structures to live, work and play in. **GB**

Source: Icynene (www.icynene.com), a developer of high-performance spray foam insulation solutions.

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FLEX HOUSE

by Shelter Dynamics

The Flex House: Right-Sized Living

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The Flex House boasts a fully integrated smart + solar system, using advanced, intelligent technology to streamline energy usage. The house serves as its own microgrid, producing all of its own energy. The Flex House features water conserving products and fixtures, and non-toxic, sustainable materials to ensure healthy indoor spaces.

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To learn more about The Flex House, visit http://www.greenbuildermedia.com/vision-house-flex-house or contact Cati O'Keefe at cati.okeefe@greenbuildermedia.com

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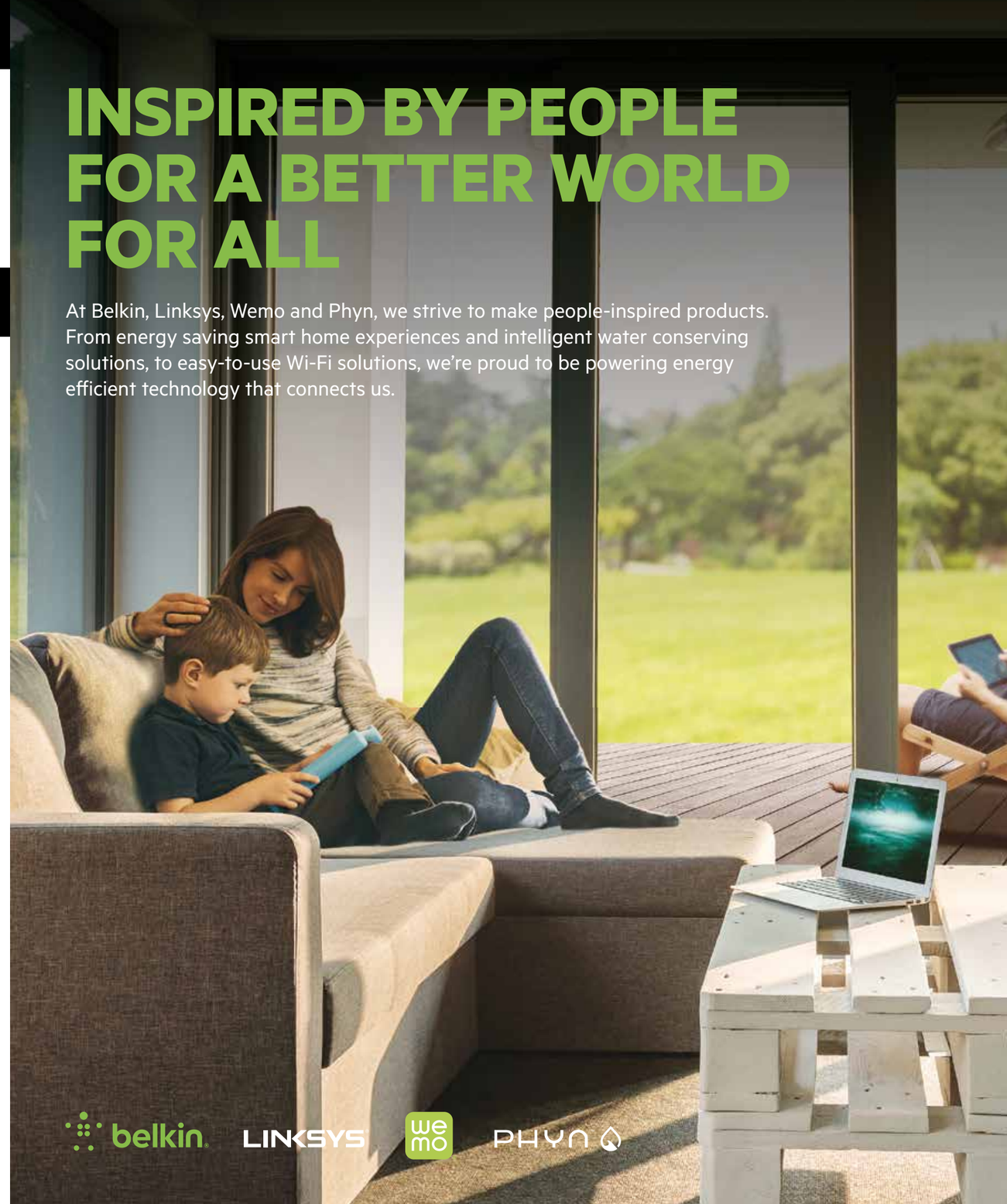

belkin. LINKSYS wemo PHYN

AIMING FOR ZERO

The Flex House's net-zero-energy readiness includes an efficient and airtight envelope, lowered demand and a responsive renewable power system.

A renewed effort. The Flex House's design combines numerous insulation techniques—including spray foam, flashing products and waterproofing agents—to make it ultra energy efficient.

CREDIT: BRECHER

BY JULIET GRABLE

WITH ITS TOUGH BUILDING STANDARDS, California is a good incubator for The Flex House, which will be built in a local factory, then transported to sites within and outside the state. The Flex House is designed to function as a net-zero-energy (NZE) home, says Jeff Cretcher, who recently joined Shelter Dynamics as the company's new CEO. There are a number of efforts underway to help the structure reach that status, starting with the home's thermal envelope. "[That envelope] is designed to be airtight and features a combination of insulation techniques," Cretcher says. "[That includes] closed-cell, low-[Global Warming Potential] spray foam insulation throughout."

Green Builder® Media presents FLEX HOUSE by Shelter Dynamics

The Flex House Envelope

The Flex House is built on a steel girder system that gives it the required stiffness during transport. All exterior walls contain three inches of Accella's *BaySeal* closed-cell spray foam insulation; ceilings contain five inches. *BaySeal* uses a next-generation blowing agent with a very low Global Warming Potential (GWP) of 1, which represents a 99 percent reduction over conventional blowing agents.

CREDIT: SHELTER DYNAMICS

In a flash. Flexible *FlexWrap NF* flashing from DuPont helps create a tight seal around windows.

DuPont *Tyvek HomeWrap* serves as the weather-resistant barrier, and DuPont flashing products, including *FlexWrap NF*, are used around windows and openings. *Tyvek HomeWrap* functions as an air barrier and provides bulk water resistance, yet it is also vapor permeable, allowing any moisture that does enter the wall to escape. *FlexWrap* is a self-adhered flashing tape that is flexible enough to wrap into and around corners and custom-shaped openings to create an air- and water-tight seal.

BayBlock HT, a fluid-applied elastomeric roof coating from Accella, serves as the finished roof. This system is ideal for the curved roofs that distinguish both modules of The Flex House. *BayBlock* serves as waterproofing and effectively seals the joints between the two modules and around the solar panel mounts. The 100 percent acrylic coating reflects harmful UV rays, and the light color enables the roof to function as a cool roof, mitigating the heat island effect and preventing solar heat gain.

CREDIT: BRECHER

A good match. *BayBlock* adheres to the *BaySeal* spray foam insulation, as well as to other substrates, including primed wood, primed metal, concrete and masonry.

Though the prototype utilizes conventional framing techniques and does not include continuous exterior insulation, subsequent iterations of the house will, says Cretcher.

"I am delighted to be taking the helm of Shelter Dynamics at this moment in time. Building on the genius of Jim Gregory and his crew, we plan to make Shelter Dynamics an industry leader in the emerging market of right-sized, environmentally friendly modular housing."

Jeff Cretcher, CEO, Shelter Dynamics

CREDIT: BOSCH USA

All in the family. Taking up much less space than conventional appliances, a stackable 24-inch washer/dryer pair from Bosch nests in a closet beside the *Greentherm* condensing gas water heater.

Lowering Demand

The next component on the path to NZE is reduced demand. At 760 square feet, the small-footprint Flex House requires less energy than a standard house to begin with. Reduced demand is also achieved through high-efficiency Sylvania LED lighting from LEDVANCE and a suite of Energy Star-certified appliances, efficient HVAC system and water heating, all supplied by Bosch.

The sleek 24-inch European appliances and *Greentherm* condensing tankless water heater are ideal for small house design. The *Climate 5000* ductless mini-split supplies separate zones, so that heating and cooling are only delivered when and where they are needed. *Sensi*, a smart Wi-Fi-enabled thermostat from Emerson, controls the HVAC system, and can be managed with a smartphone or via voice commands, thanks to Amazon *Alexa*.

The Flex House is demonstrating Amazon *Echo Plus*, a speaker and smart hub that uses *Alexa* to give the homeowner control over various home systems and devices, including lighting, HVAC and entertainment. Over time, *Alexa* learns the user's speech patterns and preferences, which enables more-precise and customized responses.

A Complete Renewable Energy Solution

The Flex House uses renewable energy system to bring the house to net zero in grid-tied situations. This holistic and integrated renewable energy solution incorporates solar energy, battery storage and clean transportation in the form of a plug-in hybrid electric vehicle that can be charged at home. Here's a look at each component:

EFFICIENT PV MODULES

The Flex House roof supports a 3.36-kW array with *Eagle 60* 310 W mono-PERC modules from JinkoSolar. These modules have a maximum power (Wp) of up to 310 with an impressive 18.33 percent efficiency. The high efficiency is made possible by passivated emitter rear contact technology, which introduces a layer to the back of each solar cell that reflects back any light that didn't generate electrons on its first pass through the cell. PERC cells can also better capture light at longer wavelengths than conventional solar cells, improving the modules' performance under cloudy or low-light conditions. The all-black *Eagle 60* modules have a striking aesthetic and complement many roof types.

CREDIT: JINKOSOLAR

Sophisticated efficiency. The all-black *Eagle 60* modules contribute to the modern aesthetic of The Flex House.

JinkoSolar is a global leader in the solar industry. The company is continually working to develop ever more efficient and versatile products, including mono-PERC modules that incorporate half-cut cells, which allow more cell surface area compared to a traditional module. This technology is expected to boost power output an additional 10 watts or more and to have fewer power losses through improved temperature coefficients. The company is also offering an integrated "plug-and-play" AC module that comes with an Enphase microinverter mounted on the module's backsheet, making for quick and easy installation. **www.jinkosolar.com**

ECO INTELLIGENT BATTERY SYSTEM

EIBS, an all-in-one residential solar plus storage solution from Tabuchi Electric, includes a hybrid inverter, storage batteries, automatic transfer switch and energy management. The DC-coupled battery allows for efficient charging from the solar array. The hybrid inverter seamlessly manage three power sources—the grid, solar array and storage battery. This flexibility allows the optimal use of electricity produced by the solar array.

For example, during times when grid-supplied electricity is inexpensive, the system may choose to send power generated by the solar array to the storage batteries. This allows it to be used in the evening when demand and rates are higher. The battery can also be used for backup power in case of grid outages. Users can access real-time data about power consumption, generation and battery storage via the remote or online application.

Tabuchi Electric developed the system in response to growing interest in solar energy following the 2011 tsunami and subsequent meltdown at the Fukushima facility in Japan. As more solar arrays came online, utilities became worried that a significant spike in solar electricity generation would destabilize the grid by creating large swings in demand between day and night.

CREDIT: TABUCHI

Outage ready. The *Eco Intelligent Battery System* from Tabuchi Electric provides instant emergency power during an outage.

"This system merges stability for the utilities with customer demand," says Masa Someha, director of business development at Tabuchi Electric of America. The two-battery *EIBS* is also a proven system for net zero. According to the company, the advantages of this system are its simplicity and reduced number of components.

Though Tabuchi may be a new name in solar in this country, the company has a 90-year history and is the world's fifth-largest manufacturer of inverters. Tabuchi has installed at least 1 million inverters and at least 20,000 of the newer hybrid inverters worldwide.

CREDIT: TOYOTA

Electric style. Thanks its larger battery pack, the *Prius Prime* now has a 25-mile electric-power-only range per charge and a mpg equivalent of 133.

PLUG-IN HYBRID EV

Building on the success of *Prius*, which since its launch in 2000 has consistently remained the most popular hybrid vehicle in the U.S., Toyota released the Toyota *Prius Prime* in 2016. This hybrid electric vehicle has a larger 8.8-kWh battery pack and uses a series parallel hybrid system, which can drive the wheels using electric motors and/or its gas engine. When the battery is fully charged, *Prius Prime* can run on the electric motors only, and it has an "EV mode" range of 25 miles. Once the battery drains down, it operates like a *Prius*, relying on the gas engine and the batteries. Drivers with shorter commutes can potentially rely on all-electric driving most of the time. Its EPA-estimated total driving range is 640 miles.

Other features that separate the *Prius Prime* from a growing pack of electric vehicles include its styling, safety and comfort features. The aerodynamic form is made possible without sacrificing headroom by lowering the engine, electric motor and seats. A heat pump provides climate control when the gasoline engine isn't running, down to temperatures as cold as 14 degrees F. Toyota also provides a suite of apps to manage charging and climate control, and to find services such as charging stations.

The *Prius Prime* can be charged using a standard wall outlet, but much faster charging is available using a 240-volt Level 2 EVSE, or Electrical Vehicle Supply Equipment, commonly referred to as a charging station.

Toyota is committed to offering a full suite of alternative-fuels vehicles, including full-sized fully electric vehicles and hydrogen fuel cell vehicles. In 2016, the company launched the Toyota Environmental Challenge 2050, a set of six challenges that address global environmental issues. Goals include eliminating greenhouse gas emissions from its vehicles, operations and supply chains. **www.toyota.com/priusprime/**

SAFE AND CONVENIENT EV CHARGING

The *Power Max 2* charger from Bosch provides charging for the Toyota *Prius Prime*. *Power Max* is available in 30-Amp or 40-Amp options, for EVs that can accept the higher current.

California's Title 24 requires that all new construction, including single-family homes, be pre-wired for EV chargers. Other jurisdictions will follow the Golden State's lead, predicts Jeff Hudnut, EV product manager for Bosch Automotive Service Solutions. With that in mind, *Power Max 2* was designed for simple installation, and it can be hard-wired or plugged in to a NEMA 6-50P receptacle. With its compact and attractive design, this charger is a good fit for smaller spaces such as The Flex House. It also comes with an 18-foot or 25-foot charging cord and, with its NEMA Type 3R enclosure, it can be installed inside or outside.

CREDIT: BOSCH USA

Attractive charging. Available in 30- and 40-Amp configurations, the *Power Max 2* works with nearly all electric vehicles sold in North America and features a weather-resistant housing.

One of the most appealing things about the *Power Max 2* is its safety features. The plug includes a thermal sensor; in the rare case of heat build-up, it will stop charging and allow the unit to cool off.

Power Max 2 can be used to charge any EV that meets SAE J1772, the standard connector used by most electric vehicles in North America. The *Power Max 2 Plus* also includes Wi-Fi connectivity. **http://bit.ly/2Afl3q4**

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BEYOND THE PRODUCT

DuPont offers resources that help builders incorporate WRBs and flashing products as part of an effective system.

DUPONT *Tyvek HomeWrap* has been around for nearly 40 years—long enough for it to become the go-to house wrap for many a builder. But while the product itself—a durable, vapor permeable fabric made with fine, high-density polyethylene fibers—hasn't changed much over the decades, construction methods have. As the drive for ever-more-efficient buildings ramps up, contractors and designers must ensure they are meeting their efficiency goals without compromising the durability of the building envelope. Air tightness is a particular concern as builders prepare to face increasing standards.

"Increased market demand for improved energy efficiency, coupled with more-stringent building codes and energy requirements, is forcing many builders to change the way they build," says Laura Dwyer, global manager at the DuPont Building Knowledge Center. "You can have a great product and great installation best practices, but if they're not carried out in the field, you're not going to get the optimal performance."

CREDIT: DUPONT

Rule Book. DuPont's installation guidelines provide detailed instructions, along with helpful graphics.

Recognizing these challenges, DuPont has ramped up its efforts to support and educate builders. The DuPont Building Knowledge Center is a hub through which builders can access a range of resources, including installation guidelines CEUs, case studies and white papers on specific topics. For example, DuPont recently produced a series of flashing guidelines for recessed windows—one set for recesses that are less than 4 inches deep; a second for recesses that are greater than 4 inches deep—to follow before or after the house wrap is installed.

"Guidelines like this reflect our systems approach," says Dwyer. "On a practical level, we want builders, contractors, architects and designers to understand how all DuPont Weatherization Systems products work together to help protect the structures they design and build today and into the future."

DUPONT®

Here are some of the specific resources available through the DuPont Building Knowledge Center:

Installation Guidelines:
http://bit.ly/2A6N99s

Technical Information: Includes links all available online resources.
http://bit.ly/2jl25WR

DuPont Tyvek Specialists Network:
http://bit.ly/2siYcoW

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NET-ZERO READY?

IF TRENDS ARE ANY INDICATION, net-zero-energy (NZE) homes will soon be everywhere. *To Zero and Beyond,* an inventory of NZE residential projects in the U.S. and Canada, shows that the number of NZE units grew by 33 percent in 2016, compared to the baseline inventory conducted in 2015.

"A lot of people think net zero is pie in the sky. But it's happening now," says Dan Varvais, West Coast regional manager for Accella, which provided spray foam insulation and the roof coating for The Flex House. "Often, it's a matter of commitment."

He points to a recent commercial project, a 1970s concrete building owned by LinkedIn, which was retrofitted to improve daylighting and energy efficiency. Accella provided spray foam insulation and a new acrylic roof for the retrofit, which also included new skylights and the addition of a 245-kW solar PV array. The company is seeking Net Zero Energy certification for the building in Sunnyvale, Calif.

California is leading the charge for NZE buildings. This is not surprising, given the State's mandate that by 2020, all new residential construction must be net zero. (All commercial buildings must meet the standard by 2030.) Ann Edminster, net-zero and green building consultant, believes a combination of policy and grassroots activity creates "hotbeds" of NZE construction. But when comparing the 2016 map of NZE buildings to the previous year's, it's clear that the movement is starting to expand.

CREDIT: ACCELLA

Locked in. The owners of the LinkedIn building committed to NZE when undertaking a major retrofit.

When contemplating NZE, the first thing many builders want to know is how much extra it's going to cost. But Edminster says that's the wrong question.

"The right question is, what do I need to do differently to achieve this?" she says. Builders should also apply design thinking rather than taking an "applique approach" to net-zero buildings, she adds. "Builders who begin with NZE integrated as one of the project goals distinguish themselves in the market and will have an advantage once stricter energy codes come online," she notes.

Either way, the NZE wave is coming. "You can either pretend it's not happening and pretend that you don't have to evolve," Edminster says, "or you can say, 'I believe this thing is coming' and actually design to make it happen."

Read the latest NZE buildings report here: **http://bit.ly/2tplcXc**

THE FLEX HOUSE PROJECT SPONSORS

On the Horizon: The next article on The Flex House will focus on the Smart Home 2.0 technology that the home is demonstrating at the Consumer Electronics Show in Las Vegas. We will also provide updates on the marketing and production of The Flex House as information becomes available.

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Smart Thermostats, Clueless Users

A deep dive into the buying trends, attitudes and behavior of smart thermostat users uncovers some missing links.

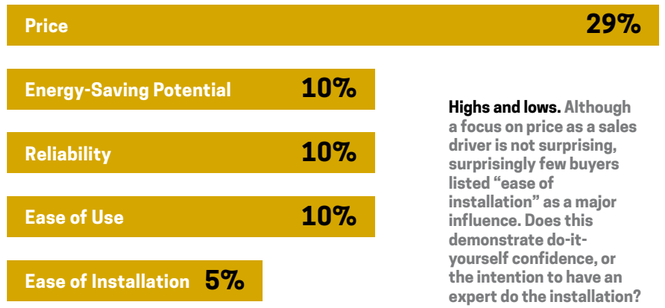
BY GREEN BUILDER STAFF

WOULD IT SURPRISE you to know that about one-third of people who own smart thermostats set the temperature, push the "HOLD" button, and walk away, thinking they are using the device properly?

That's one of the surprises we discovered when putting together a Cognition Smart Data analysis of smart thermostats last month. Cognition is a powerful new tool we've developed at Green Builder Media for researching sustainable brands and ideas. It's essentially a visualization of data: a way to "see" how buyers perceive a brand, including what they're saying about it, how they "feel" about it and what's "missing" in closing the deal—and driving more sustainable purchases.

We're well aware that data collection has a dark side. But it's a tool, we believe, that can also be harnessed for ecological good—in service to reducing consumption on non-renewable resources. Smart thermostats, for example, can reduce a home's HVAC energy use by 10 percent to 30 percent (based on manufacturer estimates). That's a massive reduction in greenhouse gases. If we can help bring more awareness (and sales) to this market, everybody wins.

Percentage of thermostat owners who listed trait as top three buying influence



Highs and lows. Although a focus on price as a sales driver is not surprising, surprisingly few buyers listed "ease of installation" as a major influence. Does this demonstrate do-it-yourself confidence, or the intention to have an expert do the installation?

SOURCE: MCKINSEY&COMPANY

A FRACTURED LANDSCAPE

Our analysis of the Smart Thermostat universe began with the basics, a synthesis of third-party research. Until recently, the market has been stalled at what smart home pundits describe as "The Chasm"—the space between early adopters and mainstream buyers. But the products have now crossed over, thanks in large part to dropping prices.

That's something else that surveys have revealed: Cost is king for new buyers. Parks Associates found that "only 30 percent of consumers believe that smart thermostats are affordable, and only 18 percent of consumers would purchase one of these devices at $250."

But riding on the heels of that finding is the powerful influence of rebates. The same Parks Associates report found that a $100 rebate could more than double "purchase intention" for smart thermostats.

REBATE BONANZA?

Piecing together the available thermostat rebates nationally is like a scavenger hunt. Some manufacturers list only the rebates where their units are covered.

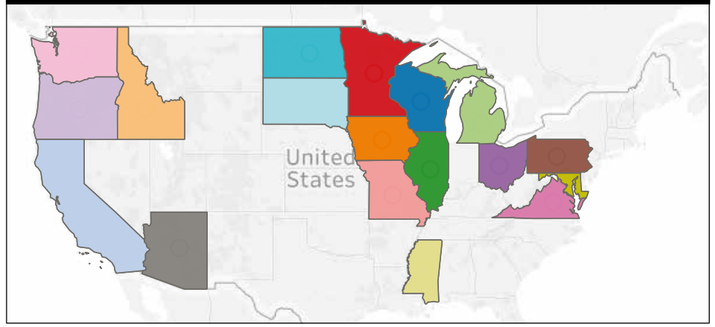
So, we compiled the latest rebate data, and created an interactive map for each state and utility. This shows that many states have no rebate in place at all—a potential white space for smart thermostat brands looking to rapidly boost sales.

Rebates vary by the amount of kickback they give to smart thermostat buyers and by the number of thermostats rebated. Among the best states for consumers is Ohio, with a $250 rebate for each thermostat.

The impact of unit price on sales may explain why the price of Nest thermostats recently dropped dramatically.

But the market is not that simple. Much of Nest's profits come from *selling the data*

Map of current thermostat rebates



The Wild Midwest? The interactive data map from our Cognition dashboard shows that states such as Kansas and Colorado lack any kind of smart thermostat rebates.

collected by their devices. Other brands must rely on product sales. It's harder for them to cut prices.

As you can see, without context like this, real-time data, the next step in our Cognition analysis, might be useless or misleading.

TRACKING THE KNOWN AND UNKNOWN

The Holy Grail of data analysis is visualization of consumer behavior as a way to discover evolving trends. With Cognition, we accomplish this by combining several online and digital tools. In tracking smart thermostats, for example, we scanned millions of pieces of data, social media, blogs, articles, news reports and other documents. This data tells us, for example, what consumer sentiment is toward each of the four brands in our analysis. It also tracks product reviews, notes the geolocation of potential buyers and hints at "points of entry" for people interested in this technology.

What's a point of entry? A related product or behavior that correlates with smart thermostat adoption. For example, we've found that people who buy home security systems are more likely to consider adding a smart thermostat. So are those with broadband Internet.

But what about undiscovered points of entry? We call these "market outliers." Our experience in the sustainable space helps us identify new correlations that may not be on the radar of manufacturers. With Cognition, we can test these "outliers" to see if they hold up. For example, we're currently tracking cities with the greatest increase in electricity rates over the past five years, and areas with the largest annual heating trends. Are these regions ripe for smart thermostat adoption?

We'll be reporting on other Cognition analyses over the coming months. Let us know if there's a topic or product category you'd like us to investigate with a "deep dive." If you're a manufacturer looking for some customized real-time data, drop us a line. With Cognition Smart Data, we're putting information to good use. GB

For more information : Sara Gutterman, **sara.gutterman@greenbuildermedia.com**

- McKinsey & Company, There's No Place Like (a Connected) Home, **http://bit.ly/1RuCiFD**
- Parks Associates, Smart Home Utility Partnership Opportunities: Offering $100 rebate more than doubles purchase intentions for smart thermostats, **http://bit.ly/2AcD1fa**

Confident Incompetence

Perhaps it shouldn't be surprising that according to surveys, Americans THINK they know their thermostats a lot better than they actually do. For example, a study by Marco Pritoni at the University of California, Davis, asked respondents with programmable thermostats how they used the programmable features.

"Fourteen percent of the subjects reported that they 'don't know where the settings are,' and 25 percent answered that they 'know where the settings are but [they] don't know how to change them,'" according to the study. "Thus, about **40 percent of programmable thermostat users do not operate their thermostats as expected** by the manufacturers."

It gets worse: **"About one-third of the thermostats were in 'permanent hold' mode;** this mode interrupts all the programs and turns the programmable thermostat into a manual thermostat. In addition, 50 percent of the photos of the units in hold mode were uploaded by those who claimed to use programmed settings."

Clearly, something is missing in thermostat messaging and/or product design. This may be the topic for another Cognition inquiry.

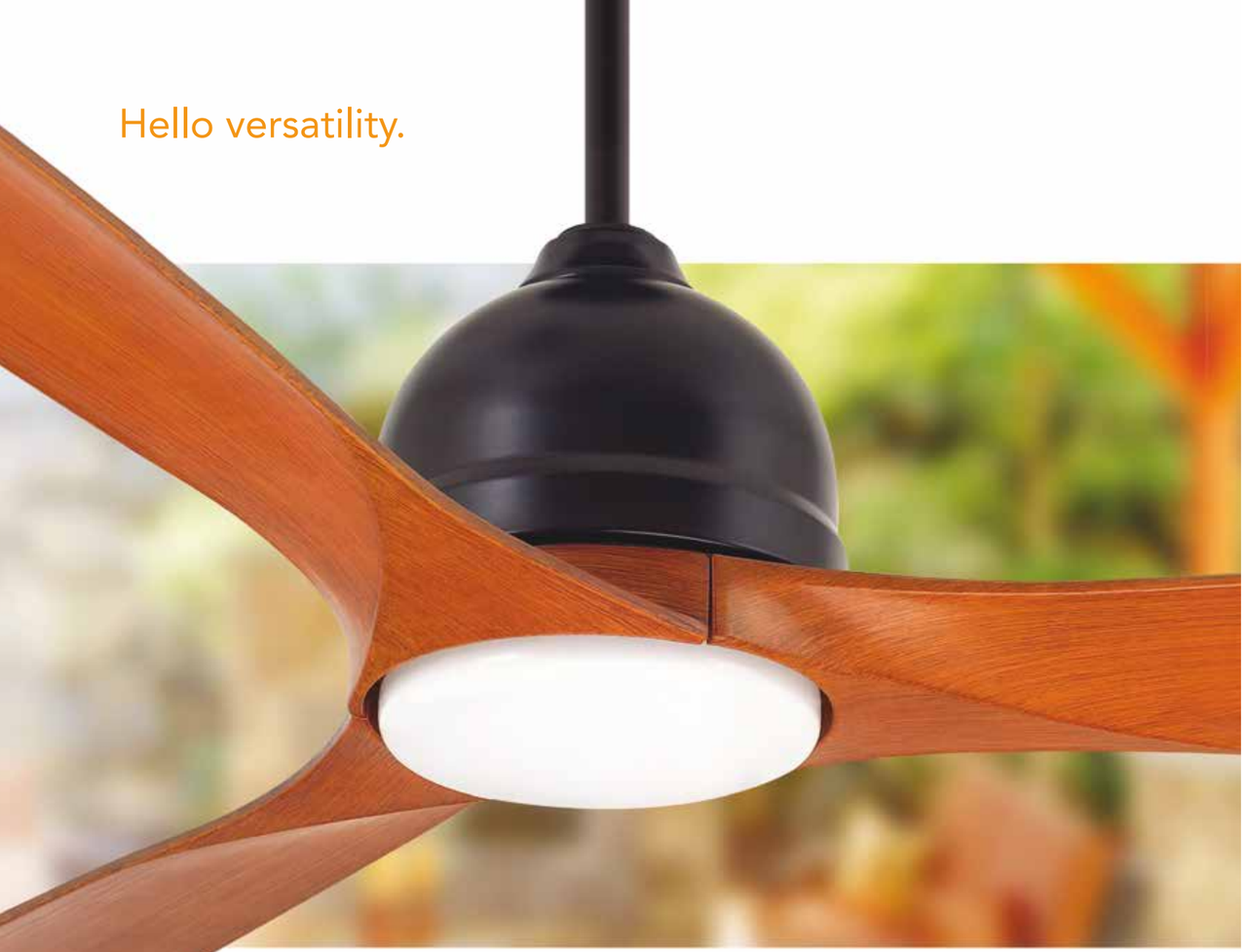
The Payback Principle

If price is paramount, shouldn't a smart thermostat's payback period be part of the consumer pitch? We arrived at some payback figures by combining different data, starting with each manufacturer's estimate of potential energy savings:

BRAND	Average Monthly Saving	Average Product Cost	Payoff Period
Ecobee (23%)	$83.62	$111	1.3 months
Emerson (*Sensi*) (30%)	$108.60	$140	1.3 months
Nest (10-15%)	$43.44	$213	4.9 months
Honeywell (16%)	$57.92	$160	6.25 months

Price points. Payback periods are based on each brand's internal savings estimates. We applied the energy savings estimate to a Massachusetts home heated with oil, with a total winter heating bill of $2,171, or $362 per month for six months. (Note that if you include a utility rebate for purchase of the thermostat, payoff period is much shorter.)

Hello versatility.



The wet rated 54" Volta ceiling fan from Emerson features the best LED light available in a ceiling fan today. The dimmable LED light has an impressive 2,600 Lumens of light output. This sleek, modern fan with contoured blades is available in three finishes and comes with a stylish no-light plate and a 4-speed wall control. Bring a contemporary vibe to your indoor or outdoor living spaces with the Volta ceiling fan from Emerson. Learn more at emersonfans.com.

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Resilient Rebuilding

After disaster, is it enough to restore the same old grid, or do we need something more?

BY MARTIN O'MALLEY

REALITY CHECK: Last fall, two of the largest hurricanes in recorded history hit Puerto Rico, the U.S. Virgin Islands and other Caribbean islands within 10 days of each other. The cause is undeniable; the devastation almost indescribable. The opportunity to rebuild a green, renewable, more resilient electric grid has never been called for more urgently.

THE CAUSE IS that we pump way too much carbon into the atmosphere. And the carbon we pump into the atmosphere is heating up the Earth. The solution is to redesign our living so we are drawing down more carbon every day out of the atmosphere than we are pumping into it.

Migrating from fossil fuels to renewable energy sources is a big part of the solution.

And rebuilding a nation's devastated electric grid is the doorway to how we get there.

Hang with me here.

The humanitarian crisis unfolding among our American neighbors in Puerto Rico will require a higher level of engagement and investment than FEMA is currently putting forth. Our fellow citizens there are still facing critical safety, survival and security concerns throughout the island.

Clearly, a lagging relief effort is our most immediate concern.

But how—as a compassionate and thinking people—do we prevent this from being an annual humanitarian crisis?

Is it enough to rebuild the same old grid, or is something more required?

To get the right answers, we must ask the right questions. And those questions have to do with how we rebuild.

What is resilience, really?

Americans know a thing or two about resilience.

Resilience means more than just picking yourself and your neighbor up off of the mat. It means adapting and changing in light of new realities. We rebuilt our cities differently—stronger, better, more resilient—after the great fires that destroyed Chicago and Baltimore in the early 1900s. We learned to farm and irrigate our land differently after the dust bowls that devastated America's heartland in the late 1920s.

Today, we must learn from the mega-hurricane disasters brought about by our global warming.

This means changing the way we feed our people, fuel our economies and heal our planet as we face the realities of climate change. For example, it means rebuilding an electric grid in Puerto Rico that will be, at once, more renewable and more resilient.

What if we were to rebuild Puerto Rico's electric grid to make it BOTH 100 percent renewable and far more resilient to the mega-hurricanes of our foreseeable future? And what if that new 21st-century power system was less expensive to operate and provided lower costs for customers?

Consider these facts:

1. At 23 cents per kWh, the price paid by Puerto Ricans today for electricity is twice what is paid for electricity on the mainland of the United States.

2. Renewable energy resources are abundant in Puerto Rico. Solar resources across the Caribbean are greater than in Hawaii, California, Texas and Spain; wind resources are competitive with resources in the leading wind states of Texas and California. And today, those kilowatts of on-shore wind can be produced competitively at 6 cents to 9 cents per kWh, while solar can be produced at 10 cents to 13 cents per kWh.

3. The cost of wind, solar and energy storage has been declining dramatically as battery storage technology continues to improve.

But until the hurricanes wiped out our fellow citizens in Puerto Rico, all we read about was Puerto Rico's debt. Less publicized is the fact that $8 billion of Puerto Rico's $74 billion of indebtedness actually derives from PREPA—the government-run utility.

Power imperfect

The truth is America's largest territory is electrified by a dirty, expensive, rickety and terribly inefficient power system. A power system whose primary fuel for its 40-year-old fleet of generators is heavy fuel oil and diesel—the most expensive and polluting petroleum products on the planet. A power system whose antiquated grid wastes 14 percent of the electricity it produces while burning the dirtiest of fossil fuels.

And every imported barrel that the people of Puerto Rico buy is dollars that leave the island, that no longer circulate, that are no longer available to lift Puerto Rico's economy.

Now is the opportunity to restructure. Now is the time to realign profit motives to renewables and resiliency. Now is the time to rebuild Puerto Rico's electric grid with a human purpose.

As Chris Burgess, director of projects at the Rocky Mountain Institute/Islands Energy Program, explains, "The new-age utility is no longer the sole monopoly producer of energy, but rather the facilitator of a dynamic grid—a grid where we all participate, we all consume. Now—thanks to declining solar and wind costs—we can all produce."

"What has been destroyed needs to be rebuilt. Why not build it in a way that allows Puerto Rico to generate its own electricity in ways that are more resilient to next year's hurricanes, better for its own economy, and less expense for its consumers and businesses?"

A full transition to renewable energy and micro-grid resiliency in Puerto Rico will produce thousands of new jobs in engineering, construction, maintenance and operations.

A new grid designed for redundancy and resiliency with distributed generation (generation in various places spread across the island's grid: rooftop solar, solar parking lots, solar farms, solar on brown fields, on-shore wind, off-shore wind and the latest technology for storage capacity) is more reliable and more resilient to extreme weather and monster hurricanes.

Other countries like Denmark, Costa Rica and Ecuador have demonstrated the capacity to go to 100 percent renewables while making their countries more secure and prosperous at the same time. Other islands like Ta'u in American Samoa, Bonaire in the Dutch Antilles and Kaua'i in the Hawaiian chain have all shown the capacity to thrive on renewables. So too, can Puerto Rico.

NGOs like the Rocky Mountain Institute-Carbon War Room and others have been actively partnering island states like Saint Lucia, Saint Vincent and Montserrat to transition from expensive and volatile imported fuel oil to domestic renewable energy with accelerated success.

The island state of Hawaii has declared a goal of 100 percent renewable energy by 2045. And the economics are already accelerating the speed of progress to goal. The Hawaiian island of


Martin O'Malley

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Storm warning. Hurricane Maria was one of two to hit Puerto Rico in September 2017. The mass destruction has officials wondering what type of power grid should go up in place of the one that was destroyed.

CREDIT: ANTTI LUPONEN/FLICKR

Kauai has transformed its energy mix from 90 percent oil fired to 40 percent renewable (with over 90 percent solar and battery during the mid-day peak) in just a few short years.

The sum of all parts

The bottom line is this:

What has been destroyed needs to be rebuilt. Why not build it in a way that allows Puerto Rico to generate its own electricity in ways that are more resilient to next year's hurricanes, better for its own economy, and less expense for its consumers and businesses?

There are some things beyond our control but regulatory policies are not. Here are a few that need to be changed if we are to create a safer, more reliable and more prosperous energy future in Puerto Rico.

- Realigning the profit motive from pure consumption of kilowatt hours to paying for the maintenance of a resilient and dynamic grid.
- Creating a predictable and guaranteed pathway for feed-in tariffs, and mutually beneficial utility and customer incentives to get more renewables on the grid quickly.
- Building out the smaller generation and storage capacities of micro-grid nodes like universities, business parks, hotels and critical infrastructure like hospitals, emergency shelters, drinking water systems, telecom, airport and seaport facilities, and police and fire facilities.
- Taking out PREPA's indebtedness so Puerto Rico can build a foundation of its new economy that will allow the island to pay off its debts by propelling its economy into a more prosperous, lower-cost energy future.

These are all human constructs, human choices and human policy choices. The engineering know-how is here. The urgency of this new normal weather threat is here. Puerto Rico's debt crisis is here and it has its roots in overpriced, fossil-fueled electricity.

The time is right to make Puerto Rico a proof positive of what can be achieved if we embrace the opportunity of climate change to create jobs and improve the well-being and prosperity of our people.

We human beings make sense of things from stories close to home. Scale can confound us. When the scale is too large, it can short-circuit the imagination. It can throw the art of the possible for a loop. But what has happened to Puerto Rico could also be a turning point. A proof point. An opportunity to imagine and rebuild at a scale that all can see and understand.

Yes, this is about alleviating the suffering of our American neighbors in Puerto Rico right now. But it also about how the United States of America protects our people in the future from the very real present danger posed by climate change.

We have the power to change and adapt.

As Americans, we have proven time and again that adaptation and change are our great strengths.

It is time to call into service the American innovation and technology that already exists.

It is time to call forward the goodness within us in rebuilding Puerto Rico.

Small things done well make bigger things possible.

We might just learn something by doing what is right and needed.

We might just remember we are capable of accomplishing great things. **GB**

Martin O'Malley served as governor of Maryland from 2007 to 2015 and as mayor of Baltimore from 1999 to 2007. He has lead widespread sustainability initiatives, from massive cleanup efforts in the Chesapeake Bay to strong advocacy for a 100 percent national renewable energy mandate by 2030.

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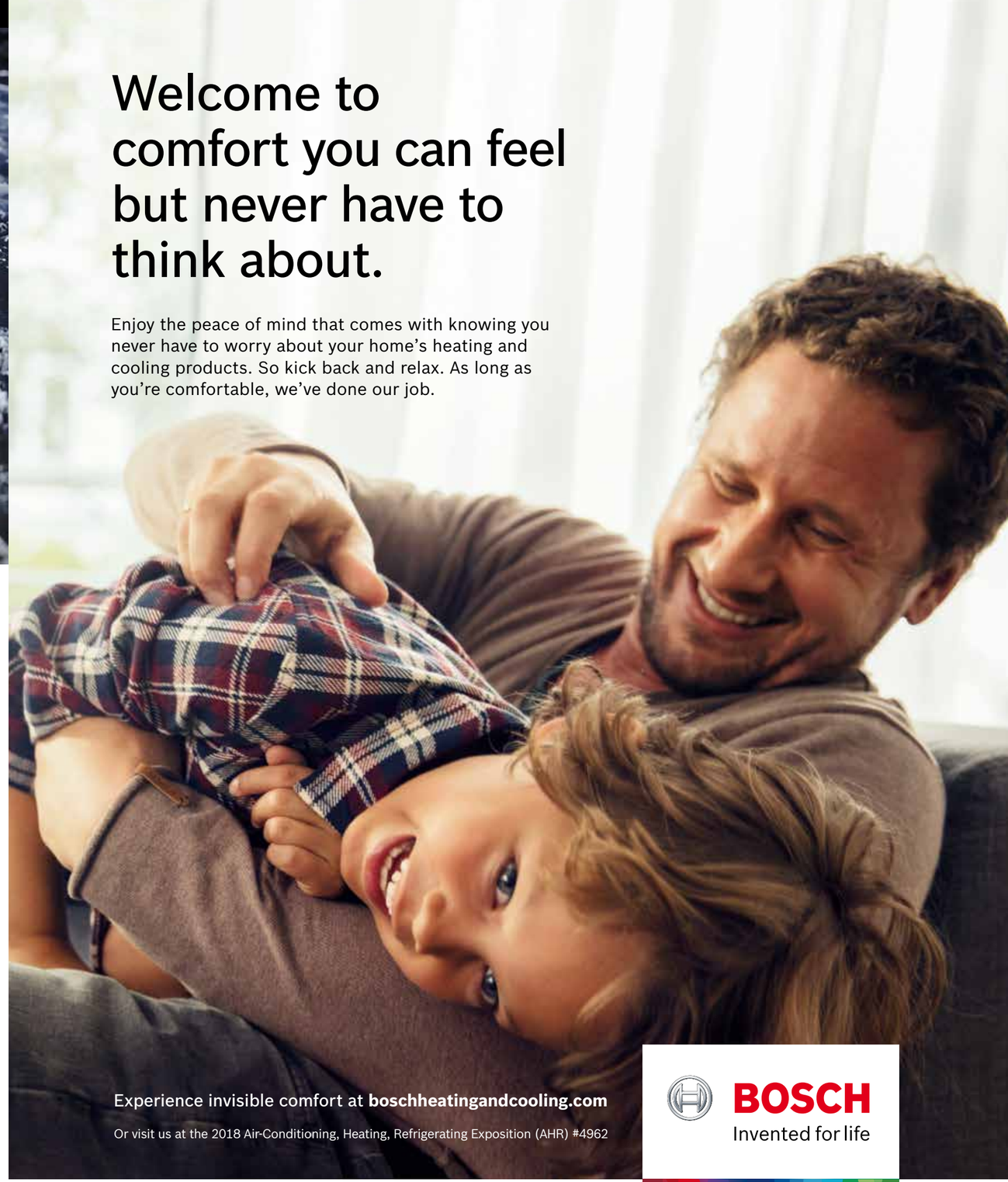

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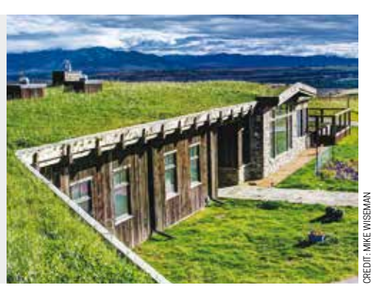

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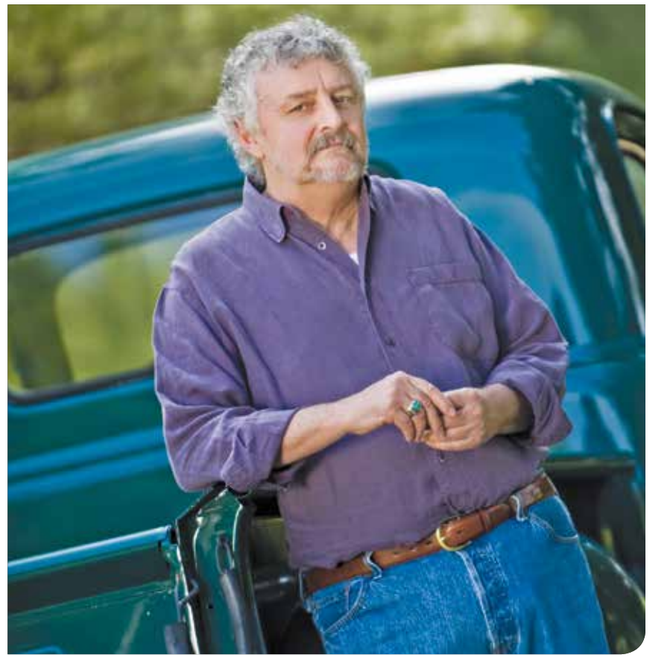
FROM THE TAILGATE

New Offerings for the Sustainable Minded

By Ron Jones

Time to Warm Up to the Big Picture and Just Be Resilient



BACK IN NOVEMBER, I closely followed the weather reports in a month that proved to be one of the warmest on record for our part of the world. The television weather reporters and news anchors gleefully cheered the unseasonable temperatures, often in sportswear and sleeveless tops to illustrate the point.

When the month finally wrapped up, it was one of the driest on record, with zero measurable precipitation officially recorded in a calendar month that usually averages about 2.5 inches. The official high temperature on Thanksgiving Day in Denver reached the low 70s, only a couple of degrees off the all-time record for that holiday. A few days later, the high was reported to be above 80.

Frankly, it was more than a little frustrating to witness carefree celebrations and lack of expressed concern about the extreme dryness and unusually warm temperatures. While some basked in the short-term comfort afforded by the conditions, I kept thinking about the record wildfires that had only weeks before dominated the news in the West—especially those in California, but in other states as well.

The nightmarish images of entire communities, croplands and vineyards, and countless acres of wild lands transformed into charred wastelands and ruin were impossible to forget. The nightly stories of the shattered lives, hopes and dreams of thousands of residents could only be described as heartbreaking. The loss of life and property were difficult to comprehend, and the millions of dollars in public and private resources that were poured into the efforts to battle the infernos, not to mention the heroic efforts of the firefighters and other first responders, boggled the mind.

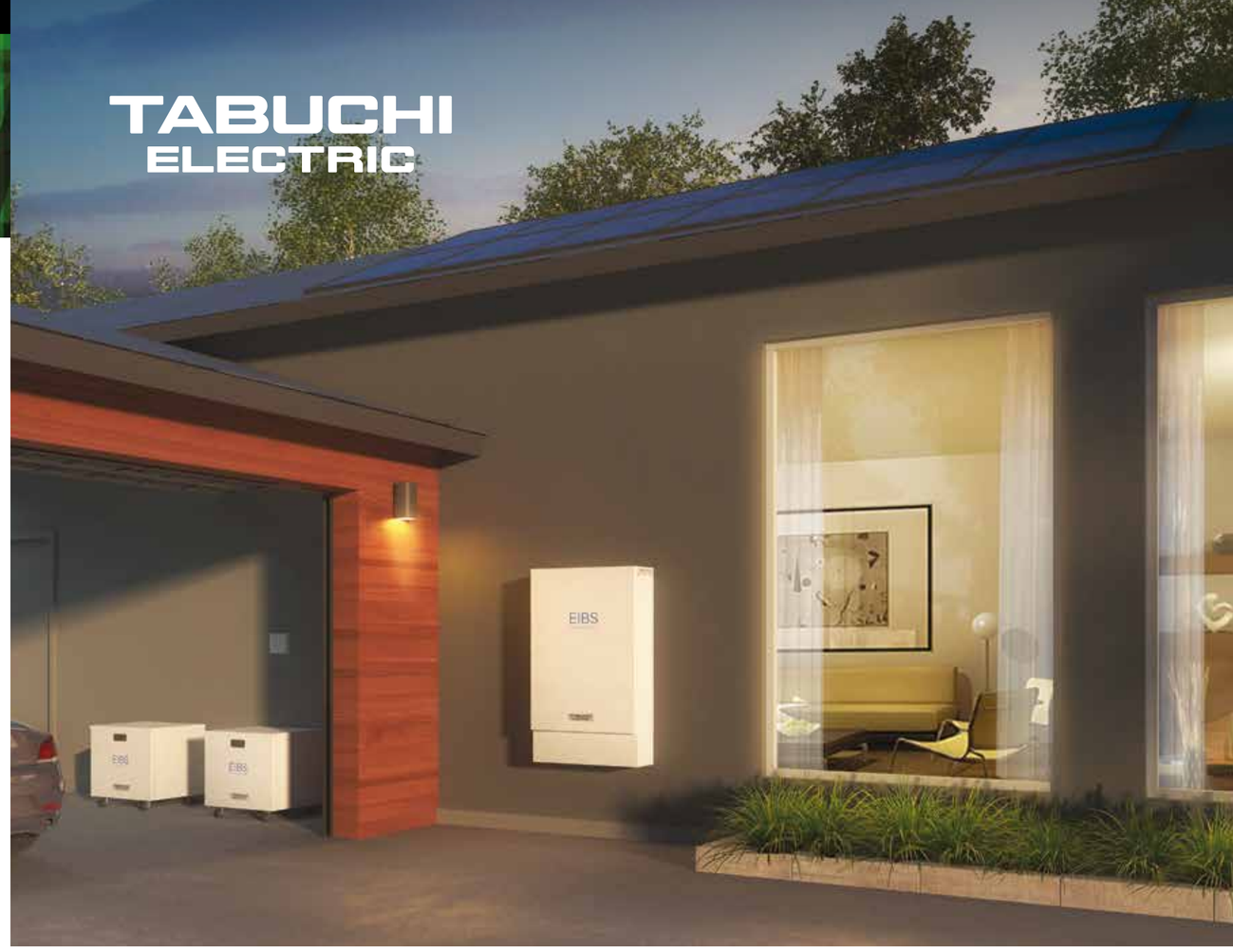
I remember thinking that the images resembled photographs of cities and towns that had been destroyed by massive bombing campaigns in wars all around the world. Often, they bore an eerie resemblance to the black and white photos of Hiroshima and Nagasaki.

Are people really as shortsighted and oblivious to the big picture, as we often seem to be? Can we actually learn from experience, and if so, why don't we apply those lessons in an effort to avoid enduring the same outcomes when these kinds of catastrophes occur?

The real estate industries, and all forms of development and construction, seem to be among the greatest offenders. We are extremely eager to rebuild in the wake of destruction, but it seems that we're adamantly resistant to adopting measures that will help prevent the same outcome the next time we encounter similar challenges.

Resilience is a topic that has captured a great deal of the dialogue these days. There are many sincere people and companies in our industry, and others, who are devoting vast amounts of energy, creativity and resources to develop products and systems, and to implement strategies intended to provide a more resiliently built environment and a safer, more secure future.

But until we are able to look beyond our immediate comforts, we will struggle to take the necessary and appropriate actions that will lead to more-resilient homes and communities. It's something we cannot continue to fail to achieve. **GB**



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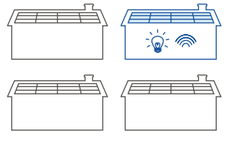

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