AIA Committee on the Environment (COTE)
Top Ten Toolkit

Phase 1
June 2018

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…and to all those who have helped build the AIA's COTE community for 25 years and counting!

Foreword to the Top Ten Toolkit

Tool: *a means to an end*
The Top Ten Toolkit is a resource and framework based on COTE's Top Ten criteria, but *so much more*. Aligned with other AIA topics such as the 2030 Commitment, materials transparency, water conservation and resilience strategies, it is the easy-to-use repository for all things sustainable design.

Spearheaded by Corey Squire and Tate Walker, assisted by passionate architects from diverse firms both large and small, this is a set of recommendations and best practices that is built to be a highly accessible resource for anyone wanting to design healthy, high performing buildings. Incorporating a super spreadsheet, best practices, strategies, web links and resources, this is a beta version; we will be expanding the Toolkit to incorporate more resources and a database of case studies from previous COTE Top Ten award recipients. We welcome your comments and suggestions for future development!

I am very excited about the launch of this resource, most specifically because it is something that all firms can begin to use and integrate right away into their everyday studio work, without waiting for award season (though it will be immensely helpful for that). I hope you use this as a framework for design, to set goals, to confirm design performance, to inform clients, to compile post-occupancy information and last, but not least, more easily submit for COTE Top Ten awards.

Onward!

Angie Brooks, FAIA
2018 Chair of AIA COTE Advisory Group

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The AIA COTE Top Ten Toolkit Executive Summary

Limited access to high-quality, concise, and usable information is a major barrier to the universal adoption of sustainable design. The COTE Top Ten Toolkit is a resource, accessible to all architects, that closes the information gap to designing high performing, equitable, beautiful buildings. The toolkit is designed to provide relevant, general guidance to architects incorporating deep green principles from the beginning of every project.

Toolkit Framework

The COTE Top Ten Toolkit is collection of four resources that help guide design teams through the process of designing high performing buildings. Each of the resources is presented in a different format and answers a different set of question. Collectively, they form an integrated tool.

- **Best practice Design Guide:** What are the top ten measures about? What are the most effective strategies that can I incorporate into my projects to improve performance along each measure of sustainable design?
- **Super Spreadsheet:** How do I accurately calculate my project's metrics? How do I interpret these numbers?
- **Web tools and Resources:** Where do I go to learn more or dig deeper?
- **AIA COTE Award Recipient Case studies:** Where can I find projects and inspiration?

Development Process

The toolkit provides a meta-analysis of the top ten measures. While the measures themselves take the form of questions, patterns for addressing them begin to emerge from winning projects. The toolkit identifies some of the patterns and a talented team of subject matter experts curated the most relevant current resources to support them.

This draft represents Phase 1 in the process: information is collected and prioritized within the measures. The next phase slated to be completed by 2018, will bring additional refinements and interactive tools. The intent is to keep the resource current and add to it over time. Ultimately, this feedback loop informs refinements to the fundamental measures themselves. Of course, with any effort of this breadth, stuff gets left out or missed entirely. The toolkit development team kindly requests your feedback.

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Introduction

There was a time when the goal of the sustainability movement was to convince people that a problem exists. Those days are long gone. Today a majority of architects understand that global problems such as climate change, air pollution, exposure to environmental toxins, and even nature deficit disorder threaten our future. Architects also understand that the built environment plays a significant role as both a cause of many of these problems and as the solution. More and more architects see sustainable design as a major component of good design; and want to improve the social, environmental, and long term economic performance of their portfolios. The problem that most architects face is not a lack of concern about the environment, but the ability to achieve deeply sustainable projects among a myriad of competing priorities and ever tightening time frames. The COTE Top Ten Toolkit serves as that missing link. The toolkit democratizes sustainable design by making simple, high-impact sustainable design strategies available to the entire profession.

Very high performance is often seen as something only available to a few ambitious buildings with the right client, program, or budget. These high performers are important as examples of what's possible, but they will not solve our environmental problems by themselves. Though the AIA COTE Top Ten awards program recognizes only the top performing projects, the COTE Top Ten Measures and this toolkit can be used as a framework to guide the design of *all* projects. This toolkit is not a resource for the 1% of projects to achieve 100%, but for 100% of projects to achieve substantially better outcomes. Only through broad implementation of sustainable design strategies can we begin to tackle the social and environmental problems that our civilization now faces.

The COTE Top Ten Measures of Sustainable Design are useful criteria for evaluating a project after it is built, however, their true potential lies in how they are applied in the design process.

The advantage of a rigid set of sustainability guidelines is that they are easy to assign responsibility, track, and translate into the physical realm. Standardized guidelines reduce ambiguity, streamline sustainability to enhance its level of adoption on a project. These are critical first steps to transforming a risk-averse, cost-conscious construction industry. However, third party rating systems often seem separate from the design process itself, and often result in incremental changes that are invisible to the end user. Furthermore, they add a significant administrative burden to an already overtaxed design team.

In contrast, the COTE Measures provide the construct for an open ended dialog that facilities a more deeply integrated, visually rich, design solution. They lead the project with vision instead of a checklist, mandating design teams to address nuanced concepts of culture and place. They are accessible to a lay audience, in a language which they understand and can contribute. These questions not only illuminate opportunities to integrate sustainability, but to further a deeper understanding of our clients, future building inhabitants and communities in which they reside.

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There are an ever increasing amount of technical resources out there, and it is a full time job in and of itself to find, download, beta test and integrate it into project delivery workflow. A common refrain amongst sustainability professionals is, "What tool do you use to calculate 'x'?" We all have hundreds of spreadsheets or research papers floating somewhere in the cloud to solve these questions. Our task with the toolkit is to combine and consolidate the most current, useful, and objective resources for architects.

This toolkit focuses on topics that are largely quantifiable and tend towards a technical perspective. This is an unfortunate shortcoming, as the COTE Top Ten is fundamentally a *design* award at its core. Unfortunately, there are few resources out there, and virtually no agreement amongst professionals about what beauty is or how to achieve it. These shortcomings are also the source of COTE Top Ten's strengths, and we look forward to how future generations interpret these criteria.

The COTE Top Ten Toolkit meets project teams where they are now and helps to make incremental improvements in the performance of their projects by presenting project teams with curated, concise, and effective strategies for all ten measures of sustainable design. The goal of the AIA Committee on the Environment that this toolkit will begin to bridge the knowledge gap that exists in the architectural profession and lead to real measurable improvement in our built environment.

In A Statement of Where We Stand, the AIA outlines its core values.
· We stand for equity and human rights
· We stand for architecture that strengthens our communities
· We stand for a sustainable future
· We stand for protecting communities from the impact of climate change
· We stand for economic opportunity
· We stand for investing in the future
· We speak up, and policymakers listen

While "We stand for a sustainable future" is one of the central tenets explicitly stated, the COTE Top Ten Measures of Design incorporate all of these values within their structure. The big idea of the Toolkit is to integrate these core values in our daily work, and celebrate those few projects that achieve our highest aspirations with the annual AIA COTE Top Ten awards.

Namaste,

Corey and Tate

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How to Use This Guide

"Studs are placed 16" on center, windows are kept below 40% of wall area"

Designing a building is a complicated endeavor. Architects are expected to dream up imaginary worlds and then guide the transformation of these images into physical reality. If this weren't difficult enough, it all has to be done on a schedule and within a budget. The resulting building needs to stand up, not burn down, keep water out, manage heat, relate to its surroundings, and generally delight its occupants. On top of this, architecture doesn't get the benefit of an extensive period of trial and error, a custom designed building needs to function from day one.

In order to accomplish such a Herculean feat, architects would need to be masters of physics, chemistry, biology, economics, sociology, art history, logistics, human relationships, and a whole suite of other disciplines that are tangentially related to the built environment. In reality, architects don't know everything. We're generalists who need to understand just enough about each field to ask the right questions at the right time with the right people. Learning and implementing best practices and general rules is how architects size beams, lay out kitchens, design parking structures, and create comfortable courtyards. To design a high performing building, there's no need to spend years learning the inner workings of an energy model or the chemical composition if drywall. Just like all other aspects of design, understanding and implementing a suite of best practices is the most effective strategy for improving the performance of every building.

The COTE Top Ten Toolkit exemplifies a philosophy of best practices. For each COTE Top Ten Measure, the toolkit presents concise, simple, and easy to implement design strategies. The toolkit is not a textbook with thorough explanations of why the best practices are effective, nor does it go into detail with unusual cases or qualifications. It simply lists strategies that can be incorporated into the vast majority of buildings to improve their performance.

These best practices can be incorporated into a project in a variety of ways and can be used to facilitate your client's understanding and decision making process:

Charrette Planning: When planning a design charrette or any sort of team kick-off meeting, the measure topic areas can serve as organizing elements and discussion points. This way a broad range of topics are covered and important areas aren't left out.

Goal Setting: Specific best practices design strategies presented in the toolkit can be used as project goals. During a design charrette, or just early in a project, the the design team can review best practices and strategies that stand out, and establish project goals that can be tracked throughout the design process.

Benchmarking: The COTE Top Ten Measures reference many metrics for objectively tracking project performance. This guide, and the accompanying Super Spreadsheet can help teams

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benchmark their projects' metrics to see how they stand in comparison to other buildings of a similar type.

Understanding the Correct Range: Building performance metrics fall in typical ranges, and it can be easy to determine if something is off, and may require a second look, by comparing calculated metrics to their expected ranges. The accompanying "Super Spreadsheet" has a color coded system to ensure these calculated metrics are inline with what makes sense.

Understanding how design decisions affect outcomes: Once a project team understands where its building stands through benchmarking, implementing additional best practices can help optimize performance.

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COTE Top Ten Measure of Sustainable Design

Design for Integration	Central Design Concept Beauty and Delight Integrated Process
Design for Community	Walkability / Human Scale / Alternative Transportation Community Engagement & Buy-In Social Equity
Design for Ecology	Landscape Dark Skies Bird Friendly Site Acoustics Biodiversity / Habitat Bioclimatic Design
Design for Water	Indoor Water Efficiency Outdoor Water Use Reduction (Irrigation Reduction / Elimination) Process Water Reuse (ex. Condensate) Recapture/Reuse of Greywater and/or Blackwater Foundation water capture (if pumped) Rainwater/Stormwater Use and Management Net Zero Water Building (NZWB) Climate Change
Design for Economy	Building Size Material Use Operational Requirements Maintenance Requirements Financing and Incentives
Design for Energy	Energy Benchmarking Energy Modeling Predicted Energy Use Intensity (pEUI) Metered Energy Use Intensity (EUI) Passive Design Features On-Site Renewables (Solar, Wind)

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	Climate Responsive Design Project Type Response Education Post Occupancy Evaluation Operational Carbon Calculation Net Zero Energy Building (NZEB) Net Zero Carbon Building (NZCB) Commissioning
Design for Wellness	Daylighting and Lighting Thermal Comfort Indoor air quality Happiness Biophilia / Connection to Nature Food/Movement/Exercise
Design for Resources	Whole Building Life Cycle Analysis (LCA) Tracking building product Environmental Impacts Raw Material Sourcing Tracking Health Impacts Construction Waste Diversion Social Equity within the Supply Chain
Design for Change	Reuse Flexibility and Future Adaptability Resilience Passive Survivability Changing Climate
Design for Discovery	Post Occupancy Engagement Occupant and Operator Relationships / Graphic Signage / Training Sharing Lessons Learned Discovery that Influences Behavior

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Measure 1: Design for Integration

What is the big idea behind this project—and how did the approach towards sustainability inform the design concept? Describe the project, program, and any unique challenges and opportunities. Specifically explain how the design is shaped around the project's goals and performance criteria, providing utility, beauty, and delight. How does the project engage all the senses for all its users, and connect people to place? What makes this building one that people will fight to preserve? Give examples of how individual design strategies provide multiple benefits across the full triple bottom line of social, economic, and environmental value.

Focus topics:

- Central Design Concept
- Beauty and Delight
- Integrated Process

If you can do only one thing…

1. Design a building to lift the spirits and delight the senses.

Of the three Vitruvian virtues -- firmitas, utilitas, and venustas -- the following nine Measures of sustainable design will cover best practices for the first two. Integrating Strategies for achieving Firmitas, or firmness and utilitas, or function, might be difficult, but the formulas are relatively straight forward. If a design team adheres to the rules of thumb for daylight, the resulting building will be well lit or if a project team provides native habitat, the site's biodiversity will benefit. Developing Strategies for Venustas, designing a building that delights, is a much more difficult endeavor.

This is the idea behind Measure 1: Design for Integration. This is the place to talk about *Design*. People don't visit Fallingwater to see its low flow shower heads, just as the Pantheon hasn't survived for two millennia because of its non-toxic material pallet. While water conservation and material health are incredibly important elements of a high performing building, they can't stand on their own. These strategies and best practices must be integrated into a work of architecture and architecture has to be beautiful.

This toolkit doesn't offer much to project teams seeking to up their building's Venustas, but this doesn't make the concept any less important. As the authors of this best practice design Toolkit, we are issuing a request to our readers for resources to help design for delight. We hope the next iteration of this toolkit will include plenty.

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Suggested Best Practices

1. Write a Vision Statement that resonates with the design team, the investors, the operators and managers, the users, the community, and the client. A shared direction, that all stakeholders can rally around will set the stage early for positive outcomes.
2. Understand and take full advantage of everything the site has to offer. This can include community amenities, local climatic conditions, or a unique history. Wrap these opportunities into a big picture design concept that can incorporate sustainable design best practices from the other nine measures.
3. Take inspiration from architectural history. The buildings we revere today provide lessons for the aesthetics or concepts that future generation will want to keep around.

References

COTE Top Ten Award Recipients
More than two decades of COTE Top Ten award recipients and their case studies can be accessed from this link. Use these projects for inspiration of what sustainable design can be and how team use big ideas to bring together excellence across measures. In a future phase of this document, the case studies of all award recipients and many entrants will be provided in a searchable database.

Lessons From The Leading Edge
This 2016 Report from the Committee On The Environment analyzes trends among 20 years of projects that received a COTE Top Ten award.

BuildingGreen: How To Run a Great Workshop: 37 Tips and Ideas
Whether you call it a charrette, a workshop, or simply a meeting, these suggestions from experts will make your next event more fun and productive.

Integration at its Finest
A thoroughly researched up to date guide on Integrated Design for the GSA that takes a deep dive into 3 different COTE award recipients. It includes a comparative analysis across several categories found in high performance buildings.

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Measure 2: Design for Community

Sustainability is inextricably tied to the wellness of communities. Describe specifically how community members, inside and outside the building, benefit from the project. How does this project contribute to creating a walkable, human-scaled community inside and outside the property lines? How were community members engaged during the design and development process? How does the project promote social equity at local, regional, and global scales? Because transportation-related emissions negatively affect public health, and because CO_2 emissions associated how those reach a building are frequently comparable to the CO_2 emissions associated with operating the building, describe how the project, by its siting and operations, helps reduce transportation-related emissions.

Focus topics:

- Human Scale / Walkability / Alternative Transportation
- Community Engagement and Buy-in
- Social Equity

If you can do only one (or three) things…

1. Seek creative strategies to promote alternative transportation and decrease the dependence on single occupancy vehicles.
2. Identify your community and ask them what they want.
3. Go out of your way to make the project accessible to someone who might not have otherwise benefited from it.

Though this measure touches many diverse topics, one common theme is addressing the impact that cars have on our urban environments. Our dependence on single occupancy vehicles does not just carry an environmental cost of carbon emissions, but also a community cost of decreased social interaction, a safety cost due to vehicular accidents, an equity cost regarding highway placement and access, and a health cost of decreased walkability and increased particulates (just to name a few).

Architecture that promotes alternative transportation can go a long way towards correcting a century of urban planning scaled to cars rather than people. Focus on strategies that give everyone the freedom to choose among multiple ways of safely and comfortably commuting to the building. Strategies that decrease the number or increase the cost of parking spots will better reflect the true cost of driving and encourage people to look for other modes of transportation. Strategies that increase density and promote mixed use development also further this goal.

The other two high-impact strategies are about broadening our concept of both the design team and the occupant group. Extending the bounds of the design team to include the community will result in a broader pool of ideas and a more relevant project. Extending the bounds of the

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occupant group to those who might not otherwise use the building will result in a more diverse, accessible, and welcoming final product.

Suggested Best Practices

1. **Human Scale / Walkability / Alternative Transportation**
   a. When possible, choose a site that has been previously developed, is close to a variety of amenities, and gives occupants a range of transportation options, including cycling and public transit.
   b. Every effort should be made to minimize the number of onsite parking spaces. As a baseline, no more parking spaces should be provided than is required by code, and seeking strategic ways to decrease that number further is even better.
   c. Minimize the visual impact of parking areas by burying, stacking, covering, or moving them to the backside of the project. Use landscaping and pedestrian walkways to help surface parking that is required to visually disappear.
   d. The primary building entrance should be designed for pedestrians, while those arriving by cars should either be directed to the main entrance via a pedestrian way, or enter the buildings through a secondary entrance on a lesser facade.
   e. Don't just add bike racks; design the bicycle entrance sequence. Provide bike racks that are covered, secure, and will not damage bikes. Provide ramps, and wide doors for easy access. Provide showers, lockers, and a system for drying towels. Provide bike storage for 25% to 50% of FTEs and showers for 3 to 5%.
   f. Scale all on-site environments for human occupants**.** Reference the Living Building Challenge Imperative 15 "Human Scale & Humane Places" guidelines for best practices. https://living-future.org/lbc/equity-petal/
   g. Maintain diverse, visually interesting environments along the site edges with plantings, landscape furniture, public art, and buildings articulation to encourage the community to interact with the project site.
   h. Make an effort to improve the environment immediately beyond the site. Advocating for new public transportation lines, community gardens in street medians, or speed bumps and stop signs are a few ways that the building can engage its immediate surroundings.
   i. Provide adequate lighting for safety. Light the path and keep luminaires out of all lines of sight. Limit dead ends and/or visually isolated spaces that may pose security concerns.

2. **Community Engagement and Buy-in**
   a. A first step to community engagement is to know who your community is. Define this group early, identify its leaders, and communicate with them. If someone thinks that they're a stakeholder, they probably are and should be treated as one.
   b. Use tools and processes for working with communities that balance sustained engagement with the design team's limited resources of time and budget. Examples include the KJ method, Elito Method, Personas, and Design

Ethnography. (See EDR's Community Engagement Toolkit in the resources section below.)

c. Provide avenues for community feedback such as public meetings and presentations. Work to foster citizen committees tasked with collecting and channeling feedback and provide opportunities for anyone to offer their thoughts.

d. Be sure that all community feedback is addressed with either a design change or an explanation as to why a desired design change will not work. Track comments and find a transparent way to communicate design decisions and progress.

e. A project must benefit both the client and broader community. The architect's challenge is to find ways to keep both parties satisfied. When the client suggests a design or strategy that goes against the best interest of the community, it's the professional responsibility of the architect to push back and seek solutions that are mutually beneficial.

f. Buildings should be proudly part of their community. Boundary walls and fences should be avoided in most (but not all) circumstances.

g. Ensure that the building does not block off any segment of the population from nature**.** Reference the Living Building Challenge Imperative 16 "Universal Access to Nature & Place" imperative guidelines for best practices. https://living-future.org/lbc/equity-petal/

h. Improve the safety and security (both real and perceived) of the community by placing "eyes on the street". Arrange workstations and residential units to look over public spaces so the community can literally look out for each other.

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Social Equity

a. First, do no harm. All design solutions should benefit not just the client, but the occupants, the community, the local ecosystem, the world as a whole, and the future of humanity. The interests of these groups are occasionally at odds and it is the job of the architect to find solutions that improve the health, safety, and well-being of all.

b. Strategies that improve access for the physically disabled, such as wide entrances, smooth thresholds, and ramp, also benefit families with strollers, bicycle commuters, and those with temporary physical injuries. Efforts should be made to design for wheels, even when not required by ADA.

c. Just as all buildings are required to be accessible to those with physical disabilities, buildings should be accessible to those at an economic disadvantage as well. Strategies include on-site amenities, welcoming public spaces, and special programs, such as museum free nights. Defensive design strategies should not be used.

d. Include one mother's room for every 200 FTE. See reference below for AIA's recommendations for designing a mother's room.

e. Within the office, make every effort to comprise teams that are culturally and economically diverse. Use this same strategy of intentional diversity when hiring consultant teams. A design team with more diverse backgrounds and perspectives is usually more creative and innovative. Their design solutions are often more comprehensive.

f. Architects should set the standard of socially equitable corporate policies by pursuing social equity and transparency programs such as the JUST label from the International Living Future Institute. Make an effort to work with consultants and sub-contractors as well as specify products from manufacturers who follow equitable business practices.

g. All projects, sites, programs, and communities have complex and winding histories that can, when researched and understood, deepen the meaning of a project's concept and cement it as part of an evolving narrative. When the full context of a design decision is not fully understood it can inadvertently send a message that is counter to what was intended. Best practice is to do the research to fully understand the broader context that you are designing in.

h. People tend to group with others from similar backgrounds. Architecture can be used to encourage chance encounters. Strategies include centralized communal spaces, such as kitchens or bathrooms, that everyone needs to visit. Wide stairs that are well daylit and prominently located are also great places for impromptu conversations and connections.

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Resources

BuildingGreen: Community-Scale Sustainability: Accelerating Change for People and Planet
By working at the neighborhood scale, designers and developers can more dramatically improve environmental performance and social equity.

Happy Homes Toolkit This best practice toolkit came out of research for the 2013 book, *Happy City.* Based in cognitive science and global case studies, The toolkit presents design strategies for creating dynamic, social, and happy urban environments.

League of American Bicyclists   A bicycle commuting advocacy group that has been around since before cars. The website has a wealth of information on designing and advocating for cyclists, and information on how to create a bicycling friendly business.

EDR Community Engagement Toolkit   This document describes a framework for community engagement that can provide tangible results in an expected timeline, therefore allowing a process of public participation to be accounted for throughout the phases of design.

Arnstien's Ladder of Social Engagement A classic article describing degrees of community participation in decision making processes.

JUST JUST, administered by the International Future Institute, is described as "a nutrition label for socially just and equitable organizations". The program is a great tool for establishing business operations best practices.

AIA Recommendations for Designing Mothers' Rooms This best practice guide goes over all you need to know about designing a mother's room. Best practice is to include one in all buildings plus one additional mothers' room for every 200 FTEs.

AIA Blueprint for Better   A resource designed to help architects engage with their communities that communicates the importance of architecture to a diverse public audience.

LEED pilot credit IPpc89 - Social equity within the community
"The goal of the Social Equity within the Community pilot credit is to help projects address disparities in access and social inequities within a project's own community. In order to go beyond charity to support meaningful transformation, building teams must begin to understand the various parts of their communities and understand how they are connected, and community members (particularly those who are vulnerable, disadvantaged and underrepresented) must have a greater voice in decisions that impact them."

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Measure 3: Design for Ecology

Sustainable design protects and benefits natural ecosystems and habitat in the presence of human development. Describe the larger or regional ecosystem (climate, soils, plant and animal systems) in which the project is sited. In what ways does the design respond to the ecology of this place? How does the design help users become more aware or connected with place and their regional ecosystems? How does the design minimize negative impacts on birds or other animals (e.g., design to prevent bird collisions, dark-sky compliant lighting). How does the project contribute to biodiversity and the preservation or restoration of habitats and ecosystem services?

Focus topics:

- Landscape
- Dark Skies
- Bird Friendly
- Site Acoustics
- Biodiversity / Habitat
- Bioclimatic Design

If you can do only one (or three) things…

1. Design landscaping that's comprised of 100% native plantings, especially species that attract pollinators. Avoid all decorative turf grass.
2. Create a nighttime habitat by eliminating artificial light and sounds while no humans are present.
3. "Vision Zero" for bird strikes: Design to eliminate all building-related bird deaths.

Measure 3: Design for Ecology is unique among AIA COTE Top Ten measures in that it focuses solely on the natural world. Though the strategies presented, such as keeping the night sky dark and minimizing undesirable noises, will improve the environment for humans, this measure asks design teams to think beyond the anthropocentric world of traditional architecture and design specifically for the rest of biodiversity.

The number one strategy is to create landscaping with native plantings; a high impact strategy for saving water, decreasing maintenance costs, and providing habitat for local animals and insects. Compared to turf grass, the ecologically-dead, default solution that requires constant water and chemicals to stay green, native landscapes will literally buzz with life. Turf grass does have legitimate applications, such as for sports fields or play areas, but it should not be used as a decorative element.

The remaining strategies -- dark sky, bird safety, and site acoustics -- are all about downplaying the presence of the human world and making every site, whether a rural farmhouse or a downtown office buildings, a little more wild.

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Suggested Best Practices

1. **Landscaping / Habitat / Biodiversity**
   a. Native plants have evolved to thrive in their local environment without irrigation or soil treatment. Cover as much of the non-building area as possible with native plantings.This will also help create a comfortable micro-climate.
   b. Before beginning to design, take some time to understand the local ecology and ecological services that are available onsite. Develop the site in a way that protects or restores these ecological services links the land with ecological history.
   c. Preserve all onsite mature trees. Work with a landscape architect or arborist to assess existing tree health and appropriate building standoff distances. Establish and carry out a protection plan during construction.
   d. Use landscape elements to preserve or create habitat for local flora and fauna. Simple urban examples include birdhouses, bat boxes, and native plantings that support pollinators. Larger and more rural sites can create and preserve habitat for a wider range of species.
   e. Use landscaping as part of a natural pest control strategy. Plant species that repel mosquitos and other pest insects. Maintain appropriate clearances between landscaping and the building to protect less durable building materials.
   f. Every bit of habitat counts. Even if the only possible intervention are a few native flowers in a planter box, those plants contribute to an ecosystem that can now support a few additional butterflies.

2. **Dark skies**
   a. Maintaining dark natural environments is a major consideration for exterior lighting design. Reference the outdoor maximum illuminance guidelines from the International Dark Skies Association's "Guidelines for Good Exterior Lighting".
   b. All exterior luminaries should be full cutoff, and aimed toward the surface that needs to be illuminated. Every effort should be made to keep the luminaire out of everyone's line of site.
   c. Site lighting should be scheduled to turn on at sunset and turn off by the time the occupants have left the property or retired indoors.
   d. Site lighting that remains on all night should be avoided. If nighttime site security is required, a combination of night vision cameras and motion activated lights can be used to keep the site both dark and safe.

3. **Bird friendly design**
   a. Roughly 100 Million birds die every year in North America by flying into windows. Without bird safety design, every building in the country will kill 1 to 10 birds every year. Strategies that prevent windows from looking like their surrounding environment will project birds and the ecosystems that depend on them.

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b. Birds tend to fly into expanses of reflective glass. A dense exterior shading system and low reflectivity glass will make windows obvious to birds.
   c. Bird safety is yet another benefit of limited glazing area. Keeping the window wall ratio below 40% will improve energy performance, daylighting, thermal comfort and reduce bird deaths.
   d. Minimize glass in the tree canopy or near water features to avoid reflected foliage and water look like they continue into the building. This is known as the oasis effect.
   e. Bird safe glazing has a pattern that birds can see but humans cannot. It's more expensive than standard glazing, but allows for unobstructed expanses of glass that birds won't fly into.

4. **Site Acoustics**
   a. Some site elements, such as compressors or chillers create unwanted site noise and vibration. It's important to place these elements away from spaces used by people or animals. The design team has less control over other acoustical sources, such as highways or flight paths. In these situations, shape the building or other site elements in a way that shields the occupants and their neighbors from site noise.
   b. The most effective way to control environmental noise is by physically blocking the source with a solid barrier. The barrier should be placed as close to either the source or the receiver as possible. The closer to the halfway point the barrier is, the less effective it will be. Shielding noise sources with plantings is significantly less effective.
   c. Send unwanted noise to the sky by angling sound barriers upwards. This is more effective than a flat surface which will reflect it back towards the source. An example is the curved sound barriers used at airports.
   d. The amount of sound that can travel through the air is determined by the air's density. Air becomes denser as it gets drier or colder, creating more environmental acoustical challenges in dry or cold climates.
   e. Sound masking of unwanted site noise can be accomplished with water features, wind features, kinetic art, beehives, or pollinator gardens.

Resources

BuildingGreen: Denver Votes Green Thumbs Up for Green Roofs
A city suffering from ozone pollution and the heat-island effect approves a ballot measure requiring green roofs.

International Dark Sky Association
This is the no to source for appropriate outdoor lighting levels, dark sky approved lighting fixtures, design strategies, research, and educational materials.

Bird Friendly Design Guidelines

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This guide, by the American Bird Conservancy, outlines many strategies to protect and support birds in urban environments.

Seven Principles of Xeriscaping
"Originally conceived by Denver Water, the seven design principles of xeriscaping have since expanded into simple and applicable concepts to creating landscapes that use less water."

Lady Bird Johnson Wildflower Center
Though it's located in Central Texas, The Lady Bird Wildflower Center is a great resources for looking up native species in any region.

Measure 4: Design for Water

How does the project use water wisely and handle rainfall responsibly? Sustainable design conserves and improves the quality of water as a precious resource. Illustrate how various water streams flow through the building and site, including major water conservation and stormwater management strategies. How does the project relate to the regional watershed? Describe strategies to reduce reliance on municipal water sources. Does the project recapture or re-use water?

Focus topics:

- Indoor Water Efficiency
- Outdoor Water Use Reduction (Irrigation Reduction / Elimination)
- Process Water Reuse (ex. Condensate)
- Recapture/Reuse of Greywater and/or Blackwater
- Foundation water capture (if pumped)
- Rainwater/Stormwater Use and Management
- Net Zero Water Building (NZWB)
- Climate Change

If you can do only one (or three) things…

1. Calculate Indoor water use and savings (Benchmark)
2. Reduce or eliminate outdoor water use (Irrigation Reduction / Elimination)
3. Focus on rainwater runoff and mitigation strategies with the intent to improve quality and quantity onsite
4. Capture and reuse rainwater onsite (stretch goal)

Water is a resource that is essential to life. Our bodies are made up of 60% water. Many of us take this resource for granted -- we turn on a tap -- yet we are all aware of parts of the country, and the world who are challenged by access to potable water. With climate change, access to potable water is getting more challenged, so it is imperative to use our projects to demonstrate what is possible. In commercial buildings, 95% of the water demands are for non-drinkable water uses, and in residential buildings, roughly 50% of the water demands are non-drinkable water uses. We can do better. As architects, engineers, and members of the building community, we are asked by this measure to show how our project has reduced the use of potable water.

To reduce the amount of potable water in a building we study the use and needs of water in the building -- for fixtures, sewage conveyance, and process equipment, and the use and needs of water outside the building for landscape. We also look at our sources of water -- rain/storm water, condensate/blowdown, foundation drainage, well water, grey and black water, and utility supplied. And we look to find reductions in usage -- such as plants that do not require irrigation, or toilet fixtures that use little to no water, and strategic reuse of captured stormwater and/or

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captured grey water for use in irrigation, or for sewage conveyance. A bigger step is using the blackwater through a designed living system, or an engineering mechanical blackwater treatment system. Many projects can achieve 30% reductions over code through smart flush and flow choices. But more and more we are seeing solutions that target 50% or more. The ultimate success story is a net zero or net positive water building. (Described below)

Suggested Best Practices

1. **Indoor Water Efficiency**
   a. Use low-flow fixtures. Every major fixture manufacturer has low-flow fixtures. From faucets to shower heads to toilets, there are options for every application. (See WaterSense Below for low flow fixtures) To go even further, specify dual flush toilets, ultra-low-flush urinals, waterless urinals, or composting toilets, but understand that these technologies require additional maintenance and user training.
   b. Calculate the quantity of water used over the code baseline. The calculation is based on building occupancy -- full time employees plus visitors or guests -- over an annual basis. The Super Spreadsheet has a calculator that is will establish a baseline and show a percent reduction of water use.

2. **Outdoor Efficiency**
   a. Reduce or eliminate Irrigation demand. Work with a landscape architect and/or irrigation consultant to design landscapes that do not require irrigation. If irrigation is needed, best practice is to use collected rainwater and feed it through a drip system that is weather smart, so not to run during or just after a rain event -- if not linked to a weather forecasting system.

3. **Process water reduction**
   a. Depending on the type of building, process water might be used in buildings for industrial or manufacturing purposes, or in a more typical way, for washing dishes or clothes. Select water efficient dishwashers, washing machines, and water fountains. (See the link for Energy Star Products below.)
   b. Condensate from HVAC systems should always be captured and used for another purpose, such as irrigation or flushing toilets.
   c. Blower blowdown or chiller makeup water are both necessary to prevent the buildup of sediments in the system; however, these maintenance strategies use excess water in the process. See the EPA's Water Efficiency Management Guide for Mechanical systems for strategies.

4. **Recapture/Reuse of Greywater and/or Blackwater**
   a. Greywater is lightly soiled water that can be reused for non-potable water uses with minimal or no treatment. Common uses of greywater are irrigation and toilet flushing. Best practice is to use all water for multiple purposes before releasing it.

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b. Blackwater is heavily soiled water, from a toilet or commercial kitchen disposal, that is dangerous to humans and cannot be used until treated. Strategies for treating blackwater onsite include engineered composting systems or ecological water treatment systems.

5. **Foundation water capture (if pumped)**
   a. If your building foundation or elevator pits require a sump pump to keep groundwater from causing problems, this water can be an additional source of potable water (after treatment). Despite this benefit, foundation pumps are energy intensive. Best practice is to avoid foundation systems that require pumping whenever possible.

6. **Rainwater / Stormwater Use and Management**
   a. Rainwater that falls on the roof is much easier to collect and store than water that falls on the ground. Best practice is to catch this water to use for irrigation as a minimum. If water collection is not part of the project scope, create a "water collection ready" plan. So that a collection system can be installed easily in the future.
   b. The majority of stormwater should be managed where it falls. Projects that manage their stormwater onsite put less pressure on the municipal water system, help to recharge the groundwater supply, and generally keep our water resources cleaner. Strategies for managing water onsite include keeping impervious cover to a minimum and storing water, either for use or for delayed release. The amount of water that does runoff the site should match the site's pre-development conditions.
   c. Because all building sites have some amount of impervious surface, all stormwater cannot be managed on site without some storage. Options for stormwater storage include above ground cisterns, below ground cisterns, or infiltration basins. Stormwater that flows on a site's surface should be slowed down as much as possible with plants or obstacles.

7. **Net Zero Water Building (NZWB)**
   a. ILFI defines this as, "One hundred percent of the project's water needs must be supplied by captured precipitation or other natural closed-loop water systems, and/or by recycling used project water, and must be purified as needed without the use of chemicals. All stormwater and water discharge, including grey and black water, must be treated onsite and managed either through reuse, a closed loop system, or infiltration. Excess stormwater can be released onto adjacent sites under certain conditions."

8. **Climate Change**
   a. Climate change will affect water resources differently in different regions. Some regions are expected to get wetter, some regions are expected to get drier, and others are expected to experience increased deluges; getting more overall

rainfall from a few individual rain events. It's important to understand these trends so that a strategy is relevant for the entire life of the building. (See GlobalChange.gov in the resources section below.)

Resources

BuildingGreen: Net-Zero Water and More: Moving Beyond "Low Flow"
These emerging water strategies are finding momentum and filling the need to address efficiency and resilience on multiple scales.

WaterSense
An EPA-created label that identifies low-flow fixtures.

LEED v4 Water Use Calculator
Use this tool to benchmark indoor water use for a design project and the calculate the reduction that can be achieved.

Water Reuse Practice Guide
"the guide presents empowering information, real world examples and step by step design, construction and technical information needed for water use systems of all types and sizes at the building and district scale."

Water Risk Analysis - Aqueduct Water Risk Analysis
"These maps show where water-related risks are most severe."

Peter Gleick - The World's Water (Pacific Institute)
"The World's Water, Volume 9, released February 2018, is the latest volume of the series that has delivered key data and expert insights into our most pressing freshwater issues for the past twenty years."

US Drought Monitor
Updated weekly, this map shows current water scarcity throughout the US.

Earth Observatory Data and Images
Global maps showing ocean surface temperature, forest fires, air pollution, and other data.

Estimated Use of Water in the United States
Resources from the USGS. Tools for understanding water use at a national scale.

Energy Star Certified Products
Energy Star certifies appliances that conserve water was well as energy. Use this list of products for specifying commercial kitchen and laundry equipment.

EPA Water Efficient Mechanical Systems Guide

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Measure 5: Design for Economy

Providing abundance while living within our means is a fundamental challenge of sustainability. How does the project provide "more with less"? Possibilities include "right-sizing" the program, cost-effective design decisions, economic performance analysis, economic equity strategies, notable return-on-investment outcomes, contributing to local and disadvantaged economies, etc. Provide examples of how first cost and lifecycle cost information influenced design choices. Identify any additional first-cost investments and how they are anticipated to improve life-cycle costs and longer-term economic performance.

Focus topics:

1. Building Size
2. Material use
3. Operational requirements
4. Maintenance Requirements
5. Financing and incentives

If you can do only one (or two) things…

1. Reduce the program size or re-use an existing building.
2. Cut back on finish materials.

Sustainable design needs to be accessible to everyone. The strategies that lead to high performing buildings across all measures are only effective if they are implemented in real buildings and they will only be implemented on a broad scale if they make sense financially. There is a misconception in the industry that sustainable design add costs; and so only a few projects with high budgets and ambitious goals can afford to "be sustainable" or achieve high levels of performance across measures. *This could not be further from the truth.* While flashy features, such as solar panels do add additional upfront costs, most of the best practices in this guide are either cost neutral or come with significant savings. Right-sizing is one such strategy. Decreasing a building's square footage will save costs while conserving energy and material resources. Reusing an existing structure is another example of strategies for both lower cost and lower embodied energy.

Suggested Best Practices

1. **Building Size:**
   a. Space should be seen as a resource to conserve, just like water or energy. Efficient use of space is a good indicator of economical design. Showing a smaller SF (per person, per other metric) is the goal here.
   b. Strategies for reducing square footage include efficient building planning, designing program elements to overlap, building reuse, and eliminating program redundancies. Building programs should be designed for typical building operations and not for an occasional overflow event.
   c. Building efficiency ratio, or net square footage divided by gross square footage, can be benchmarked by building type and tracked during design as a project goal. (See Efficiency Ratio Benchmarking below)

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2. **Material use:**
   a. Limiting the material use is an indicator of economy. This can be accomplished by limiting finish products or eliminating superfluous materials to decrease total cost/SF. Consider using materials that serve multiple functions. For example, structural shear walls are intrinsically impact resistant as well as good sound and fire barriers.
   b. Think about how material choices improve building life span or ROI. More durable materials might cost more upfront, but could have significant long term ROIs
   c. Doing Life Cycle Analysis (LCA) can inform material selections/efficient material use.

3. **Operational requirements:**
   a. Designing to achieve a better energy and water performance also decreases the operational costs of a building. Designing for economy should focus on optimizing both upfront and operational costs. Strategies that improve performance without increasing costs are particularly effective.

4. **Maintenance Requirements:**
   a. Lowering maintenance requirements, by choosing more durable materials or materials that require less intensive cleaning or longer replacement cycles will make projects more economical to operate.

5. **Financing and incentives**
   a. Researching and maximizing the use of local, state and national incentives, grants, and financing options can justify long-term investments to improve performance. Examples include energy cost payback, water savings, measured productivity gains, third party power purchase agreements (PPA), etc.
   b. Always seek equitable economic solutions that improve opportunities for disadvantaged economies.

6. **Community links:**
   a. Locally sourced materials or constructions systems can form a link to the local economy. Choose materials that local craftspeople have experience with and give them some freedom to express their skills.
   b. Seek out opportunities for workforce training opportunities during the construction of a project. These opportunities teach valuable skills and provide the experience necessary for career growth and future employment.

Definitions and Technical Terms
- **Economy:** careful management of available resources.
- **Simple Return on Investment (ROI):** amount of return on an investment, relative to the investment's cost
- **Life Cycle Assessment:** a technique to assess environmental impacts associated with all the stages of a product's life from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance

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● **Life Cycle Cost Analysis (LCCA):** a method for assessing the total cost of facility ownership that impact both pending and future costs

Resources

AIA Guide to Building Life Cycle Assessment in Practice
LCA results can help answer numerous questions that arise during the design and construction of a green building. It can reinforce the decisions taken by architects by providing a scientific justification.

BuildingGreen: How to Build Green At No Added Cost
Avoiding cost premiums on green projects is not only possible: it's a good idea, focusing design teams on simple, effective designs that can deliver savings for years to come.

BOMA Benchmarking Report
Annual benchmarking of the cost of building operations.

Ellen MacArthur Foundation report on circular economy
The Ellen MacArthur Foundation works with business, government and academia to build a framework for an economy that is restorative and regenerative by design.

DSIRE
It's ok to access the Database of State Incentives for Renewables & Efficiency during work hours. It includes a comprehensive list of programs to support funding high performance aspects of your project.

How to Calculate and Present Deep Retrofit Value
An easy to follow guide to facilitate translation of high performance buildings into economic value to investors and clients.

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Measure 6: Design for Energy

How much energy does the project use, is any of that energy generated on-site from renewable sources, and what's the net carbon impact? The burning of fossil fuels to provide energy for buildings is a major component of global GHG emissions, driving climate change. Sustainable design conserves energy while improving building performance, function, comfort, and enjoyment. How did analysis of local climate inform the design challenges & opportunities? Describe any energy challenges associated with the building type, intensity of use, or hours of operation, and how the design responds to these challenges. Describe energy- efficient design intent, including passive design strategies and active systems and technologies. How are these strategies evident in the design, not just the systems?

Focus topics:
- Energy Benchmarking
- Energy Modeling
- Predicted Energy Use Intensity (pEUI)
- Metered Energy Use Intensity (EUI)
- Passive Design Features
- On-Site Renewables (Solar, Wind)
- Climate Responsive Design
- Project Type Response
- Education
- Post Occupancy Evaluation
- Operational Carbon Calculation
- Net Zero Energy Building (NZEB)
- Net Zero Carbon Building (NZCB)
- Commissioning

If you can do only one (or eight) things…
1. Benchmark
2. Establish design targets (LPD, window-wall-ratio, pEUI, etc.)
   a. *Limiting the window-wall-ratio may feel like a design restriction for project teams. Yet how designers leverage constraints to their advantage is one of the key considerations of the AIA COTE Top Ten Awards; celebrating both beauty and performance.*
3. Energy Modeling
4. Post Occupancy Evaluation
5. Operational Carbon Calculations
6. Optimize building envelope for climate (<40% glazing ratio, etc. vs. systems efficiencies)
7. Passive strategies
8. Behavioral patterns (automated window shades)

This particular topic is vast. As a generalist, it's particularly hard to master. The resources in the toolkit focus on the purview of the architect. For example, passive measures are usually the sole

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responsibility of the architect, but impacts other systems such as lighting and HVAC design will likely follow. Very high performing buildings will require some knowledge of all the resources in this measure, particularly by the design team leader and project manager.

High performance buildings have been a central focus in COTE's lexicon since its inception. So what is different now? With advanced technologies, new tools and workflows, the architect has an increased ability and responsibility to plan for high performance.

Suggested Best Practices

1. **Energy Benchmarking**
   a. This is a critical first step for every project. For a simple building this process can be done in an hour, and is easily accessible to an architect. A more complicated building type, or a more advanced analysis can take a day or more, but can yield greater insights into energy end uses, costs, and unique loads on the building.
   b. Benchmarking informs energy targets for a proposed design or renovation.
   c. The resources section below highlights several tools to help build a robust benchmark for most building types.
   d. Benchmarks are easily shared with the design team and owner, and are a basis for a deeper conversation about how the building is intended to work.
2. **Energy Modeling**
   a. The AIA's 2030 Commitment clearly demonstrates the relationship between energy modeling and high performance. When an energy model is performed, higher performance is a typical outcome. While energy modeling is very specialized, there are clear roles for the architect in the process.
   b. Build iterative energy modeling into your project's design budget. Whether the work is done in house, in cooperation with a utility program, or working with a consultant, there are many ways to integrate analytics that inform the design into your project.
   c. Consider the energy model as a cost-control measure, not as an add-on for sustainability. Energy is relatively easy to quantify and predict (as opposed to savings from daylighting), and the report can be used to manage first costs (system size), operational costs (utility bills) as well as other Non-Energy-Benefits (NEBs).
   d. If the scope of the project is too small for an energy model, managing the Window to Wall Ratio (WWR) and Lighting Power Density (LPD). These simple calculations are excellent proxies for energy modeling.
3. **Predicted Energy Use Intensity (pEUI) / Metered Energy Use Intensity (EUI)**
   a. If you have access to metered energy data, use it.
4. **Passive Design Features**
   a. Window to Wall Ratio (WWR)
   b. Air Tightness Testing (integrated mockup and whole building testing)
   c. Sun shading
   d. Operable Windows

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5. **On-Site Renewables (Solar, Wind)**
   a. An in-depth [study by NREL](#) shows a 60% decrease in cost of commercial PV systems over a seven year period from 2010 to 2017. PV costs continue to fall, such that renewables are now less expensive than some common energy efficiency measures.
   b. Coordinate system sizing and area of your array with NREL's PV Watts tool.
   c. While large scale on-site wind production can provide a significant amount of power to the building, it is only appropriate in certain conditions (usually very rural locations with uninterrupted wind sources).
   d. Building mounted wind turbines have not performed well in tests to date.

6. **Climate Responsive Design**
   a. Indigenous and native typologies offer great clues for climate responsive design. Prior to the advent of air conditioning and other modern technologies, materiality, massing, orientation, roof design, and penetrations were the strategies used to build comfortable and protective enclosures.

7. **Project Type Response**
   a. Much of a building's energy use is tied to its use. A hospital can be incredibly energy intensive with a baseline average EUI of 280, where an office might be 100. Look closely at occupancy schedules, occupant densities, operational hours, and physical form. How do these variables affect what measures are employed?

8. **Education**
   a. Providing users with transparent feedback on the building's energy performance (and how their consumption, conservation, and use patterns impact the bottom line) can impact user behavior.
   b. Feedback can also help building operators, and design teams, understand when systems are not performing as designed and may require commissioning or calibration. It may also help identify maintenance best practices, or help reset vacancy sensors or timers, that could provide significant savings.

9. **Post Occupancy Evaluation**
   a. See Measure 10 - Design for Discovery. There are strong parallels between Energy and Discovery.

10. **Operational Carbon Calculation**
    a. This calculation isolates the carbon emitted during the life of a building, as opposed to an 'embodied carbon' assessment that would include the carbon entrained in the materials.

11. **Net Zero Energy Building (NZE / NZEB)**
    a. A number of definitions exist, but for the sake of simplicity, it is a building that creates as much energy as it uses through renewable sources (typically PV or wind) over the course of a year.
    b. A challenging goal for any building, some project types might consider Net Zero Carbon a more accessible target. Project type, shape, size, and access to adequate renewable energy sources all factor heavily into a buildings ability to meet this goal.

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     c. A building is not considered to be Net Zero Energy until after at least a year of operations to be able to verify that it performs at this extremely high level. Third party verification or certification is highly recommended.

12. Net Zero Carbon Building (NZCB)
- a. A building that offsets as much operational carbon as it uses over the course of a year. This can include some mix of on site renewables and offsite Renewable Energy Credits (RECs).
- b. Prioritize energy efficiency and the use of on-site renewables over the use of RECs. RECs play a key role in a resilient and decentralized power grid made up of primarily renewable energy sources. However, it is far more impactful to minimize the energy used on site than to draw clean energy from a distant source. Consider achieving NZC with no more than 20% RECs.
- c. Consider a Power Purchase Agreement (PPA), where a portion of the building or site is leased to a third party for on site renewable energy. The owner receives the benefits of a low carbon energy source, without substantial first costs of the renewable systems.
- d. A higher priority should be placed on RECs that are local to the project.
- e. RECs must be third party verified, so that they cannot be sold more than once on the open market.

13. Commissioning
- a. Make sure the owner is getting the building they paid for. Cx can be expensive, but tends to payback quickly and provides valuable quality assurance / quality control. Scope can vary greatly, and should be carefully coordinated with the systems being proposed in design.

Resources

AIAU +2030 Series
The AIA+2030 Online Series is an AIA and Architecture 2030 co-production, sponsored by Autodesk and delivered through AIAU. It's based on the highly successful AIA+2030 Professional Series, which was created by AIA Seattle and Architecture 2030, with support from the City of Seattle and Northwest Energy Efficiency Alliance.

BuildingGreen: Why Schools Are Embracing Net-Zero Energy
Schools are leading the way in net-zero energy, but some designers question whether these goals create the best learning environments.

Climate Consultant
Great resource for climate analysis from UCLA. This simple program will generate a variety climate graphics based on .EPW weather files and help the user visualize opportunities for the most effective passive strategies.

Sun, Wind, and Light
A comprehensive textbook of passive strategies, tools and case studies tailored to climate.

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Energy Star Target Finder
A benchmarking tool for new buildings. It has been updated to use a more recent data set CBECS 2012+ as a baseline.

PV Watts
Calculates potential for on site solar generation and required areas. The only solar energy tool you'll ever need.

AIA 2030 Commitment Design Data Exchange (DDx)
Benchmarking epicenter for architects with over 10 billion square feet of recent new construction projects across all typologies to compare against.

Architecture 2030 Zero Tool
A benchmarking tool to quickly assess many building types for compliance with the 2030 Challenge, and assess the potential for Net Zero Energy or Carbon. It uses CBECS 2003 as a baseline.

AIA Architect's Guide to Integrating Energy Modeling
Provides a comprehensive list of energy modeling software, and approach for integrating it into the design process for best results.

Energy Star Portfolio Manager
A benchmarking tool for existing buildings.

ASHRAE Procedures for Building Energy Audits
A comprehensive description of Benchmarking for existing buildings and the relationship to Retro Commissioning them.

City Benchmarking Ordinances
A map based resource to see which cities and states have enacted or have considered building energy benchmarking and transparency policies.

Design Energy Simulation for Architects
by Kjell Anderson, *Routledge* 2014

ASHRAE Advanced Energy Design Guides
This set of program specific and climate zone specific guidelines will list values of wall insulation, window SHGC, and other metrics from project teams looking for effective benchmarks above code.

New Buildings Institute Getting to Zero Database
"NBI works to identify, research, analyze and promote commercial buildings that are leaders in low- and –zero energy performance outcomes. Here you will find in-depth information about

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high performance buildings across the United States, Canada, and beyond. The database includes information on measured and modeled energy performance, environmental characteristics, design process, finances, and other aspects of each project."

USACE Air Tightness Testing Standards
Guidelines for testing whole building air infiltration from the U.S Army Corps of Engineers.

Measure 7: Design for Wellness

Sustainable design supports comfort, health, and wellness for the people who inhabit or visit buildings. Describe strategies for optimizing daylight, indoor air quality, connections to the outdoors, and thermal, visual, and acoustical comfort for occupants and others inside and outside the building. How does the design promote the health of the occupants? Describe design elements intended to promote activity or exercise, access to healthy food choices, etc. Outline any material health strategies, including any materials selection criteria based on third-party frameworks such as Health Product Declarations (HPDs), Living Building Challenge Red List, EPA chemicals of concern, etc. Include key results on occupant comfort from occupant satisfaction surveys.

Focus topics:

1. Natural and Artificial Lighting
2. Thermal Comfort
3. Indoor Air Quality
4. Happiness
5. Biophilia / Connection to Nature
6. Food / Movement / Exercise

If you can do only one (or three) things…

1. Ensure that all occupied spaces have access to an operable window.
2. Give all occupants individual control over their immediate environment.
3. Allow occupants to experience natural, biophilic elements through a variety of senses.

Dr. Claudia Miller, an immunologist and researcher of indoor environmental health with the University of Texas, likes to say that "The goal of architecture should be to put doctors like her out of business." Though buildings are where we spend more than 90% of our time, strategies to promote the health and wellbeing of the occupants are not always a major consideration during design. One of the most effective strategies in this area is to ensure that all occupied spaces have access the light, air, and nature through an operable window. In general no desk or workstation should be more than 25 feet from an operable window and special attention needs to be paid to occupied spaces that have traditionally been mostly interior, such as kitchens or event spaces. The best design strategy to achieve this is to keep buildings narrow. Historically, buildings were only lit by the sun and could not be any deeper than daylight could penetrate into the space. Electric lighting and mechanical ventilation allowed deep floor slabs which pushed occupants further and further from the outside world, with tangible negative impacts on their health. Those without access to daylight and views, are less creative, get irritated more easily, and take more sick days, all at a significant expense to their community and the companies they work for. Providing daylight, fresh air, access to natural, and other biophilic design features will go a long way towards occupants that are happy, healthy, engaged, and productive.

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Suggested Best Practices

1. **Natural and Artificial Lighting**
   a. Daylight can only penetrate about 2.5 times the ceiling height into a building. Keeping floor plates narrow (5 times the ceiling height) and ceilings tall will result in a well day lit building. A building that must be deeper, should have a top lit atrium, maintaining the same 1:5 ratio from the exterior wall to the atrium. A single story building can be lit from above, and can have a deeper floor plate.
   b. For deep, single story buildings, plan on top lighting with either skylights, monitors, or sawtooth roofs. Skylights should be 5% to 8% of the total ceiling area, spaced 2 times the ceiling height away from an exterior wall and1 times the ceiling height apart.
   c. Whenever possible, orient the long axis of a building within 15 degrees of due East-West. This will make make the daylighting and shading strategy relatively straightforward and effective, and minimize excessive solar heat gain and glare that is more difficult to control when the sun is lower in the sky
   d. Daylight and view windows have different purposes and require different geometry. View windows exist between 3 and 7 feet above the floor; while daylight windows generally exist above 7 feet. Both are important for an enjoyable indoor environment.
   e. Daylight needs opaque, light, smooth surfaces on which to land, reflect and illuminate. Too much interior glass or dark surfaces will make a space feel dark, regardless of how much daylight comes in.
   f. Glare is not a problem of too much light, but rather a high contrast between light and dark surfaces. A bright, but unevenly lit space will appear dark and occupants will turn on electric lights. The best strategy is to daylight from multiple sources.
   g. Daylighting only works as an energy saving strategy if the lights are off. To ensure this, all buildings should include daylight sensors that control continuous dimmers. Lighting should be wired parallel to the exterior wall. Each row or each light should be individually controlled with a light sensor.
   h. Democratize daylight by moving public spaces to the perminater where the daylight can benefit the most people.
   i. Providing task lights will allow the overall lighting levels to be lower which saves energy. Task lighting will also give people added control over their environment which has been shown to increase satisfaction.
   j. Set target metrics: Look up (or have the lighting designer look up) target metrics for lighting power density and footcandle level for each space. Best practice is to design towards an established target appropriate to the anticipated tasks.

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2. **Thermal Comfort**

    a. Focus on thermal symmetry to ensure that conditions are similar throughout the space and through an individual body. Strategies to achieve this include optimized insulation, low U-factor window frames, spacing windows and fans evenly, shading South, East, and West glazing, and avoiding thermal bridges. Also pay special attention to the location of air registers.
    b. A building of substantial thermal mass is generally more comfortable than a lightweight building because the dense materials even out potential thermal asymmetry. This strategy is especially effective in regions with large diurnal shifts in temperature.
    c. Radiant systems, both heating and cooling, create more comfortable spaces than forced air systems. Physiologically, humans are more efficient at regulating our body temperature through radiation than convection. These systems also eliminate drafts and can improve air quality (with a lower energy profile that forced air).
    d. Giving individual occupants the ability to control their immediate environment will result in greater occupant satisfaction. Occupants report being more comfortable when they have controls, whether or not they actually use them. Humans also report greater thermal comfort in spaces with operable windows.
    e. Address all six factors of thermal comfort: Air temperature, humidity, mean radiant environment, metabolic rate, air movement, and clothing.

3. **Indoor Air Quality**
    a. Dirt tracked into buildings on occupant's shoes is a major source of indoor air pollution and intercepting this dirt is the first strategy for indoor air quality. For commercial buildings, particle interception is usually a 10 foot walk-off mat or entrance grille in the direction of travel. For residential projects, this can be a smooth, easy to clean surface or a mat at the foyer. Encouraging people to remove their shoes near entrance thresholds is another good particle interception strategy.
    b. Combustion from gas ranges, boilers, fireplaces, or water heaters is a major contributor of indoor air pollution, even with the use of fume hoods and exhaust vents. Indoor combustion within the conditioned spaces should be eliminated whenever possible. Consider using all-electric appliances and equipment (induction ranges, etc.) to capitalize on future connections to solar PV battery backup, and to match carbon-neutral utility grids in the next 20 to 40 years.
    c. Material off-gassing is another source of indoor air pollution. Choose "no VOC" over " low VOC" for paints, sealers, and adhesives. Pay special attention to finishes, furniture, fabrics, plastics, composite materials or anything else that might off-gas. Avoid flame retardants.
    d. Chemicals, such as cleaning products, should be stored in rooms with negative pressure and single pass ventilation. Laser printers and copiers emit VOCs and fine particulate matter and should also be segregated.

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e. All buildings in humid climates (Gulf Coast and Eastern Seaboard) should have a stand-alone dehumidification system to help prevent the growth of mold and mildew.

f. Choose a high quality air filtration system to eliminate airborne contaminants and provide dedicated outdoor air to keep indoor carbon dioxide to a minimum. It's important that the ventilation system is not connected to the primary thermal conditioning system so that fresh clean air can still be delivered to a space when heating or cooling is not needed. Incoming ventilation air can be tempered by mixing with recirculated conditioned air, or air exhausted through an ERV

4. **Happiness**

a. Good health is a great indicator of happiness. Strategies that promote human health, such as providing nutritious food and opportunities for exercise, will promote happiness as well.

b. We tend to get bored when presented with the same thing over and over again. The first apple is great, the second is less so, the third is fairly average, and the fourth might even decrease happiness. The saying "variety is the spice of life" is true in that we require new and ever-changing experiences to maintain happiness. Variety is best experienced over time rather than all at once. For example, one room that can transform and create a different experience each month is better than 12 different rooms that remain static.

c. Using the same amount of money for experiences, such as a dinner or a concert, will increase happiness more than purchasing an physical item. In fact, there is a negative correlation between quantity of possessions and happiness. Along these lines, occupants will often be happier with smaller houses and fewer storage spaces.

d. People are happiest when they perceive a sense of control of their own destiny. This can be as simple as being able to open a window or adjust a thermostat. Think about flexible spaces that can be individually manipulated and provide options to experiences different environments. Generally, the more choices (even if additional choices are unlikely to be chosen) will increase perceived control.

e. Self-actualization is the realization and fulfillment of an individual's feeling of self purpose. This takes place in the form of intense concentration and creativity and is often described by athletes, artist, or musicians as being 100% engaged on their task for an extended period of time. Achieving self actualization requires an environment free of nuisances and distractions. Glare, disrupting noises, thermal discomfort, poor air quality, etc.. are all factors that can prevent occupants from achieving their self purpose.

f. People describe their best experiences as "authentic." Creating authenticity by referencing culturally meaningful ideas will make people more likely to value an experience. This also helps root a project in the community, celebrating a unique sense of place.

g. An equitable environment makes people feel that they are respected and that their thoughts and opinions matter. These environments are more likely to

encourage trust and camaraderie and will encourage people to look out for each other. An inequitable environment will make people feel pressure to compete with each other over resources. An example of an equitable environment is one where organizational hierarchy is not manifested in the architecture.

5. **Biophilia / Connection to Nature**
    a. See "14 Patterns of Biophilia" and "Economics of Biophilia" by Terrapin Bright Green
    b. See International Living Future Institute's Biophilic Design Exploration Guidebook

6. **Food / Movement / Exercise**
    a. There is a fairly strong correlation between the healthiness of food and the energy required to prepare the food. For example, french fries are both less healthy to eat and more energy intensive to prepare than a fresh salad.
    b. Look for opportunities to produce food onsite. This could be with a vegetable or herb garden, fruit trees, chickens, bees, livestock, or wild edibles.
    c. As much as possible, advocate for high performance food (simple foods) to be served in high performance buildings. Focus on options that are healthy, plant based, and local, and generally low in embodied energy. At the very least, there should be healthy choices. This is especially important in schools.
    d. Advertising for unhealthy food, such as soda, candy, or fast food should be avoided.
    e. Establishments that serve food should have a designated place, either a board or screen where food nutritional information can be displayed.
    f. Design circulation around stairs rather than elevators. The logical flow of the building should be based on human powered vertical transportation. Move the elevators to a location that's less obvious or out of the way. Make the stairs beautiful.
    g. Include equipment or amenities for structured exercise, such as pull up bars or stretching contraptions, and/or flexible spaces for group exercise.
    h. Provide a variety of options for work stations, including adjustable-height sit/stand desks.

Resources

BuildingGreen: Do Living Walls Make for Cleaner Indoor Air?
Nedlaw Living Wall Biofilters do more than most green walls to remove VOCs, but it's unclear that they provide a true fresh air supply.

Daylight Pattern Guide
This guide from the "Advanced Buildings" Gives rules of thumb for spacing windows and skylights in a variety of spaces. This is a great tool to reference when placing glazing.

CBE Thermal Comfort Tool

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The Center for the Building Environment published this free tool for modeling thermal comfort. Use this tool to test the effects of altering any of the six major factors of human comfort.

14 Patterns of Biophilic Design
Terrapin Bright Green's authoritative work on biophilic design.

Economics of Biophilia
TBG's 2015 follow up report documenting financial returns associated with health and wellbeing.

Biophilic Design Exploration Guidebook
A resource to help project teams meet the requirements of Living Building Challenge's imperative 9: Biophilic Environment

Indoor Air Quality: EPA
The EPA has great resources for designing and maintaining healthy indoor air quality in buildings.

Conditions and Chemical Exposures
A partial list of indoor contaminants and the health conditions that they can cause

Risks of Too Much Sitting
This article from the Mayo Clinic reviews the health risks attributed to sitting for a long period of time and offers some design strategies for preventing a sedentary lifestyle.

LEED Maximum VOC
This resources from the USGBC defines maximum VOC levels for a variety of products.

Active Design Guidelines
"The Active Design Guidelines provides architects and urban designers with a manual of strategies for creating healthier buildings, streets, and urban spaces, based on the latest academic research and best practices in the field."

World Happiness Report
Annual report on where people are happiest. The criteria used is a helpful framework for thinking about happiness in buildings.

Glazing and Winter Comfort Tool
The outcome of a research project from Payette, "This tool displays the impact of glazing geometry and U-value on occupant thermal comfort during winter months. It shows when it is possible to eliminate perimeter heat in cases where the U-value is low and windows are small."

WELL Building Standard, v2 pilot

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Third-party certification standard that recommends strategies to optimize design, operations, and human behavior to advance human health and wellbeing. The v2 pilot was publicly launched in May 2018.

WELL Community Standard, v1 pilot
International WELL Building Institute's district-scale benchmark for healthy, inclusive, equitable, integrated and resilient communities.

Health Data.org
Here's a great resource to understand what we are dying from. With this as a guide, architects could target solutions to address these concerns.

Measure 8: Design for Resources

Sustainable design includes the informed selection of materials and products to reduce product-cycle environmental impacts while enhancing building performance. Describe efforts to optimize the amount of material used on the project. Outline materials selection criteria and considerations, such as enhancing durability and maintenance and reducing the environmental impacts of extraction, manufacturing, and transportation. Identify any special steps taken during design to make disassembly or re-use easier at the building's end of life. What other factors helped drive decision-making around material selection on this project?

Focus topics:

- Whole Building Life Cycle Analysis (LCA)
- Tracking building product Environmental Impacts
- Raw Material Sourcing
- Tracking Health Impacts
- Construction Waste Diversion
- Social Equity within the Supply Chain

If you can do only one (or four) things…

- Calculate carbon emissions associated with building construction, including the extraction and manufacturing of materials used in construction (lbs CO_2/sf).
- Request and track building products used on the project that can provide material transparency documentation and give priority to manufacturers who provide this documentation.
- Track raw material sourcing and prioritize products that are extracted or sourced in a responsible manner.
- Work to minimize the construction and demolition waste stream from your project.

Materials selection is perhaps the most clearly defined responsibility of an architect, and yet, the goals for sustainable materials are varied and sometimes mutually exclusive. Traditionally, materials were selected for durability and accessibility. First generation sustainable metrics sought to reduce waste, prefer regional materials, and reduce VOC's. Second generation goals focus on reducing embodied carbon and providing transparency about their ingredients. Architects are working closely with manufacturers to develop new materials that are sustainably sourced, 'red list' free and fully transparent.

Suggested Best Practices

1. **Whole Building Life Cycle Analysis**
   a. A Whole Building Life Cycle Analysis (LCA), is like an energy model for a project's materials. Running an LCA will help to determine which materials are

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having the greatest environmental impact allowing the design team to make targeted improvements. Tools for preparing a LCA include Tally, Athena, One Click LCA, and GABI. (see links and case studies below)

2. **Tracking building product Environmental Impacts**
   a. Require material impact tracking by contractor during entire construction process. This information should be reviewed monthly during payment review to assure material tracking goals are met.
   b. Environmental Product Declarations (EPD)
      i. https://spot.ulprospector.com/en/na/BuiltEnvironment/
   c. EPDs track impacts in the following categories:
      i. Atmosphere:
         1. Global Warming Potential
         2. Ozone Depletion
         3. Smog/Photochemical Ozone Creation Potential
      ii. Water:
         1. Acidification Potential
         2. Eutrophication
      iii. Earth
         1. Abiotic (resource) Depletion – Elements and Fossil Fuels

3. **Raw Material Sourcing**
   a. Responsible sourcing: extracting or sourcing products in a responsible manner. Require material impact tracking by contractor during entire construction process. This information should be reviewed monthly during payment review to assure material tracking goals are met.
   b. Bio-based Materials: Percentage of materials that are biobased (and meet the Sustainable Agriculture Network's Sustainable Agriculture Standard) or that are made with regenerative properties.
      i. Bio-based materials: Review information with manufacturer and review info here: https://www.rainforest-alliance.org/business/sas/wp-content/uploads/2017/11/03_rainforest-alliance-sustainable-agriculture-standard_en.pdf
   c. Material Reuse: Percentage of materials reused from existing buildings or other local sources (identify appropriate metric—weight, volume, cost).
      i. Review information with manufacturer.
   d. Wood Products: Percentage of wood used on the project that is certified by the Forest Stewardship Council (FSC).
      i. https://info.fsc.org/certificate.php
   e. Extended Producer responsibility: Percentage of products used from a manufacturer that have a take-back program, or other extended producer responsibility
      i. Review information with manufacturer.

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    f.   Recycled Content: Percentage of recycled content of building materials (by cost), specify post or pre consumer recycled and total percentage.
        i.   Review information with manufacturer.
    g.   Regional Content: Percentage (by cost) of the project materials extracted and manufactured regionally (specify distance)
        i.   review information with manufacturer and use this calculator https://www.distancefromto.net/

4. Tracking Health Impacts
    a.   By collecting and reviewing Material Ingredient Disclosure information of each product used, building products can be selected based on the health impacts of the ingredients used, and a better interior environment can be achieved. Material Ingredient disclosure documentation can include the following:
    b.   Require material impact tracking by contractor during entire construction process. This information should be reviewed monthly during payment review to assure material tracking goals are met.
        i.   ANSI/BIFMA e3 Furniture Sustainability Standard https://level.ecomedes.com/
        ii.   Cradle to Cradle Certification https://www.c2ccertified.org/products/registry
        iii.   Cradle to Cradle Material Health Certificate https://www.c2ccertified.org/products/mhcregistry
        iv.   Declare Label https://living-future.org/declare/
        v.   Health Product Declaration (HPD) https://hpdrepository.hpd-collaborative.org/Pages/Results.aspx
        vi.   Product Lens Certification https://spot.ulprospector.com/en/na/BuiltEnvironment/Benefits/26074/Product-Lens?st=1
        vii.   Facts NSF/ANSI 336 http://contracttextiles.org/facts-sustainability-certification/
        viii.   SDS - review information with manufacturer
        ix.   Manufacturer's inventory - review information with manufacturer

5. Construction Waste Diversion
    a.   Reduce construction and demolition waste disposed of in landfills by recovering, reusing, and recycling construction and demolition debris.
    b.   Require waste tracking by contractor during entire demolition and construction process. This information should be reviewed monthly during payment review to assure waste diversion goals are met.

6. Social Equity within the Supply Chain
    a.   Promoting fair trade, respect for human rights, and other equity practices among disadvantaged communities.

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      b. Creating more equitable, healthier environments for those affected by manufacturing of the materials created for the project.

      c. Require reporting by material manufacturers via Corporate Sustainability Reports, indicating Social Equity goals are being met.

      d. Handprint is another transparent disclosure platform to share a company's positive actions within and outside of their supply chains. https://living-future.org/lpc/basics/#what-is-handprinting

Resources

BuildingGreen: The Great Eight: High-Impact Material Choices for Green Building
We're at a tipping point in insulation, flooring, textiles, and other product categories. Here's what to spec and what to avoid.

LCA Tools:
Tally
Tally Case Studies
Athena
One Click LCA
GABI

Ardente, Fulvio, Marco Beccali, Maurizio Cellura, and Marina Mistretta. "Energy and environmental benefits in public buildings as a result of retrofit actions." *Renewable and Sustainable Energy Reviews* 15, no. 1 (2011): 460-470. https://doi.org/10.1016/j.renene.2004.05.006

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Frey, Patrice, Liz Dunn, Ric Cochran, Katie Spataro, Jason F. McLennan, Ralph DiNola, and B. Heider. "The Greenest Building: Quantifying the Environmental Value of Building Reuse." (Report, The Preservation Green Lab of the National Trust for Historic Preservation, 2012).

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Vidaris, Sysska Hennessey. "Assessing the Carbon-Saving Value of Retrofitting versus Demolition and New Construction at the United Nations Headquarters" (Report, Vidaris, Inc. and Syska Hennesy Group, 2016). Accessed February 23, 2018. http://www.vidaris.com/uploads/files/assessing-the-carbon-saving-value-of-retrofitting-versus-demolition-and-new-construction-at-the-united-nations-headquarters-199.pdf

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World Resource Institute. "The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard." Accessed March 12, 2018. http://www.ghgprotocol.org/sites/default/files/ghgp/standards/ghg-protocol-revised.pdf

Living Product Challenge
International Living Future Institute's benchmark certification for building materials and systems.

Materials Transparency and Risks for Architects
An introduction to advancing professional ethics while managing professional liability risks. With increased levels of disclosure from manufacturers, this white paper explores new risks for architects specifying materials in their projects.

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Measure 9: Design for Change

Reuse, adaptability, and resilience are essential to sustainable design, which seeks to maintain and enhance usability, functionality, and value over time. Describe how the project is designed to facilitate adaptation for other uses and/or how an existing building was repurposed. What other uses could this building easily accommodate in 50-100 years? In what ways did the design process take into account climate change over the life of the building? Describe the project's resilience measures: How does the design anticipate restoring or adapting function in the face of stress or shock, such as natural disasters, blackouts, etc.? How does the project address passive survivability (providing habitable conditions in case of loss of utility power)?

Focus topics:

- Reuse
- Flexibility and Future Adaptability
- Resilience
- Passive Survivability
- Changing Climate

If you can do only one (or three) things…

1. Before assuming that old buildings need to be demolished, consider the embodied value of the existing structures, and how they might be adapted to serve the needs of current clients. What stories from a building's history can be celebrated now and expressed in the new design, to ensure that new projects will be valued by future generations.
2. Ask stakeholders and the community how projects can support operations, neighborhood cohesion, and community members in times of crisis.
3. Determine how projects can support immediate recovery in the first days and weeks of crisis, and long-term return to normalcy.

With this measure we can expand our thinking beyond /one immediate commission. By looking back and looking ahead, we recognize the value of earlier buildings that exist now - and the potential of new projects over their full lifespan into the future. Buildings are great resources which require immense effort, investment and materials to construct. In addition to operation and maintenance impacts, the construction process represents a large portion of a building's total impact on global climate change.

Design for Resources describes new tools to quantify and compare the effects of reusing an existing structure, or choosing one new material over another. Architects have a wonderful opportunity to recognize the value of existing buildings, and how they can be adapted to support new users and functions. If we carry this same thinking forward, we can imagine how future architects might see the embodied value of our current work. We can design projects today so they can adapt to support new and different uses in the future.

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Suggested Best Practices

1. **Reuse**
   a. The mandatory metric for percent of floor area adapted from existing building might range between 0% and 100%. This is not intended to exclude new construction, but rather to recognize adaptive reuse.

2. **Flexibility and Future Adaptability**
   a. Place structural elements for maximum flexibility. Consider how structural columns, lateral systems and floor-to-floor heights can accommodate different arrangements of the same use, and be adapted for different uses in the future.
   b. Design for disassembly:
      i. Use bolted not welded connections
      ii. Make interior demising walls non-bearing
      iii. Detail gypsum wallboard partitions to be reconfigurable or reuseable
   c. Plan for new arrangements of current use
   d. Plan for future different building use
   e. Plan for changes in technology (e.g. audio/visual)
   f. Parking garage:
      i. Instead of 9-foot floor-to-floor sloping floor slabs; consider 12-foot floor-to-floor flat slabs, that can be adapted to support a different purpose in the future
   g. Hospitals:
      i. Plan for changes over time, as methods of care evolve
      ii. Make the nurses station removable, and to be relocated
      iii. Flexible room sizes
      iv. Possibility of outside air ventilation
   h. Adaptable HVAC systems
      i. Use flexible distribution and return systems (classrooms, offices)
      ii. Underfloor Air Distribution (UFAD)

3. **Resilience**
   a. Each building supports people in different ways during and after emergencies. Define what "maintaining function" means for a specific project.
      i. For critical services, that could mean returning to typical operations quickly; OR
      ii. Immediate use of a community building may simply depend on passive survivability, which aligns naturally with Design for Energy.
   b. Participating in community resilience
      i. Phased recovery - immediate support and resources
      ii. Enhance services this project could provide to community
      iii. Support eventual return to normalcy

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    c. Consider two scales - how does project contribute?
        i. Macro - the environment
        ii. Micro - your site
    d. Determine percentage of power needs supported by onsite generation for self-sufficiency
        i. Determine what types of equipment to be supported by backup power. School refrigerators and water storage pumps can support resilience, beyond code required backup for egress.
        ii. Generator or battery backup system
        iii. Onsite renewable power
        iv. Onsite solar thermal heating for domestic hot water
        v. Energy efficiency will reduce total requirements

4. **Passive Survivability**
    a. Natural daylight allows circulation through buildings during the day. Communities could plan to have small lanterns available to see by night.
    b. Natural ventilation - Large groups recovering in a school gym can get fresh air supply by propping open doors and roof vents.
    c. Areas of stable temperature within expanded habitable range can be maintained with a great building envelope (good air tightness and insulation, combined with high performance windows, etc.).
    d. Access to potable water without municipal power grid

5. **Changing Climate**
6. Base design and performance analysis on predictive climate modeling, instead of historic data.
    a. Design for rising temperatures
    b. Increased weather events
        i. Storm shelters, areas of refuge
        ii. Safe zones within building
7. Design for rising sea levels
8. Anticipate flood conditions in all areas
9. Anticipate power outages

Resources

BuildingGreen: Raze or Retrofit? Six Extraordinary Answers to an Everyday Question
Saving a building is usually an environmental win, but thoughtful renovation isn't easy. And there comes a time to tear things down.

RELi
Resilience rating system

U.S. Resiliency Council Resilience rating system and assessment guide

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Measure 10: Design for Discovery

Sustainable design strategies and best practices evolve over time through documented performance and shared knowledge of lessons learned. Has the building performed in ways that matched expectations during design? Post-occupancy evaluation can include monitoring thermal and daylight conditions; energy and water consumption; surveys of occupant comfort; studies of how the building is actually occupied and used. What lessons for better design have been learned through the process of project design, construction, and occupancy, and how have these been incorporated in subsequent projects? Describe ways the lessons have been shared with a larger audience (publications, lectures, etc.) and how any ways the this project may have influenced industry practices. Describe the processes used to maintain long-term relationships between the design team and those occupying and operating the building; and identify how both the users and designers benefited.

Focus topics:

- Post Occupancy Engagement
- Occupant and operator Relationships / Graphic signage / Training
- Sharing and lessons learned
- Discovery that influences behavior

If you can do only one (or three) things…

1. Ask for utility bills and calculate actual measured EUI.
2. Call the Owner and ask how it's going (every couple of months after occupancy).
3. Share mistakes and the strategies for fixing them with … everyone. (This could be the project team, the office, or the profession at the local, regional, or national level -- or even internationally, if lessons are significant.)

After nine measures of strategies to improve a project's performance, Measure 10: Design for Discovery, is all about what the designer can learn from the finished product. Every completed building contains a textbook's worth of lessons, mistakes, strokes of genius, and strategies for improvement, but this wealth of information won't come knocking on the office door. Designers need to stay engaged with each building over the long term to extract its secrets and share them with rest of the profession. One of the simplest and most impactful ways to stay engaged with a completed project is to ask for utility bills, which most owners and operators are happy to provide. After calibrating for a specific year of actual weather data, twelve months of energy and water use will allow project teams to compare a building's resource consumption against both benchmarks and predicted values, providing clues about how the project is actually performing. Inconsistencies can then be explored more deeply and strategies for improvement can be developed.

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An additional step would be to call the Owner/Operator to ask how the building is performing or just show up and look around. Conversations will help the design team understand building performance beyond resource consumption, including how the building is being used, the satisfaction of the occupants, and the durability of the materials and details.

Nearly all buildings that architects touch are custom designed for a specific purpose at a unique site. Our industry does not have the opportunity for testing by trial and error within a single project schedule and budget. The best way design teams can improve outcomes is to learn from previous project discoveries ; identifying mistakes, looking for solutions to correct them, and documenting the strategies for avoiding them in the future. The last piece of the equation is sharing the knowledge acquired through post occupancy engagement with others who might be facing a similar design challenge. This way we can avoid repeating mistakes and keep the profession moving forward.

Suggested Best Practices

1. **Post Occupancy Engagement**
   a. Check in with the building owner frequently during the first year of occupancy.
   b. After one year, compile utility bills to calculate a measured EUI and water use per occupant. Study other ongoing costs, such as data/communications, security, cleaning, and maintenance.
   c. Survey and/or interview occupants about the satisfaction with the building. Ask about thermal comfort, lighting, air quality, acoustics, spatial design, maintenance, and general satisfaction, and satisfaction with project specific design goals.
   d. Visit the building to see how its operations align with the design intent.
   e. Pay special attention to the durability and usability of the building. Ask about building elements that needed to be replaced and record any frustrations that the building occupants might have about using the building.
   f. Based on collected data, develop strategies for improving the performance of the building and share these with the building Owner.
   g. Buildings often don't perform at their full potential after several years of occupancy. Stay engaged to guide new building occupants and operators through the learning curve.
   h. Be the first line of defense when things go wrong. The architect is often in the best position to address challenges before they become problems. Ensure that the building owners/operators know to keep you in the loop during troubleshooting.

2. **Occupant and Operator Relationships / Graphic Signage / Training**
   a. Give maintenance personnel and building operators opportunities for input throughout the design process.
   b. Keep building operations simple. Design systems to align with the expertise and resources of likely building operators.

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c. Produce a building users' manual for the operator. This manual should include: Building information, design intent of the building operations, Owner's Project Requirements (OPR) and how each item is achieved, maintenance information for each system.

d. Develop a building orientation for all occupants that covers: occupants rights and responsibilities, operational expectations, appropriate feedback mechanisms. Develop signage for both regular occupants and visitors that reinforces these ideas.

e. Record Operation and Maintenance training videos for future facilities managers to learn about the original design intent and lessons from initial commissioning efforts.

f. Form and maintain personal/professional relationships with the owners or operators of completed projects. This could improve everything from streamlining building performance, to winning more work, to not being sued when things go wrong.

g. Calibrate expectations and help users understand their role in building performance. Talk about predicted energy use (pEUI) as a range within standard deviation of possible outcomes based on energy model assumptions. Form a more nuanced understanding of predicted performance -- rather than expecting just a single EUI number -- to avoid having to troubleshoot when "actual results may vary."

3. Knowledge Sharing and Lessons Learned

a. Share the outcomes of your design decisions with the world. It's especially important for the industry to learn from undesirable outcomes, rather than something to quietly ignore.

b. Use platforms such as conference presentations, white papers and journal articles to document and share design decisions and their outcomes.

c. Use the lessons of one project to improve subsequent projects by developing an in-house platform for documenting and sharing lessons.

d. Document each Post-Occupancy exercise as a story; from the initial Design Decision > Outcome > Solution > to New Thoughts moving forward. The process is not always a linear straight line. Including some trials and tribulations, double-backs and alternative approaches makes for a richer story. (As sustainable leadership and change management guru Leith Sharp would say, "Don't be afraid of the squiggle!")

4. Discovery that Influences Behavior

a. Design building features that empower and encourage the building occupants to engage with building systems.

b. Design building elements and signage that teach occupants about building systems and sustainability.

c. Provide occupants feedback about building performance that can offer friendly motivation to engage with the building operations.

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d. Design systems that keep occupants stimulated over time; adapting to seasonal changes, engaging multiple senses (fresh breeze, outdoor sounds, etc.), or installing materials that age gracefully over the life of the building. Consider using "summer setpoints" for seasonally-adjusted occupant comfort, similar to a business scheduling adjusted summer hours.

Resources

[BuildingGreen: Why Post-Occupancy Review Is the Future of Design (And How It Can Serve You Now)](#)
A radical new paradigm is on the way for engaging with projects after they're "completed"—and clients couldn't be happier.

[Architect Magazine: Kieran Timberlake's Cool Experiment](#)
Read about Kieran Timberlake's unconventional office renovation and how they studied the design's impact on the occupants, learned valuable lessons about thermal comfort, corrected mistakes, and shared their story.

[Roast](#)
Kieran Timberlake has broken down the question "How are you feeling today?" into a science. Roast lets you build surveys quickly and easily with pre-populated questions based on building industry standards.

[GSA Occupant Satisfaction Report](#)
The GSA has a simple format for measuring occupant satisfaction that can be compared across buildings. This report shows the questions that are asked, and how 12 federal buildings scored.

[Staying Engaged](#)
This article about Lake Flato Architects Residential post occupancy program shows the value of monitoring energy to educate occupants and fine-tune performance.

[RIBA: Post Occupancy Primer](#)
The Royal Institute of British Architects prepared this primer on how to conduct a post occupancy evaluation, geared towards firms without experience in the area.

[Post Occupancy Report](#)
A Post Occupancy Evaluation can take many forms, and such variations in scope impact the tools and knowledge needed to conduct a successful POE. This survey report gathers examples from several leading firms to outline potential fundamental components of an evaluation, so that readers can determine the best type of POE for their firm or project. It also documents resources that can assist in POE development and implementation.

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Writing an Owner's Manual for a House

South Mountain Company shares their formula for writing a comprehensive owner's manual for residential projects.

Post-occupancy Evaluation

A collection of BuildingGreen articles and resources on this topic.

Architect & Design Sustainable Design Leaders POE Survey Report

2015 summary of the state of occupancy evaluation in our industry.