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The Sound of Sustainability: Acoustics in High-Performance Design

Acoustic performance is often overlooked by human-centered design. A holistic approach shows how to navigate the complexities of "sustainable acoustics."

by James Wilson

The world is filled with sound. And while our experience of a space is always influenced by its acoustics, we are especially affected by the acoustic quality of the buildings where we spend 90% of our time. These buildings all too often have poor acoustics, which can disrupt our work, activities, and health.

"It can get pretty noisy. You pretty much just have to deal with it," says Jacqueline Shaw, associate at SPAN Architecture. An architect who works in an open office, she says she has learned to save tasks requiring particularly close concentration for the times of day when she knows the office will be relatively calm and quiet. "You just have to learn to adapt to your environment, unfortunately," she says.

But to what extent should people be expected to change their behavior in response to the acoustic conditions of their environment? If the acoustic quality of a space is so poor that the effort required to comfortably use it is distracting and stressful, that space cannot be called sustainable.

But architects, even those focused on sustainable and human-centered design, have often overlooked acoustic quality as a design goal. In fact, bad acoustics has been one of the most common complaints about "green" buildings. Open offices, for example, have been popular among green designers due in part to their efficiency, and greater access to daylight and views. But these projects also often suffer from poor acoustic performance, which works against indoor environmental quality. Project teams that take a whole-building design approach can address acoustic issues by fully integrating acoustic performance with other sustainability goals.

Acoustics: The Missing Piece of Indoor Environmental Quality

"Acoustic performance" refers to the effectiveness of a building's acoustic design to protect and promote occupants' comfort, well-being, productivity, and ability to communicate. It describes the capacity of a space to provide an acoustic environment appropriate to its intended use.

Although a lot of research has shown that poor acoustic performance can have a negative impact on health, behavior, and cognitive function, acoustics has been neglected in architectural practice. This may be due in part to a lack of awareness of how poor acoustic quality affects us.

Photo: Trollbäck+Company

The open-plan office design offers many benefits, including better daylight access, greater flexibility, and a more collaborative setting. However, it can be very difficult to achieve good acoustic performance in open, shared spaces.

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The effects of poor acoustic performance

We are constantly exposed to noise (defined as unwanted, disruptive sound) and though humans are highly adaptable, we are still affected by noise in critical ways, especially in the spaces where we heal, where we learn, and where we work.

In healthcare settings noise can slow a patient's recovery by causing stress and disrupting sleep. As Jim Perry, chief technical officer at Cerami & Associates explains, "Getting a good night's sleep is a big part of healing quickly. Getting a good night's sleep requires good acoustics."

Studies have also shown that poor acoustic performance not only degrades the overall quality of the work environment for healthcare staff, but it can also cause caregivers to make more mistakes due to distraction and impaired communication.

Poor acoustic performance can also negatively affect learning. Studies have shown that in many classrooms students are able to hear only 75% of spoken words. Teachers miss an average of two days a year due to vocal fatigue from continuously straining their voices to make themselves heard over background noise.

Stephany Mason, technical director at the Collaborative for High Performance Schools (CHPS) says, "We equate trying to hear in a poor acoustical environment to trying to read in a room with poor lighting. It increases stress, your concentration decreases, and it impairs your learning." (The CHPS Best Practices Design Manual includes useful guidance on acoustic design for schools.)

Young children are especially vulnerable to the ill effects of noise because the ability to sort meaningful sound from noise typically is not fully developed until the teenage years. Students being taught in a language that is not their native language, or those who have hearing impairments or increased sensitivity to noise in their environment (like some of those with autism spectrum disorder) also have an increased vulnerability to the negative impacts of noise.

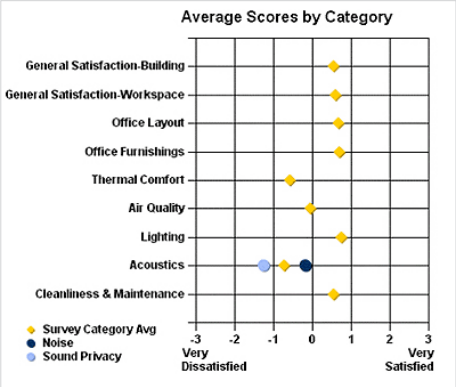


Image: Center for the Built Environment

Acoustics is consistently found to be one of the lowest-scoring components of indoor environmental quality in surveys of occupant satisfaction.

Though historically more attention has been given to lighting and ventilation in classrooms, research shows that good acoustics are just as crucial for learning, which depends on easy verbal communication. "If you can't hear you can't learn. It's as fundamental as good lighting," says Mason. (With the exception of deaf students, of course.)

Noise can also distract workers from concentrating on their tasks. Acoustical issues are especially prevalent in offices where workers are in cubicles or at desks in a shared, open space. Worker productivity and performance in these environments can be affected both by noise and by a lack of speech privacy. Researchers have found that more than half of occupants who work in cubicles think that poor acoustics interfere with their ability to do their job. (The acoustic challenges of open plan offices is discussed in further detail below.)

As awareness of these impacts increases, some in the building industry are advocating for architects to expand their goals for indoor environmental quality (IEQ) to include acoustic performance.

"Sustainable" projects don't perform any better

Since 2001, the Center for the Built Environment (CBE) has been conducting IEQ occupant surveys at

buildings—mostly offices—around the world. Lindsay Graham, who leads the Psychology of Space Research Program at CBE, says, "One of the things that we consistently find is that acoustics is one of the lowest-performing variables of environmental satisfaction."

This is true too of "green" buildings. In fact, Michael Ermann, associate professor at Virginia Tech School of Architecture + Design and author of "Architectural Acoustics Illustrated," explained that the survey results indicate that buildings categorized as "sustainable" score, at times, even lower than "conventional" buildings in the category of acoustic satisfaction. "You generally see that when it comes to overall building, air quality, thermal comfort, and daylighting, the high-performance buildings tend to do better, but when it comes to acoustics, they tend to do the same or worse," he says. One reason for this may be because some strategies meant to improve other aspects of IEQ conflict, directly or indirectly, with acoustic performance.

Designing for IEQ can be complicated, especially in spaces like shared offices and classrooms where there you have multiple people concentrating on a specific task or activity. Mason told BuildingGreen, "Schools that are trying to include natural ventilation or daylighting may have a lot of open windows, but if it's really noisy outside and you haven't accounted for that," one IEQ measure could directly conflict with another. "All these IEQ features are not implemented in a vacuum."

Why have we neglected acoustics?

Traditionally acoustics has not been understood to be integral to either aesthetics or functionality, and so has been overlooked by architects. It doesn't help that architects are, in general, visual thinkers and that sound is not easily represented in models or drawings.

But even though sound is invisible and intangible that doesn't mean it's any less of an architectural material than things like concrete or glass, according to architectural critic Michael Kimmelman. He writes in a 2015 *New York Times* article that sound "is shaped by design, albeit most architects rarely think much about it, except when their task is to come up with a pleasing concert hall or a raucous restaurant—and then acousticians are called in."

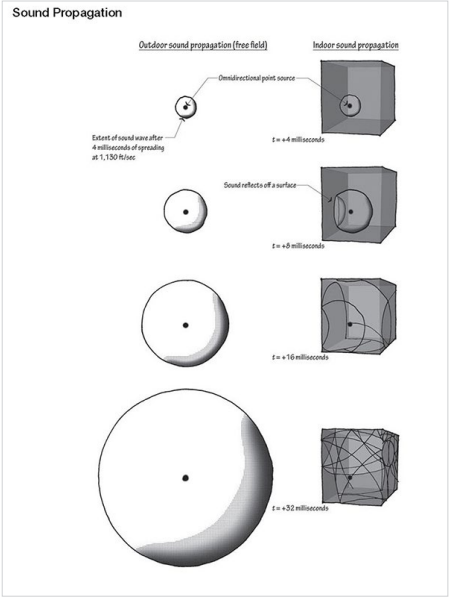


Image from "Architectural Acoustics Illustrated," courtesy of Wiley

Sound cannot be seen or touched. Visualizing the way sound interacts with the shape and volume of an interior space may help architects integrate acoustics into their design process.

A reason why even the more sustainability-minded designers have neglected acoustics might be because it's not directly related to energy. Caroline Karmann, a researcher at CBE, says, "It's about 20 years that we've been trying to reduce energy costs of buildings and LEED has been taking care of that. But acoustics does not have a direct energy benefit. There was nothing in the industry pushing designers to improve."

Ermann argues that most architects should be naturally capable of good acoustic design but that many have just not had enough exposure to the concepts. "I think there's a direct correlation between thinking three dimensionally in space and also thinking three dimensionally in terms of frequency, sound level, and time," he says.

"I blame acousticians a little bit," says Ermann. "For many applications you do not need an acoustician, but the acoustical community has made it seem mysterious somehow—that it's a mystical art or science that the architects could never understand, when in reality the architects could totally understand." (Ermann's highly visual book, *Architectural Acoustics Illustrated*, is an accessible guide to the basics of how sound and space interact.)

Focus on occupants signals a change

Karmann explains that designers are becoming more interested in how the built environment affects occupants and this shift means that acoustics is getting more attention. "Over the last twenty years the importance of acoustics has not been treated according to its actual value, but now these questions are coming to the surface," she says.

The launch of programs like the WELL Building Standard, which includes several features related to œ, and the addition of the acoustic performance credit to LEED v4 are signs that the green building industry is starting to promote acoustic performance as an integral component of sustainable design.

Though architects are more aware of the importance of acoustics, achieving good acoustic performance is not always a simple task, especially for project teams working to balance a range of equally important sustainable design goals.

Sustainability and Acoustics: A Balancing Act

Integrating acoustics into an established sustainable design process is a balancing act. Fred Bauman, project scientist at CBE, explains that achieving acoustic performance often requires a holistic view to determine the best strategy. "It's not just simply putting acoustic panels in. That's part of it, but there are a lot of other questions that might have a larger

Acoustics 101

Sound is a sequence of waves of pressure that move, or propagate, through air or another medium. When sound waves propagate throughout a space, they can be reflected (bounced back), refracted (bent), or attenuated (weakened) by the materials they come into contact with.

Noise is generally defined as unwanted sound.

The size and geometry of a space affect how sound behaves in that space. Sound vibrations move from one place to another, from a source to a receiver. Good acoustic design is based on the idea of shaping a space so that the sound moves from the source to the receiver as efficiently as possible. This allows for easy verbal communication in a space. In a classroom, the teacher who is speaking is the source, and the students listening are receivers. The room's width, length, and height can be manipulated to optimize sound reflection to get the sound to as many students as possible.

Acoustic design also involves the application of reflective or absorptive materials to surfaces in a space to further control sound, if necessary. From a sustainability standpoint, it is optimal to achieve appropriate acoustic performance by adjusting shape and size only, precluding the need to apply any additional materials for acoustic control.

The types of noise addressed by acoustic design include:

- Airborne noise, which is transmitted by air. People talking on the other side of the room, an ambulance going by outside, a dog barking down the street—these are examples of sources of airborne noise.
- Structure-borne noise, which is caused when sound waves from elsewhere impact a building element like a floor, wall, or ceiling, causing it to vibrate and generate new sound waves. Examples of sources of this type of noise include: your neighbor's footsteps in the apartment above you, an object dropped on the floor, and a heavy truck rumbling by on the street below, causing the walls to shake.

The most common acoustic issues addressed by acoustic design include:

- Intrusive noise entering the space from outside the building, from other spaces within the building, or from mechanical equipment within the space
- Reverberation, or echo, which can cause poor speech intelligibility and make verbal communication difficult
- Lack of speech privacy in multi-occupant spaces like open-plan offices, which can cause people discomfort due to the perception that others can overhear them

The most common strategies for addressing acoustic issues include:

- Absorb: Use sound-absorbing materials like drapes, carpets, ceiling tiles, and acoustic wall panels to keep a space from being too reverberant
- Block: Use partitions, walls, floors, ceilings, and "buffer spaces" to isolate sources of noise and to prevent the intrusion of noise from the exterior and adjacent spaces
- Cover: Use sound masking technology to reduce distracting interference from background noises and increase speech privacy

impact in the overall scheme of things," he says.

In describing the various sources of noise that must be controlled—from outside the building, from other parts of the building, or structure-borne noise—Ermann explains, "It's hard to talk about acoustics as one thing because each one of those categories has its own set of priorities."

And while most architects understand the basics of acoustics (for a refresher, see the sidebar: "Acoustics 101"), the intricacies of how acoustic performance interacts with other sustainable design strategies may be less familiar. A holistic design approach should be used to evaluate and track how various sustainable design decisions either conflict or harmonize with acoustic performance. Ideally, this process would start at the very outset of the project when the existing conditions are being surveyed.

Pre-design site assessment

Before design starts, understand all the factors that may have an impact on the project's acoustic performance. In assessing the site and context of a building, designers should consider everything in the environment that produces noise or vibration to determine whether it could affect what will be happening inside the building.

Raj Patel, principal at Arup Global Leader Acoustics says, "The trick here is you really need to think of all the things that are not immediately obvious when you're looking at a building on a plan drawing. Some things are visible and obvious. Some things are less visible. Some things only occur at certain times of day but can still be a nuisance." For example, in an area with a lot of bars and restaurants, there may be a lot of noise only later at night when these places close and let a crowd of people out all at once.

In addition, Patel explains that a building's structural materials, when exposed to vibration—say from a passing subway train—can convert that vibration into sound, in effect making the building a loudspeaker. "That sound you're hearing is a thing called re-radiated noise and the mechanism is called structure-borne noise," he says. It's important to be aware of all potential sources of vibration early so that the structure and foundation can be designed accordingly.

Site and orientation

The way in which a project is situated on its site can have significant impacts on acoustic performance. A building might be sited or oriented to optimize its relationship to sun and wind for solar energy generation, daylighting, and natural ventilation—but designers should also analyze impacts on acoustics. For example, it's a sustainable strategy to locate buildings near mass transit routes or public transportation centers—but roads, rail lines, and subway stations can be major sources of noise and vibration.

When planning the landscape around a project, teams may consider issues like erosion control and heat island reduction. By simultaneously considering acoustic issues, single solutions may be found that address multiple concerns. For example, a

team could plant trees to both shade hardscape and absorb noise from neighboring buildings.

Building envelope

The design of the building enclosure can greatly impact energy performance, but it can also significantly affect acoustic performance.

Patel told BuildingGreen, "The optimized, sustainable approach would be to measure and understand how much noise exists in the environs in which you're building and design a building envelope that reduces the sound to the necessary levels."

Insulating exterior walls may not only reduce energy use, it can also provide greater protection from intrusive environmental noise. But it's not as simple as just adding any kind of insulation. Rigid foam insulation offers superior thermal properties, but it is not effective at absorbing noise. Though open-cell foam is better than closed-cell foam, it is still not open enough to perform as well acoustically as more porous products like mineral fiber. (The fill material needs to be "open" enough to adequately interact with the sound waves in the cavity. Denser materials like foam can "couple" the two sides of the wall, allowing vibration to be conducted from surface to surface.)

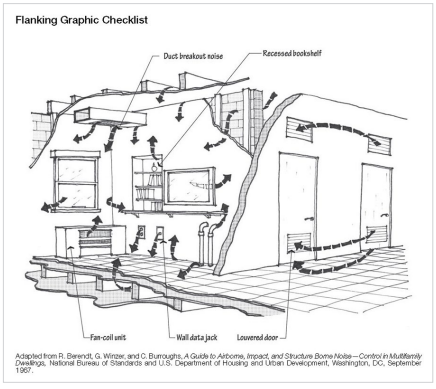


Image from "Architectural Acoustics Illustrated," courtesy of Wiley

Flanking is the transmission of sound from space to space along building elements. Addressing this issue with proper compartmentalization can also contribute to goals like air tightness and pest prevention.

Likewise, as windows are generally the envelope's "weakest link" acoustically, high-performance triple-glazed products can both increase energy efficiency and block more exterior noise. Similar to wall insulation, larger airspaces between panes typically translates to more effective acoustic insulation. Thicker laminated panes can also be used to mitigate low-frequency noises from traffic or aircraft.

Space planning

Sound should also be a key consideration when organizing a building's interior spaces. Perry explains that, when it comes to preventing acoustical issues that are difficult and costly to fix, "space planning is incredibly important. Sometimes you can fix things later on that were caused by the space planning, but not always."

Considering noise when designing the organization of a building's different program and space types is both basic and effective. During the planning process, noise-producing spaces should be isolated from sound-critical spaces using noise-neutral buffer spaces. For example, a mechanical room can be isolated from a classroom by a stairwell or janitor's closet.

Additionally, proper compartmentalization of spaces can reduce "flanking" (the transmission of sound from space to space along building elements like floor-to-floor penetrations) while also contributing to air tightness, pest prevention, and environmental tobacco smoke control.

Room size and shape

When designing spaces within a building, architects should think first about the function of a program space and then determine the appropriate acoustic criteria. This is one reason to have an acoustic consultant involved early in the design process. It can be very beneficial, before design gets too far along, to have a specialist help size and shape each space appropriately, as form and geometry is critical to how sound behaves in a room.

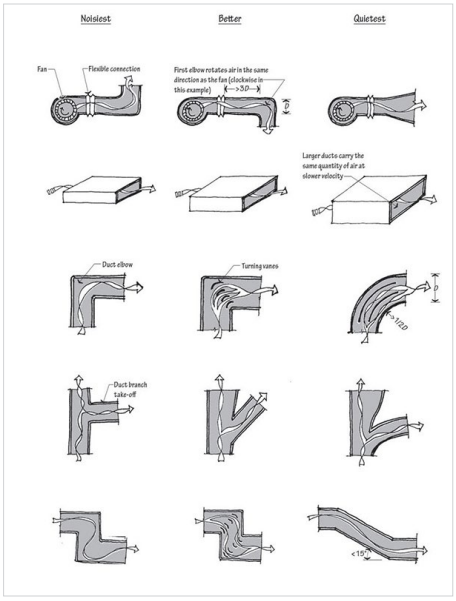


Image from "Architectural Acoustics Illustrated," courtesy of Wiley

The design of mechanical ducts can influence both energy efficiency and noise. In general, the strategies for reducing a system's energy use will also make it quieter.

"From a very fundamental standpoint, acoustics can drive sustainability of a building," says Patel. "You can build less volume, you can use less material in a building if you size and shape and get the right geometry of the spaces from the very outset."

HVAC

In addition to room geometry, the selection, location, and duct design of a building's HVAC system can also have a significant impact on acoustic performance. And there is a relation between acoustic design and the energy efficiency of the HVAC system.

According to Ermann, "There are a lot of things you can do to make a mechanical system more efficient and use less energy, and a lot of those are the same things you would do to make it quiet. Generally, well-maintained, well-balanced, low-pressure duct systems tend to do better from both a noise point of view and an energy point of view," he says. Large ducts and reduced fan speeds can also reduce noise while improving system efficiency. However, there are other acoustic design measures, like the use of longer duct runs or additional turns in the duct path, which can contribute to *increased* energy use.

Photo: © Jeffrey Totaro

The Washington Square Park House by BKSK Architects includes a solar panel array and ground source heat pumps. These systems allowed for the elimination of loud rooftop and exterior mechanical equipment, which greatly reduces noise pollution and preserves the quiet quality of the surrounding park.

Mechanical systems are also a source of noise pollution, especially in dense areas. Located on the outside of the building, or vented to the exterior, noise from the equipment emanates from the building. This can impact the enjoyment of neighboring outdoor spaces and indoor spaces, and it can even disrupt vital processes in neighboring ecosystems. (See Acoustic Ecology: Designing for the Ear.) Mechanical systems with pumps instead of fans, like ground-source heat pumps, are one solution. Besides being a highly energy-efficient and clean way to condition a building, these can also significantly reduce the amount of environmental noise the building produces.

Radiant and convective systems

Radiant slab systems can also significantly reduce energy use, but there has been the concern that these systems can cause acoustic issues. Although radiant systems reduce mechanical noise, the highly sound-reflective surfaces of the exposed concrete slabs may cause excessive reverberation.

Investigating this issue, a team at CBE conducted a study to determine the effect of installing free-hanging acoustical panels—or "clouds"—below a radiant chilled ceiling. The team's experiments showed that covering 47% of the ceiling area with acoustical clouds resulted in only an 11% reduction in cooling capacity due to the blockage of radiant exchange between the ceiling and the space. (Covering 50% of the ceiling in an open plan office achieved acceptable sound absorption at the ceiling.) Bauman, one of the scientists on the project, told BuildingGreen, "The study showed that we could really improve the acoustical quality on the reverberant side of things and not really detrimentally affect the cooling performance."

Ermann explained that chilled beam systems are another heating and cooling strategy that can reduce energy consumption while also making for quieter spaces. "If you have chilled beams, fan noise can be significantly diminished," he says. (Note that when the ducts around active chilled beam systems have had to be enlarged to increase air circulation, it can cause echoes and amplify the sound of water moving through the pipes.)

Natural ventilation

Natural ventilation is another strategy for conditioning a building while reducing energy use. Providing operable windows also gives occupants control over their thermal comfort, increasing satisfaction. However these strategies may not work if the project is exposed to high levels of environmental noise. For example, it could be tricky to use natural ventilation on a school project that's located near a busy commercial center. Proper siting and orientation can mitigate these concerns, as well as using different acoustic strategies on different façades.

Material selection

Materials that absorb sound and reduce reverberation time will generally contribute to acoustic comfort. Therefore, in addition to the usual sustainability criteria for material selection, such as minimal embodied carbon and low chemical emissions, design teams should also consider how certain materials or products would affect the acoustics of a space. That can sometimes mean a conflict.

Hard surfaces like concrete are popular in green building for reducing the use of finishes that emit VOCs, but softer surfaces are better for acoustics. Carpeting, cork, or resilient textile flooring (like Kinetex, reviewed here) are all softer acoustically but require more frequent replacement.

Wood is a popular choice for flooring and other interior surfaces because it is a durable, low-energy, and renewable material. But it is also highly reverberant. While it may be great for concert halls, wood can be too reflective for homes, offices, or classrooms. Designers who want to use wood in these spaces should opt for solid hardwood, which absorbs more sound than laminates or engineered hardwoods. When installing, the wood should be nailed or stapled, as these methods will allow the floor to vibrate with the sound and absorb some of it while also eliminating the type of noisy movement found in floating floors.

Acoustical tile ceilings reduce reverberation time in a space by absorbing sound, but they can also absorb odors and VOCs from other sources, re-emitting them later. Ceiling tiles can also collect dust, requiring more maintenance than some other ceiling systems.

Designers should also keep in mind that the acoustic properties of

Photo: David Wakely © 2015

Acoustical "clouds" were installed beneath the radiantly cooled ceilings of Ratcliff Architecture's STREAM Building at De La Salle High School. Studies show this is an effective strategy for reducing reverberation without significantly affecting cooling performance.

certain products can be affected by other interior materials. While paint generally does not affect acoustical properties, there are exceptions. Ceiling tile and concrete block lose their absorptive qualities if painted. "Unpainted concrete block is about 40% absorptive, but if you go with a painted concrete block, it's about 5% absorptive," says Ermann.

These considerations are key when designing for acoustical performance in many projects, but certain spaces have special challenges, such as open offices.

The Open Plan: Collaborative or Noisy?

The popularity of the open-plan office in recent years is a major acoustical issue.

The open plan is a more efficient and cost-effective use of space, and removing interior walls and partitions allows for cross-ventilation, and greater access to daylight and views. Open plan spaces have also been embraced for their adaptability, and their ability to support collaboration and a non-hierarchical workplace culture.

The only problem is that open offices are notorious for occupant complaints regarding acoustics. They are one of the most challenging environments in which to achieve good acoustic performance. As Karmann put it, "If you are in shared spaces your acoustic quality will be, by default, lower. There are certainly ways to try to find a way to improve acoustic quality in these situations, but you won't solve the problem entirely."

Workers in open offices are dissatisfied not only with the level of annoying and distracting noises but also with the lack of communication privacy. And cubicles do not solve the problem. As Ermann explained, "Cubicles do not prevent sound from moving. If there is shared air, there is shared noise." If anything, cubicles might make things worse because they create the perception of privacy. A person talking on the phone in a cubicle may have a false expectation of privacy and at the same tine be less conscious of the level or amount of noise they generate.

Which side wins the debate? As Perry explained, the open office model might work better for some companies than others. He told BuildingGreen, "Younger people coming into the workforce don't seem to have as much of an issue with it. We can see that in a lot of the office designs we're doing for young tech companies. They like the open environment more than anything else."

Shaw shared that, despite the noise and lack of privacy, as an architect she would not want to work in a private office. In her mind, the value of being in a shared space—the ability to easily join discussions and hear what her colleagues are working on—supports a creative design process so much that it outweighs concerns about acoustic comfort.

But regardless of what side of the collaboration debate you come down on, most are in agreement that we are not likely to go back to private offices anytime soon—so the thing to focus on is finding solutions to the acoustic issues in open offices. (For general guidance on achieving acoutic comfort in offices, see the GSA publication "Sound Matters.")

Two solutions

A commonly used "fix" for the poor acoustic performance of open offices involves adding more noise. But not everyone is convinced this is the best strategy and others are advocating for more innovative design solutions.

Sound masking is the technique of introducing unobtrusive background sound—electronically produced "white noise" or "pink noise"—into an environment as a way to reduce interference from distracting noises in the space. According to Ermann, sound masking is the most common solution for providing acoustic privacy in open offices. "But I think there's an untold story about the downside of those," he says. Though studies have shown that there are fewer complaints about lack of privacy in offices that are using sound masking, Ermann says, "as an architect and acoustician I never want to intentionally bring in extra noise to the space." He argues that while people may feel they have more privacy with sound masking, the additional noise will make them less productive and more tired, whether or not they are immediately aware of it.

This is important to keep in mind because, according to Graham, it is not always apparent how our environment is affecting us—partly because we are such naturally adaptive creatures. "But sometimes we're so adaptive to the point we could actually be negatively impacting

Common Acoustic Terms Defined

Reverberation time is a measure of the echo in a space, expressed as the length of time it takes for a sound to decay within the space.

Speech Intelligibility Index (SII) is a measure of the intelligibility of speech under a certain acoustic condition, expressed as a number between 0 and 1. A high SII value indicates that under that condition, speech sound is interrupted by little background noise or echo and more of the information carried by speech is available and audible to a listener.

Sound Transmission Classification (STC) is a rating that defines the effectiveness of a building partition to reduce the transmission of airborne sound.

Noise Criteria (NC) is a number used to define the maximum allowable noise in a given space, depending on the space's function. For example, offices and classrooms have a Noise Criteria Level of 30–40. In general, Noise Criteria applies to background noise from HVAC systems and other equipment and describes both sound level (dB) and frequency (Hz).

Noise Reduction Coefficient (NRC) is a rating that defines the sound absorptiveness of a material. It ranges from 0.00 (totally reflective) to 1.00 (totally absorptive. Materials considered to have "good" sound absorbing qualities have a minimum NRC rating of 0.65.

Ceiling Attenuation Class (CAC) is a rating that defines the sound absorptiveness of a ceiling system to block airborne sound from traveling between adjacent spaces when the dividing wall is not connected with the structural ceiling. The higher the CAC rating, the less sound is allowed to pass from space to space. Typically ceiling tiles have a CAC rating of 25 to 40.

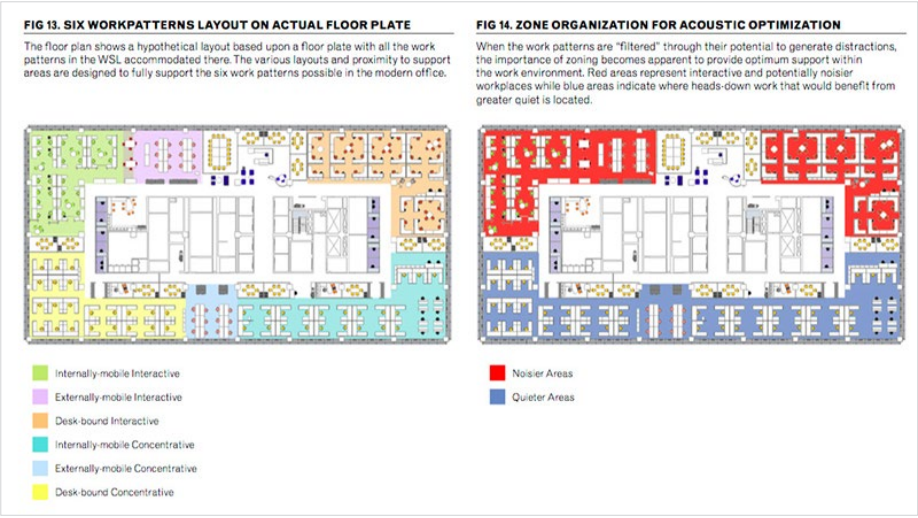


Image from GSA's "Sound Matters," courtesy of U.S. General Services Administration

Proper space planning can be an effective strategy for avoiding acoustic issues. One approach to dealing with noise and speech privacy issues in offices is to provide occupants with a variety of acoustic conditions, allowing them to situate themselves according to their current task.

our quality of life or our ability to complete something," she says, "and we're just unaware of it because we're moving through so rapidly to try to adapt to that space in general."

On the other hand, Perry emphasizes that not all noise is bad. "Some noise is good. It depends what noise it is and where it's coming from," he says. "People have to be cognizant of what they're reducing, not necessarily just eliminating all noise—which anyway is not possible." For example, Perry explains that in some situations the ambient noise from the mechanical system may actually be useful if it is masking other, more disruptive noises. In such a case, reducing the mechanical noise would make those other noises more noticeable and distracting.

Rather than using sound masking to solve acoustic issues in open offices, some are instead advocating for new approaches to workplace design. Karmann told BuildingGreen that as the design of offices evolves, there has been a paradigm shift in the way spaces are planned according to different acoustic requirements. The idea is to provide workers with separate "loud" spaces and "quiet" spaces.

For example, an office might have different spaces designated for different types of activities and different levels of noisiness. Depending on the work they're trying to complete, people could choose to be in a "loud" space where others are energetically collaborating in brain-storm sessions, or take refuge in a "quiet" space where others are silently concentrating on independent tasks. (For a related topic, see Demountable Walls: Here to Redeem the Open Office.)

Graham describes this concept of acoustical flexibility as a potential benefit of offices with open plans that could accommodate multiple types of work space. She told BuildingGreen, "One thing that tends to be helpful for people is having variety in their space." Providing occupants a variety of "acoustical landscapes" allows them to situate themselves in a space where the acoustic condition matches their current needs or desires. From a design perspective, it's not only important to think about how to create these personalized space, but also to consider the "larger scale, where you're really allowing occupants to operate within the environment in a way that best fits them so that they can interact with that space effectively," she says.

The human factor: we're all different

Flexibility and adaptability are also good strategies because they recognize the fact that human occupants come in a wide variety, each with their own acoustic preferences.

Where you are, what you're doing, your current level of awareness, your expectations—all of these things can influence how you react to noise.

Karmann told BuildingGreen, "Acoustic comfort is not all a question about noise or sound privacy—it's a pretty complex issue. And people are different. We can see this with our thermal comfort studies. People are also different in regard to the acoustical environment."

"Acoustics is a really great example of how complex designing a space that is truly sustainable for everybody really is because you get this domino effect," says Graham. "As an occupant, I may adjust one aspect of my well-being by influencing this particular component of my environment, but as a result I may also be diminishing another aspect of my well-being."

Perry explained how expectation also plays a role in acoustic comfort. "If there's a door in an room, there's an expectation that you're going to hear something through it; whereas if there's a wall next to you that is completely solid, there's an expectation that you're never going to hear anything through it. Whenever either of those things don't hold true, that's when people start to complain about things," he says.

And, as discussed earlier, because we tend to unconsciously adapt to our environments, it can be difficult for us to detect certain subtle aspects that may be affecting us, either negatively or positively. This means that we may not always understand why our mood has suddenly changed or why we're distracted. "We can detect something as loud or quiet—but it would take knowledge and self-awareness to know which types of acoustics help you work and which types don't,"

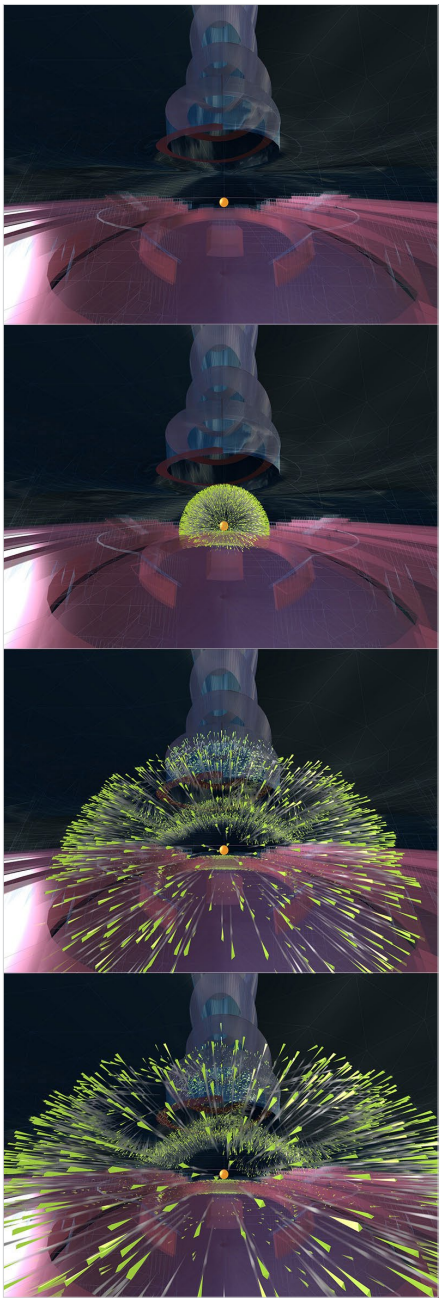


Image: Arup

Acoustic consultants can use visualizations like this to explain how sound will behave in a space. Communicating acoustic performance in an accessible, visual format supports a more open, integrative design process.

says Graham. "It goes back to this human-centered focus of design and trying to understand not only how to design better but how to help people navigate their spaces more effectively."

One strategy for doing this might be to develop design methods that are both more open and participatory, as well as more informed by the human body.

Human-centered acoustic design: use your ears

While traditionally acoustic design has been discussed largely in the abstract—with criteria expressed as technical data— there are tools that are evolving to make it a more democratic and sensory-based process.

Acoustic consultants can use 3D visualizations of sound waves propagating in a space to explain the basics of how sound will behave. This allows project team members to see how different forms or materials affect the acoustic conditions. Visual tools like this are particularly useful during the early stages of design, for example in the early schematic design (SD) phase when multiple concepts are being explored. Further along in the process, during the design development (DD) phase, auralization tools may be more useful.

Perry explains that auralization tools like audio demonstrations or audio renderings can really help people understand how a space will perform acoustically. "It's a very intangible thing and hard to understand especially when you just see a number on a page," he says. "Most people can't coordinate that to what it's going to really be in life unless they've experienced it many times." Presenting audio renderings for different design options helps everyone understand the impacts of different strategies or approaches. "It's very useful for the client," Perry says. "What we've found is people make decisions a lot easier about it."

An example of a more sophisticated auralization tool is Arup's SoundLab—an immersive simulation space that uses advanced audio technology and virtual reality tools to let designers hear the acoustic performance of an existing or conceptual space, based on a 3D digital model. It allows project teams to make changes to the design and hear the effects in real time.

Patel told BuildingGreen, "The creation of the SoundLab was to allow designers and clients to understand acoustic conditions in spaces, and then start to use sound as a proactive design tool. So not think of it as a negative, but actually think of it very proactively—what are the criteria, what are the conditions I want for this building to be optimal for its use, and what do I do to make that happen?"

The SoundLab allows a project team to be in the same room to listen together, and then discuss what they heard and how it will affect the design. This breaks down the barrier between the client, the designer, and the acoustic consultant, allowing for a more participatory decision making process.

Auralization tools can be very useful during the value-engineering process, too. For example a team can listen to the impact that one fewer layer of gypsum board might have on the acoustic performance of a room. This allows designers to really understand the importance of the acoustic criteria when making decisions. When everyone understands why certain decisions are being made, the design process is more continuous and efficient.

Experiment with your ears

In addition to making the design process more open and multisensory, tools like the SoundLab also support more critical innovation. As Patel explains, it "really liberates people from rules and allows people to start thinking with their ears in addition to thinking with their eyes."

Many architects tend to stick with the solutions and strategies that

Photo: Arup

Arup's SoundLab is an auralization tool that simulates the acoustic performance of space based on a digital model. It allows a project team to hear and easily understnad how different design options will affect the way a space sounds.

they know work rather than be inventive. But auralization provides an immediate, accessible way to test these rule-of-thumb solutions. The team is able to listen and hear if these strategies really are the best option.

Perhaps most importantly though, tools like these help us to refocus our efforts by supporting empathy in the design process. Patel says, "I always ask the question, how do you want people to feel in this space?" This adds a sensorial perspective to the process and moves it beyond just the visual. "I think that's very important. That's the missing skill right now," he says. "We all have to be better equipped to think about that idea of how you want something to feel."

Design for a noisy world

By fully integrating acoustics into the design process, architects can provide spaces where we can think and communicate clearly—no small thing in a world as noisy as ours. But beyond providing shelter from noise, architects can use sound to enhance our experience, creating spaces that more fully engage our sense of hearing and strengthen our relationship to our environment. (For a deep dive discussion about designing with sonic properties, see the book *Shape of Sound*.)

As architect Colin Ripley writes in *In the Place of Sound: Architecture | Music | Acoustics*, "Thinking about sound reminds the architect that human beings do not live in silence."

NEWS ANALYSIS

Two for One: Growing Food and Solar Energy Together

As more projects are plugging into off-site solar, dual-use installations are gaining favor to minimize adverse impact.

by Nancy Eve Cohen

Solar developers and farmers have something in common. They both need sunlight to grow their 'crops' and often the best place to do that is a flat, sunny field. For the most part, though, the two industries interact only when a farmer is leasing or selling land to a developer.

Photo: Stephen Herbert, UMass Amherst

Cattle graze underneath solar panels on a research site at the University of Massachusetts, Amherst.

But that is starting to change.

In recent years, dozens of farmers and solar developers have figured out ways to work together. And researchers are studying the benefits and tradeoffs of 'growing' food and solar energy in the same location. In addition, some developers are integrating plant species that attract pollinators in a solar array.

These efforts come in the wake of growing opposition to solar projects that take fertile land out of production.

One of the first to do field research on farming-friendly solar (also known as "dual use" or "co-location") is Stephen Herbert, Ph.D., a professor of agriculture at the University of Massachusetts, Amherst.

About seven years ago he received a call from a builder seeking advice: "I got a farmer who wants to make hay under solar panels," he recalled the builder saying. Herbert's response? "I think it is a crazy idea!"

Herbert was concerned farmers might drive their tractors into the solar arrays, damaging the panels, farm machinery, or even worse—themselves. But the idea sparked a different approach. "What we could do, though," Herbert suggested, "is graze cattle under solar panels."

No one had researched anything like this before.

For four years starting in 2011, Herbert pastured Angus beef cattle under rows of solar panels. His study found the grass and clover were 90% to 95% as productive growing under the panels as in an open field.

Herbert says it was really good for the animals. "The cattle liked it. They could rub up against the poles. They could lie down in the shade."

With a grant last year from the U.S. Department of Energy's National Renewable Energy Laboratory (NREL), Herbert shifted his research to investigate growing hand-harvested crops under solar panels, including kale, Swiss chard, and peppers.

He has learned that the panels need to be much higher than normal—about 7.5 feet from the ground at the lowest

Photo : Jeff West, Prairie Restoration, Inc.

Solar site and pollintor plant species in Menomonie, Wisconsin.

point—so cows and farm workers can move comfortably underneath.

Pushback against solar on farmland

Herbert's research coincides with a growing controversy over using productive farmland to produce solar energy. Jordan Macknick, an energy and environmental analyst with NREL, said, "There has been a major pushback from rural communities, agricultural communities, but also urban communities that don't want to see land, that could be farmed, taken forever out of production."

Macknick says traditional solar development takes its cues from residential construction, which clears the land, creating a clean slate.

"Laying gravel down so you have a flat, known surface rather than working with the natural contours of the land. That certainly has an impact on soil quality, on erosion, on storm-water management," said Macknick. "That certainly doesn't bode well for returning land back to agriculture after a 25-year project life. "

Macknick says co-location works well for grazing sheep and cows, and for small farm operations on about one to two acres.

"This would not really make sense if you are in the middle of a corn field in Iowa with a giant combine that is kicking up a lot of dust and going down the field," said Macknick. "This is really for smaller-scale sites that are focused on hand-harvested and hand-managed crops." That limits where co-location makes sense.

There are also challenges for solar developers, such as leaving extra space between the panels to allow light penetration for crops. "You would not be able to fit as many solar panels per acre of land that you are using, which would mean a slight reduction in the energy output on a per acre basis," said Macknick. In addition, raising the solar panels higher off the ground costs more, because more steel is needed for the posts.

A pocket full of posies—and panels

Some solar developers are finding ways to improve habitat around solar arrays without adding costs. SoCore Energy, a solar developer in Chicago, says it is *saving* money in the long run, by planting flowering pollinator plant species, such as Black-eyed Susans and Yarrow, next to solar panels.

Growing pollinator species has several advantages over planting turf grass, according to Gavin Meinschein, SoCore's lead civil engineer.

Although the upfront costs for establishing a mix of native pollinator species are "six times more expensive than doing a standard grass mix or a turf mix," said Meinschein, "over the 25 years of the project, from the numbers we have run… you can save up to 40%." He says the method works best for developers who own a project for the long term so they can recoup the initial investment.

Once the pollinator species are established, solar companies need to mow only once a year, rather than four or five times for turf grass. And the long roots of the native pollinator plants (several feet long, compared to several inches for grass) reduce stormwater runoff and may also reduce frost heaves that can disturb solar arrays.

According to researchers with NREL, communities often support fields of solar panels with native flowers—and nearby farms have higher crop yields because of the pollinators, attracted by the flowers.

Voluntary standards, which allow solar developers to be certified for having a pollinator-friendly site, exist or are being developed in at least three states: Maryland, Minnesota, and Vermont.

'Growing' electricity and greenhouse plants

Besides growing pollinator species and grazing animals, a handful of companies are integrating photo-voltaic (PV) panels into the roofs of greenhouses.

Soliculture, based in Sun Valley, California, produces a new kind of PV panel that not only captures light and turns it into electricity, but also changes the color of the light trans-mitted through the greenhouse roof to the plants below—reducing the green wavelengths and increasing the red, which promotes photosynthesis. Soliculture says crop yields are the same as with a traditional glass roof, although its translucent panels generate only about one-third as much electricity as conventional opaque ones.

Photo: Soliculture

Inside a greenhouse with Soliculture's "LUMO" PV panels. The panels capture light to generate electricity and they change the color of the light transmitted through the roof—reducing the green wavelengths and increasing the red, which promotes plant growth.

Photo: P4P Energy

P4P Energy PV system over the Sidhwan Canal in Punjab, India.

A greenhouse owner "could potentially earn two different kinds of revenue on the same footprint—for the energy production and having a space to lease out to a commercial grower," said Melissa Osborn, chief operating officer of Soliculture.

When dual use is required

The International Living Future Institute now requires architects to take land use into consideration when choosing off-site renewables.

"We can't just replace the negatives of fossil fuels with some of the negatives that come with renewables," said Brad Liljequist, director of ILFI's Zero Energy Program.

ILFI's certifications have a new off-site renewables exception. "We want them to be located in a previously developed site or where dual use can be provided," said Liljequist.

ILFI defines dual use this way: "installed in a way to allow continuation of ecologic or natural resource functions (e.g. solar panels installed in pasture land in a way to allow continued grazing)." (If the project team is unable to site the renewables in this type of a location, they can apply to ILFI for approval.)

"The negatives associated with a monoculture solar farm are substantial. You are removing habitat. You are removing natural resource functions," Liljequist said. "I'd hate it if we arrived at a place where we talked about solar blight, but we could if we aren't careful."

The U.S Green Building Council's LEED and SITES rating systems do not have dual-use requirements for off-site solar installations.

Multiple-use, not just dual use

Bill Reed, a principal in the ReGenesis Group, said his company is investigating doing a "massive" multiple-use project in Ghana, saying, "it's always better to stack benefits."

He points to structures designed by P4P Energy that can hold solar panels up to 40 feet (more than 12 meters) off the ground.

Steven Conger, the chief design officer of the startup P4P, said his company "uses the efficiency of cable tension structures to support solar PV over spans that can vary from 8 to 150 meters (about 26 to 492 feet)" across. The idea is to "suspend solar over things below it, without interfering with the use below."

P4P has installed two utility-scale solar projects over canals in India to reduce salinity and improve fish habitat while generating energy. They also built one over parking in California.

Reed envisions combining photovoltaic production suspended above with biomass production below, using agricultural residues and grasses as fuel. The solar panels could provide shade for grazing livestock underneath. Reed says the project could help address the shortage of power in Africa.

Feeding people while generating electricity

Back in the U.S., Herbert's biggest concern isn't power, but losing arable land. "I think it is an ethical dilemma for these solar companies, who actually put panels on the ground and take the land out of agriculture," said Herbert.

Herbert says solar companies should be *required* to do dual use rather than take the land out of production.

Macknick predicts states will pass a mix of regulations and incentive programs to increase dual use.

More on solar co-location

"Agriculture and Solar Energy Dual Land Use" by Stephen J. Herbert, Phaedra Ghazi, Kate Gervias, Emily Cole, and Sara Weiss, Stockbridge School of Agriculture

Pollinator Friendly Solar in Vermont

Overview of Opportunities for Co-Location Technologies and Vegetation, NREL

For more information

Soliculture
solicuture.com

SoCore Energy
socoreenergy.com

P4P Energy
p4penergy.com

PRODUCT REVIEW

Mineral-Based Interior Paints Go Mainstream

Mineral-based paint from Romabio contains no synthetic resins, and can be used in place of standard interior acrylic latex paint on drywall.

by Brent Ehrlich

Mineral silicate paints are some of the most sustainable coatings available. They contain few if any synthetic substances or VOCs and are extremely durable, so they would be an ideal choice for interior projects. But these paints are primarily for exterior use on mineral-based substrates such as limestone, concrete, terra cotta, and brick.

Romabio's Domus potassium silicate-based paint line has been formulated for use as a drop-in replacement for standard acrylic latex, even on drywall. Products in this line contain fewer fossil fuel-based ingredients (and in some cases, none) while providing better permeability and mold resistance.

Photo: Peter Mauss

Romabio's washable matte paint was used by Unity Homes because of its low emissions, natural ingredients, and reduced lifecycle impacts.

Acrylic vs. mineral silicate

Most interior acrylic (or acrylic latex) paints are now low- or zero-VOC and form a durable, washable film when dry, making them the standard for interior coatings. (For more BuildingGreen's paint criteria, see Interior Paints: LEED v4 and Beyond). A semi-gloss paint can be 50% acrylic—which is made from fossil fuels and requires small amounts of solvents such as polyethylene glycol to help keep it in solution and aid curing (which is why these paints usually contain a few grams per liter of VOCs). Those looking for more natural options often have to compromise durability and aesthetics.

Standard exterior potassium silicate paints are also zero- or low-VOC, but they do not form a surface coat like an acrylic. Instead, the potassium silicate reacts with minerals in the substrate to create a strong, crystalline matrix, sometimes known as waterglass. This breathable, mold-resistant surface is very durable, with some applications surviving more than 100 years. It is also very thin so it does not hide much of the surface underneath, and it does not work on paper-faced gypsum, so it is not for interior walls.

Romabio's difference

Romabio's Domus paints are modified versions of liquid potassium silicates, containing many of the same solids as acrylics—titanium dioxide and calcium carbonate, for example. With this combination, the solids provide additional cover while the potassium silicate penetrates and bonds to the substrate. According to Jeffrey Sabo, the company's vice president of sales and director of sustainability, "It [Romabio] is the only real paint system that I know of that is not a vegetable- or oil-based plastic."

"For new drywall you still need a primer," says Sabo, and Romabio offers several options that contain minerals and other ingredients that maximize adhesion. BioDomus SuperFlat and EcoDomus matte paint are self-priming and can be used as final finish, according to the company. The matte finish also serves as primer for the company's eggshell and satin paint. And BioGrip primers are formulated for use on already painted or more challenging surfaces. "You can take any of our paint and use it on new drywall," says Sabo, "but it will be better to have Micro (BioGrip) or matte as a first coat because it will have a stronger bond." (Note that Keim, the original potassium silicate paint, also offers Solaprim primer to be used with its matte-finish Optil interior paint.)

Mold resistance and permeability

Sabo says Romabio's Domus line bonds to the substrate through adhesion, similar to how acrylic paints form a surface coat. Unlike acrylics, they also penetrate into materials and bond to whatever they can on the substrate through cohesion. The primer provides the raw materials for this reaction. As the products cure, they get stronger. According to Sabo, the final coat is as durable as premium acrylic paints.

There are two significant benefits of this technology: better permeability and better mold resistance. When moisture gets into a wall, it needs to be able to dry either to the exterior or interior (and when possible both) to prevent mold or decay in the wall interior. A permeable interior wall surface allows drying to the interior. Romabio claims that acrylic latex paints are not permeable, but that is not completely true. An acrylic latex application on standard gypsum has a perm rating ranging from 3 to 10, according to Building Science Corporation's Info-500: Building Materials Property Table (1.0–10 perms are considered "semi-permeable"). So, for buildings with only a few layers of paint on the building interior, there should be no problems using standard acrylic latex, but walls painted frequently using higher gloss paints or sealants could potentially trap moisture over time. Romabio's coatings have a perm rating of between 20 and 65, depending on whether it is their higher gloss Satin or a matte Superflat, respectively, according to Sabo, so trapping moisture should not be a problem.

Mineral-based paints are also naturally mold resistant. This is important because the paper facing in drywall can promote mold growth, and acrylic latex paints provide limited protection. Mineral silicate paints, on the other hand, are alkaline by nature, so mold does not grow

on them. When applied to drywall, Domus paints penetrate the paper, according to Sabo, and bond to the gypsum, eliminating the paper as a food source and reducing the risk of mold growth, while providing a strong bond.

Emissions and translucent transparency

Romabio is promoting its sustainability, and for good reason. Its matte paint contains 75% natural ingredients, zero VOCs, and it meets testing requirements under CDPH Standard Method v1.1. The company also has a Health Product Declaration, contains no Living Building Challenge Red List chemicals, and has a Cradle to Cradle Silver v3.1 rating, with a Gold rating for Renewable Energy and Carbon Management.

Romabio's transparency information is not as fully transparent as one might hope, however. Romabio's Health Product Declaration (HPD version 1.0), for instance, covers all of the company's paints and provides a range of ingredient percentages that varies from product to product. It also lists 14 undisclosed, proprietary ingredients, making it difficult to ascertain what is in any particular paint. Some contain ethylene vinyl acetate (EVA) polymer as a binder, which is a petrochemical. Sabo says the paint is new and the company is protecting its intellectual property. He says that is also why they do not have a Declare label, which requires disclosure. Sabo claims Romabio has testing and documentation showing the ingredients are Red-List free for projects pursuing Living Building Challenge certification.

Cost competitive but not local

Sabo says Romabio paints are $60 a gallon, which is comparable to high-end acrylic latex. The coverage of Romabio paints is better than that of acrylic latex, however, with each gallon covering roughly 450 ft^2, compared to 400 ft^2 for Benjamin Moore Natura. Unfortunately, Romabio paints are only available through the company or Treehouse retailers, so matching colors and looking at samples might be harder in person. Sabo says they have nine mineral-based pigments, and seven artificial ones but they can match virtually any color using zero-VOC pigments.

And though the paint applies just like standard latex, they have to be handled slightly differently. Romabio paints have to be thinned with 25% water. Also, they do not contain biocides, so contractors have to pour the paint out of the can for each use and then seal it before storing. Dipping a brush into the can could introduce contaminants and it's not recommended if you plan on storing excess paint for later use.

On the other hand, there are upsides to mixing on site: the paint has a lower carbon footprint since the company is not shipping excess water (which weighs eight pounds per gallon), and with less water and higher solids content they do not require the amount of antimicrobials found in typical acrylic latex.

Used in Unity Homes at Greenbuild

Romabio paint was used on the Unity Home set up at Greenbuild in 2015 to showcase Cradle to Cradle products. The walls were painted with EcoDomus Matte on the walls, EggShell on the ceiling, and Satin on the doors. Rheannon DeMond, the company's energy and sustainability specialist, was impressed with Romabio, claiming it would be the company's standard paint if it were not a mail order product, "but even with fast shipping times, having to order paint and wait a few days for it is tough on job schedules." After the job, she chose to use it in her own home, citing the paint's ease of application, look, durability, and low emissions. "I absolutely love the Roma Bio line!" She says, "You can use a matte finish in every room as it can be scrubbed and will not fade [matte is normally the least durable paint sheen and is difficult to clean], which gives a light, forgiving texture that just looks great on the walls." At the end of the job, the brushes cleaned with soap and water had no latex residue, according to DeMond, and the finished walls had even color. She says the paint was more expensive than standard acrylic latex found at home improvement centers, but "it really does not need a primer, and spreads so well that I bet the actual costs are not much higher."

Using Romabio in your next project would require extra lead time, planning, and some contractor training, but for those looking for a more natural, low-emitting alternative to standard acrylic latex, this paint is worth a look.

NEWSBRIEFS

Trump's EPA Sets New Rules for Chemicals Under TSCA

Faster reviews and more industry-friendly risk assessments are among the changes.

by Paula Melton

New chemical reviews are speeding up at the U.S. Environmental Protection Agency (EPA).

Under the Toxic Substances Control Act (TSCA), before newly developed chemicals can be used in the U.S., EPA must review them for safety. Administrator Scott Pruitt recently announced how the agency plans to do this, stating that the rules will

Photo: Gage Skidmore. License: CC BY-SA 3.0.

EPA Administrator Scott Pruitt recently announced how the agency will review new chemicals under TSCA.

protect human health and the environment "while also being supportive of bringing new chemicals to market."

The changes include faster reviews, more collaboration with chemical manufacturers, and a subtle but important shift in how the agency will conduct *risk evaluations*—predictions of how likely a chemical is to harm people or the environment.

EPA will focus on the "intended uses" of new chemicals, meaning the specific uses the chemical manufacturer already expects. "Reasonably foreseen uses"—things the new chemical could be used for in the future—will be taken into account only "where facts suggest the activity is not only possible, but, over time under proper conditions, probable." This suggests the agency will focus its risk evaluations narrowly and is unlikely to account for potential hazardous impacts throughout manufacture, use, and degradation.

The American Chemistry Council praised the new rules, saying in an email statement to BuildingGreen, "We strongly support the Administrator's commitment to a more predictable and transparent process for decision-making and look forward to continued collaboration in achieving these improvements."

Chemical watchdog groups were more hesitant. "I thought we were finally making progress with TSCA reform," wrote Richard Denison, Ph.D., of the Environmental Defense Fund in a recent blog post. "The law requires … that EPA must conduct broad reviews of chemicals across their full life cycles and accounting for their known, intended, and reasonably foreseen uses," he explained. "Yet the changes made to the final rules represent a renewed effort to move us squarely away from that."

The new rules do not cover how EPA handles chemicals already on the market.

More on risk assessment and chemical regulations

EPA to Regulate Hazardous Chemicals in Building Materials

Building Products and Health: A Look at Risk vs. Hazard

TSCA Reform: Chemical Regulations, at a Cost

Chemical Risk Assessments Come to LEED v4

For more information

U.S. Environmental Protection Agency
epa.gov

California Code Scores LEED Points

All LEED v4 prerequisites and six credits are now automatic for many commercial projects meeting the CALGreen code.

by Paula Melton

Commercial buildings in California can now get a huge jumpstart on achieving LEED certification. New construction projects meeting certain requirements will enjoy streamlined documentation to achieve all LEED v4 Building Design and Construction (BD+C) prerequisites along with six optional credits, for a total of six automatic points. The move acknowledges significant overlaps between the voluntary LEED rating systems and the progressive energy and building codes in the state.

To qualify, buildings must be new, non-residential construction projects (not renovations or commercial interiors) subject to the California Energy Code and the CALGreen Code, and must register under LEED v4. USGBC has not yet released technical details explaining how documentation will be streamlined.

The credits to be awarded are:

- Light Pollution Reduction, Option 1
- Outdoor Water Use Reduction, Option 2
- Indoor Water Use Reduction
- Optimize Energy Performance, Option 1
- Construction and Demolition Waste Management, Option 1
- Construction Indoor Air Quality Management Plan

Photo: Paul Housberg. License: CC BY 2.0.

Projects like the LEED PLatinum CalSTRS headquarters could have a much easier time getting certified under new LEED guidance.

The decision updates prior guidance by USGBC that allowed far fewer automatic prerequisites and a different set of credits for California projects.

"This alignment in LEED represents an evolution by the USGBC to better support and encourage green building code adoptions across the country," said Wes Sullens, USGBC's director of codes technical development, in an email announcement. "We hope that California's leadership can showcase how a strong green building code helps fulfill the local and state goals as well as our mission to achieve green buildings for all."

For more information

U.S. Green Building Council
usgbc.org

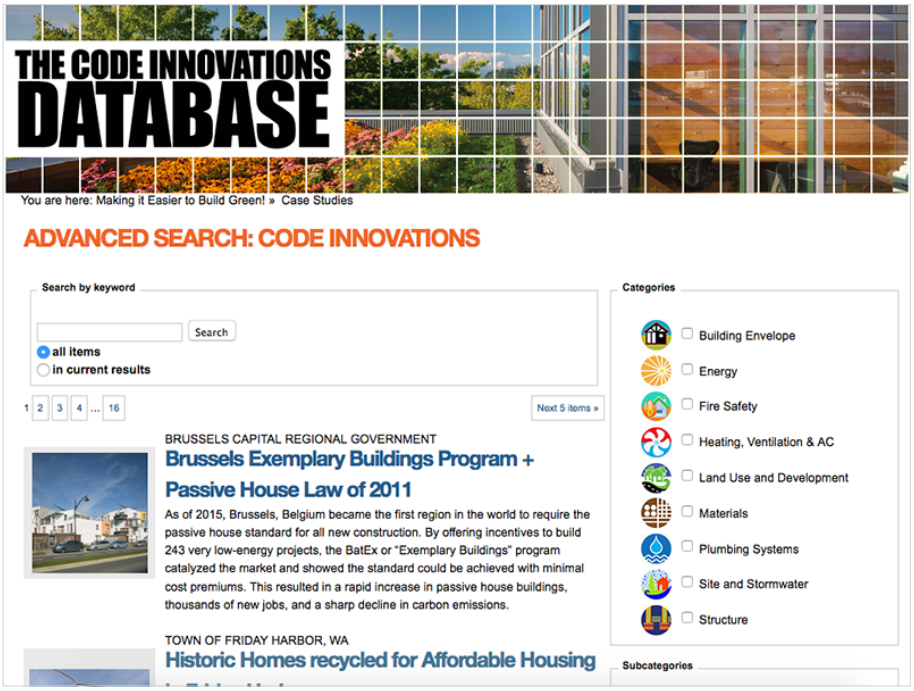
Case Studies Track Building Code Breakthroughs

Need examples of water or energy features that successfully challenged local policy? The Code Innovations Database can help.

by Paula Melton

When engineers for the six-story Bullitt Center went to Seattle code officials looking to install composting toilets, success was not assured. Composting toilets don't follow the letter of the Universal Plumbing Code, and bathrooms with composting toilets aren't ventilated in the usual way. Yet because of a local ordinance designed to encourage Living Building Challenge certification, the team had almost no trouble getting a permit for this and a number of other novel systems.

As projects push the limits of green building technology, they often push the limits of building codes as well—but it all happens quietly in the offices of local code officials. The Code Innovations Database is trying to change that by sharing small, local successes on an internationally accessible platform.



Screen Capture: Ecobuilding.org

The Code Innovations Database shares small, local successes on an internationally accessible platform.

The database records successful code variances in the form of searchable case studies. Building professionals and code officials can then find precedent-setting projects and potentially use the same methods to gain approval for similar technologies. A project of the Northwest EcoBuilding Guild, the database currently focuses on jurisdictions in the Pacific Northwest, but the owners are seeking to expand it to a national scope.

The case studies cover two types of innovation: projects that have successfully stretched or changed building codes, and policy and code updates that encourage green building. Users can filter by green building attributes (energy, materials, land use, etc.) or can search by keyword to find relevant case studies.

Users can submit their own success stories by writing to education@ecobuilding.org.

For more information

The Code Innovations Database
ecobuilding.org/code-innovations

PRODUCT NEWS & REVIEWS

Interior Paints: LEED v4 and Beyond

LEED v4 overhauled its low-emitting materials credit, with a new emphasis on VOC content and emissions. But be sure to look for durability as well.

by Brent Ehrlich

Finding a low-emitting paint used to be such a simple task. We could look at a paint can and see the volatile organic compound content in grams per liter (g/l). In LEED v2009, if a paint met the VOC requirements for South Coast Air Quality Management District (SCAQMD) Rule #1113, we were good to go. For standard flat acrylic latex paints, that meant 50 g/l or less.

But VOCs are not so simple. VOC limits were first established by SCAQMD in Southern California as a way to combat ozone and ground-level smog caused by VOCs reacting with pollutants and sunlight. The volatile solvents in paint were a major VOC source—and usually hazardous as well—so waterborne solvents

photo: Benjamin Moore

Benjamin Moore has several LEED v4-compliant paints that are rated MPI X-Green for performance and have low emissions, including the zero-VOC Natura.

replaced them in low- and zero-VOC paints, leading to less pollution and better indoor air quality.

Though interior paint is much safer today, VOCs continue to offgas after application, potentially causing respiratory problems and other long-term health impacts. Moreover, VOCs that don't react with sunlight aren't reflected in the VOC content listed on a paint can, so that number does not accurately reflect actual VOC emissions when applied onsite where it really matters. That's why LEED v4's Low-Emitting Materials credit now requires emissions testing for "wet applied products" such as paint, as well.

LEED v4 interior paints

LEED v4 requires that 100% of paint applied onsite has to meet the VOC content requirements of SCAQMD Rule #1113 or California Air Resources Board 2007. To that extent, it's a simple update from LEED v2009. But there's more to LEED v4: paint can't contain methylene chloride or perchloroethylene, and for emissions, at least 90% of the paint has to be tested to meet CDPH Standard Method v1.1-2010 criteria for emissions. That standard tests offgassing over a 14-day period, looking for chemicals of concern on the Cal-EPA list. It also looks at total VOC (TVOC) concentration, and manufacturers have to show the range of TVOCs, which can help assess cumulative low-level emissions of unknown VOCs.

Many paints that meet LEED v2009 content requirements will also meet LEED v4, but you have to verify that by checking that companies have done the testing. Check product literature to determine that CDPH Standard Method v1-2010 was used to test the product. Don't rely on the year the product was tested—check for the method.

BuildingGreen uses a higher standard

BuildingGreen has always held interior paints to a high standard because they are used everywhere and cover a lot of surface area, so contractors and occupants are exposed to their emissions. Our criteria go beyond LEED's. For example, BuildingGreen does not approve paint that contains epoxy due to its bisphenol A content. Otherwise, the acrylic paints we approve use the same content and emissions requirements as LEED v4, yet we also require that companies offer low-VOC tints (<50g/l) for those products.

In addition, paint durability is critical to its sustainability. A durable paint that lasts longer—while remaining attractive—results in less repainting, fewer VOCs introduced into the building, less occupant exposure, and less maintenance, saving the resources and energy used to manufacture, transport, and apply these products. For acrylic paint, BuildingGreen only recommends those that meet Master Painters Institute (MPI) X-Green standard, which requires performance testing as well as low VOC content and chemical restrictions.

Here is a partial list of acrylic latex paints that meet BuildingGreen Approved requirements:

- Glidden: Ultra-Hide
- PPG: Speedhide, Pure Performance
- Benjamin Moore: Regal Select, Natura, Ultra-Spec 500, ben, Super Hide, Eco Spec, Aura, and ADVANCE (waterborne alkyd)
- Sherwin-Williams: Harmony, Loxon Concrete & Masonry Primer, PrepRite, Extreme Bond, Multi-Purpose Primer/Sealer, ProMar 400 and 200, EcoSelect, Drywall Primer, Emerald, Solo, and select coatings in the Pro Industrial line

For additional information, see BuildingGreen's Interior Paints Product Guide.

PRIMER

Acoustic Ecology: Designing for the Ear

By engaging our sense of hearing, and our sonological competence, design can improve our ability to listen to and know the places we inhabit.

by James Wilson

In your building designs, do you think of noise as a nuisance—something that always needs to be reduced? Instead, what if we thought of sound as an architectural "material" that can drive the creative process and enhance the way we experience and interact with our environment?

Think of a place where you spend a lot of time. Can you describe the sounds there? Or how those sounds affect you? What about the sounds you contribute to that place? The way in which you interact with that place based on the sounds you hear and the sounds you make is a primary focus of *acoustic ecology*.

Acoustic ecology, also known as "ecoacoustics" or "soundscape studies," is the interdisciplinary study of the relationship between humans and their environment as mediated through sound. Its aim is to improve the quality of the sonic environments, or "soundscapes," that we inhabit.

Photo: Matthew Blackburn. License: CC BY 2.0.

Paley Park in New York City, designed by Zion Breen Richardson Associates, is an urban soundscape designed to offer an experience of quiet, calm refuge for city dwellers. The park's trees and waterfall absorb and mask noise from the street.

Architects play a significant role in this by ensuring that their buildings do not produce noise that disrupts or "pollutes" the ecologies in which they are situated. But architecture could also make us better listeners by engaging our sense of hearing and making us more conscious of the sounds in our environment. For example, a building could promote connection to place by highlighting or framing the sonic characteristics of its site.

Environment as music

R. Murray Schafer, the originator of acoustic ecology as a discipline, founded the World Soundscape Project as a way to raise the public's awareness of sound and promote the concept of "soundscape design."

Schafer's interest in our relationship to sound grew out of his work as a composer. He suggests that people try to hear the soundscape around them as a musical composition and actively participate in its ongoing composition by being conscious of how the sounds they make affect their surroundings.

Schafer was motivated to advance the discipline of acoustic ecology partly in response to the dominance of "eye culture"—the tendency we have to rely heavily on what we see, rather than what our other senses perceive, to understand and interact with the world around us. Schafer and others argue that this has prevented us from fully understanding and connecting to our environment.

Acoustic ecology had its origins in Schafer's work as a music teacher in the 1960s, when he sensed that children's ability to listen was deteriorating. He demonstrated the concept of what he called "sonological competence" with exercises he developed while teaching. For example, he would ask his students to name five environmental sounds, not including music, that they remember hearing that day. Or he'd have them list five sounds—other than music—they like and five they do not like.

Noise pollution

An increased awareness of the sounds in our environment makes us more attuned to the sources and impacts of noise pollution.

Human noise—from buildings, traffic, industry, etc.—can interfere with ecological processes. For example, if birds are not able to hear one another over the noise of traffic, it can impair their ability to communicate and mate.

Noise can also damage "soundmarks"—the unique sonic aspects of an urban soundscape that, like landmarks, are important to cultural and historical identity. Soundmarks are the generally human-made sounds that characterize a place and set it apart from other places. Think of the rich blend of sounds in a city like Istanbul: the shouts of market vendors, the music of street performers, the daily calls to prayer.

As the preservation of both natural systems and cultural history is essential to the concept of sustainability, it is critical that architects understand how their designs can protect or enhance the quality of existing soundscapes.

Soundscape quality

In acoustic ecology, the terms "hi-fi" or "lo-fi" soundscapes are used to refer to the acoustic quality of an environment. If people can hear sounds distinctly, at all frequencies, the soundscape is considered hi-fi (for high fidelity). This is due to minimal masking of sounds and greater propagation of "acoustic coloration." Greater acoustic coloration means that listeners have access to more information in the environment. The echoes and reverberations of different sounds cue the listener to the physical qualities of the environment, such as its size, shape, or materiality.

The experience of a hi-fi soundscape can support our sense of place because we are able to detect more of the nuances that differentiate one environment from another. The sound waves received by a listener are, in a sense, "recordings" of the physical space the sound wave has traveled through and interacted with.

But in a lo-fi soundscape, sounds mask other sounds and it is difficult to hear any individual sounds clearly. The subtleties of the environment are lost in muddled, unvaried noise. Instead of experiencing the acoustic environment

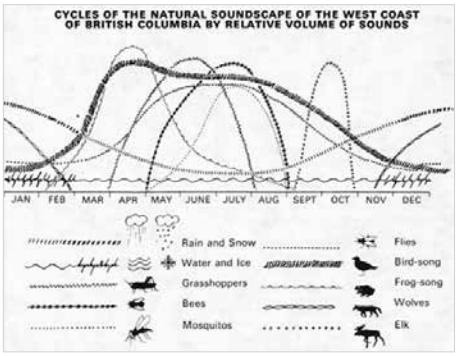


Image: World Soundscape Project, Simon Fraser University

This graph—a represention of the soundscape of the west coast of British Columbia—describes the different cycles and relative levels of the natural sounds that can be heard there.

as a diverse range of sounds, we only hear noise in broad categories, like "loud" or "quiet."

Learning to listen

A big focus of acoustic ecology is the development of "sonological competence." Improved listening skills would lead to greater appreciation for environmental sound, in turn encouraging people to take an active role in the stewardship of soundscapes.

And as architects develop their own "sonological competence," they might begin to experiment with ways of creating new sound environments to foster and support our ability to listen to and know the world around us.

For more information

World Forum for Acoustic Ecology

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