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The High Line Coalition
A New Old Housing Paradigm
Pacific Standard Time

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Institute of Architects

Stop it.

What can architecture do about climate change?

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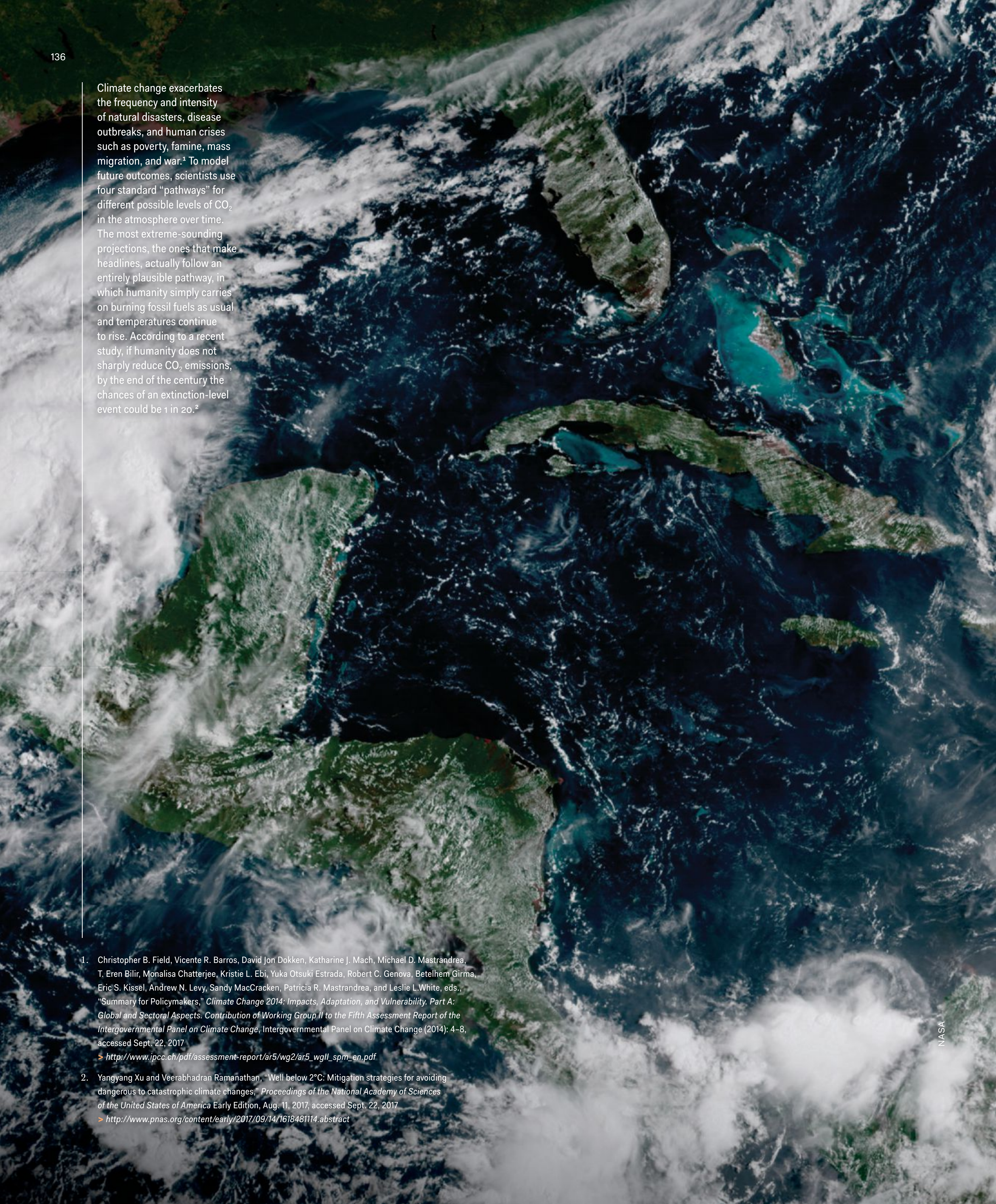

Climate change exacerbates the frequency and intensity of natural disasters, disease outbreaks, and human crises such as poverty, famine, mass migration, and war.[1] To model future outcomes, scientists use four standard "pathways" for different possible levels of CO_2 in the atmosphere over time. The most extreme-sounding projections, the ones that make headlines, actually follow an entirely plausible pathway, in which humanity simply carries on burning fossil fuels as usual and temperatures continue to rise. According to a recent study, if humanity does not sharply reduce CO_2 emissions, by the end of the century the chances of an extinction-level event could be 1 in 20.[2]

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NASA

The Climate is Changing

Hurricanes Katia, Irma, and Jose on Sept. 8, moving west across the Atlantic Ocean to North America

So Must Architect

Text by Ned Cramer

ure

Climate change is the fundamental design problem of our time. Not style, not fees, not education, not community, not health, not justice. All other concerns, many of them profoundly important, are nonetheless ancillary. The threat climate change poses is existential, and buildings are hugely complicit—even more so than that stock culprit, the automobile. As every architect should know, buildings consume some 40 percent of the energy in the U.S. annually, and they emit nearly half of the carbon dioxide (CO_2), through greenfield development, cement production, and the burning of fossil fuels such as oil, gas, and coal.[1] Because CO_2 traps solar energy in the atmosphere, thereby heating the planet, it is the chief agent of climate change, making buildings—and by association, the architecture profession—profoundly responsible.[2]

The concentration of CO_2 in the atmosphere has been increasing since the industrial age, it spiked with the collapse of the Eastern Bloc and the advent of globalization in the 1980s, and in 2013 it passed 400 parts per million for the first time since the Pliocene Epoch, 3 million to 5 million years ago.[3] During the Middle Pliocene, which scientists study because its climate foreshadows our own rapidly approaching future, the global temperature was 5.4 F to 7.2 F higher than today. Sea levels ranged 16 to 131 feet higher, and the polar regions were so warm that coniferous forests grew there.[4]

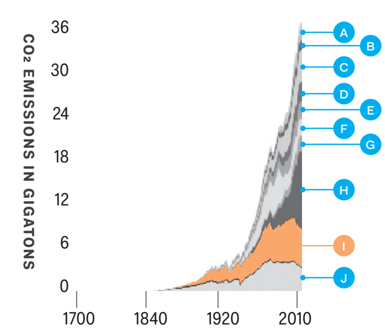
Architects face a choice: to remake the built environment so that it produces no CO_2, or to carry on, business as usual, and live with the consequences.

The World at Stake

The effects of climate change are increasingly self-evident, and costly. Hurricane Harvey took some 70 lives when it hit the Houston area in late August,[5] and Texas Governor Greg Abbott has estimated the damage at $150 billion to $180 billion.[6] At press time, the 3.5 million residents of Puerto Rico remained without power after Hurricane Maria and many of them lacked access to fresh water. “The devastation ... has set us back nearly 20 to 30 years,” Puerto Rico Resident Commissioner Jenniffer González-Colón told the Associated Press.[7] Across the globe, higher temperatures are contributing to record heat waves and droughts, rising sea levels, more intense storms, wildfires, and floods, and other extreme conditions.[8] A mass extinction is underway, thanks in part to climate change; a study in the journal *Science Advances* contextualizes it as “the sixth of its kind in Earth’s 4.5 billion years of history,” with vertebrate species going extinct at 100 times the historical background rate.[9]

Even if humanity was to immediately stop releasing CO_2, the climate would continue to change because the greenhouse gases that we have already dumped into the atmosphere could take millennia to dissipate.[10] But that doesn’t mean we can throw up our hands and ignore the problem. The sober reaction is to pursue both mitigation,

Global CO_2 emmissions by source



- **A.** International aviation and Maritime transport
- **B.** Africa
- **C.** Asia and Pacific (other)
- **D.** Middle East
- **E.** Americas (other)
- **F.** Europe (other)
- **G.** India
- **H.** China
- **I.** United States
- **J.** EU-28

SOURCE: OUR WORLD IN DATA

in order to minimize emissions, as well as resilience, to bolster cities, towns, buildings, and infrastructure so they can endure the storms to come. (The designers of Houston's Buffalo Bayou Park explain how resilient strategies made a difference with Harvey on page 180.) Skeptics should consider that innately risk-adverse institutions such as the U.S. Defense Department,[11] giant re-insurer Swiss Re,[12] and the masters of the universe at Goldman Sachs[13] are planning accordingly. (Read the Washington state insurance commissioner's take on page 148.)

And if we don't reduce CO_2 emissions? Imagine, by the end of the century, a Hurricane Sandy–level flood inundating Long Island, N.Y., every two weeks,[14] Dust Bowl–intensity drought in the Southwest that persists for decades,[15] Miami largely abandoned and under water,[16] and Missouri as hot as Arizona is now, with 46 to 115 days above 95 F each year.[17] Such catastrophic scenarios are not hyperbole, but probable consequences of inaction. Indeed, if there is a fault in climatological findings as a whole, it is that scientists have tended to underplay the threats.[18]

Climate change exacerbates poverty, disease, famine, and conflict, and the human costs will only increase along with CO_2 concentrations and temperatures. By 2100, rising oceans could force as many as 2 billion residents of coastal areas worldwide to migrate toward higher ground.[19] In Florida alone, during Hurricane Irma, some 6.3 million people came under mandatory evacuation orders,[20] and the state could permanently lose 2.5 million or more residents as inundations become more frequent.[21] Unrest will increase across the globe, as it did in drought-ridden Syria,[22] in part because heat makes people agitated,[23] and in part because deteriorating conditions will simply make people desperate.

In the U.S., a 2017 study found, the wetter, relatively cooler northern states will prosper compared to other regions of the country, and attract more crime in the bargain. Agriculture yields in huge swaths of the Midwest will decline by 50 percent or more if we don't cut emissions. The southern states in particular sound like they'll be downright miserable: People will die younger and the poor will grow poorer, with tropical diseases making even greater inroads as mosquitoes flourish in the heat and with local economies declining by as much as 20 percent by 2100.[24]

Architects should note that as temperatures rise construction will be hit particularly hard, because so much of it occurs in the open air. Keep burning CO_2 like there's no tomorrow, and by 2050 the 48 contiguous states will experience an average of 20 to 30 more days than now above 90 F.[25] Any day hotter than 90 F cuts outdoor daily labor supply by up to 14 percent, because workers simply aren't able to show up on site as regularly due to fatigue and illness.[26] On-the-job productivity will drop too. One study found that by century's end, in the sample city of Houston, the erection of a typical steel structure will require 7 percent or more additional labor hours.[27]

According to a paper that the Obama administration released in 2014, any delay in cutting CO_2 emissions "could increase economic damages by approximately 0.9 percent of global output. … These costs are not onetime, but are rather incurred year after year because of the permanent damage caused by increased climate change resulting from the delay." For context, the paper forecasted that 0.9 percent of the U.S. gross domestic product for the year would be around $150 billion.[28]

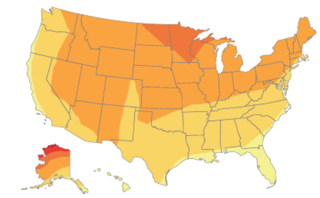
Leadership in Action

Countries participating in the 2015 Paris Climate Accord have agreed to limit emissions in the hope of preventing the global average temperature from rising more than 3.6 F above the preindustrial level (a target broadly known by its single-digit metric equivalent of 2 C). If the temperature goes any higher, numerous studies have concluded, there's no stopping the West Antarctic and Greenland ice sheets from melting, which within this century could raise the ocean 10 feet and 23 feet, respectively.[29]

Given that the national emissions commitments are voluntary, perhaps it shouldn't come as a surprise that a July study put the current chances of keeping the temperature increase below 3.6 F at a depressing 5 percent: "The likely range of global temperature increase is 2.0 C to 4.9 C [3.6 F to 8.8 F]," the authors found.[30]

Every country in the world has signed or plans to sign the Paris agreement except

Projected U.S. temperature change by 2070–99

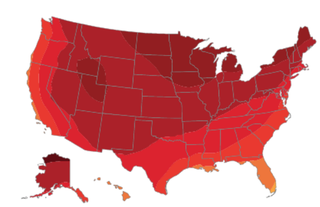


INTERMEDIATE EMISSIONS SCENARIO COMPARABLE TO GOALS OF PARIS CLIMATE ACCORD

CO_2 EMISSIONS INCREASE SLIGHTLY THEN START TO DROP AROUND 2040

STRINGENT CLIMATE POLICIES IN PLACE

STRONG REFORESTATION PROGRAMS



HIGH EMISSIONS SCENARIO WITH NO CHANGES IN CLIMATE POLICY

THREE TIMES TODAY'S CO_2 EMISSIONS BY 2100

HEAVY RELIANCE ON FOSSIL FUELS

WORLD POPULATION OF 12 BILLION BY 2100

3 4 5 6 7 8 9 10 15

TEMPERATURE CHANGE (°F)

SOURCE: NATIONAL CLIMATE ASSESSMENT

Taiwan (which the U.N. doesn't recognize as a nation but which has enacted emissions-reduction legislation anyway)[31] and Syria.[32] Since inauguration day, however, the Trump administration has not only moved to withdraw the U.S. from the Paris accord, perhaps even more alarmingly it has appointed climate-change skeptics and deniers to virtually every key agency position and begun to roll back environmental regulations and censor government officials on the subject of climate change.[33]

Such moves make no sense, environmentally or economically. A 2015 Citibank report estimated the worldwide cost of keeping temperatures below 3.6 F would be $190.2 trillion while the price of inaction would be $192 trillion.[34] What fair-minded individual wouldn't rather save $1.8 trillion, and civilization in the bargain?

Climate change denial is clearly lousy for business, unless you're in oil, gas, or coal, in which case it's a marketing plan. Fossil fuel companies, whose products are largely responsible for CO_2 emissions, and therefore climate change,[35] routinely manipulate research, policy, and public opinion to deflect liability.[36] It's not that the industry and its fronts actually doubt the underlying science. Quite the opposite. Their own in-house scientists raised the alarm.

As has been widely reported, Secretary of State Rex Tillerson, in his previous role as CEO of ExxonMobil, used an email account with the fake name "Wayne Tracker" to hide his discussions about climate change and other sensitive topics. New York State Attorney General Eric Schneiderman demanded the account records as part of an ongoing fraud investigation—alleging that Exxon lied to investors about the potential impact of climate change on the business[37]—only for a company representative to claim that seven years' worth of the emails have been inadvertently erased.[38]

A study released in August reviewed 187 Exxon climate change communications from 1977 to 2014 and found that the more publicly available the information, the more likely it was to discredit the science: "83 percent of peer-reviewed papers and 80 percent of internal documents acknowledge that climate change is real and human-caused, yet only 12 percent of advertorials do so, with 81 percent instead expressing doubt."[39]

Plainly put, evidence continues to mount that fossil fuel companies have tried to shield their businesses from a market reaction they know is inevitable, in much the same way that the tobacco industry lied to consumers for decades about the awful health effects of smoking. The motive is obvious. If cleaner energy sources take hold internationally, the Citibank report found, gas stands to lose $3.4 trillion between 2015 and 2040 and coal could lose $11.5 trillion in the same period.[40] BP estimated total proven oil reserves worldwide at 1.7 trillion barrels in 2016.[41] At the Sept. 24 price of $50.66 per barrel,[42] that's $86.4 trillion in assets that the industry and producing nations will have to write off. You can bet they won't do so willingly.

Government participation at all levels is necessary to encourage right action in the private sector, through research, underwriting, incentives, regulations, legislation, and leadership. Architecture has a relatively small financial footprint, and it will have to punch above its weight in Washington, D.C., where money is speech and legislative action demonstrably follows the dictates of the most "verbose" special interest groups rather than the collective will of voters, as measurable in the policy disconnects between polls and Acts of Congress.[43]

The architecture profession made $7 million in campaign contributions in 2016,[44] an election year, with the AIA's political action committee, ArchiPAC, contributing $226,300.[45] That year, the construction industry made $122 million in contributions,[46] and the real estate industry made $234 million.[47] By comparison, the political network of climate change deniers and petrochemical billionaires Charles and David Koch budgeted $889 million for the same cycle.[48] So while architects and firms can and should take individual responsibility for mitigation, the profession as a whole will benefit from a concerted effort to forge cross-industry alliances, single-mindedly speaking truth to power.

Ways to Go

Time is wasting. Humanity emitted some 2,075 gigatons of CO_2 from the beginning of the Industrial Revolution, circa 1750, through 2016.[49] (A gigaton is a billion metric tons.) Plants and algae do consume CO_2 through photosynthesis. But there aren't enough plants and algae on the planet to offset the emissions from the fossil fuels we burn and our other greenhouse gas–releasing activities. The ocean and atmosphere get stuck with the remainder, and they are warming rapidly.[50] We can only emit another 730 gigatons or so of CO_2 and retain a decent chance of the atmospheric average temperature staying below the Paris target of 3.6 F. In other words, we are on a carbon budget. And if current trends hold, we are on schedule to blow past the budget in little more than 18 years.[51]

It follows that architects must minimize the use of energy- and carbon-intensive technologies such as electric lighting and air-conditioning, and revive low-tech solutions such as passive ventilation.[52] Yet the future won't be a Luddite's paradise. Technology's role ought to grow in some areas, given recent advances in building design, analysis, materials, systems, construction, and operations that help mitigate climate change. (See Blaine Brownell's trends report on page 170.) Architects will have to continue using their influence as product specifiers to move recalcitrant manufacturers toward solutions that emit far less CO_2 and consume far fewer resources than current norms.

Miraculously, it is now possible for buildings to produce and store more energy—clean energy, from renewable sources such as solar and geothermal—than they consume. Whenever feasible, new construction in the United States should conform to this net-zero energy building standard, and policy needs to support that goal, as it does in the European Union.[53]

Where local circumstances make net-zero energy impossible, a carbon-neutral approach can compensate through the purchase of offsets, which are essentially payments to protect forests, increase renewable energy production, and foster other practices that sequester carbon or reduce emissions.[54] To make financial sense of such an approach, cap-and-trade rules would essentially create a market for corporations to buy and sell a governmentally limited set of allowances to pollute. The limit, or cap, would lower over time, bringing overall emissions down with it.[55] California, the world's sixth largest economy, has such a program in place.[56]

Architects generally trade on clients' respect for their expertise and innate creative vision. In a carbon economy, design will obviously still matter, but numbers will matter more, as case studies, modeling, and performance data increasingly drive client decisions. (Discover Arizona State University's process on page 166.) As the world adapts to climate change, thrift will inevitably supplant consumption as a prevailing cultural value, and the architecture profession, along with the rest of society, will have to relearn the great joy of doing more with less.

The sustainability movement provided an important start over the past two decades, but it hasn't gone nearly far enough. For instance, out of 20,000 architecture firms in the United States,[57] some 400 are participating in the AIA's 2030 Commitment to carbon neutrality by 2030, 175 of these reported data for 2016, and just six reported achieving the intermediate goal of reducing predicted energy-use intensity in their building portfolio by 70 percent.[58] (Find out how they hit the mark on page 152.)

Now architects must double down and commit themselves totally to mitigation and resilience, testing techniques and technologies for effectiveness, and hewing to conventions and standards such as the 2030 Commitment,[59] Architecture 2030's 2030 Challenge,[60] the Passive House Institute's Planning Package,[61] and the International Living Future Institute's Living Building Challenge.[62] Such tools should serve as the 21st century equivalents of Andrea Palladio's 1570 treatise *I quattro libri dell'architettura* and other influential pattern books of the past, and they should be under constant review for improvement.

Of course, the implementation of such standards requires support from numerous stakeholders, including consumers, colleagues in related fields, public officials, lenders, and most especially clients. Architects will have to aggressively promote best practices, summoning all of the information at their disposal to make quantified arguments. In order to develop rigorous case studies proving the value of sustainable and resilient construction, the profession will have to gather data with unwavering discipline and take a fiercely open-source attitude toward knowledge exchange, as facilitated by the

AIA and National Institute of Building Sciences' BRIK research directory.[63] (Gordon Gill and Ali Malkawi discuss how architectural education needs to evolve along these lines on page 176.)

Even relatively modest reforms in approach to the built environment will make a difference. By one count, if 9.7 percent of new buildings are net-zero energy by 2050, emissions will be 7.1 gigatons lower.[64] And energy efficiency is just one of many climate change–related issues that architecture has to address, such as construction waste, land use, and fresh-water consumption.[65]

A New Hope

Despite the fact that, as of last year, 97 percent of climatologists agree that climate change is occurring[66]—and, yes, occurring as a result of human activity—almost 90 percent of Americans are unaware of the consensus.[67] Fortunately, science and reason are regaining some lost ground, despite the fossil fuel industry's efforts to the contrary. According to Gallup, half of Americans now consider themselves "concerned believers" in climate change.[68] Though the number may seem confoundingly low, it's actually at a 30-year high,[69] up from 37 percent in 2015.[70]

Despite major reverses at the federal level, American universities, corporations, and state and municipal governments are stepping up and embracing the Paris goals.[71] When considered outside the politically loaded frame of climate change, some green issues prove wildly popular. Nearly 90 percent of Americans favor expanding U.S. solar-energy capacity, and 83 percent support wind capacity.[72]

Good old-fashioned economics are helping as well: Last year, for the first time, solar became the cheapest source of electricity.[73] That's great news, though there's a lot of market share left to grab. Currently, about 65 percent of the electricity used in the U.S. comes from fossil fuels, and 15 percent from renewables; the remaining 20 percent comes from nuclear power plants.[74]

If appropriate policies, regulations, incentives, and legislation were in place—and lamentably, that's a big if—climate change paradoxically would present architects with an opportunity. Construction now constitutes 4.3 percent of the U.S. GDP,[75] and the urgent need for greater efficiency and resilience ought to boost that number, on top of future gains that demographic projections suggest. Certainly, a considerable portion of the $190.2 trillion global mitigation cost that Citibank estimated would go to infrastructure and other building projects. Architects can also take advantage of the environmental crisis to advance related causes such as health and equity.

Transformation is already beginning to occur at the regional, state, and local levels. Individual projects such as ZGF Architects' Rocky Mountain Institute headquarters in Basalt, Colo., and the Miller Hull Partnership's Bullitt Center in Seattle demonstrate just how remarkably efficient buildings can be. (For insights into net-zero building, see page 158.) On the resilience front, Miami Beach, Fla., contending with the rising Atlantic, is spending $400 million to $500 million to install pumps and raise sea walls, sidewalks, and roads.[76] With water levels having plummeted in the massive Lake Mead reservoir during the 2011–17 drought, the Southern Nevada Water Authority is spending nearly $1.5 billion on a new, lower intake tunnel to ensure that the Las Vegas metro area's 2 million residents don't go thirsty.[77] And the Rebuild by Design program is leveraging the skills of architects and planners to strengthen the coastlines of Connecticut, New York, and New Jersey in the wake of Hurricane Sandy.[78] A similar initiative, Resilient by Design, is underway in the San Francisco Bay area.[79]

Without too much imaginative effort, one can see such efforts coalescing into a heroic nationwide enterprise, like the all-encompassing mobilization of the U.S. economy at the start of World War II.[80] Except this time the threat doesn't come from overseas. It's all around us: our dangerous way of living and building in the world. Rethinking the design, construction, operation, and dismantling of buildings in order to mitigate climate change and increase resilience toward its effects is the most important, and exciting, undertaking that architects of this era will likely experience in their careers. Architecture must change with the climate, and change now, in order for humanity to survive, and hopefully thrive.

Areas of the East Coast expected to flood during twice-monthly "king tides" by 2100 under high-emissions scenario

SOURCE: UNION OF CONCERNED SCIENTISTS

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Climate change is causing sea levels and temperatures to rise, expanding hurricane strength, range, and duration. At press time, the 3.4 million residents of Puerto Rico remained without power and with limited access to clean water in the wake of Hurricane Maria (pictured). If we don't decrease CO_2 emissions, by 2100 the global mean sea level would rise at least 1 foot and could rise as much as 8 feet,[1] exposing coastal and island populations to even more extreme storms, surge, and flooding.

RICARDO ARDUENGO/AFP/GETTY IMAGES

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Some people don't believe the climate is changing, but the insurance industry sure does.

EASTON RICHMOND

By its nature, the insurance industry is averse to risk. However, as the climate changes and natural events such as floods, hurricanes, and fires increase in frequency and intensity, insuring residential and commercial structures in disaster-prone areas is a growing liability. Some providers are even opting to leave the market entirely due to the increased financial risk of providing protections in these areas.

For Washington state insurance commissioner Mike Kreidler, rising rates is just one challenge the industry faces in light of climate change. Since 2007, Kreidler has chaired the National Association of Insurance Commissioners' climate change and global warming working group, advocating for insurers to disclose if, and how, they are preparing for the increased risks. Here, he discusses how regulators, policy providers, and architects can work together to prepare and protect the built environment.

This interview was edited for length and clarity.

INTERVIEW BY KATHARINE KEANE

Let's set the record straight—is climate change impacting insurance policies?

I don't think there's any question that it's having an impact on insurance rates, and certainly on insurance company behavior. There is a reluctance on the part of insurers to insure where they are going to face a significant amount of risk. They are interested in avoiding selling too many policies in an area where the risk is beyond their tolerances. We see that right now in the state of Washington with fire. There is a reluctance by at least one insurer to write more business in areas that are prone to wildfires. How many of the wildfires we experience are attributable to climate change? I'm not in a position to make that call. But this is a case where we are seeing a change in insurance company behavior as a result of the risk exposure that they experienced in that particular area.

Whether it's tornadoes, hail, hurricanes, or flooding, you're going to see this behavior by other insurers.

What does this mean for policyholders?

For homeowners, you could see higher rates, particularly if the insurer is concerned that their risk profile is higher than what they had originally subscribed to. Or, in the case of acquiring insurance, policyholders are going to find that there may be fewer insurers in that market.

I have been trying to discourage insurance companies from saying, "Oh, let's just pull out of markets, let's stop writing." I would not be surprised if after this hurricane season insurers re-evaluate where they offer insurance, what they charge for insurance, and where they are marketing going forward.

How can the insurance industry both manage financial risks and provide policies?

I think insurance companies must pay attention to the building codes. It's one thing to make it easy so contractors are warm and fuzzy. It is another to make sure that you have a structure that you want to insure.

Insurance associations are very sensitive to this and they are paying a great deal more attention right now than they were historically. They still have a long way to go to get as engaged as I think they should be. I am certainly encouraging the industry to be more imaginative and inventive in coming up with new types of insurance and I want to be encouraging and supportive of those kind of changes going forward, but I'm leaving it up to the industry. It is their money.

Is the industry making these changes?

You're starting to see it from certain segments of the industry, such as the re-insurers [insurers of insurance companies]. They're starting to realize that they could get hurt a great deal if they are not more responsive. Even the primary insurance companies are starting to push back, saying, "Hey, we've got to get a lot more engaged on this." They recognize that down the road, liability might come back and haunt their industry.

What happens if companies opt to close shop and cease offering certain policies?

We've got constituents that are getting pretty angry about the prices they have to pay for insurance or the lack of availability of insurance. That kind of pressure on policymakers is one where ultimately policymakers can come back and say to an insurance company, "You want to do business in our state? Then you're going to offer homeowners insurance in these coastal areas even though there's a higher potential here for experiencing a loss." And that is not a good practice. I don't think you'd find a regulator who would endorse it because you wind up potentially compromising that insurer if they're essentially being required to continue to offer products in an area that is prone to losses.

That is something that makes me very concerned as a regulator. We want to make sure that the financial viability of insurance companies is not compromised because policy lawmakers make arbitrary actions to satisfy their constituents.

Is there anything architects and designers can do?

Absolutely. The debate around climate change specific to the insurance industry is mitigation. Tactics for trying to mitigate against increased potential for loss include building codes, which has a direct correlation with architects, and land-use practices, which also has a direct impact on architects.

It's in the insurer's best interest and the architect's best interest to make sure that changes in building codes are not arbitrary and capricious, but actually have the most impact on the resilience of these structures in a way that is compatible with both the insurance company and the building owner.

ROBYN BECK/GETTY IMAGES

In early September, the La Tuna Fire, one of the worst conflagrations in Los Angeles history, burned through 7,194 acres in the Verdugo Mountains and drew more than 1,000 firefighters from all over California to help put it out. If we don't sharply reduce CO_2 emissions, by 2050 the risk of wildfire will increase across the country, the fire season will begin even earlier and end even later, and the greatest impact will be felt in the South Central states, including Kansas, Louisiana, Oklahoma, and Texas.[1]

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Burbank
TOWN CENTER
FITNESS
macy's
SEARS

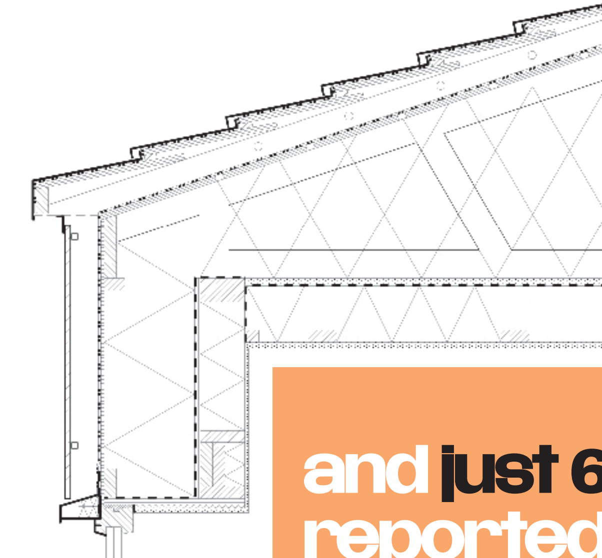
4240 Architecture · AC Martin Partners · ADD · Adrian Smith + Gordon Gill Architecture · Aecis Arkitektura · AECOM · Aedis Architecture and Planning · Aidlin Darling Design · Albert Kahn Associates · Alliiance (formerly Architectural Alliance) · Ankrom Moisan · Ann Beha Architects · ARC/Architectural Resources Cambridge · Archimania · Architecture is Fun · Architekton · Architerra · Arkin Tilt Architects · Arrowstreet · Atelier Ten · Ayers/Saint/Gross · Bahr Vermeer Haecker Architects · Ballinger · BAR Architects · Bard, Rao + Athanas Consulting Engineers · Bergmeyer Associates · Bernardon · Beyer Blinder Belle · BKSK Architects · Blackbird Architects · BLGY · BLT Architects · BNIM · Bohlin Cywinski Jackson · Booth Hansen · Bora Architects · Boulder Associates · Braun and Steidl (formerly Braun+Yoshida Architects) · Brooks + Scarpa · Browning Day Mullins Dierdorf · BRS Architects · Bruner/Cott · Building Center No. 3 · Buro Happold Consulting Engineers · BWBR · CallisonRTKL · CannonDesign · CBT Architects · Clark Nexsen · CO Architects · Coldham & Hartman · Coolearth Architecture · Cooper Carry · Coulson · Crenshaw Consulting Engineers · Croxton Collaborative · CS&P Architects · CTA Architects Engineers · Cuningham Group Architecture · Cunningham | Quill Architects · Dake Wells Architecture · Danciart Architects · Dattner Architects · David Baker Architects · Davis Partnership Architects · Dekker Perich Sabatini · Design Organization · DesignGroup · DesignLab · Dettmer Architecture · Dewberry · DIGSAU · DiMella Shaffer · DLR Group · Dore & Whittier · Dougherty + Dougherty Architects · DRAW Architecture + Urban Design (formerly Davison Architecture + Urban Design) · DSGN Associates · Dull Olson Weekes-IBI Group Architects · DWL Architects + Planners · Dyron Murphy Architects · EHDD · Ehrlich Yanai Rhee Chaney Architects · Elizabeth Eason Architecture · Elkus Manfredi · Ellenzweig · Elness Swenson Graham Architects · ELS Architecture and Urban Design · Emersion Design · Engberg Anderson · English + Associates Architects · Ennead Architects · Epstein · ESG Architecture & Design · Eskew+Dumez+Ripple · EwingCole · EYP · Fairfield/Architects · Farr Associates · Feldman Architecture · Fentress Architects · FFA Architecture and Interiors · Finegold Alexander Architects · Firmitas Architecture & Planning · FKP Architects · Flad Architects · Fraser Seiple Architects · Fraytak Veisz Hopkins Duthie · Fredrick + Fredrick Architects · FXFowle · Garcia Architecture+Design · GarthShaw · GBD Architects · Gensler · GFF · GGLO · GHT Limited · GKKworks-All Offices · Goettsch Partners · Goody Clancy · Green Hammer · Green|Spaces · Gresham Smith and Partners · Grimm+Parker · GSBS Architects · Guidon Design · GWWO Architects · Habitat Studio Architecture · Hacker (formerly THA Architecture) · Hahnfeld Hoffer Stanford · Hamilton Anderson Associates · Handel Architects · Harley Ellis Devereaux · Harriman Architects + Engineers · HarrisonKornberg Architects · Hartshorne Plunkard Architecture · Hastings · HDR · Helix Architecture + Design · Helpern Architects · Hennebery Design · HGA Architects & Engineers · Hickok Cole Architects · High Plains · HKS · HMC Architects · HMFH Architects · HOK · Holly & Smith Architects · Holst Architecture · HOLT Architects · Hord Coplan Macht · HPZS · Icon Architecture · IKM · In Balance Green Consulting · Innovative Design · Integral Group · Interface Engineering-Chicago · Interface Engineering-San Francisco · Invision · iStudio Architects · Jacobs Global Buildings · Jahn · JAMASLO-SE · Jer Greene

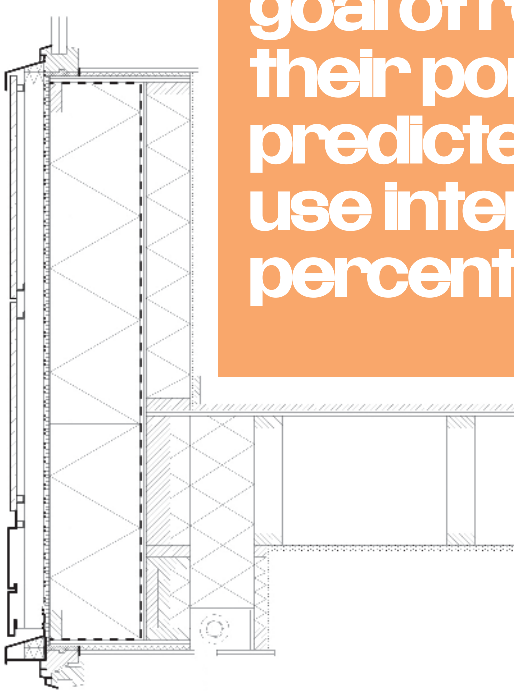
Out of the 20,000 or so architecture firms in the United States, 400 have joined the AIA 2030 Commitment to carbon neutrality…

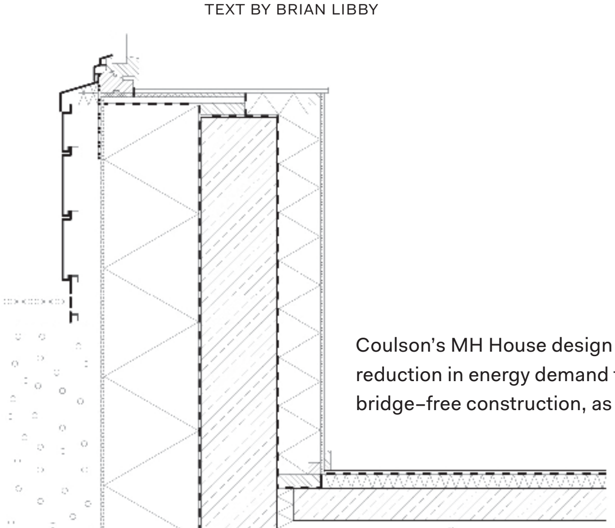
Jones Design Studio · Jones Studio · Kaplan Thompson Architects · KieranTimberlake · Kipnis Architecture and Planning · Kirksey · KlingStubbins · Kluger Architects · KMD Architects · Krueck+Sexton Architects · L.M. Holder III · Lake|Flato Architects · Landon Bone Baker Architects · Leddy Maytum Stacy Architects · Leers Weinzapfel Associates · Legat Architects · Lehrer Architects LA · Leo A Daly · Levi + Wong Design Associates · LHB · Limbacher & Godfrey Architects · Lionakis · Little Diversified Architectural Consulting · LMN Architects · Lord, Aeck & Sargent · LPA · LS3P · M.C. Harry & Associates · Maclay Architects · Mahlum · Map Lab · Marner Architecture · Maryann Thompson Architects · Mazzetti Nash Lipsey Burch · McGranahan Architects · Metrix Engineers · Meyer Scherer & Rockcastle · MHAworks · Miller Dyer Spears · Mithun · Mode Associates · Moody Nolan · Moseley Architects · MSR · Murphy Burnham & Buttrick · NAC|Architecture · NADAAA · nArchitects · NBBJ · NC-office · Neumann Monson · Nicholson Kovalchick Architects · O2 Architecture · Office for Local Architecture · Olson Kundig · OPN Architects · Opsis Architecture · Orcutt Winslow · Otak · Overland Partners · Pacific Energy Co. · Page · Paul Poirier + Associates Architects · Payette Associates · Pei Cobb Freed & Partners Architects · Pelli Clarke Pelli · Perkins Eastman · Perkins+Will · Perry Dean Rogers Partners Architects · Peters, Tschantz & Associates · Pickard Chilton · Pill-Maharam Architects · Positivenergy Practice · Quattrocchi Kwok Architects · Quinn Evans Architects · Ratcliff Architects · Ratio Architects · Ravatt Albrecht and Associates · RB+B Architects · RDG Planning & Design · Renaissance 3 Architects · Retail Design Collaborative & Studio One Eleven · RMW · RNL · Robert A.M. Stern Architects · Ross Barney · Rossetti · RSC Architects · RSP Architects · RVK Architects · Ryall Porter Seridan Architects · Sasaki · SBLM Architects · Schmidt Associates · SERA Architects · Serena Sturm Architects · Sheldon Pennoyer Architects · Shepley Bulfinch · Shive-Hattery · SHKS Architects · SHP Leading Design · Siegel & Strain · Sink Combs Dethlefs · Smith Seckman Reid · SmithGroupJJR · SMMA · Snow Kreilich Architects · Solomon Cordwell Buenz · Skidmore, Owings & Merrill · Spector Group · Spiezle Architectural Group · SRG Partnership · Stanley Studio · Steffian Bradley Architects · Steinberg Architects · Stephen Tilly, Architect · Sterner Design · Stonorov Workshop · Studio Ma · Studio Nigro · Studio2G Architects · Studios Architecture · Swanke Hayden Connell Architects · T. Howard + Associates · Taylor & Syfan Consulting Engineers · TBDA · TerraLogos: Eco Architecture · The Aztec Corp./Aztec Architects · The Beck Group · The Design Alliance · The Green Engineer · The Miller Hull Partnership · The Sheward Partnership · The SLAM Collaborative · Thompson Young Design · Thornton Tomasetti · TK-Architecture · TLC Engineering for Architecture · Touloukian Touloukian · Trapolin-Peer Architects · Treanor · Trivers Associates · TRO Jung | Brannen · Tsoi Kobus & Associates · TVS Design · Urban Design Group · Valerio Dewalt Train Associates · Vanderweil Engineers · VMDO Architects · VOA Associates · Wallace Roberts & Todd · WBRC Architects-Engineers · WDG · Weber Thompson · Westlake Reed Leskosky · WHR Architects · Wiemann Lamphere Architects · Wight & Co. · William Rawn Associates, Architects · Willoughby Engineering · Wilson Architects · WLC Architects · WRNS Studio · Yost Grube Hall Architecture · ZeroEnergy Design · ZGF Architects · Ziger/Snead Architects

Legend

- New signatories
- 2 or 1 years
- 4 or 3 years
- 5+ years







Coulson's MH House design achieves a 90 percent reduction in energy demand through airtight and thermal bridge-free construction, as shown in section.

and just 6 have reported meeting the goal of reducing their portfolio's predicted energy use intensity by 70 percent or more.

TEXT BY BRIAN LIBBY

In 2015, the AIA 2030 Commitment set a new target for predicted energy use intensity (pEUI) savings—70 percent of the performance baselines set in the U.S. Department of Energy's 2030 Commercial Building Energy Consumption Survey—as part of the initiative's goal of 100 percent carbon-neutral projects by 2030. But what does it take to conceptualize and build structures that can achieve this ambitious benchmark? Five of the successful firms share how they attained such energy savings—and why it matters.

Coulson

LOCATION	Duluth, Minn.
FIRM SIZE	Three
YEAR JOINED	2015
pEUI SAVINGS REPORTED IN 2016	100 percent
SPECIALTY	Residential, educational, commercial, and cultural

Before founding her own firm, architect Carly Coulson, AIA, worked for Foster + Partners in London, during which time she landed a lead role on 30 St. Mary Axe—better known as the Gherkin—a pioneer in energy efficiency. An overriding lesson she learned in Europe was to blend rigor and nonchalance. "Most of my architect friends in Europe are meeting rigorous energy targets and it's scarcely even discussed," Coulson says. "I really want to get to the point where we don't talk about sustainability at all."

Coulson designs all of her projects to meet Passive House Institute standards, which informs what she calls a conservation-first approach to energy efficiency. "We're trying to reduce energy demand as much as we can before we introduce renewable energy," she says. "That's really critical in order to be able to have the creative freedom to not necessarily be locked into a super-high-tech-looking project. We're able to achieve 70 or 80 percent reduction [in EUI] just by focusing on the envelope and passive strategies: superinsulation, heat recovery ventilation, passive solar, airtightness. Then getting to positive energy is really simple. You're just making up the remaining 20 percent or so."

Though she sees the 2030 Commitment as a way for many firms to shift their design cultures, Coulson thinks of becoming a signatory as a way of giving back. "When I started 10 years ago, the pioneers in deep energy reduction and green building were super supportive and transparent about their experiences and knowledge ... and we benefited greatly," Coulson says. "We want to make sure that firms and architects that are starting this process now aren't starting from scratch, but they're able to use our experience as a springboard. Because otherwise it can seem daunting and fraught with a lot of risk."

Though Coulson engages in energy modeling for each project, the architect has deliberately kept her firm small, which means she can hire consultants "based on the project needs and really learn from them."

What's the 2030 Commitment?

The 2030 Commitment is a framework created by the AIA to provide standardized tools for U.S. firms to track their progress toward achieving carbon-neutral construction by 2030. Participants are asked to submit an annual portfolio—all projects in an active design phase during that calendar year—to an online database with statistics including average predicted energy use intensity (pEUI) savings projections, building type, area, baseline energy performance, and other details. The pEUI of each project in a firm's portfolio is averaged to determine the total annual savings. Firms are responsible for self-reporting and portfolios are not audited by the AIA. The AIA's current overall target reduction for signatories is 70 percent pEUI savings, and this target will increase incrementally by 10 percent in 2020, 2025, and 2030, when pEUI savings should reach 100 percent. According to a recent AIA Commitment By the Numbers report, projects by signatory firms only reached an average of 42 percent pEUI savings in 2016.

ZeroEnergy Design

LOCATION	Boston
FIRM SIZE	Seven
YEAR JOINED	2010
pEUI SAVINGS REPORTED IN 2016	84.3 percent
SPECIALTY	Residential

The name of this firm says it all, denoting a commitment to net-zero energy buildings across its portfolio. "For us, it's about accountability," says co-founder Stephanie Horowitz, AIA. "It's about reporting on all of your projects, not just the shining stars. We think it's important to share that information with the profession and to be able to benchmark our own performance against other firms to see how we're doing."

The firm's portfolio is primarily residential, an area of design where Horowitz noticed "a lack of technical rigor among design firms," she says. "I think that's probably still the case, but not nearly as bad as it was over a decade ago when we started." The firm was already dedicated to net-zero energy design before signing on to the 2030 Commitment, according to Horowitz, but she sees it as "increasing energy literacy" in the public, and especially in the profession. "The social network of joining is absolutely a catalyst for change," Horowitz says. "Being able to compare yourself against your peers is a great motivator for enacting change within a firm."

Co-founder Jordan Goldman says residential design can be both easier and harder to pull off in terms of energy efficiency. "You're avoiding big process loads from a large commercial building: plug loads, elevators," he says. "In that way, residential is easier by sealing the envelope, high-efficiency heating and cooling systems, and good windows." However, many homeowners do not want to look past five years for a return on investment, Goldman notes. "Commercial clients may be willing to invest in energy efficiency if it's a long-term strategy," he says.

Since its founding in 2005, ZeroEnergy Design has made use of energy modeling. "If you're not measuring, you have no idea if it's working," Goldman says. In recent years, the firm has posted both the pEUI of each project and the actual result on its website, for the purposes of transparency.

Insisting on high-performance design means the firm won't accept just any commission. "Our clients are self-selecting," Horowitz says. "We go through a vetting process to make sure their values are aligned with ours." But she says it has helped rather than hurt their business. "We're creating this niche, this area of expertise we have."

Mode Associates

LOCATION	San Luis Obispo, Calif.
FIRM SIZE	Five
YEAR JOINED	2010
pEUI SAVINGS REPORTED IN 2016	74.5 percent
SPECIALTY	Higher education

When Mode Associates signed onto the 2030 Commitment in 2010, founder Stacey White, AIA, knew she was not alone. "Another firm and I signed on nearly at the same time," she says, "and through our AIA chapter, we were able to get 11 other firms to sign on. We went through the first year of cultural shift and getting processes in place and setting up the structures of our firms together." The group shared the cost of training, for example, and even established a referral network among each other. "I don't do housing unless it's for myself or my family," says White, whose firm designs K–12 schools and higher-education projects. "But if someone reaches out to me and says, 'I want a high-performance residential project,' I hand it off to [one of] these other firms because I know the rigor with which they are designing things. You can coexist in a community without it feeling like competition."

White laments that architects may mistake meeting the 2030 Challenge benchmark as "another add-on when as an architect you're already exhausted." But, she says, "It's not as complicated as one might perceive." By employing energy modeling on every project and arriving to client meetings with statistics in hand, the architects can show that decisions about materials, siting, or insulation are in the client's best interest. "It's freed us up to have deeper, more meaningful conversations with our clients because we have better information for them."

As for energy modeling, "some say it's the engineers' job," White says. "It's my position that the tools are now at a place that allows the iterative modeling—energy, daylight modeling—that can flow with your design process seamlessly. Once you embed that thinking and data-driven, multi-option testing as you move through the design process, it is nearly seamless, and allows us to test our ideas very quickly and rapidly." Technological advances have also been beneficial for making energy predictions. "When I started 20 years ago, you became dependent on the engineer to find if we were doing it right, and that came too late in the process," she says. "Now we can do it very early. It puts those important decisions back in the architect's hands."

EHDD

LOCATION	San Francisco
FIRM SIZE	55
YEAR JOINED	2011
pEUI SAVINGS REPORTED IN 2016	80.1 percent
SPECIALTY	Education K–12, commercial, science centers and aquariums, multifamily student housing, civic, and restoration/ adaptive reuse

For EHDD, meeting the 2030 Commitment's energy-efficiency goal isn't enough. "Every year we've beaten the target," says associate principal Brad Jacobson, AIA. "We're actually achieving 80 percent reduction, which is the 2020 target. We're proud of that because we feel like as a firm that's done net-zero, we need to be out ahead of the curve. Ideally we're going to get to the 2030 target by 2025."

Jacobson admits the firm's energy-efficiency success starts with being in California, where a mild Bay Area climate and a head start from the state's rigid Title 24 of California Code of Regulations efficiency standards makes reducing energy easier. "The delta between what standard code requires for efficiency and what you need to get to do a cost effective net-zero building is very small now," he says. "It's not asking our clients to take a huge leap. It's nudging them just a little bit further."

Yet the architect does credit pricing for renewable energy, particularly solar, for moving the energy-saving dial. "It's just mind-blowing what's happened in the last few years," Jacobson says. "Solar costs less than traditional grid-based fossil fuel electricity. It has crossed that line. So we're pushing photovoltaics more than maybe others are. When you do your calculations in the 2030 Challenge, energy produced counts as much as energy saved." He says not only EHDD's public-sector clients are embracing solar but even speculative developers, "because they see it as higher returns on their investment."

Jacobson says most medium-to-large firms "tend to do much more modeling in-house than us." Instead, he explains, EHDD favors local consultants. "In other areas people may struggle to find that talent, so they have to go more internal and use their BIM tools to do the analysis," Jacobson says. "But I think for us it's a little bit more old-school coordination."

Arkin Tilt Architects

LOCATION	Berkeley, Calif.
FIRM SIZE	Nine
YEAR JOINED	2016
pEUI SAVINGS REPORTED IN 2016	76 percent
SPECIALTY	Residential, commercial, education, camps, and recreation

Arkin Tilt Architects is deeply rooted in sustainability, placing climate analysis at the beginning of a project before any forms or materials are chosen. Yet co-founder David Arkin, AIA, who runs the office with wife Anni Tilt, AIA, has a confession to make about the firm's 2030 Commitment reporting: "I have to be honest: I believe we are one for one," he says. "Only last year did we join the 2030 Commitment. So we've reported one project so far." And that project, designed to both LEED Platinum and Passive House Institute standards while also achieving net-zero energy, happens to surpass the 70-pEUI benchmark.

Arkin Tilt's portfolio nevertheless serves as an argument for attending to sustainability beyond just energy efficiency. Arkin, who co-founded the California Straw Building Association and is a past president of Architects/Designers/Planners for Social Responsibility, shares with Tilt an emphasis on materials and carbon neutrality. For the firm's projects, "it's the construction of the building itself—photosynthetic materials that can sequester more carbon than is emitted in their manufacture and use—that represent a growing percentage of the carbon impact of a building, and its more immediate one," Arkin says.

Yet signing on to the 2030 Commitment isn't something the architect takes lightly. "For us it set real targets as well as a means of communicating to our clients why we are targeting carbon-neutral buildings today," Arkin says. The firm performs some in-house energy modeling early in a project to determine glazing and daylighting strategies, and to right-size mechanical systems or photovoltaics. But Arkin also cites collaboration with outside engineering and energy consultants.

Has embracing energy and carbon neutrality been good for business? "When we started our practice 20 years ago, we decided to wear our environmental and solar values on our sleeves," he says. "Each published project, each class I taught, each award seemed to lead to another client motivated to express their environmental values in their building projects."

Each of the past three years has successively been the hottest on record, and across the planet new local records are being set with astonishing frequency. On July 21, Shanghai (pictured) experienced its hottest day since monitoring began in 1872, with the thermometer topping off at 105.6 F. And as of press time in late September, Chicago was having an unprecedented six consecutive days and counting above 90 F. If we don't sharply reduce CO_2 emissions, by 2100 the average global temperature could increase by 10 F or more,[1] and 75 percent of the world's population could be exposed to lethal heat levels for at least 20 days a year.[2]

1. Donald Wuebbles, David Fahey, Kathleen Hibbard, Benjamin DeAngelo, Sarah Doherty, Katharine Hayhoe, Radley Horton, James Kossin, Patrick Taylor, Anne Waple, and Chris Weaver, "Executive summary," in *Climate Science Special Report: A Sustained Assessment Activity of the U.S. Global Change Research Program* [D.J. Wuebbles, D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock, eds.], U.S. Global Change Research Program (2017): 16, accessed Sept. 22, 2017
> *https://assets.documentcloud.org/documents/3920195/Final-Draft-of-the-Climate-Science-Special-Report.pdf*

2. Camilo Mora, Bénédicte Dousset, Iain R. Caldwell, Farrah E. Powell, Rollan C. Geronimo, Coral R. Bielecki, Chelsie W.W. Counsell, Bonnie S. Dietrich, Emily T. Johnston, Leo V. Louis, Matthew P. Lucas, Marie M. McKenzie, Alessandra G. Shea, Han Tseng, Thomas W. Giambelluca, Lisa R. Leon, Ed Hawkins, and Clay Trauernicht, "Global risk of deadly heat," *Nature Climate Change* (June 19, 2017): 501–506, accessed Sept. 22, 2017
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ROLAND NAGY

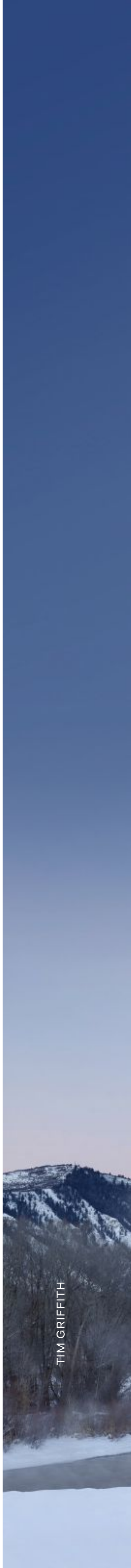
At this point, the technology exists for buildings to produce all the energy they need—and that needs to be the norm. Don't worry: It's not as hard as it sounds.

TEXT BY DAVID HILL

William Maclay, FAIA, has a mission: to make net-zero-energy buildings the new normal. "We have the technology, tools, and knowledge we need to do this right now," he writes in his book, *The New Net Zero: Leading-Edge Design and Construction of Homes and Buildings for a Renewable Energy Future* (Chelsea Green Publishing, 2014). "We can do it one home, one building, and one community at a time."

Among the net-zero projects Maclay's 12-person Waitsfield, Vt., firm has designed: the firm's own office, in a renovated carriage barn; a traditional gable-roofed house in Newton, Mass.; and the first net-zero, LEED Platinum secondary school building in the United States. Completed in 2009, the Putney School Field House in Vermont achieves a staggeringly low energy use intensity (EUI) rating of 9 thanks to superinsulated walls and windows, a 36.8-kilowatt solar array, extensive daylighting, and air-source heat pumps for use in the winter. In fact, the building produces more electricity than it uses.

From the start, school officials wanted a sustainable gym, but with a budget of $3 million, net-zero was out of reach. Maclay presented three different proposals at three different performance levels, along with projected operating costs for each one over a 20-year period. In the end, the school opted to raise additional funds—about $2 million—for the net-zero version. The calculation was relatively simple: pay now for a building with virtually no energy costs, or pay more later to heat and cool a typical code-compliant structure.


TIM GRIFFITH

Net-Zero in All Climates

The U.S. Department of Energy has designated eight different climate zones in the U.S., and there are net-zero buildings in all but the coldest one. Hot and humid Florida: check. Frigid Maine: check. Rainy Washington state: check. Sun-baked Arizona: check.

In Basalt, Colo., which is in North America's second coldest climate zone, the Rocky Mountain Institute Innovation Center is achieving net-zero without conventional heating or cooling. The two-story office building, designed by ZGF Architects, is superinsulated and relies largely on passive solar strategies for heating in the winter, when outside temperatures can drop into the single digits. In the summer, windows open automatically at night to draw in cool air, which keeps the building comfortable without air conditioning. A rooftop photovoltaic system generates enough electricity to meet the building's energy needs. The average U.S. office building has an energy use intensity rating of 91. Based on its first year of occupancy, the Innovation Center's EUI is 15.9.

Meanwhile, in hot and humid Dallas (climate zone 3), Austin- and San Antonio–based Lake|Flato Architects recently completed a net-zero big-box store for TreeHouse, an eco-friendly home-improvement company. The interior of the 25,000-square-foot building is lit almost entirely by natural light, which enters the structure via north-facing clerestory windows. A sawtooth roof design maximizes surface area for a huge photovoltaic system, which produces 164 kilowatts of electricity. A Tesla battery stores energy to power the building at night. The building's heating and cooling systems, says project architect Lewis McNeel, AIA, are "fairly ordinary," though 60 percent more efficient than those found in a conventional building. A dramatic roof eave projects over the entrance, creating a kind of front porch and shading the building from the blazing Texas sun. Inside, Big Ass Fans help circulate air, allowing for a broader air-temperature range.

McNeel says a typical big-box store in the same location would have an EUI of about 72. "Our target for TreeHouse is 33," he says. "We're still looking at the numbers, but we think we're pretty close."

TreeHouse co-founder and CEO Jason Ballard, who commissioned Lake|Flato for the project, told *Inc.* magazine that he estimated the building would cost 25 percent more than a traditional big-box store. Initially, he said, the developer balked at the company's plans. "But I said I'd pay for it as long as they let me realize the savings on my electric bill," he explained. Ballard estimates payback could take seven years or less.

Convincing the Client

Many net-zero buildings begin with motivated clients who decide to go deep green and then hire an architect to get the job done. Maybe it's a university that's willing to pay a premium for a net-zero library because of its long-term goals for sustainability. Or a retailer that wants to show customers its commitment to the environment.

Increasingly, however, architects are leading the way, convincing clients that net-zero is the way to go. "Firms need to be proactive about it," says Greg Mella, FAIA, SmithGroupJJR's director of sustainable design and co-chair of the AIA's 2030 Commitment Working Group. "Clients have fixed budgets, and you can't necessarily convince them to increase their budgets to make it happen. But you can at least identify a path to allow them to meet their energy goals, and then look at net-zero strategies as an investment. More often than not, a lot of these things make good economic sense."

More firms are using net-zero experience as a market differentiator, says Ralph DiNola, CEO of the New Buildings Institute. "If you're going to pitch net-zero to a potential client," he says, "it's easier to do if you've done it before, or if your firm's office is a net-zero building."

Consider the case of Charlottesville, Va.–based VMDO Architects. When the firm met with officials from Arlington, Va., to discuss a

Net-zero projects still represent a fraction of total new construction, but their numbers are on the rise. According to the Portland, Ore.–based New Buildings Institute (NBI), which has been tracking net-zero buildings since 2000, there were 332 verified or anticipated net-zero buildings in the United States and Canada at the end of 2016. Verified buildings have achieved net-zero energy performance for at least one full year. "We see them in every building type and climate zone, but not in every state," says Ralph DiNola, NBI's CEO.

California leads the way, with 137 verified or anticipated net-zero buildings, according to NBI's most recent tally. That's no surprise, since the state has set ambitious targets for all new residential buildings to be net-zero by 2020, and all new commercial buildings by 2030. Oregon, with 16 verified or anticipated net-zero buildings, is next on the list, followed by New York (14), Massachusetts (11), and Florida (11). K–12 schools make up the largest portion of verified or anticipated net-zero buildings, followed by offices, colleges and universities, "other" (including a tennis club and a transit center), and multifamily housing.

"If we want to take climate action and try to solve this in the near term," DiNola says, "we should be focusing on the building sector. We know we can do this today. There are lots of

ALAN KARCHMER/OTTO

VMDO's Wyck Knox, AIA, recalls: "The client basically said to us, 'We want one of those, but make it better.' In response, we said, 'We think that means net-zero.'" VMDO pitched a "zero-energy-ready" building (that is, without solar panels) for $30.7 million, or a full net-zero version for $1.3 million more, which would still be less than the $36 million budget. Not surprisingly, the school district said yes to the full version.

The 98,000-square-foot Discovery Elementary School (left), which opened in 2015, is the largest net-zero school in the country and was the first built in the region. The design features 1,706 roof-mounted solar panels, enough to produce nearly 500 kilowatts of electricity; a geothermal well field; extensive daylighting plus 100 percent LED lighting; and insulating concrete form construction for high thermal mass. The district is saving about $100,000 a year in energy costs, Knox says.

VMDO and district officials set an initial EUI goal of 23. "We ended up blowing that away," Knox says. "It modeled at 21, and it's been performing at 15. And this year, it's on track to perform at 13.2, which makes it one of the most energy efficient K–12 buildings in the country."

proposal for a new elementary school, net-zero wasn't a consideration—at least not at first. School officials knew about a VMDO-designed elementary school in nearby Manassas Park that had won several awards for sustainability, including a 2010 AIA Committee on the Environment (COTE) Top Ten Project Award.

The Economics of Net-Zero

The RMI Innovation Center's net-zero construction premium

+10%

(AS COMPARED TO A LEED SILVER BUILDING IN THE SAME AREA)

The Innovation Center's estimated annual payback

$8,100

ENERGY SAVINGS

$3,000

MAINTENANCE COST SAVINGS

$334k

INCREASE IN EMPLOYEE PRODUCTIVITY

Quantifying the added cost of going net-zero is difficult, given the number of variables: climate zone, building type, and energy and construction costs. A 2014 study commissioned by the Washington, D.C., Department of the Environment determined that the cost premium for conventional energy-efficiency measures was 1 percent to 12 percent, depending on the building type, versus 5 percent to 19 percent for net-zero strategies.

Net-zero design advocates argue that any cost premium will be offset over time by energy savings. "This is particularly valuable to nonprofits, educational and public institutions, the elderly, and others on a fixed income," William Maclay writes in *The New Net Zero*. That can be an especially strong argument in the Northeast and other areas where fuel costs are high.

Consider the case of the Rocky Mountain Institute's Innovation Center. RMI concluded that the project cost 10 percent more to construct (excluding an additional premium for top-grade finishes) than a LEED Silver building in the same area. The institute projects a four-year payback based on estimated annual savings on energy ($8,100) and maintenance costs ($3,000), and a significant annual increase in employee productivity and satisfaction that will benefit the company's bottom line ($334,100). To calculate that last figure, RMI looked at hundreds of studies compiled and analyzed by Carnegie Mellon's Center for Building Performance and Diagnostics and computed a conservative 3 percent annual increase in productivity.

Although the institute doesn't track revenue for each of its individual offices, the numbers have been growing company-wide since the building was completed. The staff at the Innovation Center, for instance, is eventually expected to grow from 30 to 50 employees. "We want people to look at the building and be inspired by it," says Cara Carmichael, a manager in the buildings practice at RMI's Boulder, Colo., office., "and realize that net-zero is totally achievable—and it's not that much more expensive."

great examples of buildings that have achieved net-zero energy, and in many cases they're within the cost range of a conventional building."

The economics of net-zero is changing quickly, adds Amanda Sturgeon, FAIA, CEO of the International Living Future Institute (ILFI), which administers a certification process for net-zero buildings. (The ILFI recently teamed up with the NBI to streamline the process, now called Zero Energy Certification.) "The investment to go net-zero is now about half of what it was about three or four years ago," she says. "And it can pay back quickly, generally in less than five years, and in some places, even less."

One factor: the cost of the technology to achieve net-zero—photovoltaic systems and LED lighting, for example—has plummeted. And it keeps improving. "That's huge," says Maclay, who says he's now able to use air-source heat pumps in Vermont's cold climate zone, something that was impossible just a few years ago.

"This is not leading-edge technology," DiNola says. "These buildings assemble a set of what we would call 'state of the shelf' technologies and strategies."

For a building to be certified as net-zero by the ILFI, all of its energy needs over a 12-month period must be supplied by on-site renewable energy. No combustion is allowed. The ILFI does allow an "off-site renewables" exception for buildings that, for example, are located in tight urban areas where solar panels aren't feasible.

The nonprofit think tank Architecture 2030, which in 2006 issued the 2030 Challenge calling for all new buildings, developments, and major renovations to be carbon-neutral by 2030, recently announced a partnership with the World Bank Group's International Finance Corp. The goal is to support the international architecture and building community in designing net-zero carbon buildings around the world, which they define as "highly energy efficient building[s] that produce on-site, or procure, enough carbon-free renewable energy to meet building operations energy consumption annually."

DiNola cautions against getting too hung up on labels like "net-zero," "carbon neutral," and others. "There should be an openness to these different approaches," he says. Maclay agrees: Although he believes strongly in the certification process for net-zero, including the ILFI's highly rigorous Living Building Challenge, he also acknowledges that even "near" net-zero buildings are far better than conventional structures. "If we're trying to solve the carbon problem," he says, "I think we need to get pretty creative about the solutions. I'm not so concerned about the label as actually getting the world to change."

What It's Like to Live or Work in a Net-Zero Building

Net-zero buildings tend to rely on natural daylighting to help reduce energy use: Conventional lighting accounts for about 11 percent of energy use in residential buildings, and 18 percent in commercial buildings, according to the U.S. Department of Energy. But there's a side benefit as well: daylighting is known to improve employee health, well-being, and productivity.

At the net-zero, Living Building Challenge–certified Bullitt Center in Seattle, daylight is the primary illumination source for every workstation, on every floor of the six-story office building. Even on cloudy days—something Seattle is quite famous for—backup LED lighting is barely used. Employees have celebrated the building's ample daylight, which is maximized by floor-to-ceiling, triple-pane windows. Generous 14-foot ceiling heights allow for deeper sunlight penetration.

Similarly, the Rocky Mountain Institute (RMI) Innovation Center relies on extensive daylighting, supplemented by LED desk and overhead lights. Workstations are clustered along south-facing windows for maximum daylight exposure. According to a survey of occupants, a full 100 percent of employees said they are either satisfied or very satisfied with the building's daylighting and LED illumination, and 37 percent felt the lighting "significantly enhanced" their ability to get their jobs done.

Perhaps the most remarkable thing about the Innovation Center, especially given its location, is that is has no central heating or air conditioning. In the winter, it relies mostly on passive-solar measures for heating, combined with a supertight envelope, including R-50 walls and quad-pane windows. On the very coldest winter days, an in-floor electric resistance radiant heating system helps keep employees comfortable. Employees also have the option of using battery-powered Hyperchairs, which look like conventional office chairs but have built-in heating elements (as well as fans for summer use). In the summer,

Average gains in worker productivity calculated for RMI's Innovation Center

+3.6%
INDIVIDUALIZED TEMPERATURE CONTROL

+5.5%
MAXIMIZED DAYLIGHT

+9%
MIXED-MODE OR ALL-NATURAL VENTILATION

the building automatically draws in cool air overnight, which keeps the interior comfortable throughout the day.

All of these strategies aimed at achieving net-zero also enhance the employee experience. RMI looked at hundreds of studies compiled and analyzed by Carnegie Mellon University's Center for Building Performance and Diagnostics that showed a 3.6 percent average gain in productivity for individualized temperature control, a 5.5 percent gain for maximized daylighting, and a 9 percent gain for mixed-mode or all-natural ventilation.

Learning Net-Zero

Given the growing interest in net-zero design, it's no surprise that some architecture firms have already positioned themselves as specialists in the field. For many firms, however, doing net-zero means, essentially, jumping right in. That's what Archimania did when it proposed a net-zero welcome center on I-55, just south of Memphis, Tenn., where the 25-person firm is based. Archimania had done a number of LEED projects, but tackling a net-zero building required some preparation. "I think we all read a lot," says principal and founding partner Todd Walker, FAIA. "And we looked at a lot of case studies."

The $3.2 million welcome center, which opened in July, is on track to become Tennessee's first net-zero structure. (The state didn't have enough funds for a full array of solar panels on the roof, so, for now, the building is considered zero-energy ready.)

Archimania also plans to build a net-zero office for its growing firm by retrofitting two 60-year-old buildings in Memphis. And construction has started on a net-zero case study house called Civitas (shown), which principal Barry Alan Yoakum, FAIA—who will own and live in the structure—envisions as a kind of "white paper" for sustainable residential design. The 2,700-square-foot house overlooking the Mississippi River will generate 170 percent more energy than it uses and has a targeted EUI of 9.

Yoakum and Walker want to show that net-zero is possible—and affordable—even in hot and humid Memphis. "We're serious about net-zero," says Yoakum. "And we want to demonstrate our knowledge to our clients."

The drought that just ended in the West lasted six years and drew down the water in Nevada's Lake Mead (pictured), the largest reservoir in the U.S., to the lowest level since it was formed by the construction of the Hoover Dam in the 1930s. If we don't sharply reduce CO_2 emissions, by 2100 the Southwest could face a 99 percent likelihood of Dust Bowl–intensity drought that lasts for decades.[1]

MARKUS MAINKA

1. Toby R. Ault, Justin S. Mankin, Benjamin I. Cook, and Jason E. Smerdon, "Relative impacts of mitigation, temperature, and precipitation on 21st-century megadrought risk in the American Southwest," *ScienceAdvances*, vol. 2, no. 10 (2016), accessed Sept. 22, 2017 > *http://advances.sciencemag.org/content/2/10/e1600873/tab-pdf*

You can't force clients to make the right choices, but you can introduce them to projects, ideas, individuals, and institutions that are making a difference.

Arizona State University (ASU) wants to green the desert. An early conceptual plan by the university and Phoenix-based Studio Ma for the new Interdisciplinary Science and Technology Building Number Seven (ISTB7, left), which is now out for RFQ, explores the possibility of the Tempe campus's greenest building yet, with a large wastewater treatment plant that would recycle graywater and blackwater for both the campus and city, and carbon-sequestering façade tiles that would help scrub the surrounding air. But ASU's ambitious sustainability initiatives go far beyond a single building: University architect and assistant vice president Edmundo Soltero, FAIA, explains how the school is working toward a carbon-neutral future, and offers tips on how other organizations can reach green benchmarks quickly, without blowing their budget.

This interview has been edited for length and clarity.

INTERVIEW BY KATIE GERFEN

What is the university's long-term plan, and how does it factor as a priority for new projects?

Sustainability initiatives are very much a part of the mantra of the university, and we're aspiring to achieve climate neutrality by the year 2025 (with the exception of transportation). The portfolio that I manage—development of the capital improvement projects—is going to have a large impact on that. We are actively exploring energy-use reduction but also carbon footprint reduction. For example, if we're building something that has the main infrastructure built out of concrete, we analyze how much of the carbon footprint we could reduce if we did it with steel or cross-laminated timber. We also track our waste. When we built our new student pavilion, we diverted roughly 95 percent of the waste away from landfill.

We do virtual modeling and computational fluid dynamics of all our facilities, and we review those from the programming stage and set the goals that are important to us. In schematic design, we assemble a committee of faculty that are recognized leaders in sustainability in our design and engineering school. We go through the design, the operations, the maintenance—anything that's going to have an impact on the carbon footprint.

Do you measure performance after projects open?

We are actively trying to do post-occupancy evaluations. In our student pavilion, we track the energy used by lighting and HVAC. A lot comes down to occupant behavior: We built a Prius, now we've got to teach the kids how to drive it like a Prius, and not a Mustang. We're installing a dashboard in that building that will have real-time analysis so students can see the impact of leaving the lights on all night or in a room they're not using. We also have a website called Campus Metabolism that tracks the daily global energy usage of all campus buildings and pushes updates to the students on their iPhones.

We are also looking at energy conservation measures in existing campus buildings. We're trying to build a quasi-religious process about looking at all the systems. Some buildings actually are very difficult to improve—it's hard to upgrade the envelope, for example, where you don't allow the Arizona heat to come in. We try to offset energy penalties as much as we can with new construction.

How so?

For example, with ISTB7, we're trying a more comprehensively sustainable approach where we track more than energy. We are thinking about refrigeration systems used to cool the buildings—now, we literally just dump millions of gallons of condensate straight down the drain. We started small—catching some of that condensate and using it to wash balls in the athletic department—and now we're looking to see if we can change the pH balance of the water so that we can use it for irrigation. We're also looking at a partnership with the City of Tempe because ISTB7 will be in a location where a lot of the effluents from the city move to sanitary waste facilities. We have the opportunity to take some of the waste from our campus and theirs and make an industrial-scale waterworks. The discussion about actually treating the blackwater for uses such as flushing toilets and urinals in the new building has just started.

How much water would you be able to treat?

Probably a third of the campus, and a large quantity from the city. The larger metro area doesn't manage water very well, but we could start teaching people how to behave responsibly with such a valuable asset in the desert.

How do you find ways to be creative with a tight budget?

Cost is an undertone in everything we do. Lots of interim meetings with our CFO happen even during the course of these conceptual design developments. But for public institutions, state funding is dwindling. We look to grants, and to issuing a combination of bonds and debt and being very careful to manage our debt-equity ratio. Our auxiliary projects, mainly the student union or residence halls, are managed through a public-private partnership so that we can maximize the use of our funds for buildings that will support the educational mission directly. And obviously we seek donations.

As a client focused on sustainability, what advice would you give to institutions that say they can't afford it?

We try to engage people from many different disciplines and establish a common language. We collect all the ideas for a building and see how those would manifest in square footage and specific infrastructure early on, and run a budget analysis. So even two weeks in, we'll know how much over budget we are and be able to start the paring down and prioritization process. It's different than a design-centric approach. We are always looking for excellence in design, but the first conversation we have with any architect for any project is about this collaborative process where everyone down to the facilities department is going to be engaged—and their input is equally important.

One in nine people worldwide lives in a state of hunger, and climate change is making matters even worse. In Yemen, global warming, civil war, and a rapidly growing population are exacerbating severe water shortages, leaving 17 million people on the brink of famine and humanitarian groups scrambling to provide adequate food (shown). If we don't sharply reduce CO_2 emissions, every degree-Celsius increase in mean global temperature will reduce yields of wheat by 6 percent, rice by 3.2 percent, corn by 7.4 percent, and soybeans by 3.1 percent.[1]

ANADOLU AGENCY/GETTY IMAGES

1. Chuang Zhao, Bing Liu, Shilong Piao, Xuhui Wang, David B. Lobell, Yao Huang, Mengtian Huang, Yitong Yao, Simona Bassu, Philippe Ciais, Jean-Louis Durand, Joshua Elliott, Frank Ewert, Ivan A. Janssens, Tao Li, Erda Lin, Qiang Liu, Pierre Martre, Christoph Müller, Shushi Peng, Josep Peñuelas, Alex C. Ruane, Daniel Wallach, Tao Wang, Donghai Wu, Zhuo Liu, Yan Zhu, Zaichun Zhu, and Senthold Asseng, "Temperature increase reduces global yields of major crops in four independent estimates," *Proceedings of the National Academy of Sciences of the United States of America*, vol. 114 no. 35 (2017): 9326–9331, accessed Sept. 22, 2017.
> http://www.pnas.org/content/114/35/9326

حملة إغاثة الشعب اليمني
إهداء / دولة الكويت
مشروع توزيع السلة الغذائية للعام ١٤٣٧هـ - ٢٠١٦م - محافظة الحديدة

Waste is a crime. Embrace your inner pragmatist and celebrate materials, methods, and technologies that do more with less.

TEXT BY BLAINE BROWNELL, AIA

Bamboo's high tensile strength makes the material a viable option for construction.

JEFF ELKINS

Though sustainability rating systems such as the U.S. Green Building Council's LEED program have inspired environmentally responsible material approaches in the AEC industry, future strategies will demand a more significant effort to achieve measurable benefits. Next-generation material approaches must increasingly address material effects both within and beyond an architectural project. Significant improvements are possible at the intersections of established sustainable design categories—where materials meet energy, site design, and environmental equality. The following case studies exemplify innovative material strategies for architects to make a more significant contribution to building resilience.

Adapt and Reuse

A commonly held tenet within sustainable design circles is that the greenest building is the one that is already built, since relatively fewer new materials and energy are required for renovations. By reusing existing structures, building systems, and materials, a design team can reduce the environmental impact of a structure while "creating successful cities and neighborhoods," writes the National Trust for Historic Preservation in its Preservation Leadership Forum website. Moreover, the Trust argues, "historic fabric creates economically vital, socially equitable, and strong, resilient neighborhoods."

Increasingly, there are compelling instances of retrofit structures that once might have been considered raze-and-build projects. For example, Paris-based Local Architecture Network (LAN) decided to wrap a collection of unloved concrete towers in Bordeaux, France, in new skins of glimmering polycarbonate cladding. The decision avoided a massive demolition and construction effort, and the sliding translucent panels have increased the versatility of the façade for users. To achieve the full potential of reuse, the architects could have specified repurposed or recycled materials for this envelope—including the plastic sheeting as well as the aluminum framing and connections. An architect's default strategy at every scale—site, structure, and materials—should be to privilege the existing over the new. Of course, new products are always an option, but they should not be the first.

Banking Carbon

The currency of sustainable design is carbon, yet we still treat it as an abstract concept based on estimates of how much carbon dioxide is produced throughout a material's life cycle. Although conceptual carbon accounting is an important process for measuring environmental effects, we forget that carbon can also literally be stored within certain substances. While the manufacture of many building materials, including steel, concrete, and plastics, contribute measurable quantities of carbon dioxide to the atmosphere—resulting in poor environmental performance—biomass, such as wood and other plant materials, acts as a carbon sequester, storing more carbon than it releases. Unless the material decays, burns, or is destroyed, the carbon will remain embedded within. Buildings with a significant amount of biomass-based materials (sustainably harvested, of course) may therefore be viewed as carbon banks.

The recent surge of interest in tall wood construction is, in large part, a testament to the environmental appeal of "depositing" carbon versus effectively "withdrawing" it in a concrete or steel structure. To appreciate the difference, consider that mild steel has a carbon dioxide footprint of about 1.8 kg/kg (approximately 3.9 lbs./lb.) in primary production—which is nearly five times that of softwood, at about 0.38 kg/kg (approximately 0.83 lbs./lb.). The notion of carbon banking is exemplified in projects such as Beijing-based Penda's 2015 Beijing Design Week contribution Rising Canes, an adaptable, multistory construction system that uses nothing but bamboo and natural fiber rope—two biomass products that require minimal processing and therefore maximize this kind of literal carbon accounting in architecture.

Follow the Light

The building envelope is a territory of continuous conflict: Occupants require daylight, views, and fresh air, but these are only available at the expense of the façade's thermal performance. It is often assumed that a window is a thermal hole—with poor insulative capacity compared to solid wall construction—and that more glazing equals more energy use, but less occupant comfort due to increases in glare and solar heat gain. However, not all light-transmitting materials have this problem.

For example, Boston-based chemical and performance materials company Cabot Corp. manufactures Lumira aerogel, a translucent, silica-based insulating material for a variety of glazing applications. Aerogel is more than 90 percent air and comprises a microporous structure that inhibits air molecule movement, thus severely limiting heat transfer. This advantageous characteristic results in energy savings and increased user comfort over standard glazing. Depending on the installation, the aerogel can deliver a thermal-resistance value ranging from R-6 to R-20, which compares favorably with a typical R-24 solid insulating wall. (In other words, the aerogel-based envelope can almost provide the thermal savings of a solid exterior wall.) Although aerogel is translucent rather than transparent, other glazing systems may be incorporated within aerogel-based façades for clear views to the outside.

Buildings as Power Plants

The U.S. electricity grid is woefully antiquated: on average, power plants are more than three decades old and distribution grids more than 25 years old. "Not only do we have more outages than most other industrial countries, but ours are getting longer," writes cultural anthropologist Gretchen Bakke in *The Grid: The Fraying Wires Between Americans and Our Energy Future* (Bloomsbury Publishing, 2016). Bakke and other critics of outmoded, centrally organized power networks—like that of the U.S.—advocate the more reliable and resilient combination of distributed energy generation and storage. To borrow a proven financial investing strategy, we need to diversify our energy portfolio rather than rely on a single, vulnerable source.

For example, offerings such as Tesla's Solar Roof tiles can facilitate the integration of on-site renewable energy generation into individual buildings. The glass-based tiles also serve as a comprehensive substitute for conventional roofing materials. According to an August 2017 *Consumer Reports* article, a typical detached house in a state offering green energy tax credits—such as New York or California—could save money with the Tesla Solar Roof after 30 years of use. And pairing this and similar products with building-integrated batteries will serve the increasingly critical needs for nighttime and peak-demand energy.

Tesla's Powerwall, for example, is a lithium-ion energy unit that stores 14 kilowatt-hours of power—enough to run a one-bedroom house for a day—and may be grouped with up to nine additional modules. Mercedes-Benz, Nissan, and LG Chem offer similar products, suggesting that building-integrated power storage is a rapidly growing commercial niche. Once architects accept that buildings can be responsible for both power-generation and storage, they can provide more reliable and sustainable energy to clients while alleviating pressures on a strained, predominantly fossil fuel–powered electricity grid.

Design Backwards

One of the most significant impediments to environmentally responsible construction is the notion that all buildings are permanent. "Most designers do not design with an end in mind," write Fernanda Cruz Rios, Wai Chong, and David Grau, AIA, the authors of a recent Arizona State University study on deconstruction. Despite incremental gains delivered by LEED and other sustainable building programs, 160 million tons of waste related to building construction and demolition are disposed of each year in the U.S.—about a third of the overall solid-waste stream. Design for Disassembly (DfD), a method that demonstrates an awareness of eventual deconstruction and employs measures to facilitate the process, is seen as a pivotal tool for reducing construction and demolition waste. The approach champions principles such as the use of standardized components and reconfigurable connections. However, few incentives, other than environmental altruism, currently exist for architecture firms to adopt such a practice. As a result, designers are considered to be the primary impediment in DfD planning.

An alternative approach is to include reverse construction considerations in the design process. In this method, every stage of material design and specification, beginning with initial product surveys, should include DfD valuations, and design teams should associate quantifiable metrics that factor into material selections. They should also view construction documents as having multiple lives and functions, informing not only how materials come together, but also how they come apart. New tools are on the horizon that can ease the way for DfD tracking. One example is the Building Information Modeling–based Deconstructability Assessment Score, proposed by University of the West of England, Bristol research fellow Olugbenga Akinade and his colleagues, that will enable designers to measure the DfD potential of a project during the design phase.

Looking Forward

Today we are continually reminded of the importance of responsible environmental choices. The climate change–exacerbated devastation caused by Hurricanes Harvey, Irma, and Maria has only punctuated the necessity for resilient design. Future strategies for building performance will increasingly combine material, energy, and other resource-related considerations to develop more holistic approaches to high-performance, environmentally responsible design and construction. To date, we have targeted the low-hanging fruit of environmental material strategies. Now comes the real work.

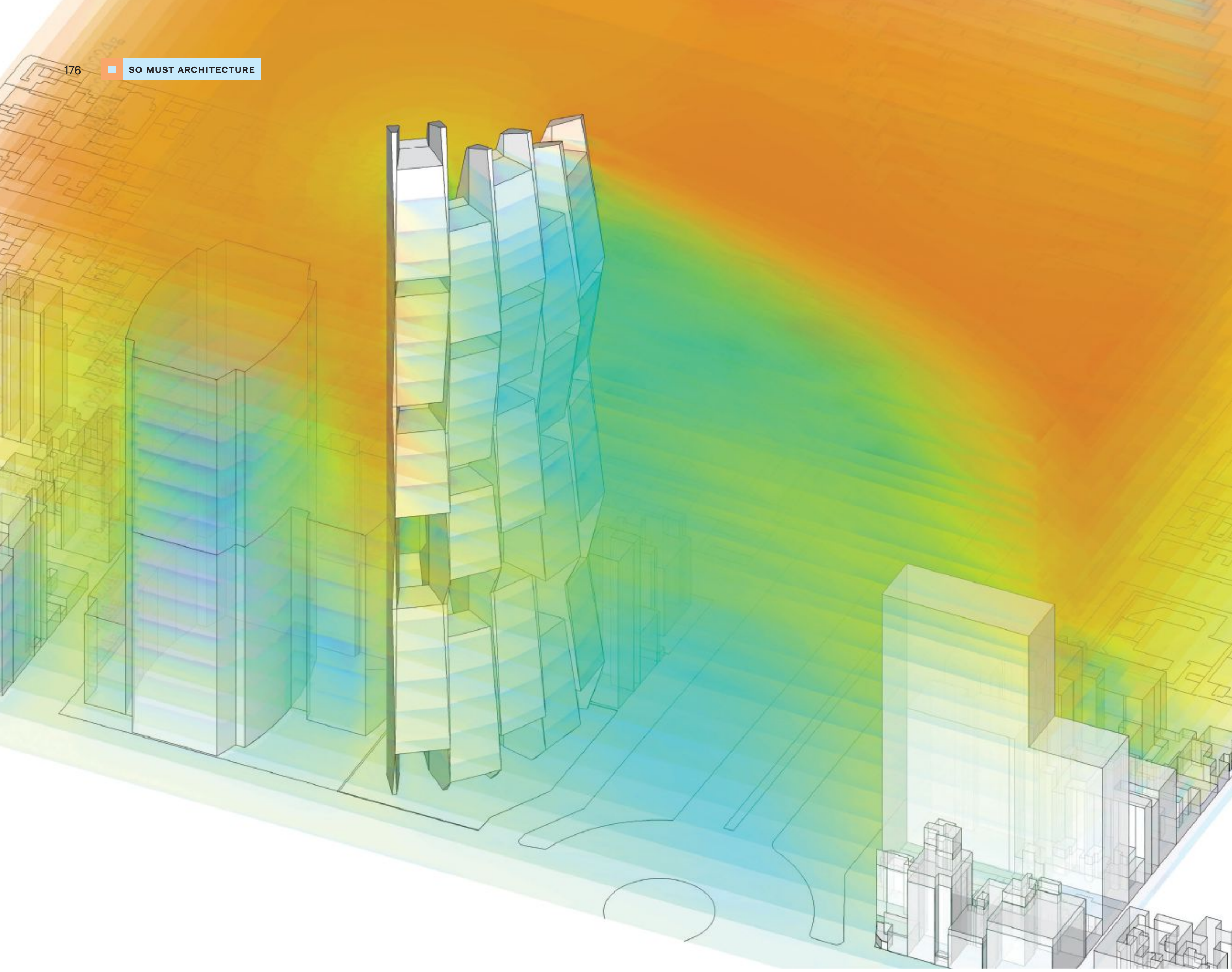
JEFF ELKINS

Lumira aerogel both diffuses light and provides insulation in Pilkington's Profilit channel glass.

For the past three years, climate change has brought rising water temperatures and plummeting pH levels to the world's ocean reefs, causing an unprecedented bleaching of living corals. U.S. reefs such as those in American Samoa (pictured) were especially hard-hit. If we don't sharply reduce CO_2 emissions, which cause seawater to become hotter and more acidic, by 2100 all 29 World Heritage–listed coral reefs, including Australia's Great Barrier Reef, will be lifeless.[1]

1. Heron et al., "Impacts of Climate Change on World Heritage Coral Reefs: A First Global Scientific Assessment," UNESCO World Heritage Centre (2017), accessed Sept. 22, 2017 > *http://whc.unesco.org/document/158688*

RICHARD VEVERS/THE OCEAN AGENCY/XL CATLIN SEAVIEW SURVEY



Teaching a design studio without consideration for sustainability, resilience, and performance leads future architects in the wrong direction.

This spring, Ali Malkawi and Gordon Gill, FAIA, co-taught a studio at Harvard University's Graduate School of Design (GSD) called Zero Energy Residential High-Rise that saw students from architecture, landscape architecture, and urban design come together to design environmentally responsive towers for Chicago and Mexico City (facing page). The course's integrated approach to design and data blended the expertise of Malkawi, professor of architectural technology at the GSD and founding director of the Harvard Center for Green Buildings and Cities, with that of Gill, a founding partner at Chicago-based Adrian Smith + Gordon Gill Architecture. The two spoke with ARCHITECT about why sustainability and design need to go hand in hand in architectural education, and about how to prepare the next generation of practitioners to design for climate change.

This interview has been edited for length and clarity.

INTERVIEW BY KATIE GERFEN

JI XIN

What differentiated the high-rise studio that you ran last year at the GSD from other studios that focus on sustainability and net-zero design?

Ali Malkawi: The intention was to try to take some of the work that we've been doing at the Harvard Center for Green Buildings and Cities, expand it, and relate it to education—and design education in particular. We chose the residential high-rise typology since there are so many of them around the world, and they've been developing in a way that is repetitive and mostly with the intention to maximize profit—relying very little on the concepts of the local situation.

The intention was also to find ways of educating the students on how to deploy the right principles, and to be able to utilize the same type of ideas for any kind of project. It was important to give the students the tools and techniques to be able to generate information about environmental and site-specific issues early in the design process, which allowed them to be able to respond to that information and integrate it into a design.

Gordon Gill: The students were asked to conceptualize the environmental issues at the same time as the architectural issues, analyze the environmental issues and apply that back to the architectural concept—and then go back and test it again. There was serious accountability, which, in a professional environment is what it's all about. I also think that what was different was the idea that these were simultaneous actions. This was not about a linear approach to design. That is at the root of what the studio is about: one holistic mindset where you do not design something, hand it off to an expert, and wait for information that you're not aware of.

How do you think that holistic approach is different?

GG: When people talk about integrated design, what they really mean is that they have multiple disciplines that they layer one on top of the other, but the process is still linear. If the individual who is envisioning a place or a building does not have an all-encompassing approach to sustainable design, then by default, the process becomes reactionary.

Architecture is the integration of art and science. We want beautiful architecture, but if we can create beautiful architecture that has genuine purpose and intelligence behind it, then we're on a path to a much more integrated mindset.

AM: The students always need to know the principles. But there's also the translation issue—how do we take the principles and techniques and translate them into design? That is a really delicate and important part of the equation.

You're talking about embedding this awareness in the design DNA of students. Are we there yet? Or are we still treating how we teach design and sustainable design as different things?

GG: I think they're being treated independently. I think we're in a transitional period as it relates to understanding energy, the environment, and how to design for it. We're making huge strides as to the blending and merging of an integrated approach. But I think there's still a lot of skepticism among some students, and architects—one process is about collecting information and analysis and the other is about art, and they think they are two separate things. But I don't think that they are.

AM: And things are changing, right? This is a very critical moment, where environmental considerations are becoming highlighted now more than ever. We have the capacity to do this in a way that would allow a new generation to take those issues very seriously. I think it's evolving, but the topic is not new, this connection between science and art. It's always been there. The story is putting these two things together—how to do it.

The educational responsibility is high. The more that you educate students, the more you are inching toward a solution that would be environmentally responsive. You've got to have really good examples of buildings that students can see, so that they believe that they do exist, they can happen, and that this integration idea is inherently beautiful and applicable, and that there is a demand for it. And not just demand, it's also responsibility.

How can we be making some of these changes that you're talking about across design education nationwide?

AM: It takes time to build the belief and build a system. It's not just about the need. It's going to be a requirement in cities, and I'm hoping that it's going to be natural for most schools to take that into consideration and to respond. Most of the schools that I'm aware of have been trying to figure out how to do this for many, many years. Gordon and I think this is one way of doing it. I'm sure there are others. But at the end of the day, we wanted to ensure that students would understand that performance and good design go hand in hand. You're going to have to have that approach. It's fundamental, and we cannot afford not to have it anymore.

Increasingly heavy precipitation is a highly visible outcome of climate change. Hurricane Harvey dumped more than 49 inches of rain on East Texas in August, and downpours last month triggered floods in Tuscany and the Italian city of Livorno (pictured), killing at least six people. If we don't reduce CO_2 emissions, by 2100 the frequency of local 100-year floods could increase 3,467-fold.[1]

1. Maya K. Buchanan, Michael Oppenheimer, and Robert E. Kopp, "Amplification of flood frequencies with local sea level rise and emerging flood regimes," *Environmental Research Letters*, vol. 12, no. 6 (2017), accessed Sept. 22, 2017
> http://iopscience.iop.org/article/10.1088/1748-9326/aa6cb3/pdf

As Harvey, Irma, and Maria have made painfully clear, there is no escaping climate change. So assess the risks, and design for resilience.

TEXT BY KATIE GERFEN

On an average sunny day in Houston, the water in Buffalo Bayou Park burbles along at an elevation of about 2 feet. When the bayou floods—which, as one of the lowest points in a flat city and the natural runoff path for a large watershed, it is wont to do—the park can contain things until the water tops 28 feet. When Hurricane Harvey barreled through the city in August, the water reached 39 feet. "We knew from Day One that the reason that landscape is there is because it's in a flood plain," says Page senior principal Lawrence W. Speck, FAIA, who designed the park structures (which ARCHITECT featured in March). "But no one ever thought there would be this kind of flood."

In the lower parts of the park, shade pavilions made from board-formed concrete, paved trails, stairs, handrails, signage, and even lighting were all designed to be able to withstand submersion—and lo, they did. When the water began to recede, these structures emerged largely unscathed. "They were hosed off and back to working order," Speck says.

The plantings were also designed to be able to take a beating. "We know that the trees can take being submerged for a long period of time," says Scott McCready, a principal at SWA Group, which did the park's landscape design. But the lower parts of the park may remain submerged for weeks, and "because the water carries silt that blocks sunlight, the lower vegetation might be impacted. And if you start losing those, you start losing the stability of the slopes."

Even as parts of the park remain under water, the way that it has weathered the storm makes it a poster child for resiliency. Much of the flood receded within days, and bikers and joggers were soon back in the upper trails. But "we have to remind ourselves that this is a learning process," McCready says. "You can engineer your way into resiliency with big heavy walls, but this park is a model to gauge what is the right amount of development and infrastructure, especially if this type of event is going to become more frequent."

For Speck, a proven focus on resilience is a chance turn a hardship into an opportunity for designers: "Think of the heartbreak, the huge amounts of damage and repair that could be saved. We can either complain and patch things up, or we can say, 'This could fundamentally reshape architecture,'" he says. "This could reshape the way buildings meet the ground, the way we do land planning. This could be very positive."

A jogging path in Houston's Buffalo Bayou Park, seen here on Sept. 10, is covered in silt deposits left by the still-receding floodwaters from Hurricane Harvey, which made landfall in Texas on Aug. 25.

ALBERT VECERKA/ESTO

Editorial:
A Brief Climate Change Reading List

TEXT BY NED CRAMER

The fossil fuel industry and its allies have fueled a massive disinformation campaign on the subject of climate change. If you're looking for honest reporting and informed opinion on the subject, check out the following six books:

Climate Change: What Everyone Needs to Know, by Joseph Romm (Oxford University Press, 2015)
Lost in a sea of data and jargon? Romm's scientific primer answers essential questions such as "What is the difference between weather and climate?" and "What will the impacts of sea-level rise be?"

Collapse: How Societies Choose to Fail or Succeed, by Jared Diamond (Penguin Books, 2005)
Easter Island, Angkor, Copán: We've been down this road before. That's the message Diamond sends with *Collapse*, through eye-opening case studies of self-inflicted environmental catastrophe throughout history.

The Sixth Extinction: An Unnatural History, by Elizabeth Kolbert (Henry Holt & Co., 2014)
Farewell, Golden Toad: Amphibians are going extinct at 45,000 times the historical background rate. *The New Yorker*'s Kolbert documents the tragic evidence of mass species loss due to human activity.

This Changes Everything: Capitalism vs. the Climate, by Naomi Klein (Simon & Schuster, 2014)
Perhaps the most challenging of the books on the list, *This Changes Everything* exposes the often terrible socio-environmental costs of privatization, deregulation, and other tenets of neoliberal economics.

Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming, edited by Paul Hawken (Penguin Books, 2017)
For those who fear all is lost, Hawken provides an antidote—dozens of them, actually. *Drawdown* compiles proven methods to reduce CO_2 emissions and increase efficiency, in arenas from agriculture to architecture.

Eaarth: Making a Life on a Tough New Planet, by Bill McKibben (Henry Holt & Co., 2010)
McKibben, writing during the Great Recession, characterizes the society and systems we need to build in response to climate change: slower, smaller, more durable, decentralized, and, possibly, more rewarding.

JEFF ELKINS