

Award-Winning Coverage of Sustainable Construction, Products and Lifestyles

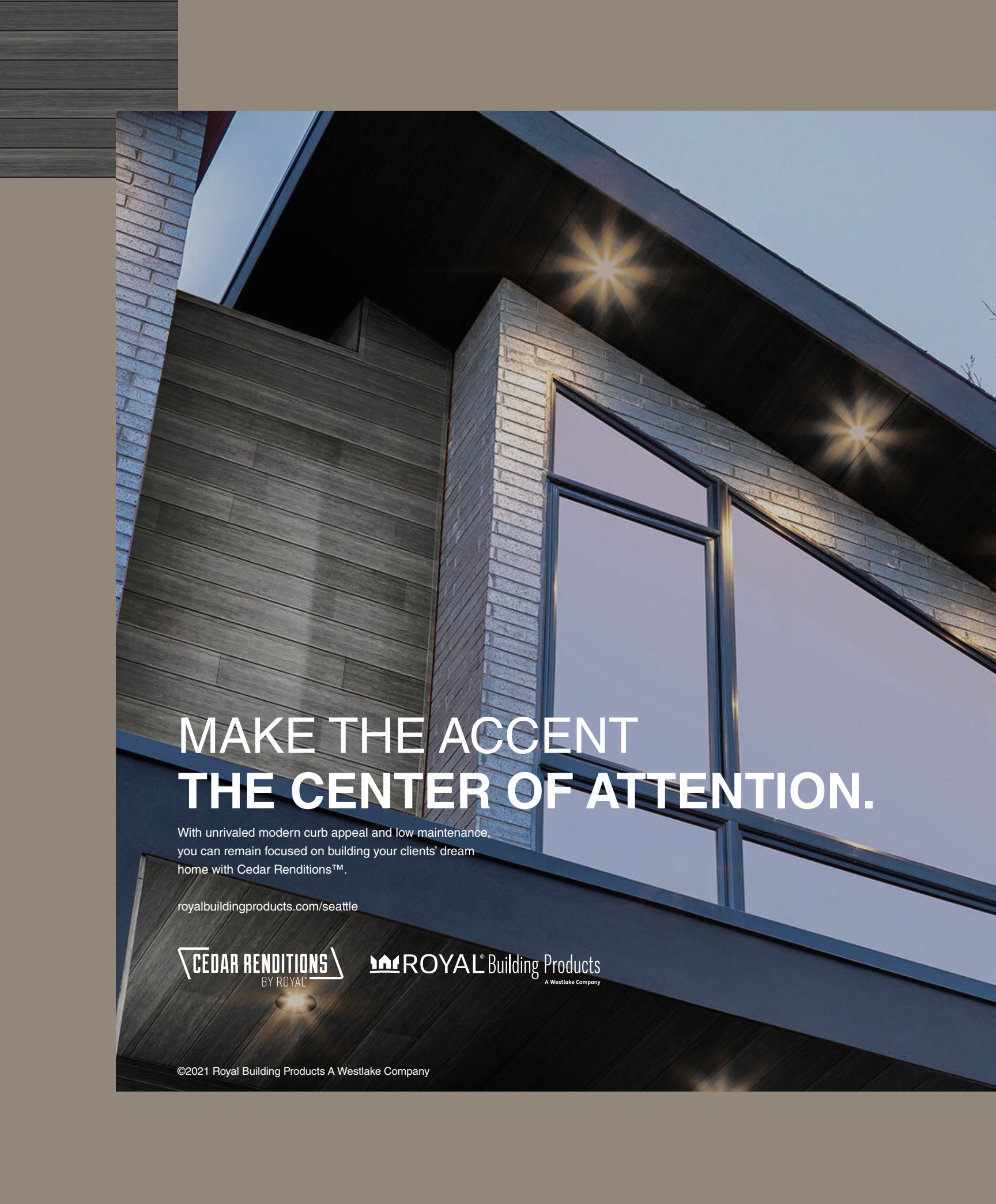
GREEN BUILDER[®]

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FRENZY

Relentless demand for new homes and remodeling has pushed the industry into uncharted territory. Our annual look at who's buying and who's building offers a snapshot of high-performance design, process and products.





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The Tangle of Transparency

Fly ash may finally come clean, as the 'big guns' follow their self interest.

A

N INTRIGUING STUDY CAME ACROSS MY DESK YESTERDAY, titled “**Environmentally hazardous coal waste diminished by citric acid.**” What’s intriguing is that, for years now, I’ve been trying to find definitive information about whether fly ash is a safe additive for concrete and other building products such as porous pavers or cement board. It matters, because fly ash is plentiful, relatively inexpensive and when used in place of cement, actually **results in a slightly harder** concrete.

I’ve assigned freelancers to dig into the topic too, **with mixed results.** We’ve been told by industry experts that there’s no definitive measure of just how many heavy metals and other toxins remain in the post-industrial residue left behind from burning coal — and every batch is different.

But concerns about leaching and human health after contact with fly ash linger. It turns out that these concerns are not unfounded. The study I mentioned touts the performance of a new citrus-

based additive. This solvent removed about 42 percent of the rare earth metals found in a test batch of what the author refers to as the “environmental pariah” — coal ash (of which fly ash is a part). The more typical method used to achieve the same goal involves nitric, sulfuric or phosphoric acids, which “leave the environment in worse shape than before.” And they only remove about half as much of the bad stuff.

But entities such as Sandia National Laboratories, which sponsored this research, want those metals for their fighter jets, submarines and other military industrial complex profit centers. Sandia also plays a large role in America’s nuclear arsenal. Is it cynical to suggest that the company’s interest in cleaning up coal ash has less to do with sustainability, and more to do with selling drones, missiles and surveillance?

Some of you will say, “What does it matter WHY they’re doing it?” I understand that viewpoint. Ultimately, the research may unlock fly ash as a resource, reducing the vast footprint of cement, which is responsible for about 8 percent of the world’s CO₂. On the other hand, the U.S. military and its hired contractors currently rank among the world’s

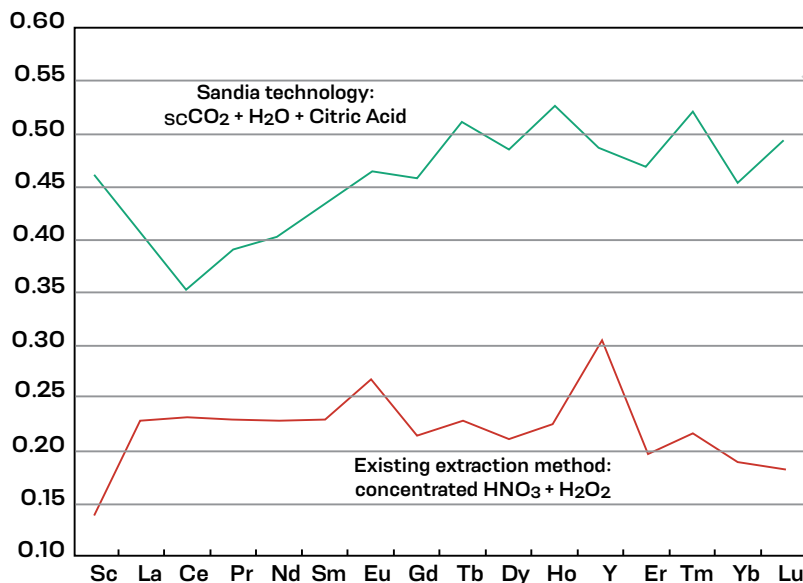


Fig 1. Comparison of extraction efficiency between Sandia’s environmentally benign technology and existing method using strong acids—concentrated nitric acid and hydrogen peroxide. SOURCE: SANDIA NATIONAL LABORATORIES

biggest polluters. Will the gains in cement zero out the additional CO₂ released by future bombs and hardware made possible by rare metals?

Fly ash offers just one example of why it’s so hard to make real change in the status quo of Climate Change. Why did it take 10 years to find a less-intensive way to clean fly ash? Where were government regulators in solving the problem? Were they simply underfunded, or uninterested?

It’s great that private industry may solve the problem of toxicity, but the impetus for change shouldn’t arise from the material needs of bomb makers. That’s a low bar at best, with a net ecological gain that’s clouded by entanglement. Let’s put technology together with the public interest for a change. Let’s put our tax dollars to work directly on solving ecological problems, not subsidize military contractors to “solve” them for us. The computing power and tools are widely available. We can look at complex data and weigh cost-benefit, just like the “big guns” do. Unless we look at the Climate Change problem with full transparency and neutrality, we may never escape our current downward spiral toward self-induced oblivion. **GB**



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National Windmill Plan Takes Shape

The Biden administration says offshore turbines will help make the U.S. clean-powered by 2050.

The Biden administration is pressing forward with a plan to develop large-scale wind farms along nearly the entire coastline of the United States by 2025, the first long-term strategy from the government to produce electricity from offshore turbines. Interior Secretary Deb Haaland says that her office will identify and eventually lease land ranging from the Gulf of Mexico to the Northeast, California and Oregon.

Earlier this year, President Biden committed to generating 30 gigawatts of offshore wind energy by 2030, which is enough to power 10 million American homes. Experts and industry leaders say that the new wind leasing commitment could ultimately bring the U.S. to Biden's goal of relying only on clean sources of power by 2050.

Wind energy boosters hope that the new leasing opportunities create a robust U.S. offshore wind industry capable of delivering a lot more power by mid-century. Opponents dislike the aesthetics of the windmills, as well as potential economic impact on existing industries such as oil and coal. The plan will undoubtedly face legal challenges that drag on for years, as well as changing attitudes of different administrations.



Up in the air. Offshore windmill farms like this one like this one, the Block Island farm in Rhode Island, will power millions of homes with clean energy starting as early as mid-century — if various legal hurdles are overcome.

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Oklahoma Eyes Electricity Transition Fee

Natural gas customers would be billed almost \$1,400 to switch to all-electric service.

Oklahoma's largest natural gas distributor wants to charge residential customers up to \$1,375 for shutting off their gas service and switching to all-electric homes. Oklahoma Natural Gas (ONG) says the fee will help the utility recover \$1.4 billion in costs from a February 2021 winter storm that resulted in higher gas rates for suppliers.

According to a report by KFOR News, ONG's existing customers will pay slightly higher gas bills over the next 25 years, totaling \$7.80 per customer. Anyone who wants to switch to all-electric must pay a \$35 to \$55 termination fee, multiplied by the years remaining in ONG's loss recovery period. Someone cancelling their gas service in 2022, for example, would pay \$875 to \$1,375; a customer who does it 24 years from now would pay \$35 to \$55.

Opponents say the measure will create a



Power grab. A fee proposal by Oklahoma Natural Gas might make moving from natural gas to all-electric energy throws a roadblock in the path of transitioning away from fossil fuels.

CREDIT: GREEN BUILDER MEDIA

new way for pro-gas regulators to prevent consumer transitions from fossil fuels to clean air alternatives. The proposal,

if approved by the Oklahoma Corporate Commission, would take effect by June 2022, according to the Huffington Post.

East Coast Rising

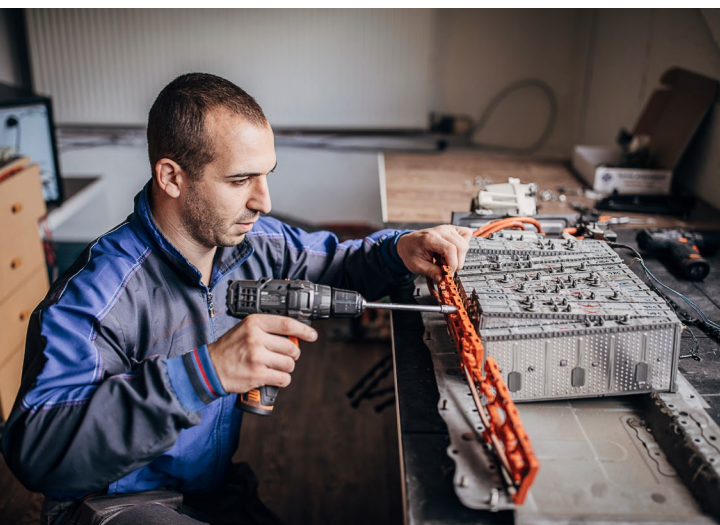
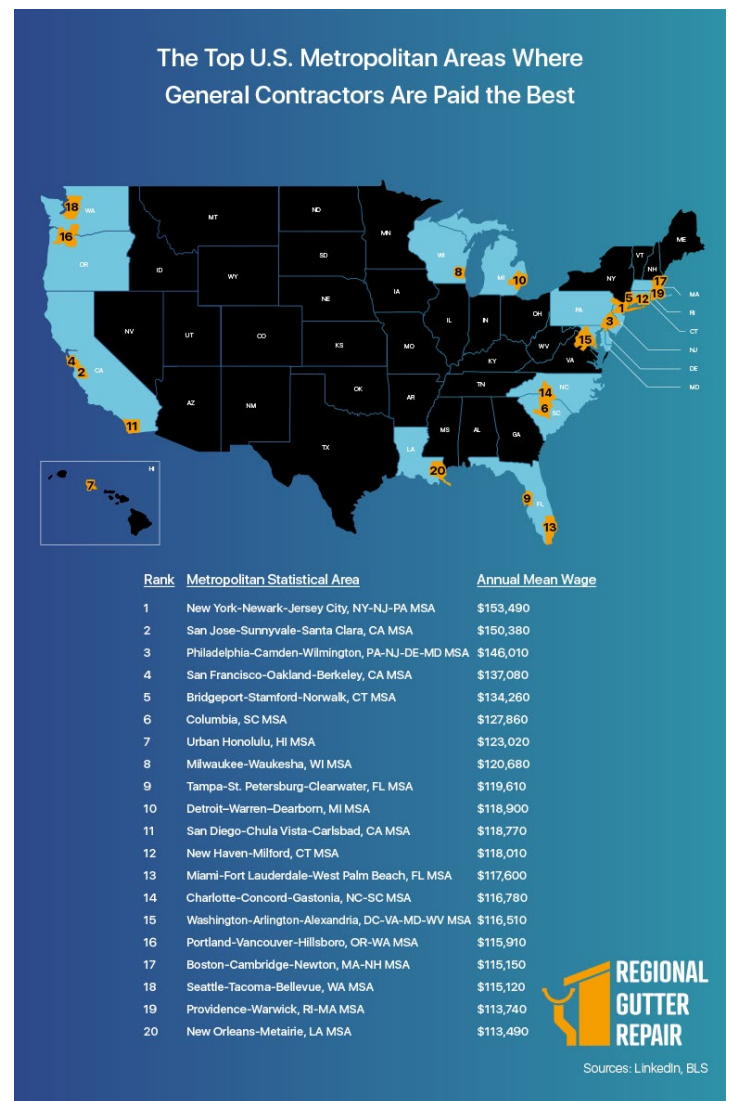
General contractors' best opportunities for work and income can be found near the Atlantic, not the Pacific.

If you are a general contractor looking for a job, your chances are best if you head to Columbia, South Carolina. If you want to make the most money, make your way to New York and New Jersey. Those are the surprise findings in a new report that gauges the U.S. construction markets for open positions, salary, new home builds and more.

The study by New York City-based Regional Gutter Repair identifies Columbia as the metropolitan area with the best work opportunities for general contractors, followed by the North Port/Sarasota/Bradenton, Florida market, and Greenville/Andersen, South Carolina. Meanwhile, the New York/Newark, New Jersey market pays contractors an average of \$153,490 per year, followed by the San Jose/Sunnyvale/Santa Clara, California market at \$150,380, and Philadelphia/Camden/Wilmington, Delaware at \$146,010.

Regional Gutter Repair's study combines data from LinkedIn, Bureau of Labor Statistics, National Association of Realtors, and Massachusetts Institute of Technology to determine the top 25 markets for jobs and top 20 for income. The findings did not relate to subcontractors, who work under the general contractor's direction, according to RGR specialist Henry Gerbin. The report may be found on [Regional Gutter Repair's](#) website

Hot markets. General contractors have a lot of choices when it comes to the best metropolitan areas in which to operate a business, according to a new market report. SOURCE: REGIONAL GUTTER REPAIR



Taking charge. Lithium-ion battery makers are studying ways to recycle old product, including how to disassemble them, burn the batteries for disposal, or extract metals through leaching. CREDIT: ISTOCK/SOUTH_AGENCY

A Powerful Problem

As they age, rechargeable car batteries pose a disposal challenge for their makers.

An estimated 12 tons of lithium-ion batteries, the heart of electric vehicles (EVs), will be a major environmental problem as they reach end of life by 2030, according to a report in The Guardian. Manufacturers are trying to figure out what to do.

Rechargeable batteries have few recyclable parts and can contaminate water and soil if discarded in landfills. World Economic Forum (WEF) manager James Pennington says the first solution should be to “keep things in use longer.”

Lund University environmental policy researcher Jessika Richter says old batteries have a lot of capacity left at the end of their first use in EVs. “They could have second lives storing excess power generated by solar or wind farms,” she notes.

Meanwhile, nations are allocating hundreds of millions of dollars toward figuring out how to disassemble dead batteries and extract valuable metals to help repurpose the cells and create a “closed loop” supply chain, according to WEF.

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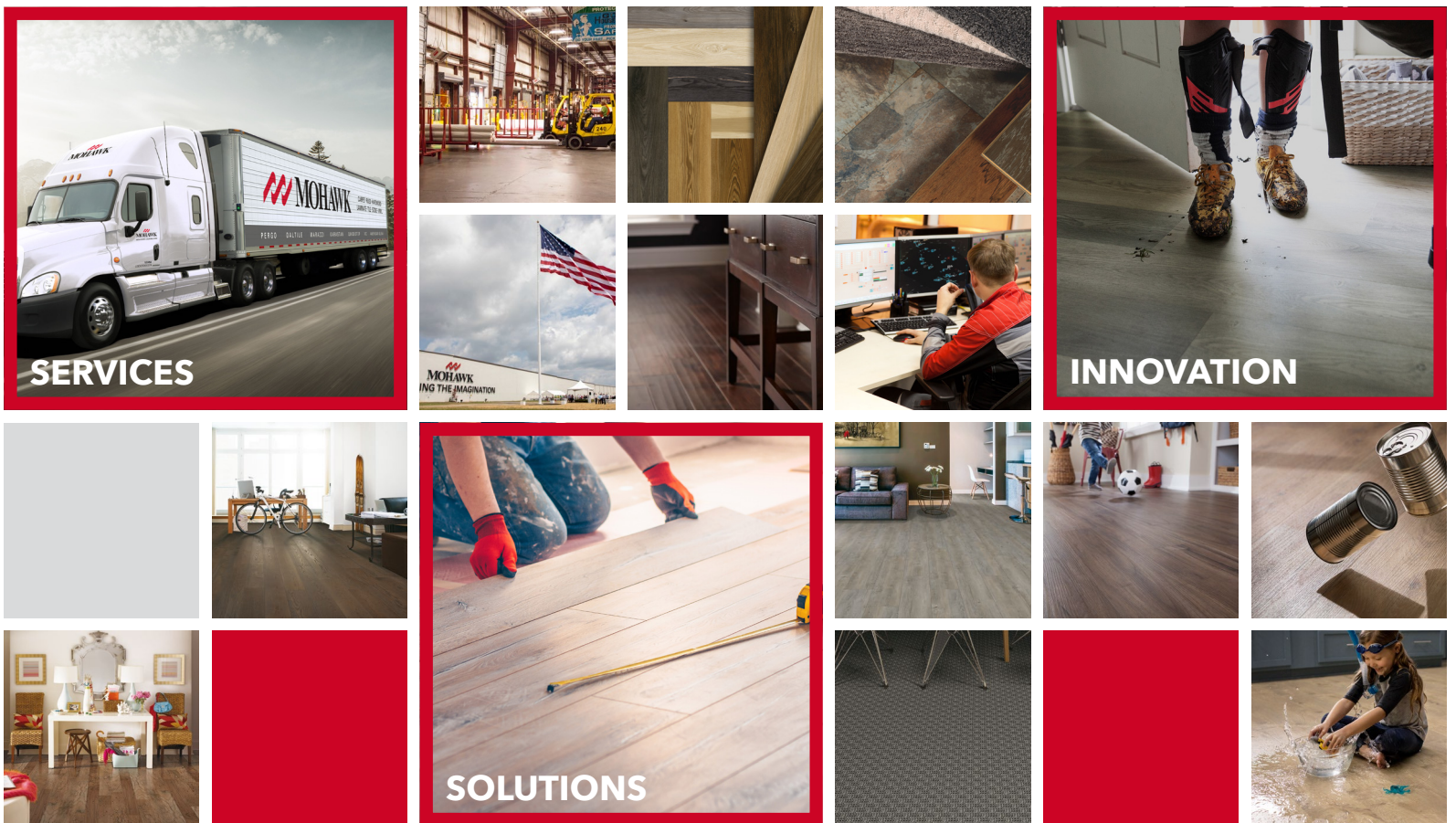
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FEATURES

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THE STATE OF SUSTAINABLE BUILDING 2022: A Time of Transition

To create a meaningful impact on runaway Climate Change, we need to set our sights on the full-scale decarbonization of our economy. But are we up to the challenge?

SKY-HIGH DEMAND: The booming construction and sales activity of 2021 is going to level off – but nobody’s sure by how much.

ALTERNATIVE SYSTEMS RISING: Shortages of lumber and other construction materials offer a golden opportunity for other ways to build a home.

NEW PRIORITIES: Fear, contemplation and technology have converged to change where people want to live, and what kind of housing they prefer.

THE GREAT DECARBONIZATION: As time grows short, greenhouse gas reduction takes center stage with manufacturers – along with national, state and local governments.



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More Than Mobility

When powerful, all-electric pickups hit the road next year, they’ll change not only the way you and your employees drive, but the way you work.



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ReVISION HOUSE AUSTIN: Clean, Efficient Pool Products Make a Splash

Austin’s heat and the combined forces of allergies and her dogs are no match for the cooling systems in Tiana Cooper’s ReVISION house.



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Can A Home Last 200 Years?

With walls and roof clad in aluminum, this ultra-modern home aims for record-setting durability.

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“Nothing is worse than being involved in a project and making certain assumptions about what can be done on a specific parcel, only to discover that you cannot do something that you planned.” **Page 54**

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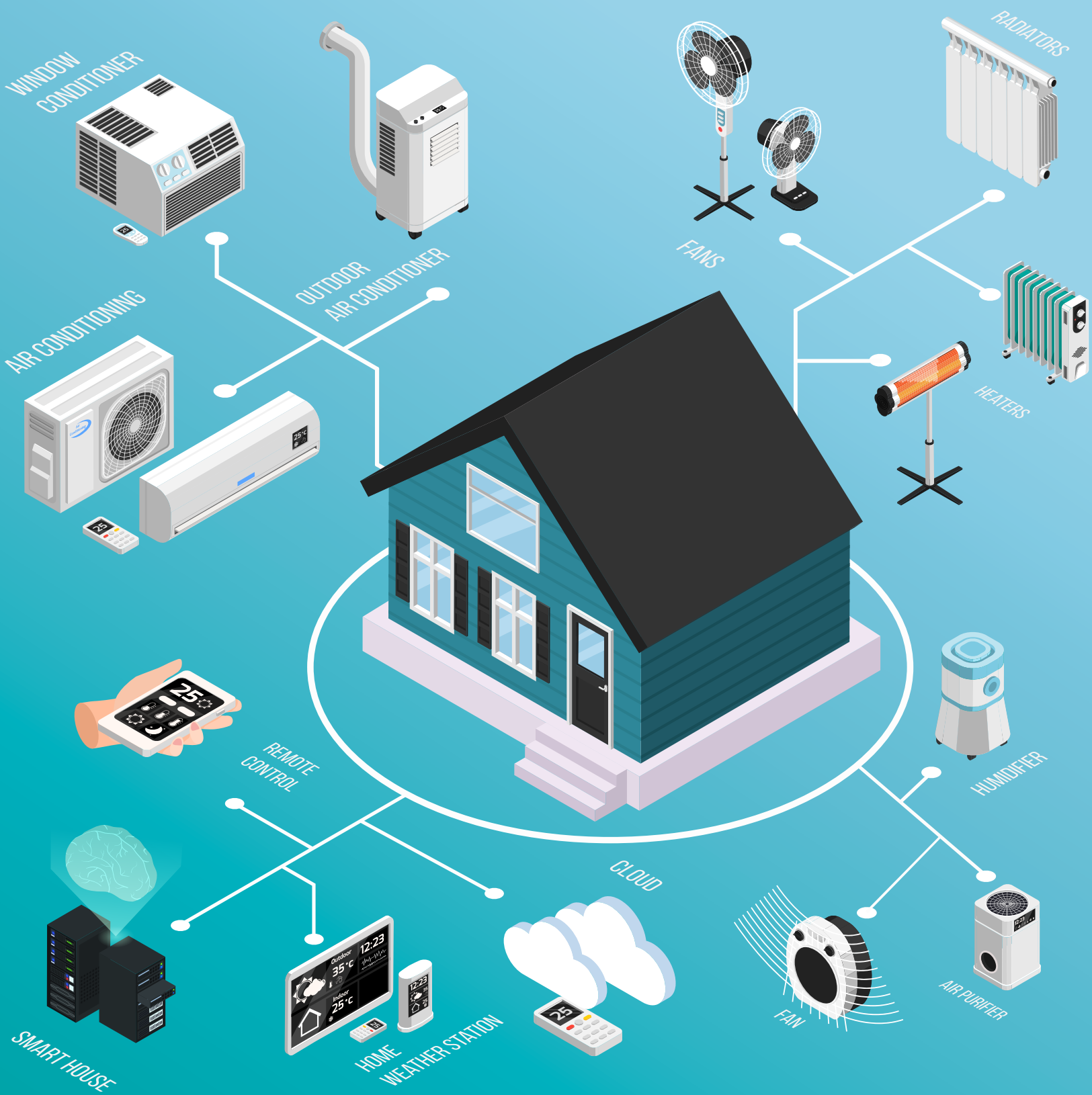
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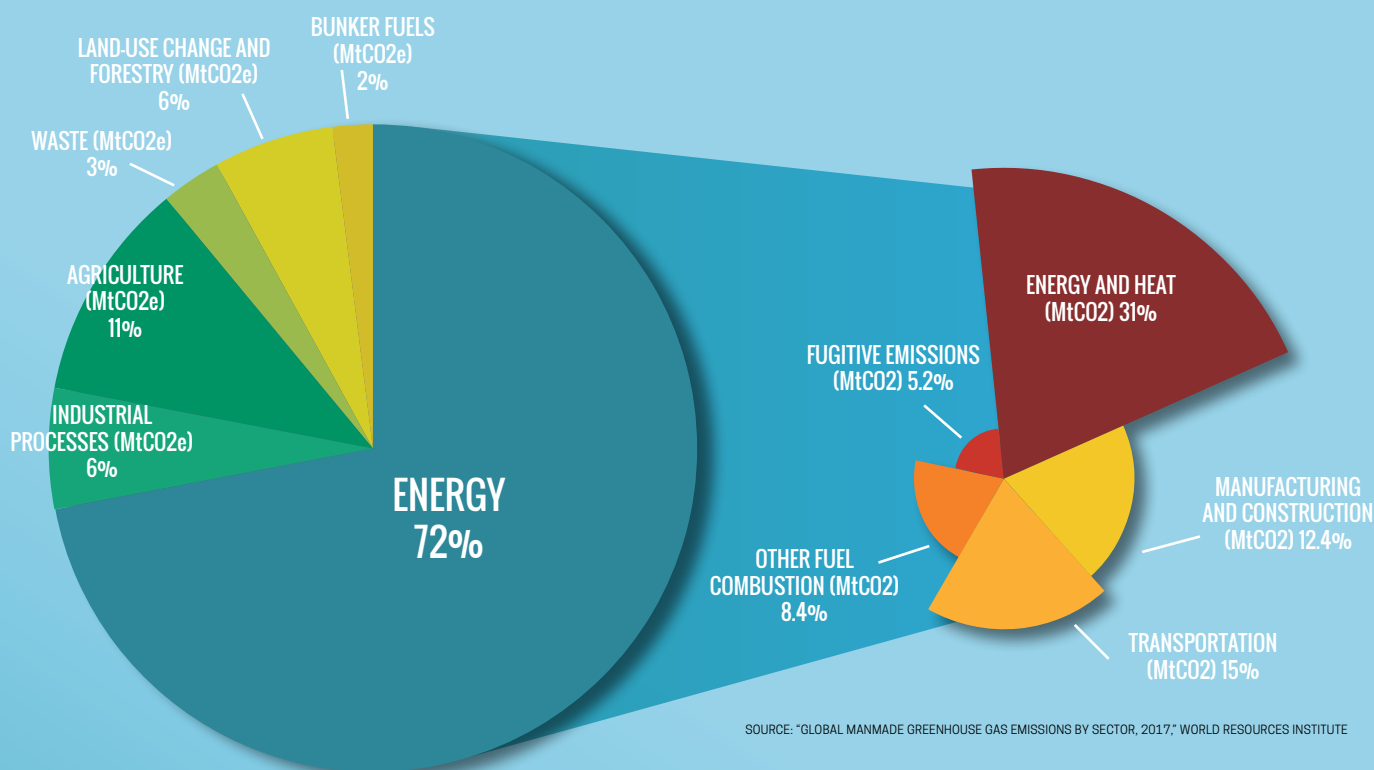
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A TIME OF TRANSITION: THE DATA SAYS IT ALL



THE STATE OF SUSTAINABLE BUILDING 2022



SOURCE: "GLOBAL MANMADE GREENHOUSE GAS EMISSIONS BY SECTOR, 2017," WORLD RESOURCES INSTITUTE

Over nearly two years, the pandemic has acted like a surprise electric jolt upon the building industry. **BY GREEN BUILDER STAFF**

What's not yet clear is whether we'll use this power surge to accelerate sustainable practices, or whether it will make the CO₂ impact of building worse.

To create a meaningful impact on runaway Climate Change, we need to set our sights on the full-scale decarbonization of our economy, reaching net zero emissions across all sectors as quickly as possible. But are we up to the challenge? Author George Monbiot argues that we've first got to stop believing in "green growth," and start "using less of everything."

That honorable intention may become our species' epitaph, but for now, we can do our part in the shelter sector, and tackle pollution priorities: the burning of fossil fuels for heat and electricity, construction materials, methods, and innovations.

For building pros, that means doubling down on the direction many have been moving in for some time: upgrading energy efficiency and insulation, encouraging product innovation along with conservation. Let's take a closer look at where we stand, and where we need to go.



PART 1

Sky-High Demand

The booming construction and sales activity of 2021 is going to level off—but nobody’s sure by how much.



CREDIT: ISTOCK/DIMENSIONS

Despite, or perhaps because of, the pandemic, homebuilding and remodeling surged in 2021. A “perfect storm” of limited housing inventory, high material costs and labor shortages pushed competent building companies into high demand. Analysts expect the storm to continue in 2022—at first.

Most of the good news will be in the early part of the year, as the once-blistering housing economy cools and gives way to a general correction. Economic experts are forecasting growth in single-family home construction, sales and pricing at a pace that is about 40 percent to 50 percent the levels seen in 2021. Much of that depends on how the pandemic plays out in coming months, as well as the government’s ability to resolve infrastructure and debt ceiling issues.

According to Beth Sorvino, U.S. chief economist for S&P Global, there are two probable scenarios. The positive one portrays a



A Real Estate Gold Rush



\$475,000
in late 2019

\$625,000
in late 2021

A single-family home may not change much in appearance in only a couple years, but its sticker price can. This Sacramento, California-area residence sold for \$475,000 in late 2019 but was worth \$625,000 in late 2021. CREDIT: GREEN BUILDER MEDIA

stimulus-driven economic recovery, along with a massive vaccine push, that results in herd immunity that brings back consumer confidence, increases public demand and ultimately leads to production growth and reduced inflation by the end of 2022.

The not-so-positive version sees the U.S. economy continuing to suffer shortages of labor and goods, inflation that creeps up consistently, stagnant job growth, weakening of consumer real disposable income, and big-ticket spending that slows through the first half of 2023.

Marco Santarelli, founder of Norada Real Estate Investments, believes more in the former scenario. “While we still face economic and health challenges ahead,” he notes, “there is no doubt that the nation will continue to recover from this pandemic, and an improving economy will continue to prop up the housing market competition.”

THE HOUSING MARKET—BOOM OR BUST?

Nearly every real estate analyst acknowledges that 2021 has surpassed their predictions in terms of housing prices, sales and construction starts. The record-setting numbers in these categories were attributed in part to a nation’s recovery from the pandemic—and resulting need to “get back to life”—and to government-sustained low interest rates.

Homes in general, always considered a strong source of family wealth, became an even greater investment in 2021. The numbers

Housing Market Stats	2021 Year-Over-Year Predictions	2021 Year-Over-Year Actual (projected)
Existing home sales	↑ Up 8.5%	↑ Up 21.9%
Newly built home sales	↑ Up 12.8%	↓ Down 3.4%
Home prices	↑ Up 7.5%	↑ Up 19.5%
Mortgage rates (30-year fixed)	3%	2.99%

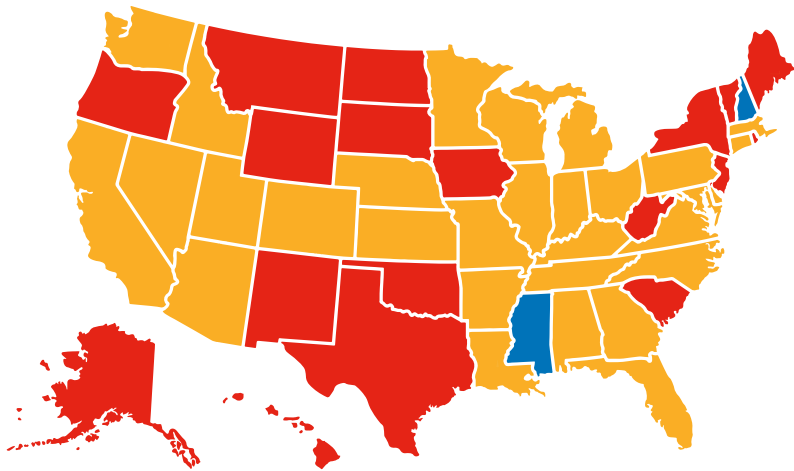
SOURCE: U.S. CENSUS BUREAU AND THE U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

varied slightly, but analysts nationwide forecast double-digit growth in valuation. For example, market projections by **COGNITION Smart Data**, Green Builder Media’s market intelligence division, showed a 13.5 percent growth rate by mid-year, a number financial experts called “very reasonable.” Small mortgage handler **Freddie Mac** offered a 16.1 percent forecast, considered to be “on the high end.” Online real estate marketer **Zillow** saw a 17.7 percent year-to-year increase, a number some analysts said was “very bullish.”

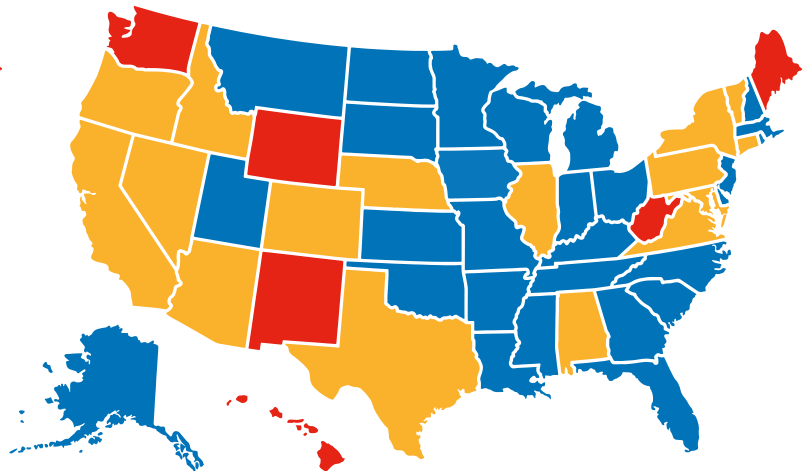
But the bottom line was that it meant more financially to own a home than it has at any time since the early 1980s, according to research firm **Statista**. Many owners took advantage of their homes’ increased equity—and pandemic-induced free time—to take out a second loan for remodeling, or refinance for extra

Supply vs. demand

HOME BUYER TRAFFIC



HOME SELLER TRAFFIC



STABLE

HIGH

SUPER HIGH

In 2021, most of the nation experienced excessive home buyer traffic. Meanwhile, there were far fewer sellers with product, making it harder for buyers to find their dream homes. SOURCE: REALTORS CONFIDENCE INDEX SURVEY, 2021

cash. That won't change, according to the [Leading Indicator of Remodeling Activity \(LIRA\)](#) report by Harvard University's Joint Center for Housing Studies. Annual growth in home renovation and repair expenditures is expected to climb from 4.7 percent in

the first quarter of 2021, to 9.2 percent by year's end and up to 12.3 percent by fall 2022. If it does, total spending on residential remodeling by then would hit \$401 billion, up from \$351 billion in mid-2021.

"Residential remodeling continues to benefit from a strong housing market with elevated home construction and sales activity, and immense house price appreciation in markets across the country," says Carlos Martín, project director of the Remodeling Futures Program. "The rapid expansion of owners' equity is likely to fuel demand for more and

larger remodeling projects into next year."

Heading into 2022, some homeowners may decide to completely cash it in. Experts note that there could be more homes on the market than there were at the end of 2020 because of how

much more they are worth. As such, it's a prime time to sell, according to Sherry Chris, president and CEO of Better Homes and Gardens Real Estate. She notes that a person who sold a house in the first quarter of 2021 made an average of \$94,500 and had an average return of 44.9 percent on the home's original price. Those numbers won't be as high in the coming year but they will still be a significant jump from two years earlier, experts note.

Sales volume didn't change much from 2020 to 2021, largely due to limited inventory. COGNITION forecast a 6.9 million unit total, about the same as government large mortgage handler [Fannie Mae's](#) 6.8 million estimate. Total sales were up from 6.5 million in 2020, and are expected to remain flat in 2022, according to Freddie Mac Chief Economist Sam Khater.

Median list prices increased by 13.7 percent, up to \$353,000 nationally, according to COGNITION. Findings by real estate brokerage firm [RedFin](#) support these numbers, adding that 54 percent of all homes sold above list price in 2021. Freddie Mac and the National Association of Realtors each reported a list price increase of 16.9 percent, to about \$385,000.

Skylar Olsen, principal economist at digital home buying platform [Tomo Networks](#), considers the speed of home sales and rising home prices over the past year "staggering." Tomo notes that the pace will slow a bit in 2022 as sales competition lessens, "but don't expect prices to come down drastically any time soon."

Experts' opinions vary. Financial analyst [CoreLogic](#) expects home prices to increase by only 2.2 percent; Freddie Mac believes it will be more like 5.3 percent. Zillow, meanwhile, is exceptionally optimistic at 11.7 percent. Research firm [Pulsenomics](#) takes

"Despite some obvious headwinds, the housing market remains strong. Even as mortgage rates are expected to increase and home prices continue to rise, homebuyer demand remains steady as inventory issues have slightly improved."

SAM KHATER, CHIEF ECONOMIST, FREDDIE MAC



A Runaway Remodeling Market?

Rising home equity and pandemic-related free time led to homeowners investing in remodeling projects at a record pace over the past two years. Homeowners spent an average of almost \$18,000, up from a pre-COVID \$12,000, and projects increased by 75 percent in some U.S. markets, according to COGNITION. There's more to come: nearly 4 out of 5 homeowners surveyed said they plan to undertake at least one new project within the next year, or have already done so.

Most of those projects are related to outdoor living (61 percent), interior upgrades like repainting, reflooring, and kitchen and bathroom renovations (58 percent), and tech improvements (44 percent), the survey notes.

Kitchens and bathrooms have long been two of the most frequently updated rooms in the home due to the "joy factor," or how much personal enjoyment homeowners get from creating dream spaces, COGNITION notes. They are also the two most frequently used rooms in the house, so enhancing their aesthetics and functionality improves quality of life.

Rising home prices also played a role in whether owners opened up their wallets, according to Houzz senior economist Marine Sargsyan. "While the pandemic caused initial concern for the residential renovation industry, many homeowners finally had the time and financial means to move forward with long awaited projects in the past year," Sargsyan notes. "This pent up demand, along with other long-standing market fundamentals such as accumulated equity, will empower homeowners to continue investing in their current homes, rather than face skyrocketing prices in the housing market."

Nearly half of the respondents to Houzz's own market survey said they had already planned, pre-pandemic, to undertake a home improvement project. Another one-third cited financial means as being the key trigger. One-quarter of respondents said they wanted to renovate because it was less expensive than buying a new home.

Remodeling can also often be done over time, which allows homeowners the ability to budget and stretch their finances, COGNITION notes.

The generation most likely to remodel their homes are millennials, the current 20- and 30-somethings that made up more than half of consumers surveyed by COGNITION. Generation X, which is only half the size of millennials, and baby boomers, most of whom are 60- or 70-plus and beginning to age out of the market, combine for about 30 percent. Generation Z, the oldest of whom just reached the legal voting age, make up less than 10 percent of those with remodeling interest. But this group's 67-million person size—only about 5 million less than the millennials—definitely makes it the wave of the future, according to the Pew Research Center.

4 of 5 homeowners surveyed said they plan to undertake at least one new project within the next year

Homeowners spent an average of almost \$18,000, up from a pre-COVID \$12,000 on remodeling

Projects increased by 75 percent in some U.S. markets

How people prefer to pay for remodeling:
Cash (83 percent)
Credit cards (29 percent)
Tax refunds (10 percent)

Homeowner
Improvements & Repairs
Four-Quarter Moving
Totals in Billions

LEADING INDICATOR OF REMODELING ACTIVITY Second Quarter 2021



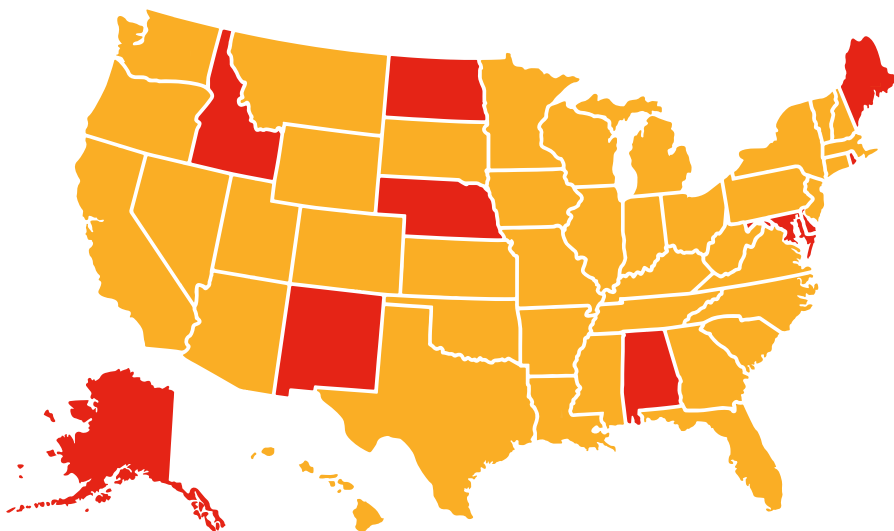


How fast do homes leave the market?

MEDIAN DAYS ON MARKET

WITHIN 15

16-30



Going, going, gone. Sellers have not needed to wait long to pass the house keys to their buyers—homes nationwide were off the market in less than a month, sometimes even less than two weeks. SOURCE: REALTORS CONFIDENCE INDEX SURVEY, 2021

The average home stayed/
will stay on the market for:

38 days
in 2019

21 days
in 2020

17 days
in 2021

19 days
in 2022
(estimated)



a longer-term approach, forecasting an annual rate of 5.7 percent through 2025.

All of those projections are well below the list price increases of 2021, a sign that the market may finally be moving, as Zillow puts it, “from white hot to just red hot.”

Still, housing prices are expected to continue to rise in the coming year. The biggest reason? The same as in 2021: low inventory. Analysts at Freddie Mac say there is still a 4 million home shortage heading into 2022, a guarantee that things are not going to level off significantly any time soon.

A potential glass of water on the hot housing market: higher interest rates. The average rate stayed at about 3 percent throughout the year. This is expected to increase, perhaps reaching Fannie Mae’s estimate of 4 percent by the end of 2022. This could price some potential buyers out of the market, the government lender notes.

Brian Bernard, director of industrial equity research for financial services firm **Morningstar**, agrees. But it won’t be enough to slow the housing market on its own. “In our view, there is still plenty of pent-up demand from households that can shoulder higher, but still palatable, mortgage rates,” Bernard says.

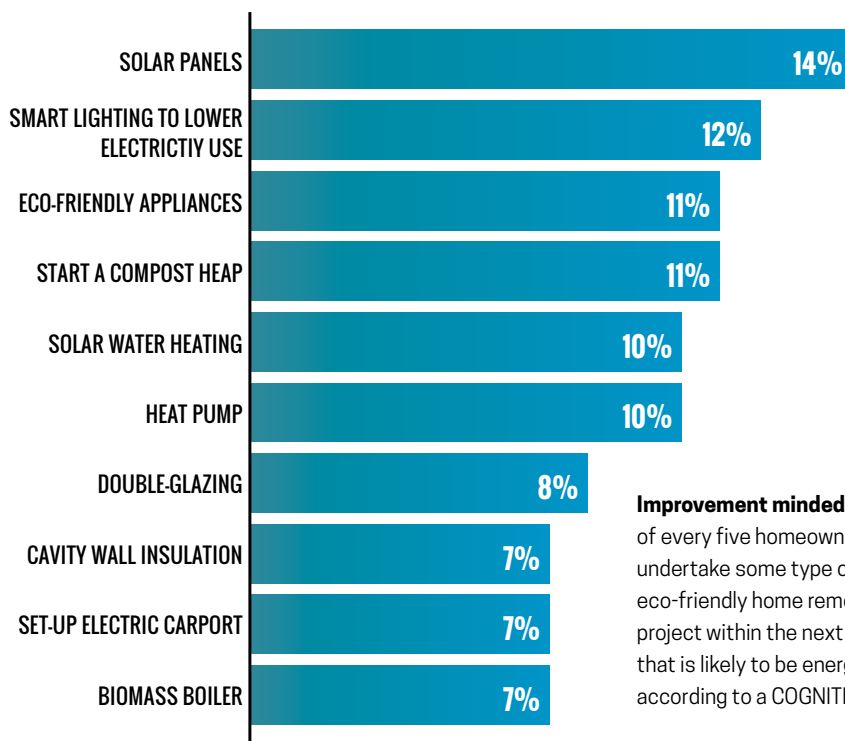
A second, possible deterrent: Financial necessity. Homeowners who are on the verge of foreclosure—largely due to pandemic-induced financial problems—will create underpriced inventory. This won’t be enough to pull home values down overall—foreclosures are expected to make up only 5.4 percent of available inventory in 2022—but it will give buyers a bit more selection at slightly better cost, Fannie Mae notes.

Overall, homeowners listing their houses will make up about 39.7 percent of the available inventory in 2022, according to Zillow. It’s the largest source of inventory, but not as influential as new housing, analysts note.

NEW HOME CONSTRUCTION: KING OF MARKET GROWTH

Although it’s the second-largest generator of housing inventory—accounting for 22.5 percent of all sales, about 17.2 percent behind existing homes—nothing pushes the market ahead like new construction, according to Zillow. “New home construction has been weighed down in 2021, due to shortages of key building materials,” says Cory Hopkins, manager of economists at Zillow. “But despite the setbacks, [construction] has largely remained above pre-pandemic levels.”

Eco-friendly improvements homeowners are planning to make in the next year



Improvement minded. Two out of every five homeowners plan to undertake some type of eco-friendly home remodeling project within the next year, one that is likely to be energy-saving, according to a COGNITION survey.

COGNITION predicted 2021 single-family housing starts totaling 1.134 million, right in line with the **Mortgage Bankers Association’s** numbers and an arm’s length from Morningstar, at 1.115 million, and real estate firm **Windmere Economics** at 1.117 million.

While 2021 was “another strong year” for single-family construction, it’s unreasonable to expect more of the same in 2022 and beyond, Bernard notes. “Construction growth will moderate,” he says. “Homebuilders will boost production to address the under-supply of single-family homes, [but] we don’t think the homebuilding industry has the capacity for housing starts to sustain the levels seen in the mid-2000s.”

Morningstar’s findings are echoed by COGNITION. The market

“The silver lining for aspiring homeowners is that the worst of the housing supply crunch looks to finally be behind us, and most experts believe that the past year’s rapid price boil has begun to simmer down.”

TERRY LOEBS, FOUNDER, PULSENOMICS



CREDIT: ISTOCK/SOLSTOCK

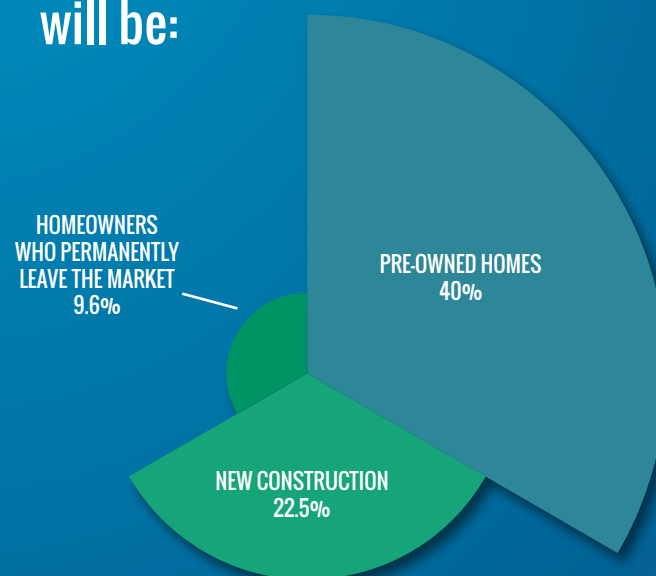
Crisis-Level Labor Shortage

With the construction industry facing a projected shortage of about 61,000 workers per month—and the expected loss of about 3 percent of its current workforce over the next several years due to aging or people simply leaving the sector for good—there's an immediate need to bring in some new blood. "We need to build the next generation of skilled tradespeople in construction," says HBI President and CEO Ed Brady. "One of our most important tasks as an industry is to work with parents, educators and students, as early as the middle school years, to demonstrate that young people can have the promise of great jobs and careers in the trades."

Brady says there are six fundamental steps that home builders can take to increase the number of skilled construction trade workers:

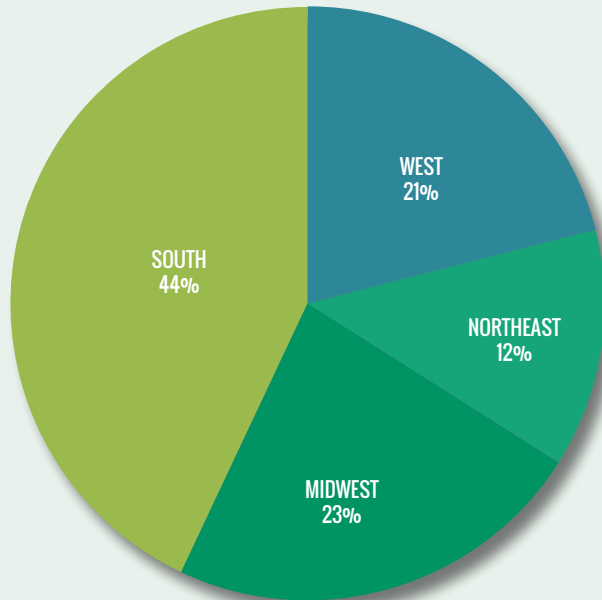
1. Reach out to secondary school students, and those who influence their decisions, to change their perception of careers in construction.
2. Increase worker pay while balancing the need to keep homeownership affordable.
3. Attract more women into careers in construction.
4. Train and place more minority and lower-income youth and adults in important industry jobs.
5. Increase trade skills education for veterans and transitioning military.
6. Work for bipartisan approaches to sensible immigration policies.

The largest sources of housing inventory in 2022 will be:





Existing Home Sales by region



Southern comfort. If you sold a home last fall, there's a good chance it was in the southern U.S., where prices were lowest but seller equity was among the best in the nation.

SOURCE: NATIONAL ASSOCIATION OF REALTORS

The 10 most-expensive U.S. cities to live in, by real estate

Manhattan, NY	(\$1,400/square foot)
San Francisco, CA	(\$1,100/square foot)
Boston, MA	(\$760/square foot)
Brooklyn, NY	(\$720/square foot)
Honolulu, HI	(\$700/square foot)
San Jose, CA	(\$610/square foot)
Los Angeles, CA	(\$550/square foot)
Oakland, CA	(\$525/square foot)
Seattle, WA	(\$520/square foot)
Bethesda, MD	(\$500/square foot)

intelligence service expects moderate growth rates of 1.165 million starts in 2022 and 1.210 million in 2023.

Another key indicator, building permits, shows a continued spike from coast to coast over the past two years. According to **Omni Panels'** latest analysis of U.S. Census Bureau and U.S. Department of Housing and Urban Development data, the overall number of residential construction permits issued in 2020 and 2021 increased 36 percent nationally. For single family homes, the increase was 30 percent; for large buildings containing 5 or more units, the increase was 21 percent.

Much of the new residential construction has taken place in the southern U.S. A report by New York City-based Regional Gutter Repair (RGR) shows that five of the nation's six most-active metropolitan areas in 2021 were in Florida, North Carolina, and South Carolina. The ringleader, North Port/Sarasota/Bradenton, averaged nearly 1,400 new permits per 100,000 residents. According to RGR specialist Henry Gerbin, this equates to more than 1 percent of the market population requiring new construction, "a clear indication of a housing boom, and good news for general contractors."

But getting those new homes started is impossible if there's no one to do the work. The lack of skilled labor continues to hinder construction growth just as it did pre-pandemic. According to a

labor market report by the **Home Builders Institute (HBI)**, the construction industry needs 740,000 available workers per year for the next three years to keep up with demand. That's about 61,000 new hires per month from 2022 to 2024, a figure that HBI President and CEO Ed Brady calls "staggering."

"The construction worker shortage has reached crisis level," Brady says. "The situation will become even more challenging in the coming year when other industries rebound and offer competitive wages and benefits to prospective employees."

A big wildcard in terms of how active construction will really be in 2022? Lumber. Prices hit an otherworldly high in the summer of 2021 at \$1,670 per thousand board feet—and later scaled back to about \$615 in mid-November, according to Trend Economics. That total is still a light year above the pre-pandemic five-year average of \$356, and it is more than likely where things are going to stay, according to Bryan Shaffer, principal and managing director at Los Angeles-based real estate investment firm George Smith Partners. "I think the \$500 to \$600 range is going to be more the new normal for at least the next 12 months," Shaffer **reported in GlobeSt.com**. "Nothing's normalized yet. And you have the inflation and labor issues cropping into pricing of everything. It's very hard to get labor today so it's made it harder for all the producers to get goods out."

PART 2

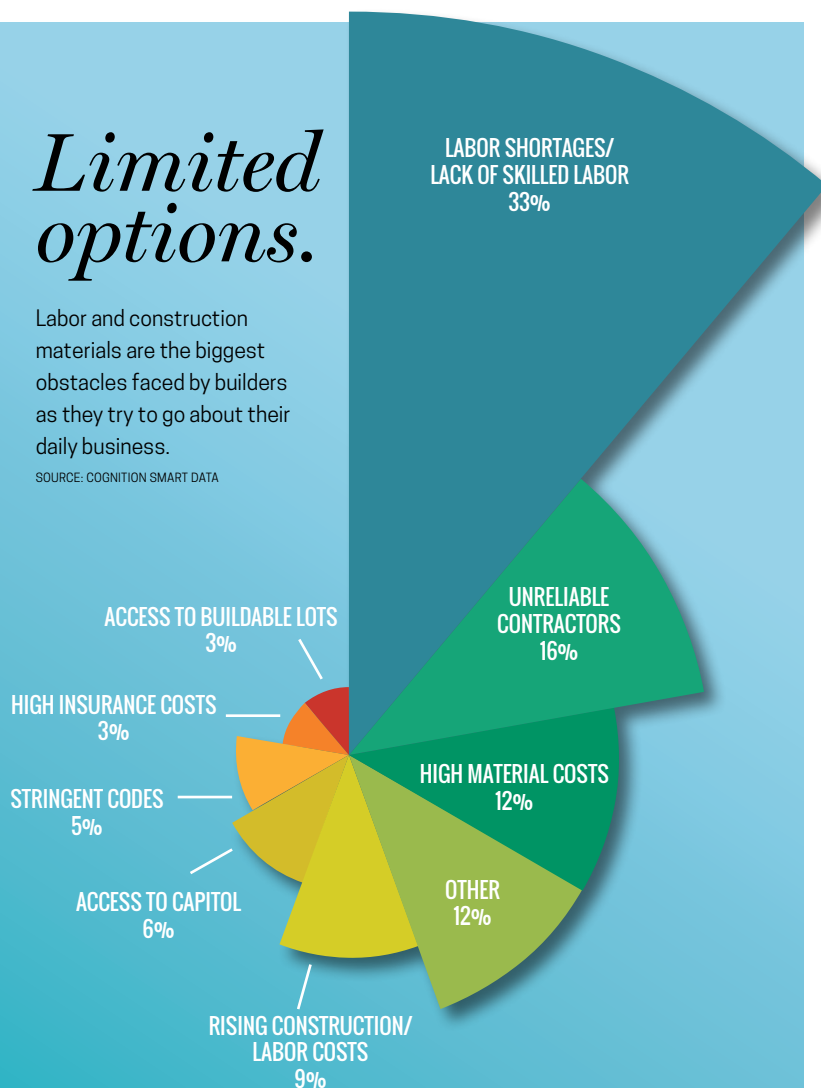
Alternative Systems Rising

Shortages of lumber and other construction materials offer a golden opportunity for other ways to build a home.

Limited options.

Labor and construction materials are the biggest obstacles faced by builders as they try to go about their daily business.

SOURCE: COGNITION SMART DATA



For the construction sector, the past year can be summed up with two modified statements: If you don't have it, you can't build it. If you don't build it, they won't come. Thanks to the pandemic, builders have seen a lot of the former en route to the latter: Higher prices, materials shortages and workforce problems have the industry searching for other ways to get the job done.

The effort has given insulated concrete forms (ICFs), structural insulated panels (SIPs) and other energy-efficient structural systems a tremendous boost. But not every material shift moves the needle toward greater sustainability. Replacing wood with steel framing, for example, infers the need for additional, CO₂-intensive insulation or other methods to achieve a thermal break, to compensate for steel's extremely high thermal transfer characteristics. It's not just an easy swap.

It's a complicated situation, one that's going to be a headache for a while longer. Data indicates that some construction supplies will remain tight until at least next summer. Meanwhile, all anyone can do is plan carefully.

THE CONSTRUCTION SECTOR: CHALLENGES TO OVERCOME

Going into 2020, experts presented a familiar slate of problems facing builders. These included lumber costs, which were expected to rise (again); materials that were harder to find; and a workforce that would continue to shrink. More than 80 percent of builders surveyed by COGNITION Smart Data cited these challenges as being the items they have been and will be struggling with while doing business.

In a survey by the National Association of Home Builders conducted last May, 90 percent of respondents reported shortages of appliances, framing lumber oriented strand board (OSB), and plywood. Eighty-seven percent also cited shortages of doors and windows; 50 percent reported shortages of steel beams, insulation, roofing materials, vinyl siding, copper wiring, and plumbing fixtures, among other materials.

Deepa Raghavan, a housing market analyst for Wells Fargo & Company, doesn't find the numbers surprising. But they are frustrating. "It used to be like Whac-A-Mole, where you would whack one thing and another one would pop up," Raghavan said in a report from the Wall Street Journal. "This is like six of them coming out and you can only whack two at a time."

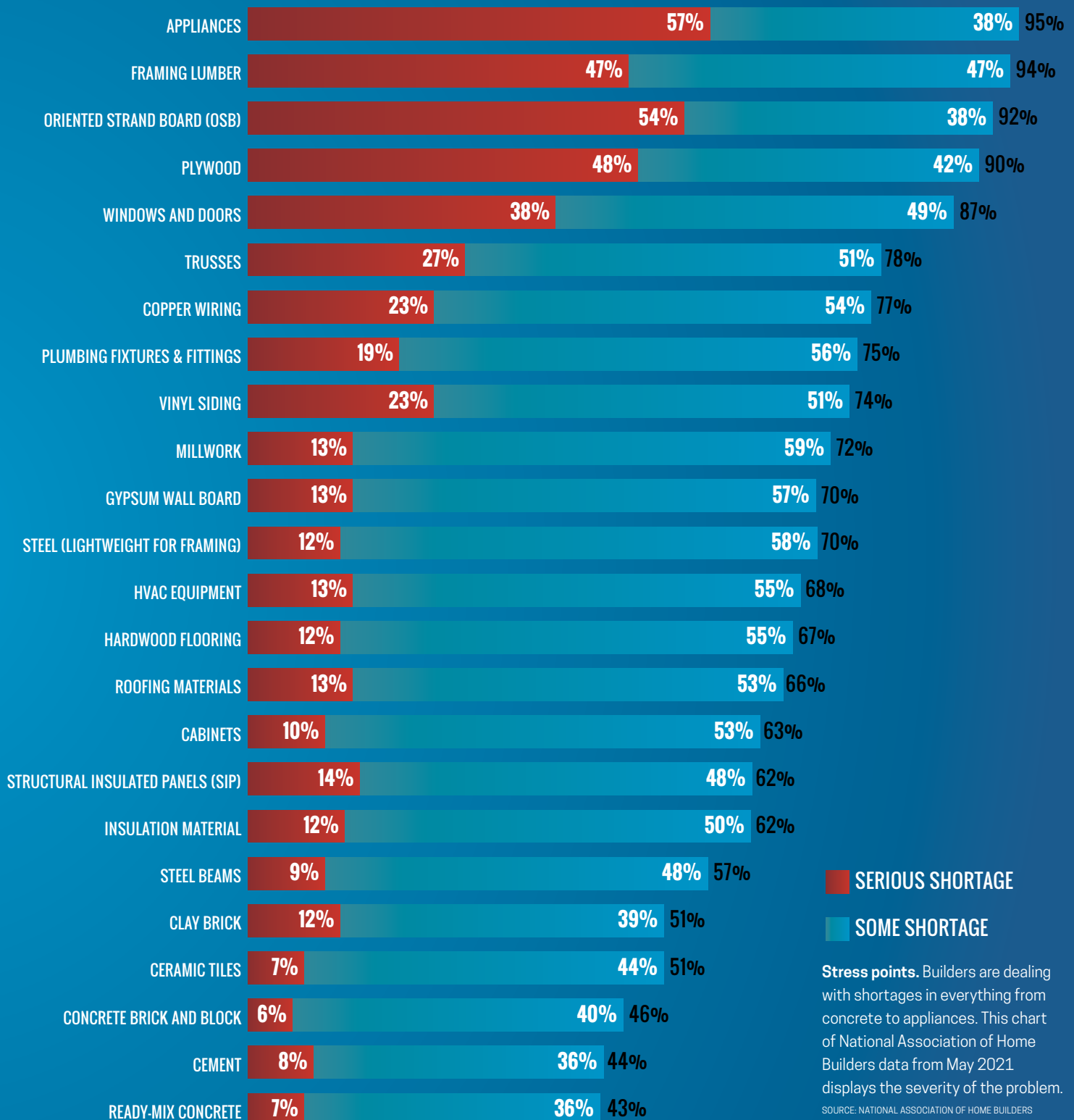
Builders have been forced to seek new suppliers or alternative products, sometimes with mixed results. Delivery times have been delayed, with many builders being forced to place orders without concrete dates or prices. These delays disrupt construction schedules, which costs builders time and money, leading to increased costs for consumers. That, in turn, has priced 2.1 million U.S. consumers out of home ownership.

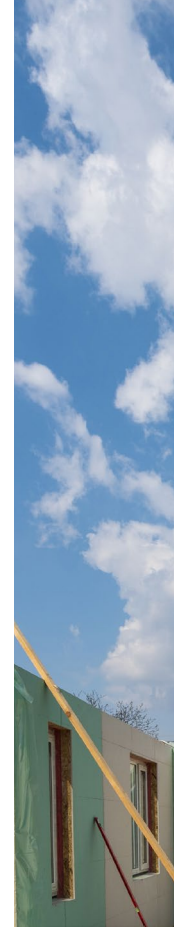
Straub Construction in Shawnee, Kansas, changed insulation materials when its usual supplier couldn't fill the order. The switch added \$20,000 to the project's cost, but it was better than delaying things by six to nine months before the original product arrived. "It's unprecedented," company president Parker Young said in a report from the Wall Street Journal. "I've been in the business for 30 years and never seen anything like this."

Nor has Greg Sizemore, vice president of workforce development

Builders Reporting Shortages in May 2021

(Percent of Builders who Purchase the Material or Product)





at Associated Builders and Contractors in Washington, D.C. He acknowledges that every project has a start date and an end date. But these days, it's harder than ever to stick to those, which often

“As the United States recovers from a devastating economic crisis caused by the COVID-19 pandemic, there is new demand—nationally and internationally—for critical materials that have not seen price spikes in years.”

TIM HOFFER, CHIEF OPERATING OFFICER,
UNDERGROUND SERVICES INC. (SOFTDIG)

“disheartening.” But there are alternatives to traditional building. The materials shortage, the company advises, “doesn’t have to be the end of the story.”

AN ALPHABETICAL ENVELOPE: ICP, ICF, SIP AND VIP

When searching for an alternative building envelope system, insulated concrete panels (ICPs), Insulated Concrete Forms (ICFs), and SIPs have advantages.

means negotiating what gets done when. “Maybe you were planning to install a refrigerator one day, but the wood for the floor gets delayed,” he notes in a report at [Marketplace.org](https://www.marketplace.org). “You can’t install the refrigerator. So, we do something else—like the countertops, which might be marble if granite’s not available.”

On its website, officials at modular home contractor Vesta Modular in Southfield, Michigan notes that many people may find the situation

In terms of moisture management, ICP, ICF and factory-built SIP wall panels are nearly completely moisture impermeable. They also have the advantage of being equally impermeable from the outside-in and the inside-out, giving them multi-climate, all-season resistance to condensation issues.

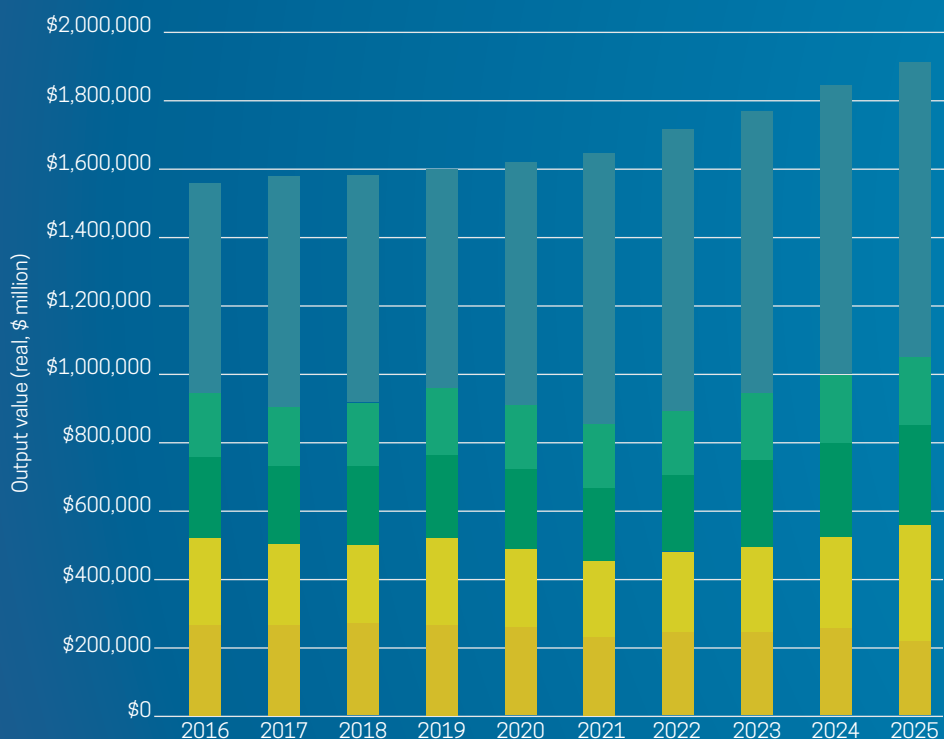
With ICPs, ICFs, and SIPs, the insulation is already in the wall when assembled, so one less trade is required. The required framing crew is about the same in terms of number of people, but there is less handwork involved, meaning the job goes quicker.

“What makes ICFs so attractive is that they are cost competitive with wood frame, steel frame and masonry construction,” notes Lionel Lemay, executive vice president of structures and sustainability for the National Ready Mixed Concrete Association. “A building owner gets a building that is more disaster resilient and energy efficient, at or nearly at, the same cost.”

BASF *Neopor* and other graphite-infused foams are already impacting the ICP, ICF and SIP industry by offering higher true R-values in the same thickness of wall assembly. When the cost of lumber is high, SIPs can be installed for the same cost as a stick-framed wall.

Most stick-frame builders fail to calculate more than the cost of the framing and insulation, leaving out the value of time savings and other intangibles. For example, being able to build six homes in the time it would otherwise take to build five with the same size crew and the same group of sub-contractors yields a substantial economic advantage.

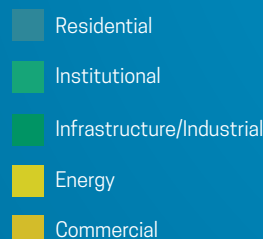
Advocates of ICPs, ICFs and SIPs are also keeping their eye on vacuum insulated panels (VIPs), especially for existing home applications and when space is tight. VIPs are comprised of rigid panels with a microporous core that has been evacuated, encased,



Supporting factor

Unlike other segments of the industry, residential construction has more than held its own since 2016. That trend is expected to continue through at least 2025.

SOURCE: GLOBALDATA



Predicted U.S. construction growth rates:

1.4% in 2021

2.8% in 2022

2.2% thru 2025



Attractive option. Structural insulated panels (SIPs) offer higher true R-values in the same thickness of a wall assembly. And, when the lumber prices are high, SIPs can be installed for the same cost as a stick-framed wall.

CREDIT: ISTOCK/BRIZMAKER

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and sealed in a thin, gas-tight envelope to give outstanding R-values and an ultra-thin insulation solution. Manufacturers tout that VIPs have a high level of thermal efficiency (up to five times better than other commonly available building insulation materials) with minimal thickness. VIPs are also more than 90 percent (by weight) recyclable and therefore make for a very sustainable option, according to the [U.S. Green Building Council \(USGBC\)](#).

MODULAR AND PREFABS: INSTANT ACHIEVEMENTS

Projected to gain momentum and market adoption over time due to the resource and labor efficiencies that the process can achieve, modular and prefabricated construction makes it possible to take

advantage of economies of scale, faster speed, and improved quality control, making it an increasingly attractive option. Modular construction also exhibits a substantial decrease in waste generation when compared to traditional building methods—up to 90 percent, according to the [Waste & Resources Action Programme \(WRAP\)](#).

“Green building efforts for site-built construction focus on reuse, recycling or diversion of waste that is generated on site,” notes the [Modular Building Institute](#). “With off-site construction, however, the materials can be managed prior to leaving the factory, offering a much more efficient process to reduce the amount of waste sent to landfills.”

The global modular construction market size is projected to grow from \$85.4 billion in 2020 to USD \$107.9 billion by 2025, according to COGNITION. This market growth is attributed to increased concern about labor shortages, work-zone safety, environmental impact, ongoing investment in residential housing development, renewed focus on upgrading healthcare infrastructure, and government incentives.

QUALITY CONTROL'S TOP ALLY: PANELIZATION

Quality insulation, windows and other building envelope systems are paramount for home performance. Experts note that poor insulation installation can cut a building's energy performance by up to 28 percent. This is a growing concern, particularly as energy performance targets continue to ratchet up. Enter panelization, which solves for quality issues because the wall framing is so precise that insulation installation can be exact.

Panelization, or prefabricated wall panels, can also solve water and moisture management concerns. Fiberglass and other “soft fill” insulation materials are the most common failure points in wood-frame construction, according to COGNITION data. They are prone to trapping moisture, leading to mold, fungus, and rot.

States recognize the method's importance to quality control in housing. For example, California's [Quality Installation Inspection \(QII\)](#) sets specific standards for panelization in residential dwellings and offers incentives to builders who meet the standards. It has also become a key factor when a builder seeks Leadership in Energy and Environmental Design (LEED) certification for a home.

There's a labor-friendly aspect as well. Prefabricated wall systems can be installed with smaller crew sizes—typically six to eight people—which is a 60 percent or greater reduction in jobsite workforce compared to on-site construction, according to a report in [Walls & Ceilings](#).

“Throughout the pandemic, the construction industry has witnessed how a controlled manufacturing environment has allowed fabrication and construction to stay on schedule,” the report notes. “In a post-pandemic world, these benefits will remain important.”

Insulation Imperfect

The Alexandria, Virginia-based [Insulation Institute](#) and Plano, Texas-headquartered construction consulting firm [Burgess Construction Consultants](#) conducted a survey of more than 100 of the nation's top production builders to identify the five most common insulation install flaws. The study also asked builders to identify their biggest challenges in working with insulation contractors. Most responses pointed toward use of incorrect materials and improper installation. According to the results, the top five areas in which insulation flaws can compromise a building's energy performance are:

1. Improper sealing around windows, doors, and rough openings
2. No sealing of plate penetrations and chases
3. Improperly installed air barriers around double walls, tubs, and showers
4. Drywall not sealed to top plates
5. Misalignment of insulation



Play space. Working at home successfully means crafting a personal space that inspires you to do your best work—something many people did over this past year.

CREDIT: FLICKR/DALE CRUSE

PART 3 New Priorities

Fear, contemplation and technology have converged to change where people want to live, and what kind of housing they prefer.

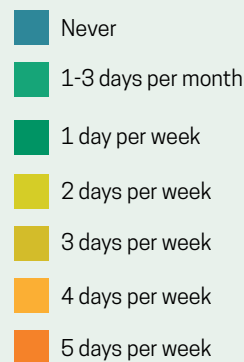
With the pandemic's lingering impact on daily life came many shifts in how people perceive and use their living spaces. Along with this came the first signs of American climate migration—for example, as homeowners fled the drought and wildfires of the West, they moved east. Call it a quest for resilience: People want a life with less anxiety, a safe haven with more family time at home, an easier cooking experience, more home office spaces. Change has come, and it's driving remodeling, relocation and re-thinking of what “home” means.

SANCTUARY SPACE

Home has become, more than ever, a sanctuary and a safe space, changing the way people think about well-being, belonging, health, and peace of mind.

Pre-COVID-19, only about 10 to 15 percent of homes had a

Employees would like to work remotely...

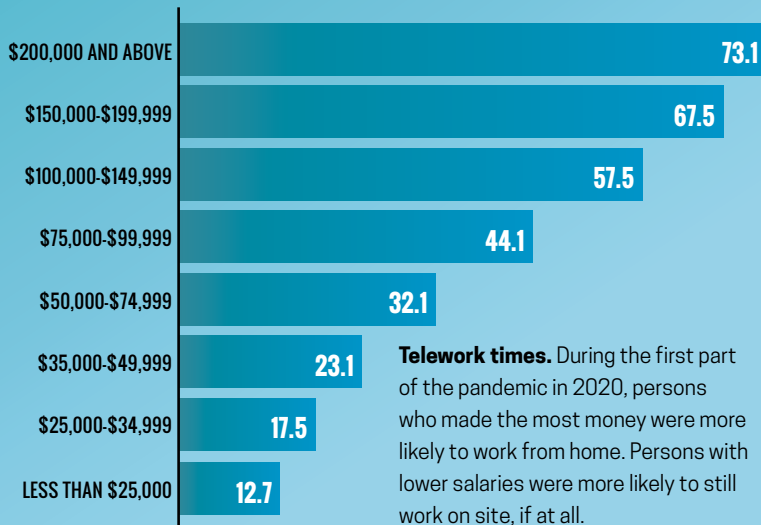


SOURCE: PWC U.S. REMOTE WORK SURVEY 2021

dedicated office space. Now, that number is closer to 75 percent, according to COGNITION Smart Data. A big reason for the new in-home office space is necessity: studies from Pew Research, Gallup, Stanford University, the Census Bureau and others reveal that at least 50 to 75 percent of the workforce began teleworking in 2020 due to the pandemic. About one-third want to continue telecommuting after they would normally go back to the office.

“People who plan to work from home want more than just a

Percentage of Households by Income with Adult(s) Who Switched to Telework Because of the Coronavirus Pandemic



Telework times. During the first part of the pandemic in 2020, persons who made the most money were more likely to work from home. Persons with lower salaries were more likely to still work on site, if at all.

SOURCE: U.S. CENSUS BUREAU HOUSEHOLD PULSE SURVEY

Thinking Smart



Nearly 75 percent of Americans currently use smart technology in their homes



Americans will spend \$90 billion on smart home devices by 2023



Once a homeowner purchases one smart home device, they are 70 percent likely to purchase another one



60 percent of homebuyers will pay more for a smart home



57 percent of homeowners say that smart home technology saves them at least 30 minutes per day (182.5 hours a year, or roughly 1.5 weeks)

SOURCE: COGNITION SMART DATA

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kitchen table and chair to work from,” COGNITION notes. “They want a place where they can feel comfortable—because they’re going to be spending a lot of time there.”

Those who worked (and may still be working) from home face several decisions when creating a dream office, including size of room, type of work and its needs for maximum productivity, location within the house for best access to Wi-Fi and least amount of interruption, and adequate lighting and ventilation.

There’s also room design. Modern times call for sleek, uncluttered, light and airy spaces to help increase work productivity. A blue color scheme is also in, as it can promote clear thought, calm the mind and aid concentration, according to COGNITION.

“We’ve been quarantined in our homes for more than a year...we’ve had the opportunity to really exist in our spaces and adapt them to make our new homebound lifestyle more tolerable.”

ELIZABETH YUKO, PH.D., ADJUNCT PROFESSOR OF ETHICS, FORDHAM UNIVERSITY

COMFORTS OF HOME

Because they were indoors for quite a while—the most movement-restricted moments were in spring and summer 2020—homeowners went for long-term comforts that made their lives more enjoyable.

For health and wellness, focus was on indoor air quality—ventilation, source control, and contaminant containment; antimicrobial surfaces and finishes; touchless faucets and bidets; home healthcare and telemedicine; and home fitness.

Because of the extended need for contact with the outside world, connected living became a bigger deal. Cue bandwidth, network, and connectivity technologies for enhanced working and schooling from home, along with energy efficiency, performance, and comfort efforts. These included voice-activated locks, appliances and other systems.

There were also resiliency and self-sufficiency matters, such as on-site power production via solar processing and storage tools, on-site food production via outdoor garden areas and indoor growing opportunities like living walls, larger storage and pantry spaces, and water monitoring and leak detection.

A NEW ERA OF CONNECTED LIVING

The idea of going “smart” with a home isn’t a new one. Devices to remotely control lights, temperature, alarms, appliances, sprinkler systems and more have been available for almost 20 years. But homeowners have found other reasons to improve in-house technologies.

Being smart adds value. Smart technologies offer home and



CREDIT: ISTOCK/HISPANOLISTIC

Screen New Deal

It's not just smartphones and Zoom calls. Homebuyers have become more adept than ever with smart home products. Have we crossed a tipping point?

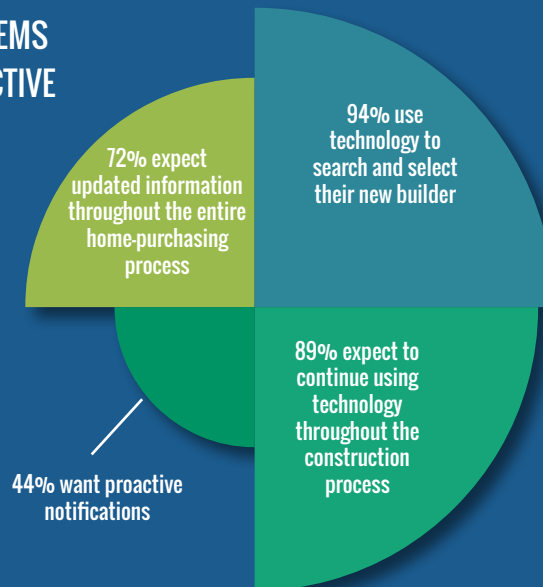
Given current consumer preference and purchasing pattern trends, baseline smart home offerings should include:

- Security—cameras, locks, intruder alerts, remote check-in/monitoring
- Smart thermostats
- Lighting
- Audio/speakers
- An integrated indoor air quality (IAQ) system with monitors and sensors that connect with vent fans, energy recovery ventilators (ERVs) and range hoods to facilitate fresh air exchange
- Water monitoring and leak detection
- Carbon monoxide/smoke detector
- Smart switches/plugs
- Built-in data protection and privacy technologies/protocols
- Enhanced connectivity and bandwidth capabilities to address increased working/schooling from home

Upgraded offerings should include:

- Smart appliances
- Smart irrigation systems
- Integration with solar system
- Aging in place functionality for active adults, including non-intrusive cameras/monitors, fall detection, and voice-controlled technologies

AMONG THE ITEMS THAT PROSPECTIVE CUSTOMERS CONSIDER AS IMPERATIVES:



The Great Digital Beyond

Given that more homebuyers are relying on online tools to shop for homes and willing to purchase a home sight unseen, it's essential for the building industry to participate in the digital revolution.

Builders can augment a buyer's online experience with enhanced 3D home tours, having a social media presence, and providing access to items such as online information, FAQs, and educational videos. "Not only will this position builders as an essential resource to homebuyers, it will also help decrease the stress of purchasing a home," COGNITION notes.

Manufacturers can contribute to this transition by providing building professionals with content, data, research, and insights about key trends and topics to share with buyers, thereby enhancing the online experience.



building owners new levels of convenience, efficiency, comfort, independence, and security.

There's an evolution from the "mindless structure"—disparate devices with separate functionality—to the "mindful structure"—those items integrated by voice control—to the "intuitive structure"—a central hub that connects devices, products, systems and vehicles.

Smart technologies can now learn our behaviors, upgrade themselves seamlessly, and take human error out of building performance to optimize comfort, cost effectiveness, and sustainability.

And there are innovation opportunities. The quickly evolving connected living space provides an opportunity to be creative and stay ahead of the pack.

ROOM TO MOVE

Home ownership has slowed due to COVID-19 and various product supply shortages. But having a set of keys of their own is still on prospective buyers' minds. Pew Research notes that 72 percent of renters want to own a home someday.

As buyers flock to less dense outer suburbs and even rural markets, some of which have been suffering from declining home values for years, they're seeking reasonably priced homes with lawns, gardens, and elbow room.

Limited inventory has shifted consumer priorities and expectations. "While most buyers prefer move-in ready homes, they're no longer turning up their noses at listings that need improvements," COGNITION notes. "It's the veritable return of retro—'dated' is in, especially when the payoff is more outdoor living space."

Consumers are looking to decrease monthly costs and increase asset value. It therefore makes more sense to invest in a home rather than rent, especially with record-low mortgage rates.

AL FRESCO LIVING

There has been a discernable uptick in interest and investment in outdoor living due to an increased interest in a connection with nature, and a desire to entertain outdoors during the pandemic.

Trending projects include deck expansions and replacements, transition spaces such as roof covers, pergolas, and gazebos, outdoor kitchens and entertainment systems, and edible gardens. There's also a preference for rooftop gardens, balconies, and terraces; and integrated planters and greenspace transformed into decks.

There is a move toward "flexible privacy"—the ability to enjoy



Peace offering. COVID-19 kept people home, resulting in a desire to entertain outdoors. With little effort, homeowners transformed basic backyards into nature-friendly places with gazebos, plants, and lawn ornaments.

SOURCE: FLICKR/ERIC SAVAGE

nature while screening out neighbors, and reducing sight lines.

Homeowners are favoring composites over wood because they are durable, require low maintenance, and are impervious to moisture and pests. There's also an enhanced interest in recycled materials and zero waste generation.

To meet these design upgrades, contractor projects are becoming bigger and more elaborate, featuring multi-level structures, and incorporating covered spaces, cabanas and flex spaces.

Meanwhile, many homeowners are into do-it-yourself (DIY) projects: smaller efforts that are personalized and unique, using colors and patterns to distinguish the item visually.

The bottom line with all of the home design and lifestyle changes of the past two years is that they're here to stay, according to Elizabeth Yuko, Ph.D., an adjunct professor of ethics at Fordham University in New York City. "We might not keep our voice-controlled appliances solely because they reduce the spread of germs—but because they also make it easier to cook dinner while taking a Zoom call," she notes, in a blog on [Real Simple.com](https://www.realsimple.com). "And once we've experienced cooking a meal using vegetables from our garden and enjoyed that meal in our beautifully landscaped backyard, how can we go back to undervaluing our outdoor space?"



Air scrubber. Orca is the world's largest direct air capture plant, capable of eliminating 4,000 tons of CO₂ from the atmosphere each year. It's also aptly named: "Orca" is the Swiss word for "energy." COURTESY OF CLIMEWORKS

PART 4

The Great Decarbonization

As time grows short, greenhouse gas reduction takes center stage with manufacturers—along with national, state and local governments.

As the localized impacts of climate change become more existential, it's clear that we must break our addiction to fossil fuels. It's time to think about decarbonization—the full-scale elimination of all greenhouse gas emissions.

In 2021, many hopeful data trends emerged. Cities have taken real action to phase out natural gas, for example, in favor of electrification. Electricity, goes the thinking, can be created from sunlight. But there's still a long way to go, as only 1 percent of homes today are net zero. The Climate Change tipping point is upon us.

POWERING UP DECARBONIZATION

There are actually two types of decarbonization—engine and energy. Although they achieve the same ends, they are different processes.

According to carbon offset service provider [Terrapass](#), engine decarbonization involves removing built-up carbon residue that

accumulates in internal combustion engines from fossil fuels that release carbon when they are burned. The residue is physically scraped off by a professional technician, or a chemical solvent can be poured into the gas tank. It's not meant to be done on a regular basis, and most vehicles manufactured within the past 15-plus years comply with emissions standards that also reduce the amount of accumulated carbon.

Electricity decarbonization has the same basic principle as engine decarbonization: removing carbon from the system. However, the main difference is that removing CO₂ from the electrical grid means stopping it from occurring in the first place.

"This means more than simply switching off fossil fuels in favor of renewable energy, such as solar power and geothermal energy," Terrapass notes. "It involves increasing energy efficiency and looking for clean energy resources that are not typical renewables."

TERRAPASS

"Every form of alternative energy, from small-scale nuclear power to methanol to all forms of hydrogen, needs to be utilized to get us to the point where carbon emissions are reduced to nothing and we reach a net-zero carbon world."

ELECTRIFICATION: ALL OR NOTHING

Electrification technologies—those that promote all-electric status of homes, transportation and businesses—are rapidly becoming more cost effective and more reliable than fossil fuel systems in a variety of planning scenarios and climatic conditions, according to COGNITION data.



Accelerating Decarbonization

It's been documented through numerous studies, conferences, white papers and even fund raisers that the world has until roughly 2050 to change its global greenhouse gas emission habits or begin to see permanent environmental damage. The United States is currently part of the Paris Agreement, which calls for voluntary sustainability efforts by participating nations to help them reach carbon neutral status and keep global warming to less than 1.5 degrees Celsius within 30 years from now.

According to the National Academies of Sciences, Engineering and Medicine, there are five main technology-driven goals that the United States must meet by 2030 to eventually hold up its end of the Agreement 20 years later:

1. Produce carbon-free electricity.

The nation needs to double the share of electricity generated by non-carbon-emitting sources to at least 75 percent by 2030. This will require record-setting deployment of solar and wind technologies, scaling back coal and some gas-fired power plants, and preserving operating nuclear plants and hydroelectric facilities where possible.

2. Invest in energy efficiency and productivity.

By 2030, total energy use by new buildings should be reduced by 50 percent. In existing buildings, energy used for space conditioning and plug-in devices should be lowered every year to achieve a 30 percent reduction by 2030. Goals for industrial energy productivity (dollars of economic output per energy consumed) should increase each year.

3. Plan, permit and build critical infrastructure.

By 2030, the nation should increase overall electrical transmission capacity by approximately 40 percent in order to better distribute high quality and low-cost wind and solar power from where it is generated to where it can be used across the country. The nation should also accelerate the build-out of the electric vehicle recharging network and initiate a national CO₂ capture, transport, and disposal network to ensure that CO₂ can be removed from point sources across the country.

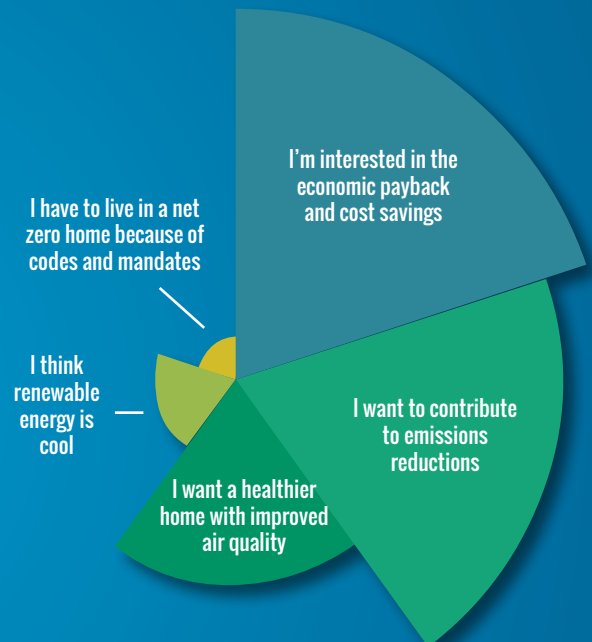
4. Electrify energy services in transportation, buildings, and industry.

By 2030, the nation should aim for 50 percent of new vehicle sales across all classes to be zero-emission vehicles. The U.S. should replace 20 percent or more of fossil fuel furnaces with electric heat pumps in buildings and initiate policies so that new construction is all electric except in the coldest climate zones. Where industrial processes cannot be fully electrified, they should begin the transition to low-carbon heat sources.

5. Expand the innovation toolkit.

The nation should triple federal investment in clean energy research, development, and demonstration (RD&D) to provide new technology options, reduce costs for existing options, and better understand how to manage a socially just energy transition.

COGNITION survey: Why would you live in a net zero home?



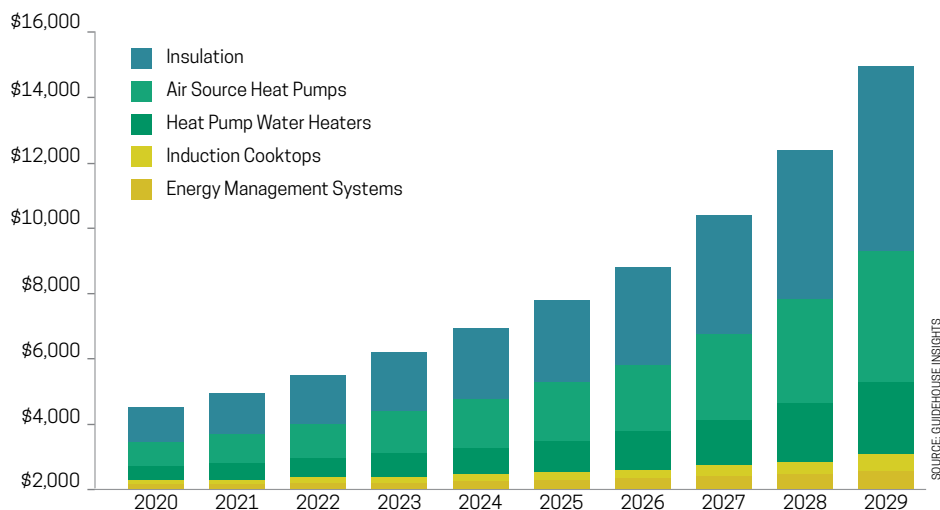
Top 4 greenhouse gasses emitted by human activities:
Carbon dioxide
Methane
Nitrous oxide
Fluorinated gases



4.6 metric tons of carbon dioxide are released annually by a typical car engine



Total Revenue from Fully Electrified Home Technologies World Markets: 2020-2029



For example, the electrification of homes is expected to increase substantially in the next decade, with market growth from \$2.4 billion in 2020 to \$12.9 billion in 2029 for electrified home technologies. These include air-source heat pumps, heat pump water heaters, and induction cooking products. Use of these technologies will “improve cost and performance metrics across climate zones and markets, and lead to high job creation associated with new construction and retrofit projects,” COGNITION notes.

Electrification is not a new concept: more than 37 percent of all homes nationwide are all-electric, most in the South, according to the U.S. Energy Information Administration. Jurisdictions across the country are requiring new homes and commercial buildings to be all-electric; more than 50 cities in California thus far have

taken this route since 2019. This includes San Jose and San Francisco, the nation’s 10th and 17th most-populated cities, according to the [Sierra Club](#). Cities in other states, including Massachusetts, Oregon, Texas, New Mexico, Washington and Louisiana have plans under consideration or taking effect in 2022.

“We can’t ignore that we are seeing the consequences of the climate crisis every day,” San Francisco Supervisor Catherine Stefani noted in a report in the *San Francisco Examiner*. “Whether it is the impact of sea level rise on our sea wall or the wildfires that are devastating communities locally and around the globe, we will be paying for the consequences of climate decisions for a very long time.”

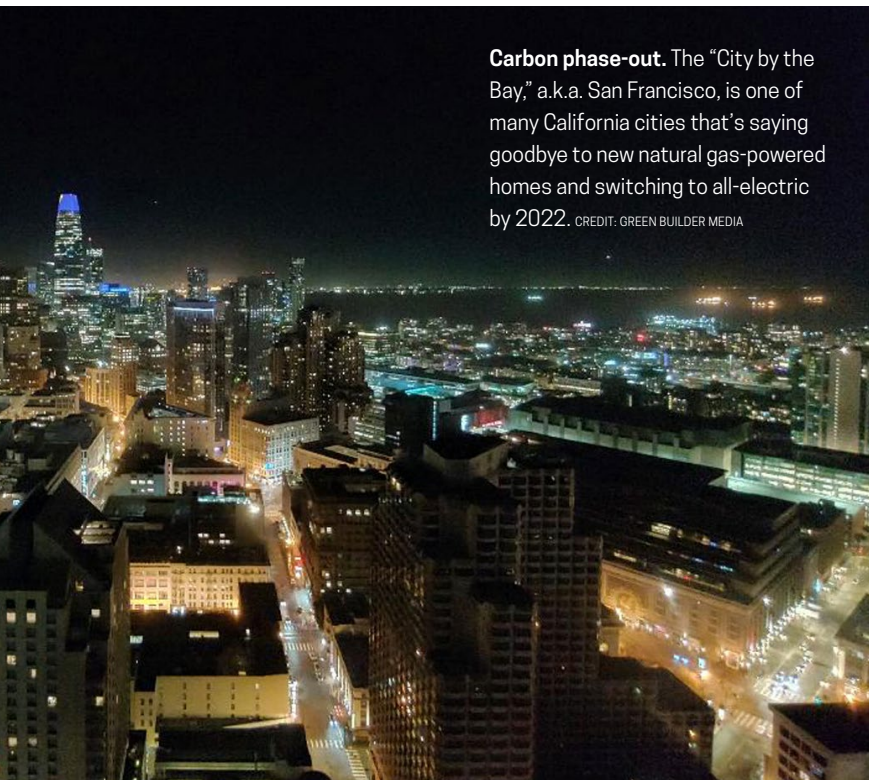
THE LAST DEFENSE: CARBON TECH

Decarbonization has two green processes. The first are Earth’s forests and oceans, which regularly filter pollution from the atmosphere.

For thousands of years, this method was sufficient to keep things in check. But over the past 50 years, increasing emission levels and destruction of natural purifiers such as rainforests and algae have caused carbon levels to rise by 90 percent, according to the U.S. Environmental Protection Agency (EPA).

That brings the other cleaning effort into play: technology. A slew of tech products and processes are on hand to help slow the rate of emissions and speed up how fast we dispose of them. They include:

Direct-air capture. In this process, an industrial plant uses massive fans to pull in air and sends it through a liquid or solid filter to remove the CO₂. The carbon is eventually injected deep into the ground, where additional natural processes turn it into



Carbon phase-out. The “City by the Bay,” a.k.a. San Francisco, is one of many California cities that’s saying goodbye to new natural gas-powered homes and switching to all-electric by 2022. CREDIT: GREEN BUILDER MEDIA

solid rock within a couple years. Swiss clean air technology manufacturer **Climeworks** recently went online in Iceland with Orca, the world’s largest direct air capture plant. It’s capable of drawing down 4,000 tons of CO₂ annually—about the amount that 790 passenger vehicles pump out in a year.

Carbon utilization. This process of taking carbon particles out of the air and infusing them into products is necessary for highly intensive industries like concrete, asphalt and steel. One method, mineralization, transforms CO₂ into mineral carbonates, which can be used to make concrete and cement. Because these building construction materials are used at an enormous scale and have product lifetimes that span decades, mineralization “represents a significant opportunity for long-term carbon storage as well as utilization,” according to the **National Academies of Sciences, Engineering and Medicine**. A variety of processes that use carbon dioxide in the production of concrete and cement are already operating at limited commercial scales.

Other technologies use chemical and biological processes to transform CO₂ and methane into fuels, polymers and chemicals. Some of these processes are already producing high-value chemicals, National Academies notes.

But being able to use technology to reduce GHGs is only part of its environmental benefit. The process also assigns a value to CO₂ and changes the way people think of the gas, according to COGNITION.

There are also government incentives. More than \$20 million has already been allocated to companies that have sequestered or reused carbon in products. Another \$6 billion has been earmarked for companies developing carbon capture, storage, and utilization technologies. And Congress is considering the **Storing CO₂ and Lowering Emissions Act (SCALE) Act**, a \$5 billion plan calling for an infrastructure to transport carbon dioxide from the sites of capture to locations where it can be utilized in manufacturing or sequestered safely and securely underground. **GB**

THE STATE OF SUSTAINABLE BUILDING 2022



Where Fresh Air Isn't

One of the biggest sources of carbon emissions comes from inside U.S. (and world) households. According to the U.S. Environmental Protection Agency (EPA):

- Approximately 70 million American homes burn natural gas, oil, or propane on site to heat interior space and water.
- This generates 560 million tons of CO₂ each year—one-tenth of total U.S. emissions and just under half of all residential end-use energy consumption nationally.
- Gas stoves also emit pollutants such as nitrogen dioxide and carbon monoxide into the home, resulting in asthma and other ailments. Everyday indoor activities, such as cooking meals, can enable those invisible pollutants to easily reach levels that would be illegal outdoors.



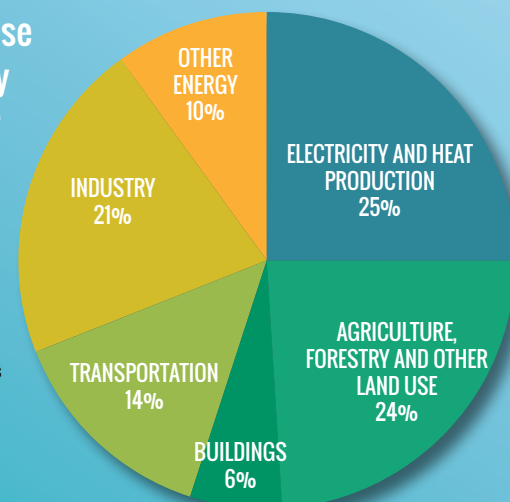
CREDIT: ISTOCK/PEOPLEIMAGES

Global Greenhouse Gas Emissions by Economic Sector

Building up heat.

Greenhouse gas (GHG) emissions from the Buildings sector result from on-site energy generation, and burning fuels for heat in buildings or cooking in homes. But they're the smallest source of GHGs when stacked against other parts of the economy.

SOURCE: INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE



“I know of no other such attempt to wrangle the moving parts of empowered consumers in the internet age, housing affordability, 21st Century labor challenges, productivity, and innovation in the industry.”

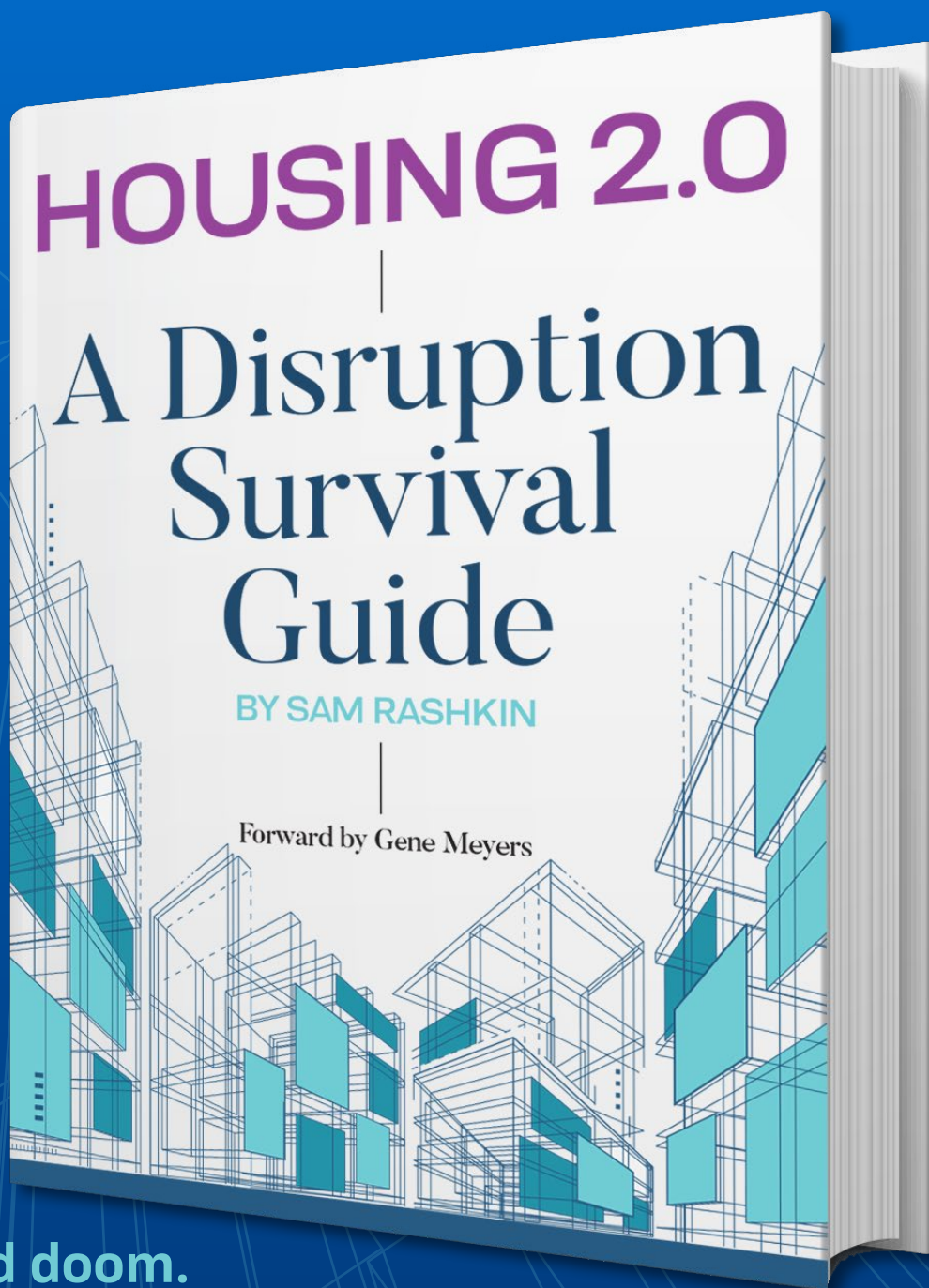
GENE MEYERS, THRIVE HOME BUILDER OWNER AND CEO



Home building luminary Sam Rashkin announces the publication of his latest book—order your copy today!

Rashkin's latest book on home building features more than 400 pages of hard-hitting stats on the state of the home building industry with hundreds of diagrams, photos, illustrations, and tips for building professionals to change how they think about building and selling homes.

Nine chapters encapsulate Rashkin's lessons learned from his time as National Director for the ENERGY STAR Certified Home program and Chief Architect with the U.S. DOE Building Technologies Office.



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BATTERY-POWERED TRUCKS Promise More Than Mobility

When powerful, all-electric pickups hit the road next year, they'll change not only the way you and your employees drive, but the way you work.

BY MATT POWER, EDITOR-IN-CHIEF

AS WE LOOK FORWARD TO 2022, car makers worldwide have doubled down on a massive shift from combustion to electric, battery-powered work vehicles. There's a reason, however, that trucks have been slower to hit the market than sedans. Pickup trucks, in particular, occupy a hallowed place in the American psyche. That's the kind of loyalty car makers hesitate to disrupt. But change has come. Electric trucks break ground in so many ways that they're almost a new species of vehicle. And automakers clearly feel that the time is right. Their new philosophy: "If we build it, they will buy."

Based on early sales, they've made the right choice. "We have 150,000 reservations already," notes Nathan Oscarson, brand manager for commercial vehicles at Ford Motor Co. "We're going to build as many as we can to meet the demand, and we're expanding."

The scale of that growth eclipses old records of investment and commitment, even for Ford Motor Co. Ford is partnering with SK Innovation and pouring \$11.2 billion into construction of two new plants—one in Kentucky, the other in Tennessee—to build the batteries and chassis for the new *F-Series* electric trucks.

At the center of Ford's plan: In-house production of the all-important batteries that will drive their power trains. Oscarson says that carefully controlling manufacturing of the battery cells, including materials sourcing and testing, will make the company feel confident in the availability and performance of its battery packs.

"The key thing is developing these batteries with a 300-mile



Ready to rumble. Far more than just pickup trucks, electric vehicles such as the *F-150 Lightning*, due out in 2022, can power your jobsite, help you hook up a trailer and coach your employees on how to drive more safely.

COURTESY OF FORD MOTOR CO.

range," Oscarson adds. "Our batteries will be lighter than others, plus they'll ride low in the chassis, so [the *F-150 Lightning*] won't ride like a typical truck. It will be better."

PRICING: SAFE BETS

How much would-be electric vehicle (EV) truck buyers pay? No one knows. But so far, car makers apparently haven't hit the ceiling.

GMC, for example, targeted luxury buyers first with its *Hummer EV* SUV. An EV version of the *Chevy Silverado* will follow. The company captured 10,000 pre-orders for the *Hummer* in the first 10 minutes it became available online a year ago.

GMC's price for the *Hummer EV*, at \$113,000 (U.S.), tracks significantly higher than Ford or other electric pickups. Ford's *F-150 Lightning* base model could go as low as \$42,000, although the \$53,000 mid-range *XLT* model may appeal to building pros. The



presumption, of course, is that to reach the mainstream buyer (how very Ford), price does matter, and vendors will begin offering less expensive models as factories come online.

Ford North America's president, Kumar Galhotra, has made no secret of the company's big EV plans: "We're not here to make an electric truck for the few," he says. "Ford is committed to building one that solves real problems for real people."

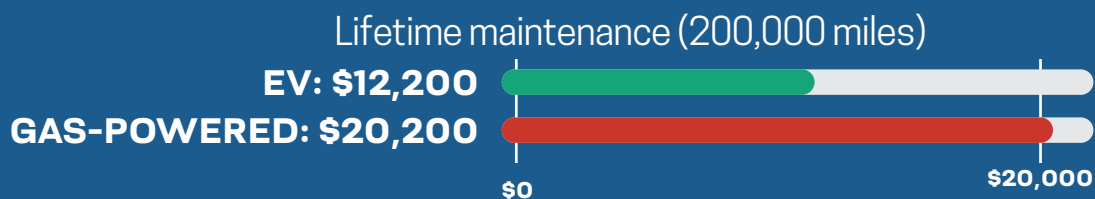
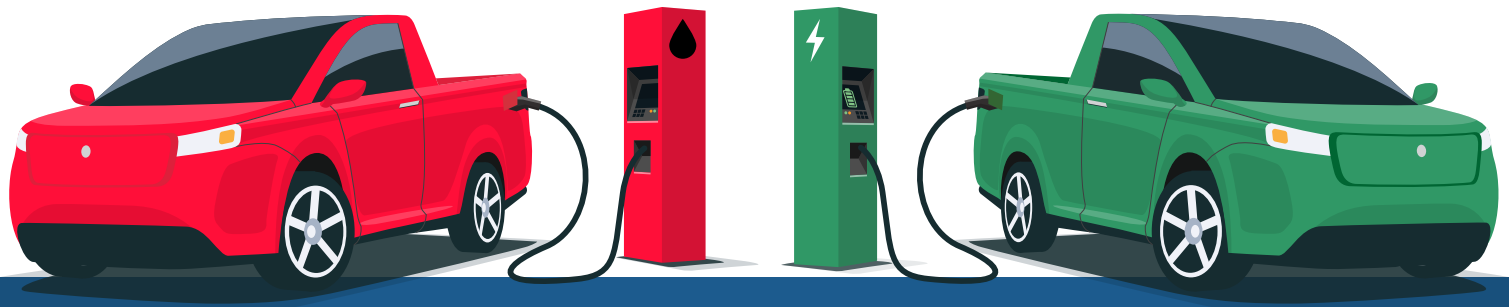
Ford's pricing stays closer to that of Tesla, although Tesla's planned *Cybertruck*, with a base model the company claims will sell for under \$40,000, won't look much like pickup truck (more on that later). But not every electric "truck" promises to be a work vehicle. Building pros will be looking for something that closely resembles the cherished pickup truck they've known for decades—as reliable transportation, yes, but also as roving offices and transport modules and (in the case of fleets) employee-operated workstations.

CONSUMERS' TOP 5 REASONS FOR BUYING AN ELECTRIC VEHICLE:

1. MONETARY SAVINGS
2. FEWER CARBON EMISSIONS
3. A BETTER DRIVING EXPERIENCE
4. REDUCED OIL USE
5. CONVENIENCE

SOURCE: UNION OF CONCERNED SCIENTISTS

MONETARY COST OF ELECTRIC CARS VS. GAS-POWERED



SOURCE: U.S. DEPARTMENT OF ENERGY

Per-mile cost of
vehicle maintenance:

SOURCE: U.S. DEPARTMENT OF ENERGY

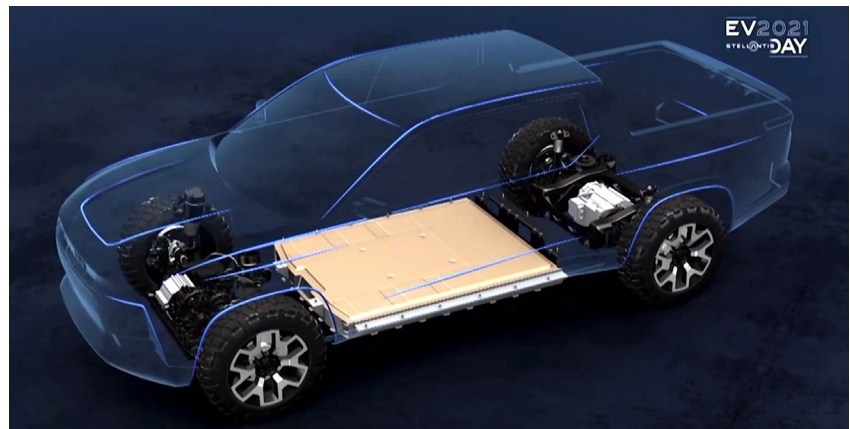


Oscarson says Ford has built its electric truck with all of these things in mind, and will offer remote observation and “real-time driver coaching through SYNC 4 voice assistant” for EV trucks belonging to a commercial fleet.

This service mines data from the vehicle and sends it back to the fleet owner, while also nudging the driver. As described by a Ford press release: “Any time a driver exceeds a speed limit, rapidly accelerates, brakes harshly, leaves the engine running while parked or fails to fasten a seatbelt, they will receive an in-car audio message asking them to correct their behavior.”

Oscarson adds that with Ford’s **fleet management software**, the vehicle can let the dispatcher know if the owners forgets to plug the vehicle in at night, or if it detects a theft. “It also monitors ‘check engine’ lights,” he says. “Drivers tend to ignore those lights, which can damage the engine. The same is true of other warnings, such as the ‘low tire pressure’ light. You can generate driver behavior scores too. You have all these ways to try to improve the safety of the vehicle.”

That top-down control may appeal to fleet managers, but for small contracting companies, trades and other construction pros, an electric work truck purchase will likely be motivated by self interest: What can this truck do for me?



Low rider. This illustration of the upcoming *Ram 1500* electric truck shows some of the major differences between EV and fossil fuel-powered pickup trucks: a much smaller motor assembly, and a low, heavy center of gravity (due to batteries). COURTESY OF RAM-STELLANTIS

BRAND HIGHLIGHTS

Each EV truck maker seems to have doubled down on one or two special features. While batteries and range are prerequisite to every brand, automakers have taken the opportunity to reimagine what automobiles can do: from running jobsites to maneuvering like a skid steer, to towing heavy gear.

GMC’s *Hummer EV*, with its short truck bed, has a James Bond-worthy “crab mode,” which allows all four of the truck’s wheels to



BUT CAN THEY TOW?

Electric motors have tremendous torque and power, but their range depends on the details.

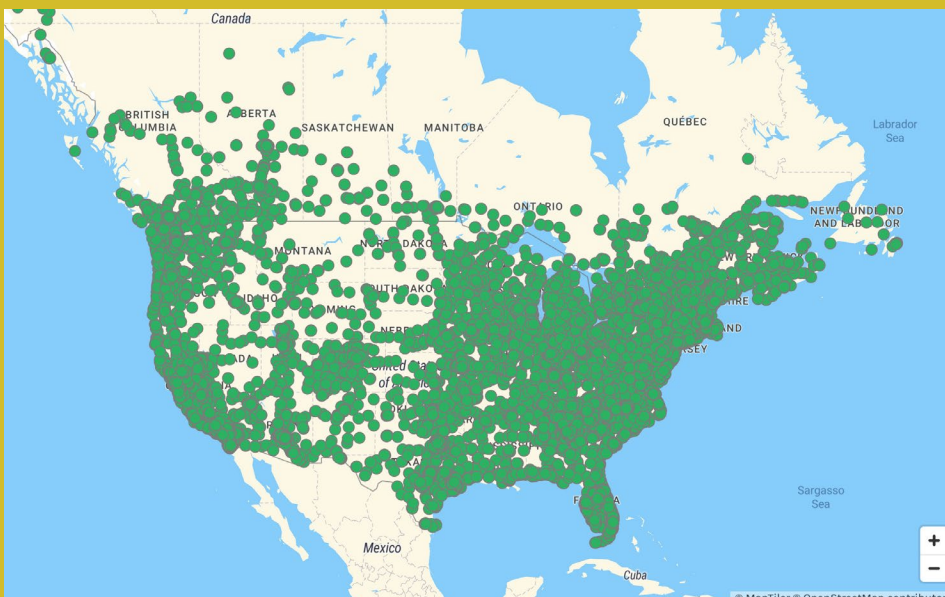
WHAT'S KNOWN ABOUT ELECTRIC VEHICLE (EV) TRUCKS is that they have enough power to tow substantial loads. What's not known is exactly how real-world variables will affect their towing range. Past studies of EVs have found that their range with a trailer in tow can drop significantly. For example, a field test of a Tesla *Model 3* towing a 750-pound trailer noted an efficiency drop of 40 percent.

It's obvious that these truck makers know towing matters. Most have included some

kind of hitch in their EV work trucks. Ford, in particular, has a sophisticated monitoring system that estimates the tow load and its impact on range. The *F-150 Lightning* will have a 10,000-pound towing capacity. That's enough to haul a mid-sized ditch digger to the jobsite, or haul a load of construction and demolition (C&D) waste to the landfill. Meanwhile, the Rivian *R1T* claims an 11,000-pound towing capacity.

As EV trucks hit the road, we'll see a wealth of new data about how inclines, trailer shape,

tread wear and other factors affect towing range. One can imagine a scenario, for example, where a builder wants to know if an EV truck can safely haul a maxxed out load of lumber up a 6-mile highway incline on Route 84 in Pennsylvania. Fortunately, the availability of charging stations nationwide keeps rising (see "charging station" caption/sidebar). That means that even with heavy loads, you may be able to jump from one charge station to the next to keep batteries topped off.



CHARGING STATIONS.

Public EV charging stations have proliferated in the U.S., making cross-country travel with battery power much more viable. Many more are on the way. For example, GM has announced that it will install 40,000 new Ultium charging stations across the U.S. and Canada by 2025, helping fill gaps in so-called "charging deserts," where charging stations are lacking.

SOURCE: U.S. DEPARTMENT OF ENERGY

partially rotate, so the vehicle can move diagonally. Will this turn buyers' heads? The question may be academic. General interest in EV trucks is so intense right now, it's hard to say how much difference any single special feature makes. Americans seem to be buying EV trucks in most price ranges as fast as preorders become available.

Right behind the *Hummer EV*, GM expects to release an all-electric *Silverado* pickup in 2023. The truck, GM says, will have a 400-mile range, 100 miles per charge more than the *F-150 Lightning*. Note how increases in projected vehicle range increase with the timeline. Automakers may encourage buyers to wait a little longer to buy the EV truck they've been waiting for, if range is a priority.

As another example, the *Ram 1500* electric pickup truck, currently slated to debut in 2024, has promised a 500-mile range. Priced at about the same point as Ford's truck (\$45,000), it may also tow more, with a boosted towing capacity of 10,000 pounds. Will RAM hit those benchmarks? Time will tell, but as Car and Driver astutely points out, the company will likely use the extra two years of ramping up production to "capitalize on any missteps [earlier] competitors encounter."

A LONG-LASTING, SILENT GENERATOR

My favorite game-changing perk of EV trucks? Their potential as jobsite generators. Think about the benefits of this unlooked-for feature: It could help contractors deal with local noise ordinances on jobsites, reduce accidents and workman comp claims. One of the most-common causes of worker deaths on construction sites is getting run over by small skid steers. Crews sometimes can't hear them coming over the din of generators.

How bad is the din from combustion generators? According to OSHA, exposure to 85 dba for 8 hours can permanently damage your hearing.

With the *F-150 EV* system, using the truck to power tools isn't like plugging a cordless drill into a 12-volt cigarette lighter. It's



Power up. With enough inverter power to drive compressors, saws and table saws, the *F-150 Lightning* can fully replace your on-site generator.

COURTESY OF FORD MOTOR CO.

a full-on inverter. You can run a table saw, or a compressor for a nail gun, and not just for a few hours. It needs to be for days.

"We don't talk a lot about the bidirectional power," Oscarson notes. "But the truck comes with 2.4-kilowatt (kW) inverter that you can upgrade up to 9.6 kW. What's great is that you get a 240-volt plug in the back, plus eight 120-volt outlets and five USB ports."

Oscarson adds that Ford has conducted tests that show the extended range model can run a job site on all-electric for 10 days. "Software on board monitors what power is being used on the jobsite, and you have complete control," he says. "So, if you need to save enough power to drive 40 miles back to the office, you can tell it to save that much for your return trip."

This power-tapping inverter also offers intriguing possibilities for resilience. The truck batteries can run most of the critical equipment in a home for several days.

THE NEXT WAVE

Between now and 2025, options for EV trucks will hit the market with a regular cadence, provided supply chain issues can be managed. Following Ford, it looks like Tesla, GMC, Dodge RAM



SMART TECH FEATURES

U.S. manufacturers have their own long list of superpowers built into these pickup trucks of the future. For example, here's a short list of some of the *F-150 Lightning* "extras."

SELF DRIVING.

The truck can tap into *Ford Co-Pilot360™* technology. This "BlueCruise" feature allows the *Lightning* to self drive on 100,000 miles of pre-qualified divided highways in the U.S. and Canada, and that network of roads is growing.

ONBOARD SCALES.

Built-in sensors tell the driver not only how much payload is in the bed, but also how much of a trailer load they're hauling. This data ties into the truck's *Intelligent Range* computer, so a user gets an accurate estimate of how far they can tow a heavy load.

PRO TRAILER HITCH ASSIST.

This feature takes control of the vehicle as the driver backs up to attach a trailer, removing most of the guesswork.

PHONE AS A KEY.

Drivers can unlock or start the truck with a cellphone, with no key fob or touch required.

AUTO UPDATES.

Ford *Power-Up* software installs upgrades and tweaks automatically, without need for logging in or user intervention.

HIDDEN FRONT STORAGE TRUNK.

Where the truck's old gas engine used to reside, you'll find a huge front "Frunk." It's lockable and waterproof, with tie downs, capable of storing tools or picking up groceries on the way home.



COURTESY OF FORD MOTOR CO.

“We’re not here to make an electric truck for the few. We’re committed to building one that solves real problems for real people.”

**KUMAE GALHOTRA, PRESIDENT,
FORD NORTH AMERICA**

and several other brands will release EV trucks, along with some lesser-known brands.

Tesla has promised to start shipping its *Cybertruck* in 2022, but given the company’s past performance on product release deadlines, I wouldn’t mark any dates on the calendar. Also, this truck looks more like a lightly armored Humvee than a work vehicle, and the styling seems aimed at buyers with *Mad Max* fantasies, not working contractors. But maybe that’s the *Cybertruck* niche:



Apocalypse ready? Looking more like a futuristic military vehicle than a truck, Tesla’s *Cybertruck* is slated to become available in 2022.

COURTESY OF TESLA



Mystery truck. With backing from Ford and Amazon, Rivian’s *R1T* beat all other EV pickup trucks to market. COURTESY OF FORD MOTOR CO.

wanna-be anti-heroes, roving the countryside with “Not-a-Flame-throwers” cued up in the passenger seat. **The company claims** that it has 1 million \$100 deposits in place for these trendy trucks.

Soon will come the European invasion, led by Stellantis, the fourth-largest car maker in the world (the company also makes the RAM EV here in the U.S.). Stellantis also owns Jeep and other familiar brands. According to **CNBC**, the company plans to have 55 EV offerings in the U.S. by 2025, including work trucks.

Another wild card is a company called Rivian, which is heavily supported by investments from Amazon and Ford. This U.S.-based company has beat all the big players to market, and expects to deliver 1,000 EV trucks this year. The **RIT** pickup is priced at \$67,500. Rivian also makes an all-electric SUV, the *RIS*. According to FleetOwner.com, the company had roughly 55,400 *RIT* and *RIS* preorders in the United States and Canada as of Oct. 31, “a backlog its leaders expect to fill by the end of 2023.”

One thing that’s clear: The auto industry is all in with electric work vehicles this time. It’s poured millions into R&D and plans to add billions in factory space and innovations. So far, buyers have responded enthusiastically. In the ideal scenario, as more of the grid converts to solar energy, each of these electric vehicles will surpass its conventional, gas-powered counterpart, running cleaner, greener (less polluting) meaner (with greater torque and acceleration) and quieter.

Will there be hiccups and setbacks as this new technology rolls out? Inevitably. But with each new iteration of vehicle and battery system, each software upgrade, these trucks should get better. And one of the perks rarely mentioned are the maintenance costs you won’t have any more. Think about what it takes to keep a combustion engine running: fluids, hose replacements, air filters, carburetors, gas pumps, and on and on. Many of these parts and services will simply become irrelevant, as gas vehicles age out, and EVs dominate the scene. The future of trucks is quiet, durable and less polluting. **GB**

CLEAN, EFFICIENT POOL PRODUCTS MAKE A SPLASH

Hayward's line of innovative devices helps make it fun and more affordable to take a backyard swim.

Refresher course. The renovation process at ReVISION House Austin isn't relegated to just the inside of the home — the pool required a makeover as well. Hayward brought sustainable and efficient pool products to the project to offer the homeowner an environmentally friendly outdoor oasis.

BY SAMANTHA CARLIN

AT THE REVISION HOUSE AUSTIN, Hayward's pool products play an important role in improving the home's sustainability. Owner Tiana Cooper fell in love with her dated home but knew she would need to make significant renovations to improve its energy efficiency, health, and performance.

The outside entertaining spaces of her home are just as important as the inside ones. "The pool is somewhere I can relax, have friends over, and escape from the Texas heat," Cooper explains.

Pools are typically known to be energy-intensive, and expensive to use and maintain. Plus, they can require harsh chemicals to adhere to proper hygiene requirements. By using Hayward's pool solutions, Cooper overcomes these challenges.

ENERGY EFFICIENCY IS EVERYTHING

When Cooper purchased the house, the existing pool equipment was outdated and non-functional. The elements of the pool's cleaning and filter system were either extremely inefficient or completely broken. Cooper was told by her pool maintenance company that she would need to upgrade her equipment if she wanted to enjoy her pool.

Fortunately, Hayward came to the rescue, providing a suite of new equipment and cleaning solutions so that Cooper could take the plunge again.

Cooper's new variable-speed pump dramatically increases efficiency levels versus older pool pump models. According to Dave MacNair, vice president of marketing at Hayward, the new pump is rated No. 1 for energy efficiency by the U.S. Department of Energy.

The pump can modulate its speed, meaning the unit slows



Pumped Up

The *Tristar* pump, which can modulate its speed based on the current demand, may reduce homeowner Tiana Cooper's energy consumption and cost by up to 90 percent.

COURTESY OF HAYWARD



Self Control

Hayward's *OmniLogic* smart control system and mobile app makes setting timing for fountains, lights, and cleaning as easy as using the spa.

COURTESY OF HAYWARD



Factoring variables.

Hayward's line of robotic pool cleaners, such as the *TigerShark Plus*, have been engineered for superior hydraulic efficiency.

COURTESY OF HAYWARD



Kathleen Baker
COURTESY OF OLYMPICS.COM

Green Products, Green Company

Hayward manufactures most of its products in the United States. The company currently partners with Kathleen Baker, a U.S. Olympic champion swimmer who advocates for health and wellness. Baker, who has a Crohn's diagnosis, has been a spokesperson for Hayward because its sanitation products, like the Hayward *AquaRite* salt chlorine generator, provide a healthier pool environment than others.

COURTESY OF HAYWARD

Three Tips for an Energy-Saving Pool

According to Dave MacNair, vice president of marketing at Hayward, there are three must-dos for decreasing the energy consumption of a pool:

1. Install a variable speed pump and program it to run most of the basic pool circulation on a low speed
2. Oversize the filter to reduce head loss (back pressure) and allow the pump to run more easily
3. Get a robotic pool cleaner because they use very little energy compared to alternatives



Liquid Asset

Currently, almost 70 percent of pools in North America are treated with chlorine, providing the opportunity for conversion to more sustainable options. Hayward recently released *HydraPure*, which works with existing chlorination or salt chlorination systems to reduce chlorine usage by 60 percent.

COURTESY OF HAYWARD

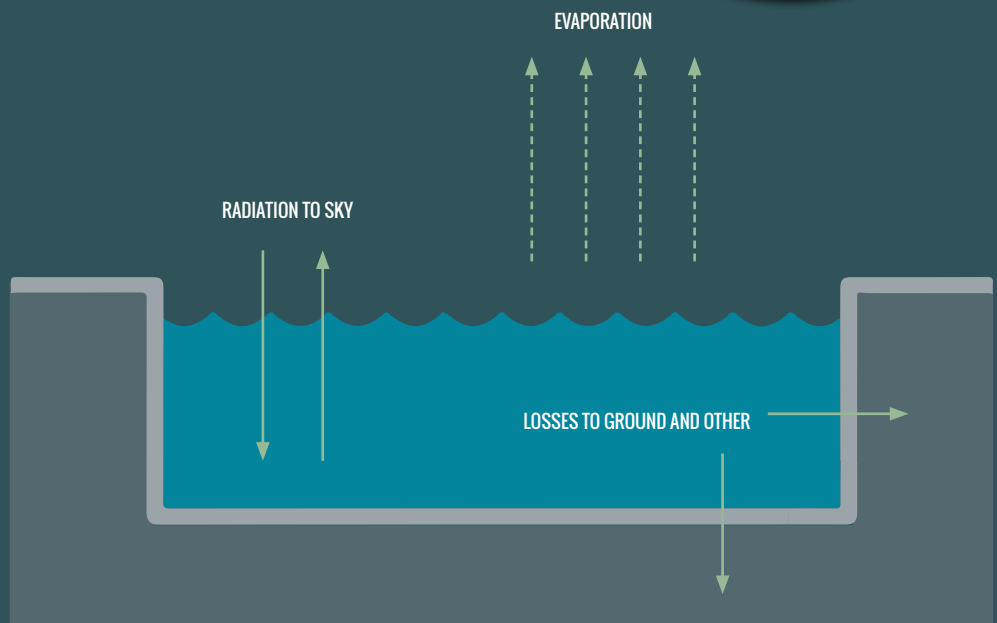
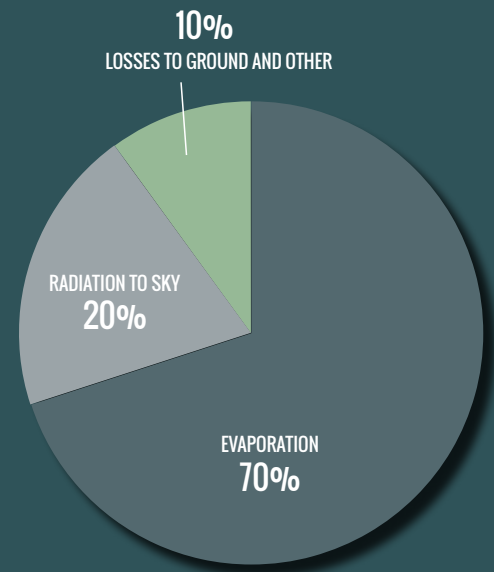
Don't Forget to Cover Up

Swimming pools lose energy in multiple ways, but evaporation is by far the largest source of energy loss. “Evaporating water requires tremendous amounts of energy,” notes the [U.S. Department of Energy on its website](#). “It only takes 1 Btu (British thermal unit) to raise 1 pound of water by 1 degree, but each pound of 80 degrees Fahrenheit water that evaporates takes a whopping 1,048 Btus of heat out of the pool.”

Under cover. Pool covers minimize evaporation from outdoor and indoor pools. Covering a pool when it is not in use is the single most effective means of reducing its heating costs. Savings of 50 percent to 70 percent are possible.

CREDIT: U.S. DEPARTMENT OF ENERGY

OUTDOOR POOL ENERGY LOSS CHARACTERISTICS



down or speeds up depending on the current demand. Cooper's new *Tristar* pump is expected to reduce her energy consumption and heating costs by up to 90 percent. In addition, the new unit features an enclosed fan-cooled motor that allows the pump to run more efficiently, and it requires less maintenance.

COMPLETE SWIMMING POOL CONTROL

In addition to several functional upgrades, Hayward also brings its *OmniLogic* smart control system with a mobile app to the table. Cooper says she struggled to properly operate her old pool system and had to bombard the maintenance person with questions every week. But now, “having a connected pool that I can go on an app and set the timing for fountains, lights, and cleaning is going to be great.”

According to MacNair, Hayward has the highest rated pool control app in the industry, providing a top-notch user experience. So, after a stressful day — and with just a couple swipes on her phone, Cooper can even turn on her spa before she leaves work, ensuring that she comes home to a hot tub ready to take her stress away.

NO MORE TRADITIONALLY CHLORINATED POOLS

Before Hayward, Cooper lamented that she was using a lot of unnecessary chemicals. “Chlorine leaves my eyes irritated and turns my hair green,” she says. And Cooper isn't alone: Roughly 70 percent of pools in North America are chemically treated with chlorine, according to MacNair.

Hayward's *AquaRite* family of salt chlorine generators reduce the need for extra harsh chemicals, offering a sustainable way to clean pools and make the water feel softer. Similarly, *HydraPure* harnesses the power of ultraviolet and ozone to dramatically reduce the required amount of chlorine.

Overall, Cooper is thrilled, and not just for the instant gratification of an efficient, clean, refreshing backyard pool. “I picked Hayward because of its reputation for having the best pool equipment,” she says. “If I was going to make an investment in my pool and its equipment, I wanted to make it last.” **GB**

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Can a Home Last 200 Years?

With walls and roof clad in aluminum, this ultra-modern home aims for record-setting durability.



Progressive approach. The Civitas house in Memphis combines modern architecture with sustainable practices to create a luxurious and long-lasting home.

COURTESY OF ARCHIMANIA 2020



Sky high. Custom-fabricated, flat-seam panels create an interplay of shadow and light that deliver a more-dynamic appearance throughout the day.

COURTESY OF ARCHIMANIA 2020

a hidden channel along the home's most exposed façade that enables rainwater harvesting and supports passive cooling of the interior space.

The 2,800-square-foot home was designed by the team at Memphis-based firm archimania and led by principal Barry Alan Yoakum, FAIA. Yoakum was his own client for this home, which he has since moved into, along with his wife and son. In addition to creating a living space where his family could thrive, Yoakum — who has sustainable design credentials that go back decades — saw the house as an opportunity to answer a question he sees as critical today: “How does a modern piece of architecture begin to solve the problems of the planet?”

Only time will tell how far this one house takes humans toward reducing their impact on the climate. But, it certainly has gained a lot of attention from others striving to develop such solutions. It has earned Leadership in Energy and Environmental Design (LEED) Platinum certification and is one of the first U.S. homes to meet the goals of the American Institute of Architects AIA 2030 Commitment a full decade ahead of the target date. It also is the first single-family home in the Americas to be registered as a Zero Energy/Zero Carbon home, according to standards established by the International Living Future Institute.

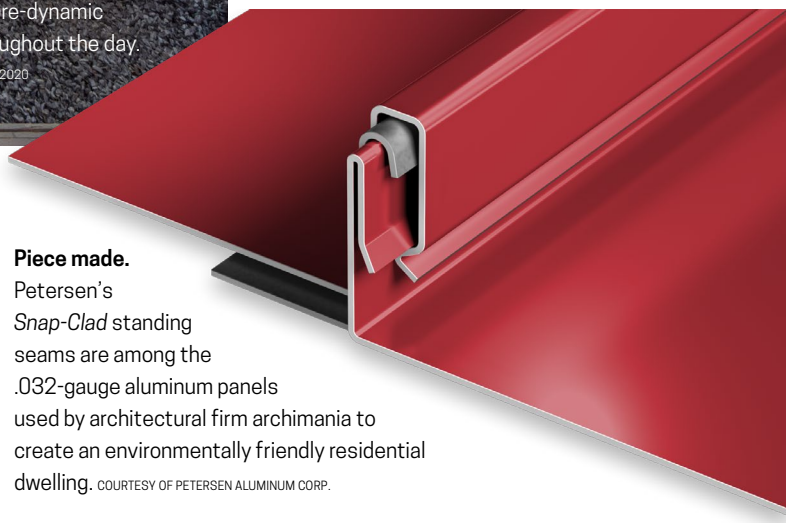
LONG-LASTING EFFORT

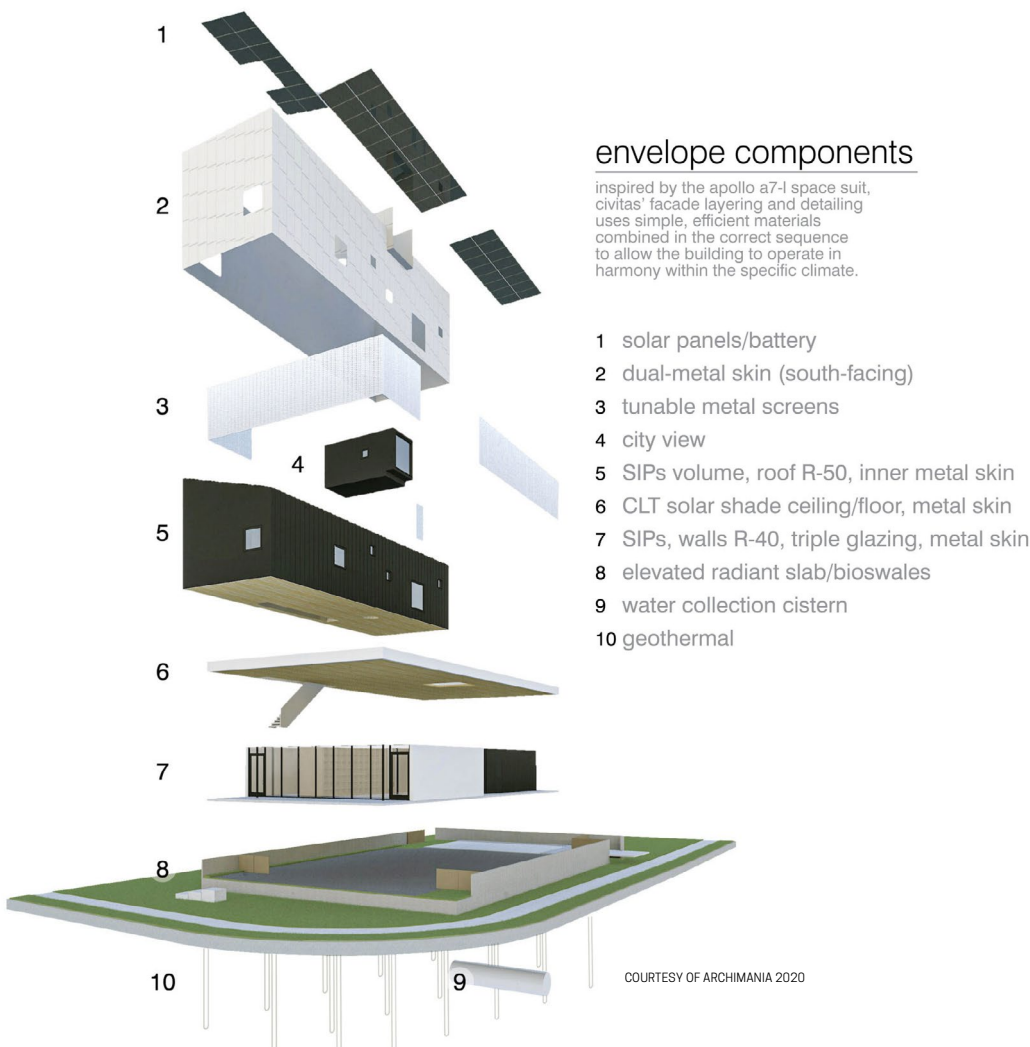
The materials Yoakum chose for the house were selected for their durability, with the goal of creating a home that would remain

SITED WITHIN A NEW URBANIST NEIGHBORHOOD OF TRADITIONAL-STYLE HOMES — and across the street from Memphis' Mississippi River shoreline — the new Civitas residence makes a strong statement with its looks alone. It's a high-performance dwelling, achieving multiple energy and environmental certifications. Aluminum wall and roof panels play a starring role in its design and performance, by creating

Piece made.

Petersen's *Snap-Clad* standing seams are among the .032-gauge aluminum panels used by architectural firm archimania to create an environmentally friendly residential dwelling. COURTESY OF PETERSEN ALUMINUM CORP.





envelope components

inspired by the apollo a7-l space suit, civitas' facade layering and detailing uses simple, efficient materials combined in the correct sequence to allow the building to operate in harmony within the specific climate.

- 1 solar panels/battery
- 2 dual-metal skin (south-facing)
- 3 tunable metal screens
- 4 city view
- 5 SIPs volume, roof R-50, inner metal skin
- 6 CLT solar shade ceiling/floor, metal skin
- 7 SIPs, walls R-40, triple glazing, metal skin
- 8 elevated radiant slab/bioswales
- 9 water collection cistern
- 10 geothermal

COURTESY OF ARCHIMANIA 2020

standing two centuries from now. To this end, long-lasting structural insulated panels (SIPs) and cross-laminated timbers were used for the structural system. When it came to the exterior wall system, Yoakum says aluminum quickly rose to the top on his list of options.

"We went through a process of energy studies, and aluminum started coming in" as a favored choice, he says. "If you install it correctly, it will last forever."

Petersen was the supplier of choice for almost all the aluminum used in the project, supplying 15,200 square feet of panels and sheet metal, including .032-gauge aluminum panels from PAC-CLAD (corrugated), *Snap-Clad* (standing-seam), and *Tite-Loc Plus* (standing seam), along with PAC-CLAD 24-gauge galvalume M panels.

Yoakum worked closely with the installation pros at the local firm of Ralph Jones Sheet Metal in Arlington, Tennessee, an archimania collaborator on several previous projects. Company president Gordon Jones helped Yoakum develop the unique façade system for the structure's highly exposed southern elevation. The architect wanted a way to capture rainwater on site, to reduce stormwater impacts and minimize his family's demands on the municipal water supply. He also didn't

WHAT MAKES METAL SIDING SUSTAINABLE?

A lot can be said about whether metal siding is good for the environment. Because the primary metal is usually aluminum, there are concerns about the amount of energy needed to create it, as well as its contribution to deforestation and groundwater pollution. But proponents say there are a number of natural benefits that make aluminum a positive choice for housing:

- Producing 1 million tons of aluminum in tech-friendly Norway releases 15 million tons less pollution than the same material produced in industrial China.
- Because of its recyclable quality, 75 percent of all aluminum ever produced is still in use. Recycling aluminum uses 95 percent less energy to recreate than the virgin material.
- Well-maintained aluminum cladding can last for up to a half century. Wood siding, by contrast, can typically go 20-40 years under



Grid lock. A combination of C channels, Z channels and M panels create an exterior that enables easier collection of rainwater, and reduced strain on the city water system. COURTESY OF ARCHIMANIA 2020

ideal circumstances (although this number also varies greatly by type of wood used). A longer lifespan means less environmental impact due to reduced need for production.

- The paint footprint. Wood siding requires more-frequent painting—roughly every 5-8 years. Aluminum siding's embodied energy—a calculation of all of the energy, clean or otherwise, used to produce a material—is not quite 1.5 times that of acrylic paint used on wood. Assuming the same square footage of siding, aluminum is slightly greener.
- Recycling is key. Provided it is sourced primarily from

recycled material, aluminum siding should have a lower overall embodied energy than other durable claddings, including vinyl, brick and fiber cement.

SOURCE: RISE; BOB VILA; HOMEDECORBLISS.COM; UNIVERSITY OF MELBOURNE

want visible guttering to mar the home's clean lines. Instead, he designed a rain-screen on this façade that allows rainwater to pass behind the exterior wall to ground-mounted guttering that then channels it to an underground storage cistern.

To develop this wall, Jones's team first fastened the *Snap-Clad* standing seam panels to the exterior sheathing. The seams provided an attachment point for 4-inch Z channels to create the needed gap through which the rainwater could pass. Galvalume M panels then were attached to the other side of the Z channels to create a substrate for attaching the flat-seam panels that Jones' shop custom fabricated from sheet metal that also was supplied by Petersen. C channels were installed around the wall's periphery to create seamless corners and obscure the fact the south elevation walls actually extend 5 inches from the exterior substrate.

The home has roofs at two levels, which appear flat from street level but in reality feature Petersen's *Tite-Loc Plus* panels installed at a 0.5:12 pitch. The roof panels provide a point of attachment for solar panels that generate electricity for the home and the local utility. Low-rise parapets hide the panels from the street-level view, creating the illusion of flat roofs. Metal from another supplier was used to create the screens that move along rails (which Yoakum calls "scrim") that provide shading and some visual interruption as Yoakum and his family reposition them around the first floor's triple-glazed, floor-to-ceiling windows.

TRIAL BY SUCCESS

Exploration played a big role in Yoakum's design, which shows up in the installation of the custom-fabricated, flat-seam panels. Instead of simple rows, the architect wanted to use the panel seams to create an interplay of shadow and light across the monochromatic exterior. The resulting stair-stepped pattern makes for a more dynamic appearance throughout the day and year, he says.

"We studied about a dozen different patterns," Yoakum says, adding that an early plan called for simple vertical rows. "It didn't have the scale we wanted for the house — we really wanted to break down

Sight unseen. Low-rise parapets hide roofing panels from street-level, creating the illusion of flat roofs.

COURTESY OF ARCHIMANIA 2020



the scale. We didn't want it to look like an industrial building."

For Jones' installers, this shingled effect meant added attention to ensure Yoakum's vision was realized in the finished structure. "Your layout has to be correct — as long as you start the first few rows correctly, the rest of it is fine," Jones says, noting that such extra care was required during every step of the installation process to meet Yoakum's intent. "All of this had to be thought out. Every seam has a design point. Nothing was done without him thinking about it. I like this architecture — it's challenging."

This isn't a first-time experience for archimania or Jones in working with Petersen products. The two companies have collaborated on several other area projects incorporating the company's metal panels, including the home of the Memphis Ballet. Plus, Jones' relationship

with the company goes back decades.

"The only metal we use is Petersen. We've been dealing with them since the 1980s," Jones says. "We dealt with the same people then; it still has a sense of a small company. When I talk to them, they have the knowledge we need. I could count on one hand the warranty claims I've had on the paint finish, and Petersen's always worked with me and taken care of it." **GB**

Article courtesy of **Carlisle Companies Inc.** and **Petersen Aluminum Corp.** Peterson manufactures PAC-CLAD metal cladding products in multiple gauges of steel and aluminum. PAC-CLAD products include standing-seam roof panels, hidden- and exposed-fastener wall panels, flush panels, soffit panels, perforated metal, fascia and coping systems, composite panels, column covers, coil and flat sheet.

HOUSING 2.0

The Missing Air Barrier

From OSB to drywall, there's a heavy-duty path to insulated performance.

BY SAM RASHKIN

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

CONSTRUCTION ASSEMBLIES with fibrous insulation (such as fiberglass, rock wool, or cellulose) need a complete air barrier on all six sides. This ensures the thermal control layer works effectively, since air can flow through it. Think of the difference outdoors on a cold windy day with a sweater and jacket made of a water repellent fabric: Without the jacket, the cold wind easily passes through the sweater and mitigates its thermal resistance.

In contrast, with the jacket functioning as an air impervious control layer, air flow through the sweater is blocked, resulting in much more effective thermal protection. It's the same with buildings. Note that some types of insulation are air impervious (e.g., closed cell foam, foil faced rigid insulation) and can function as the air and thermal control layers.

Exterior weather resistance barrier (think house wrap, building paper, liquid membrane, and roofing felts) is often mistaken as the primary air barrier on the exterior of homes. Yes, such barriers do resist air flow, but this function is already provided by traditional exterior sheathing materials (e.g., oriented strand board [OSB], plywood, rigid insulation boards). To ensure a complete air control layer, sheathing needs to be sealed at all joints, gaps where sheathing is attached to framing, and penetrations. Thus, the weather resistant barrier primarily functions as the water control layer for shedding bulk moisture that gets past the cladding or roofing. And water gets past all claddings and roofing. They also need to provide adequate vapor flow for wall and roof assemblies to dry to the outdoors.

On the interior, the primary air barrier is the drywall. The joints are filled with spackle and taped to form a complete air

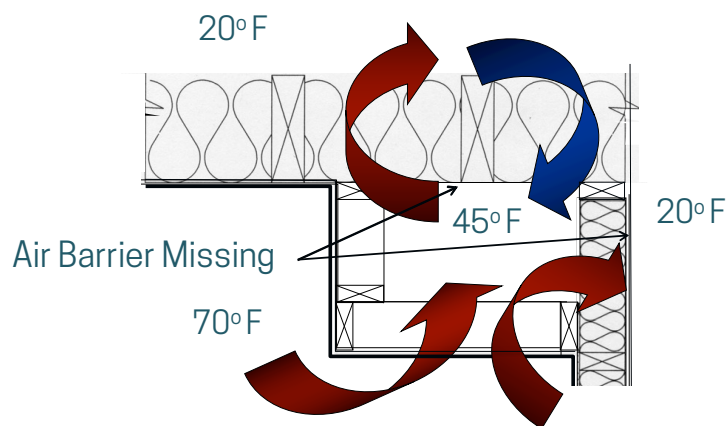
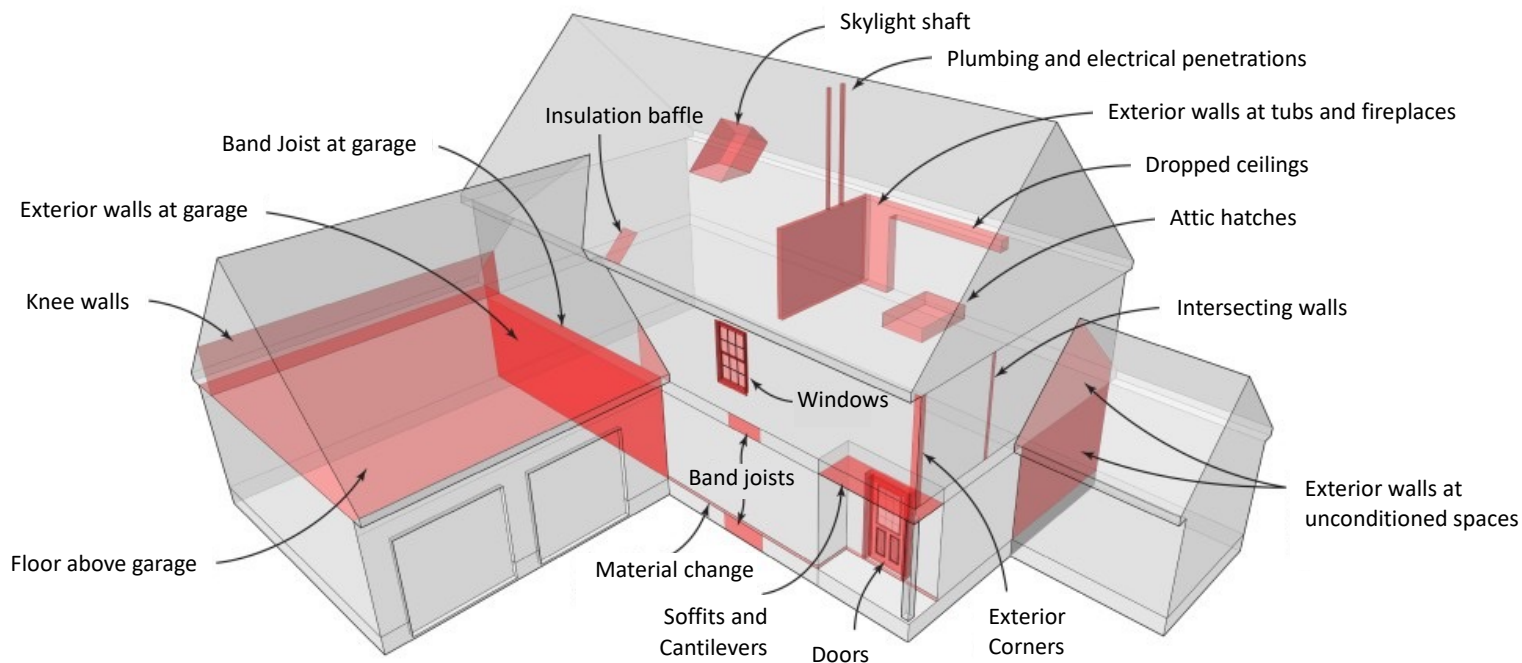


Figure 1: Air barrier missing at dropped ceiling

Figure 2: Common air barrier details

COURTESY: STEVEN BACZEK / JOURNAL OF LIGHT CONSTRUCTION



barrier. In addition, the drywall needs to be sealed to the top and bottom plates adjoining unconditioned attics or basements, and at all penetrations (outlets, switches, and duct boots).

The dropped framing detail adjoining a vented attic and exterior wall shown in Figure 1 demonstrates how the absence of a complete air barrier contributes to thermal bypass and moisture risk. As shown here, the air barrier below the attic insulation and at the exterior wall (e.g., drywall) is often missing in older construction because it is difficult to install once framed.

In the winter condition shown, the exterior and attic are at the same sub-freezing temperature and the house is heated to 70 degrees Fahrenheit. The space in the dropped ceiling would quickly assume the 70 degrees Fahrenheit room temperature (not shown in the diagram) since the drywall covering the soffit provides little thermal resistance. Where there is a pressure difference between the attic and home (e.g., windy day), there will be driving forces from more to less air pressure, and more to less heat.

Since fibrous insulation resists thermal flow but not air flow, the driving forces would result in a thermal flow between the dropped ceiling and attic until some balance point is reached. This is shown in the diagram as 45 degrees Fahrenheit, the mid-point of the temperature difference across the dropped ceiling and attic. This results in a cold surface temperature at the dropped ceiling drywall. Also note that if fibrous insulation is used in the walls, the same driving forces could result in air flow through the wall insulation to the cold exterior sheathing where condensation and moisture damage can occur.

In a home missing air barriers at dropped ceilings, a wintertime



Key Air Barrier Details

AIR BARRIER LOCATION	AIR BARRIER DETAIL
Walls Adjoining Exterior or Unconditioned Spaces	Wall Behind Shower/Tub
	Wall Behind Fireplace
	Insulated Attic Slopes in Unvented Attics
	Attic Knee Walls
	Skylight Shaft Walls
	Wall Adjoining Porch Roof
	Staircase Walls Adjoining Exterior
	Double Walls with Air Space
	Rim/Band Joists
Floors Between Conditioned and Unconditioned Space	Insulated Floor Above Garage, Basement, Crawl Space
	Cantilevered Floor
	Floor Framing Adjoining Garage
Shafts Between Conditioned and Unconditioned Space	Duct Shaft
	Piping Shaft
	Flue Shaft
Attic/Ceiling Interface	Attic Access Panel
	Attic Drop Down Stair
	Dropped Ceiling/Soffit
	Raised Ceiling
	Recessed Lighting Fixtures
	Wind Baffles at Attic Eaves
	Whole-House Fan

Table 1: Comprehensive Air Barrier Details
SOURCE: U.S. ENVIRONMENTAL PROTECTION AGENCY

infrared image shows light images are warm and dark surfaces are cold. It will also show extensive thermal bypass through the attic insulation resulting in extensive cold surfaces.

In the summer, this thermal bypass will work in reverse and lead to excessively hot surface temperatures at the dropped ceilings. This can cause significant comfort issues due to the disproportionate impact mean radiant surface temperatures have on comfort relative to ambient temperature.

Figure 3 shows a solution to the dropped ceiling air barrier detail, where drywall has been installed at the ceiling and wall adjoining an unconditioned attic and garage ahead of the soffit framing. Note that all seams are fully taped and spackled, and edges sealed for a complete air control layer. This will mitigate the type of thermal bypass problems that were noted earlier.

A complete air barrier requires a wide range of special details that occur in home construction as shown in Table 1. An excellent reference for these details is the “[ENERGY STAR Qualified Home Thermal Bypass Checklist Guide](#).”

A section through the whole house should pass a red line test where the exterior and interior air barrier can each be drawn continuously without lifting the pen. An example of this red line test is shown in Figure 4 for two homes: one with a vented

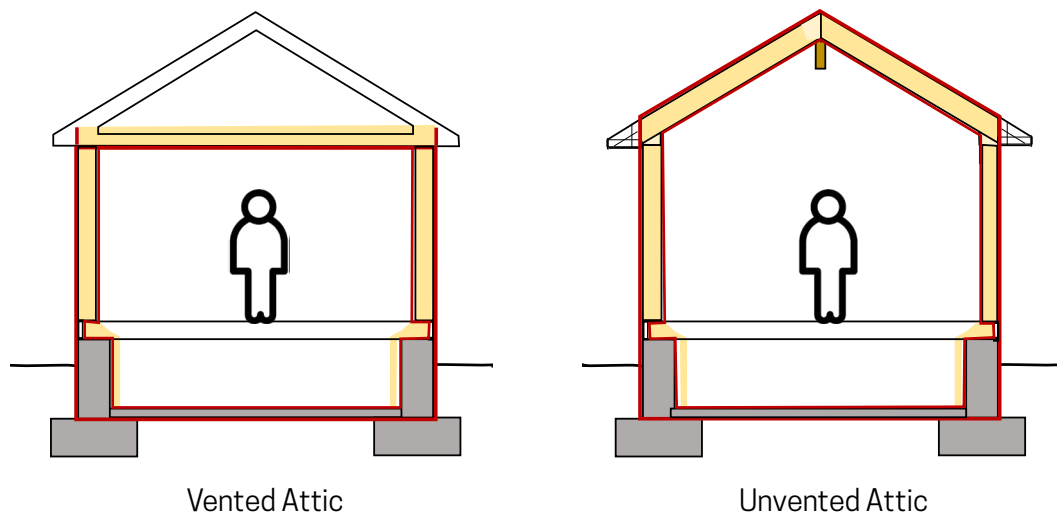
attic and one with an unvented attic. The choice between these two roof insulation options has a significant impact on cost and performance.

In the unvented attic, the interior drywall ceiling serves as the only air barrier at the attic/ceiling interface with the air barrier missing at the top side of the insulation. Therefore, this is not a six-sided assembly with nearly half of the ceiling insulation surface area exposed to the attic (assuming wind baffles or blocking at the eaves between rafters).

Since fibrous insulation is typically used for ceiling insulation, this top layer is exposed to air flow. Thus, any driving forces in the attic due to wind, excessive temperatures, and high humidity can lead to more to less air, heat, and moisture flow through the attic insulation. In addition, fibrous insulation in the attic is subject to compression and reduced performance over time, as it accumulates moisture and maintenance work involves workers in the attic.

I assume code insulation requirements are much greater for attics than walls to account for the missing topside air barrier and more egregious attic summer temperatures. A six-sided assembly can easily be implemented in most climates, with an unvented attic insulated at the slope with spray foam or structural insulated

Figure 4: Air Barrier Red Line Test for vented attic compared to unvented attic



panels. This dramatically improves the effectiveness of the roof insulation albeit with added volume of conditioned or semi-conditioned space. I personally don't believe that codes and modeling software adequately recognize the thermal performance benefit with this option.

In addition, an unvented attic saves significant cost by eliminating the need for all the air leakage and air barrier details at the attic/ceiling interface, as well as attic venting (e.g., soffit vents, gable vents, ridge vents).

As a bonus, unvented attics provide enhanced structural

performance, greater resistance to wildfires and heavy winds, and extra conditioned or semi-conditioned space that can be used for additional rooms, storage, and heating and cooling systems. Thus, unvented attics fix the missing air barrier problem while also providing impressive benefits. This is the type of extra value targeted by **Housing 2.0** best practices for optimizing the user experience. **GB**

Sam Rashkin's two-decade career as a licensed architect includes

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

The Housing 2.0 program is sponsored by Mitsubishi Electric, Huber ZIP System™, Panasonic, and Schneider Electric.

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se.com/us/en/home



CREDIT: ISTOCK/VM

A Green Building TEAM APPROACH

Your project's success starts with knowing all the rules.

BY TERRY BEAUBOIS

Whether you are an architect, engineer, contractor, or homeowner/building owner, knowing what is allowed and not allowed on a specific lot, in the specific community in which a project is being built, is of paramount importance.

At the beginning of any project, it may not always be clear what building rules and requirements will be applied — what will be allowed or restricted. You may be working in a less-familiar location. There are three very good reasons to know clearly what the rules and regulations will be, when your project will be reviewed.

REASON 1: Nothing is worse than being involved in a project and making certain

assumptions about what can be done on a specific parcel, only to discover that you cannot do something that you planned. The project must be re-designed, and this can result in a significant time delay, possible cost increases, and even a final product that doesn't reflect what was originally wanted.

REASON 2: Conversely, discovering too late that you could have done something that others deemed impossible is equally frustrating. This is a compelling reason for fully understanding any regulations that will be applied to a project before beginning.

REASON 3: Another factor is understanding what rules and regulations might be “in the pipeline,” or under consideration

by the regulatory agency that oversees your project. These impending new rules may affect your project — and not always in a good way — by the time you submit for review. This can be a surprise worth avoiding.

Whose responsibility is it? The team approach.

With these reasons for clarity in mind, many homeowners and building owners approach their projects in need of guidance. Offering clients that guidance requires an early analysis to identify the appropriate responsibilities for every project's team.

This responsibility can fall, by default,

to the general contractor/builder or to the architect/designer. Being able to accept such a responsibility emphasizes the importance of a good green building team, one that informs or asks the builder about rules and regulations related to the project.

I know of a case where a “designer” designed a house, not knowing that the property was in a county that required a septic field. The builder’s design did not allow for the septic field and 100 percent expansion. Having a local contractor involved on the team early in the design process and meeting with the local review agency can avoid such a disaster. The homeowners were shocked and upset at finding themselves in such a situation,



Neighborhood watch. To avoid neighborhood-wide and city-wide issues, extensive research needs to be done before any new construction or remodeling project begins. CREDIT: ISTOCK/SLOBO



Upward and outward. Carefully planned multi-family housing will become easier to build in California with the activation of SB10, which goes into effect on Jan. 1, 2022. CREDIT: ISTOCK/EWG3D

and at the costs already incurred for a project that could not be built.

Counseling building owners to build a team that will serve them well in their project is the responsibility of each member of the architecture, engineering, and construction (AEC) sector for all building projects. The more AEC members collaborate from the beginning of any project, the better the outcomes will be.

Example of rules “in the pipeline” that can affect your project.

An issue currently in the California pipeline — one projected to impact well over 100,000 single-family homes throughout the state — is the recent passage of the state’s SB 9 and SB 10. These bills make it easier for Californians to build more than one housing unit on many properties that for decades have been reserved for single-family homes, and will give cities greater flexibility to place small apartment complexes in neighborhoods near public transit. The effects of these zoning changes on the community level have yet to be determined, but they could be far reaching. I mention this because

rules like this may not be limited to California in the future. The movement to change single-family zoning has already happened in Calgary, Canada, and other locations in North America.

It could soon be routine for two or more houses to be built in R-1 zones that have previously been limited to one house per lot. Some large lots may even be allowed as many as four houses in R-1 zones. The places most likely to experience legislation like the new bills in California are those with housing shortages.

Check with local governments to see what the plans are in your prospective project locations. Remember that many new homes you plan to build can be green building projects, and many communities will look more favorably on those projects and are more likely to allow them — if they can review them. Savvy green builders who know of a pending zoning change can be of great value to property owners looking to understand the potential of their property. **GB**

Terry Beaubois, M.Arch, is CEO of BKS: Building Knowledge Systems in Palo Alto, California. He can be reached at tbeaubois@gmail.com.

A man and a woman are sitting at a wooden table in a kitchen, looking at a large sheet of paper, likely architectural plans. The man is on the left, wearing a grey polo shirt, and the woman is on the right, wearing an orange tank top. A laptop is open on the table to the right, and a white mug is in the foreground. The background shows a kitchen with shelves and a window.

COMMON CONSTRUCTION CONCERNS OF HOMEOWNERS

CREDIT: ISTOCK/PEOPLEIMAGES

Homeowners are usually thrilled at the prospect of having a new home built or a major remodeling made to their prized dwelling. But they still have concerns that architects, contractors and construction crews should keep in mind before and during a project.

IDENTIFICATION OF THE CONTRACTOR

Choosing the right contractor or execution agency is the most important part of the project. The most common approach for customers is to go online to look up the city's "best" contractors. But many contractors have bogus claims on their websites, or are not tech-savvy and lack a web presence. Customers also reach out to friends and family for referrals. But this is not the best way to get the most optimum design and best price to service value. The customer may agree for a "lower" price and end up with a 10 percent to 20 percent higher cost in the end.

TIME DELAYS

Up to 90 percent of home construction and renovation projects take more time than committed due to improper scheduling and project management. Planning ahead solves the problem: Schedule the project before the start and wadd buffers at each stage. Also, run parallel tasks to reduce project expenses during construction, and raise and resolve red flags immediately.

PROJECT APPROVALS

Before the dream home can be built, there are approvals needed from municipal administration, local utilities, and even prospective neighbors. Anyone not well-versed in the approval process may spend a lot of time, money and energy trying to acquire the proper permits or authorizations.

INEFFECTIVE COMMUNICATION

Using inefficient tools to communicate and track the project leads to loss of information, and in turn, ineffective communication between different stakeholders. Keep all channels open between the customer, builder, and other stakeholders.

QUALITY ISSUES

Not having a quality assurance plan can hamper the overall quality of the project. Necessary rework will lead to cost and time overrun, and result in material waste that goes into the landfill and causes environmental pollution.

COST OVERRUN

The major reason for cost overrun, and result in material waste is ineffective communication of the scope of work, leading to time delays due to improper planning and execution. Quality issues also add to the time taken to rework any mistakes. Clear communication of the deliverables and expected quality, and sticking to the committed timelines, can prevent the problem.

SOURCE: AMPLIFY MART

No ducts? No problem.



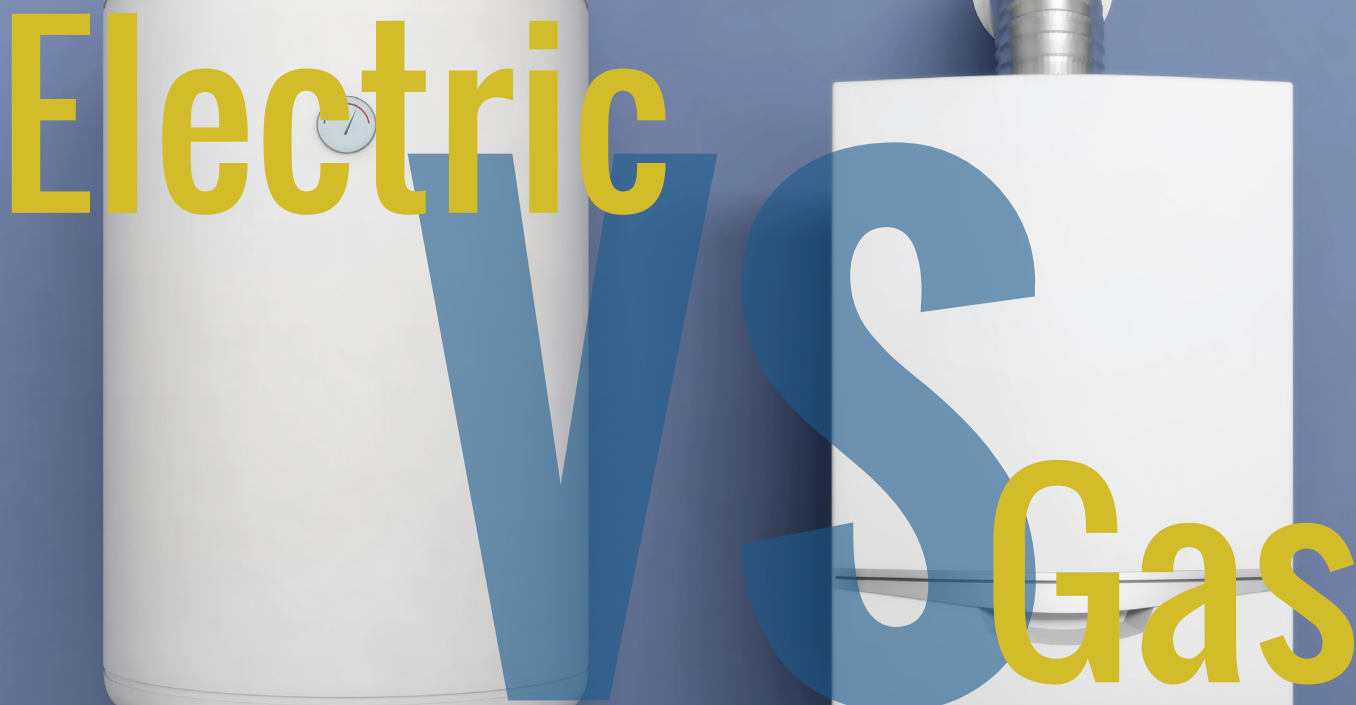
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Electric vs Gas

WATER HEATING BY THE NUMBERS

Innovation, plus the growing menace from Climate Change, support conversion from gas to electric technology for domestic hot water.

BY SHERRY LISTGARTEN

With colder weather coming, it's a good time to think about reducing our heating emissions. When we burn gas and oil to heat the air and water in our buildings, we generate about 10 percent of our emissions in California and an even larger share in less-temperate states (for example, 25 percent in New York). How can we reduce our heating emissions? One good approach is to use electric heat pumps rather than gas-based heaters. In fact, beginning in 2022 the updated California building code specifies these as the default option for space or water heating in each of its 16 climate zones.

Many building owners and contractors are skeptical about this. After all, they reason, modern gas furnaces are 90 percent or even 95 percent efficient, while even the best combined-cycle gas turbines used to generate electricity are

about 60 percent efficient. On top of that, the grid suffers from transmission and distribution losses. While the grid does have some clean energy, solar power is least available when we most need the heat (e.g., nights and winters). Given all of that, can it really be true that electric heat has lower emissions?

Let me tackle that question by focusing on California, which relies heavily on solar energy. There are two parts to the question. The first is, how much pollution is produced in order to get energy for heating (gas or electricity) delivered to the building? And the second is, for each unit of electric or gas energy that gets to the building, how much heat can it produce? (That is, how efficient is the heater?) The answers, based on what is currently known, are largely inspired by a few presentations by Martha Brook, a policy advisor to the California Energy Commission (CEC).

If you want the short summary for California:

- The extraordinary efficiency of electric heat pumps trumps the inefficiency of electricity production and transmission. As the grid gets cleaner, the case for heat pumps grows even stronger.
- Hot water is used year-round, including when the grid is cleanest in California, which makes heat pump water heaters an easy win.
- Heat pump space heaters are a win in well-insulated homes, and even more so when the heat is turned down for a few hours when the grid is dirtiest (e.g., evenings). For other homes, it may be best to improve the building envelope first.

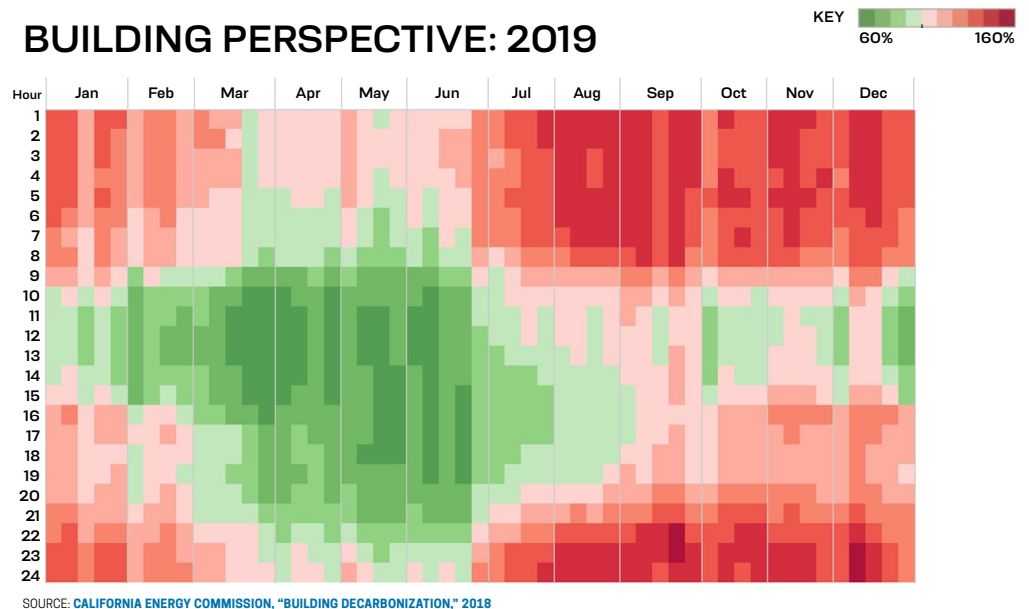
The California analysis has some gaps, and work on this is ongoing. The analysis will be quite different for states with different grid mixes and heating needs. For example, a state that relies more on wind energy and less on solar would have relatively more clean energy available during colder times, further strengthening the case for heat pumps.

GETTING ENERGY TO THE BUILDING: GAS VS. ELECTRICITY EMISSIONS

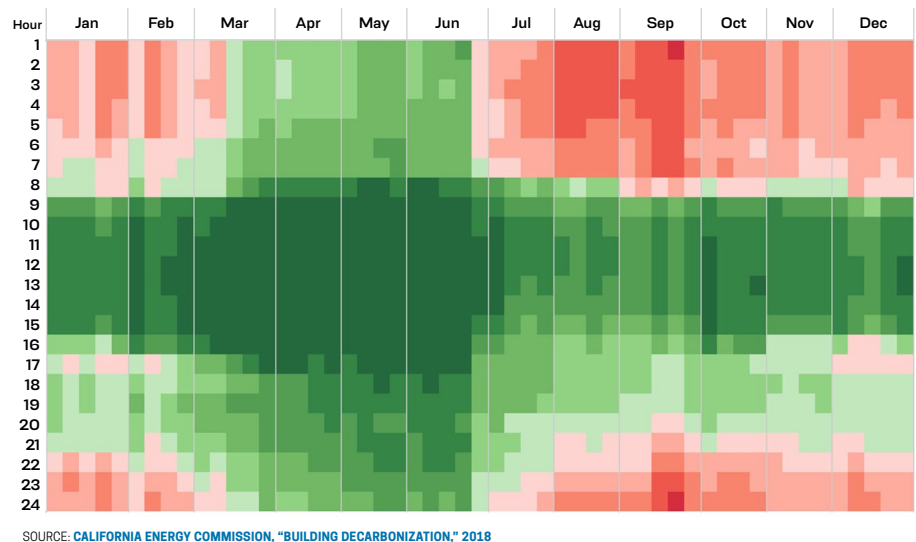
How much pollution is generated, just to transfer energy to a building? The chart at the top right compares electricity emissions to gas emissions, as delivered to the building. No appliance is using the energy yet; the chart reflects emissions just from generating and delivering the energy. The chart has one square for each hour of the year. Months go across the x-axis (from January on the left to December on the right), and hours go along the y-axis (from early morning at the top to late night at the bottom). A green square indicates that electricity has lower emissions intensity than gas, measured in emissions per unit of energy, while red means electricity has higher emissions.

You can see that 40 percent of the squares here are green, and 60 percent

BUILDING PERSPECTIVE: 2019



BUILDING PERSPECTIVE: 2030



are red. On average, gas emissions are lower than electricity emissions. Yes, you read that right. And, in particular, you can see that the comparison is poor for electricity during times when you are likely to be heating a building the most (e.g., fall and winter mornings and evenings).

If you look to 2030 (above), when we will have more renewables (60 percent compared to 31 percent in 2019), the picture is better, with 70 percent of the squares favorable for electricity, though it has a similar overall pattern.

It is important to note that fugitive emissions (methane leaks from transmission and distribution) are not included in the calculations behind this diagram, while the corresponding adjustments for electricity (transmission and distribution losses to the home) are included. Methane leaks can be significant, so incorporating those leaks would make these pictures greener.

HEATER EFFICIENCY

Given the above, we know that heater efficiency is critical if we want to reduce

2019 GHG ELEC HPWH VS. GAS TANKLESS

emissions by switching from gas to electric. An electric heater that is “just” 95 percent efficient, like the best modern gas furnace, is not going to cut it. And that is the magic of heat pumps. A modern heat pump water heater produces about three times as much energy (heat) as it consumes. Instead of creating heat, it extracts heat from the outside air, using a refrigerant, and moves it into the building. This is more or less how a refrigerator operates, but in reverse.

A measure called UEF, or Uniform Energy Factor, is used to compare heat pump water heaters. It is a ratio of the energy output to input, but with some nuances. Per a spokesperson at the CEC, the metric is pretty reliable for temperate areas: UEF includes standby tank losses during the test procedure, as well as measuring the performance of the heat pump over the whole test procedure. In general, the UEF gets you in the ballpark of actual performance in mild climates, but for colder climates or larger households, there is more backup electric resistance use and therefore the performance would be lower.

The 2019 California building code requires that replacement electric water heaters for consumers have a UEF of at least 2 when more than 55 gallons. In practice, it is easy to find heat pump water heaters with much higher efficiency (i.e., UEF 3 or more) for residential buildings. These water heaters are a clear emissions win. The chart at right shows how such a heat pump water heater compares with a tankless gas water heater, which is already much more efficient than a gas tank water heater. This chart is similar to the 2019 chart above, but it takes into account the efficiency of the water heater.

Space heat pumps have a more difficult job in some ways, because they tend to run more when it is cooler. These heat pumps will run nearly constantly in the relatively dirty night hours, while a gas furnace will run infrequently. That means the

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1.1	1.6	1.4	0.5	0.4	0.2	2.5	0.5	1.3	3.2	7.5	0.4
2	4.9	1.8	0.9	0.6	0.1	1.3	0.3	1.1	1.2	0.4	2.6	2.9
3	3.8	2.1	0.3	3.2	0.3	2.0	1.0	0.6	8.5	4.3	0.1	1.8
4	6.1	6.3	0.6	0.5	0.7	0.3	0.3	0.3	0.5	0.4	1.3	1.1
5	0.6	0.4	0.5	0.7	0.3	0.3	0.3	0.3	0.0	0.5	0.8	1.4
6	1.1	0.8	0.2	0.2	0.3	0.2	0.3	0.2	0.2	0.4	0.7	1.2
7	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.4
8	0.3	0.3	0.4	0.3	0.3	0.5	0.3	0.3	0.7	0.2	0.3	0.2
9	0.3	0.5	0.4	0.3	0.5	0.3	0.4	0.3	0.7	0.4	0.4	0.4
10	0.2	0.3	0.3	0.3	0.5	0.4	0.6	0.3	0.4	0.5	0.3	0.8
11	0.5	0.6	0.2	0.4	0.4	0.3	0.3	0.6	0.3	0.6	0.4	1.1
12	0.5	1.0	0.3	0.3	0.5	0.1	0.3	0.5	0.4	0.4	0.4	0.4
13	0.4	0.3	0.3	0.2	0.3	0.1	0.2	0.3	0.2	0.3	0.5	0.3
14	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.5	0.2
15	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.2	0.3
16	0.3	0.2	0.1	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1
17	0.3	0.4	0.1	0.5	0.1	0.2	0.1	0.2	0.1	0.1	0.2	0.2
18	0.9	0.2	0.2	0.3	0.2	0.1	0.1	0.2	0.2	0.3	0.2	0.3
19	0.7	0.3	0.3	0.3	0.2	0.1	0.3	0.1	0.2	0.4	0.3	0.3
20	0.5	0.4	1.0	0.2	0.2	0.4	0.3	0.5	0.5	0.4	0.3	0.3
21	0.6	0.5	0.3	0.2	0.2	0.6	0.3	0.8	0.5	0.2	0.5	0.7
22	0.3	0.8	0.7	0.7	0.4	0.2	0.8	0.6	0.7	0.7	0.5	0.9
23	1.1	0.3	0.8	1.6	0.5	0.7	0.9	1.3	1.2	0.9	1.4	2.9
24	0.7	0.3	1.9	0.7	1.3	0.4	0.9	3.0	0.7	1.1	0.7	1.4

SOURCE: REDWOOD ENERGY ZERO CARBON RETREAT, FEBRUARY 2019

2019 GHG ELEC HP RELATIVE TO GAS FURNACE

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	792.6	452.1	231.7	166.4	19.8	13.9	0.0	0.0	0.0	51.6	411.9	807.6
2	887.6	568.2	290.5	248.1	37.3	11.8	0.0	0.0	0.0	43.7	493.6	888.9
3	969.1	649.8	352.7	315.1	59.1	13.1	0.0	0.0	0.0	58.0	585.5	975.0
4	134.8	731.3	429.0	384.8	78.8	15.0	0.0	0.0	0.0	74.9	671.6	1040.9
5	30.8	239.1	477.3	387.0	90.2	15.4	0.0	0.0	0.0	92.2	55.4	116.8
6	11.9	17.6	0.9	0.5	81.4	11.3	0.0	0.0	0.0	19.6	20.6	14.6
7	0.3	0.3	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.6	0.3
8	0.1	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.3	0.1	0.2
9	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.2	0.2	0.2
10	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.2	0.1	0.2
11	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.1	0.1
12	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.1
13	0.2	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.1
14	0.2	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.2
15	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.2
16	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.2
17	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.2
18	0.2	0.2	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.2
19	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.3
20	0.3	0.2	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.3
21	0.3	0.2	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.3
22	0.4	0.2	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.3
23	0.4	0.3	0.5	61.7	4.4	0.0	0.0	0.0	0.0	16.8	0.3	0.4
24	703.3	332.5	163.7	101.1	10.6	2.4	0.0	0.0	0.0	19.6	349.0	685.9

SOURCE: REDWOOD ENERGY ZERO CARBON RETREAT, FEBRUARY 2019

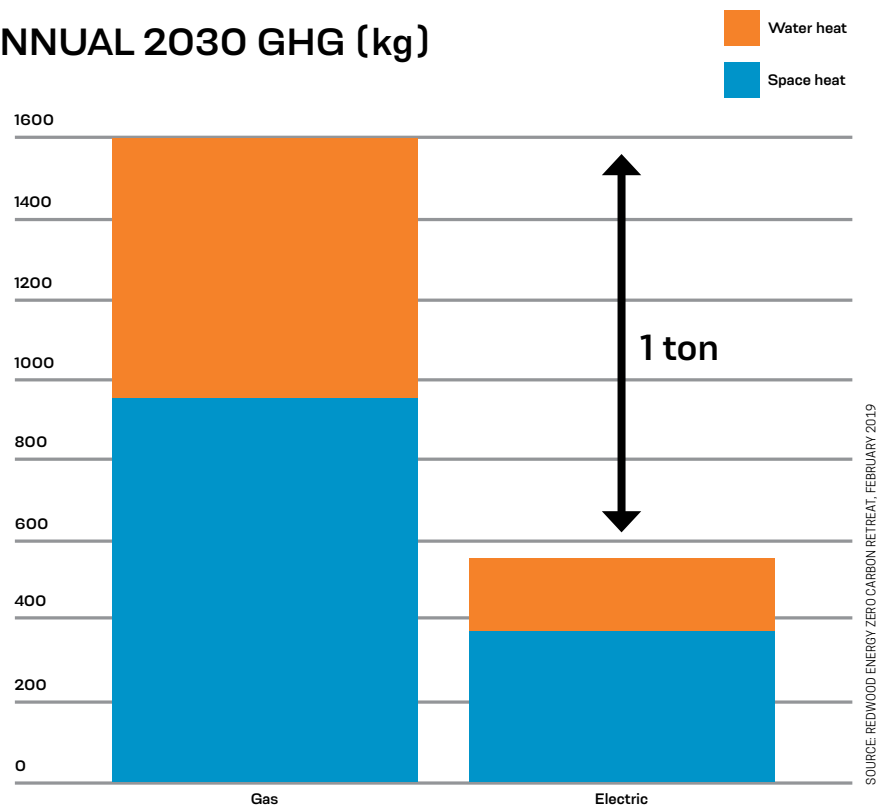
gas furnace has much lower emissions at nighttime, even in a well-insulated house as shown below.

This is true even when using the cleaner power of 2030, as shown below. The heater used in this case meets but does not exceed minimum federal standards, as required for this testing. (“HSPF” or “Heating Seasonal Performance Factor” is a seasonally averaged COP expressed as BTU’s of heat delivered per Watt-hour of electricity consumed.) A more-efficient heater would do better, but note that the red areas will largely stay red, given the multipliers in those squares.

But when you look across the whole day, there is still a benefit to using a heat pump for space heating. The 2019 GHG chart was made using the federal minimum efficiency of 8.2 HSPF. A typical heat pump today would be at least 20 percent more efficient (HSPF of 10), while a high quality heat pump would be 70 percent more efficient (HSPF of 14).

As California’s grid gets cleaner, the

ANNUAL 2030 GHG (kg)



2030 GHG ELEC HP RELATIVE TO GAS FURNACE

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	708.9	435.7	210.0	134.5	14.5	8.9	0.0	0.0	0.0	47.1	351.1	704.0
2	799.3	542.7	262.3	198.9	27.7	7.6	0.0	0.0	0.0	39.4	420.5	779.7
3	875.3	618.5	323.1	251.0	43.9	9.0	0.0	0.0	0.0	52.6	496.9	856.7
4	121.2	695.6	388.5	307.0	57.0	10.0	0.0	0.0	0.0	69.1	568.1	913.9
5	26.8	221.4	422.4	305.0	63.5	9.8	0.0	0.0	0.0	78.3	46.2	100.6
6	10.2	15.7	0.8	0.4	58.9	7.5	0.0	0.0	0.0	16.4	16.7	12.3
7	0.2	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.3
8	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.2	0.1	0.1
9	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.1
10	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1
11	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1
12	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
13	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
14	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
15	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
16	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.2
17	0.2	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.2
18	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.2
19	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.2
20	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.2
21	0.3	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.2
22	0.3	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.3
23	0.4	0.2	0.4	48.9	3.0	0.0	0.0	0.0	0.0	15.4	0.3	0.4
24	621.1	312.7	149.8	80.2	7.3	1.3	0.0	0.0	0.0	18.7	287.5	587.7

advantage grows. Below you can see the overall advantage of using heat pumps for space and water heating, assuming California’s projected 2030 grid.

As always, keep in mind that insulation will save energy and can simplify installations. Heaters in well-insulated homes can time-shift to avoid the dirtiest and most expensive electricity. Good building envelopes also reduce the amount of conditioned air that needs to flow through any duct system.

In summary, even though modern gas furnaces are very efficient, heat pumps save on emissions, because they use much less energy to extract and deliver the same amount of heat. Furthermore, heat pump emissions will only go down as our grids get cleaner. As an important added bonus in our warming climates, heat pumps can provide cooling as well. **GB**

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AT THIS TIME A YEAR AGO, I wrote a column about a disappointing experience that had occurred when we hosted a group of college students at our Mariposa project. What had seemed like a promising opportunity turned into a missed connection and left me less than optimistic about the trajectory of those young folks, and questioning my own ability to relate and communicate with them.

I am pleased to report that a much more encouraging experience happened just a couple of weeks ago.

A foursome of young entrepreneurs from the the company **Deadwood Revival Design** on the West Coast hand-delivered several pieces of magnificent custom furniture to our project. In a rental truck and an SUV, they crossed multiple states, including stretches involving early winter weather that required them to buy tire chains and helped them get in and out of our remote, high-altitude location.

These young men specialize in one-of-a-kind creations that are constructed with salvaged urban trees such as California redwood, red gum, American elm, and sycamore. Their artistry and commitment to quality were quite evident, but equally impressive was their knowledge of the various tree species and the characteristics of the wood each produces.

Arriving in the late afternoon, after many hours of driving, they immediately began unpacking and unloading their cargo of spectacular beds, dressers and tables. They stuck with it until all the pieces were safely indoors, which was well after dark, and then followed us back into town, where they would spend the night. The next morning they would return to the project to complete the assembly and installation. Some of the items

required all four of them just to move.

At dinner, we learned their stories. Their backgrounds ranged from forest firefighters to one with a degree in architecture, but they shared a common love of the work they have undertaken and a dedication to participating in improving the future in every sense. Undaunted by the challenges of climate crisis, social and political conflicts, economic uncertainties, and the ongoing global pandemic that has now claimed more than 5 million lives, they are determined to have a positive effect on the world they are ultimately inheriting. It was immensely gratifying to experience their enthusiasm and confidence.

The following morning, they carefully completed the rest of the work and then took time to tour the project one building at a time. Rather than only being concerned with the long drive home that lay ahead of them, they demonstrated genuine interest in all aspects of our project, from design concepts and material selections, to energy performance and resiliency issues.

They all expressed their intentions to come back next summer for an opportunity to enjoy the facilities and take advantage of all its recreational offerings.

It was a refreshing and reassuring experience for us. We were left with a shared feeling that the future world may be in good hands after all, and that despite all the hurdles we collectively face, there are those who are up to the task. **GB**

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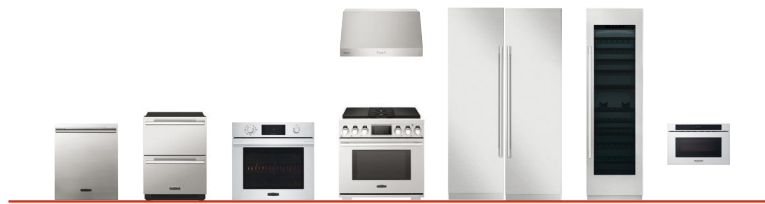
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