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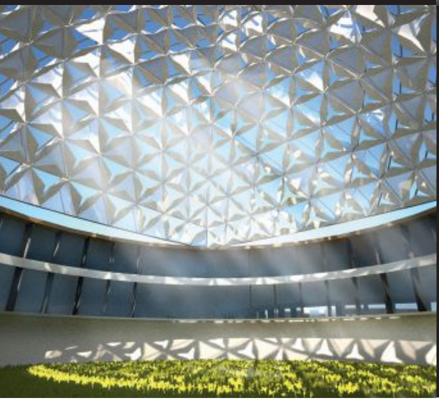
CEU LEARNING OBJECTIVES

1. Discuss innovations and futuristic objectives for using shade structures constructed with fabric in commercial architecture.
2. Explain how shade structures made of fabric can add both appealing design and functionality to building structures.
3. Define the benefits of shade structures for personal health and UV protection.
4. Discuss how the use of textiles in shade structures can positively impact thermal performance and energy efficiency.
5. List LEED® V4 credits to which awnings and solar shades can contribute directly.

Learn more about the future of shade by completing this continuing education course at sunbrella.com/fosceu.

Responsive Shading System by Arman Hadilou is a kinetic façade composed of large strips of fabric mounted on a frame system that can open and close the fabric strips in response to existing light conditions.

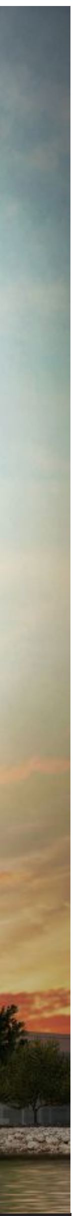


SHADE IS ARGUABLY ONE OF THE VITAL ELEMENTS IN MODERN LIFE, THOUGH NOT SOMETHING THAT TYPICALLY TAKES CENTER STAGE IN THE DESIGN DIALOGUE. UNTIL RECENTLY, FABRIC SHADE STRUCTURES WERE AN APPENDAGE TO A BUILDING, AN AFTERTHOUGHT, AN ACCESSORY.

Invertible Shade by Ehsan Fatehifar is a tensile shade system of repeating geometric shapes that can be adjusted to allow varying amounts of light inside the building.

OF SHADE

FABRIC COMPONENTS IN SUSTAINABLE ARCHITECTURAL DESIGN



Increasingly, shade structures begin the design conversation especially for commercial buildings, structures in sunny climates, those which will inhabit a warming planet (this one) and architects looking for new ways to create built environments in harmony with nature's forces. The future includes a conscious intention toward shade structures.

THE EVOLUTION OF SHADING FABRICS

In order to appreciate the future of shade and position oneself on the leading edge of this movement, it helps to review the past, the long history of using fabrics as architectural add-ons and how the practice has evolved.

Prior to the 1960s, most awnings and shading fabrics were made of cotton canvas, which the sun broke down quickly. In 1961, the owners of one of the oldest, most respected fabric brands decided to change the nature of shading materials the company had been making since the 1880s. They replaced cotton with acrylic fibers and pre-extrusion pigments and offered an unheard-of warranty of five years. They were dubbed "performance fabrics."

In the 1970s, performance fabrics got the attention of boaters, and the outdoor furnishings industry exploded with these new, long-lasting yet pliable fabrics. In 1988, BMW became the first car brand to adopt this company's fabrics for its convertible models.

By the early 2000s, as the green building movement gained momentum with the U.S. Green Building Council's LEED rating program, more attention was paid to the sustainable nature of performance fabrics. As high-performing shade fabrics last longer, people use less fabric and thus generate less waste as compared to other fabrics that might fade, lose strength or give in to mildew and atmospheric chemicals. In fact, some fabrics can be recycled through manufacturer recycling programs, reducing impact on landfills.

SIGNAGE AND BRANDING WITH FABRICS

As the use of shading fabric continues its trajectory in modern architecture, its use as a business branding strategy spans the decades. Historically, a print canvas canopy over a cigar shop or beauty parlor signaled the establishment's presence to passersby. While that design practice continues today, modern corporate branding with fabric is often spectacular, with enormous printed banners moving in the breeze. They are a signal to passersby and even passing aircraft that business or cultural events are happening there. The colors of the shading fabric convey their own branding message, tying into the corporate, company, educational or nonprofit organization's identity.

EXPANDING SPACE

Shading strategies in corporate, cultural and residential settings create copious amounts of added space for meetings, gatherings, meals and leisure. While the cost of walls and a roof could be prohibitive, and most likely exceeding a particular lot's allowable square footage of structure, the addition of shaded "rooms" becomes a possible way to expand the amount of usable space. Fabric enclosures in commercial spaces such as restaurants can help boost profits by increasing the amount of outdoor seating available year-round.

SHADE STRUCTURES FOR HEALTH AND UV PROTECTION

Protection from the sun has always been important to humanity, but never so much as it is in modern times, with holes in the ozone layer and the unprecedented speed at which our planet is warming. Whereas natural climate change occurs gradually, giving organisms the opportunity to evolve their own protections, the speed of this man-induced climate change requires man-made protections. Ideally, we don't want sunlight to be totally "on" or "off," and that is where UV-resistant shading fabric (as well as shade itself) comes into play.

Frames to Shams-Ol-Emareh by Nastaran Torabi and Zahra Noori Jamshidi is a series of orange-fabric-covered frames suspended in the forecourt of the historic Shams-ol-Emareh mansion in Tehran. The frames provide shade and seating, while also offering visitors a new framed perspective on the mansion.

Cotton Hill by Sergii Borodenko and Aljona Kolesznikova uses Sunbrella fabric to create a modular shading system that doubles as a no-soil planting system for urban areas that lack space for landscaping.

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Volume 106, number 10. October 2017.
On the cover: Part of a house blown upside-down in Seaside Heights, N.J., in 2012 after Superstorm Sandy hit the New York area. Original photo by Julio Cortez/Associated Press.

TOP: DOC SEARLS

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SKYLER FIKE

Focusing on Dignity

In response to client feedback that a single-family model "sounded downright luxurious," architect Brent Brown, AIA, designed the Cottages at Hickory Crossing in Dallas as a village instead of taking a typical multifamily affordable housing approach. John Cary features this and 19 other built projects in his new book, *Design for Good: A New Era of Architecture for Everyone* (Island Press, 2017). "I hope it gives designers the opportunity to reconnect with what drew them to the work in the first place and, perhaps, some practical ideas about how to put dignity at the center of their practice," he writes. —SARA JOHNSON

> *Read more about "Design for Good" at bit.ly/DesignforGood.*

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MARK LAMSTER

Documenting "The Island That Nobody Knows"

Boston's Deer Island, which in the past has served as a women's prison and as a concentration camp for Native Americans, is today home to the city's wastewater treatment plant. Mark Lamster, architecture critic for *The Dallas Morning News*, photographed the plant over the past year while studying as a Loeb Fellow at the Harvard Graduate School of Design, and his work is the subject of a new exhibition, "The Island That Nobody Knows," at Boston's Pinkcomma Gallery. The images, on display through Oct. 27, capture the plant's industrial architecture, machinery, and underground spaces. —ASHLEIGH POPERA

> *See more of Lamster's photographs at bit.ly/LamsterExhibition.*


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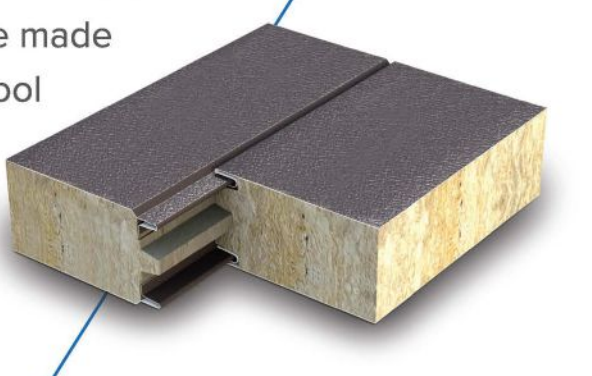
Columbus Reconsidered

Through Nov. 26, Columbus, Ind.—the site of industrialist and philanthropist J. Irwin Miller's experiment in municipal Modernism—is hosting the inaugural Exhibit Columbus, a biennial-like exhibition featuring 17 temporary installations. Five firms each received $70,000 to create a piece in dialogue with a famous site or building along Fifth Street, and another five got $10,000 to produce more tactical work along Washington Street. Teams from six universities and local high schools also produced pavilions, such as Indiana University Bloomington's "Synergia" (above) sited adjacent to Eero Saarinen's 1964 North Christian Church. —MIMI ZEIGER

> Read Mimi Zeiger's critique of the inaugural exhibition at bit.ly/ColumbusReconsidered.



SAHAR COSTON-HARDY/OLIN

Laurie Olin, the 17th Laureate of the Vincent Scully Prize

At a ceremony this month, the National Building Museum will bestow landscape architect Laurie Olin, HON. AIA, with its 2017 Vincent Scully Prize, an annual award recognizing notable theory and practice in architecture, historic preservation, and urban design. While overseeing the Philadelphia and Los Angeles offices of his eponymous firm, Olin has spearheaded projects such as New York's Bryant Park and Philadelphia's Barnes Foundation. "[Olin's] work has left (many) cities invaluably richer in terms of public space, civic pride, and quality of life," wrote landscape architect James Corner in his nomination. —CHELSEA BLAHUT

> *Read more about Laurie Olin's career at bit.ly/ScullyPrize2017.*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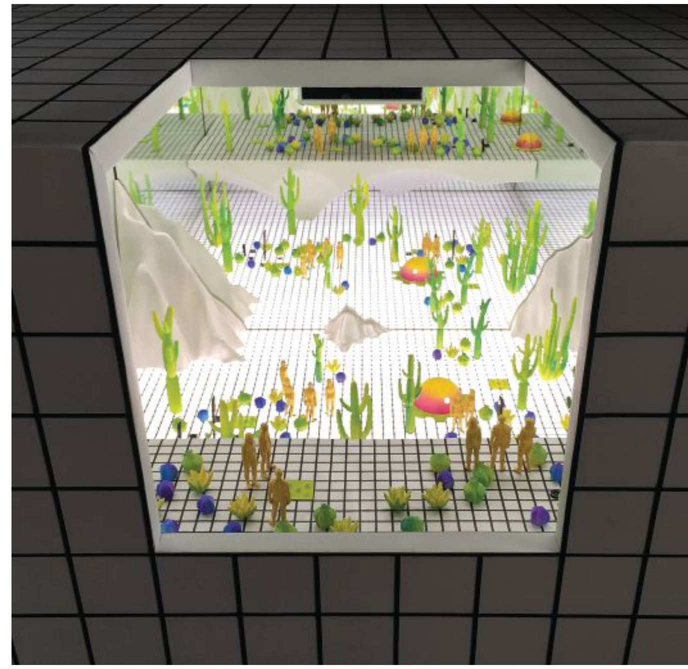
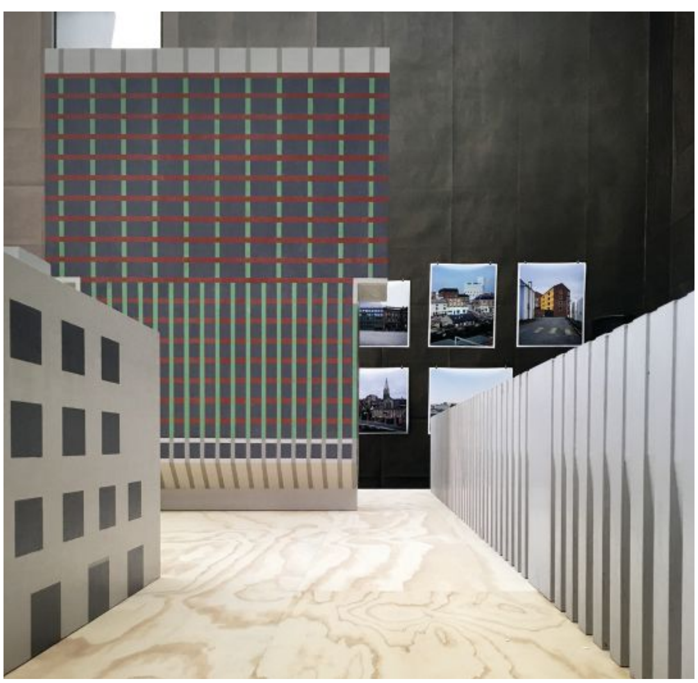
RICHARD BARNES

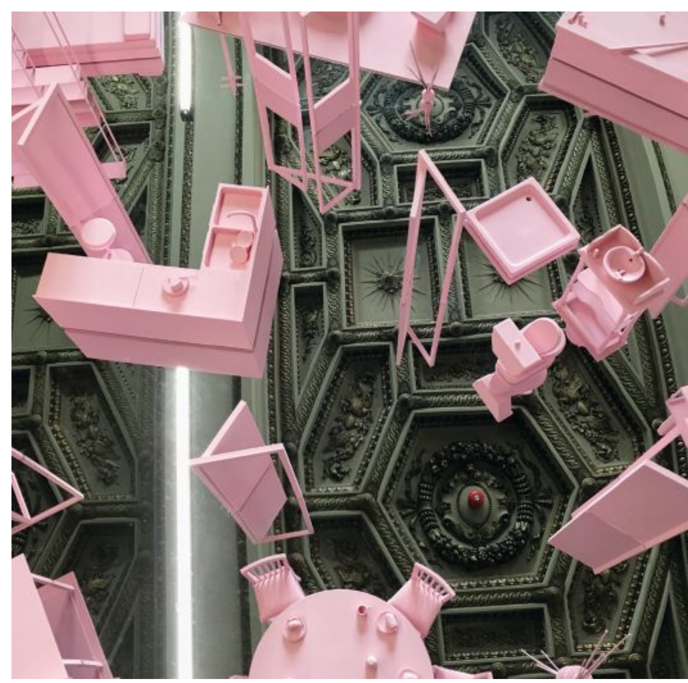
12 Ways to Design for Education

For this year's Education Facility Design Awards, the American Institute of Architects' Committee on Architecture for Education recognized 11 projects in eight U.S. states and one project in China. Five projects received an award of excellence, including Ennead Architects' Vassar College Bridge for Laboratory Sciences, Integrated Science Commons in Poughkeepsie, N.Y. (above). The jury also bestowed awards of excellence on work from Robert A.M. Stern Architects, Integrus Architecture, Mahlum Architects, and Opsis Architecture, as well as seven additional awards of merit. —SARA JOHNSON

> *For information about all of the 2017 Education Facility Design Awards winners, visit bit.ly/AIAEdFacility17.*







Chicago's Second Architecture Biennial Debuts

Chicago Architecture Biennial artistic directors Sharon Johnston, FAIA, and Mark Lee chose the theme "Make New History" and, not surprisingly, the pastel fingerprints of postmodernism are all over the place. The show, on view through Jan. 7, features work by more than 140 artists, architects, and designers, including (clockwise from top left): "The Room of One's Own: The Architecture of the Private Room" by Dogma, "Re-Encampment" by UrbanLab, "The Grand Interior" by MAIO, and "Constructions and References" by Caruso St John Architects with photographers Thomas Demand and Hélène Binet. —SARA JOHNSON

BRUCE DAMONTE

> Catch up on ARCHITECT's Chicago Architecture Biennial coverage at bit.ly/ChicagoArchBiennial.

Hunter Xci NB helps contractor shave 25% off cladding installation time

Job Name St. Marcus Lutheran School

Location Milwaukee, Wisconsin

Product Hunter Xci NB 3.6" Polyiso + 5/8" Plywood

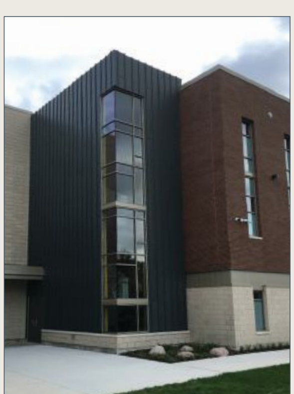
Contractor M.M. Schranz Roof and Sheet Metal, Inc., Milwaukee, Wisconsin

Architect Rinka Chung Architecture, Milwaukee, Wisconsin

General Contractor Catalyst Construction, Milwaukee, Wisconsin

To meet growing demand for student enrollments, Milwaukee's St. Marcus Lutheran School completed a 40,000 sq. ft. expansion in 2016. The addition will allow the popular private voucher school to grow enrollments from 860 to 1,120, reports the Milwaukee Journal Sentinel.

Rinka Chung Architecture's design called for 22-gauge standing seam metal roof panels to be used for wall cladding. To simplify attachment of the cladding, while providing continuous insulation for the building envelope, the contractors installed Hunter Xci NB. The product is a high thermal rigid insulation panel composed of a closed cell polyisocyanurate foam core bonded to a premium performance coated glass facer on one side and oriented strand board (OSB) or plywood on the other.



The entire wood surface can be used as a cladding attachment point, which greatly simplifies cladding installation compared to trying to align fasteners with a girt, clip or rail. Additionally, while the Xci NB panels are secured firmly to the base wall, the cladding attachment is thermally broken by being attached to the wood of the composite panel—which reduces thermal bridging, for a more energy-efficient building.

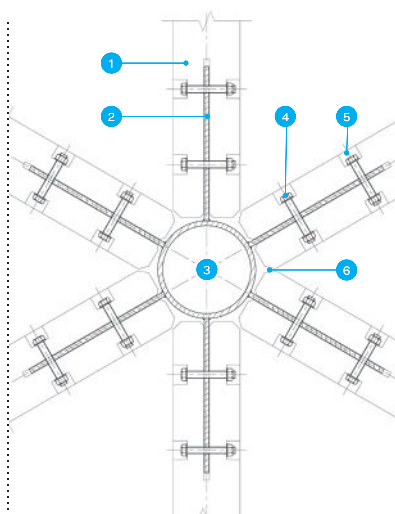
"Hunter Xci NB probably saved us 25% in time to attach the standing seam cladding, since we didn't have to add another layer of furring for the cladding to attach to," says Kevin Brennan, sheet metal project manager with M.M. Schranz Roofing, Inc.

Detail: University of Essex's Geodesic Dome Roof

TEXT BY TIMOTHY A. SCHULER

Designed by the London office of BDP under the direction of former chairman Tony McGuirk, the three-story, 59,200-square-foot Essex Business School, sited at the edge of the University of Essex's campus in Colchester, England, features distinctive "roundels"—circular lecture halls that pop out of the building mass—which emerged from a site analysis that also examined solar exposure and wind patterns.

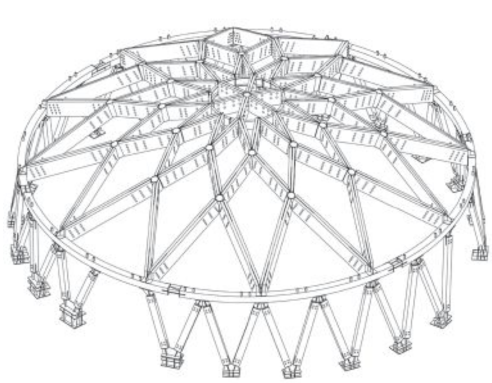
The largest roundel, 60 feet in diameter, houses the main lecture theater and is topped by a geodesic timber roof. A lattice of angled glulam beams, each 8.7 inches wide and ranging in depth from 15.7 inches to 26.7 inches, connects in diamond formation via steel knife plates welded to custom hollow steel tubes. As the lattice ascends to the dome's apex "almost like a crown," as McGuirk describes it, it meets a



118-inch-diameter steel ring beam, within which a central steel node with welded knife plates connects the six topmost beams in a radial array.

The geodesic structure was erected from the ground up, with temporary centering used for each ring until the "key," or central node of the dome, was securely in place. At its base, the entire timber dome roof ties into an outer steel ring beam that sits on angled glulam columns arranged in "V" formation.

In addition to the pine used in the glulam structure, at least six other types of wood appear in the school, for a total of 45,000 cubic feet of timber. Given the project's complexity and just 1-millimeter tolerance for the glulam, Derek Foster, contracts manager for the U.K. construction company Morgan Sindall, says it was "extraordinary how it all fit together."



1. 15.7"-deep × 8.7"-wide glulam beam
2. Steel knife plate
3. Ø12.8" × 0.63"-thick cold-formed S355 hollow section
4. Ø24mm, grade 8.8 bolts (four per plate)
5. Timber plug in bolt head recess
6. 25mm chamfer

GARETH GARDNER

> To read more about the Essex Business School's geodesic dome, visit bit.ly/AREssexDome.

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Marshall Brown
Matilde Cassani
MG&Co.
Michelle Chang
Monadnock
MOS
Norman Kelley
Nuno Brandão Costa with André Cepeda
OFFICE Kersten Geers David Van Severen with Peter Wächtler and Michael Van den Abeele
Pascal Flammer
Paul Andersen and Paul Preissner
Pezo von Ellrichshausen Arquitectos
Philipp Schaerer
Philippe Rahm architectes
Piovene Fabi and Giovanna Silva
Point Supreme
PRODUCTORA
REAL Foundation
Robert Somol
SADAR+VUGA
Sam Jacob Studio
SAMI-arquitectos and Paulo Catrica
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Sergison Bates
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Sylvia Lavin with Erin Besler and Norman Kelley
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Tatiana Bilbao Estudio
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The Empire with Ilaria Forti, Joseph Swerdlin, and Barbara Mondolo
The Living
The Los Angeles Design Group
Theaster Gates
Thomas Baecker Bettina Kraus
Tigerman McCurry Architects
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WELCOMEPROJECTS
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Zago Architecture
ZAO/Standardarchitecture

WOOD: STRUCTURAL PERFORMANCE WITH FAMILY-FRIENDLY EXCITEMENT

Don't blame the children and parents of northwest Arkansas for taking wood's role in the success of the **Scott Family Amazeum** for granted. There's a reason why it's easy for families to overlook the welcoming drama of the glulam canopy outside or a wood-crafted climbing gym inside: They're having too much fun learning.

It's fitting that the Scott Family Amazeum is, well, an amazing exhibition of building materials.

After all, the chief mission of the $12.2 million, 52,000 square foot discovery museum "… encourages creativity, curiosity, and community." What better way to do that than with a structure that dramatically showcases concrete, steel, glazing, and wood playing exceptionally well together?

Star billing for the Bentonville, Arkansas facility arguably goes to wood for the way it is used by project architect Reb Haizlip, FAIA, and his design team at Memphis-based Haizlip Studio to complement its neighbor, the Crystal Bridges Museum of American Art.

Living Design Lab

"The precedent was set by Moshe Safdie, Crystal Bridges architect," explains Haizlip. "Crystal Bridges is, in part, a magnificent wood composition, truly poetic and stunning. The Amazeum in turn explores the use of structural wood, particularly glue-laminated materials."

For visitors, that structural exploration starts with the sweeping, soaring drama of the

Wood served to unify and warm the facility while paying homage to Arkansas' strong outdoor tradition. Exposed wood was integral to the roof. Glulam was also used for exposed structural beams. Cedar beams were used for the southside pergola. "Our practice is drawn to the use of wood," notes Reb Haizlip, FAIA, and project architect. "Wood grounds a project in its place."

Maintaining the seamless continuity of the soaring, delicately concave glulam roofline proved to be an interesting challenge for project architect Reb Haizlip, FAIA, principal of Haizlip Studio. At issue: Elegantly transitioning from the layered roof assembly to a majestically-braced, single-plane canopy of complex joist and beam connections. Haizlip recalls thinking, "I've got to make this work." The link is at the curtainwall. The outlying glulam joist does double-duty as the entrance fascia. The structural versatility of wood proved to be a welcome design advantage.

exposed structural deck of a Southern Pine glulam roof. The use of exposed glulam was used for the exposed structural beams. By design, building connections are visible wherever possible. "The owner requested that building connections be bare, lean, and muscular so kids could understand the physicality of the building," says Haizlip.

Structural Workhorse

Glulam joists span the building's 25-foot width and support 18-inch by 10.5-inch glulam beams. The beams are engineered to appear to run continuously across the lobby to the signature 34-foot long west-facing canopy. The three-story high canopy presents beams and joists on a single plane, enhancing the entrance's visual drama. Wood is also central to the lobby ceiling: 3-inch wide tongue-and-groove pine decking completes the overhead natural effect.

Wood vs. Sound

For acoustic control, Haizlip also turned to wood's structural performance. Maple grills were installed at the ceiling and turn 90 degrees down the wall to provide excellent sound absorption for the lobby and café areas. To help mitigate solar gain on the southern flank, the pergola was constructed with cedar. "If there's a major public space, we used glue-laminated wood," observes Haizlip.

Code officials and the fire marshal had no concerns with the construction plans. "Code compliance was never an issue," reports Haizlip. "Glulam structures are well-known for their natural fire resistance."

Record Attendance

Meeting the budget was achieved without surprise, too. Off-site fabrication of wood components minimized installation complications. Haizlip says the Amazeum delivered on time "… for an amazing square-foot price."

In the months following its July 2015 opening, the Amazeum more than lived up to its name. Feasibility studies projected annual attendance at 165,000, a generous forecast for a town of less than 50,000 people. "The museum blew past that in the first six months and has topped 350,000 the first year," says Haizlip.

Architect: Haizlip Studio, PLLC

Associate Architect + Mechanical, Electrical, Plumbing and Structural Engineering: Crafton Tull

Civil Engineering + Landscape Architecture: CEI Engineering Associates

Discovery Garden Landscape Architect: Howell and Vancuren

General Contractor: Nabholz Corporation

Photography: Ken Petersen (left); Jeremy Jacobs (center & right)

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Next Progressives: French 2D

EDITED BY KATHARINE KEANE

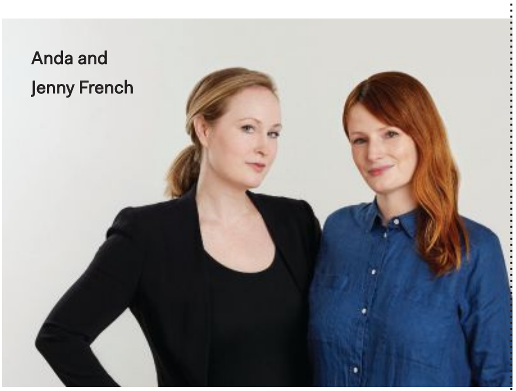
Location:
Boston

Year founded:
2008

Firm leadership:
Anda French, AIA, and Jenny French

Education:
Anda: B.A., Barnard College; M.Arch., Princeton University; *Jenny:* B.A., Dartmouth College; M.Arch., Harvard University Graduate School of Design (GSD)

Anda and Jenny French



Mission:
Our practice reworks social, spatial, and visual norms. We use storytelling as a way into our projects (the stories we tell ourselves) and to present to our clients (the stories we tell other people). We project origin myths and future destinies onto given problems, objects, and places. Current projections include two categories that we call "strange housing," meaning microhousing, co-housing, and adaptive reuse, and "sets in the city"—civically engaged installations and building-scale graphics.

Experience:
Anda: While establishing our firm, I taught at the Syracuse University School of Architecture, as well as in the Barnard + Columbia Architecture program. Right out of Princeton, I worked directly for Bob Hillier, FAIA, at Studio Hillier, to understand how to run a firm. *Jenny:* I spent the year after grad school on a traveling fellowship to study the sites of unbuilt projects. I've worked for SHoP Architects, learned retail design at Bergmeyer Associates, and I currently teach core studio at the GSD.

How founders met:
Anda: Jenny was born, which resulted in our meeting. [They are sisters.]

Firm size:
Two to four

First commission:
We designed a bagel shop in Manhattan that turned into an after-hours party space at night. The former tenants left a wild wavy ceiling that we used as the base for a hanging topography of metal mesh—used for commercial coffee filters—strung up on hospital curtain tracks. We installed late into the night of Valentine's Day in 2009, with no heat. The client did bring us a bottle of bourbon, so it was all worth it.

Origin of firm name:
Our name comes from our shared lack of depth perception that continues to influence our work. There are also two of us. We have been toying with some subsidiary and alter-ego names—French & Sister is one of them. Mohsen Mostafavi, INTL. ASSOC. AIA, suggested that we be called Frenchies.

Favorite project:
We are working with a group of 30 families that is self-developing an urban co-housing community in greater Boston. Not only is this a chance to rethink housing typologies, resilience, and social models, it is an exercise in inventing our own participatory design process.

Design heroes:
Wes Anderson for his immersive stories and the exuberant, mannered environments in which those stories exist. Odile Decq for her unapologetic boldness.

When we're not working in architecture, we are:
Working on our multiverse-themed romance novel.

Morning or evening people:
Right-before-lunch people.

Vice:
Shared references to bad movies. This may be a secret to our twin-like hive mind.

STEPH LARSEN

> *To learn more about Anda and Jenny's inspiration and work, visit bit.ly/ARFrench2D.*


GLISTENING ICE
11.2 KM OFF CAPE HORN
SUMMER SOLSTICE

Next Progressives: French 2D

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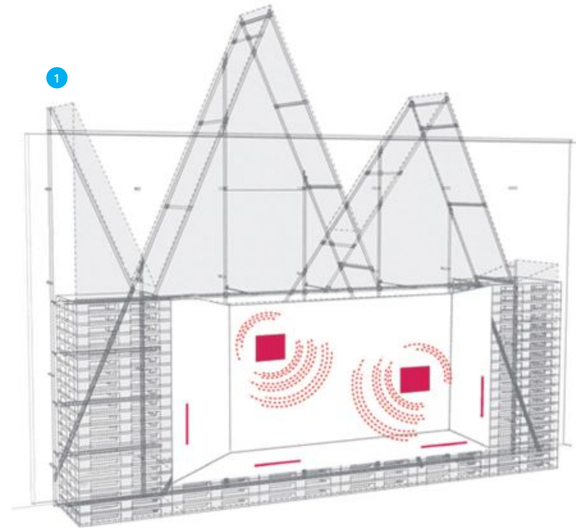

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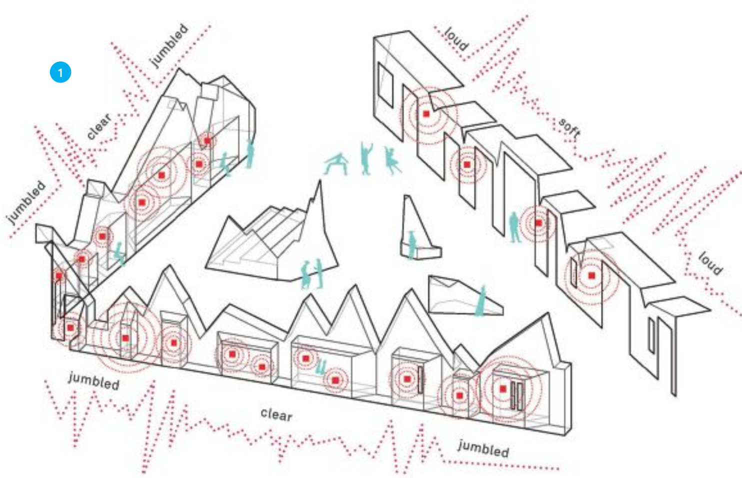

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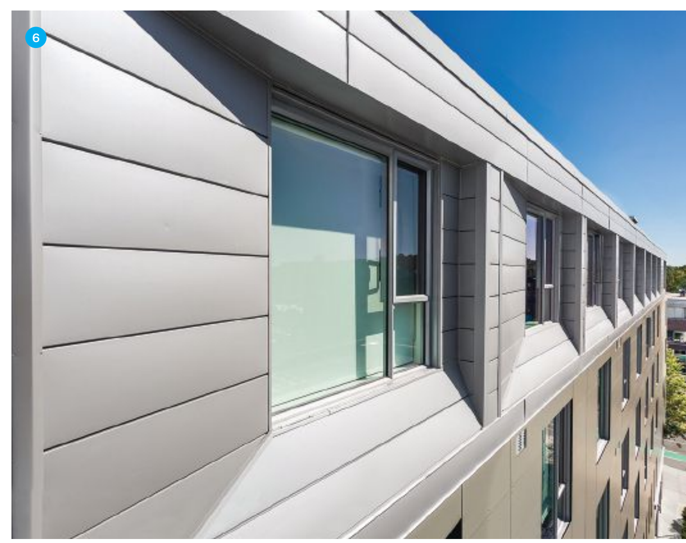
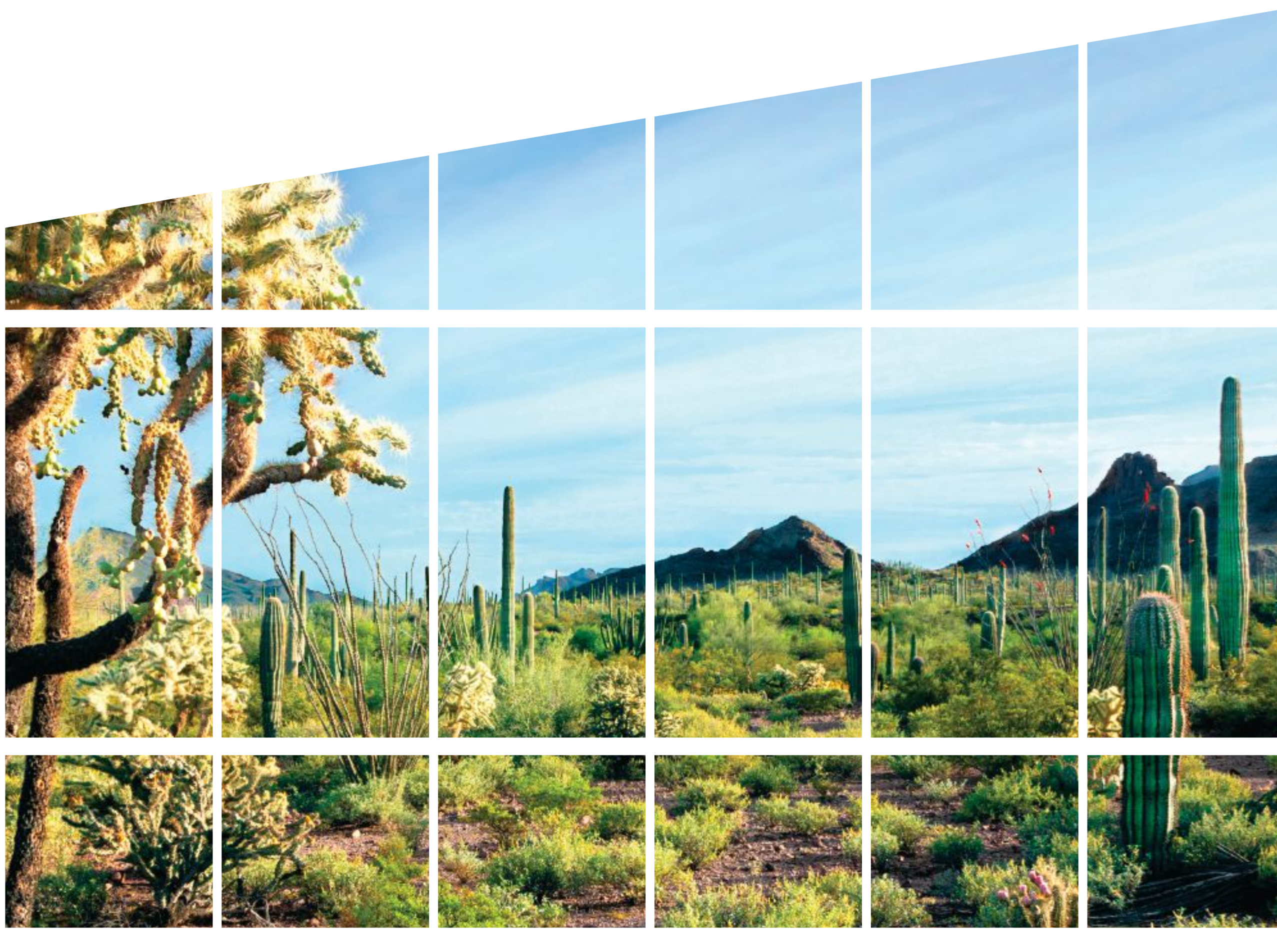
1, 2, 4, 5: COURTESY FRENCH 2D; 3: NAT WARD



1. This 2013 MoMA PS1 Young Architects Program finalist, titled White Noise, is a sound-sharing environment composed of large, white, synthetic turf–covered geometric volumes with embedded speakers. To encourage participation and community within the space, visitors are invited to share sounds via a cellphone app, which are then transmitted through the volumes. **2.** This proposal for an inclusive entrance and new lobby for the School of Education at Syracuse University makes use of outdoor pedestrian space to create a sleek ramp and floating stairs. **3.** Vic's Bagel Bar in Manhattan (now closed) includes a custom ruffled-mesh metal ceiling installation that spans the length of the restaurant, diffusing light and masking the irregular ceiling above. **4.** The duo is collaborating with media and technology researcher Gabriel Mugar (Anda's husband) on their Place/Setting installation for an event in Boston. Decorated with colorful and reflective surfaces, Place/Setting will host five public, themed meals relating to the growing income disparity in the Boston area. **5.** French 2D is working with 30 families for its Cohousing Community apartment project in Malden, Mass. The building includes floor plans ranging from micro-studio to three-bedroom units with shared community spaces. Construction is scheduled to begin in 2018. **6.** The sisters collaborated with their mother and late father's Boston-based firm, Neshamkin French Architects, on the Commonwealth Micro-Housing project, completed in 2016, which comprises 180 units, each ranging from 340 to 370 square feet.

6: EDUA WILDE

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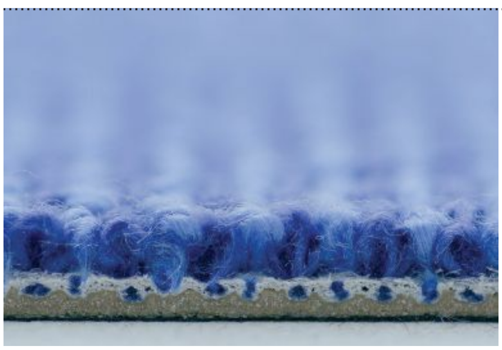
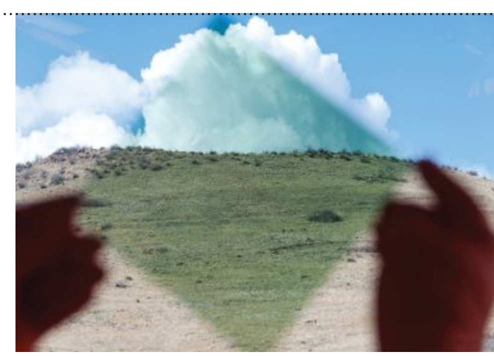
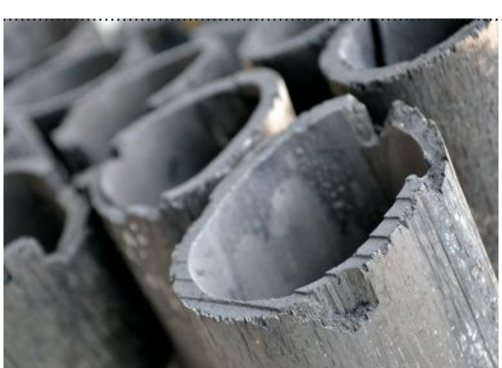


Proof Positive Tile, Interface
Exhibited at this year's NeoCon commercial furniture show in Chicago, this prototype carpet tile has a negative carbon footprint thanks to a closed-loop manufacturing process, according to its Atlanta-based manufacturer, Interface. The process turns carbon derived from plants (via photosynthesis) into durable materials that store the carbon within the product for at least a century. The tile can then be recycled at the end of its lifetime. Interface, whose manufacturing facilities operate on 96% renewable energy as of 2016, has been developing the technology to fabricate this product for 20 years. Though it is not yet available on the commercial market, the company is working on proper draping and scalability for the carpet tile, which is now being toured around the globe to gather feedback. *interface.com*

SolarWindow, SolarWindow Technologies
In development since 2009, SolarWindow is an energy-generating liquid veneer intended for new or retrofit architectural glass and flexible plastic surfaces. The patent-pending technology—an alternative to rooftop solar panels—utilizes windows as vertical power generators. SolarWindow modules are coated with tiny solar cells that form a network of arrays made of polymers, which include hydrogen and carbon elements. The energy produced by SolarWindow, intended for application on every window of a building, is unaffected by the angle of the sun. According to SolarWindow Technologies, installing these integrated windows could reduce a building's total electricity bill by 30% to 50%. Currently, the Maryland-based company is looking for tall towers and skyscrapers for test applications. *solarwindow.com*





Breathe Wall, Ripple Architecture Studio
Developed by Charlottesville, Va.–based Ripple Architecture Studio, Breathe Wall utilizes the naturally dense microstructure of bamboo to help with the adsorption of volatile organic compounds and toxins that are prevalent in the air. The bamboo is cut at an angle to expose a larger section of its end grain and then charred in a kiln (using the traditional Japanese shou sugi ban technique) to create a more porous, adsorptive surface. Various lengths of these stalks are then arranged into an undulating form, which can be installed as a retrofit attachment to freeway sound barriers. The studio previously experimented with bamboo tubes arranged horizontally, but found that the current prototype—its third—required less raw-material processing. The studio hopes the product will create manufacturing and agricultural jobs in the United States. *ripplearchitecture.com*

> *To discover more innovative products visit, bit.ly/InnovativePrototypes.*

Presented by:

HIGH PERFORMANCE JOINT SEALANTS

UNDERSTANDING THE TECHNOLOGY AND SPECIFICATION CONSIDERATIONS

By Steven Reinstadtler, Construction Market Manager, Coatings, Adhesives and Sealants Covestro LLC Pittsburgh, Pa., U.S.A.

High performance joint sealants prevent fluids, like wind driven rain, and air from passing through a filled gap while staying adhered to a substrate that can move for environmental and structural reasons.

LEARNING OBJECTIVES

By the end of this educational unit you will be able to:

1. Understand the definition of sealants and related terms.
2. Review end use applications of high performance joint sealants.
3. Describe the different types of joint sealants and where they are used in the built environment.
4. Explore the different divisions in MasterSpec where joint sealants can be prescribed..

CONTINUING EDUCATION

AIA CREDIT: 1 LU
AIA COURSE NUMBER: AR092017-2

Use the learning objectives above to focus your study as you read this article. To earn credit and obtain a certificate of completion, visit http://go.hw.net/AR092017-2 and complete the quiz for free as you read this article. If you are new to Hanley Wood University, create a free learner account; returning users log in as usual.

INTRODUCTION TO JOINT SEALANTS

Every year, architects, engineers and specifiers are offered extensive learning units related to the latest siding, lighting and flooring product—some of the more sexy presentation topics. However, chemistry-dependent coatings and joint sealants courses are routinely requested by the specification community because these products can have a significant impact on the asset and building owner, but there is a lack of technical information available. For that reason, the architectural and engineering community has asked for more information that covers sealant terminology, attributes and properties of joint sealants, where and why they are most often used in the built environment, where joint sealants are prescribed in MasterSpec and what to consider when specifying them in the different applicable divisions of MasterSpec.

Definitions

There are many sealant types used in the built environment. First it is important to learn some of the basic terminology in this space in order to understand what a sealant is, and just as importantly, what it isn't.

A joint sealant, within the scope of the building and infrastructure area, is a material that fills a gap and prevents fluids, air or other materials from passing through the sealed area. It also has adequate adhesive and cohesive properties to form a seal and needs to be able to adhere and move with the substrate while remaining in place to keep the joint filled and sealed.

The terms 'sealant' and 'caulk' are often used interchangeably but there are differences between the two. As defined previously, a joint sealant has several desired properties related to flexibility, adhesion and cohesion in a moving joint. A caulk, however, is usually composed of a lower property compound, often a putty, with limited initial and long term compressive and elongation properties. Caulks are usually specified in a non-moving joint where the main purpose is to fill a gap or joint between two substrates. Anne Whitacre, Senior Architectural Specifications Writer at HOK, explained how she sees the differences: "For exterior fenestration or roofing applications where joints can see movement, water infiltration and weathering effects, I usually will specify a high performance joint sealant such as a silicone or polyurethane. For less critical, non-moving interior joints such as some of the openings covered by MasterSpec Division 08, a latex or acrylic caulk is adequate."

Another source of terminology confusion comes up when discussing the terms 'sealant' and 'sealer.' A sealer is usually a low viscosity

ASTM C 920 defines a joint sealant using several descriptor categories. For example, this sealant would be a Type S: Single component, Grade NS: Non-sag product.

liquid that is applied to a surface such as concrete to protect it from wear, chemical attack and staining. The sealer can penetrate into small voids in the concrete surface to reduce absorption of water and salts or form an impermeable layer or coating that prevents chemicals or staining agents from passing into the substrate.

Characterization

Within ASTM, there are two committees significantly involved with joint sealants: Committee C24 on Building Seals and Sealants and Committee E06 on Performance of Buildings. C24 has jurisdiction over standards specifically covering joint sealants. Familiar examples are specifications C 920 on Elastomeric Joint Sealants and C 834 on Latex Sealants. For the scope of this training, we will be focusing primarily on high performance joint sealants.

ASTM C 920 defines elastomeric joint sealants using terminology such as types, grades, classes and uses that are used in reference specifications as follows:

- Type S: Single component material
- Type M: Multi-component material
- Grade P: Pourable grade that can self-level
- Grade NS: Non-sag grade that is often used in vertical joints
- Class XX: Movement capability, expressed as a percent
- Class XX/YY: Movement capability, expressed as a percent in expansion/contraction
- Exposure Use T: Can accept traffic
- Exposure Use NT: Non-traffic applications
- Substrate Use G: Glass
- Substrate Use M: Mortars
- Substrate Use A: Aluminum
- Substrate Use O: Other

ASTM C 920 includes additional standards used to characterize different types of sealants such as:

- Sealant hardness (ASTM C 661)
- Movement capability (ASTM C 719)
- Tack free time (ASTM C 679)
- Peel adhesion (ASTM C 794)

Two other joint sealant considerations that can affect long term performance is the stress relaxation properties and modulus of the compound. Stress relaxation is the ability of the sealant to elongate without imparting significant stress to the bond line on the substrate. Sealants that recover quickly and fully after being stretched usually are considered to have less stress relaxation than those that recover slower. For modulus, sealants can be grouped into three general categories:

High Modulus: typically used in glazing applications, non-moving joints

Medium Modulus: typically would cover most general purpose sealants used as an elastomeric joint sealant

Low Modulus: have a higher movement or elongation capability and reduce stress at the sealant bond line which accommodates more joint movement

END USE APPLICATIONS

There are several familiar end use applications for joint sealants in a building that have very different needs and therefore the sealants specified can vary greatly from application to application. Some typical joint sealant application areas include:

Exterior joints in the following vertical surfaces and horizontal non-traffic surfaces:

- Construction joints in cast-in-place concrete
- Joints between plant-precast architectural concrete
- Joints and sealant associated with exterior cladding
- Joints associated with aluminum trim and exterior envelope
- Perimeter joints between materials listed above
- Perimeter joints between materials listed above and frames of doors, windows and louvers
- Control and expansion joints in ceilings and other overhead surfaces

Exterior joints in the following horizontal traffic surfaces:

- Control and expansion joints in brick pavers
- Isolation and contraction joints in cast-in-place concrete slabs
- Joints between different materials listed above

Interior joints in the following vertical surfaces and horizontal non traffic surfaces:

- Control and expansion joints on exposed interior surfaces of exterior walls
- Perimeter joints of exterior openings where indicated
- Tile control and expansion joints
- Vertical joints on exposed surfaces of concrete walls
- Perimeter joints between interior wall surfaces and frames of interior doors, windows and elevator entrances
- Joints between plumbing fixtures and adjoining walls, floors and counters

Interior joints in the following horizontal traffic surfaces:

- Isolation and saw-cut joints in poured-in-place concrete slabs
- Control and expansion joints in tile flooring

In all of these applications, there is a degree of expertise needed to understand how to correctly apply the myriad of joint sealant

Interior joints on horizontal surfaces that see traffic such as this decorative stained concrete floor can be sealed to make cleaning easier.

products to the different substrates. Wayne Belcher, consultant and estimator for Unipro out of Seahurst, WA, makes a living at doing just that. "More than just chemistry, ideally, the implementation of a sustainable sealant installation can benefit significantly from proper design assessment, sealant selection and synergy on the part of the construction team. The basic requirements for the installation of elastomeric sealants are ever-changing and increasing as new and remedial construction technologies expand," stated Belcher.

This is the reason why some architects and specifiers favor a one-sub approach for all of the sealant work on a project. Whitacre said that the general contractor encourages the trades to apply the sealant only for their specific area and that makes her nervous. "The preference is to have one sealant subcontractor perform all of the sealant installation for all the needed joint areas," explained Whitacre.

HIGH PERFORMANCE SEALANT TECHNOLOGY OVERVIEW

When considering high performance joint sealant technologies, there are several that make up the majority of products that are applied in the more challenging areas of the built environment. These are silicones, polyureas and polyurethanes. In some niche applications, such as uneven floor joints, an epoxy may also be used.

One component silicone sealant is often used on vertical exterior joints such as those around openings like curtain walls and windows.

Silicone

Silicone joint sealants are an inorganic material derived from a silicone polymer that is available primarily as a single component product.

Silicone inorganic sealants have good adhesion to ceramic and glass. They provide excellent weatherability and UV resistance and retain their physical properties well. They remain flexible long term and are therefore often specified in exterior fenestration applications like those in Division 08. Silicone based sealants have very good water resistance in vertical joints and are relatively surface moisture tolerant. Being a one component product, they can be applied with easy-to-use standard application tools.

One issue with silicone is the compatibility with other sealants and some substrates such as painted surfaces and wood—silicones generally adhere well to silicones. Also, silicones are not usually paintable and need to be sourced in a color compatible with the fenestration color palette. Suppliers usually have a limited list of color choices. Additionally, some architects and contractors prefer not to use clear silicone joint sealants since they have observed some yellowing of the clear versions. Silicone sealants usually exhibit lower abrasion and tear resistance which limits their use in traffic bearing exposed joint applications such as concrete floor joints. Finally, some silicone formulations contain products that can leach out during application and stain certain substrates such as brick, stone or concrete.

Two component polyurea based joint sealants are applied using specialized plural component equipment and cure quickly to reduce downtime.

Polyurea

Polyurea joint sealants are typically nearly 100% solids, depending on the formulation, are typically two-component, and rapidly cure to form a sealant with moderate elongation and high tensile strength.

There are two general types of polyurea sealants – aromatic and aliphatic. Aromatic polyurea joint sealants are often used in interior applications such as control, day or saw-cut joints. In many cases, the entire concrete floor surface and joints are then coated with an epoxy or polyurethane topcoat or the joint sealant is pigmented in a similar or complimentary color. Aliphatic polyurea joint sealants can be used in either interior or exterior application since they are formulated with light stable components. For example, some aliphatic based systems are formulated with polyaspartic resins, a technology used in high durability exterior protective and marine coatings.

The main advantage of a polyurea joint sealant is their fast cure. This allows for quick finishing by cutting them smooth and flush if needed in applications such as concrete joints in Divisions 03 and 32. Another advantage is the toughness, measured in tensile strength, and water, chemical, abrasion and tear resistance due to their reactive chemistry. These sealants can be rained on or walked on often within minutes of application and are relatively surface moisture tolerant.

Polyureas require plural component equipment that can be expensive and requires a specifically trained operator/contractor for application. Therefore, there is potential for an off-ratio mix if the equipment experiences issues. Also, aromatic polyurea sealants can yellow over time if exposed to UV light. Polyurea sealant products with lower elongation and higher hardness cannot accommodate high joint movement.

Polyurethane

During the late 1930's, Otto Bayer pioneered the chemistry of polyisocyanates, a technology that led to the advent of polyurethanes for a variety of applications. Due to their ability to vary physical properties such as hardness, elongation, abrasion resistance and modulus, polyurethanes are widely used in a variety of materials such as foams for building insulation and sealing, adhesives for construction and specialty applications, protective coatings for a variety of substrates, and a variety of sealants for OEM, general industrial and construction applications. Polyurethane joint sealants used in the building, infrastructure and architectural markets, which we are discussing here, fall under this category.

Polyurethanes are one of the most versatile polymer technologies and have found application in the infrastructure and construction protection markets because they provide a unique combination of flexibility and weatherability, as well as chemical and abrasion resistance. These joint sealants also provide reduced VOC emissions, the ability to adjust modulus via formulation, and superior adhesion. A well formulated polyurethane joint sealant provides the advantage of water resistance, long term flexibility and a higher level of performance on traffic surfaces. Furthermore, polyurethanes have faster curing times, allowing for increased productivity and a more forgiving nature in the field which drives their acceptance in multiple building applications.

Polyurethane joint sealants come in both single component (moisture cure) and plural component (chemical cure) systems with different speeds of reactivity. Single component polyurethanes are moisture cured and offer longer working life, while plural component products have a standard-to-fast cure time, limiting the window of opportunity when installing. However, the faster cure time provides a faster finish, which limits defects due to rain or environmental contaminants such as leaves or insects. If necessary, it also allows for faster cutting or grinding in the case of concrete floor joints as specified in Divisions 03 or 32.

The solids content of polyurethane sealants is typically medium to high. High solids sealants have little to no solvent in their composition and were first introduced to comply with increasingly stringent VOC regulations. Due to this increased solids content and lack of solvent, these types of sealants needed to be formulated differently than those coatings with low solids. The removal of solvents, which are used to compensate for viscosity, flow and curing, require the low solvent sealants to have different characteristics and methods of handling.

In most cases, fillers, pigments and other modifiers such as flow and leveling agents, solvents and specialty additives may also be used to formulate a complete commercial joint sealant. Raw material suppliers have developed technology and methods for joint sealant formulators to employ to allow for user-friendly yet robust joint sealant systems.

QUIZ

1. True or False: Silicone joint sealants generally adhere well to both glass and ceramic surfaces.

2. True or False: Joint sealants and caulks are basically different words describing the same technology.

3. Which of the following is a characteristic of a high performance joint sealant?
   a. Fills a gap
   b. Prevents liquid from entering a joint
   c. Has adhesive and cohesive properties
   d. Can move with the substrate to keep the joint sealed
   e. All of the above

4. Which type of joint sealant can be formulated to both seal as well as protect concrete floor joint shoulders?
   a. Silicone
   b. Polyurethane
   c. Polyurea
   d. Both B and C

5. Which type of joint sealant provides a unique combination of flexibility, weatherability, as well as chemical and abrasion resistance?
   a. Acrylic
   b. Polyurethane
   c. Silicone

6. True or False: Polyurethane joint sealants only come in single component (moisture cure) systems.

7. Which high performance joint sealant discussed has a very fast cure time as an attribute?
   a. Polyurea
   b. Silicone
   c. Polyurethane

8. The solids content of polyurethane joint sealants is typically ______________ .
   a. Medium to high
   b. Low to medium

9. High performance joint sealants can be specified in which of the following divisions?
   a. Division 03
   b. Division 04
   c. Division 07
   d. Division 08
   e. Division 32
   f. All of the above

10. True or False: In Division 07 9200, joint sealants are specified depending on the type of joint and application.

This article continues on http://go.hw.net/AR092017-2. Go online to read the rest of the article and complete the corresponding quiz for credit.

SPONSOR INFORMATION

VECTOR GRAPHICS IN ARCHITECTURAL LAMINATED GLASS

Presented by:

FORMS+SURFACES®

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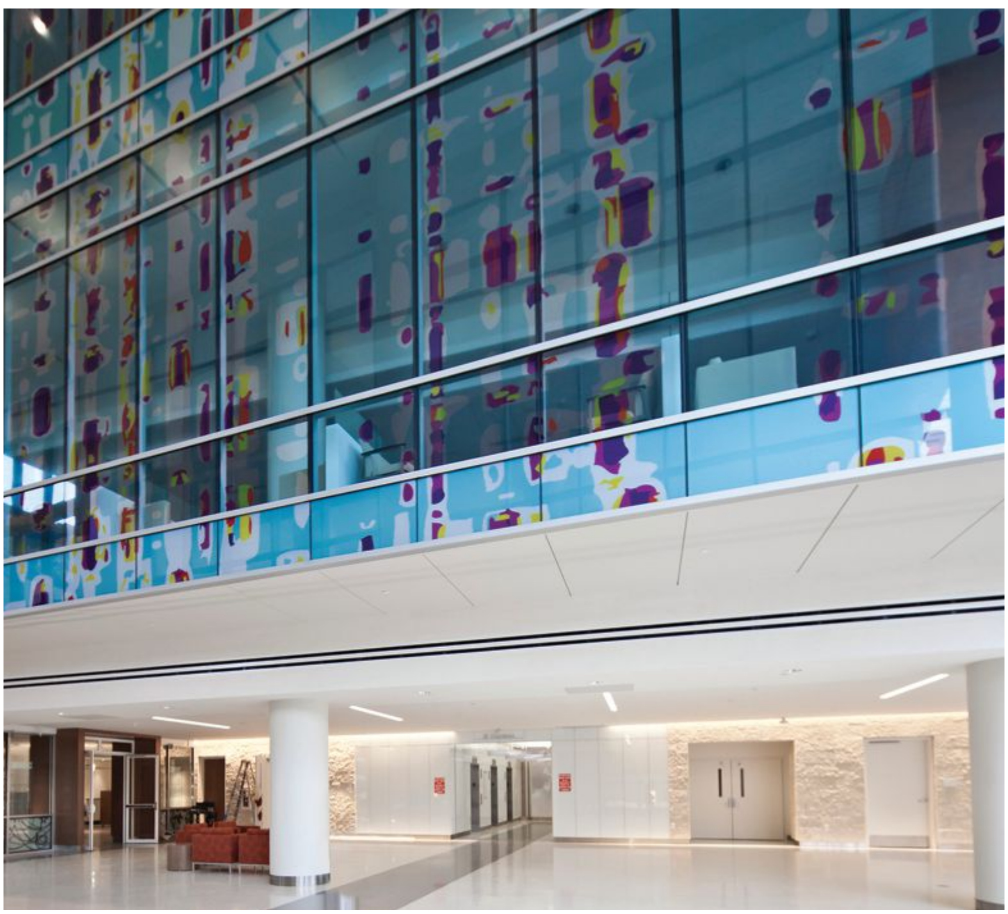

LEARNING OBJECTIVES

Upon completion of this course the student will be able to:

1. Review examples of how and why vector graphics are used in a variety of architectural materials.
2. Explain how vector graphics differ from raster graphics and how they address challenges of resolution and scale.
3. Describe how vector graphics can be used in architectural laminated glass, including the role of new technologies and design tools that expand the creative options for bringing photographs and digital imagery to architectural laminated glass applications.
4. Cite examples of how vector graphics can be used in architectural laminated glass applications to achieve project-specific creative objectives.

CONTINUING EDUCATION

AIA CREDIT: 1 LU
AIA COURSE NUMBER: AR102017-3

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Architectural laminated glass has become a favored material for indoor and outdoor projects, in large part due to its beauty, durability, functionality and remarkable design versatility. Increasingly, photography and other digital images are popular choices for incorporating design elements into the glass. However, it can be difficult for designers to find and source imagery of an appropriate size for their projects, especially large-scale applications.

New online design tools that use vector graphics help solve this problem, and give designers the ability to bring virtually any digital image or photo to laminated glass applications of any size or scale.

This course introduces participants to how vector graphics are used in architectural design by exploring where, why and how they're incorporated into a variety of materials, manufacturing processes and applications. Next, it explains what vector graphics are and how they differ from raster images. The course then examines in detail how vector graphics are used in architectural laminated glass. It ends with project examples.

To begin, it will help to understand a few vector basics.

VECTOR GRAPHICS IN ARCHITECTURE

A "vector" graphic or image refers to a specific type of digital file format. Because they're made from a series of mathematical curves, vector graphics are infinitely scalable. This means they retain their visual integrity regardless of output size or scale. For example: a vector logo created at business card size can be successfully enlarged for a billboard without sacrificing image quality. Or vice versa.

The beauty of vector graphics lies in this infinite scalability. Regardless of output size, application or viewing distance, the precision of vector graphics ensures clean, crisp detailing and high-quality end results. This makes them an ideal format for drawings, typefaces, logos, patterns, and other design elements that benefit from unhindered size/scale flexibility.

Vector graphic files can be output through a variety of processes (like printing) and used with a wide range of media. Vector files can also be used to drive automated tooling that produces imagery, shapes and patterns in, on or for different materials and architectural applications.

Vector graphics are routinely incorporated into architectural design in many different ways. Following are a few common examples.

Vinyl Signage

Since scale isn't an issue with vector graphics, large-scale vector images can be printed directly onto vinyl sheets for use as high-impact signs and banners that communicate wayfinding, branding, and promotional information.

Vector files can also drive vinyl die-cutting equipment. Letters, patterns and shapes cut from sheets of adhesive-backed vinyl and adhered to windows or walls are routinely used to bring personality to retail store fronts, identify or define space, and label exhibits and displays.

Perforated Metal

Perforated metal is frequently seen in indoor and outdoor settings. Perforated designs on partition walls, railing infill panels, benches, chairs, and directional lighting shields are just a few examples.

Vector files enter into the perforation equation on many fronts. Used with automated punch tools or lasers to puncture metal, they ensure precise lines, smooth arcs and consistent spacing between perforations. They can create complex punch files that produce fairly intricate perforated designs. Vector files also mean perforation patterns can be efficiently automated and repeated at any scale.

Etched Metal

Etching is another method of bringing patterns and imagery to metal surfaces. Designs are

Vector files can be used to create designs in etched and perforated metal—in this case, stainless steel—to make statements of any scale, indoors or out.

applied to the metal by "masking" (covering) the areas in which a design will appear, then etching around the mask. The masked portions retain the original metal finish, while the etched areas display a contrasting surface appearance.

Vector files are often involved in creating etching masks. Sometimes they're used to generate masks that are directly applied to the metal surface with inks or other substances—an approach that produces distinct, smooth edges around the etched areas.

In other cases, masks are die-cut or hand-cut from vinyl sheets. When vector files drive the die-cutting equipment, the vinyl edges—and resulting etched design—tend to be crisper than those produced of hand-cut vinyl.

Regardless of mask type, once the mask is positioned, the metal is etched, typically by one of two processes: Acid etching is a traditional method that requires the use of acids and other corrosive chemicals to etch the unmasked metal. Bead blasting is a more environmentally friendly option that uses a photolithographic bead-blasting system instead harmful acids or chemicals to achieve the final etched design.

Etched Glass

Etching is also used to bring patterns and designs to architectural glass. The process is similar to metal etching: a mask produced through one of several methods—with or without the use of vector graphics—is used to designate areas of a design that won't be etched. As with metal, the more precise the mask (i.e., those created with vector files), the more precise the end result.

As with metal etching, once the mask is in place, the glass is etched through one of two methods: chemically or by sandblasting. Regardless of which method is used, the masked portions retain the original glass finish and the etched areas have a different look and feel.

Branded Glass

Many techniques can be used to bring branding elements to architectural glass. As described elsewhere in this section, vector files might drive cutting equipment for vinyl graphics that will adhere to windows or glass walls. They might be used to incorporate brand designs in etched glass. Or they may be output as brand-aligned graphics for laminated glass interlayers.

In addition to logos—a common use for vector graphics in branding packages—their infinite scalability makes them ideal for typefaces, patterns and other identity components that benefit from the lack of size/scale constraints—perfect for taking brand messaging across glass applications of any size or scale.

Laminated Glass

Laminated glass is a versatile material when it comes to incorporating colors, graphics and other project-specific artwork. Laminated glass is typically constructed of two or more glass lites, between which one or more decorative interlayers are sandwiched. The interlayers serve as the "canvas" for a wide range of decorative treatments, including vector graphics.

Because laminated glass is frequently used in large-scale glass applications, the ability to use infinitely scalable vector graphics gives designers countless ways to create design statements in glass, for spaces of all kinds.

Vector graphics have numerous applications in architectural design. Because their potential is vast, it's worth examining them in greater detail.

AN IN-DEPTH LOOK AT VECTOR GRAPHICS

One of the key things to understand about vector graphics is how they differ from raster images. Before we get into the details, let's start with some basic terminology.

Key Terminology

Raster (or bitmap) graphics are made up of tiny squares called pixels. Once a raster graphic is created at a certain size, meaning a fixed

With their infinite scalability, vector graphics can make an artistic statement at any scale. Precise vector output ensures high-quality end results.

number of pixels, it can't be scaled up without losing image quality. Digital photos are typically raster images.

A **vector graphic** is another type of digital image, but instead of pixels, it's made of points and paths (lines between points) that are created through mathematical equations.

A **pixel** is the smallest addressable element in a display device. It's also a physical square in a raster image. Pixels are the smallest controllable elements of a picture represented on a display screen.

PPI stands for "pixels per inch", and is used to measure the resolution, or pixel density, of devices such as digital displays, image scanners, or digital camera image sensors.

DPI stands for "dots per inch". When used in reference to display screens, it's a measure of sharpness, or the density of illuminated points. When used in reference to printing, DPI refers to the measure of printed image quality on paper, identifying the number of dots that can be placed within a 1-inch line.

Size refers to the number of pixels in an image along the width and height.

Resolution refers to the fineness of detail in an image, and can be measured in pixels per inch or dots per inch.

Vector Graphics

What are vector graphics, and why are they useful?

Vector graphics use mathematical equations to create infinitely scalable images by converting any graphic into points that are smoothly connected by lines and/or curves. These lines and curves are called "paths". The paths are often filled in with color to make up the different shapes you see in a vector graphic.

Vector graphics use mathematical equations to convert any graphic into points that are smoothly connected by lines and/or curves, also known as paths.

One of the main benefits of converting a graphic to path-connected points is that the resulting image can be infinitely scaled up or down without losing image quality or changing the file size.

Because they can be infinitely scaled, vector graphics provide tremendous design flexibility. For example, if a company's logo is created in a vector format, it can be used as small as a letterhead graphic or as large as a building feature wall.

Because file sizes don't change when vector graphics are scaled up or down, very large vector images retain a relatively small file size, which makes image processing, handling and storage more manageable than with larger image file formats, including raster files.

This is not to say that vector graphics are always small files. File size is proportionally tied to the complexity of the vector image. A simple two-color logo might create a very small file, while the file for a process color illustration may be as large or larger than its corresponding raster image.

Commonly used vector formats are SVG, EPS, XML and CGM.

Raster Images

What are raster images, and what are their limitations?

Raster images are created from a finite number of tiny squares called pixels. Once a raster graphic is created at a certain size, meaning a fixed number of pixels, it can't be scaled up without sacrificing image quality.

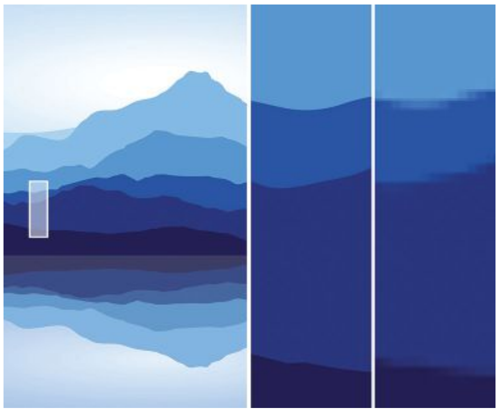
The greater the number of pixels in an image, the larger the file size, or resolution. While the two are positively correlated—larger file size affords greater flexibility—the bottom line remains: raster graphics can't be dramatically resized without compromising their resolution. If stretched to fit a space they weren't designed to fill, their pixels become visibly grainy and the image distorts.

Because raster images are comprised of a finite number of pixels, increasing the image size also proportionally increases the pixel size. This results in degraded image resolution because the larger pixels are now more visible and contribute to the image looking blurry, rather than crisp.

The use of raster images for large-scale design applications requires careful consideration. Both image size and resolution must be factored in to achieve optimal end results. This is critical for two reasons: insufficient resolution can significantly compromise the quality of the end design. And because large-scale raster images imply a large number of pixels and thus a large file size, the image can be more difficult to process, handle, and store than an alternate file format like a vector graphic.

To know whether a raster image can used be for an application, start by checking the pixel density. This density is measured in dots per inch (DPI) or pixels per inch (PPI). The PPI value is for digital displays of the image; the DPI value is for analog prints of the image. The PPI value is the same as the DPI value, but the terms should be properly applied based on the image display application.

For example: web applications display images at 72 PPI, and can look very crisp in that context. The Apple Retina display, however, is set at 227 PPI, so more modern technology would make this problematic. And, even this DPI is still much too low for print applications, which require high-resolution raster files of around 300 DPI at actual output width and height.



When resized, infinitely scalable vector graphics (close-up at left) can offer a clearer picture than raster images (close-up at right).

Common raster file types are JPG, TIFF, PNG, GIF and BMP.

Why Use Vector Graphics instead of Raster Images?

Why use vector graphics instead of raster images? There are many reasons.

As we've just seen, there are three main challenges with raster imagery:

- Raster images cannot be resized without potentially sacrificing image quality or resolution.
- Raster images appropriate for use in large-scale applications are often difficult to source because personal and online stock photos, and even professional photography to a certain extent, does not usually have the dimensional resolution suitable for large-scale designs.
- Large, high-resolution raster images result in large file sizes that can be cumbersome to store, process and produce.

By converting raster images to vector graphics, all of those challenges can be resolved.

- Vector images can be infinitely scaled up or down without losing image quality.
- Because vector graphics are flexible in terms of scaling, they can be customized for many different purposes, including large-scale projects and end uses. Again, while it's not uncommon to think of vector graphics largely for use in logos or branding elements, they have many potential applications.
- Vector art is ideal for printing: since the art is made from a series of mathematical curves, it will print or otherwise output very crisply even when resized.
- When a vector image is scaled up to a larger size, the overall file size doesn't change. Large vector image can have a relatively small, easily managed file size.

Vector images are considerably more flexible than raster images, and therefore much more beneficial in large-scale architectural applications.

That said, designers need to be aware that in converting raster images to vector graphics, the conversion process is more of a "translation", and that a vector graphic will never be a true one-to-one depiction of the original raster image.

QUIZ

1. True or False: Vector graphics are infinitely scalable, retaining their visual integrity regardless of output size or scale.

2. True or False: Raster images can be converted to vector graphics.

3. True or False: A vector graphic will always be a one-to-one depiction of the original raster image.

4. Which is not a challenge with raster imagery?
   - a. Images cannot be resized
   - b. Large scale application image clarity
   - c. Original 1:1 size application of imagery
   - d. Large file sizes

5. Where are vector graphics least likely to be incorporated?
   - a. Perforated Metal
   - b. Cement
   - c. Branded Glass
   - d. Laminated Glass

6. Which is not a characteristic of laminated glass:
   - a. It holds together when shattered
   - b. It's difficult to clean and maintain
   - c. It can address a wide range of light transmission scenarios
   - d. It may help meet project sustainability goals

7. Which element does not need to be considered when designing with laminated glass?
   - a. Finishes
   - b. Flatness
   - c. Opacity
   - d. Light Sources

8. Laminated glass is suitable for:
   - a. Only indoor use
   - b. Only outdoor use
   - c. Both indoor and outdoor use

9. What spaces can laminated glass be incorporated into?
   - a. Elevator interiors
   - b. Outdoor spaces
   - c. Backlit displays
   - d. Walls
   - e. All the above

10. What type of graphic uses mathematical equations to alter images?
    - a. Raster graphics
    - b. Vector graphics
    - c. Both raster and vector graphics
    - d. None of the above

SPONSOR INFORMATION

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Forms+Surfaces is a leading designer and manufacturer of architectural and outdoor products used in public spaces worldwide. The company's integrated product lines include laminated glass, stainless steel, and other surfacing materials; wall cladding, column, and elevator interior systems; and a growing collection of online design tools that make it easy for architects and designers to creatively work with their products.

This article continues on http://go.hw.net/AR102017-3. Go online to read the rest of the article and complete the corresponding quiz for credit.

DESIGNING WITH CONTINUOUS INSULATION FOR THERMAL AND MOISTURE MANAGEMENT

Presented by: ZIP system R-SHEATHING

Streamlining Continuous Insulation into Exterior Walls

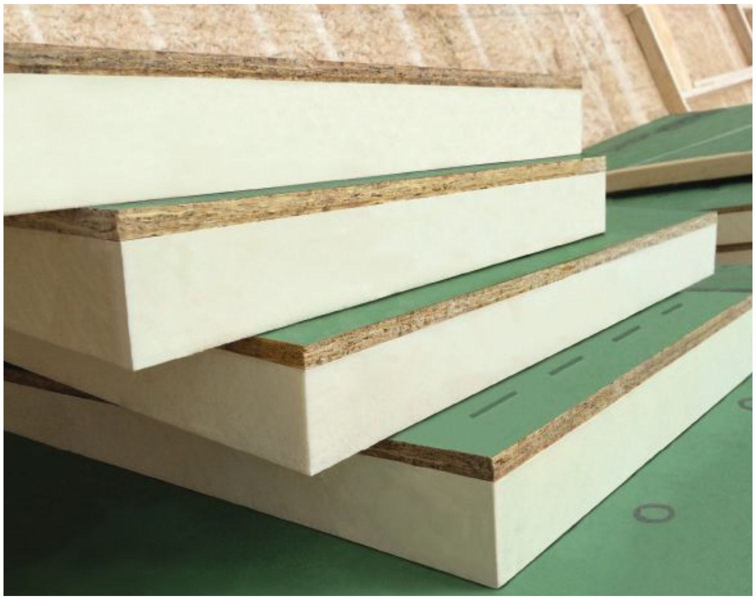
Building codes and green building standards continue to raise the bar on energy efficiency and high performance in buildings. In wood-framed buildings, addressing both insulation levels and air tightness in the building enclosure continue to be refined by code and elective program standards. While this is a positive trend, determining the best amount and type of exterior continuous insulation can be challenging.

Codes suggest different amounts of continuous insulation for different climate zones. There is also concern that continuous insulation can impact the ability of the wall to "breathe" and release any trapped moisture from within the assembly so, in some cases, it can impact the choice of an interior vapor retarder on the warm, inner side of the building. All of these variables and options have led to some significant confusion concerning the best way to properly address both code required thermal insulation and manage vapor in wall assemblies. The new "Designing with Continuous Insulation for Thermal and Moisture Management" CEU course now available on Hanley Wood University helps provide clarity on the differences between the varied prescriptive code requirements for continuous insulation in different climate zones along with principles and choices related to proper moisture management. Here's a glance at some of the topics covered.

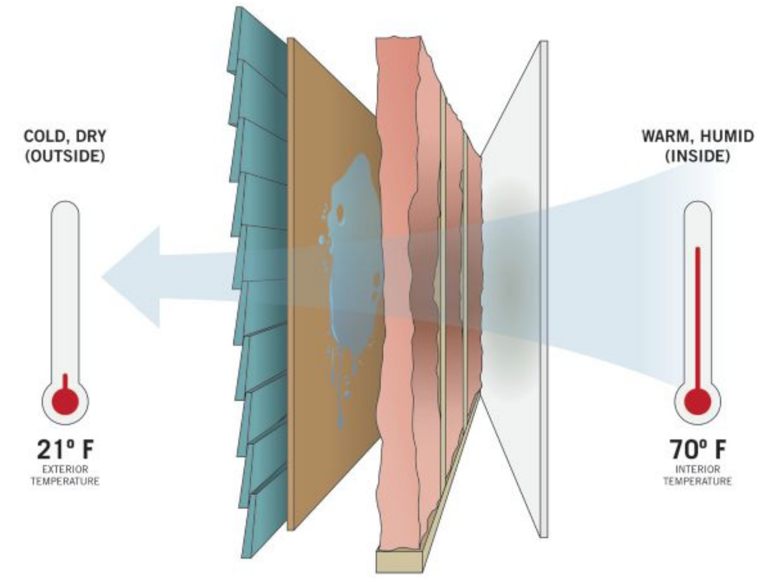
Heat Transfer

Framed wall construction, whether using wood studs or metal studs, has an inherent weakness from a thermal efficiency point of view. Simply put, the framing allows more heat to flow through it than insulation does and heat always seeks a balance by flowing from a warm source to a cooler place. In buildings, heat transfer is based on U-factors, which indicate how much

> Determining the best amount and type of exterior continuous insulation can be challenging.



ZIP System® R-sheathing meets structural bracing with integrated control layers to manage heat, water and air.



One of the benefits of continuous insulation is reducing the chance of condensation inside wall cavities separating two disparate cavities. Watch the ZIP System® R-sheathing CEU for more on managing dew point.

energy passes through material over time for each degree in temperature difference. (The greater the difference in temperature between the two sides of the material, the faster or more intensely the heat flows.) In order to determine how much heat is transferred through any specific material, its U-factor is determined by testing that material on a square foot basis over time while measuring the temperature difference between the two sides. The resulting number is generally a decimal (e.g., 0.5) with smaller numbers indicating small amounts of heat transfer (think insulation) and higher numbers indicating more heat transfer (think conductive metal). Applying this to a building, the fundamental formula used is (U × A) × dT where U = the tested U-factor for one square foot of material, A = the area in square feet installed in a construction assembly, and dT = the design or actual temperature difference between indoors and outdoors. All thermal energy calculations in building enclosures (i.e., walls, roofs, etc.) are based on this fundamental formula.

Thermal Bridging

Construction assemblies are very rarely monolithic. Rather, they require different materials that are assembled to make up the overall construction. In typical situations, the framing can account for 20-30 percent of the area of any given exterior wall with only about 70-80 percent of the wall area actually containing insulation. Since the framed sections will not have the same U-factor/R-value of the insulation, the thermal effectiveness of the wall is directly compromised. It is easy to ask: is this 20-30 percent framing area really a big deal? It turns out that the answer is yes. Any building material, including framing or sheathing, that has a capacity to transfer heat more than insulation will follow the laws of physics and do so. In this case, every stud or other solid structural item like floor band joists, columns, etc., is acting as a breach in the insulated wall allowing heat to transfer through it. This solid connection between the warm side and the cool side of an assembly acts as a "thermal bridge" and allows heat to flow freely between the sections where the insulation is present.

Continuous Insulation Choices

A solution to all of these thermal bridges can be continuous insulation. A variety of insulating sheathing products have become available over the past few decades. In framed walls, there is also the need for solid sheathing over the studs that can provide structural bracing for the wall and a durable nailbase for the attachment of siding, cladding, brick ties, etc. Many exterior insulation products aren't rated to be structural and don't necessarily provide a good nail base. That usually means the continuous insulation is put up after structural sheathing goes over the studs. In many cases, another layer is needed to provide a nail base or else the exterior cladding needs to be carefully attached to the studs. This multistep process can add to the labor involved and the detailed design of multiple layers.

Design and construction teams are turning to a streamlined approach to incorporate continuous insulation with an engineered wood system that not only solves for a structural, nailable exterior on the outside of continuous insulation, but also eliminates the need for housewrap. ZIP System® R-sheathing by Huber Engineered Woods LLC is a next-generation engineered wood sheathing system with a built-in water-resistive barrier, rigid air barrier and integrated polyisocyanurate continuous foam insulation on the back of the panel. Completed with taped panel seams, the system helps create a tight exterior envelope with optimal permeance that allows panels to dry to the outside. ZIP System R-sheathing is available with multiple insulation thicknesses from ½" to 2" to meet needs in all climate zones. Learn more at ZIPSystem.com/R-Sheathing.

Visit http://go.hw.net/Huber1017 to listen to the "Designing with Continuous Insulation for Thermal and Moisture Management" CEU course, sponsored by ZIP System® R-sheathing.

LIFE CYCLE ASSESSMENT OF CONCRETE BUILDINGS

Presented by:

BUILD WITH STRENGTH

LEARNING OBJECTIVES

Upon completion of this course the student will be able to:

1. Recognize how concrete can reduce the life cycle impacts of a building.
2. Understand life cycle assessment (LCA) and how it can be used to help measure and reduce the environmental impacts of a building.
3. Explore how LCA is used in the green building standards.
4. Explore an example of how LCA software tools can be used to reduce the environmental impact of a building.

CONTINUING EDUCATION

AIA CREDIT: 1 LU/HSW
AIA COURSE NUMBER: AR102017-1

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Figure 1. Capitol Tower, Houston, TX. This 35-story, 750,000 square foot, Class A office building features concrete pan formed beams with post-tensioned girders, a mat foundation and concrete core/shear walls. This LEED Platinum pre-certified project demonstrates significantly lower environmental impacts over a typical building and meets the rigorous life cycle assessment (LCA) credit in LEED v4 by using high volume supplementary cementitious material concrete mixes. Developer: Skanska. Architect: Gensler; Structural Engineer: Walter P. Moore; Image: courtesy of Skanska USA Commercial Development, Inc.

By: Lionel Lemay, PE, SE, LEED AP. Executive Vice President, Structures and Sustainability, National Ready Mixed Concrete Association

INTRODUCTION

Concrete offers several environmental benefits that can help reduce the overall impact of a building. For example, the production of concrete is resource efficient and the ingredients require little processing. Most materials for concrete are acquired and manufactured locally which minimizes transportation energy and associated greenhouse gas emissions. Concrete incorporates recycled industrial byproducts such as fly ash, slag and silica fume which helps reduce embodied energy, carbon footprint and landfill disposal. Concrete has a long service life, thereby decreasing reconstruction, repair and maintenance and associated environmental impacts.

Most importantly, because of concrete's thermal mass, concrete buildings can be extremely energy efficient. From a life cycle perspective, concrete buildings perform well when compared to steel- and wood-frame buildings. As a result, concrete buildings have a lower carbon footprint over their entire life cycle. This paper explores how life cycle assessment (LCA) methods can be used to quantify and improve the environmental performance of a building.

WHAT IS LIFE CYCLE ASSESSMENT?

LCA is the investigation and evaluation of the environmental impacts of a product, process or service. LCA evaluates all stages of a product's life and considers each stage interdependently. There are several inputs, life cycle stages and outputs as shown in Figure 2. Inputs include raw materials and energy. Life cycle stages include raw material acquisition, manufacturing, operations, maintenance and end-of-life including recycling and waste management. The outputs include atmospheric emissions, waterborne wastes, solid wastes, coproducts and other releases. These outputs are then converted to potential environmental impacts based on scientific knowledge of how these outputs affect the planet, ecosystems and human health.

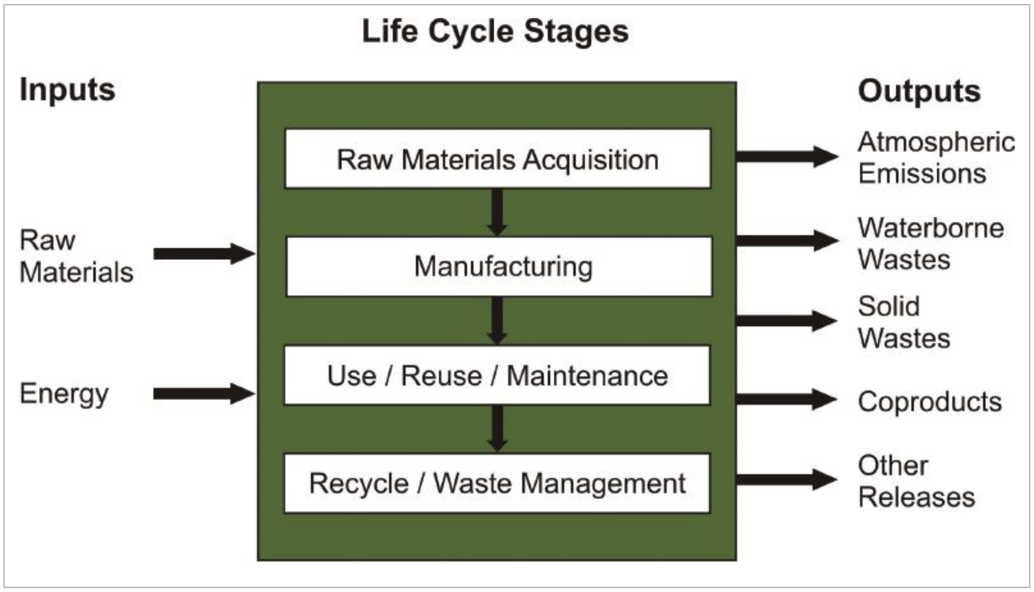


Figure 2. Life cycle stages, inputs and outputs for life cycle assessment (adapted from U.S. EPA).

The United States Environmental Protection Agency (U.S. EPA) developed the Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI). TRACI allows the examination of impacts associated with the raw material usage and energy consumption (inputs) and chemical releases (outputs) resulting from the processes involved in producing a product or, in this case, construction and operation of a building over a specific lifetime. These environmental impacts include ozone depletion, global warming, acidification, eutrophication, photochemical smog, human health issues, ecotoxicity, fossil fuel use, land use and water use among others.

Figure 3 provides a schematic representation of potential environmental impacts and one possible interpretation of their relative importance for the purposes of identifying the most critical impacts. The relative importance of each impact might change depending on the product or process being analyzed or on other factors such as location and/or political influences. For example, many governments have declared climate change as today's most important environmental impact. However, there are some locations where water is scarce and therefore water intake and waterborne releases may be more important.

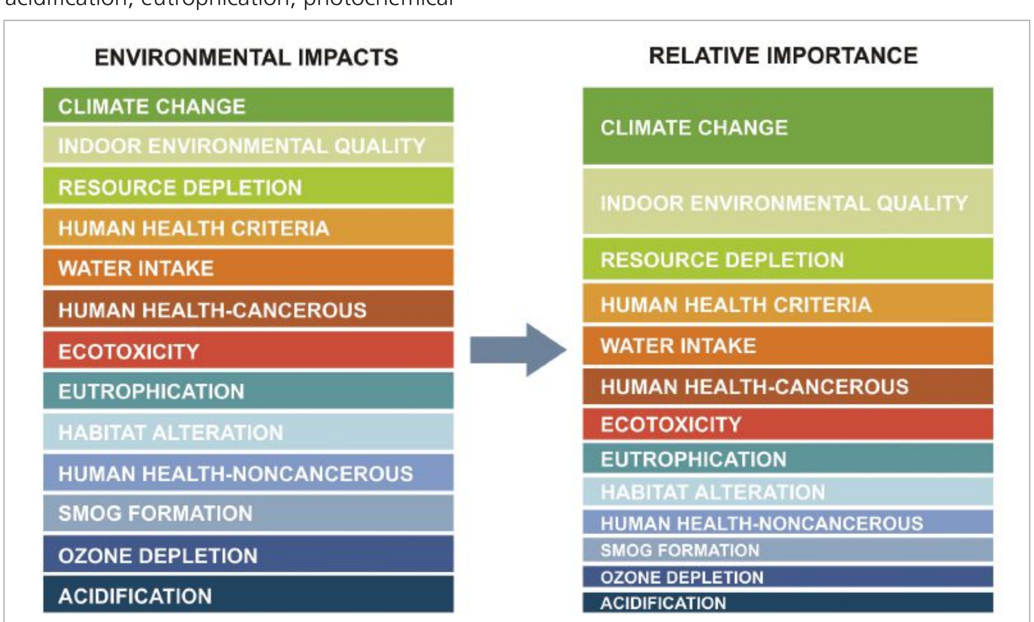


Figure 3. Environmental impacts and relative importance of impacts (adapted from USGBC).

When looking at the environmental impact of a building, it is important to assess every stage of the environmental life cycle including material extraction, manufacturing and construction, building operations, and the end-of-life stage where the building components are demolished and reused or discarded. LCA is the most comprehensive approach to determining the environmental life cycle impacts of a building and can be used as a tool to make design decisions that would result in lower environmental impacts.

There are inputs, outputs and associated environmental impacts for each life cycle stage. For a building, energy and materials are consumed to manufacture building products. As a result, there are environmental releases and associated impacts from transporting raw materials to the manufacturing facility and from the manufacturing facility to the construction site that must be accounted for. Similarly, there are inputs and environmental releases from the construction stage. For buildings, the use or operational life cycle stage impacts are significantly greater than those in the other life cycle stages. A building usually operates for decades consuming energy and raw materials with associated environmental releases. These operational stage impacts typically dwarf the environmental impacts from material extraction, manufacturing and end-of-life stages for commercial and residential buildings.

One of the major hurdles to adopting LCA as a tool for evaluating and improving the environmental impacts of buildings is the lack of data. Generally, product manufacturers can communicate their environmental impacts using a document called Environmental Product Declaration (EPD). An EPD provides information about environmental impacts such as global warming potential, smog formation and water use based on a comprehensive LCA of their product.

A Product Category Rule (PCR) is a standard that provides instructions on how to conduct the LCA in order to produce EPDs that are consistent within a product category (such as concrete, carpeting, ceiling tile, etc.). Generally, plant or site specific data are more desirable for conducting an LCA for the product, however, industry average data is sometimes used if site specific data is not available. There are many concrete producers that have published product specific EPDs and the National Ready Mixed Concrete Association (NRMCA) has published an Industry-Wide EPD that provides average impacts that can be used in lieu of product specific EPDs.[1]

Ideally, LCAs for products are conducted for the entire life cycle or from "cradle-to-grave." However, for many products, their impacts during the use stage are minimal or life cycle inventory data for the use stage is difficult or nearly impossible to obtain. In some cases, it may be preferable to conduct partial LCAs such as "cradle-to-gate" type analyses where only the first two life cycle stages, raw material acquisition and manufacturing, are included since this data is needed to conduct the more comprehensive whole building LCA.

Although it depends on the type of building and the impacts being measured, the operational stage impacts are typically 5 to 20 times larger than stages associated with building product manufacturing, construction and demolition combined. In fact, operating buildings in the U.S. consumes 40% of the nation's energy and is responsible for 37% of the CO_2 emissions.[2] Therefore, when conducting an LCA for buildings, it is extremely important to include the operational stage.

Operational stage impacts for a building are typically obtained by conducting a comprehensive energy analysis to identify the environmental impacts associated with heating, cooling, illuminating and operating a building. The results of the energy analysis would be entered into LCA software as energy inputs, delineating what fuel type will be used and so on. In addition, information about water use, waste production and any other source of emissions must be estimated to conduct a whole building LCA.

HOW CAN CONCRETE HELP REDUCE LIFE CYCLE IMPACTS OF A BUILDING?

Reduced Manufacturing Process Energy

Water, sand, stone, gravel and other ingredients make up about 90% of a concrete mixture by weight. The process of mining sand and gravel, crushing stone, combining the materials in a concrete plant and transporting concrete to the construction site requires very little energy and only emits a relatively small amount of CO_2 into the atmosphere. The amount of CO_2 embodied in concrete is primarily a function of the cement content in the mix.

One of the most effective ways to reduce the embodied impacts of concrete manufacturing is to increase the use of industrial byproducts such as fly ash, blast furnace slag and silica fume to supplement a portion of the cement used in concrete. These industrial byproducts, which would otherwise end up in landfills, are called supplementary cementitious materials or SCMs for short. SCMs work in combination with portland cement to improve strength and durability of concrete. Their use reduces the CO_2 embodied in concrete by as much as 70%, with typical reductions ranging from 15 to 40%, depending on the percent replacement of portland cement.

Concrete producers also incorporate a variety of environmental best management practices in the production of concrete. These include the reuse and recycling of waste from concrete manufacturing such as water and unused returned concrete. Additionally waste byproducts are incorporated from other industries such as recycled industrial wastewater, foundry sands, glass and other materials that would typically end up in landfills. In addition to the use of SCMs in the concrete mix, concrete from demolition can be crushed and recycled as aggregate. Recycled aggregate is often used as backfill and a pavement base and can be used for making new concrete. Reinforcing steel in concrete, which is made from recycled materials, can be recycled and reused.

Durability

Concrete structures can withstand the test of time. For a building to last for generations, durability must be an inherent quality of its construction materials. Concrete does not rust, rot or burn. Concrete buildings are durable, long-lasting structures that resist natural disasters such as hurricanes, tornadoes, earthquakes, fires and floods. Because of its longevity, concrete is a viable solution for environmentally responsible design over the lifetime of a building. As a result, concrete buildings have low environmental impacts associated with maintenance and repair.

Thermal Mass

In a building, it is the mass of the building elements that stores heat during the hottest periods of the day and releases the heat during the cooler evening hours. Concrete is one of few building materials that possess thermal mass properties. In the winter season, high thermal mass concrete walls and floors absorb radiant heat from the sun and gradually releases it back into the occupied space during the night when the outdoor temperature drops.

The distinct benefits of high thermal mass buildings are:

- Moderate shifts in peak loads of energy requirements due to the reduction in high fluctuations between indoor and outdoor temperatures;
- Heat transfer through a high thermal mass wall is reduced, therefore less energy is used to heat and cool the interior space;
- Thermal mass of concrete delays peak temperatures to reduce and space out peak energy loads, therefore shifting the energy demand to off peak periods when utility rates may be lower (see Figure 4).

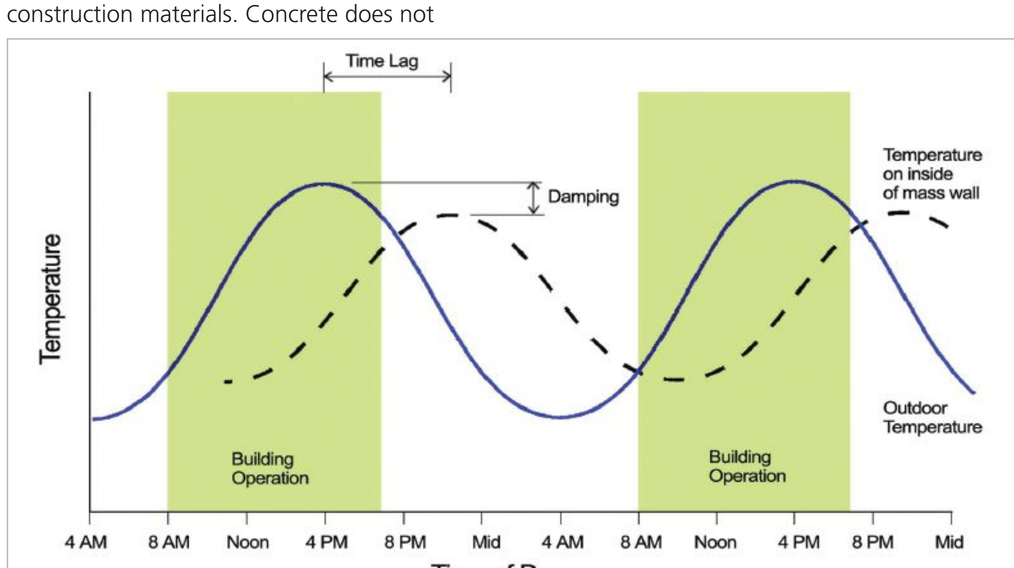


Figure 4. Damping and lag effect of thermal mass.

RESEARCH EXAMPLES OF WHOLE BUILDING LCA

There are relatively few examples of whole building LCAs in literature. LCA is still a relatively new science for the purposes of measuring environmental impacts of buildings and can be extremely time consuming and expensive. Most researchers have only conducted partial LCAs and choose to limit the scope of an LCA by ignoring certain life cycle stages because of the lack of data or scope of research. Others focus on specific impacts to simplify the LCA process. The following are several examples of research that compare the life cycle impacts of concrete, steel and wood-framed buildings.

A comprehensive whole building LCA study was conducted at Massachusetts Institute of Technology (MIT) and published in a report titled *Methods, Impacts, and Opportunities in the Concrete Building Life Cycle*.[3] The research explores and advances key areas relevant to the field of whole building LCA, including methodology, benchmarking and impact reduction. In particular, the research compared the environmental impacts of a concrete building to a steel building for a large commercial structure in two different climate zones and of single and multifamily structures built with concrete and wood-frame in two different climate zones.

LCA OF A COMMERCIAL BUILDING

A comprehensive LCA was conducted for a 12-story, 498,590 ft^2 (46,321 m^2) commercial building (Figure 5). The building was analyzed for two climates, Phoenix and Chicago, and for two different structural materials, concrete and steel. The annual operating energy, determined using building energy analysis software, was conducted for a 60-year life cycle. The Global Warming Potential (GWP) was quantified using CO_2 equivalents (CO_2e) for several purposes, including benchmarking emissions for current construction practices, comparing impacts of concrete versus steel and understanding the relative magnitude of impacts for different life cycle stages.

This article continues on http://go.hw.net/AR102017-1. Go online to read the rest of the article and complete the corresponding quiz for credit.

QUIZ

1. Life Cycle Assessment (LCA) is the study of:
   - a. Long term costs
   - b. Environmental impacts
   - c. Political implications
   - d. Environmental regulations

2. Which of the following is considered an input when conducting an LCA of a product or building?
   - a. Atmospheric emissions
   - b. Manufacturing
   - c. Recycling
   - d. Energy

3. TRACI is:
   - a. A tool developed by U.S. EPA to convert LCA outputs into environmental impacts
   - b. The woman at U.S. EPA who developed the LCA methodology
   - c. The software used to conduct whole building LCA
   - d. The agreement signed by most countries of the world to reduce climate change

4. What life cycle stage of a building typically has the highest environmental impacts?
   - a. End-of-life
   - b. Product manufacturing
   - c. Material acquisition
   - d. Operational or use

5. An Environmental Product Declaration (EPD) is:
   - a. A certification that indicates a product is sustainable
   - b. A required submittal to obtain a building permit
   - c. A document that communicates the environmental impacts of a product
   - d. A document required by the U.S. EPA from concrete producers

6. True of False: The embodied environmental impact of building product manufacturing far outweighs the impact of operating a building.

7. The most effective way to reduce the embodied impacts of concrete is by:
   - a. Using chemical admixtures
   - b. Incorporating SCMs into concrete mixes
   - c. Increasing the specified compressive strength of concrete
   - d. Adding more portland cement

8. Thermal mass can help reduce _______ of a building.
   - a. Overturning moment and associated damage during an earthquake
   - b. High fluctuations between indoor and outdoor temperatures
   - c. Embodied impacts
   - d. Recycled content

9. True or False: MIT estimated that greenhouse gas emissions due to operational energy of a large commercial building was responsible for 95-96% of life cycle emissions.

10. According to research conducted at MIT, energy savings of an ICF house in a cold climate can save ______ of total operating energy.
    - a. 95–96%
    - b. 23%
    - c. 5%
    - d. 13%

SPONSOR INFORMATION

BUILD WITH STRENGTH

Build with Strength, a coalition of the National Ready Mixed Concrete Association, educates the building and design communities and policymakers on the benefits of ready mixed concrete, and encourages its use as the building material of choice. No other material can replicate concrete's advantages in terms of strength, durability, safety and ease of use.

Those who claim nothing lasts forever... have never built with concrete.

Only one material has strength, durability and value that gets better as it gets older.

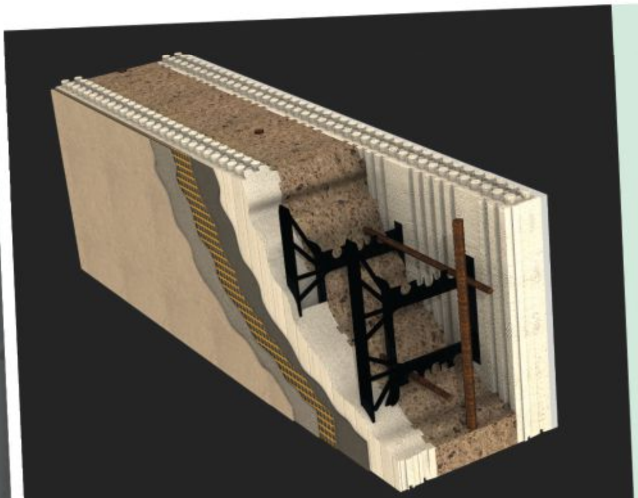
A 60-year lifecycle study showcases the advantages of concrete over softwood lumber.

Environmentally responsible. Over the building's life cycle, concrete reduced greenhouse gas emissions by 3-5% over softwood lumber.

Lasting value. The energy efficiency, reduced maintenance and resiliency contributed to overall value and life cycle savings.

Air tightness and quality. In colder climates, thicker wall insulation and right air filtration levels can save up to 23% on total operating energy costs.

Energy efficiency. Concrete's thermal mass properties saved 5% to 8% annually on energy bills.



The materials you choose matter.

If you're looking for one of the most durable and innovative concrete products out there, look no further than Insulated Concrete Forms (ICFs). They're strong, fire-safe, virtually sound proof and easy to build. In fact, ICF walls are 10X more durable than cross-laminated timbers (CLT).

SELECTING PLUMBING FIXTURES FOR COMMERCIAL RESTROOMS IN HEALTHCARE FACILITIES

Presented by:

SLOAN. Water Connects Us

This healthcare bathroom includes a wall-mounted water closet and flushometer and a lavatory with a sensor-activated faucet. Note the grab bars and clearances around the fixtures.

LEARNING OBJECTIVES

At the end of this program, participants will be able to:

1. Understand infectious disease control and implications of Healthcare-Associated Infections (HAIs).
2. Explain the importance of washing hands, and describe the pros and cons of various approaches, including hand dryers vs. paper towels and sensor-activated (hands-free) vs. manual products.
3. List implications of unique plumbing products designed for healthcare facilities, including bed pan washers, toilets with bed pan lugs, surgeon stainless steel sinks, clinic service sinks and bariatric water closets.
4. Describe how compliance with ADA regulations affects commercial restroom product selection.

CONTINUING EDUCATION

CREDIT: 1 LU/HSW
COURSE NUMBER: AR102017-2
IDCEC CREDIT: 1 CEU
IDCEC #: CEU-106656
ASPE CREDIT: 0.10 CEU
ASPE #: 753

Use the learning objectives above to focus your study as you read this article. To earn credit and obtain a certificate of completion, visit http://go.hw.net/AR102017-2 and complete the quiz for free as you read this article. If you are new to Hanley Wood University, create a free learner account; returning users log in as usual.

INTRODUCTION

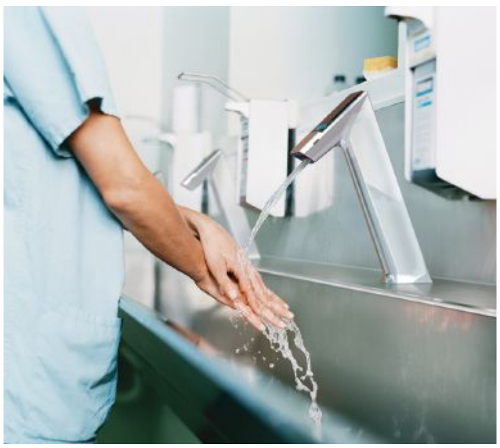
Hospitals and healthcare facilities cater to vulnerable populations. Not only are patients often more susceptible to disease-causing organisms than healthy people, healthcare facilities provide treatment for a higher proportion of people with physical challenges. This unique set of circumstances requires these facilities to focus on reducing the risk of acquiring and spreading pathogens, as well as accommodating patients who are physically challenged.

The transmission of infectious disease is a serious problem in hospitals and other health care settings. Proper hand washing is the single most effective means of preventing the spread of pathogens; however, people do not always practice proper technique. Through strategies such as antimicrobial coatings and hands-free operation, plumbing fixtures can help prevent the spread of these disease-causing pathogens. This article will provide an overview of the technologies and products specific to healthcare settings; it also will include a discussion of ADA requirements and a review of products that may enhance the safety and comfort of hospital occupants.

WHAT ARE HAIS?

Healthcare-Associated Infections, or HAIs, are infections patients contract while they are receiving care in a healthcare facility, whether a hospital, surgical center or long-term care facility. These infections are caused by any number of microorganisms, which include bacteria, fungi, viruses and other pathogens. According to the United States Centers for Disease Control and Prevention (CDC), at any given time, about one in 25 patients has at least one healthcare-related infection. A 2007 CDC report estimated that approximately 1.7 million HAIs occur in United States hospitals each year, resulting in 99,000 deaths and an estimated $20 billion in healthcare costs.

Some of the most common HAIs include pneumonia, surgical site infections, catheter-associated urinary tract infections (CAUTIs) and methicillin-resistant *Staphylococcus aureus* infections (MRSA). It is often difficult to treat HAIs with antibiotics, in part because some of these disease organisms have developed resistance to antibiotics.



Patients and healthcare workers can unwittingly spread infection-causing disease organisms by touching contaminated fixtures and surfaces and/or by not practicing good hygiene.

Paths to Infection

Water, used extensively in healthcare environments, is often a carrier for organisms that can cause HAIs. There is an established association between *Pseudonomas auruginosa* and water, for example. This bacteria can cause infections leading to inflammation and sepsis, and it can be fatal if the organisms colonize in critical organs. *Pseudonomas* and other waterborne organisms can infect people in several ways: through direct contact, through ingestion of water or ice, through inhalation of aerosols that are dispersed from water sources and/or through the aspiration of contaminated water. These microorganisms can also contaminate faucets, aerators and showers.

Patients and healthcare workers can unwittingly spread infection-causing disease organisms by touching contaminated fixtures and surfaces and/or by not practicing good hygiene. *Clostridium difficile*, which, according to the CDC, caused almost half a million infections in the United States in 2011, is often spread in these ways. The bacterium can cause mild to severe diarrhea in some cases and life-threatening colitis, or inflammation of the colon, in others, especially for those with compromised immune systems or who have taken multiple courses of antibiotics.

Legionnaires' Disease

Though less common, infections caused by *Legionella* bacteria are a serious concern in healthcare environments. The bacteria is associated with Legionnaires' disease, a lung infection (pneumonia) that people can acquire by breathing in small droplets of water containing *Legionella* bacteria, and a less serious form called Pontiac fever.

Most healthy people will not contract Legionnaires' disease if exposed to *Legionella* bacteria, but people with weakened immune systems are at risk. Groups that are especially vulnerable include the elderly and those undergoing organ transplantation or suffering from late-stage kidney disease. People with HIV, diabetes and chronic lung disease are also at risk. Children rarely get the disease.

About 6,000 cases of Legionnaires' disease were reported in the United States in 2015; however, the CDC believes that the disease is likely under-diagnosed, so the actual number of cases could be much higher.

A recent analysis conducted by the CDC found that among the 21 United States jurisdictions studied, 76 percent reported healthcare-associated cases of Legionnaires' disease. This is reason for alarm because the disease is often more serious when acquired from healthcare facilities. Twenty-five percent of the people who contract the disease from a healthcare facility will die—a mortality rate that is much higher than in the normal population.

Implications of HAIs

Obviously, the most urgent reason for infectious disease control is to prevent and reduce the incidence of illness and death in healthcare patients. However, HAIs also have huge financial implications.

A 2013 meta-analysis study conducted by Harvard researchers and using data from the CDC database found that the five most common HAIs cost United States hospitals $9.8 billion, with surgical site infections contributing the most to overall costs. According to the study, treatment of a single central line-associated bloodstream infection averaged $45,814 per case.

In addition, starting in 2015, hospitals that perform poorly on "preventable conditions," which include HAIs, can be penalized as per the Hospital Acquired Condition Reduction Program, which was passed as part of the Affordable Care Act. In 2015, hospitals that performed in the lowest 25th percentile received a 1 percent reduction in their Medicare reimbursements; in 2016, hospitals that didn't meet a performance threshold saw a reduction in their payments.

TACKLING *LEGIONELLA* INFECTIONS

Legionella growth occurs in building water systems that are not managed adequately and where disinfectant levels are low, water is stagnant, or water temperatures are ideal for growth of bacteria. Healthcare facilities are expected to develop and adhere to policies and procedures to reduce the risk of *Legionella* and other waterborne pathogens. Last year, the CDC released a toolkit for building owners and managers called *Developing a Water Management Program to Reduce Legionella Growth & Spread in Buildings: A Practical Guide to Implementing Industry Standards*. Based on ASHRAE Standard 188, a document for building engineers, the toolkit provides a checklist to help identify when a water management program is needed. It also includes examples to help identify where *Legionella* could grow and spread in a building and list ways to reduce the risk of *Legionella* contamination. The toolkit also includes examples relevant for healthcare facilities.

The knee-activated soap dispensers and sensor-activated faucets on these surgical scrub sinks enable hands-free operation.

THE IMPORTANCE OF HAND WASHING

Facility owners and managers must ensure best practices are carried out in the healthcare environment. But as a specifier, you play an important role in preventing these diseases as well.

Hand washing is the single most effective means of preventing the spread of germs; however, people do not always practice proper technique. According to the CDC, healthcare providers clean their hands half as often as they should. Plumbing fixtures, through strategies such as antimicrobial coatings and hands-free operation, can help prevent the spread of these disease-causing germs.

In restrooms with manual faucets, handles serve as a breeding ground for germs. Touching faucet handles after washing simply re-contaminates hands and may negate the benefits of washing them. While some experts recommend that restroom visitors use a paper towel to turn faucets off, in practice, users are either unaware of this advice or choose not to follow it. In some cases, restrooms are not stocked with paper towels and instead provide hot air dryers.

Electronic or Touch-Free Faucets

Electronic faucets use sensors to activate and shut off the flow of water. The most obvious benefit of these touch-free faucets is improved sanitation. The absence of handles removes a contact point for spreading dirt or harmful bacteria from one user to the next. Hands-free operation also allows the faucets to be used by anyone, regardless of age or physical ability. Another plus is water conservation, as sensor-activated faucets can save water by running only when the user is actively wetting or rinsing hands.

Most electronic faucets rely on an infrared sensor. Once the user enters the sensor's effective range, the solenoid activates the water flow. Tempered water flows from the faucet until hands are moved away; the loss of reflected light initiates an electrical signal that deactivates the solenoid valve, shutting off the water flow. The circuit then automatically resets and is ready for the next user.

Touchless faucets are often designed to operate for a pre-set amount of time when a user's hands are in the active area. This type of faucet uses approximately 3.8 L (1 gal) less water per activation than a manual faucet.

An infrared sensor on this faucet enables hands-free operation, and the high gooseneck spout also makes it easier for staff and patients to wash forearms as well as hands.

FAUCET AND SINK DESIGN

In addition to how faucets are operated, there are a number of other design considerations particular to the healthcare environment. Hospitals require several types of sinks for specialized applications, but the design goals are similar.

Basin Design. To minimize splashing, the sink basin should be deep enough so that water doesn't splash over the sides, and the faucet should be oriented so that water falls on the "sweet spot"—the gently sloping portion of the sink, which encourages water to flow toward the drain. If instead water hits the drain directly, it can cause the splashing of potentially contaminated water. Moving the faucet so that it is not centered over the drain is also an option, as is an offset drain

Materials. To meet the goals for both durability and sanitation, the best materials for most healthcare sinks include high-quality vitreous china, stainless steel and solid surface.

Mounting. Faucets are usually mounted on either a countertop "deck" or in a wall above a basin. The application will usually determine whether the faucet is wall or deck mounted. Wall mounted faucets often are preferred when ample room is required for activity below the spout. Gooseneck style spouts tend to be specified in healthcare environments, as the design allows the user to wash not only hands but forearms.

Spray Heads. By definition, an aerator spray head adds air to the stream of water flowing from a faucet. As water flows through a mesh screen, it is divided into many small streams with air in between. This creates a feeling of high pressure with less actual water consumption. However, air may contain bacteria, which, when mixed with water, can potentially contaminate drinking water. For this reason, "laminar flow" spray heads are recommended in healthcare facilities. These spray heads provide a single, non-aerated, non-splashing stream. In cases where the flow rate is too low to produce an aerated or laminar stream, a "multi-laminar" spray head can be used to produce a miniature shower pattern to provide full, non-splashing coverage of the hands during washing. Multi-laminar spray heads are recommended for use in public restrooms. If possible, choose faucets that position all components above the sink deck, which makes for faster and easier servicing.

Flow Rates. Plumbing regulations and codes throughout the United States limit the flow rates of commercial faucets to 0.5 gallons per minute, though higher flow rates are permitted for specific applications such as surgical scrub stations and in private hospital rooms. Faucets in buildings striving to meet LEED v4 or CalGreen standards have even lower allowable flow rates.

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PREVENTING LEGIONELLA

Stagnant water, resulting from low or limited use, can create ideal conditions for bacterial growth, including Legionella. Ironically, many facilities have implemented water-conserving measures, which may incur stagnation and exacerbate problems with Legionella and other waterborne pathogens. Some manufactures have addressed this problem by adding a feature to electronic faucets that regularly purges faucets, ensuring against the stagnant conditions that encourage the growth of microorganisms. These fixtures automatically activate the fixture and flush the plumbing lines if the fixture has not been used within a specified time.

Another strategy for controlling Legionella is "thermal disinfection," which involves running hot water through plumbing lines. However, faucets equipped with tempering valves that prevent scalding by setting a maximum temperature will not benefit from thermal disinfection. To circumvent this issue, some manufacturers offer faucets with built-in bypass valves that allow them to take advantage of the thermal disinfection event.

At least one company now offers a hydrophobic glaze for its vitreous china water closets, urinals and lavatories that repels liquids and oils and inhibits the growth of germs and bacteria.

Antimicrobial Coatings

Another strategy is to treat the fixture itself with an antimicrobial coating that protects the handle by making it harder for microbes to grow on the surface. Both solid and soft surfaces impregnated by antimicrobial agents are increasingly available as a tool for reducing infections in healthcare settings. The most common antimicrobials used in solid surfaces such as plumbing fixtures include copper or silver nano-particles and organosilanes, which are silicon-based compounds that include at least one carbon-silicon bond.

This article continues on http://go.hw.net/AR102017-2. Go online to read the rest of the article and complete the corresponding quiz for credit.

QUIZ

1. When are Healthcare-Associated Infections (HAIs) contracted?
   a. In a home not properly set up for treatment of diseases
   b. Before entering a hospital for treatment
   c. While receiving care in a healthcare facility
   d. In public spaces

2. What is an effective strategy for reducing bacterial growth potentially caused by stagnant water in plumbing lines?
   a. Washing hands
   b. Regularly purging lines
   c. Filtering the water
   d. Biocides

3. Who is most at risk for Legionnaire's disease?
   a. Healthy people
   b. People with weakened immune systems
   c. Children
   d. Those exposed to Legion syndrome

4. What is the main benefit of touch-free faucets?
   a. Ease of use for users
   b. Timed shut off
   c. Improved sanitation
   d. Enhanced spray functions

5. What is a characteristic of a laminar flow spray head?
   a. Highly aerated stream
   b. Reduced noise
   c. Increased flow rates
   d. Non-aerated, non-splashing stream

6. What is involved in the process of thermal disinfection?
   a. Running hot water through the plumbing lines
   b. Intermittently running hot and cold water at various intervals
   c. Heating the pipes from the outside killing bacteria in the water
   d. Using a thermal coupler attached to the aerator to disinfect

7. True or false: Antimicrobial surfaces can be a substitute for cleaning and disinfection protocols.
   a. True
   b. False

8. What is an ADA requirement for showers in healthcare facilities?
   a. High flow showerheads
   b. No temperature limits (scald guards)
   c. Handheld and stationary showerheads
   d. Built only to 48" wide

9. What does using a sensor or touch-free flushometer eliminate?
   a. The thin microbial coating on seats
   b. The need for user contact
   c. The need for floor mounted toilets
   d. Assistance from health care staff sitting and standing

10. How many pounds of pressure (maximum) should the user have to exert to turn a faucet lever?
   a. 1 lb
   b. 5 lbs
   c. 10 lbs
   d. 20 lbs

SPONSOR INFORMATION

SLOAN.
Water Connects Us

Sloan is the world's leading manufacturer of commercial plumbing systems. Sloan has been at the forefront of the green building movement since 1906 and provides sustainable restroom solutions by manufacturing water-efficient products such as flushometers, electronic faucets, and soap dispensing systems, sink systems and vitreous china fixtures for commercial, industrial and institutional markets worldwide.

REDEFINING HIGH-PERFORMANCE METALESCENT COATING SYSTEMS FOR ARCHITECTURAL METAL

Presented by:

valspar

LEARNING OBJECTIVES

Upon completion of this course the student will be able to:

1. Define the basic terminology used when discussing metalescent coatings for metal architecture.
2. Describe pigment types used to create metalescent looks, and their advantages and disadvantages.
3. List common myths and misconceptions of mica- and aluminum-based coating systems.
4. Discuss three case studies that illustrate aesthetic options for metalescent coating systems.

CONTINUING EDUCATION

AIA CREDIT: 1 LU
AIA COURSE NUMBER: AR102017-4

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INTRODUCTION TO ARCHITECTURAL METAL COATINGS

Color is one of the most important design elements in architecture. It conveys emotion and defines cultures; it inspires us and provokes reaction. Historically the use of vibrant and unique colors has been limited in the metal coatings world, but as manufacturers seek to meet customer warranties with new technologies and expanding architectural creativity, they are now experiencing a wider range of aesthetic requests from architects. Many of these requests are for exterior metallic and pearlescent coatings, which can include aluminum, mica or other pigments. In this article, we refer to metallic and mica coatings as "metalescents" and will later define the benefits and disadvantages of each.

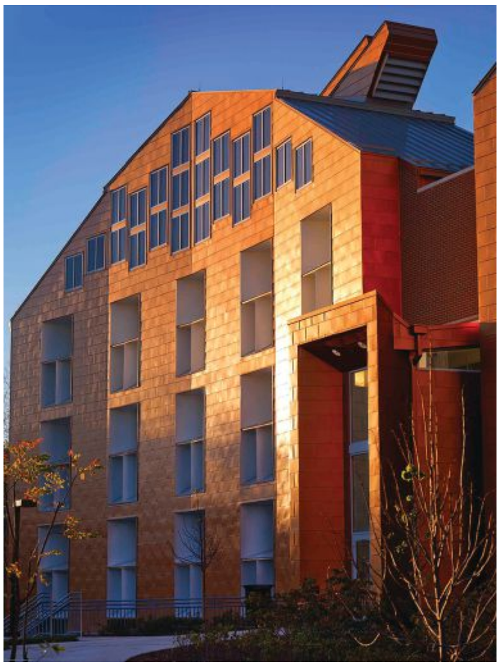
The world of architectural coatings is always evolving. Large coatings manufacturers invest tens of millions of dollars in research and development every year to innovate coating formulations, enhance performance and reduce environmental impact. Metal architectural coatings have advanced tremendously, and can now be specified on projects in more creative ways than ever before.

METAL COATINGS TERMINOLOGY

Before we discuss some of the myths and misconceptions about metallic and mica coatings, it helps to understand the terminology. For factory-applied liquid metal coatings, two methods are used: coil coating and spray applied.

Coils are metal rolls of aluminum or steel typically 24" to 60" wide and large enough to weigh up to 7 tons. Coatings are applied to the metal at up to 700 feet per minute through a continuous, automated process. The metal is unwound, cleaned, treated, primed, color coated and baked before being recoiled for shipment. It is then cut into sheets, formed by a manufacturer and installed on a building. Common prepainted coil building products include roof and wall panels.

Spray-applied liquid coatings are applied to preformed aluminum extrusions or panels on a vertical or horizontal coating line. The process consists of cleaning and pretreating the aluminum extrusions, priming and color coating, and then thermally curing the coating to set the system.



Coil coatings are applied in a continuous process to large sheets of steel or aluminum and then formed into metal building products like the metal wall panels shown.

Four Principal Ingredients in Coatings

There are four principal ingredients in every high-performance coating:

1. Resins
2. Pigments
3. Solvents
4. Additives

The percentage of each element can change, depending on the coating's final application and color.

Resins

Resins bind together all the components of a paint formulation, serving as the source for durability and performance. Resins are the workhorse of the coating system. They increase the physical strength and chemical resistance of the coating. Resin types vary by quality and price. Here is the good/better/best breakdown of resin types used in coatings for metal building products:

Good: Polyester—Polyester coatings are ideal for limited sun exposure or interior applications using a generic polymer system with limited weathering performance; they can achieve a wide variety of colors because of organic pigments used.

Better: Silicon-Modified Polyester (SMP)—SMP coatings are used for coil coatings only and feature a two-coat finish recognized for its durability, offering stronger protection and endurance during extreme conditions. They provide superior weatherability; good resistance to scratching, chalking and fading; exceptional color and gloss retention; outstanding color consistency; and extreme resistance to abrasion, chipping and marring. Note that SMP coatings are not available in metalescent formulations.

50% PVDF coatings are used for aluminum extrusion only and offer enhanced protection against weathering.

Best: 70% PVDF—70% PVDF systems are the superior-performing coatings in the industry, offering best-in-class color and gloss retention. The carbon/fluorine bond is one of the strongest chemical bonds known. 70% PVDF coatings are ideal for high-performance exterior-facing building products because they have outstanding resistance to humidity, color change, chalk, fade and chemical degradation to ensure a long-lasting, durable finish.

FEVE: These fluoropolymer coatings offer the same excellent weathering as 70% PVDF and offer an increased range of vibrant colors through higher gloss levels.

Metalescent pigments are composed of tiny metal flakes of aluminum, natural mica or synthetic mica-like material. They can produce coatings that shine and sparkle as a result of the size and shape of the metalescent flakes.

Pigments

Pigments provide the coating with color, while hiding the primer and substrate. Color is almost always the most important design element of an architectural coating. Not only does pigment give a design beautiful aesthetic properties, but it also influences the coating's durability. For both aesthetic and performance criteria, it is essential to choose the right pigments. The three main types of decorative pigments used to create color for architectural metal coatings are organic, inorganic and metalescent. Solid color coatings are made using organic and inorganic pigments, while metallic effect coatings combine these traditional pigments with mica and aluminum flakes to achieve a beautiful shimmering appearance.

Solid Colors

Organic pigments can achieve bright, bold colors, but their carbon-based chemical structures degrade more quickly than inorganic pigments. These pigments are more easily affected by sunlight, moisture and temperature changes. Many bright colors can still be achieved in high-performance coatings, but these colors will often require a clear coat or will carry a limited warranty due to the pigments used.

Inorganic, or ceramic, pigments are made of metal oxides and mixed metal oxides that have higher resistance to fading and excellent weatherability. The coloration imparted by these pigments tends toward the earth tones of gray, brown, and muted reds and yellows.

Metalescent Colors

Metalescent pigments are composed of tiny metal flakes of aluminum, natural mica or synthetic mica-like material. The size, shape and concentration of these metal or mica flakes can influence the shine and sparkle of a coating. Some coatings with metalescent pigments also change color depending on the viewing angle and light conditions.

Metalescent pigments made of aluminum were once considered state of the art, but have largely been replaced by mica and other effect pigments in high-performance metal coatings. While aluminum pigments remain in metalescent coating formulations today, coatings manufacturers are now combining aluminum with mica and other effect pigments to offer better performing and more consistent products. Metallic coatings that are made primarily with aluminum pigments are subject to "flop of the flake" effect, which means that when electromagnetically spray-applied, the statically charged aluminum flakes in the coating can follow the direction of the spray equipment, creating an inconsistent appearance. They also require a protective clear coat to keep the aluminum flakes from oxidizing and changing color.

Mica flakes are inert, which means they do not oxidize or react to environmental exposure. Mica-based coatings require only two coats, with a clear coat optional. Some architects still prefer using a clear coat because of the added film thickness, but it is not required to achieve the same level of performance. Because the added clear coat is not a necessary step on the coating line, mica-based coatings typically have lower applied costs than an aluminum-based formulation. Mica-based coatings are also not as prone to "flop of the flake" effect, which we will discuss further in a bit.

Key Differences Between Mica and Metallic Paint Systems

Mica-Based Pigmentation	Aluminum-Based Pigmentation
Typically a 2-coat system (no clear coat required)	Typically a 3-coat system (clear coat required)
Excellent overall color consistency	Prone to "flop of the flake" effect
Wider range of colors and special effects	Standard metallic colors
Lower-Applied Cost	Higher-Applied Cost due to clear coat
Inert	Reacts with elements

Solvents

Solvents are the liquid part of the coatings' composition that volatilize during curing, leaving behind the resin, pigment and additives.Solvents maintain a liquid state until cured and allow the manufacturer to properly control application.

Additives

Added to the formulation in very small quantities specific to the application, additives are used to enhance specific properties of the coating, including flow, smoothness, hardness, gloss, mar resistance and other performance attributes.

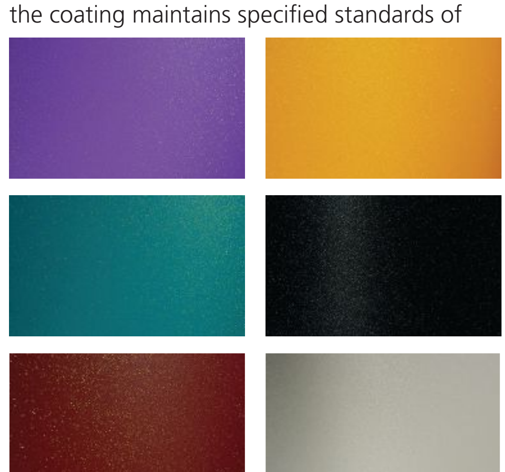
COATING PERFORMANCE AND WEATHER TESTING

Exposure to sun (UV light), moisture, humidity, high temperatures and temperature fluctuations can change the physical factors of a protective metal coating, causing color fade, chalking, blistering and corrosion. High-performance coating systems for metal building products are formulated to resist these types of degradation and can maintain color and gloss integrity for 20+ years. Manufacturers perform both accelerated and natural exposure weather testing to minimize degradation.

Weather testing includes both long-term, natural exterior weather exposure and laboratory-accelerated weathering. Exterior weather exposure involves placing sample panels on inclined open racks orientated at the sun, usually at a 45-degree angle in a southerly direction. This angle ensures full UV exposure.

One global coating company maintains a 6.25-acre test facility in Fort Myers, Florida. This location has some of the harshest conditions in North America with high UV, humidity and salt spray. Here, 100,000 panels are being tested in various stages of exposure and certain products have endured more than 40 years of exposure time. For an accelerated testing process, special environmental cabinets and instruments are used to speed up the weathering process and measure its effects under extreme conditions. All high-performance coating formulations are tested using both natural weathering and accelerated testing to meet industry requirements. Through both natural and accelerated testing, mica-based coatings have proven performance equal or better to their three-coat aluminum-based counterparts.

All of these test methods are critical in the AAMA 2605 specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels. Liquid finishes that meet AAMA 2605-17 are considered the gold standard and are ideally suited for long-life external use on monumental high-rise structures. AAMA's rigorous 2605-17 testing standards include more than 2,000 hours of prohesion (cyclic corrosion) exposure, 4,000 hours of humidity resistance, and a variety of physical property and chemical resistance testing. AAMA standards also require that the coating maintains specified standards of



film integrity, color retention, chalk resistance and gloss retention after enduring outdoor weathering exposure in South Florida for a period of 10 years.

While metalescent coatings were traditionally silver, gold, bronze and champagne, the new pigments allow orange, red and other bright colors with performance equal to traditional coatings. Coatings manufacturers are able to match custom colors with a sparkle effect, and can control the amount of sparkle desired by manipulating the flake size, gloss and other factors.

HOW WE GOT HERE: THE HISTORY OF METAL COATINGS

Despite the sparkling finish and its aesthetic appeal over solid color, many architects and builders hold some misconceptions about metalescent coating solutions. To fully understand the significance of modern metal coating technologies, and to understand why certain outdated beliefs or myths persist, it helps to know how we got where we are today.

In a nutshell, metalescent coatings contain flakes of material with reflective qualities. In the early days these materials were primarily aluminum. These aluminum flakes reflect light at myriad angles, creating the desired shimmering effect.

In the 1960s, a three-coat metallic high-performance coating system was introduced into the design and build industry. It consisted of a primer, a metallic color base coat and a clear coat. The metallic base coat's pigmentation was made of both aluminum flake and color pigments. A pitfall of this early development was that the aluminum oxidizes, causing color change and deterioration of the coating surface if used without a protective clear coat.

As could be expected, the extra topcoat required for this type of finish added to the cost, which is still true today. Most coaters used an application process that could handle only two coats, the primer and color coat. When the facility had to coat a three-coat product, the coiled metal or aluminum extrusion needed to be run through the line a second time to put the clear coat on. Some modern coating lines can now add the clear coat without an extra run through the line, but the cost of the additional clear coat can still add up, especially for large projects that require thousands of

Color-shifting pigmentation was introduced in the 1990s and early 2000s, creating a new color space for architects. Color-shifting coatings can be either subtle or dramatic depending on the architect's desired aesthetic.

square feet to be coated.

Today, paint chemists have increased the sophistication of metalescent coating formulations, relying less on aluminum for its gorgeous effects. Some manufacturers' formulations take the sophistication one step further, blending flake pigmentations that make clear coats optional. These formulations include mica, a unique mineral with properties that make it perfect for use in paint. Mica is a group of minerals found all over the world that have a layered texture. Mica-based coatings have a pearlescent finish that can add shine and shimmer, and even change colors.

In the late 1980s, a leading coatings company introduced a two-coat metalescent coating that eliminated the need for a protective clear coat. This new solution offered the same aesthetic as the earlier technology at a lower applied cost, with even greater performance and weathering characteristics. There are test panels of two-coat mica-based systems that show no visible change in color or gloss after 20 years of natural exposure in a high UV environment. Since this innovation, mica-based high-performance coatings have become more requested by architects and specifiers, and have grown as a percentage of the overall architectural coatings industry.

For these metalescent coatings, the color and amount of shimmer produced depends on the mica particles used. When light hits the mica particles, it is partially reflected out and partially absorbed in. As the light travels into the particles and the various layers of oxide surrounding them, a sense of visual depth is created which, adds dimension and sparkle to the metal building product.

The next innovation occurred in the 1990s and early 2000s when color-shifting pigmentation was introduced, creating a new color space for architects. These pigments first showed up in the automotive industry, followed by the building industry. Color-shifting coatings can be either subtle or dramatic depending on the architect's desired aesthetic.

Pigment manufacturers have invested heavily in research and development within the past five years. With advanced pigment technologies came new and brighter colors that are able to meet AAMA 2605 performance requirements. The new color spaces provide different looks, creating intense and brilliant sparkle, and the color range that's available has expanded significantly. While metalescent coatings were traditionally silver, gold, bronze and champagne, the new pigments allow orange, red and other bright colors with performance equal to traditional coatings. Coatings manufacturers are able to match custom colors with this sparkle effect, and can even control the amount of sparkle desired by manipulating the flake size, gloss and other factors.

QUIZ

1. ________are applied to preformed aluminum extrusions or panels on a vertical or horizontal coating line.
   a. Coil coatings　　b. Spray-applied liquid coatings

2. Which principle coating ingredient allows the manufacturer to properly control application?
   a. Resin　　b. Primer
   c. Solvent　　d. Additive

3. What is the current state-of-the-art coating that meets the AAMA 2605 Standard?
   a. Polyester　　b. Silicon-modified polyester
   c. 50% PVDF　　d. 70% PVDF

4. Which type of pigment is composed of tiny metal flakes of aluminum, natural mica or synthetic mica-like material?
   a. Organic　　b. Inorganic
   c. Metalescent

5. Which of the following is a benefit of mica over metallic paint systems?
   a. Improved overall color consistency　　b. One- or two-coat system
   c. Clear coat optional　　d. Less expensive due to fewer coats
   e. Inert　　f. All of the above

6. True or False: High-performance coating systems for metal building products are formulated to resist degradation to maintain color and gloss integrity for 20+ years.

7. True or False: A clear coat is required to keep mica flakes suspended in the coating from oxidizing, staining and reacting to UV light.

8. True or False: Mica is stable when exposed to electricity, light, moisture and extreme temperatures.

9. When ________ coatings are electrostatically applied, they can fall prey to the "flop of the flake" effect in spray application, which can make the color appear different from panel to panel.
   a. Aluminum-based　　b. Mica-based

10. In which case study did architects choose a FEVE coating in prismatic blue, which added to the dimensionality of the intricate exterior and provided an illuminating shine?
    a. Ryerson University Student Learning Centre　　b. Judson University
    c. Polk Penguin Conservation Center

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This article continues on http://go.hw.net/AR102017-4. Go online to read the rest of the article and complete the corresponding quiz for credit.


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AIA Architect

The Paradox of Water

Last year, the U.S. Office of the Director of National Intelligence ranked water scarcity on a par with terrorism as a national security threat. The U.S. Environmental Protection Agency estimates that it would cost more than $380 billion to repair America's aging and inadequate water infrastructure over the next 20 years. Yet analysts say that even an effort of that magnitude might not be enough to address the profound and imminent "water stress" that plagues many cities and towns.

In recent years, water security in Africa, the Middle East, and Latin America has contributed to violent conflicts in Cameroon, Chad, Darfur, and Sudan; shortages and political upheaval in Bolivia, Ecuador, and Peru; and civil war in Syria. And, as the saying goes, oil and water do not mix—some of the world's most oil-rich nations are also some of the world's most water-stressed, including Bahrain, Iran, Israel, Kuwait, Lebanon, Oman, Qatar, and the United Arab Emirates.

On the other hand, the world's coastal regions suffer from a surfeit of seawater. As polar ice and glacial reserves have melted at an alarming rate over the last decade, sea levels have risen at an equally alarming rate—eroding coastlines, compounding the deleterious effects of hurricanes and typhoons, and threatening ill-prepared cities and towns. These regions are poised not only for near-destruction, but for a population shift on an unimaginable scale. From Miami to Mumbai to Mauritius, sea level rise will change the landscape and our habitation of cities.

In light of all of this, it shouldn't surprise anyone that when *Time* magazine published an infrastructure round robin on March 30, architects were billed as "visionary thinkers" at the center of the debate—along with their colleagues in engineering, landscape architecture, planning, and sustainability. Seizing the moment to act is not the domain of one leader, one government agency, one NGO, or even one nation. It must be a collective effort guided by vigorous debate about the dire paradox that water presents to our time and our stewardship of this planet for future generations. As millions of Americans recover from last month's devastating hurricanes, here are some water-related lines of inquiry by experts in key disciplines.

—William Richards

AIAFeature

What is the Worth of Water?

“Water, when simple, is insipid, inodorous, colorless, and smooth,” said Edmund Burke, and to that list we should add “vexing.” Sea level rise is inevitable and supplies of freshwater will inevitably dwindle for a global population expected to top 8.4 billion by 2035. But we can plan for these changes. Five experts weigh in on what change looks like, and how to get there.

As told to Steve Cimino

John Englander

John Englander is an oceanographer and expert on sea level rise who takes pride in his ability to explain the watery issues plaguing our planet without jargon or bias. His weekly *Sea Level Rise Now* newsletter on his website (johnenglander.net) is an invaluable resource for anyone seeking to educate themselves on the societal and financial impacts ahead. When it comes to designing for a rising sea, he recognizes that it can pose a real challenge for architects, but that they inevitably must be the leaders.

One element of sea level rise that affects architects locally is land subsiding—going down—or uplifting—going up. And it’s a very big variation from place to place. In the last century, sea level has risen about 9 inches as a global average. But in New Orleans, it looks like 46 inches; in Virginia Beach, it looks like 30 inches; in New York, 14, and in Los Angeles, 4. The difference between those numbers, over the same period of time, is because the land has moved up or down to a certain degree. So if the global sea level rises 8 to 10 inches, but land is also rising or sinking for various reasons that can have a huge effect on the amount of rise that projects need to anticipate. Sea level rise adds to other flooding risks but it is different in that it is relatively slow, global in scope, and will not recede for centuries.

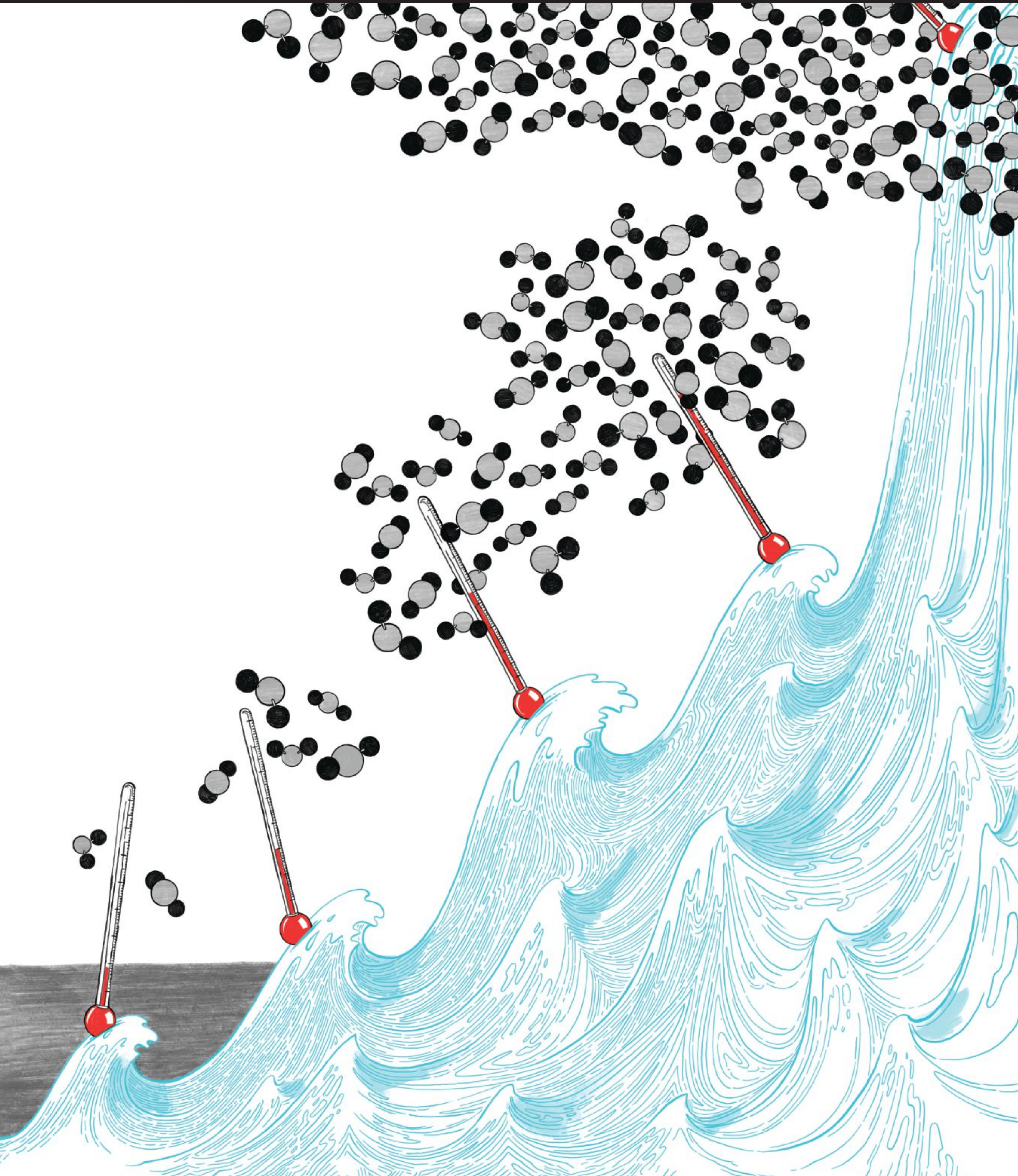
Architects, like most people, want to believe that we can fix the problem of sea level rise. They’re deeply into designing energy-efficient buildings to slow global warming—and that’s great. We need that. You just shouldn’t think that it will stop the seas from rising. I try to leave every audience I speak to with two simple messages: We should try to slow the warming as much as possible and we must start planning for sea level rise, to the degree that it’s unstoppable. We need to do both things at once.

The biggest issue we’re facing is that Greenland and Antarctica hold 98 percent of the ice in the world. While there are glaciers all over the world—Alaska, the Alps, Peru—the vast majority are in those two places. They hold enough ice to raise sea level hundreds of feet. But how fast will they melt, and how much rise will there be? That partly depends on how warm we let the planet get—if we burn all the coal or if we switch to renewable energy. The latest estimates are that this century we’ll get between 2 and 8 feet. That’s a huge range, and therein lies the problem in terms of design.

The rate of rise won’t be a straight line; it’ll be an exponential growth curve, so the recent past is misleading for the future. For the next 30 years, we may see a foot to 18 inches. Even though most buildings may be designed or mortgaged for 30 years, we know that more and more buildings survive 100 years. This is where architects need to talk to clients—whether it be a city, a commercial firm, a hotel, or just a homeowner—to help them think through different time frames. They need to start considering what things are going to be like in five to 10 years, then 20 to 30 years, and then beyond that.

You can design for this on your own, to a certain degree, but you really have to get the public aware of the issues so there’s buy-in on the other end. Architects are going to respond to what the client wants, so it’s necessary to frame messages in regard to their needs and provide tools that help them see over the horizon.

ILLUSTRATION: LAUREN NASSEF



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William Morrish

William Morrish is a professor of urban ecologies at the New School–Parsons School of Design in New York City, as well as a recognized expert on physical and social infrastructure, urban planning, and design. He has devoted his life to asking the big questions about water issues, recognizing that architects and designers need to take an “up river view” design perspective to identify the threads of the larger embedded urban context.

I’ve traveled on the waters of the Mississippi River, from Pilottown, La., to Lake Itasca, Minn.; I’ve charted the water flows of the California Aqueducts into Los Angeles; and I’ve walked the soggy ground after Hurricane Katrina water-deluged New Orleans. Through these travels, it has become clear to me that water exists at the intersection of landscape and infrastructure, “crossing between visible and the invisible,” as noted by geographer Matthew Gandy in his recent book *The Fabric of Space*.

Another way to describe this intersection is to state that water is a ubiquitous element. It is an intermediary agent flowing between every human and non-human act of inhabiting a particular urban landscape. Simultaneously, its turbulent currents and backflow loops unsettle the best-laid plans of our federal government all the way down to municipal maintenance, which constitutes our political-urban landscapes.

When water poisons the people of Flint or drought impacts the health of Californians, it is because we haven’t been looking at water as an everyday part of our basic systems of life. We have only been looking at it when catastrophe strikes. If we should have learned anything by now, it’s that we cannot simply manage water. We need to realize, instead, that it’s a multidimensional cultural, ecological, and political element of all of our lives.

One of the reasons for the shift between the two diagrams (at right) is that as a society, we don’t invest in everyday systems or design them with the capacity to be resilient. You can’t be resilient until you’re reflexive—which is to say actively reinvesting into society so that people in multilayered economic classes have the capacity to thrive. In many ways, water is at the intersection of ecology and economy, but it’s also a social element. How is water exchanged? How it is used? Those are multilayered ecological and economic questions, but they are also culture questions, understood by different societies in different ways.

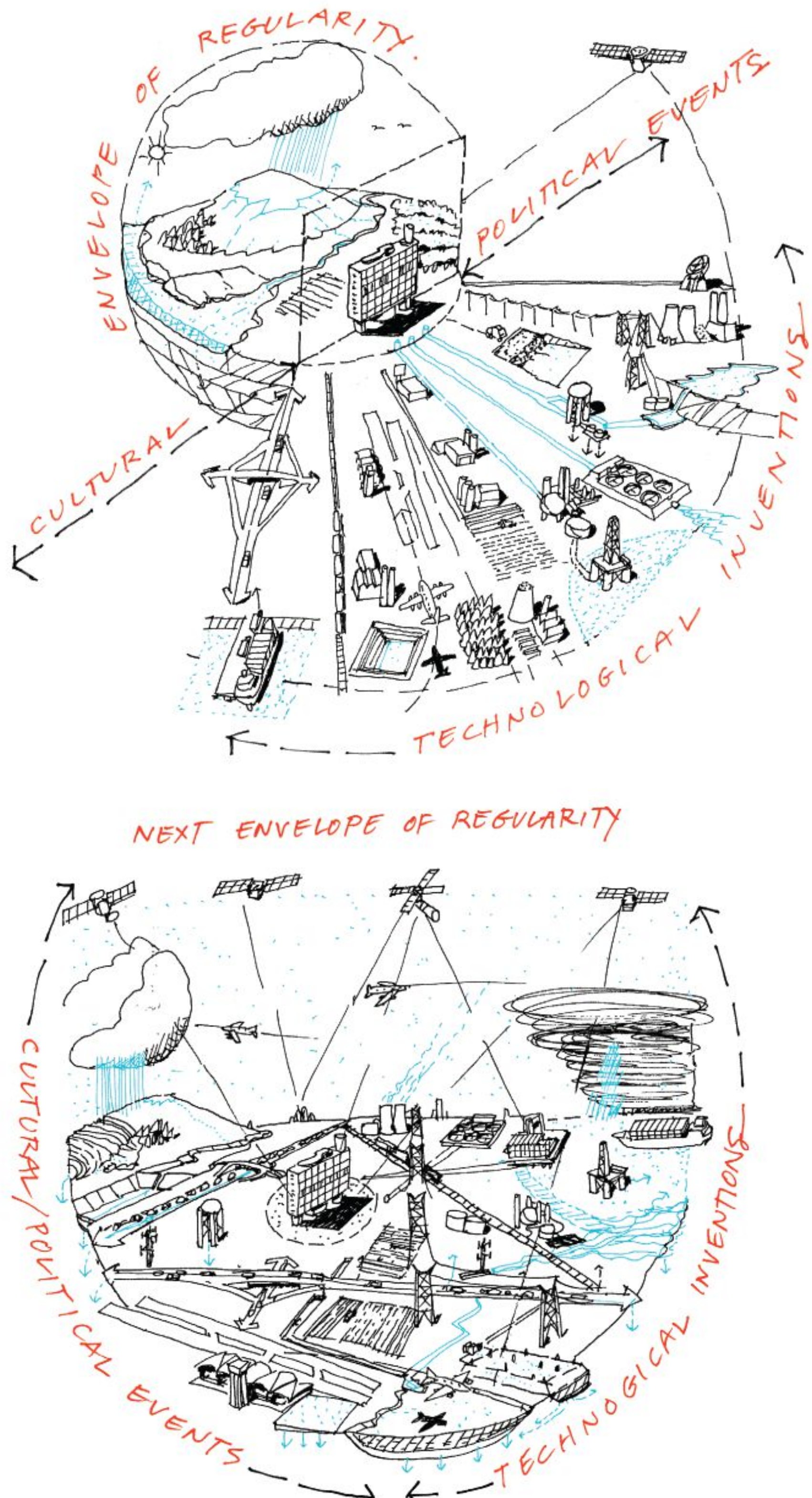

ILLUSTRATION: WILLIAM MORRISH

These diagrams seek to visualize my shift in perspective on water over the years. The first one illustrates our existing design and development policies, or what I call the “envelope of regularity,” which stand on outdated notions where water regimes are segregated into technological channels and segregated into political events. The second one proposes a different perspective, where the ubiquity of water becomes a uniting medium.

Building a levee around lower Manhattan isn’t going to make us resilient when there are icebergs melting around the globe. We still don’t value, as a big project, the architecture of the everyday—or the buildings and spaces that define the experience of the majority of people on this planet. And we’ve never done that. So, sure, let’s save lower Manhattan, but let’s look at the deeper systems that have created our inability to understand water and try to make communities more resilient for the 99 percent as well.

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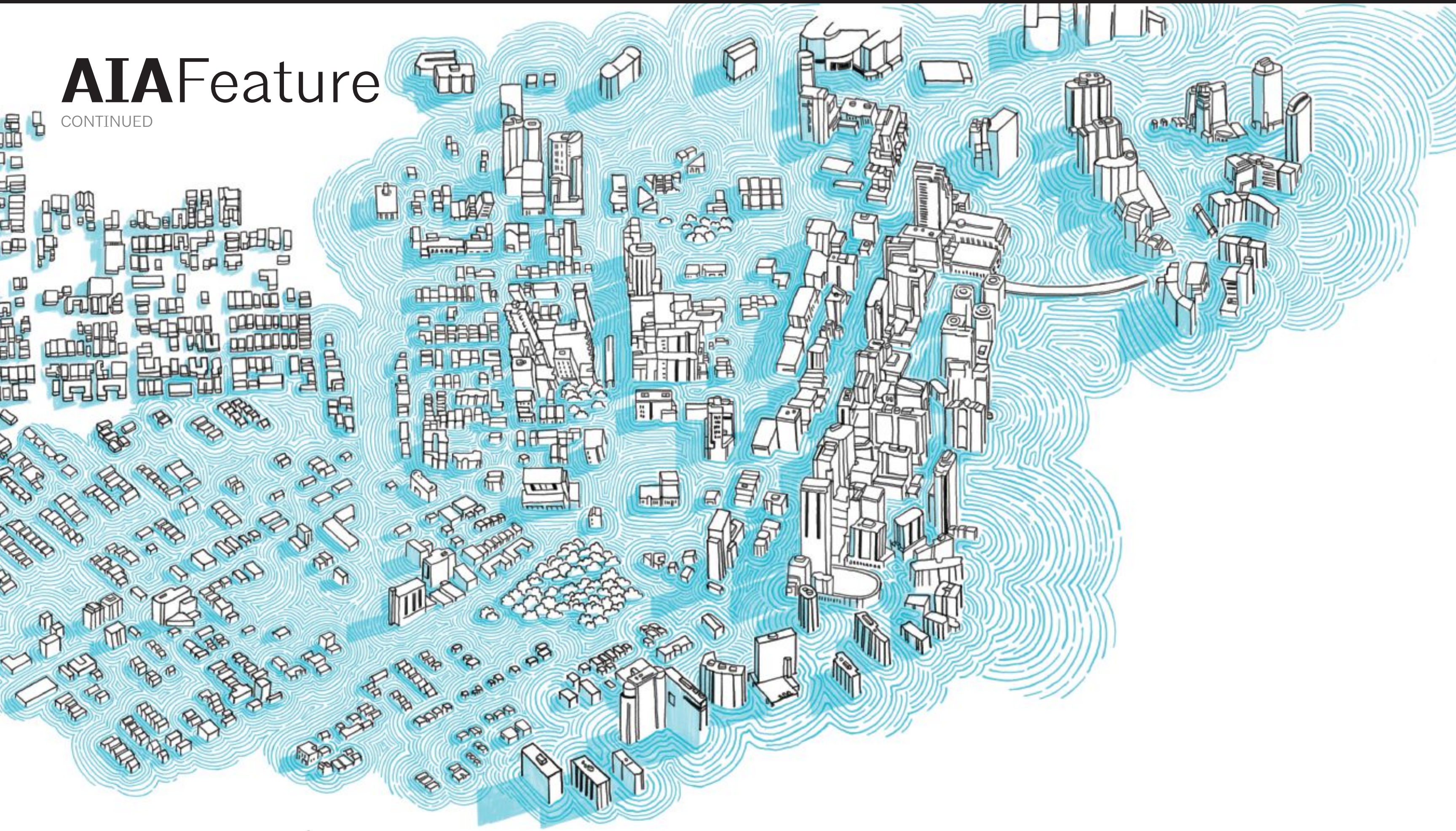


David Rifkind

David Rifkind is an associate professor of architecture at Florida International University (FIU) in Miami and the interim chair of FIU's Department of Landscape Architecture + Environmental and Urban Design. He's on the front lines of the fight against sea level rise, but he also recognizes that this opportunity to transform our cities needs to account for more than just rising waters and the resulting financial impacts. When it comes to designing for a rising sea, he recognizes that sea level rise can pose a real challenge for architects but that they inevitably must be the leaders.

Very often, I'll look students straight in the face and tell them, "You're going to outlive the city you grew up in." As an architectural historian, I am not given to hyperbolic statements, but it's hard to imagine a future where that is not true. It's also very hard to imagine a past where any generation of humans has ever known that they would outlive their city.

Miami, remember, has a good deal of experience with displaced people. We've been the shore that received large numbers of refugees from many places. Cuba is the most notable, but the list also includes Haiti and Venezuela. When nearby countries go through political or economic upheavals, we have accepted their people. A lot of locals have the personal or family memory of that kind of disruption, and there now looms another major disruption in their future.

One of the big problems we may face in Florida is an economic catastrophe that precedes any major ecological catastrophe or "submerged city" situation. Before we have water in the streets permanently, we could see a huge panic where the value of real estate evaporates overnight. The nightmare scenario is that insurers stop writing new policies, which means mortgage institutions won't write any new mortgages, which means fewer buyers and no long-term prognosis for selling real estate, which means the value of real estate drops to zero. That kind of economic shock would cripple the region and the state. As the third-largest state in the country, it would be a national disaster.

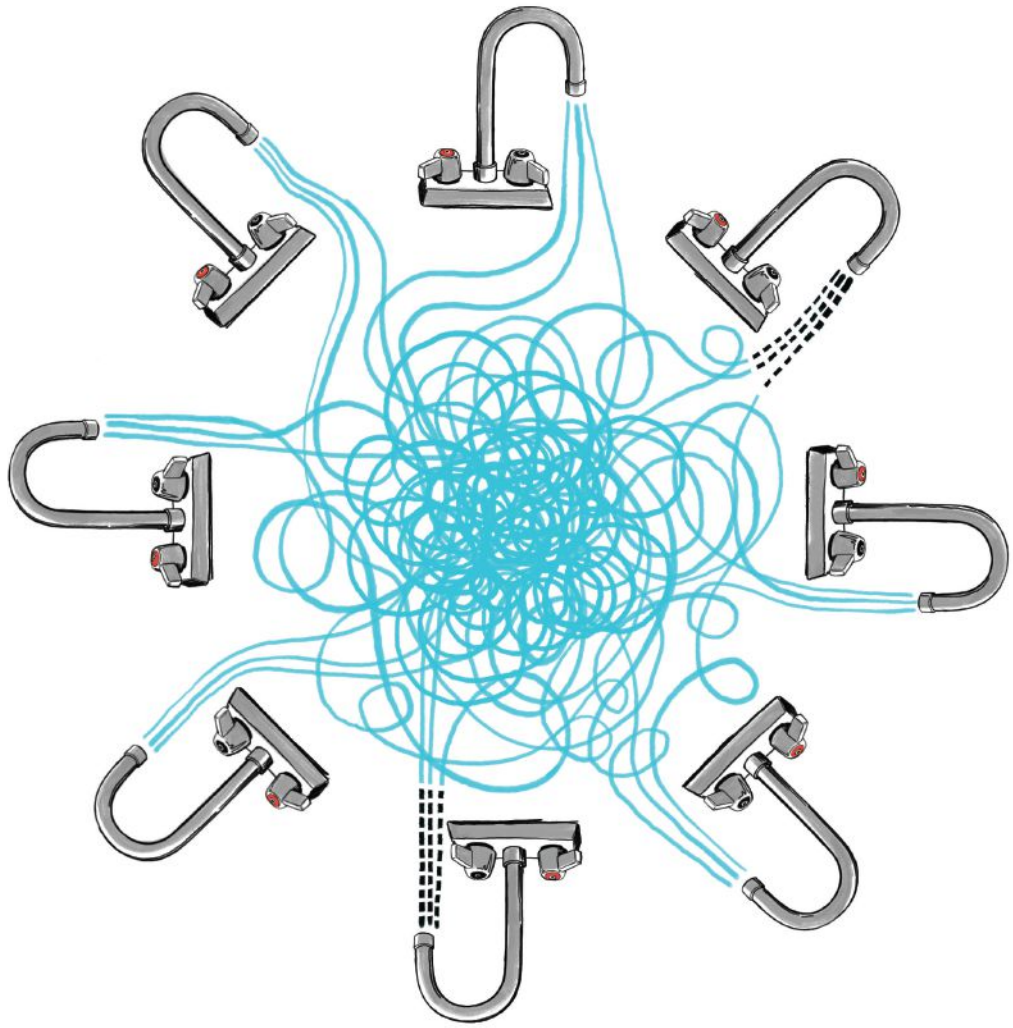
The issues are both natural and manmade, and perhaps beyond any technological fix. But what my students do—because they are problem-solvers and critical thinkers—is they think, "Why not figure out a way to transform the metropolis that accounts for sea level rise beyond even what's been predicted? And how do we plan overall for the next 100 years of Miami's life?" What I love about FIU students is that because so many of them come from working-class backgrounds, they're particularly concerned about issues of social equity in a way that many other schools are not. The other great dilemma facing Miami—beyond climate change—is income disparity. This is one of the cities where you see inequality in some of its most savage forms. You see a visual demonstration of the distance between the very wealthy and the very disadvantaged just by walking a few blocks in any direction.

How do we change that? How do you make an equitable, more democratic city? Because the city has to change in dramatic fashion, in response to sea level rise, this then becomes our opportunity to rethink social equity in the built environment.

We're aware of the threat to us in Miami, but we also recognize the opportunity as the most visible example of sea level rise in the United States. We have a unique chance to transform the way Americans deal with climate issues, and to become a thought leader globally. Miami makes sea level rise real for Americans, and it changes the way we talk about climate change in the United States.

Dana Bourland

Dana Bourland is vice president of the environment program at the JPB Foundation, a philanthropic organization that focuses on enhancing the quality of life in the United States through pioneering medical research, creating opportunities for people in poverty and enriching our environment. As such, she understands how water—or a lack thereof—factors into every facet of our natural and built environment.



Every community in America has a relationship with water that is either life-enriching or life-depleting. We need to collaborate at all levels, across all professions, to ensure water systems are life-enriching. We will be unable to advance the quality of life in this country unless we do.

Water is an essential community resource and access to clean water is a basic human right. Through my work at the JPB Foundation, we approach protecting this human right as we do others, such as access to nature and access to affordable housing: by starting where people live.

A home that conserves water and energy can save lives and improve the planet. We know people die when they cannot heat or cool their homes adequately. Disproportionately, this affects people with low incomes and in particular low-income African-Americans. High utility bills from underperforming housing conditions can put households at risk for eviction.

And because we face growing housing insecurity—with 11.2 million households facing extreme housing unaffordability—there is a nationwide shortage of 7.4 million rental homes. This means that low-income people are moving into naturally occurring affordable housing that is in remote locations, deteriorating, inefficient, and unhealthy. It is a ripe moment for philanthropy, housing practitioners, building professionals, and designers to come together in an even bigger way than is happening today.

I often give out blue marbles in meetings. I bought them in support of the Blue Marbles Project, which promotes connecting people to water and raising awareness about the importance of protecting our water sources and the oceans. Water is a great connector. And while the focus has generally been on energy and not water, this is changing—especially in light of last month's disasters.

"When we try to pick out anything by itself, we find it hitched to everything else in the Universe."
—John Muir

We must exponentially increase our intention to protect our basic human right to clean water, and prepare our communities to live with water as it rises around our shores and pours down on our streets. Our waterways should be swimmable and enjoyable. Being in and on the water is restorative; it improves our mental, physical, and spiritual health. We depend on the ocean with every other breath we take. Water is a lifeline; we must stop taking it for granted.

One lesson here is that it pays to think holistically. We need to understand how all our actions are interrelated and have impacts across the essential resources that communities and people need to thrive. As John Muir is quoted as having written: "When we try to pick out anything by itself, we find it hitched to everything else in the Universe."

ILLUSTRATIONS: LAUREN NASSEF

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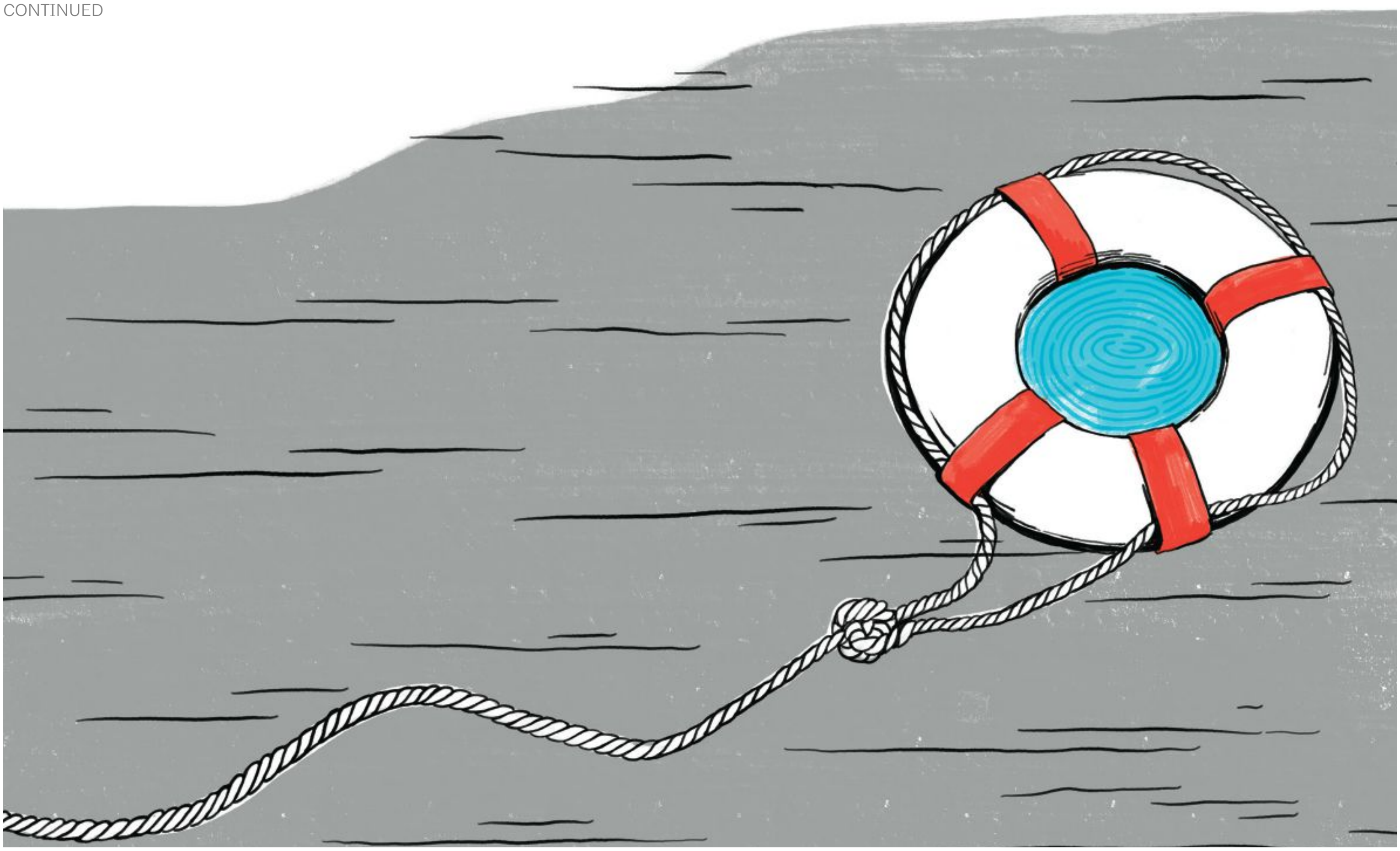

ILLUSTRATION: LAUREN NASSEF

Henk Ovink

Henk Ovink is both principal of Rebuild By Design and the first Special Envoy for International Water Affairs for the Kingdom of the Netherlands. He also served as senior adviser to HUD's Hurricane Sandy Rebuilding Task Force, making him one of the most qualified water experts in the field today and someone very aware of the need to connect global and local solutions.

Our world is an urban world. Large parts of the population live in low-lying deltas, the safety and well-being of which depend on the hinterland's riverine basins where the quality of nature, ecology, and water is determined. More often than not, the poorest people live in the most vulnerable places, and climate disasters easily develop into humanitarian disasters and geopolitical conflicts. Locally, survival depends on global action. But, local solutions can also provide answers to larger global challenges.

Water represents man's most challenging and complex risk. Floods and droughts, pollution, and water conflicts combine in conceivably disastrous ways with rapid urbanization, a growing demand for food and energy, migration, and climate change. The water challenges carry with them the risk of disruptive transitions. Only a better understanding of these risks will allow us to de-risk the world effectively.

Numerous funding initiatives have contributed large amounts toward these issues. Formal development funding related to water has nearly tripled between 2003 and 2014, while across-the-board climate funding is based on the agreement to mobilize an equal amount for mitigation and adaptation. Almost 80 percent of the funds provided for the latter are water-related, generating countless opportunities in the sector. However, as budgets allocated for water-related projects are increasing to meet global needs, another problem becomes clear: how to effectively, adaptively, and swiftly allocate these funds for genuine transformation. It is becoming evident that we lack the tools that enable us to effectively tip the balance.

When we acknowledge that complexity needs to be embraced, we get a better sense of how to deal with it. This understanding can only be advanced when global and local expertise is connected, in an inclusive way and on the ground, where risk is real and urgent. We therefore need a new approach that matches long-term comprehensive planning with short-term innovative interventions; state-of-the-art science, research, and data collection with local stories and facts; and innovation with implementation through collaborations across all sectors and all layers of government, involving all stakeholders—from activists and vulnerable communities to private enterprises and public institutions.

Water is at the heart of our uncertain future. It is mainly through water that we feel the impact of climate change. Of all disasters worldwide, 90 percent are water-related, either floods or droughts. And while 50 percent of the world's groundwater storage capacity is beyond its tipping point, the quality of surface water everywhere is at risk. Water-related climate risks cascade through food, energy, urban, and environmental systems. Water is essential for our economy as well as for our social and cultural well-being. Water quality affects our future economic and societal prosperity, while water risks—too much or too little—define our societies' vulnerability. Water is life. AIA

AIAPerspective

PHOTOGRAPHY: CARL BOWER

All Around Us

Water comes to the fore—again.

The challenges are great—warming waters, saltwater encroachment, rising sea levels, crumbling bulwarks, mounting carbon levels, dwindling forests, growing metropolises, and, with them, ever-expanding areas of impermeable urban surface.

Communities everywhere are facing challenges with water. In Louisiana, New York, New Jersey, Connecticut, Missouri, and especially in Texas and Florida, storm-induced floods have recently destroyed lives and property, on scales that defy description.

Also upon us—and slower to destroy, certainly, but with staggering prospects for disruption—are inexorable gains in sea levels. Rising seas are a key element of plans and programs for AIA Florida, as portions of that state begin to experience the effects.

Disaster impacts can last for decades—some last forever. Every season seems to bring new difficulties, more trouble. And this is happening all over the globe.

So let's sound this encouraging note: Architecture and design can really help.

The challenges are great—warming waters, saltwater encroachment, rising sea levels, crumbling bulwarks, mounting carbon levels, dwindling forests, growing metropolises, and, with them, ever-expanding areas of impermeable urban surface. Today, we probably have only an inkling of how cities will have to adjust relationships with the water that is over, under, and all around them.

We will need new design measures as well as new planning and development rules. We will have new and different costs, and adjustments in how we work and live. Some changes will be thrust upon us by need and circumstance; others we will seek.

Like other challenges, many of which are interrelated, water has much to do with physical design—the care we take in how we juxtapose buildings, land, water, people, and infrastructure. Urban planning and architecture are at the core of efforts to house and feed rapidly expanding poor populations, to reduce harmful climate impacts, to promote health.

We must develop and adopt new measures, concepts, practices, and policies. We must reduce unwanted environmental impacts, helping people to meet new realities.

That is why, in the wake of Sandy and Katrina, the Institute began to invest in programs that foster community resilience, and now, after Harvey and Irma, AIA members are applying lessons learned. Our chapters are assisting communities all over the country hit by catastrophes—helping them to be better prepared next time.

Our purpose is first to learn from experts in sea-level forecasting, from architects innovating with new designs for high water, from industry leaders preparing for a future with higher sea levels, and from officials improving policies for land planning and development. Next we must stimulate the public demand for architecture by showing how design makes communities stronger. This year, and no doubt for some time to come, architects have a responsibility to address water in their work on behalf of clients, and in their influence over communities in light of architecture's great capacity to ensure the health and safety of everyone—no matter where they live, play, or work. AIA

Thomas Vonier, FAIA
2017 AIA President

“Housing was once a part of the modernist ethos, some would say its central anchor. Lakeside demonstrates how it might become so again.”

Housing Redux at Princeton by Witold Rybczynski, HON. FAIA

Two years ago, Phoenix-based firm Studio Ma completed its first major project in the Northeast, the Lakeside Graduate Student Community at Princeton University. Situated at the south end of the campus on a sloping site overlooking Carnegie Lake, the complex of a dozen buildings consists of townhouses and apartments as well as a commons building and a parking structure. Two of the founders of Studio Ma, Christiana Moss, AIA, and Christopher Alt, while students at Cornell University in the 1990s, spent a semester at the Oslo School of Architecture studying with Norwegian master Sverre Fehn. It shows. Lakeside's low-key architecture has a definite Nordic flavor—reserved, unsentimental, and carefully built.

According to university architect Ron McCoy, FAIA, Lakeside "recalls the scale and richness of form that is characteristic of the historic residential buildings on the Princeton campus." That description applies literally to Demetri Porphyrios' nearby Whitman College, a recent exercise in the Collegiate Gothic that Walter Cope and John Stewardson introduced to the Princeton campus in the 1890s. But Lakeside is not an Oxbridge quad, it is—and I use the word advisedly—a housing project. Housing was once a part of the modernist ethos, some would say its central anchor. Lakeside demonstrates how it might become so again.

The Importance of the Horizon

Like a public housing project, Lakeside is organized in linear blocks, in this case two- and three-story-tall townhouse terraces and four- and five-story-tall apartment buildings. Most housing projects are laid out mechanically on a right-angled grid. That is not the case here. The organic plan is almost Olmstedian. The chief feature of this casual arrangement is the way that the buildings accommodate themselves to the sloping terrain. Fehn was known for stressing the importance of siting and was quoted this way in Per Olaf Fjeld's 2009 biography, *Sverre Fehn: The Pattern of Thoughts*: "Everything we build must be adjusted in relation to the ground, thus the horizon becomes an important aspect of architecture. The simplest form of architecture is to cultivate the surface of the earth, to make a platform. Then the horizon is the only direction you have." At Lakeside, the buildings maintain a constant roofline, increasing in height as they step down the slope—that's one sort of horizon. The spaces framed by the terraces open up to views of the horizontal surface of the lake—that's another.

The 16-acre site was previously occupied by two eight-story apartment slabs designed in 1959–64 by the New York City firm Ballard, Todd & Snibbe. Like so much midcentury modern student housing, the long buildings, with their egg-crate façades and open-air access galleries, were pretty grim—the Princeton alumni magazine recently described them as "barracks-style." They're gone now. The university considered reusing and adding to the old buildings, but instead decided to start over. The energy-efficient new buildings, which use geo-exchange mechanical systems and improved thermal envelopes, not only reduce greenhouse gas emissions but are located on parts of the footprints of the demolished apartments and old parking lots in order to keep the impermeable surface to a minimum. Stormwater management also guided the design of the manmade landscape, which is the work of Towson, Md.–based Hoehn Landscape Architecture. Most of the spaces between the housing terraces are bioswales and heavily planted rain gardens. The wild vegetation of ferns and marsh grasses, as well as the adjacent woods—a preserved wetlands—and the bucolic views to the lake, subvert any latent sense

Site plan

Apartment buildings (left) and townhouse terraces at Lakeside

BILL TIMMERMAN


Townhouses featuring Ludowici terra-cotta tiles

of institutional uniformity. It's hard to overstate the effect of this landscape, which turns Lakeside from a hardheaded housing project into a sylvan retreat.

Then there is the architecture. The back-to-back townhouses are framed in wood and the apartment buildings are framed in lightweight steel, but the exterior skins are similar: smooth ironspot brick with patches of rough artisan brickwork, and occasional shingled walls of Ludowici terra-cotta tiles. From a distance, the latter resemble weathered cedar shingles; close up they look like slate. The scale is further broken down by Mondrianesque stringcourses of white brick. The shingled roofs are conventionally sloped and broken up by occasional wall dormers. The variety of shapes, patterns, and textures disguises the fact that the buildings incorporate many repetitive features. (All the windows—casement and fixed—are identical, for example.) The architectural vocabulary might be tightly controlled, but instead of conveying a sense of mass-produced uniformity, the quilt-like façades, the irregularly spaced windows, and the projecting dormers are frankly decorative and picturesque—not qualities generally associated with modernist housing.

Many housing projects exhibit a one-size-fits-all mentality that produces a mind-numbing atmosphere of anonymity. Not here. "Princeton had assumed that the large majority of the units would be studios and one bedrooms," the architects told the website World-Architects. "After a series of surveys and focus groups, however, it was found that the graduate community was made up of a range of groups, each with their own living needs and preferences. It was also found that the community changed over time, with the younger students expressing a strong preference for the relatively low-cost, communal option offered by larger two-, and three-bedroom units. The privacy and individual amenities offered by studios and one-bedroom units became more important with more established students and couples."

The largest shared units—three and four bedrooms—are in the townhouses, and the apartment buildings contain one-, two-, and three-bedroom units; 715 bedrooms in total, distributed among 329 units. Adaptability is achieved by providing all the bedrooms with lockable doors. Some of these bedrooms have en suite bathrooms and function as mini hotel rooms; in other cases, pairs of bedrooms share a bathroom and have their own private vanities. Both variations share living rooms and kitchens. Do graduate students cook a lot? I saw at least one Amazon Fresh box outside a front door. "Pet-friendly" apartments on the first floor have exterior as well as corridor access. Providing first-floor units with their own outdoor entries is an old trick, but an effective one. The oversize stoops animate the public spaces and function as small sitting areas, with lawn chairs, potted plants, and, in one case, a glider love seat.

The housing units are well-equipped—each has a washer, dryer, and a dishwasher, and about a quarter of them are furnished—but the decor is spartan. Think Days Inn with 9-foot ceilings. An exception is the occasional presence of a dormer, which creates a tall space bringing light in from above. Thanks to the varied building footprints, some bedrooms have windows on two sides. The apartment buildings are entered through large brick-paved breezeways that provide shelter for scores of bicycles. The spare industrial details in the lobbies look chic but promise to be hard-wearing. The upper elevator lobbies have windows, which provide the short corridors with views and natural light, further undermining the institutional atmosphere.

The one area with a degree of luxury, albeit a restrained Scandinavian variety, is the commons building, which includes a lounge, communal kitchen, library, study area, fitness room, and childrens' playroom. The lounge is an elegant space with floor-to-ceiling glazing, hickory and through-body porcelain

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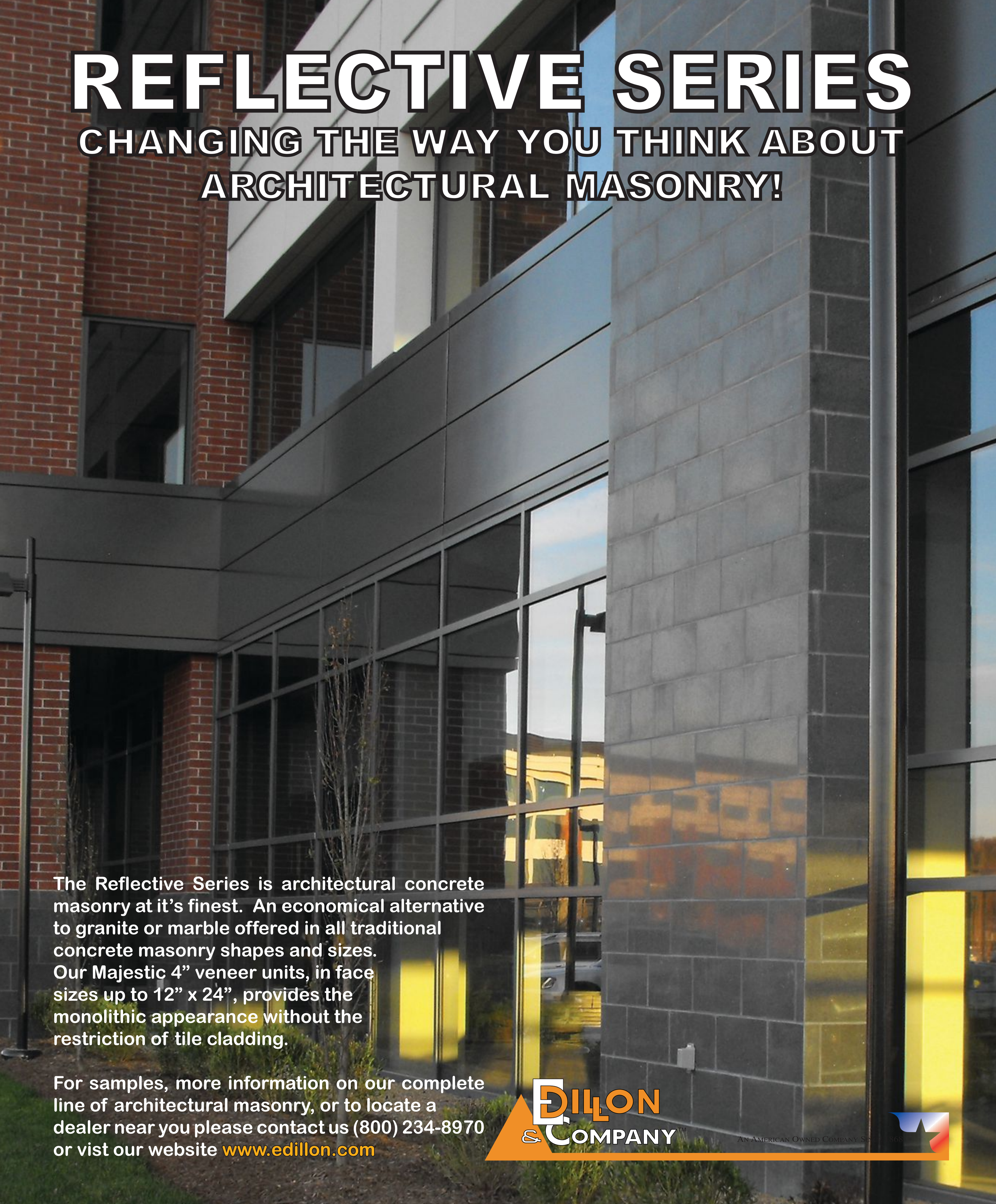
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tile floors, accent walls of red oak (salvaged on site), and a glass-doored fireplace. The style of the furniture reminded me of Ikea—modern but not aggressively designed; the comfortable easy chairs in the reading room recall Saarinen Womb Chairs. This room opens up onto a sheltered deck with benches and tables and a fully equipped outdoor barbecue kitchen.

Eschewing the Clever

The architects' strategy at Lakeside is evident: keep the overall planning simple, avoid building gymnastics, and invest in good quality materials and details. I am reminded of Sverre Fehn's 1997 Pritzker Prize citation: "Eschewing the clever, the novel and the sensational, Fehn has pursued his version of twentieth century modernism steadily and patiently for the past fifty years." Except for the "fifty years"—Studio Ma was founded in 2003—this could well describe the Arizona firm's work at Lakeside. The site plan builds on early modernist prototypes; the materials are traditional; the aesthetic is humanist; and the buildings look like buildings, not sculptural objects. In a period when being clever—and especially novel—passes for design talent, Lakeside demonstrates traditional skills and virtues.

The result is hardly revolutionary, but that is precisely the point. This is not about reinventing the wheel. Instead of grand gestures, Studio Ma has provided small effects and subtle variations. This is the kind of Modernism that architects such as Aldo Van Eyck explored—scaled to its users, controlled, yet occasionally almost fey. There are hints of Alvar Aalto in the variegated brickwork, and the lessons learned from Fehn, apart from careful siting, include his consistent attitude to details and materials. What especially makes Lakeside old-fashioned is that it chooses to grapple with the age-old challenge of mass housing: how to personalize the impersonal, how to contextualize what risks being anonymous, and how to create a sense of community without sacrificing the individual's experience. That should warm any old modernist's heart.

BILL TIMMERMAN

The landscape helps transform Lakeside from a hardheaded housing project into a sylvan retreat.

“Having unwittingly helped transform an industrial relic into an overheated engine for gentrification, Hammond is now doing his best to use the lessons he learned for the greater good.”

The High Line Network Tackles Gentrification by Karrie Jacobs

If you want to live in an apartment building designed by Zaha Hadid and can afford $5 million for a two bedroom, the place to go is West 28th Street, in the Chelsea neighborhood of Manhattan. Or perhaps you'd prefer a luxury unit designed by Shigeru Ban, HON. FAIA, Annabelle Selldorf, FAIA, Neil Denari, FAIA, or Jean Nouvel, HON. FAIA. In which case you'd also be looking in Chelsea, more specifically along the 1.45-mile stretch of the abandoned freight railroad turned High Line. And that doesn't even include the dazzling towers by Diller Scofidio + Renfro and the Rockwell Group, Kohn Pedersen Fox, and Skidmore, Owings & Merrill that are now under construction at Hudson Yards, an 18-million-square-foot development encircled by the High Line's northern end.

Since the first section opened in 2009, the High Line has been a magnet for visitors (over 7 million last year) and architecturally adventurous, high-end real estate. Anyone strolling along it today would assume that encouraging luxury development was its raison d'être. Except that it wasn't. Not really. Robert Hammond and Joshua David, the two neighborhood activists who teamed up to save the industrial relic from demolition, did sell the Bloomberg administration on the idea that the project would help generate some $200 million in new real estate taxes, a bit more than it would cost to build the park. But they wildly underestimated its impact: development adjacent to the High Line will pump $900 million into the city's coffers by about 2038.

Initially, the appearance of forward-looking architecture along the High Line was heralded as a boon, a miraculous transformation of stodgy old Manhattan. But the thrill soon faded, at least for some critics. As Jeremiah Moss, author of *Vanishing New York* (Dey Street Books, 2017), wrote in a 2012 *New York Times* op-ed: the High Line has been "a catalyst for some of the most rapid gentrification in the city's history."

For former Mayor Mike Bloomberg and his administration, rapid redevelopment of a neglected, heavily industrial swath of Manhattan was absolutely the goal. In 2005, as part of the plan to transform the High Line into a park, the department of city planning under Amanda Burden rezoned industrial West Chelsea for residential development with provisions that allowed the transfer of air rights from properties directly next to (or under) the park to sites on nearby 10th and 11th Avenues. Developers of sites next to the park could build taller than zoning allowed if they paid into a fund to equip the new park with stairways, elevators, and public restrooms. The city's Economic Development Corp. website indicates that some 1,374 units of housing and half a million

Buildings by Gehry, Nouvel, Ban, and Seldorff have sprouted up around New York's High Line.

square feet of commercial development have cropped up along the High Line since the 2005 rezoning, but those numbers are clearly dated—understating the park's enormous impact—and no city agency was able to supply new ones at press time.

Having unwittingly helped transform an industrial relic into an overheated engine for gentrification, Hammond is now doing his best to use the lessons he learned for the greater good. In June of this year, Hammond convened the High Line Network. "Joshua David and I had met with hundreds of these projects over more than a decade. And we were trying to figure out how we could be helpful over the long term," he says. "That's when we came up with the idea of a network. Let's learn from each other."

A subsidiary of the nonprofit Friends of the High Line, the grant-funded network consists of 19 urban park projects in U.S. and Canadian cities that embrace the High Line ethos: seeing the beauty in some discarded piece of infrastructure and transforming it into a public place. Membership is free and by invitation, says network director Emma Bloomfield, and includes projects "that reuse different kinds of infrastructure to create public space, represent geographic diversity, and have momentum." Houston's Buffalo Bayou Park (see page 180) is part of the network; so is Philadelphia's Rail Park and Miami's Underline.

Social issues—gentrification, displacement, equitable development—dominated Hammond's thoughts when the network first met. But he wasn't sure that those issues would matter to the other members. "We actually thought other projects might not be that interested. What we found after the first gathering was that the number one issue was around equity."

SHINYA SUZUKI

A Rude Surprise

Building a new park in a 21st-century city isn't easy, given the complicated task of securing financing, political support, and approvals, not to mention the actual design and construction of the project. Factoring in social problems like displacement and equitable development introduces even more complexity. Transforming an eyesore into an amenity is almost guaranteed to boost real estate values in the surrounding area. Certainly that's one of the reasons that historic green spaces like Central Park and Prospect Park exist. Back in 1867, Frederick Law Olmsted was already envisioning the area surrounding Prospect Park's entry plaza as "a great residence quarter of the Metropolis." And HR&A Advisors, the New York–based real estate consulting firm that was an adviser to the High Line, has "identified that these kind of big parks in other cities across the country could raise property values anywhere from 5 percent to 40 percent," according to Scott Kratz, the director of Washington, D.C.'s 11th Street Bridge Park project, a network member.

As housing prices in many American cities have steadily climbed, the economic benefit these projects offer their surrounding neighborhoods, long a desirable trait, has often come to be seen as a rude surprise. In Chicago, for instance, in the neighborhoods adjoining the 606, a 2.7-mile-elevated-rail-line-turned-park and a network member, there's been a 50 percent surge in home prices since 2013, when construction on the project began. The most dramatic increases have hit the trail's less affluent west end, in the Humboldt Park and Logan Square neighborhoods. Chicago aldermen are trying to dampen the real estate speculation by imposing steep fees on developers looking to demolish affordable housing in favor of new market-rate homes. Unfortunately, the aldermen's efforts are too little, too late.

To have any chance of managing the issue of inequality, projects must confront it from the very beginning. For network members, the results, so far, are mixed. Consider the Atlanta BeltLine, a 33-mile loop of former rail-lines-turned-recreational trails (designed by Perkins+Will and Kimley-Horn) to be accompanied (eventually) by 22 miles of light rail linking some 45 urban neighborhoods. Scheduled for completion in 2030, the project began as a graduate thesis by Ryan Gravel at Georgia Tech. After he graduated in 1999, Gravel teamed up with his colleagues at an architecture firm to pitch the idea to city and state officials. Only one recipient evinced genuine interest in the project: Atlanta councilwoman Cathy Woolard, then chair of the council's transportation committee. Says Gravel: She "had a background in community organizing and she understood the project just intuitively." By 2005, they had managed to secure what's known in Georgia as Tax Allocation District [TAD] funding to pay for close to half the projected $4.8 billion project. The general idea is that as a "blighted" area improves, the increases in property tax revenues pay for the project that's driving the improvements.

But the BeltLine advocates included some housing activists who insisted that 15 percent of the TAD funds be allocated to building affordable housing along the trail. "We got it in there," Gravel says. "They're committed by state law to do 5,600 units, which is a

Washington, D.C.'s 11th Street Bridge Park by OMA and Olin

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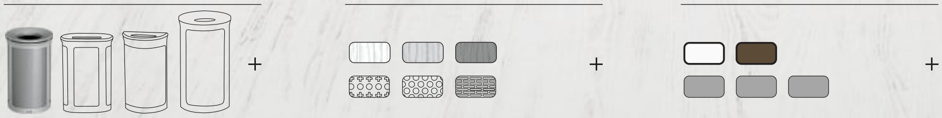

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significant investment … but not enough.” Indeed, Atlanta’s housing prices have steadily soared since 2012, with a 9.5 percent increase in the past year alone. “Atlanta is on fire right now,” Gravel says. “And that’s not bad. These communities need more people. They need an economy, they need jobs and grocery stores. But it shouldn’t come at their expense. That’s the hard part, to make sure you can make improvements but also protect people who live there.”

The mandated affordable housing along the BeltLine—now a third complete—has been slow to emerge. In July, an investigation by the *Atlanta Journal Constitution* determined that only 785 affordable units had been financed by the BeltLine’s TAD funds. Meanwhile, low-income homeowners along the BeltLine path are seeing the assessed values of their houses rise and are struggling to pay property taxes, and low-income renters are being priced out.

The *Journal Constitution* story prompted the resignation of the director of the Atlanta BeltLine Inc., the quasi-public agency that is actually building the trail. Gravel, for his part, resigned in frustration last year from the Atlanta BeltLine Partnership (ABP), a nonprofit fundraising and advocacy organization. Still, he contends, “The answer to this problem can’t be to not improve communities. The answer is not to not build parks and trails and transit and grocery stores. You don’t hold a neighborhood down just to keep it affordable.”

A Blueprint for Equitable Development

For a more promising case study, consider the 11th Street Bridge Park project in Washington, D.C., designed by OMA and Olin and scheduled for completion in 2019. The park will span the Anacostia River on piers left over from a demolished highway bridge. A dramatic, angular, multilevel landscape, the park creates, for the first time, a significant pedestrian connection between the rapidly gentrifying neighborhoods north and west of the river—those surrounding Capitol Hill—with the entrenched poverty of Anacostia on the river’s south and east side.

The appeal of the Bridge Park was clear to Scott Kratz, formerly of the National Building Museum: “The river has been this dividing line for generations, so can we create a physical and metaphorical bridge between these communities?” But the pitfalls were also obvious: “If this becomes a real destination, how do we ensure that this park can be not only an anchor for economic development but equitable and inclusive development?”

After working closely with neighborhood stakeholders to write a design brief and choose the design team, the Bridge Park advocates joined

The Atlanta BeltLine

forces with an existing area nonprofit that is called, coincidentally, Building Bridges Across the River. That nonprofit, which now employs Kratz, oversees the project and its social mission. The selection of OMA and Olin occurred in tandem with the drafting of a detailed Equitable Development Plan. "We collected data of property values, change over time, demographics, poverty levels, renter versus homeowner, all of that data," says Kratz. "But more importantly, we then spent six, seven months meeting with the stakeholders, meeting with the broader community to identify clear action steps that the parks could take to make sure that those residents nearby, if they chose to, could stay and thrive."

The Equitable Development Plan lays out 19 recommendations in three categories: workforce development, small business enterprises, and housing. As mandated by the plan, a "Home Buyers' Club" teaches renters how to buy property: 53 club members are now in the process of purchasing a home. The Bridge Park team is also working to organize renters in small apartment buildings so that they are poised to make an offer if their buildings are put on the market. (Under D.C. law, the tenants of a building have the right of first refusal, but only have 45 days to make an offer.) And the 11th Street Bridge Park is helping to start a community land trust to ensure that "the community will maintain permanent affordability in perpetuity," Kratz says.

"We just received a large grant last year," he says, "where the senior scholars from the Urban Institute are not only helping us set clear, measurable goals for each of our 19 recommendations, they're also going to be with us for the next three years to provide a constant feedback loop."


Hurricane resistant and historic?
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Most significant, perhaps, is the fact that the grant Kratz mentions—$50 million from the Local Initiatives Support Corp. of Washington, D.C.—actually exceeds the $45 million budgeted for the construction of the Bridge Park itself. JPMorgan Chase also announced a $10 million donation in late September to help preserve affordable housing for area residents.

A Blueprint for Equitable Development

More than a decade later, it's easy to forget that the West Chelsea rezoning plan that made the High Line possible and triggered the accompanying real estate bonanza had a social component, too. Certain areas around the High Line were designated for "inclusionary zoning," meaning that developers could build larger buildings than the zoning normally allowed if 20 percent of the units were affordable. The zoning rules were intended to encourage the construction of 1,000 units of affordable rentals. A survey of the inclusionary zoning program from 2005 to 2013 by New York's Department of City Planning shows that 1,470 new affordable units were built on Manhattan's West Side, but a separate study by a city councilman's office indicates that only 348 of them are in West Chelsea. Clearly, providing a funding mechanism or incentives for affordable housing isn't nearly enough. What's required is a much more focused effort, something that has the depth and determination of the 11th Street Bridge Park's plan.

Still, the question remains: If park advocates can devise effective ways to enhance the economic viability of a neighborhood without displacing its residents and figure out how to fund and execute such a transformation, why hasn't it been done already? How is it that these crucial tasks have been left, by default, to park builders?

Gravel offers a partial explanation: "I say this about the BeltLine a lot, but it's true of all the projects in the High Line Network: They're not only changing the physical form of the cities they're in, they're changing the way we think about those places and what our expectations are for living in them. The BeltLine didn't cause all the problems the city is facing right now, and it can't solve all of them … it can't be everything. But what it can be is a catalyst for change."

Hammond has a similar view. Park activists can't solve all of a city's problems, but they can force the city to confront them: "I think we have to make the government accountable," he says. "You can't just build these [parks] and hope for increased property taxes. You have to look at them holistically. We can't enact zoning. That's the job of the city. But these projects can encourage the city, prod the city, and hold the city accountable."


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“Conceptually the series is taking a bigger leap this time, attempting to grapple with the hall-of-mirrors cultural relationship that has existed for several centuries between Southern California and Latin America.”

The Return of Pacific Standard Time by Christopher Hawthorne

"Launch Pad" tapestry by Evelyn Ackerman, c. 1970

While the idea that Los Angeles has no history is a crude caricature—one not infrequently sketched out by people who wish their own cities had a little more going on in the present day—it would certainly be fair to say that L.A. hasn't always tended especially well to its past. We have ignored the work of certain artists and architects and destroyed the work of others. We have whitewashed important figures and communities in a figurative sense and important murals in a literal one. We have fostered a culture, relentlessly fixated on churning progress and expansion, that produces what the writer Norman Klein has called "collective forgetting." Paraphrasing Italo Calvino, Klein describes Los Angeles as "a city incapable of holding a memory, or a shape, rather like a bad battery unable to hold a charge."

Just as important, the informal, ad hoc, and even improvisational nature of so much art—and especially architecture—in Los Angeles has made both documenting and preserving our cultural heritage especially difficult. A modern house made of plywood and inexpensive aluminum-frame windows, clinging to a steep hillside, isn't simply an alternative to the monumentality of East Coast and European architecture; it's also a challenge to the idea of permanence, to the business of conservation, and even to the state of cultural record keeping. The same could be said of structures both markedly ambitious and designed to be temporary, of which Los Angeles has built an unusually large number over the last century, by architects and designers including Frank Lloyd Wright, Frank Gehry, FAIA, Jon Jerde, Deborah Sussman, and the husband-and-wife team of Craig Hodgetts, FAIA, and Ming Fung, AIA.

For all those reasons, "Pacific Standard Time" (PST), a series of exhibitions, publications, and public events on the art and architecture of 20th-century Los Angeles, has brought about a sea change in how the city frames (and markets) its own cultural history. Conceived and largely funded by the Getty Foundation, PST launched in 2011 with a focus on the postwar art movements of Southern California. It returned two years later with a collection of exhibitions on the region's experiments, spanning the years 1945 to 1980, in modern architecture.

A Hall of Mirrors

This fall, the third iteration of the series, "Pacific Standard Time: LA/LA," takes a wide-ranging look at the traffic in art, architecture, and other fields between Los Angeles and Latin America. Propelled by $16 million in Getty Foundation funding and the product of nearly four full years of planning, it in certain ways is the most ambitious PST effort yet—and not simply because it involves 70 different cultural institutions, from heavyweights such as the Los Angeles County Museum of Art (LACMA) and the Los Angeles Philharmonic to lesser-known locales including the Torrance Art Museum and the Mingei International Museum in San Diego, as well as another 65 commercial galleries.

Conceptually, too, the series is taking a bigger leap this time, attempting to grapple with the hall-of-mirrors cultural relationship that has existed for several centuries between Southern California and Latin America. That means the pre-Hispanic art and architecture of the Maya and the Aztecs and how it has been repurposed by artists both Anglo and Latin is as much fodder for the new round of exhibitions as the Spanish Colonial Revival architecture that began to spread across Los Angeles a century ago or the Chicano art movements that first gained notice in the 1970s. Given the extent to which our border with Mexico emerged as a primary theme—arguably the primary theme—of last year's presidential race, exploring the historical roots of this north–south relationship is also, unmistakably, a political act.

One major contention of "PST: LA/LA" is how deeply established this cultural conversation is, how many twists and turns it has taken; in that sense the series also becomes, inevitably, a commentary on the relationship between west and east, which to say it makes clear just how much more in common Los Angeles has with Latin America, in terms of history, language, art, architecture, music, and food, than it has with the East Coast of the United States.

EVELYN ACKERMAN/ERA INDUSTRIES; COURTESY LACMA


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There are several museum and gallery shows that focus directly on architecture and design, and dozens more that include significant references to architecture or artworks with architectural themes. Many of those exhibitions hadn't opened as this article was going to press, but enough had to suggest a pretty clear sense of the role architecture plays in this installment of the Getty series. Unlike the first two editions, which largely ignored the period before World War II, this one can't help but extend deeper into the past, preoccupied as so many of the shows are with the various regimes—Spanish, Mexican, independent, the U.S.—that have ruled over Southern California, not to mention the ways in which nostalgia for the Spanish period produced the varied revivalism of the 1920s in L.A., with its simultaneous infatuation with Mission architecture and Spanish palaces.

In a broader sense, the shows serve to deepen—and in much-needed ways to complicate—our understanding of the trajectory of Southern California architecture over the last century. The ways in which our buildings were shaped by the region's Latin inheritance, and how that inheritance has been undermined, rejected, pre-empted, or remade by the most talented and ambitious architects to work here, has never been especially well understood, even by historians, critics, and designers who've spent their entire careers in Los Angeles.

What is the relationship between Wright's pre-Columbian experiments in residential architecture in 1920s Los Angeles and the handsome Spanish Colonial Revival villas of Gordon Kaufmann, Myron Hunt, or George Washington Smith? How much Latin American influence can we detect in the Modernism of R.M. Schindler, Richard Neutra, or Irving Gill? Why does interest in the Mexico City architect Luis Barragán (1902–88) remain strong in the United States when the work of his compatriot Juan O'Gorman (1905–82) is so little known? Are there threads, historical through-lines, connecting that work from the early 20th century with the better-known Los Angeles architecture of the postwar decades, the buildings that put L.A. on the design map in a global sense? Taken together, the

"Excision" by Leyla Cárdenas

LEYLA CÁRDENAS; COURTESY LACMA

"PST: LA/LA" exhibitions sketch out some fascinating answers to these questions, suggesting a more coherent connection between prewar, largely Latin American–centric revivalism and postwar Modernism in L.A. architecture than we have acknowledged up until now.

An Eye to Mexico

The exhibition that tackles these questions most directly is LACMA's "Found in Translation: Design in California and Mexico, 1915–1985." Organized by LACMA's Wendy Kaplan and Staci Steinberger, the exhibition, as Kaplan writes in the remarkably well-illustrated catalog, "explores interconnections essential for understanding the material culture of Mexico and California in the twentieth century. … [E]ach place has found a more distinct voice through 'translations' of the other."

Among the most important revelations in this intelligent and wide-ranging show, whose installation was designed by Frederick Fisher, AIA, and is squeezed into fewer square feet of LACMA's Renzo Piano, HON. FAIA–designed Resnick Pavilion than it deserves, is that California architects designing prominent Spanish Colonial Revival buildings in the 1910s and 1920s were often looking more closely at Mexican sources than Spanish ones. For example, the model for Bertram Goodhue's exuberant Churrigueresque-style California building at the 1915 Panama-California Exposition in San Diego, a legendary design in the annals of the Spanish Colonial style in Southern California, was a parish church, Santa Prisca y San Sebastián, in Taxco, Mexico.

Chronologically, the exhibition stretches all the way through the 1984 Los Angeles Summer Olympics, contrasting the design of those Olympics (by Jerde and the Eames office alumna Sussman) with the 1968 Summer Games in Mexico City. In between it explores the way L.A.'s first important architecture critic, Esther McCoy, promoted the work of O'Gorman and other Mexican modernists in both the *Los Angeles Times* and *Arts & Architecture* magazine. It also includes fascinating material on the 1957 film *Day of the Dead* by Charles and Ray Eames, the influence of Mexican arts and crafts on the sculpture of Ruth Asawa, and the ways in which Maya, Aztec, and other pre-Columbian design motifs were borrowed first by American architects like Frank Lloyd Wright and his son, Lloyd, and later by a number of Chicano political activists.

On the top floor of LACMA's other Piano building, the Broad Contemporary Art Museum, is installed another PST exhibition with strong architectural overtones. "Home—So Different, So Appealing," which takes its title from an arch-ironic 1956 collage by British artist Richard Hamilton, brings together work by more than three dozen Latino and Latin-American artists on the subjects of domesticity, residential architecture, and the American Dream. Given that the subset of the American Dream that involves homeownership has long been inseparable from the idea of Los Angeles (this is the place, as everybody knows, of bungalows, glass boxes, and backyard swimming pools), the show is mining an especially deep vein; the focus on Latin American artists adds a layer of symbolism involving immigration and domestic labor. Among the standout pieces are "Under Discussion," a video by Jennifer Allora and Guillermo Calzadilla that shows a man circumnavigating the Puerto Rican island of Vieques in a motorboat made of a dining room table flipped upside down, and "Excision," by the Colombian artist Leyla Cárdenas, which consists of an almost impossibly thin slice of a Bogotá living room, from a house built in 1886, displayed in the center of the gallery, with each of its layers, from moldings to various coats of paint,


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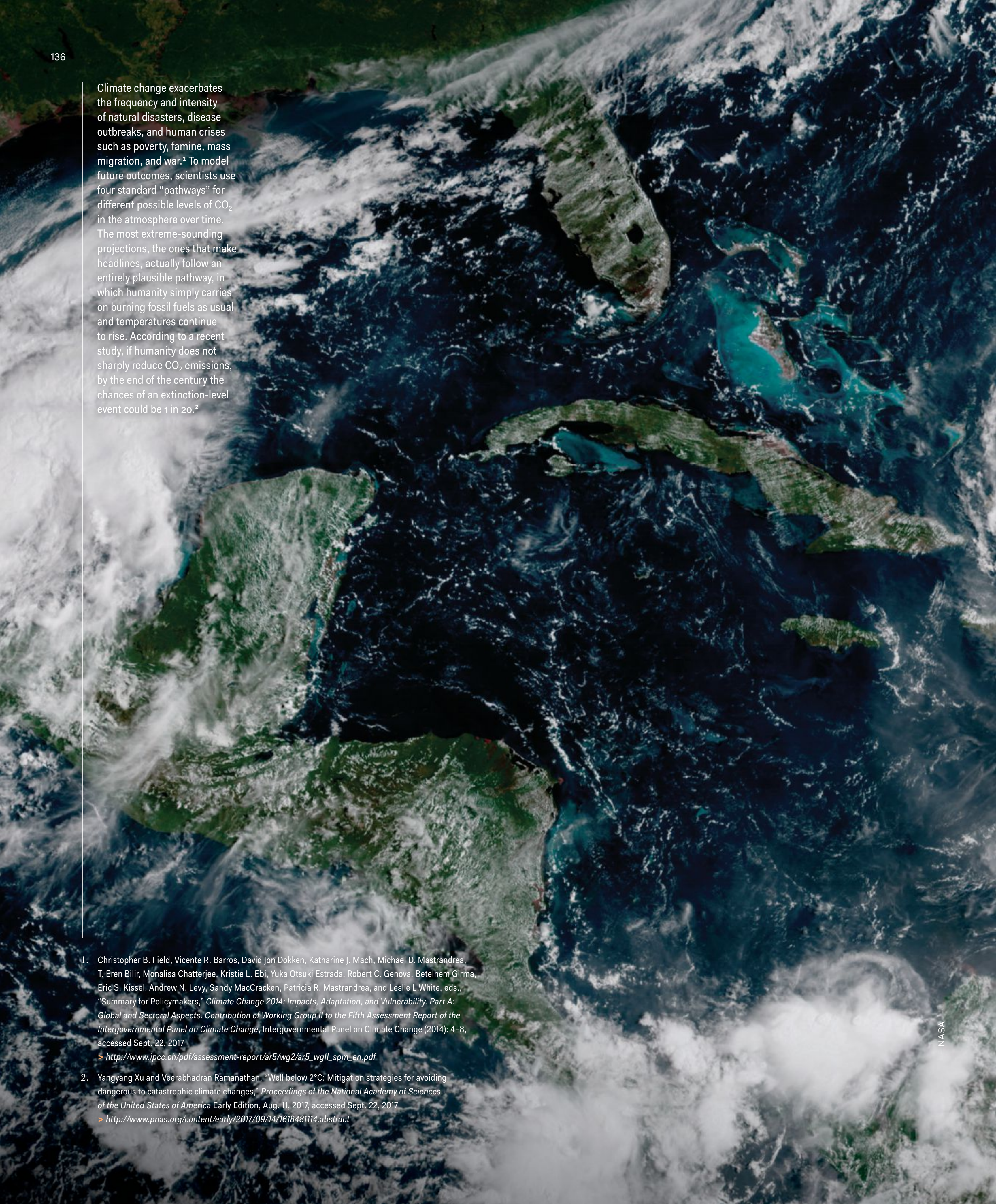
"A Country Condemned to be Modern"

Though not the biggest of the PST shows with links to architecture, "Condemned to be Modern," on view at the Municipal Art Gallery (MAG) next door to Wright's Barnsdall (aka Hollyhock) House, packs a serious punch. The MAG, operated like Barnsdall by the city of Los Angeles, scored a major coup in landing the show's curator, Clara Kim, moonlighting from her day job at the Tate Modern in London. She's organized an exhibition featuring work—some of it a few years old, some of it brand new—by Latin American artists who take modernist architecture, and often modernist state architecture, as subject matter. Its title is borrowed from the Brazilian critic Mário Pedrosa, who used the phrase to describe the peculiar architectural conditions of Brasília, his nation's just-add-water capital. ("We are a country condemned to be modern," he lamented.) In that sardonic spirit, the work in the show suggests the ways in which architectural modernity, as well as the economic variety, was often imposed on Latin American cities from the outside, less an inheritance than a kind of straitjacket.

Yet it doesn't stop there. The most affecting pieces in the exhibition suggest the tenderness with which many Latin Americans now see the decaying, sometimes abandoned products of that colonizing Modernism, and how much of it is now ripe for rediscovery by a new generation of artists and architects. In cases where the modern architecture was genuinely homegrown rather than forced on a subject nation, the tenderness can become nearly impossible to bear, as in a multimedia installation by the Cuban artist Felipe Dulzaides called "Water Runs." The work stars Cuba's vaulted, red-brick National Art Schools, designed in a burst of utopianism in the early stages of the Cuban Revolution by Ricardo Porro, Vittorio Garatti, and Roberto Gottardi. Dulzaides cleans the brick gutters of the ballet school with a hose, nudging out the leaves that have clogged them, and then films water as it trickles down roofs and across wide plazas. It's an act of archaeology, hopefulness, and palliative care all at once, touchingly highlighting a group of buildings that hover near death.

And it suggests that the role of PST extends well beyond the scholarly or historical. The series has grown flexible enough to include the sort of humanizing portraits of architectural experimentation that only an artist can provide.



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]

1. Christopher B. Field, Vicente R. Barros, David Jon Dokken, Katharine J. Mach, Michael D. Mastrandrea, T. Eren Bilir, Monalisa Chatterjee, Kristie L. Ebi, Yuka Otsuki Estrada, Robert C. Genova, Betelhem Girma, Eric S. Kissel, Andrew N. Levy, Sandy MacCracken, Patricia R. Mastrandrea, and Leslie L.White, eds., "Summary for Policymakers," *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Intergovernmental Panel on Climate Change (2014): 4–8, accessed Sept. 22, 2017
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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]

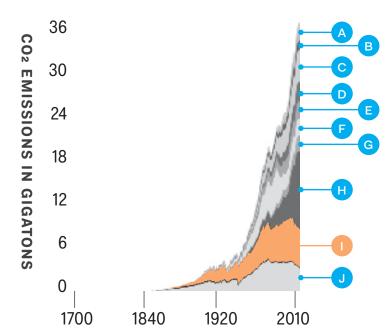
Architects face a choice: to remake the built environment so that it produces no CO_2, or to carry on, business as usual, and live with the consequences.

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

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.

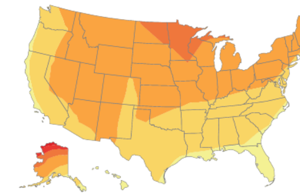
Government participation at all levels is necessary to encourage right action in the private sector, through research, underwriting, incentives, regulations, legislation, and leadership. Architecture has a relatively small financial footprint, and it will have to punch above its weight in Washington, 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

Projected U.S. temperature change by 2070–99

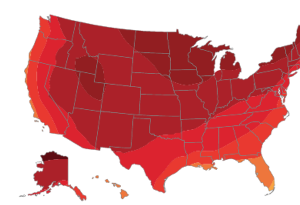


INTERMEDIATE EMISSIONS SCENARIO COMPARABLE TO GOALS OF PARIS CLIMATE ACCORD

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

SOURCE: NATIONAL CLIMATE ASSESSMENT

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.

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]

ROBYN BECK/GETTY IMAGES

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Burbank
TOWN CENTER
FITNESS
macy's
SEARS
LD NAVY
ED BATH &
EYOND
HOOTERS
macy's

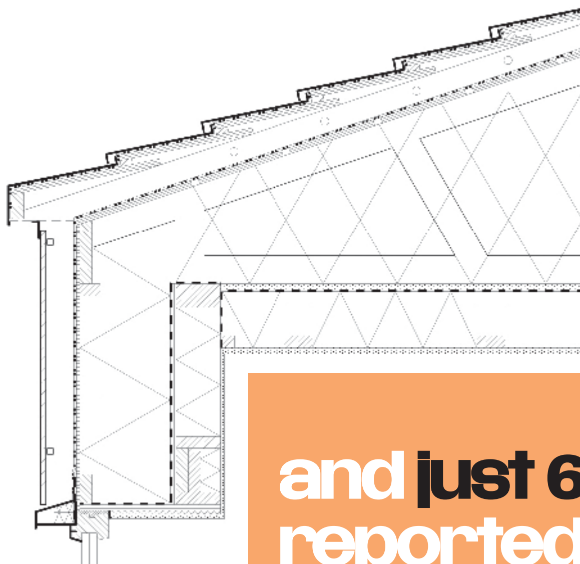
- 4240 Architecture
- AC Martin Partners
- ADD
- Adrian Smith + Gordon Gill Architecture
- Aecis Arkitektura
- AECOM
- Aedis Architecture and Planning
- Aidlin Darling Design
- Albert Kahn Associates
- Alliiance (formerly Architectural Alliance)
- Ankrom Moisan
- Ann Beha Architects
- ARC/Architectural 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
- Cunningham 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

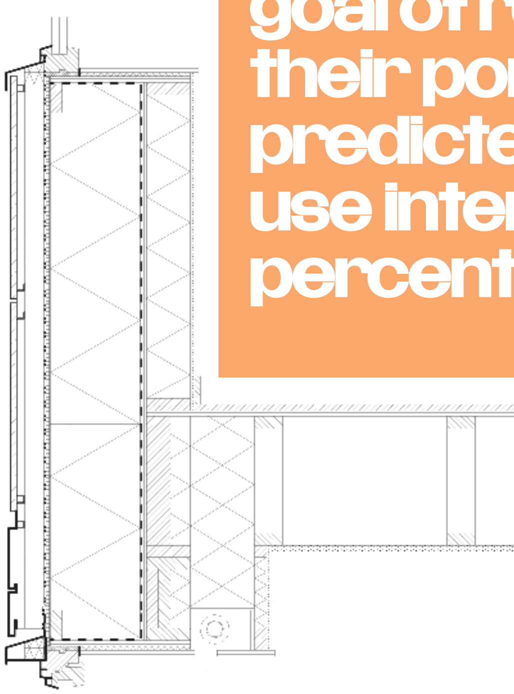
Out of the 20,000 or so architecture firms in the United States, 400 have joined the AIA 2030 Commitment to carbon neutrality...

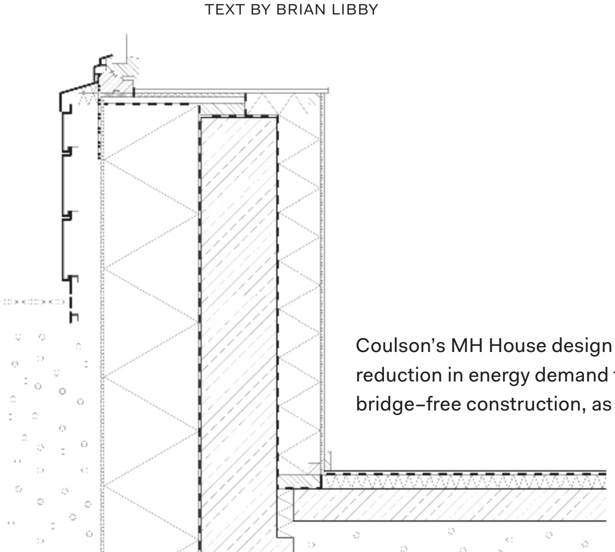
- Elizabeth Eason Architecture
- Elkus Manfredi
- Ellenzweig
- Elness Swenson Graham Architects
- ELS Architecture and Urban Design
- Emersion Design
- Engberg Anderson
- English + Associates Architects
- Ennead Architects
- Epstein
- ESG Architecture & Design
- Eskew+Dumez+Ripple
- EwingCole
- EYP
- 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
- 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.

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.

TEXT BY BRIAN LIBBY

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
> *http://www.nature.com/nclimate/journal/v7/n7/full/nclimate3322.html*

ROLAND NAGY

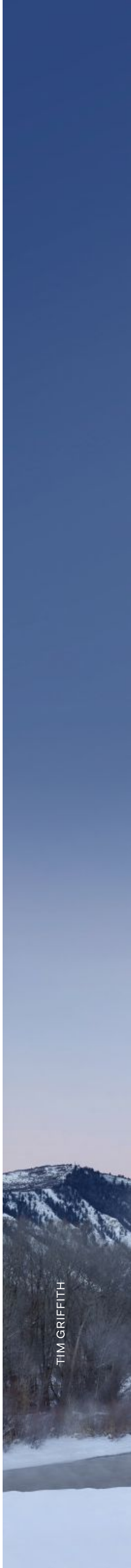
At this point, the technology exists for buildings to produce all the energy they need—and that needs to be the norm. Don't worry: It's not as hard as it sounds.

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.

ALAN KARCHMER/OTTO

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

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.

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."

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, 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.

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


COURTESY ARCHIMANIA

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.

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.

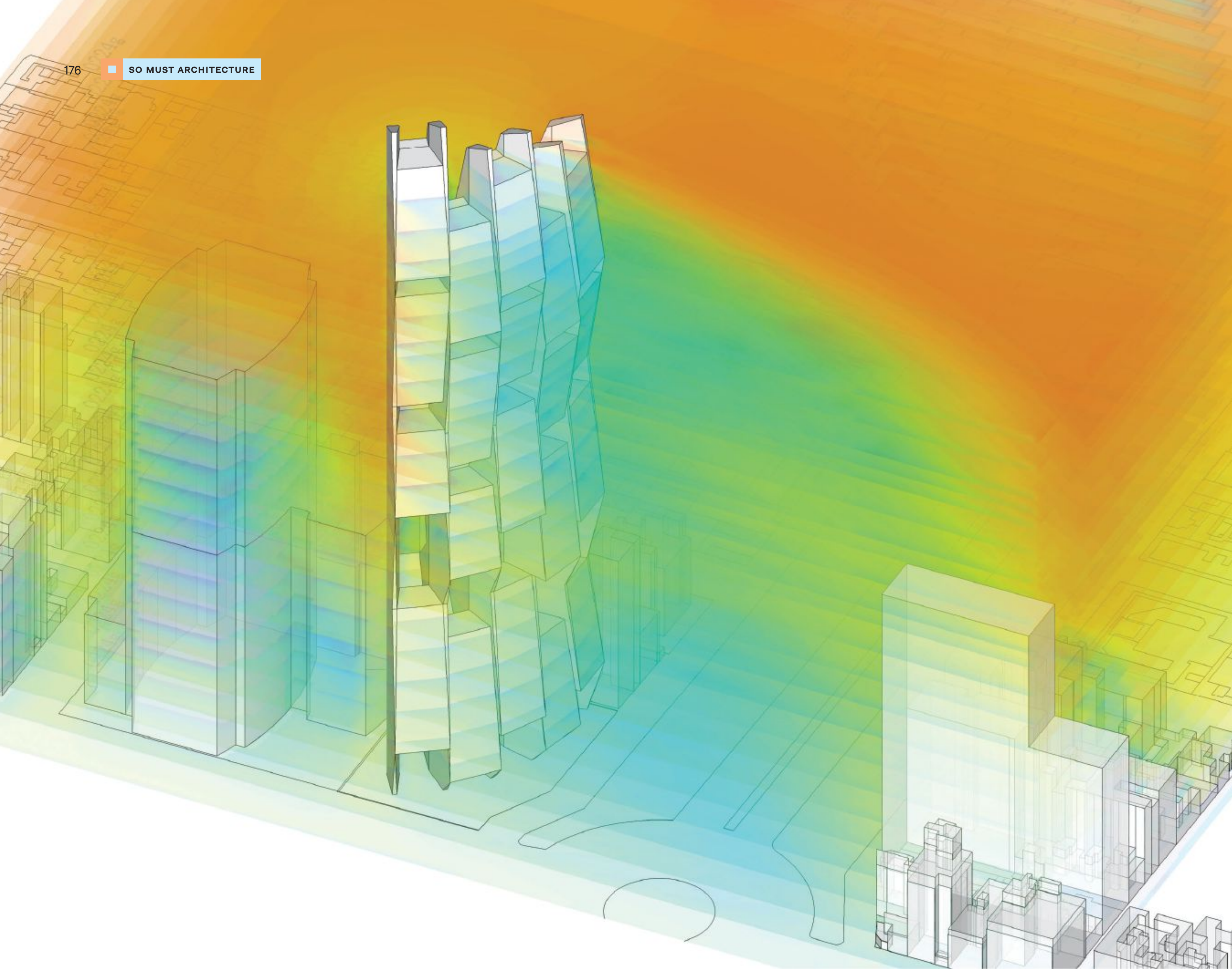
JEFF ELKINS

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]

STR/AFP/GETTY IMAGES

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

DUROPAL Gives You the Design Edge

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Residential:

TEXT BY ASHLEIGH POPERA

A team led by the Office for Metropolitan Architecture (OMA) with Fabrications and LOLA Landscape Architects has been selected to master plan and design some buildings for the Bajes Kwartier, a development on the site of Amsterdam's former Bijlmerbajes prison complex. Sold to AM Real Estate, the property will be remade into a 1.45 million-square-foot, primarily residential mixed-use complex with a restaurant, health center, and school. Ninety-eight percent of the materials from the prison structures will be reused: Prison bars will become balustrades and prefab wall elements will be used as cladding. Five of the six existing towers will be taken down to make way for the new complex; the remaining one will be transformed into an urban park for vertical farming. The prison's administrative building will become an arts and design center. The 1,350 planned residences include apartments, condos, affordable housing, and housing for students and seniors. Construction will begin in early 2018.

Once an Amsterdam Prison, Now Multifamily Housing

ROBOTA; COURTESY OMA

> *For more information about the Bajes Kwartier master plan, visit ARCHITECT's Project Gallery at bit.ly/BajesKwartier.*

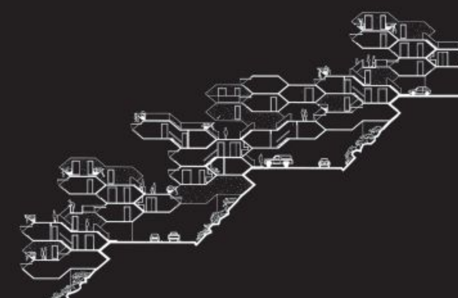
Mod Design Elevates Energy-Efficient Garage Doors

TEXT BY SELIN ASHABOGLU

Canyon Ridge Collection
Modern Series, Clopay

These faux-wood garage doors are available in sizes up to 10' tall and 20' wide, in plank, metal inlay, and full-view designs. The doors offer four layers of protection: 3"- or 6"-wide faux-wood composite planks that are resistant to rot and weathering, a steel layer, 2" of Clopay's proprietary Intellicore polyurethane insulation, and a steel backing. The Intellicore foam can provide an R-value of up to 20.4; it also reduces outdoor noise. The plank design option can be fitted with staggered, impact-rated glass inserts (shown above) measuring 14" long by 6" wide or 35" long by 6" wide. The metal-inlay design (top left) comes with slim aluminum inserts that stretch across the single or double doors, while the full-view design (bottom left) comes with gridded glass inserts offered in the same two sizes as the plank design. Five cladding options and four glass options are available. *clopaydoor.com*

> *To discover more garage door products, visit bit.ly/ModernGarageDoors.*



A Reflection on Moshe Safdie's Uncompleted Habitat Puerto Rico

TEXT BY SARA JOHNSON

Fifty years have passed since Moshe Safdie, FAIA, debuted his now-iconic prefabricated housing project Habitat 67 in Montreal for Expo 67. "He spent the decade after Expo designing versions of Habitat, for Washington, New York, Rochester, Baltimore, Jerusalem, and San Juan, Puerto Rico," wrote ARCHITECT contributor Witold Rybczynski, HON. FAIA, in a 1990 article for *The New York Times*. Rybczynski explained that only the Puerto Rico project "managed to get off the drawing table." However, the government pulled funding after only 30 of the 800 planned 430-square-foot units were built. "The '70s were, for me, a series of disappointments," Safdie told Rybczynski.

The new exhibition "In the Forest" at Chicago's Graham Foundation examines this stopped housing experiment. Artist David Hartt, an assistant professor of fine arts at the University of Pennsylvania School of Design, explores Habitat Puerto Rico with sculpture, photographs, plants, objects, sound, and a film—all of which Hartt produced himself—showing the project's original and alternate sites and how the remnants had survived decades after construction ceased. "In the Forest" runs through Jan. 6, 2018, and then travels to Ontario's Oakville Galleries.

FILM STILL: DAVID HARTT; SECTION DRAWING: SAFDIE ARCHITECTS

> Read more about the exhibition at bit.ly/HabitatPuertoRico.

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JENN-AIR

Michigan Lake House
Leelanau County, Mich.
Desai Chia Architecture with Environment Architects

TEXT BY NATE BERG
PHOTOS BY PAUL WARCHOL

Previous Page: A 20-foot-long cantilevered roof shelters an outdoor terrace on the house's southwest side.

This Spread: The master suite, seen here from the northwest, faces the lake.

Shortly after accepting a commission to design a weekend lake house for a family in northern Michigan, Arjun Desai, AIA, and Katherine Chia, AIA, founding principals of New York–based Desai Chia Architecture, took a trip to Japan that would have an unexpected and dramatic impact on their approach.

Their client sought a house that could stand up to Michigan's hot summers and snowy winters with minimal maintenance, and suggested the architects look at the Japanese shou sugi ban technique, which involves charring wood to a blackened crisp, making it resistant to pests and rot. The architects observed examples on ancient teahouses and shrines. "These buildings have been around for centuries," Chia says. It seemed an ideal solution.

The architects also took inspiration from traditional Japanese fishing villages, similar to building groupings found in fishing towns near the site on Michigan's Leelanau Peninsula—the pinky of the state's mitten-shaped Lower Peninsula. "The charm of those clusters of buildings was part of a local vernacular that I thought was really interesting," Chia says.

That clustering became the guiding principle of the house's form, which is three masses linked by a breezeway. One volume contains the kitchen and living rooms and connects to a covered terrace. The other two volumes hold the master suite and three additional bedrooms. The dining area sits in the breezeway, which also serves a performative role; the client insisted on not having air conditioning, so the breezeway and windows were oriented to the prevailing winds to encourage cross ventilation in the warm months.

The house's lakeside location has the potential for erosion due to snow accumulation in the winter months. Designed to reduce maintenance and risk, the butterfly roofs also direct drainage away from the house and into gravel beds and a dry well cistern for later use in irrigation. The local architect of record, Environment Architects, offered insights on the area's unique climate conditions. Principal Ray Kendra, AIA, says that the firm advised orienting the project to accommodate the path of the sun across a high latitude as well as how the lake affects snowfall.

The roof shape is evident inside, where the ceilings dip and rise, allowing the natural light to take on a different character in each vaulted space. Although the house's exterior is Japanese in inspiration, the interior is hyperlocal. Ash trees from the site, killed by an invasive pest, were milled nearby and reused for flooring, the dining room ceiling, the master suite bed, and custom nightstands and coffee tables throughout the house. "We wanted to connect the site and the house back to the landscape," Chia says.

Lower-Level Plan

First-Floor Plan

Opposite, Top: The house is clad in shou sugi ban siding from Delta Millworks.

Opposite, Bottom: Windows in the breezeway dining area encourage cross ventilation.

Wood flooring in the living area and elsewhere comes from on-site ash trees killed by pests, milled locally, and finished with Bona Naturale.

Project Credits

Project: Michigan Lake House, Leelanau County, Mich.
Client: Michael and Barbara Collins
Design Architect: Desai Chia Architecture, New York · Arjun Desai, AIA, Katherine Chia, AIA (founding principals)
Architect of Record: Environment Architects, Traverse City, Mich. · Ray Kendra, AIA (principal)
Structural: Apex Engineering & Management
Mechanical: Bayshore Engineering
Civil: Jozwiak Consulting
Lighting: Christine Sciulli Light + Design
Landscape Architect: Surfacedesign
Landscaper: Darling Botanical Co.
Envelope Consultant: James R. Gainfort AIA Consulting Architects
Custom Furniture: Woodbine Custom Furniture & Cabinetry
Audiovisual: Waara Technologies
Contractor: Easling Construction
Size: 4,800 square feet
Cost: Withheld


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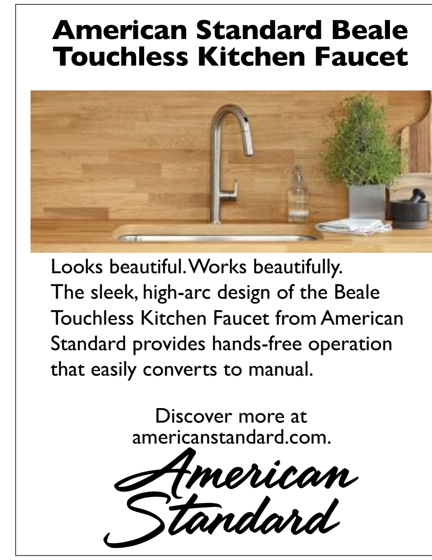
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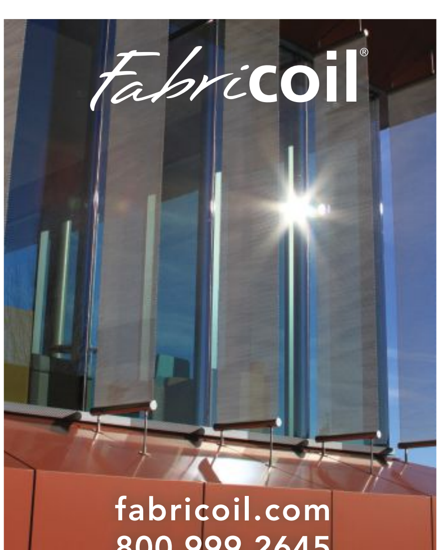
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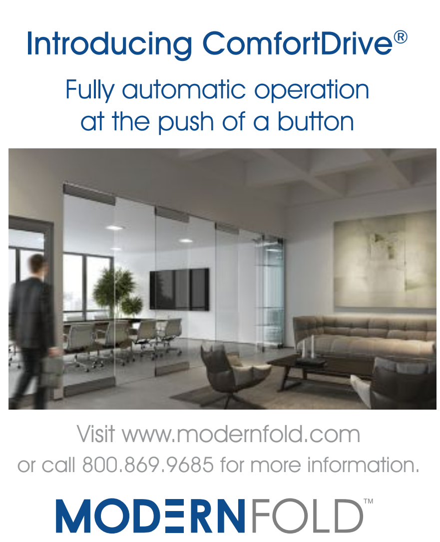
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Editorial:
A Brief Climate Change Reading List

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