TODAY'S BUILDINGS FOR TOMORROW:

GUIDE TO BUILDING REUSE FOR CLIMATE ACTION

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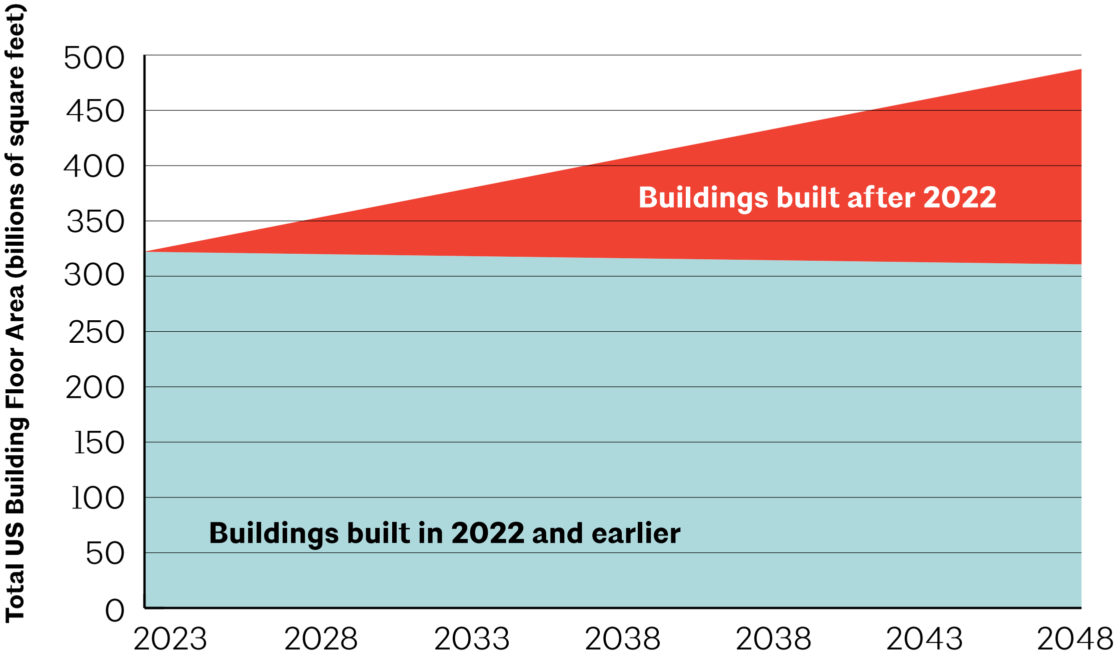
INTRODUCTION

>INTRODUCTION

OVERVIEW: WHY BUILDING REUSE FOR CLIMATE ACTION?

The purpose of this guide is to provide practical information to help architects involved with the renovation and adaptive reuse of existing buildings make smart choices that have the greatest positive impact at the least cost. It helps architects ask the right questions, links them to useful resources, and provides case studies that illustrate these ideas in action.

The renovation and transformation of existing buildings is a significant part of the business of architecture and also a significant opportunity for architects to address climate change. By floor area, about half of the U.S. building stock is over 40 years old, and *over 50% of billings by AIA membership are for renovation and reuse projects*. Moreover, about 65% of the *projected* U.S. building stock (in floor area) in 2050 will be buildings that were already standing in 2022.



As former AIA President Carl Elefante *observed*, "There is no pathway to a zero-emissions building sector without zeroing out emissions from America's 325 billion square feet of existing buildings."

In 2022, the fuel and electricity consumed by existing buildings were responsible for *an estimated* 28% of global emissions. Building construction (including the manufacturing of the steel, concrete, glass, and other materials that go into buildings) *is responsible for another* 9% of global emissions—this is sometimes referred to as "embodied carbon." Because the emissions associated with constructing a new building are typically significantly greater than the emissions to renovate one, renovating, rather than demolishing and replacing, existing buildings can be a carbon-smart approach to decarbonizing existing building stock. The good news captured in this guide is that reused and renovated buildings can be transformed into low- and zero-emissions buildings, achieving energy performance comparable to that of new construction—at a fraction of the embodied carbon.

Therefore, building reuse and renovation is an essential part of climate mitigation—slowing the emissions driving climate change. But climate change is already underway, with extreme heat events, more severe storms, and more frequent wildfires already impacting air quality and daily life across the world. Even with everyone's best efforts, these impacts are likely to get worse before they get better. So, if we are investing in reusing existing buildings, we need them to be designed to handle these new conditions—they have to be designed for climate adaptation. Building reuse provides an opportunity to improve resilience. As discussed in subsequent sections of this guide, improved insulation can reduce occupant vulnerability to extreme heat or cold during power outages; roofing, windows, or glazing can be strengthened to withstand more severe storms; and heating, cooling, and ventilation equipment can be specified with filtration to deal with particulate-laden smoke from distant wildfires.

Finally, building reuse can help improve both public health and *social equity*. In both urban and rural communities, low-income residents and *communities of color often live in substandard older buildings* that may have inadequate ventilation and high utility bills. High energy burdens—the percentage of income that goes to energy bills—plays a significant role in housing insecurity, where a few unexpectedly high bills in a row can lead to low-income residents losing their homes.

According to the Department of Energy's *Low-Income Energy Affordability Data* (LEAD) Tool, households across the U.S. with incomes below 30% of their state's median income pay 18% of that income for electricity and gas.

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In New Orleans, *23% of all households had incomes below 30% of the area median, and these households spent an average of 23% of their income on electricity and gas for their residences*.

Transforming our existing building stock can support a transition to a healthier, more equitable society.All of this presents architects with a business opportunity to transform the existing building stock in ways that aid the transition to zero carbon emissions while promoting health, equity, and adaptation to the climate change impacts that are already here, as well as those that are coming.

BUILDING REUSE FOR CLIMATE ACTION

GUIDE BY BUILDING COMPONENT

SITE

Although the site has already been selected in a building reuse project, the changing climate requires us to take a fresh look at site conditions today and those anticipated for the next few decades. It's also a good opportunity to explore ways to improve the performance of the site landscape and hardscape.

Image credit: Jim Gage

OPPORTUNITIES

- What are the predicted climate projections for the site, such as changes in temperature and precipitation patterns, sea-level rise, or more frequent and intense extreme weather events? Tools such as *The Climate Explorer* or the *National Climate Assessment* can help.
- What are the potential climate change risks associated with the site, such as flooding, extreme heat, or wildfires? How resilient is the site to extreme weather events?
- Is the site located in a flood-prone area? If so, what measures can be taken to mitigate the risk of flooding?
- Can the building be elevated above potential flood levels or incorporate flood-resistant design features, such as watertight barriers or flood vents?
- How can landscaping and site drainage be designed to prevent water accumulation and flooding?
- Is the site located in a wildfire-prone area? If so, how can the building design incorporate wildfire-resistant features, such as non-combustible materials, fire-rated windows and doors, and vegetation management?
- Can landscaping be designed to create a defensible space around the building to minimize the risk of ignition from nearby wildfires?
- What emergency response strategies can be incorporated to evacuate the building safely during an emergency?
- What is the likelihood and frequency of these risks occurring?
- What is the severity of the consequences of these risks occurring?

- What ecosystems or habitats are on or surround the site? Are there any vulnerable or at-risk species? Do any provide natural resilience that could be mimicked or enhanced? What design strategies can be incorporated to enhance site resilience?
- What elements of the *Climate Positive Design Toolkit* for low-carbon and carbon-sequestering landscape and hardscape design are appropriate for this project?
- How does water interact with the site?
    - > Is there a need for landscape irrigation? Can irrigation loads be reduced through native plantings or xeriscaping?
    - > Would water storage benefit the immediate landscape or relieve infrastructure in times of stress (like flooding or severe storm events?) Would water storage (retention ponds, cisterns, blue roof) benefit the building users and provide possible water reuse/indoor water use savings?
    - > How can runoff be filtered and returned back to the local ecosystem cleaner? How can runoff be reduced?
    - > How can the design reduce the use of impermeable surfaces?
    - > How can permeable pavement and plantings be used to reduce runoff and increase percolation throughout the site.
- What public spaces or features can be incorporated to support community resilience, such as accessible and safe cooling centers or resilient infrastructure for emergency preparedness?
- What is the solar exposure of the site and the building? Can introducing trees or shade structures extend outdoor comfort for more of the year or improve the energy performance of the building?
- What types of renewable energy could be accommodated on-site? Determine on-site capacity to provide renewable energy (e.g., photovoltaic arrays, solar water heater, etc.).
    - > On-site power generation can reduce a building's reliance on fossil fuels and provide power during disaster and recovery. Look at the project site, parking, and rooftops to understand where a solar array could be placed.
    - > What infrastructure and transportation networks surround the site and/or could be supported and enhanced with site features?

Image credit: Mike Haupt

BEST PRACTICES

The building site presents opportunities to manage the changing climate and contribute to community resilience. Excess water (e.g., inland flooding, sea-level rise, tsunamis, and increased rainfall), extreme drought, fire, and species migration (e.g., termites expanding their range) can be expected with the changing climate.

Most climate projections show, in addition to slowly rising average temperatures, a dramatic increase in weather extremes.

Based on a site's climate region, architects need to plan for chronic heat, severe cold, and increased freeze/thaw cycles as well as heavy precipitation events, drought, and wildfires/smoke. Increased extreme heat events can mean that an existing building that was previously able to provide comfort without air conditioning may need to consider it now. Simple, passive design strategies often considered in new construction when siting a project can be achieved through new plantings and landscaping. Our changing climate will also bring increased wind from more frequent and intense tornadoes and/or hurricanes. Plantings can be a buffer for wind, protecting the building, but they can also be a hazard during severe wind events, so all design strategies need to be appropriately considered. How can the project site adapt to new and existing challenges?

While it's widely appreciated that adapting and reusing existing buildings helps avoid the carbon emissions associated with new structures and building envelopes, similar benefits come from siting projects on previously developed sites. Doing so allows reuse of the site infrastructure (roads, drainage, water lines, power lines) already in place.

Where possible, replacing or augmenting conventional drainage systems with green infrastructure can offer multiple benefits, including handling more severe storm events without overloading existing drainage.

CHALLENGES

Making modifications to the site surrounding a building reuse project can often be difficult because conditions below grade are either unknown or costly to work around.

Interventions at the scale of raising a building to a higher flood elevation can be quite costly, unfeasible for some building structural systems, or not allowed for certain historic structures. In such cases, architects will need to consider alternative approaches to resisting floods or reducing flood damage, such as installing removable flood dams or treating areas below anticipated flood levels with materials that allow a structure to take on water without damage. For more information on this, see FEMA resources on *wet floodproofing* vs. *dry floodproofing*.

CONCLUSION

Architects are used to considering site issues when planning for new construction—but site considerations can also have big impacts for building reuse projects. By considering how your project can adapt to a changing climate while mitigating its contributions to climate change, your project can perform better on the day it opens—and be prepared for what's coming.

STRUCTURE/SPACE PLAN

A building's structure typically represents 50–75% of the embodied energy and carbon emissions in that building, largely due to the weight and quantity of the materials that comprise the structure. For that reason, building reuse that maintains all of the existing structure can meet today's needs with significantly lower carbon emissions than new construction.

The service life of most building structures often outlasts the initial building use. A critical consideration in adapting existing structures to future use and extended service life is how well the structure can perform at today's standards and tomorrow's hazards and risks. Buildings that historically weathered regional hazards may have inherent resilience features or may require fortification to ensure a continued service life for new shocks and stresses. They may need to employ new strategies to withstand more intense storms and climate events to function and/or serve the community during and after a disaster. The first strategy for reducing embodied carbon in the *AIA-CLF Embodied Carbon Toolkit for Architects* is to reuse/retrofit existing buildings. Tools like the Carbon-Avoided Retrofit Estimator (*CARE*) and the Early Phase Integrated Carbon (*EPIC*) Assessment website can help you develop quick (minutes, not hours) estimates quantifying the reduction in carbon emissions from the reuse of a structure and other building components. Architects can take advantage of the big benefits from reusing existing structures while balancing their ability to function in their extended service life.

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OPPORTUNITIES

- Can the existing structure withstand load capacity?
  - For example, adapting an existing parking garage to other uses is usually challenged by the fact that parking garages tend to be designed to support lighter live loads than offices or other building types.
- Which programs work well with the existing building structural bay sizes?
  - For example, existing buildings with narrowly spaced columns may work well for residential programs but less well for offices and assembly spaces.
- What passive strategies can be incorporated?
  - When laying out the program, identify the areas that could benefit most from access to views, daylight, and natural ventilation, and locate those near the perimeter while locating storage and less-frequently used spaces in the areas where these resources are less available.
  - Spaces near an operable window can take advantage of natural ventilation when outdoor air conditions are appropriate. Typical guidance states that spaces within 20–25 feet of an operable window can be naturally ventilated if the open area is at least 5% of the floor area being served.
  - Spaces with operable windows on opposite sides (but separated by less than five times the room height) can take effective advantage of cross-ventilation.
  - For taller buildings, stack ventilation can use the buoyancy of warm air rising to draw air up and through the building, as long as care is taken to meet code requirements limiting the number of interconnected floors.
  - Floor areas no deeper than twice the height of the top of the glazing can typically be effectively daylit.
  - Pay attention to existing features like column or window spacing, and explore which test layouts work best with these rhythms.

Image credit: AIA

BEST PRACTICES

Is the structure equipped to handle current and future climate stresses, or to meet updated structural codes? When adding to a structure, look for opportunities to make the added structure support project goals. For example, if cross-bracing or a shear wall needs to be added to meet increased wind or seismic loads, look for places to locate this additional structure that works well with the program.

Tips for maintaining as much of the existing structure as possible:

- Work within the existing floor area to meet the program requirements.
- Validate space needs and look for opportunities to incorporate flexible, adaptable spaces into an existing structure, both creating and providing long life and loose fit.

CHALLENGES

If the work contemplates a change of use or the scope exceeds the threshold requiring compliance with current codes, structural upgrades may be required to meet current seismic or wind load requirements.

Existing structures, especially those with steel members, may have used fireproofing containing asbestos or be coated in paint containing lead. Hazardous materials mitigation can add substantially to project cost and schedule. Investigating these issues at the beginning of design can reduce schedule delays.

>ENVELOPE

Building envelopes (the roof, exterior walls, windows, etc.) play a critical role in not just how buildings look but also in occupant comfort and building energy use. So, a key consideration in any building reuse project is whether to restore, upgrade, or replace the envelope. Complete re-skinning of a building can provide a "new" building at less expense and lower embodied carbon emissions than new construction, but the *embodied carbon emissions associated with building envelopes can still be significant*. It's worth carefully considering preserving as much of the building envelope as possible while improving its performance through better air sealing, insulation, or selectively replacing the glazing. This approach can provide new-building performance at significantly lower cost and carbon.

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OPPORTUNITIES

- What in the current envelope is working well? Which elements have caused problems with, for example, air infiltration or water entry?
- For the opaque portions of the envelope, can infiltration be located via field testing and sealed with caulk?
- For the opaque portions of the envelope, can insulation be safely added?
- If the project is located in a region where severe storms, hurricanes, or tornadoes make large missile impact a concern, are the existing windows, storefront, or curtain wall rated to withstand these impacts? If not, what are the options for upgrading?
  - > Note that impact resistance is a property of the glass, the frame, and how the frame is tied into the rest of the building structure. Replacing the glass or applying a film to the existing glass may offer some improved safety but will likely not perform the same as a replaced window, storefront, or curtain wall.
- For windows, storefront, and curtain wall, what changes can be made to provide the most benefit for the least cost and embodied carbon?
  - > If existing windows are wood-framed, especially older windows likely made from tight-grained, old-growth wood, it's often well worth finding ways to restore these rather than replace them. *Research by the Preservation Green Lab indicates that*, in many climates, a restored wood window with good air-sealing can perform nearly as well as replacement windows. In the most challenging climates, interior or exterior storm windows can provide added performance at a fraction of the cost and carbon of replacement.

Image credit: Anna Holowetzki

- In commercial projects using aluminum-framed curtain wall or storefront systems, note that some manufacturers now offer takeback programs that allow replacement of existing frames with ones with better thermal or impact performance at a much lower environmental impact.
- Glass and glazing have evolved substantially over the last century, from the clear, single-pane glass manufactured before 1950 to the low-visible-transmittance solar control glazing of the 1950s through the 1980s to the high-visible-transmittance, highly insulating glazing units available today. Many commercial buildings designed in the 1960s through the 1990s used dark, low visible-transmittance glass to limit solar gain, reducing daylight levels indoors and offering poor thermal comfort near the glass. Replacing this glazing with modern glazing can improve the occupant experience even if the glazing replacement is not paid back in simple energy savings. Even for projects under stringent historic preservation restrictions, neutral-color, single-pane, hard-coat, low-e glazing, and, more recently, innovations in *vacuum-insulated* and *glazing* units can offer high performance in a very thin system.

BEST PRACTICES

For many projects, it's useful to consider envelope interventions in the following order to evaluate their potential cost and savings potential:

- Improved air sealing
- Increased insulation
- Repair/restoration of seals and gaskets at doors and windows
- Secondary window layers (storm windows, curtains, blinds)
- Glass modification (applied films)
- Glazing unit replacement
- Window unit replacement
- Roof replacement
- Complete envelope replacement

Airtightness: It has long been understood that reducing unintended infiltration and air leakage through the building envelope is important, but it is often incorrectly assumed that this is only a significant concern for homes and residences. *Measurements on a broad range of commercial buildings have demonstrated* that infiltration has a significant impact on HVAC energy in these buildings as well.

Image credit: Liudmila / Adobe Stock

- While whole-building envelope replacement offers the opportunity to provide continuous air-weather barriers, *before-and-after tests of infiltration for historic building retrofits* have shown that **attention to reducing leakage at building penetrations (such as windows, doors, and vents)** and at the **interface between walls and roofs** can cut infiltration to levels below that specified by the most recent codes for new construction.

Insulation: Many architects are surprised by the huge range of embodied carbon and global warming potential (GWP) in different insulation options.

- Insulation is undergoing a rapid evolution due to architects specifying lower GWP alternatives. Manufacturers continue to develop lower GWP versions of their products, so while articles and guides related to insulation provide a useful framework for thinking about the pros and cons of each option, older surveys may be out of date. Architects can verify the GWP of current products by searching for the Environmental Product Declaration (EPD) on a manufacturer's website. The *EC3 (Embodied Carbon in Construction Calculator) tool* makes it easy to compare EPDs from various manufacturers.
- Specify low-GWP *insulation* and cladding materials where climate factors allow. In humid, mold prone environments, detail any natural fiber insulation to vent and be properly protected from moisture. Balance additional insulation with mechanical efficiency for overall operational improvement.
- In houses, insulating the attic has a high ROI. *This Old House* notes that, "The Department of Energy estimates that a properly insulated attic can shave 10 to 50 percent off your heating bill…and stabilize your house's indoor temps to keep cooling needs in check."
- An infrared camera scan of the building by a trained professional can help identify both points of air leakage and points of thermal bridging.

Windows: In older houses and small-scale commercial buildings, research by the *Preservation Green Lab* found that "a number of existing window retrofit strategies come very close to the energy performance of high-performance replacement windows at a fraction of the cost." The retrofit strategies evaluated for locations across the country (with varying climates and utility costs) included:

- weather stripping
- applied window films
- insulating cellular shades or insulating curtains
- interior or exterior storm windows

Image credit: Getty Images

Only after evaluating these retrofit strategies should architects consider replacing the glazing or the entire window system. The *Advanced Energy Design Guides* are a good resource for U-values and the solar heat gain coefficient (SHGC) appropriate to your climate.

Roofing: The roof may be the least-seen but most-important component for preserving a building. The roof can also have a significant impact on energy performance and occupant comfort. Upgrading the roof can be a relatively easy way to protect the building and improve performance.

- In buildings with low-slope ("flat") roofs where insulation is typically above the roof deck:
  - Inspect for ponding that may indicate compression of roof insulation or settling of structural members.
  - If the roof still appears to have a substantial service life ahead, consider application of high-reflectance "cool roof" coatings.
  - If the roof is close to the end of its service life, consider replacing the roofing along with upgrading insulation levels to meet or exceed those of the latest national energy code or of the *Advanced Energy Design Guides*. Select for low-GWP insulations using tools such as EC3.
- In buildings with high-sloped roofs or attics:
  - If ductwork for the HVAC system is currently run within the unconditioned attic, it may be worth considering moving the point of insulation to the underside of the roof decking. This *"conditioned attic" or "unvented attic" approach* means that ducts are not sitting in a hot attic in summer and leaking conditioned air into the great outdoors.

If complete envelope replacement is the most appropriate option for your project, free tools like *Kaleidoscope* can help you identify building envelope assemblies with a lower embodied carbon footprint.

Meeting the standards of *Passive House* certification, which *has been achieved in building retrofits*, might be the "gold standard" of envelope performance. Doing so typically involves full window replacement with triple-glazed units and additional layers added to the inside or outside of exterior walls. In such cases, it's important to evaluate the embodied carbon of the new components to verify that the carbon spent on the upgrade is paid back by the savings due to reduced emissions.

CHALLENGES

- Special attention is required when adding insulation, air barriers, and/or vapor retarders to previously uninsulated or under-insulated wall assemblies; such assemblies can trap moisture or condensation inside the walls. Moisture can increase the risks of producing conditions favorable for mold growth. Any modifications to the envelope should anticipate the possibility that water may get into the wall, so it is imperative to provide ways for the assembly to dry out. Using materials that promote good air sealing while allowing for drying through high-vapor permeability can be a safer choice. The Building Science Corporation offers a library of resources and best practices adapted for each climate—for example, the group offers guidance on *how best to insulate existing load-bearing masonry walls*.
- Historic preservation groups often prize the appearance of single-pane historic windows and resist their replacement, even with reproduction windows capable of accommodating higher-performance insulated glazing units. In many climates, a well-restored single-pane window can perform remarkably well if attention is paid to air sealing. Performance can be improved further with hard-coat, low-e, single-pane glass or vacuum-insulated glazing.
- In new construction, many designers prefer the defense-in-depth approach afforded by *rainscreen building envelopes*, where the wall exposed to the elements is held off the building sheathing, allowing for a "drainage plane" behind, and the air/weather barrier separating indoors from outdoors is protected from the elements. *Converting a non-rainscreen envelope to one based on rainscreen principles typically requires adding additional exterior layers*.

>HVAC/SYSTEMS

Mechanical equipment in existing buildings is often dated and inefficient, and full or partial replacement can result in dramatic energy savings and air quality improvements that can promote occupant health. On the other hand, relatively new and well-maintained equipment may have years of service life remaining. A careful component-by-component assessment of performance and remaining service life is an important first step in the design process. In efforts to reduce operational carbon, evaluating the efficiency of a system and planning for simple upgrades can improve performance. What energy codes are the current systems meeting? Since an improved building envelope can reduce peak heating and cooling demands, replacement equipment may be significantly smaller and less expensive. The best mechanical system is a great building envelope.

Image credit: Getty Images

OPPORTUNITIES

- Can the passive strategies that may have informed the original design of the building—for example, cross-ventilation—be reactivated?
- Can the roof structure support photovoltaic or solar thermal systems?
- In regions where utility-provided electricity is threatened during severe weather or seismic events, is it worth considering on-site emergency generation or battery storage?
- With extreme weather events such as heat domes becoming more common, is it worth sizing systems to handle prolonged heat or cold? Can increased insulation levels help reduce heating and cooling system oversizing while ensuring occupant safety during power outages, as explored by Urban Green in its *study "Baby It's Cold Inside"*?

BEST PRACTICES

Design for the climate that's coming. Future weather patterns may require greater cooling, less heating, or improved filtration to remove particulate matter from outdoor air impacted by wildfires hundreds or even thousands of miles away. While existing systems may have sufficient capacity, plan for how additional capacity will be added in the future.

Conduct an energy audit to identify appropriate energy conservation measures (ECMs) for the project. These audits can be conducted at increasing levels of detail following the *ASHRAE definitions of Level 1, 2, or 3 audits*.

TYPES OF AUDIT	TYPES OF AUDIT BRIEF DESCRIPTION
Level 1	• Brief on-site of the building • Savings and cost analysis of low-cost/no-cost Energy Conservation Measures (ECMs) • Identifications of potential capital improvements meriting further consideration
Level 2	• More detailed building survey • Breakdown of energy use • Savings and cost analysis of all ECMs • Identification of ECMs requiring more thorough data collection and analysis (Level 3)
Level 3	• Attention to capital-intensive projects identified during the Level 2 audit • More detailed filed analysis • More rigorous engineering analysis • Cost and savings calculations with a high level of accuracy

Typical low-cost ECMs include energy recovery ventilators (which use the heat content and humidity level of stale air being expelled to pre-condition fresh air being taken in) and replacing old lighting fixtures with LED lighting. When looking to improve operational efficiency, additional high-impact options to explore include:

- Replacing furnaces with electric heat to eliminate combustion. If loads are modest, inexpensive electric resistance heat can be an affordable, 100% efficient option. If loads are larger, a heat pump, which can deliver 3 or 4 kilowatt-hours of heat for every kilowatt-hour of electricity consumed, can be an attractive choice. For existing buildings in warm climates that already have air conditioning, electric service may already allow the replacement of the AC unit with an air-sourced heat pump. For buildings without air conditioning, the electric service may not have sufficient capacity to support a heat pump, especially if it is determined that electric resistance strip heaters will be needed during the coldest temperatures. In the U.S., incentive programs can help cover the cost of electric service upgrades.

- Adding insulation (see the "Envelope" chapter).
- Locating and repairing any leaks in ductwork or refrigerant lines.
- Considering replacement of older appliances with high-efficiency models if they are near the end of their service life. In the U.S., EnergyStar denotes appliances of a given size or capacity that are among the 25% most efficient.

Go all-electric. Most existing buildings have both electric and fossil-fuel services (gas, propane, oil). Fossil fuel infrastructure is aging and is a large source of carbon emissions. "*A tenth of total US carbon emissions come from burning fossil fuels—primarily gas—for heating and cooking in homes and businesses*," according to clean energy nonprofit RMI. The primary component of natural gas is methane, a potent greenhouse gas (many times more effective at absorbing heat than the carbon dioxide produced when it is burned), and it is estimated that the global warming *impact from leaks in the natural gas distribution system may be comparable to that produced by gas combustion*. The average natural gas pipe in service in the U.S. is over 30 years old, and the *cost to replace the services lines is significant*. Cooking with gas also creates *air quality and health concerns for building occupants*. A device that uses natural gas today will have the same carbon footprint in the future, while a device that uses electricity will have a carbon footprint that shrinks as more renewable sources are deployed and the grid decarbonizes.


Image credit: Annie Spratt

Heat pumps. "Existing conventional heating, ventilation, and air conditioning (HVAC) systems, including gas- and oil-fired furnaces, gas- and oil-fired boilers, low-efficiency air conditioners, electric resistance furnaces, and electric resistance unit heaters, in both residential and commercial applications can all be replaced with *[electric, high-efficiency heat pumps*]," according to Project Drawdown, a climate solutions organization. Heat pumps are devices that move heat from a cooler area to a hotter area. They can extract heat from cool outdoor air (or from the ground, in the case of ground-source heat pumps) and deliver it to the building in winter, or extract heat from inside the building and expel it outside in summer—so they can both heat and cool. RMI *observes*, "Electrifying air heating and cooling with air-source heat pumps will immediately reduce emissions...even in the coldest, most heating-intensive climates." Air-sourced heat pumps are generally *recommended for climates that get as cold as -15°F* (–26°C). For projects in locations that routinely get colder than that, electric resistance strip heaters may be required, or, where adjacent land is available, ground-source heat pumps (which draw heat from the relatively constant temperatures underground) may be an attractive option. Heat pumps provide energy and carbon savings across all building types and climate regions.

DOAS. When upgrading the heating and cooling systems in existing buildings, HVAC strategies that use dedicated outdoor air systems (DOAS) can offer better indoor air quality and occupant comfort while taking less space for ductwork. Compared with conventional ducted HVAC systems, where ducts contain a mix of fresh and recirculated air, in a DOAS system, the ducts contain only 100% fresh air and so can be smaller; temperature control is maintained independently through fan coil units or radiant systems. Thus the amount of fresh air an occupant receives is not dependent on how much heating or cooling they are requesting. This approach is sometimes less expensive than conventional air-based systems and sometimes more expensive, depending on the particular conditions of the project.

Filtration. Whatever the HVAC system, it's prudent to plan for high-efficiency filters. In the past, filters in HVAC systems were present mostly to protect the systems themselves, preventing the accumulation of lint and other materials on the heating or cooling coils. However, recent research on airborne infectious agents, such as influenza or COVID-19 (which can hitchhike on fine water droplet aerosols suspended in the air), has shown that high-efficiency filters (characterized by a MERV rating of 13 or higher) can significantly reduce disease spread. The same filters can also trap fine particulate pollution from vehicles or distant wildfires. In the past, pushing air through high-MERV filters placed excessive loads on circulation fans, but recent improvements in filter technologies has largely eliminated these issues.

LED lighting. The previous generation faced the task of replacing incandescent lighting with more efficient fluorescent or compact fluorescent lighting; today's generation can go even further by using LED lighting, which offers greater efficiency, improved lighting quality and color rendering, and lower environmental impact than fluorescents. As with any electric light source, both lighting quantity and quality matter. For lighting quantity, you want as much visible light (lumens) per unit of electric power consumed (watts); the best LED lights deliver more than 100 lumens per watt. An important measure of lighting quality is characterized by the color rendering index (CRI), with a "perfect" light source defined as CRI 100; look for fixtures with CRI greater than 90.

Lighting controls and occupancy sensors. Even with more efficient light sources, it still makes sense to have lights on only when they are needed. Modern energy codes require the use of occupancy sensors to turn lights off in unoccupied spaces and automatic daylight dimming in spaces with sufficient daylight. Even if your local code doesn't yet require sensors, consider using them on your project.

Refrigerant leaks. Refrigerators, air conditioners, and heat pumps move heat around by compressing a refrigerant gas into liquid form at one location (giving off heat) and then letting it expand into gas form at another location (absorbing heat). These refrigerant chemicals, which include the one known commonly by its trade name "freon," do wonderful things as long as they are completely contained. But when they escape into the atmosphere, many become powerful greenhouse gases due to absorption of infrared radiation that acts as a blanket trapping heat in the atmosphere. There are dozens of different types of refrigerants, and different refrigerants have different heat-trapping power—or global warming potential—compared with the same quantity of carbon dioxide. *The most common refrigerant today, R-22, has a 100-year GWP of 1,810, almost 2,000 times the potency of carbon dioxide, so just one pound of R-22 is nearly as potent as a ton of carbon dioxide*. Because of this, eliminating refrigerant leaks, either by decommissioning refrigerant systems and replacing them or by a comprehensive maintenance plan, provides high impact.

Image credit: Getty Images

- Plan to replace existing systems with equipment that uses next-generation, *low-GWP refrigerants*. Instead of GWP 1,800, the newest systems have a GWP as low as 1—essentially the same as a comparable quantity of carbon dioxide.
- Use prefabricated systems and elements to manage potential leakage points.
- If equipment and refrigerant lines are to remain, make a *refrigerant management* plan to manage leaks if the existing system will continue to operate.

Appliances. For multifamily residential projects, appliance loads can make up a substantial portion of energy use. Using ENERGY STAR appliances can result in a 10–50% savings in energy. ENERGY STAR–rated appliances are made by a wide variety of manufacturers and often do not have a cost premium compared to nonrated appliances! Note that ENERGY STAR–certified appliances are those in the most efficient 25% of those offered; so even among those carrying the ENERGY STAR label, some may be significantly more efficient than others. You can search by appliance type, residential or commercial, size, and more using the *ENERGY STAR product finder*.

Water. As power outages become more frequent, it may be important to consider the resilience of access to potable water. High-rise buildings that use water pumps to reach higher floors may consider putting them on backup power or (where health regulations allow) using a rooftop cistern to provide water during power outages.

The first strategy in reducing energy consumption and carbon emissions associated with heating water is to reduce the amount of hot water needed by using *low-flow fixtures* such as those meeting the EPA WaterSense certification criteria.

Consider whether *solar hot water systems* are an appropriate option at your location; in some climates, the same amount of roof area covered with solar electric (photovoltaic, or PV) panels driving a heat pump water heater may deliver more hot water.

Building controls. Depending on the size of the project, smart-building controls can be as simple as a programmable or smart thermostat or as sophisticated as a building automation system (BAS).

- Consider a smart thermostat that combines an occupancy sensor with algorithms that learn from occupant temperature requests while minimizing heating and cooling demand when no one is present.
- Use occupancy sensors to reduce the load on mechanical systems.
- Make it easy for occupants to take advantage of “free cooling” through natural ventilation without triggering excess mechanical heating and cooling.

Image credit: Saklakova / Adobe Stock

CHALLENGES

The more sophisticated the building systems, the more difficult it may be for building occupants or building operations staff to control or diagnose problems. An efficient system that is being operated in ways the designer did not intend can result in both excessive energy use and unhappy occupants. Training, clear documentation, and simplified "quick-start" user guides can make the difference.

Electrifying any one building may be straightforward, but electrifying every building on a street or in a neighborhood may require upgrades to the electrical distribution service and coordination with the local electric utility. If building reuse projects focus on upgrading building envelopes first, the peak-demand impact of electrifying heating can be reduced.

>MATERIALS

Over the life of a building, successive renovations (tearing out interior walls, installing new ones, replacing flooring or ceilings) can have a substantial carbon footprint; *one study* of an office building found that the cumulative carbon footprint of "tenant improvements" over six decades rivaled the carbon footprint of constructing the building. Planning for projects to be easily adapted to new uses over time minimizes the cost to the owner along with life cycle carbon. Consider planned replacement cycles and expected element lifespans using *Stewart Brand's "pace layering": site, structure, skin, services, space plan, and stuff*. Space plan and stuff commonly have high turnover and short replacement cycles, while skin, structure, and systems have longer operation and performance lifespans. Choose finishes appropriate for their expected lifespan, and opt to design for more durable, flexible materials to reduce replacement cycles in favor of maintenance.

OPPORTUNITIES

- Do any materials need to be removed and remediated to reduce or eliminate unhealthy off-gassing, toxins, or mold?
- Can elements with high turnover utilize highly recyclable, material buy-back, or circular products? Can these elements be designed for disassembly?
- Where can new finishes be eliminated and instead use existing building elements as a design feature?
- Instead of standard demolition, can portions of the building be carefully dismantled to allow the components to be salvaged on-site or elsewhere?

BEST PRACTICES

Balance maintenance, replaceability, and planned obsolescence with service life and expected durability tests of material finishes. Understand project use and advocate for more durable, low-maintenance materials appropriate for the climate and risks. Find materials that can withstand shocks rather than require replacement after experiencing a hazard event. For example, materials that resist salt, moisture, corrosion, and leaching work well for flood-prone areas.

If materials require regular maintenance to ensure their function and durability, work with the owner to ensure a conservation and maintenance plan is in place. Proper care for buildings as resources can safeguard occupant health and offer comfort and long-term replacement cycle savings.

No matter the project scale or scope, architects choose and write specifications for materials and finishes. LMN Architects found that *over the lifespan of a building, the embodied carbon of interior finishes can equal that of the structure and envelope due to replacement cycles and maintenance*. When considering climate action strategies in buildings, it's important to consider planned replacement cycles and expected element lifespans as well as how they will weather in the changing climate. Finishes can also have occupant health implications, as well as affect workers involved in the manufacturing of a building product. For any project undergoing a renovation, follow guidance similar to the common phrase “refuse, reduce, reuse, and recycle.”

Minimize finishes. Reduce additional finishes by using existing features as finishes where possible. Reduce duplication: For example, can the structural floor also be the finished floor? Where a finish is not needed, celebrate beautiful construction and materials. During design, demolition, and construction, look for opportunities to deconstruct and reuse existing building materials that would be suitable as finishes.

Low carbon. Embodied carbon is created each time a product is manufactured. Once a material has been produced, it makes sense to reuse it as much as its usable service life allows. Look for opportunities to use salvaged and reclaimed materials. If a new product is needed, *carbon-sequestering materials* (such as bio-based materials that have drawn carbon dioxide out of the air and locked the carbon in the material structure) are market-ready and available, especially at the residential scale. Carpets, ceiling tiles, and metal products can be low-carbon materials because of high recycled content, and many manufacturers in this market sector offer material take-back programs in which they accept old materials removed from the project and use them as feed stock for new materials. Take-back programs move toward a circular economy at product end-of-life—a great thing for embodied carbon. Look for Environmental Product Declarations (EPDs) to understand manufacturer transparency and measurement for things like carbon.

Healthy materials. While the focus of this guide is climate action, it’s important to recognize that any renovation is an opportunity to provide spaces that support human health. The *AIA Materials Pledge* helps you specify low-carbon, healthy materials. The goals of the pledge are supported by product certifications and eliminating the substances identified in the Living Future Red List. If the *Red List* is new to you or your firm, *aim to eliminate one Red List chemical* from your materials library per project. Set a goal for full product and supply chain transparency for finishes. Ask for and specify products with *Declare*, Just, *GREENGUARD Gold, Cradle to Cradle*, and other certifications focused on material toxicity and transparency.

- Require products with Health Product Declarations (HPDs) or other material health transparency in product specifications.
- Aim for low-VOC, Red List–free materials.
- Measure and report waste material, waste diverted, and health and safety of on-site workers.

Image credit: Getty Images

CHALLENGES

Every year, thousands of new paint, carpet, flooring, and ceiling products are introduced. Investigating what goes into even the most commonly specified materials can feel like an overwhelming task. Using screening tools like the Materials Pledge or the other certification labels discussed here can help keep the process manageable.

CONCLUSION

This guide provides a high-level overview of the opportunities and challenges associated with reusing existing buildings in an age of climate change. By reusing existing buildings, we can adapt existing structures to meet today's needs while anticipating a changing climate and reducing the built environment's contribution to climate change.

The approach the guide has outlined can be summarized as:

- Design for the climate that's coming, not just the one we have today.
- Reuse as much of the existing structure as possible, and organize spaces within that structure in ways that take advantage of what's there.
- Upgrade the building envelope to improve the occupant experience while reducing the need for mechanical heating, cooling, and lighting, and select materials with low embodied carbon.
- Select building systems (heating, ventilation, cooling, lighting, and water heating) and appliances that take advantage of the move toward a zero-carbon electric grid while supporting occupant comfort, health, and productivity.
- Select materials without negative human health impacts—which is especially important because upgraded buildings are typically tighter; select low-embodied carbon materials and ones that can be disassembled and easily recycled.

Building reuse reminds us that sustainability is design with time and consequences in mind.

> CASE STUDIES

CASE STUDY: MYERS-HECKMAN RESIDENCE, OVER-THE-RHINE, OHIO

Myers-Heckman Exterior Historic Facade | Myers-Heckman Contemporary addition
Image Credit: Sol design + consulting

ARCHITECT: Sol Design + Consulting

BUILDING TYPE: Single-family residence

LOCATION: Cincinnati, OH

AREA: 3,962 SF

YEAR BUILT (ORIGINAL): 1870

YEAR OF RENOVATION: 2020

PEUI: 16.7kBTU/sf/yr vs. 75kBTU/sf/yr pre-retrofit

EMBODIED CARBON: 108 kgCO2e/m2 vs. equivalent new single family 200 kgCO2e/m2

Longtime residents of historic Over-the-Rhine, Ohio, renovated their single-family residence to promote neighborhood preservation and showcase sustainability alongside historic preservation goals. The project, situated in a dense urban area, reused the existing structure, improved performance, and reduced strain on city infrastructure with reduced energy and water needs.

CLIMATE HAZARDS

Ohio has historically been prone to:

1. **Flooding:** The area has faced periodic flooding due to its proximity to the Ohio River and inadequate stormwater management.
2. **Extreme heat:** The urban heat island effect has resulted in higher temperatures, particularly during heatwaves, affecting occupant comfort and energy consumption.
3. **Storm damage:** The district is susceptible to damage from severe weather events such as storms, high winds, and hail.

Design for energy

Design for water

Design for resources

Design for change

In Ohio, the most acute anticipated effects of climate change are largely more severe versions of the historic regional hazards:

1. **Increase in high-intensity rain events and associated flooding:** The area is expected to experience more frequent and intense rain events, leading to a higher risk of flooding and water damage.
2. **Increase in extreme heat events:** The region will likely see more frequent and prolonged heatwaves, resulting in elevated temperatures and potential risks to human health.
3. **More frequent power outages:** With the intensification of weather events, the likelihood of power outages may increase, impacting daily life and infrastructure reliability.

The homeowners were deeply committed to historic preservation and sustainability, embracing energy efficiency, walkability, and renewable energy. The renovation project prioritized reuse, preserving almost all of the existing building and finishes. Historic trim, baseboards, and wainscoting were carefully restored and reinstalled over new rigid insulation. Original wood flooring, plaster walls, and exposed brick were celebrated, eliminating the need for new finishes in those areas.

Myers-Heckman Kitchen | Image Credit: Sol design + consulting

ARCHITECT'S AGENCY

The design team's agency played a crucial role in recognizing the renovation project's potential and creating a more holistic and sustainable building through these key actions:

1. **Informed material choices:** Offering guidance on embodied carbon, resilient and durable materials, and health impacts to inform material choices.
2. **Envelope improvements:** Ensuring high-performance envelopes with insulation and airtightness to support passive energy efficiency and survivability during extreme events.
3. **Efficient and resilient systems:** Providing insights on efficient systems to achieve sustainability, health, and resilience goals.

The existing masonry walls were found to be durable, and interior insulation was added with meticulous attention to best practices, avoiding durability issues related to moisture or freeze-thaw conditions. Mindful of climate hazard risks, the design incorporated durable materials for the roof and facade to withstand heavy rainfall. Standing seam metal roofing and a rainscreen system for new walls were chosen. High-performance envelopes with enhanced insulation and airtightness ensure habitable interior conditions during power outages and extreme weather events, creating a home with passive survivability and shelter-in-place capability.

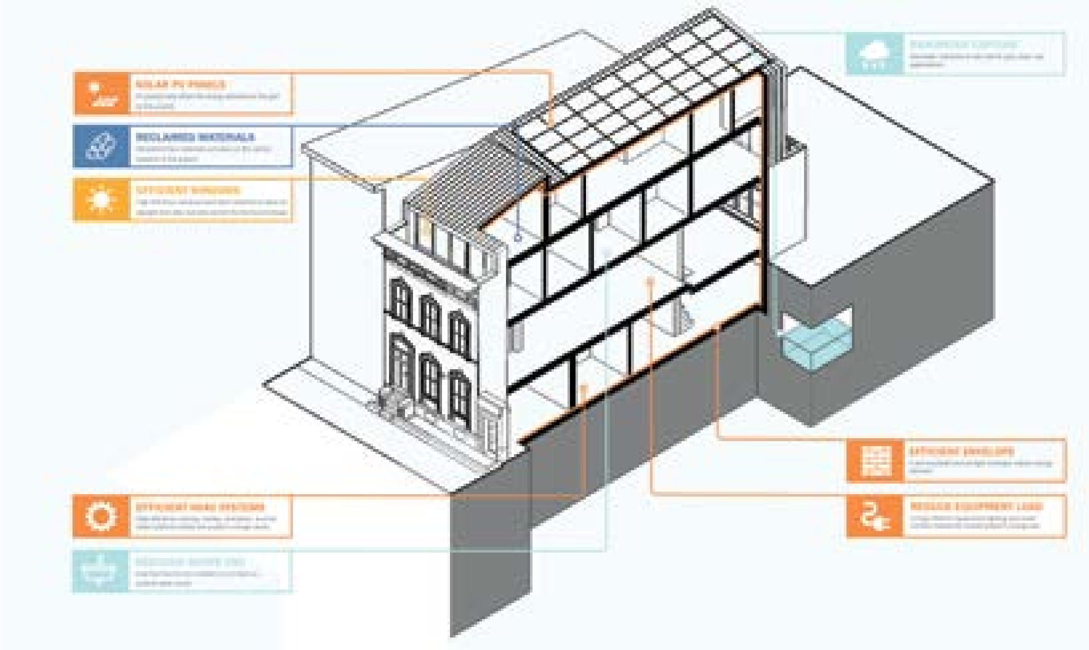

Figure 1: Diagram of design and retrofit elements contributing to a better building. | Image Credit: Sol design + consulting

Paired with on-site solar and battery storage to provide temporary power during outages, the project realized a pEUI reduction from 75 kBTU/sf/yr pre-retrofit to 16.7 post-retrofit. The project also electrified HVAC systems, avoiding combustion and associated pollutants. An ERV saves energy and provides filtered (MERV 13) fresh air. The envelope was designed to manage humidity and moisture, avoiding potential condensation and mold issues.

Carbon emissions, pre-retrofit: 140,200 lbs CO2e/yr
Carbon emissions, post-retrofit w/o solar: 36,979 lbs CO2e/yr
Carbon emissions, post-retrofit with solar: 15,498 lbs CO2e/yr
Carbon payback without solar: 0.9 yrs
Carbon payback with solar: 2.3 yrs
(**Embodied carbon of solar array:** 203,175 lbs CO2e)

Despite being on a small lot in an urban site, the project manages 65% of stormwater from its roof via a 550-gallon cistern buried in the backyard. This water is used for irrigation and then infiltrates back into the earth, mimicking natural hydrology. This system helps alleviate stress on Cincinnati's already-overburdened combined sewer system.

QUESTIONS TO ASK IN BUILDING REUSE AND KEY TAKEAWAYS

1. How can we preserve existing elements to minimize environmental impact and strategically improve long-term sustainability?

   LESSONS LEARNED: The team found that existing elements can be largely preserved while still significantly upgrading performance. The project reused the following:

   98% of existing exterior walls
   88% of existing interior walls
   100% of existing foundation
   94% of existing finish flooring
   98% of existing trim, baseboards, and wainscoting
   Retaining the structure and envelope saves carbon, and the team still made dramatic operational carbon improvements.

2. How can we enhance the building's envelope with new and existing materials, maintaining historical integrity while improving energy efficiency?

   LESSONS LEARNED: Careful attention must be paid to detailing when adding insulation to a masonry structure. The team added a new roof with R-50 insulation over the entire structure (both new and old portions). Continuous R-10.5 interior insulation was added to existing brick walls. New walls were framed as double stud with R-25 insulation. Windows were replaced with low-e double-pane windows (U-0.29).

3. How can we integrate an updated and efficient system, leveraging existing conditions to enhance resilience against climate hazards?

   LESSONS LEARNED: The cooling system and envelope assemblies were designed together to manage humidity and moisture, avoiding potential condensation and mold issues. A high-performance envelope with additional insulation and airtightness can maintain habitable interior conditions for longer durations during power outages and/or extreme heat or cold events, allowing for passive survivability.

Myers-Heckman Side Exterior
Image Credit: Sol design + consulting

The renovation of this single-family residence in Cincinnati's historic Over-the-Rhine district is an exemplary model of sustainability and historic preservation. By addressing climate hazards and responding to the anticipated effects of climate change, the project showcases how thoughtful architectural agency can create resilient and sustainable urban spaces.

Incorporating historic preservation, energy efficiency, and sustainable design principles, this project not only exemplifies the compatibility of sustainability with historic neighborhoods but also offers valuable lessons for future renovation endeavors in the face of a changing climate. The commitment to resilience and sustainability showcased in this renovation is a testament to the vital role architects play in creating buildings that harmoniously coexist with their environment and promote the well-being of occupants and communities.

CASE STUDY: CENTER FOR CREATIVITY, FOUNDRY 101

Foundry 101, Exterior | Anton Grassl courtesy of CambridgeSeven

ARCHITECT: CambridgeSeven

BUILDING TYPE: Center for Creativity

LOCATION: Cambridge, MA

AREA: 50,200 sf

YEAR BUILT (ORIGINAL): 1890

YEAR OF RENOVATION: 2022

PEUI: 30.95 kBTU/sf/yr

The Foundry 101 project is at the intersection of the Kendall Square innovation district and the East Cambridge residential neighborhood in Massachusetts. The Foundry's program was developed in response to requests from community groups. The building is used 24/7 by a variety of users, especially residents from underrepresented communities in adjacent neighborhoods. The dynamic working and learning environment focuses on visual and performing arts, entrepreneurship, technology, and workforce education within its historic, industrial setting.

CLIMATE HAZARDS

Cambridge has historically faced several climate hazards, including:

1. **Coastal storms:** The area is vulnerable to coastal storms, leading to flooding and damage to buildings and infrastructure.
2. **Extreme heat:** Heatwaves and elevated temperatures pose challenges to public health and increase energy demands.
3. **Heavy rainfall:** Intense rainfall events can cause flooding in low-lying areas and increase stormwater runoff.

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Design for resources

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Future hazards largely mirror the historic regional hazards:

1. **Flooding and increasing rainfall:** Buildings in Cambridge face heightened flood risks, requiring flood-resistant measures like elevated foundations and improved drainage. The project is just outside of the 100-year floodplain but inside the 500-year floodplain.
2. **Warmer climate:** Buildings will need to passively cope with heatwaves and reduce cooling demands.
3. **Power outages:** Integrating on-site renewable energy like solar panels with battery storage enhances resilience and provides backup power during outages.

ARCHITECT'S AGENCY

As architectural agents, the team created shared, accessible community spaces; celebrated existing features; and reduced the energy needs of the building.

1. **Shared street and plaza:** The design of the Foundry eliminated the 1980s-excavated, below-grade parking garage, allowing all of the building's program and equipment to sit above the projected base flood elevation for 2070. It also allowed for creation of an at-grade, barrier-free ground plane adjacent to the street and community courtyard.
2. **Maximize existing features:** The historic building's brick envelope was restored and retained, and as much of the roof and wood building structure as was feasible was retained to reduce embodied carbon. Much of the interior floorplates and finishes were replaced. The design team encouraged the client to retain two of the three skylights to provide natural lighting in the central core of the building.
3. **Energy solutions:** The project focused on reducing operational carbon by using a high-efficiency variable refrigerant flow (VRF) system that allows for maximum occupant and operational flexibility, reduction in the lighting power density to 24% less than a baseline design, and high-efficiency heat recovery ventilation units. Building envelope improvements included photovoltaic panel design, which is projected to offset 28.5% of annual energy use and emissions with renewable energy generated on-site.

The Foundry 101 project is at the intersection of the Kendall Square innovation district and the East Cambridge residential neighborhood. The program, born from the community's needs, includes youth workforce training, local arts group studio space, and a warm and welcoming community gathering space. Individual workshops include a food lab, maker space, textile and metalsmith workshops, and dance studio and performance space.

Foundry 101, Dance Shop, interior | Image credit: Anton Grassl courtesy of CambridgeSeven

In the new project the design team omitted the garage and brought the ground-floor plane back to meet universal access. This change also reduced vulnerability to flooding damage. A robust stormwater run-off design was installed, including permeable paving and a stormwater retention system. All mechanical equipment is located on the roof.

The performance space, designed as a versatile black box theater, can adapt to host music, dance, and theater performances with various seating arrangements. The space doubles as a community meeting room, fostering engagement and inclusivity.

Foundry 101 Performance Center, interior after | Image credit: Anton Grassl courtesy of CambridgeSeven

Conference rooms on the first floor serve both internal and community needs, and a demonstration kitchen provides career training opportunities while catering to community events. The offices were designed with both closed offices and open workspaces, ensuring flexibility for future tenants.

The design team balanced preservation and innovation. They retained exposed concrete floors for the first-floor community spaces and public areas on the office floors, minimizing waste. The historic building's brick envelope was restored and preserved, and whenever possible, the roof and wood building structure were retained to reduce embodied carbon. Increased insulation was applied at the roof and in the new addition, and high-performance windows were installed throughout the building. No insulation was added to the historic brick envelope in order to minimize condensation within the brick wall.

By incorporating an all-electric, high-efficiency VRF system and energy-efficient lighting and ventilation units, operational carbon was significantly reduced. The building is projected to have an annual gross electricity use of 2,024,213.36 kBtu/yr with 28.5% of the building's annual energy generated by an on-site PV array for a net annual energy usage of 1,553,725.85 kBtu/yr and an EUI of 30.95 kBtu/ft^2/yr. The energy needs are also forward-thinking. A wire mold system was used in public workspaces, multi-use spaces, and art studios to minimize the need for future electrical work. On-site photovoltaic panels were designed to allow for future on-site battery energy storage.

QUESTIONS TO ASK IN BUILDING REUSE AND KEY TAKEAWAYS

1. How can we ensure that the design accommodates the needs and aspirations of diverse community groups while preserving the historical and industrial character of the building?

   LESSONS LEARNED: The Foundry's program was developed in response to requests from community groups. The architect worked with the City of Cambridge and Cambridge Redevelopment Authority to lead large community meetings and monthly advisory committee meetings, and collaborated with neighborhood groups and local planning and development officials to solicit ideas and tailor. An advisory board was formed to reach out to houses of worship, workforce training programs, and schools, and artist Candy Chang held a community event called "I wish this was." The final program was created after two years of research.

2. What strategies can we implement to enhance the building's resilience and reduce its vulnerability to potential water damage?

   LESSONS LEARNED: Balance the general recommendation to keep what exists with an evaluation of future hazards. Though the structure is outside of the 100-year floodplain, it is vulnerable to more intense flooding as a result of climate change. The team removed the underground parking garage and created a public plaza with robust stormwater runoff design. It doesn't take a whole-building life cycle assessment to thoughtfully weigh risk vs. reward.

3. How can we carefully evaluate and balance the retention of existing elements with the introduction of new energy-efficient systems?

   LESSONS LEARNED: A VRF system was chosen to provide programmatic flexibility for future building use without installing new HVAC equipment.

The Foundry 101 project is a remarkable example of how thoughtful architectural design can harmonize community needs, historical preservation, and sustainability. By strategically omitting the underground parking garage in favor of a shared plaza and implementing flood resilience measures, the design team demonstrated their commitment to enhancing the building's adaptability to climate hazards while serving the community.

The retention of historical elements, such as the exposed wood roof decking and truss system and brick envelope, alongside the integration of high-performance windows and increased insulation, exemplifies how preservation and innovation can coexist harmoniously. With all-electric operation and on-site PV panels offsetting a significant portion of energy use, the project showcases the power of design to shape a thriving and sustainable community for generations to come.

Foundry 101, Exterior Post-renovation | Image credit: Anton Grassl courtesy of CambridgeSeven

CASE STUDY: WAVELAND CIVIC CENTER

Old Waveland Elementary School post-Hurricane Katrina in 2005, and after restoration in 2008.
Image credit: unabridged Architecture

ARCHITECT: unabridged Architecture

BUILDING TYPE: Community Center and Cafe

LOCATION: Waveland, MS

AREA: 7,575 sf

YEAR BUILT (ORIGINAL): 1927

YEAR OF RENOVATION: 2007

EUI: 36.6 kBTU/sf/yr

The Waveland Civic Center in Waveland, Mississippi, is a historic elementary school building that was renovated in 2007 to restore its functionality after over a decade of vacancy and to improve its resilience after being severely damaged by Hurricane Katrina. The project aimed to provide a versatile space for community activities while ensuring climate resilience to withstand future hazards.

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CLIMATE HAZARDS

Waveland, Mississippi, has historically faced various climate hazards, including:

1. **Hurricanes:** The Gulf Coast region is vulnerable to hurricanes, leading to storm surge, wind damage, and flooding.
2. **Heavy rainfall:** Intense rainfall associated with hurricanes and tropical storms can cause widespread flooding.
3. **Storm surge:** The low-lying coastal area is susceptible to storm surges, exacerbating flooding and erosion.

The region is projected to face increased climate risks in the future:

1. **Intensified hurricanes:** Climate change may lead to more intense hurricanes with greater potential for damage.
2. **Increased heavy rainfall events:** More intense hurricanes and severe storms will come with more rain.
3. **Sea-level rise:** Rising sea levels may amplify the impact of storm surges and increase coastal flooding.

ARCHITECT'S AGENCY

The architect played a significant role in advocating for the restoration of the Civic Center after Hurricane Katrina, ensuring that it would continue to serve as a community hub and gathering place, particularly for vulnerable populations impacted by the hurricane.

1. **Advocacy for restoration:** Despite doubts from the city and budget constraints, the architect succeeded in protecting and restoring this building. It was the first building completed after Hurricane Katrina and was used for city council meetings and other gatherings until other structures were replaced.
2. **Climate-resilient improvements:** The project team prioritized climate-resilient design, contributing to the community's resilience and equitable recovery.
3. **Integration of HVAC and energy performance:** The rehabilitation introduced HVAC systems and accessibility improvements for the first time, allowing the building to be occupied after decades of disuse.

This building was significantly damaged by Hurricane Katrina due to 1980s-era modifications that had increased the surface area but had not improved the wall strength. After the storm, the City Council questioned the need to restore the building, saying, "It is cheaper to tear it down and build a metal building." Luckily, grant funding became available to restore the building, which was the only structure left standing on the city's historic main street. The architect advocated for the restoration along with many community members. Funding for the restoration came from insurance proceeds supplemented by grants from the Mississippi Department of Archives and History and the Mississippi Development Authority.

The restoration involved critical improvements to withstand new climate challenges, including a deeper anti-scour foundation to act against storm surge, lateral bracing to stabilize unreinforced masonry from high winds, restoration of the flat roof and a reinforced parapet wall, and flood prevention measures at the site and beneath the structure. The new service life is expected to match the pre-renovation service life—80-100 years.

Brick salvage | Image credit: unabridged Architecture

Original wood and bricks were carefully salvaged for reuse, and new materials were sourced to match the profile and characteristics of the historic materials. The brick wing that collapsed due to the storm was painstakingly separated from other debris, cleaned, and reused. “New” bricks—12,000 of them—were carefully chosen from a historic source to match color, dimension, and hardness. Approximately 80% of what remained in the building after the storm was retained and reused.

WCC front door | Image credit: unabridged Architecture

Interior finishes, such as wood flooring and beaded board—any lumber over 24 inches of good material—were salvaged. The community was consulted in multiple public meetings, resulting in saving an interior mural painted by Boy Scouts in the 1960s. The Hurricane Katrina waterline was painted on the interior walls, and the building hosts the Ground Zero Hurricane Museum, which has permanent exhibits about the storm and recovery.

While not designated as a critical facility, the building’s location on relatively higher ground allows it to be used for public gatherings during the recovery phase of future storms. The introduction of HVAC systems allowed the building to be occupied after decades of disuse. Recent measured EUI was 36.6 kBtu/sf/yr. It’s an all-electric building, which was one condition of funding for the historic restoration.

Civic Center multi-purpose room | Image credit: unabridged Architecture

QUESTIONS TO ASK IN BUILDING REUSE AND KEY TAKEAWAYS

1. How can we prioritize design and construction methods that ensure the building can withstand potential future hazards and contribute to the community's resilience?

   LESSONS LEARNED: Think structurally and holistically when making repairs. Prior renovations removed the parapet wall and added surface area to an unbraced wall, causing it to fail against high winds. Anticipating similar and stronger future hazards, the architect rebuilt the brick façade with lateral bracing.

2. What strategies can be implemented to salvage and reuse as much of the original building materials as possible, maintaining historical and cultural significance while reducing waste and embodied carbon?

   LESSONS LEARNED: By thinking thoughtfully about salvage and reuse, and spending time sourcing existing materials, embodied carbon can be saved, even if you don't have the time or resources to do a whole-building life cycle assessment. Use what's on-site, use what's close, replace as little as possible, and think structurally. Reinforce where needed. Work, time, and destruction could have been saved or minimized if the prior envelope renovations included proper structural reinforcement.

3. How can we actively engage with local community stakeholders to advocate for the restoration of a building, ensuring it continues to serve the community even after significant damage from natural disasters?

   LESSONS LEARNED: Advocate and invite others in. In this case, the architect cared for this building and preservation deeply and found a community standing with them to restore the building.

The historic Civic Center's restoration stands as a testament to climate-resilient design and community advocacy. Despite significant damage caused by Hurricane Katrina, the building was preserved because the architect played a vital role in making it happen. Key takeaways from this project include prioritizing design and construction methods to withstand potential future hazards, salvaging and reusing original building materials to maintain historical significance, and actively engaging the community to advocate for restoration.

The restored Civic Center now serves as an anchor for the revitalized Coleman Avenue, symbolizing community resilience. With climate risks projected to intensify in the future, lessons from this project offer valuable insights for rehabilitation projects in vulnerable areas. The project's success exemplifies how community involvement and a focus on heritage can contribute to the recovery and resilience of communities facing climate-related challenges.

CASE STUDY: BELOIT POWER PLANT TO STUDENT UNION

Beloit College Powerhouse Exterior | Image credit: © Tom Harris. Courtesy Studio Gang

ARCHITECT: Studio Gang

BUILDING TYPE: Student Union, Athletic and Wellness Center

LOCATION: Beloit, WI

AREA: 120,000 sf (including new Field House addition)

YEAR BUILT (ORIGINAL): 1908

YEAR OF RENOVATION: 2020

PEUI: 33 kBTU/sf/yr vs. 62 kBtu/sf/yr baseline

EMBODIED CARBON: 171 kgCO2e/m2 vs. 371 kgCO2e/m2 if new (structure + envelope)

Once a coal-burning power plant, the Beloit College Powerhouse now serves as a student union centered on recreation and wellness, along with spaces for community events from farmers markets to public lectures. Located on the Rock River, the design retains and adapts the power plant's historic structures and industrial equipment, constructed between 1908–1947, and adds a new field house. Together with strategies to reduce operational carbon emissions, the design also anticipates changes to the use of the building through flexible spaces that can accommodate different programs and systems that maximize access for maintenance and future retrofits.

CLIMATE HAZARDS:

Beloit, Wisconsin, has historically faced various climate hazards, including:

1. **Extreme Cold:** The region experiences extreme temperature variations, with cold winters.
2. **Extreme Heat:** The region also experiences hot summers.

The region is projected to face increased climate risks in the future:

1. **Increased Heat:** Climate change may result in higher average temperatures and more frequent heatwaves.
2. **Flood:** Changes in precipitation patterns, including more intense rain events, pose flooding risks.

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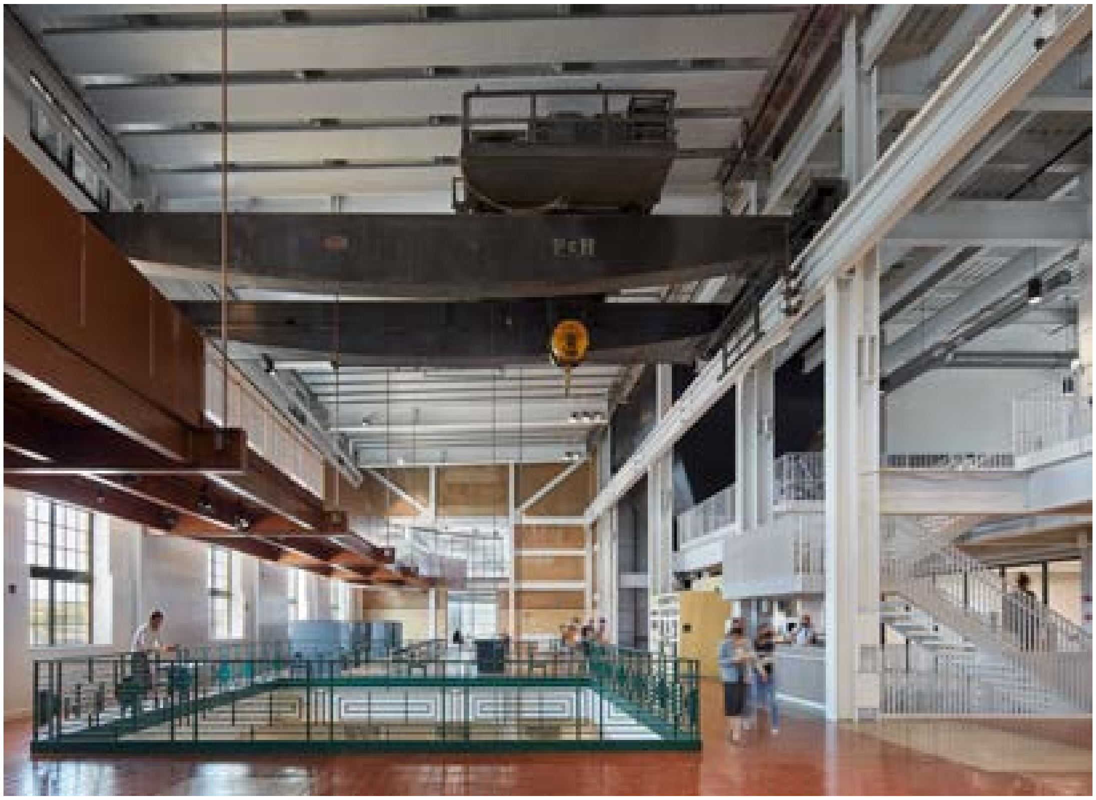
ARCHITECT'S AGENCY:

Faced with the unique challenges of preserving and adapting the existing structure, the team leveraged the following skills, tools, and approaches:

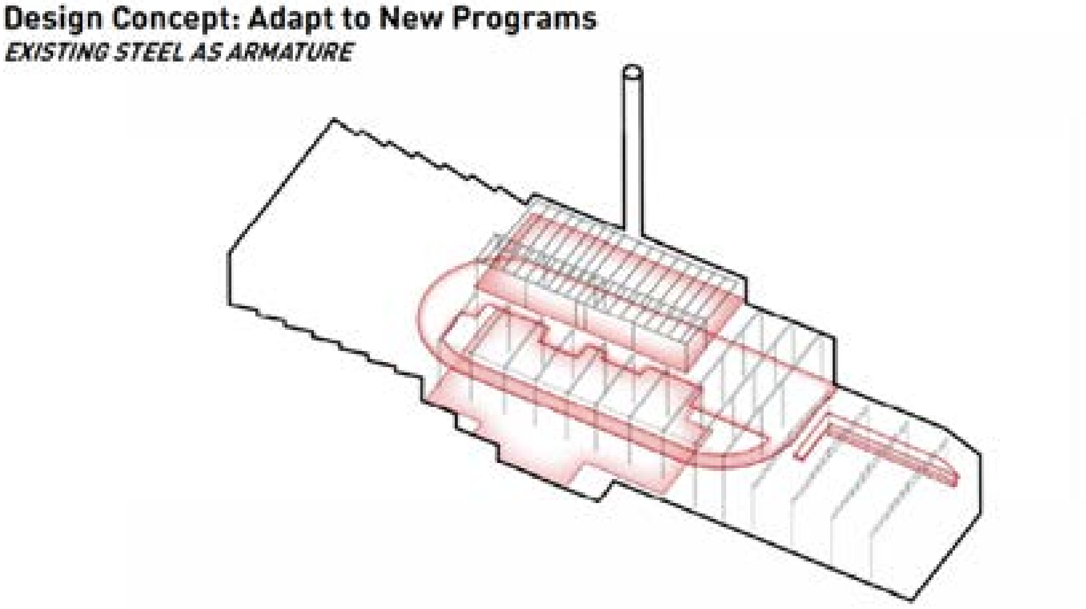
1. **Quantifying impact:** The team emphasized the importance of data-based carbon emissions analysis and encouraged a long-term perspective regarding both embodied and operational emissions.
2. **Holistic approach to reducing emmissions:** The carbon savings of material reuse can be overshadowed in regions with an inefficient and environmentally unfriendly electricity grid. The design team implemented significant reductions in energy use through river thermal heat exchange, heat pumps and radiant systems.
3. **Reveal gracious scale of industrial architecture:** Originally designed for machines, the Powerhouse was well suited to the new program after strategic modifications. The resulting spaces were more generous and richly detailed than what would have been possible in a new building with similar budget.



Beloit College Powerhouse Turbine Hall | Image credit: © Tom Harris. Courtesy Studio Gang

The Powerhouse underwent creative reuse and reprogramming to accommodate new spaces that worked with the industrial scale of the original structure. The resulting spaces became more spacious and cost-effective compared to building from scratch. Historic catwalks and machinery were replaced with new steel beams and entirely new floors. In this manner, tens of thousands of square feet were added to the existing structure—in essence, using the historic steel structure as an armature to house new floors and programs.

Instances where large program elements were required, the design team creatively modified the Powerhouse's structure to fit within the existing building footprint.



Beloit College Powerhouse Design Concept diagram | Image credit: Studio Gang

Innovative structural solutions, such as removing a major divider wall and inserting an overhead steel truss, allowed for a regulation-sized pool and a running track within the building's footprint. By reusing the existing structure and enclosure, the project achieved a 53.9% emissions reduction in emissions compared to a building constructed entirely of new materials. The embodied carbon of new materials (structure, interiors, and mechanical system) for retrofit and addition was 171 kgCO2e/ m2 compared to 371 kgCO2e/m2 for new construction of this building.

The Field House addition is a versatile facility that serves as an athletic practice space for college sports teams while also hosting various programs, including events, community gatherings, and serving as an "outdoor" classroom. The building's proximity to the Rock River necessitated planning for water infiltration. A network of drain tile and sumps, surrounded by 18 inches of loose gravel, accommodates rather than seals off and resists periodic infiltration. Glass garage doors divide student meeting rooms, allowing for flexible space expansion. Exposed mechanical ducts and piping facilitate maintenance and future retrofits, minimizing the need for extensive modifications.

The new Pool House presented special mechanical challenges, including controlling for very high ambient moisture levels and maintaining high air quality. An air return at the level of the pool deck reduces chlorine-saturated air stagnation, thereby improving the air quality for the swimmers.

Mechanical systems were designed for longevity and adaptability, with the potential to phase out back-up boilers, gas domestic hot water heaters, and dedicated outdoor air system DOAS units in the future as technology advances. The project incorporated river water for low energy heat exchange, which was permitted thanks to the original use of the building. The team also included other innovations such as heat pumps (a first in the region) and radiant panel/floor systems, which (with the DOAS) provide conditioned air directly to occupants.

In order to secure historical tax credits for historic structures, the building's enclosure had to remain largely undisturbed. To that end, the building's roof received a minimum of 6-inch polyiso insulation and TPO or EPDM roofing. The triple-wythe brick walls were repointed and repaired. Insulation was added to the interior of the walls along with gwb finish. Historic windows fit for reuse were repaired and "storm windows" were added to meet performance goals.

Due to the rigorous amounts of thermal mass and retrofitted insulation, the project is well situated for stable internal temperatures despite increasing extreme weather events. The building pEUI is 33 kBtu/sf/yr, which represents a 53.2% reduction from baseline (62 kBtu/sf/yr).

The team evaluated operational carbon over a 60-year lifespan with grid-specific emissions and a grid cleaning scenario. With the existing grid, 60-year emissions total to approximately 42,000,000 kgCO2e, with operational carbon representing 98% of overall emissions. With grid cleaning, that sum drops dramatically to approximately 15,000,000 kgCO2e, and with operational carbon representing 89% of 60-year emissions. While the embodied carbon savings are important now, for adaptation and long-term climate mitigation, a clean grid is necessary and critical.

QUESTIONS TO ASK IN BUILDING REUSE AND KEY TAKEAWAYS:

1. How can we creatively leverage the inherent flexibility of existing industrial-scale structures to accommodate new programmatic needs without expanding the building's physical footprint?

LESSONS LEARNED: Look at volume and structure together. Volumes of existing spaces may offer flexibility in solving for new space uses and offer opportunities for sectionally interconnected social spaces.

2. What structural modifications and innovative solutions can we implement to integrate large, fixed—program elements while preserving the historical integrity of existing structures?

LESSONS LEARNED: Structural elements can be removed and replaced to create more flexible spaces. A major divider wall in this project was replaced with a new, overhead structural truss, uniting two spaces into one to accommodate larger program elements.

3. How can we strategically design mechanical systems to address unique challenges, while ensuring adaptability for future technology advancements and reduced fossil-fuel use?

LESSONS LEARNED: Even if a building's systems are high-performing, the local grid mix will determine the overall emissions footprint in the long-term. The benefits of material reuse can be overshadowed by an emissions-intensive grid. Evaluate embodied and operational carbon together to make informed design and performance decisions. The positive climate impact of investment in PV systems comes into greater focus once the source energy profile is known.

The Beloit College Powerhouse leveraged the inherent flexibility of the existing industrial-scale structure to accommodate new programmatic needs without expanding the building's footprint, resulting in a cost-effective use of space.

Addressing the challenge of improving energy efficiency in the face of future extreme temperatures— especially extreme cold—the team found a balance between bolstered envelope R-value, mechanical systems required for day-to-day use, and back-up equipment to ensure occupant comfort and safety. Through the adaptive reuse of the historic structure, the design extends its usable service life, enhancing the student and local riverfront experience for generations to come.

CASE STUDY: LWCC HEADQUARTERS, BATON ROUGE, LA

LWCC Renovation Stairway | Image credit: Michael Mantese

ARCHITECT: EskewDumezRipple

BUILDING TYPE: Office

LOCATION: Baton Rouge, LA

AREA: 130,467 sf

YEAR BUILT (ORIGINAL): 1984

YEAR OF RENOVATION: 2020

PEUI: 32kBTU/sf/yr vs. 93kBTU/sf/yr before renovation

EMBODIED CARBON: 48 kgCO2e/m2 vs. 500 kgCO2e/m2 average new

The LWCC office building renovation aimed to transform an unremarkable existing building into a model of sustainable design, addressing energy efficiency, thermal performance, and occupant comfort. It presents a design opportunity through necessary mechanical system upgrades that improve efficiency and space quality. The project demonstrates that “unloved,” non-historic buildings have value, offer architectural and design opportunity, and can improve both the environment for building occupants and energy performance, all while reducing overall carbon emissions impact through building reuse.

LWCC Renovation Entrance Image credit: Sara Essex Bradley

LWCC Renovation Stairway 2 | Image credit: Sara Essex Bradley

Design for energy

Design for well-being

Design for resources

CLIMATE HAZARDS

Baton Rouge has historically faced various climate hazards, including:

1. **Hurricanes and storms:** The region is susceptible to hurricanes and severe storms, leading to building damage and disruptions.
2. **Flooding:** Low-lying areas in Baton Rouge experience flooding during heavy rainfall and storm events.
3. **Extreme heat events:** The region faces high temperatures during the summer months, leading to increased energy demands for cooling and potential risks to occupant comfort.

In Louisiana, the most acute anticipated effects of climate change are more intense and severe versions of the historic regional hazards:

1. **More intense hurricanes:** Climate change may lead to more frequent and intense hurricanes, exacerbating storm-related damages.
2. **Flooding and sea-level rise:** Rising sea levels may increase the risk of coastal flooding, affecting low-lying areas and infrastructure.
3. **More and hotter heatwaves:** The region is likely to experience more prolonged and intense heatwaves, impacting human health and energy demand.

ARCHITECT'S AGENCY

The design team's agency played a crucial role in recognizing the potential of the renovation project and creating a more holistic and sustainable building through these key actions:

1. **Identifying design opportunities:** Leveraging the mechanical systems upgrade, the architects integrated energy-efficient and climate-resilient strategies into the building's design, enhancing the overall interior environment and occupant well-being.
2. **Promoting health and wellness:** By creating continuous connections between floors through selective demolition and incorporating inviting stairs, the architects encouraged physical activity for those who are able and interaction among occupants while prioritizing indoor air quality, daylighting, and thermal control for enhanced comfort and health.
3. **Emphasizing building reuse:** Demonstrating the value of non-historic buildings, the design team preserved and reused the existing envelope and windows, significantly reducing waste and embodied carbon, highlighting the potential of sustainable building reuse with minimal intervention.

The existing facility, built in 1984, consisted of eight isolated floors with private offices and high-wall cubicles, leading to frequent thermal comfort complaints.

LWCC Renovation Office Space Pre | Image credit, left: EskewDumezRipple | Image credit, right: Sara Essex Bradley

The design team introduced peer-reviewed research on air quality to bring thermal comfort, daylight, and physical activity into the project, recognizing their impact on worker health and productivity.

The project reused the existing envelope and windows and found that changing the internal office layout and zoning provided better thermal comfort. As a result, the embodied carbon associated with the renovation is extremely low—nearly a 90% savings compared to new construction! The embodied carbon of the new materials (structure; interiors partitions, not including flexible furnishing; and mechanical system) for the retrofit and addition was 48 kgCO2e/m2 compared to 500 kgCO2e/m2 for average new construction of office buildings.

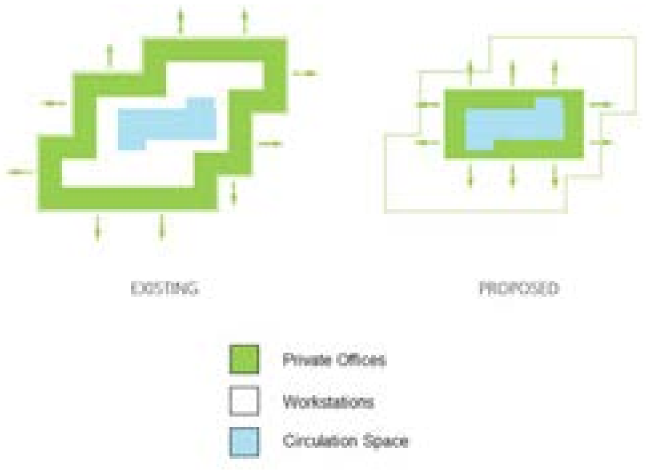


Figure 1: Diagram of the floorplan shifts that allow for more daylight penetration and provide a buffer in workspace from "drafty" windows for thermal comfort throughout the circulation corridor, which also encourages occupant movement.

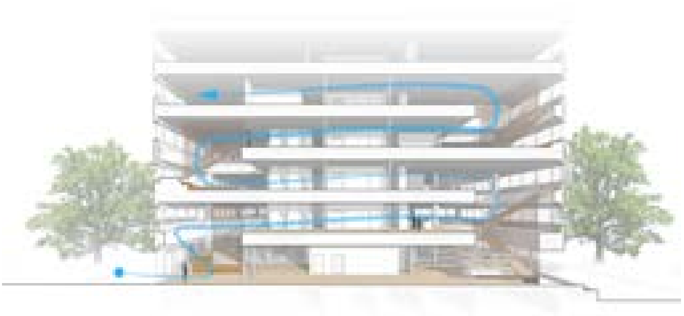


Figure 2: The reimagined facility inserts a succession of double-height, daylight-filled social spaces with inviting stairs that draw employees up and through the building.

The project's big architectural move involved surgical interventions via selective demolition to create a continuous connection between floors. Vertical connections between separate departments one floor above or below each other allow users to easily access staff and resources while promoting exercise and movement.

The project achieved a dual benefit of improved thermal comfort and enhanced physical activity, contributing to a separate key goal of improving occupant health and well-being. The big takeaway is that strategies that improve occupant health also lead to substantial energy savings, benefiting both people and the planet.

Carbon emissions were reduced from 22.38 lbs CO2e/sf/yr to 7 lbs CO2e/sf/yr post-retrofit, largely attributed to the variable refrigerant flow system and lighting upgrades. This cut operational carbon to a third of its pre-retrofit levels—from 93/kBTU/sf/yr to 32 kBTU/sf/yr. That translates to pre-retrofit emissions of approximately 3,000,000 lbs CO2e/yr to approximately 900,000 lbs CO2e/yr today.

QUESTIONS TO ASK IN BUILDING REUSE AND KEY TAKEAWAYS

1. How can we improve energy efficiency while ensuring occupant comfort?

   LESSONS LEARNED: If you are employing an energy efficiency measure not yet in widespread use in the region, schedule focused training on that measure with your installers and building operators.

2. How can we leverage building reuse to minimize embodied carbon and promote sustainability while preserving the existing envelope and windows?

   LESSONS LEARNED: Keep what you can, and evaluate your options. Replacing glazing yields little to no energy savings itself and may not be worth the embodied carbon.

3. How can we prioritize occupant health with inviting spaces and daylight integration within a building that had none?

   LESSONS LEARNED: Look at layout creatively. Perimeter spaces with access to daylight and views can become public spaces. Creating multistory atria volumes where there were none created more shared spaces and daylight penetration.

The LWCC office building renovation exemplifies a comprehensive and data-driven approach to sustainable design. By addressing energy efficiency, thermal performance, and occupant comfort together, the project showcases building reuse as a model for climate mitigation.

By prioritizing occupant well-being, reducing carbon emissions, and integrating health initiatives, the project achieved remarkable improvements through thoughtful architectural agency. As climate risks evolve, this case study provides valuable insights for future building reuse endeavors that emphasize sustainability, energy efficiency, and occupant well-being.

LWCC Renovation Common Area | Image credit: Michael Mantese

CASE STUDY: CUSTOM BLOCKS

Custom Blocks | Image credit: Lincoln Barbour

ARCHITECT: Mahlum

BUILDING TYPE: Office

LOCATION: Portland, OR

AREA: 7,341 sf

YEAR BUILT (ORIGINAL): 1940s

YEAR OF RENOVATION: 2019

PEUI: mEUI: 31 kBTU/sf/yr

EMBODIED CARBON: 109 kgCO2e/m2 vs. 500 kgCO2e/m2 average new

The renovation of an 80-year-old industrial building in Portland's Central Eastside neighborhood resulted in Portland, Oregon's first Living Building Challenge (LBC)–certified project: It successfully achieved the rigorous Materials Petal, in addition to the Place, Equity, and Beauty Petals, and fulfilled imperatives for the Health and Happiness Petals.

Custom Blocks | Image credit: Lincoln Barbour

Design for energy

Design for well-being

Design for change

CLIMATE HAZARDS

The Pacific Northwest has historically faced various climate hazards, including:

1. **Wildfires:** Oregon has historically experienced wildfires in the summer months due to lightning or human-caused combustion combined with its dry climate, extensive forests, and limited summer rain.
2. **Drought:** Precipitation has had a predictable temporal pattern with summer months prone to droughts.
3. **Flooding:** During the cool rainy season, from fall to early spring, floods are common in Oregon. River flooding is the most common type in the region, although flash flooding has historically occurred as well.

In Portland, the most acute anticipated effects of climate change are more intense and severe versions of the historic regional hazards:

1. **Heatwaves:** The region is likely to experience more prolonged and intense heatwaves, impacting human health and increasing demand for mechanical cooling, a rarity in the region until recently. This increased energy demand is expected to cause power outages. Droughts increase the risk of power outages because of the region's reliance on hydro power.
2. **Increased wildfires and drought:** The reduction in summer precipitation has expanded the period when wildfires occur. Summer drought combined with the elevated nighttime temperature heightens the intensity and spread of wildfires.
3. **Flooding and landslides:** More precipitation is now falling as rain instead of snow. Snowpack loss, earlier snowmelt, increased winter rainfall, and more extreme precipitation are expected to increase due to climate change. This will lead to increased flooding risk and landslides from rain events.

ARCHITECT'S AGENCY

The design team's agency played a crucial role in recognizing the potential of the renovation project and creating a more holistic and sustainable building through these key actions:

4. **Promoting health and wellness:** All products and materials that went into the studio met the strict LBC Red List requirements. Additionally, it was imperative that equitable work environments were provided for all, including equal access to daylight and views. The result is a daylit studio with exemplary indoor air quality, which is a great source of pride and satisfaction, confirmed by post-occupancy evaluations from staff.
5. **Building reuse as a design opportunity:** Restoring an old industrial building goes beyond the carbon footprint savings; it carries forward neighborhood history and adds distinct beauty and character to the quality of the space.
6. **Reducing waste:** The new studio accommodates an expanded program within the same overall square footage as the previous office by inverting the proportion of individual and collaboration spaces. Utilizing salvaged materials and furniture was an important driver in reducing first costs and embodied carbon. Superfluous finishes were eliminated wherever possible. The design prioritizes materials that perform multiple functions; for example, perforated gypsum wall board provides acoustic control and ceiling finish; original concrete floors are patched and polished; and exposed timber structure remains untouched.

3. **Water conservation through material selection:** As a tenant improvement project, the design team went beyond the obvious indoor potable water conservation strategies. Reaching further, product selection criteria included reduced embodied water used during the manufacturing process. For example, the selected gypsum wallboard consumes 25% less water during production than competing brands. This equated to a savings of 7,837 gallons of water, or 4,898 toilet flushes.

The commitment to International Living Future Institute (ILFI) as a Petal-Certified project drove all major and minor design decisions. The design team recognized that conducting deep materials research in-house would reap benefits for future projects, and transparency and market transformation were major drivers for the design process.

Custom Blocks | Image credit: Lincoln Barbour

The Custom Blocks Studio achieved net zero embodied carbon using a three-pronged approach. First, the team established an early carbon budget with the Build Carbon Neutral calculator. Then, in addition to vetting products for material health, the team also performed a whole building life cycle assessment (WBLCA) focused on improving materials with traditionally high global warming impacts. By reviewing Environmental Product Declarations (EPDs) submitted during construction, the team further calibrated the carbon footprint analysis, optimizing reductions for installed products based on reduced global warming potential (GWP) and volume of greenhouse gas emissions. Finally, the firm purchased carbon offsets to reduce the project's total GWP. Additionally, more than 50% of all the materials were sourced within 500 km of the project site. And 100% of the wood in the project is either salvaged or Forest Stewardship Council (FSC) certified.

Mahlum, a JUST-labeled organization with the goal of connecting with their our community, their 1,000 sf community space serves as the living room, dining room, and kitchen for staff, as well as a resource offered to nonprofit organizations to host events on evenings and weekends.

QUESTIONS TO ASK IN BUILDING REUSE AND KEY TAKEAWAYS

1. What is it made of and how did it get here?

LESSONS LEARNED: We still use new materials in existing buildings. Simple materials that provide multiple benefits were prioritized. Over 350 products were vetted using the LBC Red List. Wood products were either FSC certified or salvaged. The team optimized specifications for materials with traditionally high climate (GWP) impact. All wet-applied products were vetted for their VOC content. Once all of these primary criteria were met, the team selected products with manufacturing locations closest to the project site.

2. How can we design waste out of our projects?

LESSONS LEARNED: Two existing windows at the new entrance were designed to be reused as interior relites. However, during demolition, that salvage was not feasible, so the project team pivoted and instead recovered those two existing windows for the owner's on-site "attic stock" to be used for future maintenance.

3. How can we prioritize equitable daylight access?

LESSONS LEARNED: Democratize daylight as a resource. Group areas that do not need daylight at the building core, and locate community spaces around one contiguous daylit space to provide equitable access to daylight.

The historic 1940s shop building had already seen over 75 years of industrial service before the Custom Blocks Studio project opened in 2019. The current building is expected to last an additional 50–100 years, so the team worked diligently to respect building core elements and services that the owner will need to upgrade in the future. This approach minimizes potential interruptions to future tenants and values the history of the structure.

Achieving the studio's ambitious sustainable design goals and Living Building Challenge certification was only possible with the unrelenting support of community partners, AIA resources, and research shared by professional organizations. Hearing from professionals who are willing to share what they have learned was motivating to the design team. To carry this torch forward, a 20-minute video about the new studio was created in 2020 to share the team's knowledge and lessons. This video has since been shared at multiple conferences, locally and internationally.

Custom Blocks | Image credit: Lincoln Barbour

Custom Blocks | Image credit: Lincoln Barbour

CASE STUDY: THE PACKING HOUSE, CAMBRIDGE, MARYLAND

The Packing House Exterior | Image credit: Patrick Ross Photography

ARCHITECT: Quinn Evans

BUILDING TYPE: Commercial Mixed Use

LOCATION: Cambridge, MD

AREA: 60,000 sf

YEAR BUILT (ORIGINAL): 1920

YEAR OF RENOVATION: 2021

PEUI: 156 VS 199 ZEROTOOL BASELINE

EMBODIED CARBON: 46 KG CO2E/SF

The Packing House, the historic Phillips Packing Company, Factory F, building in Cambridge, Maryland, has been vacant and uncared for since the 1960s. Cross Street Partners, a vertically integrated real estate company focused on creating vibrant, mixed-use spaces that foster innovation and help rebuild communities, envisioned a new life for the building. Recognizing the food packing, agriculture, and aquaculture history of the region, the project was reimagined to support and grow economic opportunity and tourism tied to these industries.

CLIMATE HAZARDS

Cambridge, Maryland, is situated along the Chesapeake Bay, making it vulnerable to various historical climate hazards, including:

1. **Sea-level rise:** Coastal areas like Cambridge have historically faced risks from rising sea levels, leading to inundation, erosion, and saltwater intrusion.
2. **Extreme weather events:** The region has historically experienced extreme weather events, including heavy rainfall and heat waves, which have caused flooding, property damage, and disruptions to infrastructure and agriculture.

Design for resources

Design for equitable communities

Design for well-being

Design for change

Climate change is expected to exacerbate these hazards, increasing their frequency and intensity, posing significant challenges to the region's resilience.

1. **Intensified sea-level rise:** Climate change is projected to increase sea-level rise, leading to more frequent and intense flooding and inundation events.
2. **More frequent and severe extreme weather events:** Climate change is projected to increase the frequency and severity of extreme weather events, leading to more frequent and intense heavy rainfall events and heatwaves, and possibly more frequent hurricanes in an area that was historically at moderate risk for hurricanes.

ARCHITECT'S AGENCY

The architects played a crucial role in realizing the vision of The Packing House as a catalyst for community resilience and economic revitalization. Their expertise in adaptive reuse, sustainable design, and community engagement was instrumental in the project's success.

1. **Adaptive reuse vision:** The architects recognized the potential of the vacant industrial building, envisioning its transformation into a vibrant mixed-use space that would breathe new life into the surrounding neighborhood.
2. **Sustainable design leadership:** The architects championed sustainable design principles, incorporating energy-efficient measures, utilizing locally sourced and recycled materials, and implementing green infrastructure solutions.
3. **Community engagement facilitation:** The architects and developers fostered open communication and collaboration with the community, conducting public meetings, incorporating local input, and ensuring that The Packing House truly reflected the needs and aspirations of Cambridge residents.

The transformative redevelopment of The Packing House stands as a testament to the power of community-driven, climate-resilient development. From its inception, the project was guided by a vision of equity and inclusion, ensuring that the benefits of revitalization extended to all members of the community.

The Packing House Event Space | Image credit: Patrick Ross Photography

The development team at Cross Street Partners recognized the importance of creating a space that was accessible and welcoming to all. The architects incorporated design elements that prioritized equitable access to daylight, ensuring that all residents and visitors could enjoy the benefits of natural light. With its blend of commercial, light industrial, and restaurant space the building fosters a sense of community and belonging for people from all walks of life.

Beyond its physical design, The Packing House also promotes equity through its operational practices. The project's tenants support local food business through Four Eleven Kitchen, a shared kitchen facility, and the Merge workspace tenant provides opportunities for entrepreneurs and small businesses to thrive. The incubator kitchen and commercial spaces provide affordable access to resources and facilities for food-based businesses, further leveling the playing field and promoting economic empowerment.

The Packing House's success highlights the importance of equity in community revitalization projects. By prioritizing accessibility, inclusivity, and economic empowerment, the project has created a space that benefits all members of the Cambridge community. The architects fostered open communication and collaboration with residents, conducting public meetings and incorporating local input. This inclusive approach ensured that The Packing House aligns with the needs and aspirations of the Cambridge community.

The Packing House Hall Space | Image credit: Patrick Ross Photography

QUESTIONS TO ASK IN BUILDING REUSE AND KEY TAKEAWAYS

1. How can we revitalize underutilized spaces and foster economic growth while ensuring resilience to climate change impacts?

   LESSONS LEARNED: Revitalizing underutilized spaces like The Packing House can contribute to economic growth by attracting businesses, creating jobs, and enhancing the overall vibrancy of the community.

2. How can we create mixed-use spaces that promote community engagement, celebrate local heritage, and support sustainable food systems?

   LESSONS LEARNED: Cross Street Partners actively sought input from residents throughout the planning and design process, ensuring that The Packing House truly reflected the Cambridge community's needs and aspirations. This inclusive approach fostered a sense of ownership and pride among residents, further strengthening the project's equitable foundation. Additionally, the project's emphasis on local food initiatives and its incorporation of a shared kitchen and commercial spaces promote sustainable food practices and strengthen the local food system.

3. How can we incorporate sustainable design principles and adaptive reuse strategies to minimize environmental impact and enhance long-term resilience?

   LESSONS LEARNED: Adaptive reuse of existing structures, as demonstrated by The Packing House, can significantly reduce the environmental impact associated with new construction by minimizing waste and embodied carbon. Furthermore, incorporating sustainable design principles, such as energy efficiency measures, the use of locally sourced and recycled materials, and the implementation of green infrastructure solutions, can further reduce the project's environmental footprint and enhance long-term resilience to climate change.

The revitalized Packing House has emerged as a thriving hub for the Cambridge community, fostering economic development, promoting local food initiatives, and contributing to the city's resilience. By embracing adaptive reuse, sustainable design, and community engagement, the project stands as a model for how to transform underutilized spaces into vibrant, sustainable, and resilient community resources in the face of climate change.

GLOSSARY

GLOSSARY

Climate change adaptation (accommodating needs throughout service life): The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. [*IPCC*]

Climate change mitigation (reducing negative impact): The lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability. [*IPCC*]

Climate justice: Where the burdens of climate change and the responsibilities to deal with it are borne fairly and equitably, acknowledging that up until now the benefits associated with the activities that have led to climate change have accrued disproportionately to the older and wealthier while the burdens have been borne disproportionately by women, the poor, people of color, and future generations. [*United Nations Sustainable Development*]

Equity: The state in which everyone is treated in a manner that results in equal opportunity and access, according to their individual needs. Equity requires identifying and eliminating barriers that have disadvantaged nondominant identity groups to assure that all individuals receive equitable treatment, opportunity, and advancement regardless of identity; it also means that some individuals will need more support (due to existing structural barriers) than others. [*AIA Guides for Equitable Practice*]

Global warming potential (GWP): A measure of how a given gas in the atmosphere helps hold heat over a given period of time. While most are familiar with carbon dioxide (CO2) as a global warming gas, some gases emitted in smaller quantities, such as methane, some refrigerants, and some blowing agents used in spray insulation, pound for pound, have a higher GWP than CO2. [*EPA*]

Healthy: Supporting health and well-being for building occupants and the surrounding community, through design that inclusively promotes activity within the building and active transportation options, an indoor environment (air, temperature, light, and sound) conducive to health, connecting occupants with place and with nature, and avoiding materials that pose health hazards.
[*AIA Framework for Design Excellence*]

Resilience (inherent durability or flexibility): The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions. [*IPCC*]

Sustainability: Design that seeks to avoid depletion of energy, water, and raw material resources; prevent environmental degradation caused by facility and infrastructure development over its life cycle; and create environments that are livable, comfortable, and safe and that promote productivity. [*Architect's Handbook of Professional Practice*]

RESOURCES

RELATED RESOURCES

- The *AIA Resilient Project Process Guide*, developed through a collaborative effort of practitioners at firms across AIA, helps designers ask themselves the right questions at each phase of a project so that their finished buildings can respond well to shocks and stressors now and in the future.

- Because the impacts of climate change fall disproportionately on poorer communities and communities of color, and because a disproportionate share of the building stock in greatest need of renewal is often in those same communities, the *AIA Guides for Equitable Practice* provide a wealth of useful resources. Many of these tools focus on improving equity within the practice of architecture, but *Justice in the Built Environment* looks at the ways we can pursue projects in ways that really meet the needs of the communities where they are located.

- The AIA *Framework for Design Excellence* is the organizing resource for sustainable, resilient, and inclusive design. The framework provides a wealth of tools, case studies, and simple recommendations to help you move your design work toward four key outcomes:
    - **Zero carbon**—helping reduce the contributions of buildings to climate change
    - **Equitable**—shaping projects in ways that reduce social inequities
    - **Resilient**—designing projects to support the ability of communities to come back after shocks and stresses, including those driven by climate change
    - **Healthy**—shaping projects in ways that promote the wellness of those who use buildings and those impacted by the production of building materials

- The *Advanced Energy Design Guides* by ASHRAE provide cost-effective approaches to achieve energy saving for the different project types.

- The *AIA-CLF Embodied Carbon Toolkit* for Architects provides a comprehensive resource for architects to take these issues further.

- *Renovate, Retrofit and Reuse Guide* Prepare your firm to take advantage of the increasing number of retrofit projects with this guide uncovering the hidden economic, health, and environmental benefits in America's existing building stock.

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