National Institute of BUILDING SCIENCES™

2022 MOVING FORWARD REPORT

Prepared by the NIBS Consultative Council

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Introduction

The National Institute of Building Sciences (NIBS) serves as the unbiased forum for solving common issues and identifying opportunities within the building community. The NIBS Consultative Council assembles high-level building community leaders to make collective recommendations directly to policymakers to improve our nation's buildings and infrastructure. Members of the council include organizations representing consumers, architects, engineers, government officials, contractors, researchers, and housing officials. The goals of the council are three-fold:

- **Convening Thought Leaders:** bringing together industry leaders and experts from across the built environment to improve our nation's infrastructure and buildings.
- **Identifying Challenges:** assembling experts who identify key issues they believe will be facing the industry in the year ahead.
- **Finding Solutions:** developing and publishing a yearly report that offers solutions to key challenges the built environment faces.

Each year, the Consultative Council publishes the Moving Forward Report to investigate critical challenges facing the building industry and to make recommendations to the industry and policymakers to help overcome those challenges. These reports provide a reference point on the state of the industry at a specific point in time. NIBS and the Consultative Council intend to revisit each report topic periodically, to track progress and discuss potential new challenges and solutions.

Decarbonizing the Built Environment: Recommendations Summary

The 2022 Moving Forward Report explores the topic of building sector decarbonization, examining key concepts, challenges, and considerations that can help inform decisions about if, where, and how to pursue decarbonization goals, and providing recommendations to policymakers and industry stakeholders on priority actions and next steps.

The building sector is a significant contributor to carbon dioxide and other greenhouse gas (GHG) emissions, both in the U.S. and globally. These GHG emissions contribute to the widespread and worsening impacts of human-induced climate change, and can have adverse effects on local environments and populations by compromising indoor air quality and exacerbating outdoor air pollution. Mitigating these effects by decarbonizing the building sector will take an economy-wide effort, but the need to achieve near- and long-term emissions reductions is critically important.

The below points of emphasis are a summary of the topics and recommendations discussed in this report. Detailed recommendations from the NIBS Consultative Council can be found on page 20. Both in summary and detailed formats, the Council's recommendations supplement, and should not replace, other necessary actions to adapt the built environment to a changing climate and make our buildings and communities healthier and more resilient to natural hazards.

1. **Policymakers should prioritize and leverage private sector input and expertise in the pursuit of decarbonization goals**, and together with the building industry should continue to collaborate, align, and harmonize activities across sectors.
2. **Improved embodied carbon accounting and data transparency and disclosure will be critical to meeting**

decarbonization goals. A common definition of decarbonization, broad access to publicly supported lifecycle carbon evaluation tools and resources, and publicly available performance data will help to set a common baseline, against which different approaches to decarbonization can be evaluated and progress can be measured.

3. **Market transformation** to advance building sector decarbonization will require a continuum of policy support, from all levels of government, to facilitate decarbonization efforts at all stages of the building lifecycle.
4. **Increased investment in compliance activities for energy codes and standards, as well as increased training for code officials**, will be critical to meeting the decarbonization potential of the building sector.
5. **Industry and government at all levels should increase investment in understanding and overcoming the challenges to decarbonization posed by the existing building stock.** A significant portion of existing buildings will continue to operate for decades, but extreme variability in the age, design, and construction of these buildings constrains the implementation and widespread applicability of technologies and approaches that can drive decarbonization.
6. **Increased investment in building sector workforce development**, included continuing education and re-training opportunities for the current workforce, will be critical to meet decarbonization goals and address the current workforce shortage.
7. **Pursuing decarbonization must include considerations of social equity for disadvantaged populations and communities.**

The Challenge: Carbon Emissions and the Building Sector

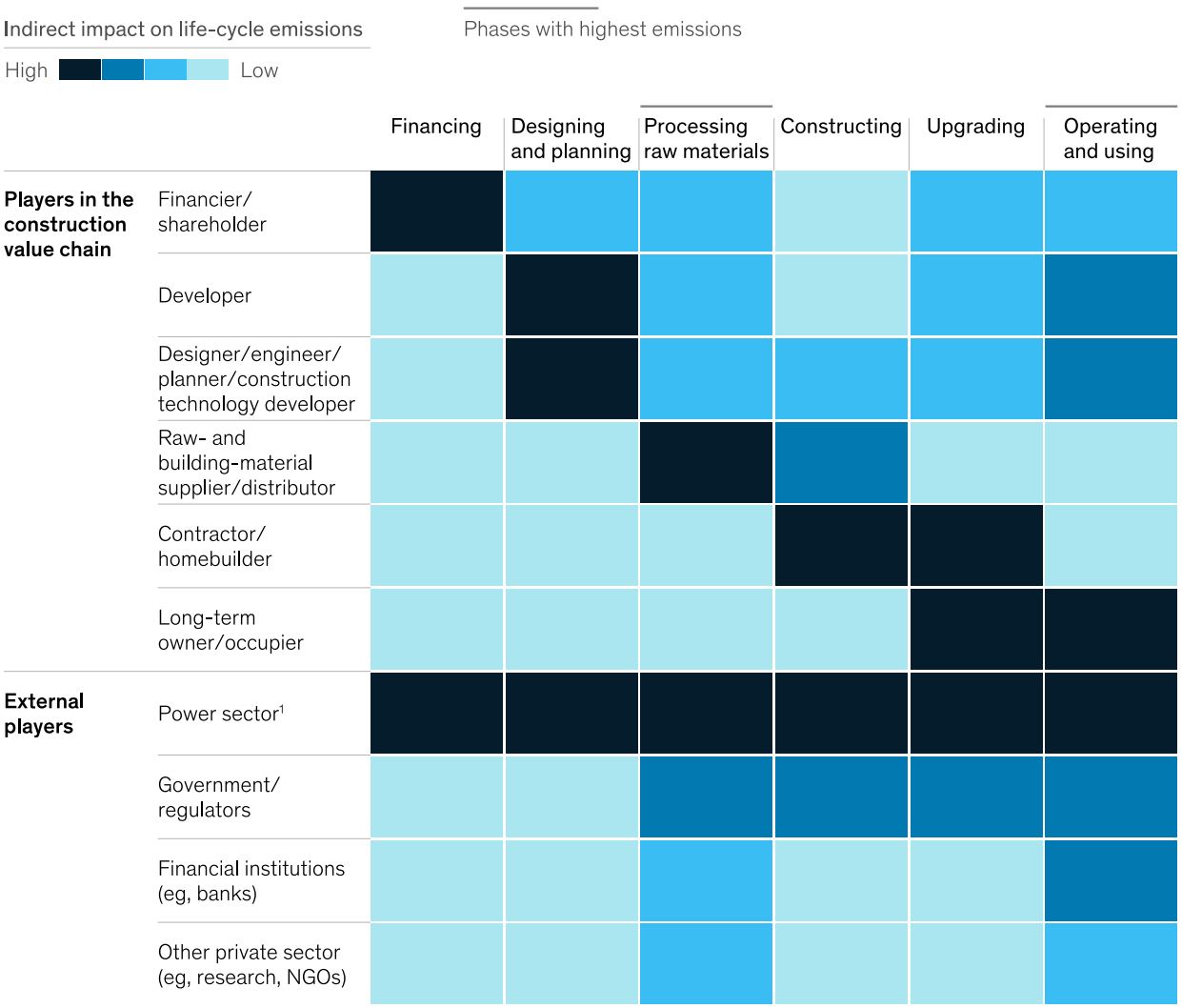
Facts are facts: The building sector is a significant contributor to global greenhouse gas (GHG) emissions. At the macro level, these emissions contribute to and accelerate the harmful effects of climate change. Locally, these emissions have a direct, negative impact on buildings' occupants and surrounding communities by reducing indoor air quality and contributing to outdoor air pollution. Mitigating these adverse effects will require achieving both near- and long-term emissions reductions throughout the built environment. Further, the potential near-term consequences of climate change mean that there is a critical need to accelerate reductions in GHG emissions

sooner rather than later. This calls for a sector- and economy-wide effort, involving stakeholders throughout the building lifecycle, as the chart below from McKinsey & Company makes clear.[1]

To support this effort, NIBS and the Consultative Council have issued this report to examine key concepts, challenges, and considerations related to building sector decarbonization, and also to provide recommendations to policymakers and industry stakeholders on priority actions and next steps.

Each player has an impact at a specific phase of the construction life cycle; major opportunities require collaborative action.

Impact and influence on emissions at each stage of the construction life cycle



[1]Direct Scope 2 responsibility through driving increase in renewables.
Source: McKinsey analysis

McKinsey & Company

Several terms used in this report—including decarbonization, operational carbon, and embodied carbon—are colloquial terms of art within the building sector, where the word "carbon" is used as shorthand for the full range of GHG emissions that are produced during a building's lifecycle. The word "carbon" refers to carbon dioxide (CO2), which represents the vast majority of GHG emissions each year. However, there are several other GHGs of major concern that are also a focus of decarbonization efforts, including methane (a byproduct of the production and transport of coal, natural gas, and oil), nitrous oxide (a byproduct of fossil fuel combustion and industrial and land use activities), and fluorinated gases (which are man-made chemicals used as refrigerants, aerosol propellants, foam blowing agents, solvents, and fire retardants). Though methane, nitrous oxide, and fluorinated gases together represent less than a quarter of all GHG emissions, their relative environmental impacts are significantly higher than CO2 on a pound-for-pound basis.[2]

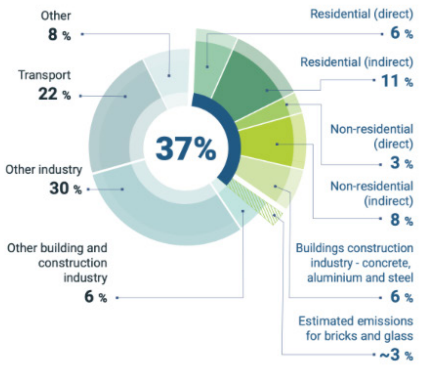
Building Sector Emissions – Global Outlook

The UN Environment Programme Global Status Report for Buildings and Construction 2022 found that the building sector accounted for 37% of global energy-related CO2 equivalent (CO2e)[i] emissions, and for 34% of global final energy consumption in 2021.[3] While the onset of the COVID-19 pandemic in 2020 reduced global GHG emissions and energy demand, emissions in 2021 reached new highs and are likely to continue to grow.[4] Per the report:

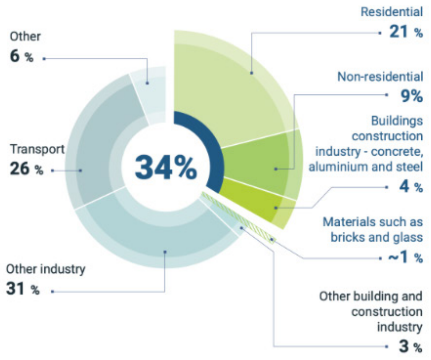
- In 2021, the buildings sector's operational energy-related CO2e emissions reached an all-time high of around 10 GtCO2e (gigatonnes of carbon dioxide equivalent), an increase that exceeds the 2020 level by around 5% and the pre-pandemic peak in 2019 by 2%.
- In 2021, operational energy demand in buildings reached an all-time high of 135 EJ (exajoules), which is an increase of around 4% from the 2020 period and exceeds the previous peak in 2019 by over 3%.

[i] CO2e is a measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of CO2 with the same GWP. GWP measures the amount of energy that one ton of a GHG will absorb over a given period of time. Gases with a higher GWP absorb more energy and therefore contribute more to global warming. One ton of CO2 has a GWP of 1, whereas one ton of other GHGs have GWPs that range from 25 (methane) to more than 10,000 (fluorinated gases).

Global share of buildings and construction operational and process CO2 emissions, 2021



Global share of buildings and construction final energy demand, 2021



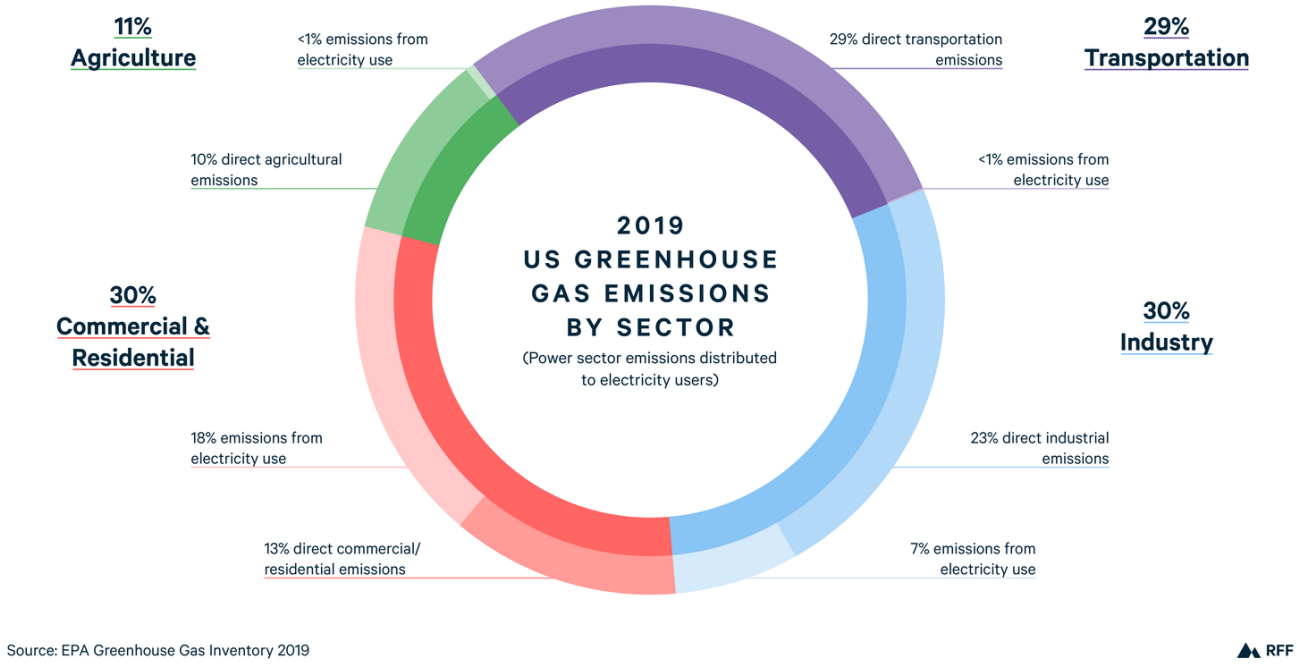
Source: United Nations Environment Programme (2022). 2022 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Nairobi.

Though progress has been made in reducing global emissions from buildings over the past several decades, a number of challenges are likely to stress this forward momentum:

- In 2040, it is anticipated that two-thirds of today's existing building stock will still be in use. Reducing the carbon emissions from those buildings in operation today is critical to reducing sector emissions tomorrow.
- Global building floor area is expected to double by 2060. Per Architecture 2030, this is the equivalent of "adding an entire New York City to the world, every month, for forty years."[5]

Building Sector Emissions — U.S. Summary

As in the case globally, buildings are also one of the leading sources of carbon emissions in the U.S. Per the U.S. Environmental Protection Agency (EPA), the residential and commercial building sector directly contributes 12.5% of total GHG emissions in the U.S., primarily through the direct combustion of fossil fuels for building operations like heating, cooling, and cooking.[6] When also accounting for indirect emissions associated with the generation and transmission of electricity used in buildings, the residential and commercial building sector's share of total U.S. GHG emissions increases to over 30%, and continues to rise.



Source: Resources for the Future

Further, these totals do not account for the full lifecycle of a building's GHG emissions, particularly those emissions associated with raw material processing and construction phases. Lifecycle emissions include those from:

- Resource extraction
- Manufacturing
- Transportation
- Construction/installation
- Equipment replacement and maintenance
- Demolition/end of life

Accounting for each of these lifecycle elements produces total emissions for the building sector that are much higher than traditionally estimated.[ii]

[ii] According to the World Green Building Council, as much as 11% of global GHG emissions can be attributed to building sector materials and construction activity. See: https://worldgbc.org/article/bringing-embodied-carbon-upfront/.

What is Decarbonization?

Decarbonization broadly refers to the process of reducing the amount of CO2 and other GHG emissions that are released into the atmosphere, by moderating or replacing carbon-intensive activities and energy sources with low- or no-carbon alternatives. As applied to the building sector, decarbonization entails reducing or eliminating lifecycle GHG emissions associated with the construction, operation, and decommissioning of buildings. Decarbonization moves beyond a specific focus on operational energy use, with its associated impact on GHG emissions serving as a secondary measure, by explicitly redefining success for sustainability efforts as a reduction in the building sector's carbon footprint throughout the building lifecycle.

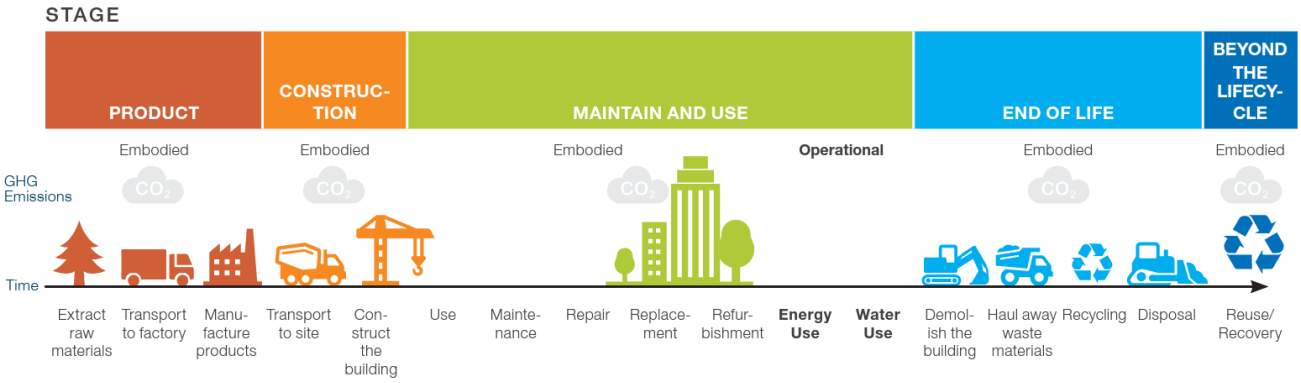


Chart from New Buildings Institute

How to Decarbonize the Building Sector

Efforts to reduce the carbon footprint of the building sector are differentiated between decarbonization activities targeting operational carbon and those targeting embodied carbon. Due to advancements in building energy codes, minimum energy performance standards for appliances and other equipment, and efficient building technologies; growth in both utility-scale and distributed renewable generation capacity; and other regulatory and market innovations, the building sector has observed a significant decrease in operational energy use and operational carbon emissions in new-construction buildings over the last three-plus decades. In contrast, tools, guidance, and other informational resources designed to help architects, engineers, builders, and others to reduce embodied carbon have only recently emerged in popular discourse, and embodied carbon has only recently been established as a priority target of public policy and regulatory requirements.

Operational Carbon

Operational carbon refers to those GHG emissions associated with the energy used to heat, cool, ventilate, illuminate, and otherwise operate a building, i.e. emissions resulting from regular building operations after it is built and occupied. Traditionally, reducing operational carbon emissions has been the focus of policymakers, designers, builders, engineers, and contractors, and this focus has not been without warrant—over two-thirds of total building emissions currently stem from building operations.[7]

Decarbonizing Building Operations

To continue achieving significant and meaningful reductions in buildings' operational carbon emissions, the same basic formula can be applied to most structures: Step One is minimizing a building's energy needs through

the application of energy efficient design and construction; the completion of energy efficiency retrofits in existing buildings; the installation of high-efficiency equipment, appliances, and other building technologies; the implementation of building commissioning practices; and/or the application of efficient operational strategies, such as the use of advanced building controls and energy management systems. Step Two is meeting a building's resulting balance of energy needs with energy sources that have the lowest possible GHG intensity, such as renewable energy. One approach to achieving this objective is to invest in onsite renewable generation capacity and energy storage; another approach is to operate a building in harmony with the power grid, implementing demand response and other forms of building-to-grid integration to reduce peak demand and time-of-use-related emissions.

One goal advocated by many stakeholder groups iin the building industry—including several member organizations of NIBS' Consultative Council—is Carbon Neutrality, also referred to as Net Zero Carbon or Net Zero Emissions. A "carbon neutral building" is one whose annual operational GHG emissions are completely offset, such that a building's net annual GHG emissions zero out over the course of a year. This means, for example, that any GHG emissions from the building due to fossil fuel use or leakage from pressurized systems (e.g. refrigerants used in air conditioning units) are offset by an overproduction of renewable energy that is sent back to the grid to be used by others. In order to reduce operational energy use sufficiently to achieve carbon neutrality, investments in energy efficiency are key to minimizing both direct and indirect GHG emissions. The electrification of buildings is often considered essential to reduce direct (i.e. Scope 1) GHG emissions attributed to the onsite combustion of fossil fuels.

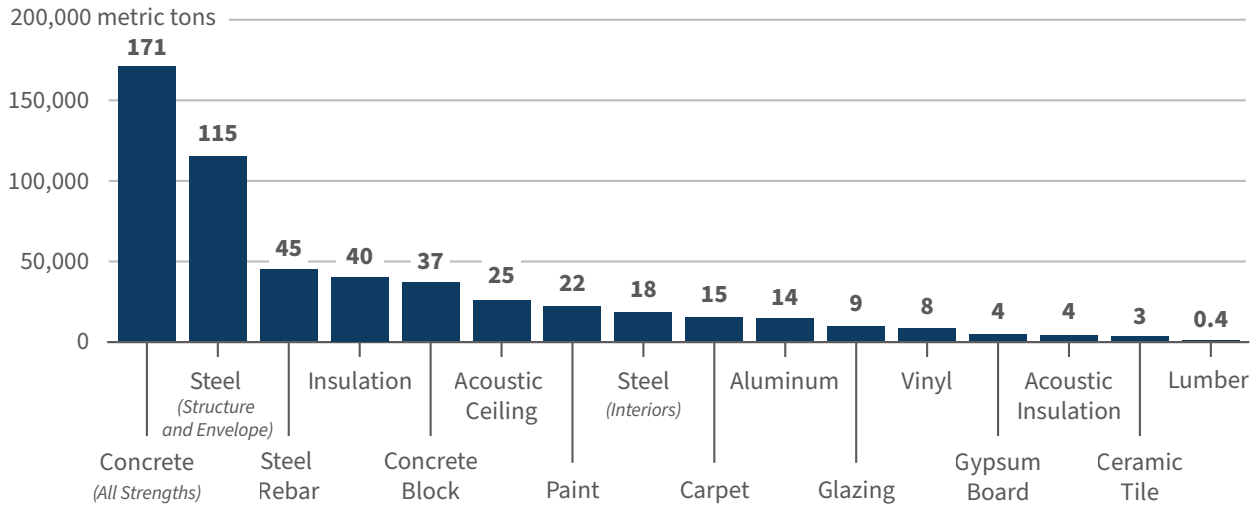
Though this formula for decarbonizing building operations is quite simple, there is no one-size-fits-all approach to actual implementation. The most realistic and effective emissions reduction pathway for any given building will vary significantly based on a myriad of factors, including but not limited to: geographic location, building type, the cost and availability of compatible equipment and materials, the availability of financing, the availability of a trained and experienced workforce, and applicable state and local requirements. In addition, relevant considerations will vary based on whether the building in question is an existing building (where the original design approach and building vintage matters) or a planned new-construction project. Finally, efforts to decarbonize building operations can inadvertently impact a building's ability to withstand expected severe weather—for example, improper installation of roof-based solar panels could negatively impact the resilience of the roof system—so decarbonization activities need to be carefully integrated with resilience planning and resilient building practices.

Some building technologies are broadly applicable to most decarbonization pathways, including tight, well-insulated envelopes; high-performance windows; appropriate ventilation; and efficient lighting. One implementation of sustainable design that incorporates these tools is the Passive House approach, which drives decarbonization outcomes by focusing on passive designs that reduce the need for energy inputs for heating and cooling while emphasizing occupant comfort and indoor air quality. The Passive House approach can be applied to both residential and commercial new construction buildings, as well as residential retrofit projects.

Embodied Carbon

Per the New Buildings Institute, embodied carbon is the sum total of all GHGs emitted from nonrenewable sources resulting from sourcing raw materials, manufacturing, transporting, construction and installation activities, ongoing material/product use, maintenance, repair, and disposal.[8] Generally, with some material exceptions, the embodied carbon in a structure cannot be reduced—once expended or embodied in the walls, windows, and surfaces of a building, this emitted carbon from non-operational activities cannot be recovered.[9]

Exhibit 2 **Estimated annual cradle-to-gate embodied carbon emissions from federal building projects, by common building materials**



Source: RMI analysis

In an analysis of federal building projects,[10] RMI highlighted the "cradle-to-gate" embodied carbon across common building materials.

Traditionally, embodied carbon has been a secondary concern of industry and policymakers, with primary attention paid to GHG emissions associated with building operations. However, as recognition grows that—absent intervention—embodied carbon will begin to represent a larger and larger share of total building sector emissions as operational carbon emissions decline, this balance of attention has begun to shift. Presently, both the building industry and governments at the federal, state, and local levels are expanding their focus to also include policies aimed at reducing buildings' embodied carbon. This must continue if there is to be a meaningful reduction in total lifecycle emissions from the buildings sector.

Reducing Embodied Carbon in Buildings

Given that a majority of a building's embodied GHG emissions are locked in once a building has been constructed and occupied, strategies and approaches for reducing a building's embodied carbon footprint are most impactful when applied to new construction or major rehabilitation projects. The American Institute of Architects (AIA) identifies the following 10 steps that can be taken to reduce embodied carbon as part of the design and construction of such projects:[11]

1. Reuse buildings instead of constructing new ones.
2. Use low carbon concrete mixes.
3. Limit carbon intensive materials.
4. Choose lower carbon alternatives.
5. Choose carbon sequestering materials.
6. Reuse materials.
7. Use high-recycled content materials.
8. Maximize structural efficiency.
9. Use fewer finish materials.
10. Minimize waste.

Addressing embodied carbon in buildings requires a mindset akin to the "Reduce, Reuse, Recycle" mantra from waste management, augmented by a very intentional approach to product selection. In other words: when it comes to building materials, use only as much as you need (e.g. maximize structural efficiency, minimize waste, or don't build at all), reuse or recycle as much as you can (e.g. reclaim and reuse all appropriate material during demolition or renovation), and prioritize low-carbon products whenever it is practical and possible. Federal, state, and local governments are implementing procurement policies to try and increase the number, and reduce the cost, of low-embodied-carbon products on the market. These "Buy Clean" programs leverage the purchasing power of public agencies to transform the market by attaching low-embodied-carbon construction purchasing requirements to publicly-financed projects.[12]

Any renovations, maintenance activities, or repairs that add to or replace materials during a building's lifetime contribute to its embodied carbon calculation, and the same strategies used during design and initial construction can also be applied during renovation or repairs to minimize lifetime embodied emissions. Emissions associated with the decommissioning of a building also count against its ultimate embodied carbon tally, so prior to rehabilitation or demolition it is important to consider what building materials can be recycled or reclaimed for use elsewhere.

Why Decarbonization Matters

Given the U.S. building sector's significant contributions to both national and global GHG emissions totals, there is a clear case for expanding efforts to target reductions in building sector GHG emissions. The scale of the industry's emissions poses a challenge, but they also present an opportunity to achieve significant reductions through decarbonization, thus contributing to mitigation efforts that can slow or even reverse the harmful effects of anthropogenic climate change and other environmental impacts.

In addition to mitigating the effect of global climate change, successful decarbonization can also yield more immediate environmental benefits, notably a decrease in local air pollution—and consequent improvement in outdoor air quality—as a result of reductions regional GHG emissions.

Finally, many potential benefits can accrue directly to those building owners who invest in decarbonization. For one, energy efficiency improvements and onsite renewable generation capacity can reduce owners' utility bills and other related energy costs, while also increasing a building's resilience to extreme weather events; efforts to quantify the monetary value of resilience enhancements are ongoing, but it is known that buildings with lower energy requirements and renewable backup power are better equipped to maintain critical facility operations during total power interruptions. In addition to reducing operating costs, buildings that are energy efficient and have low GHG emissions may be more attractive to buyers or renters, which can increase overall property values, and decarbonization investments can also improve a building's indoor air quality, which can be beneficial for the health and well-being of building occupants.[13]

Many older buildings have poor ventilation that is inadequate for maintaining healthy indoor air quality during normal operation, but this challenge can be addressed through ventilation upgrades completed as part of a broader energy efficiency retrofit. If pursued, the electrification of building services like HVAC, water heating, and cooking can eliminate indoor air pollutants associated with the operation of fossil-fuel fired appliances and equipment.

Challenges to Decarbonization

As one of largest carbon-emitting sectors of the U.S. economy, decarbonizing the building sector will take a massive, strategic, all-hands-on-deck effort. Both the private sector and federal, state, and local governments have

begun taking important steps to reduce operational GHG emissions and embodied carbon in the nation's building stock (see pages 18-19), but numerous challenges remain that require broad buy-in and coordination across sectors.

New vs. Existing Buildings

Much of the emphasis on decarbonization efforts, until fairly recently, has focused on new buildings. However, new construction represents less than 2% of annual building sector activity.[14] While the impact of existing buildings on GHG emissions has received more attention from policymakers in recent years, additional effort is needed. With much of the current building stock expected to continue to operate well into the second half of the 21st century, improving the energy efficiency of existing buildings represents a huge opportunity to reduce GHG emissions. However, improving existing buildings represents a unique set of challenges that need to be addressed by policymakers.[15]

- Existing buildings, many of which are decades or even centuries old, are highly variable. No two buildings are alike, nor have the changes made to any single building over time been consistent in technology or practice. Thousands of buildings from different decades, constructed with different materials, subject to different regulatory regimes, and maintained to different standards, will require a far more custom-tailored approach to decarbonization than would a group of new buildings designed and constructed with modern materials and adhering to modern code requirements.

- Relative to new construction, there are fewer opportunities for intervention in the form of renovation to an existing building, and such opportunities vary in both cost and complexity. However, encouraging or incentivizing the reuse of existing buildings—where applicable and/or viable—is a key pathway to delaying or voiding significant additions to the building sector's embodied carbon tally, in comparison to pursuing demolition and new construction.

- Existing buildings have diverse ownership models, where the building owner has very different motivations for performance improvements. Frequently, buildings are not owned or held in a portfolio for as long as the anticipated return-on-investment of these performance improvements, making it more difficult for building owners to justify the expense. This difference in motivation creates a special challenge for owned versus leased space.

- Financing and incentive programs vary in success and effectiveness.

Decarbonizing existing buildings must be a focus of policymakers because that is where our collective efforts will have their greatest impact. However, addressing these challenges will require a coordinated effort on the part of the federal government, states, localities, owners, developers, designers, operators, and the building industry at large.

Code Adoption and Enforcement

Updated building code requirements for both new buildings and existing buildings undergoing renovation, if adopted and enforced, have the potential to significantly reduce GHG emissions through energy efficiency. A U.S. Department of Energy (DOE) estimate states that model energy codes for buildings are projected to save almost 841 MMT (million metric tonnes) of avoided carbon emissions between 2010 and 2040.[16] However, the adoption of energy codes at the state and local level is highly variable—some jurisdictions have no energy code in place or a code from 2009 or earlier, while others have energy codes that meet or exceed the latest model codes. Even where codes are adopted, enforcement of the code is lagging significantly, and states and local jurisdictions

frequently pick and choose only portions of updated codes to implement and enforce. In order to realize savings from codes, authorities having jurisdiction need to significantly step up code enforcement and compliance rates. This includes additional technical training and resources for local code officials, as well as developing incentives to reduce and/or penalties for noncompliance.[17]

System-Level Considerations

Buildings do not operate in a vacuum, and efforts to decarbonize the building sector cannot succeed without considering the broader systems in which buildings operate. Of note, the characteristics of the power grids that serve buildings can heavily impact the efficacy of building decarbonization investments. For example, the grid's energy mix can influence the scale of GHG emissions reductions associated with efficiency-induced decreases in a building's electricity demand. Additionally, federal-, state-, and utility-level power sector regulations and policies all influence the ultimate cost borne by building owners who seek to interconnect onsite renewable generation capacity with the grid. Ultimately, the success of efforts to advance building decarbonization objectives—particularly ambitious goals like carbon neutrality—will in part depend on parallel efforts to establish favorable system-level conditions.

Workforce Considerations

Recent federal legislation, including the Inflation Reduction Act (IRA), the Infrastructure Investment and Jobs Act (IIJA) of 2021, and the Creating Helpful Incentives to Produce Semiconductors and Science (CHIPS and Science) Act of 2022, has directed significant new funding toward workforce development to help grow the pipeline of skilled professionals that can manufacture, install, operate, and maintain emerging low-emission technologies and advanced building controls. However, as the NIBS Consultative Council has discussed previously—notably in prior years' Moving Forward Reports—the U.S. building industry is already facing a dire workforce shortage.[18,19] Consequently, while the decarbonization of the building sector serves as a jobs creator in fields such as energy efficiency, renewable energy installation, retrofitting, and green building design, maintaining a narrow focus on new and emerging building technologies and services risks crowding out existing workforce development efforts that are designed to meet longstanding needs among established trades and professions. There is both a risk and a likelihood that some segments of the existing building sector workforce will also be displaced due to the transition to low-emissions technologies and low-embodied-carbon products, so both training and retraining opportunities will be essential to enable existing workers to develop new skills and find new employment within the industry as it evolves.

Equity Concerns

A drive towards decarbonization must focus on ensuring fairness and an equal sharing of both benefits and costs. The historic, status quo building and energy system currently disadvantages low-income and minority populations. These communities face larger exposure to pollution, especially from energy infrastructure, and are less likely to be the focus of policy improvements to the built environment.[20] Improvements should strive to ensure an equitable sharing of benefits.[iii] The private building sector and policymakers should focus on improvements for all communities, and not simply focus on "champion" projects that, while important, do not represent a broad sharing of the benefits of decarbonization.

[iii] The Justice40 Initiative is a federal program whose goal is for 40 percent of the overall benefits of certain federal investments to flow to disadvantaged communities that are marginalized, underserved, and overburdened by pollution.

In addition to benefits, policymakers should ensure that disadvantaged communities do not bear the brunt of the costs for these policies. For example, recent federal initiatives to improve the emissions performance of federal facilities should provide opportunity for incentives and tradeoffs for buildings or portfolios that represent a substantial source of employment for disadvantaged communities.[21] Federal agencies should ensure that, as they seek to meet facility performance goals, equity and justice are key considerations that help guide agency actions.[iv] Additionally, as the building and utility sectors modernize, providing wealthier customers the ability to take early advantage of decarbonized power solutions, disadvantaged communities should not be left to pay the full costs of maintaining legacy systems.

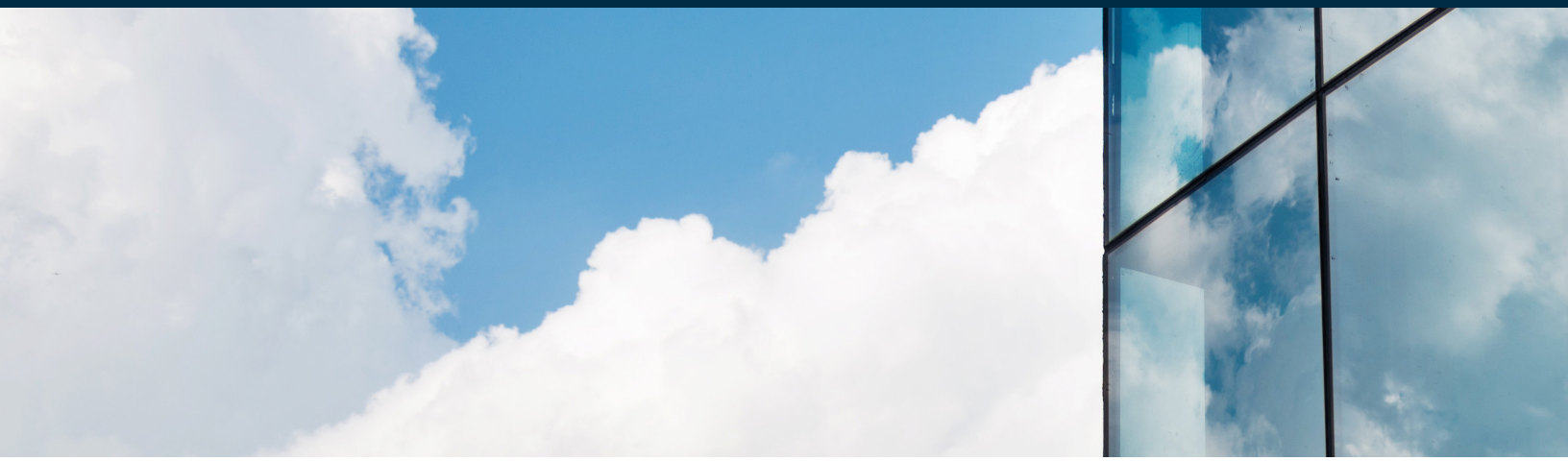
Finally, and similar to the challenges faced by some segments of the workforce, some small businesses within the building sector could face obsolescence as a result of the sector-wide pivot toward low-carbon goods and services, particularly when these smaller companies lack the resources to quickly retool their offerings to meet new and emerging demands. Consequently, providing continuing support to small businesses, particularly those owned by minorities and other disadvantaged groups, will be vital as they re-establish their role in the changing economy in order to support the industry's evolution.

[iv] CEQ has developed the Climate and Economic Justice Screening Tool to help identify census tracts that are overburdened and underserved by federal climate, clean energy, affordable and sustainable housing, clean water, and other investments.

Decarbonization Policies and Programs at the Federal Level

The federal government has enacted several key efforts to reduce both embodied carbon and operational GHG emissions throughout the building lifecycle, including:

- **The Infrastructure Investment and Jobs Act (IIJA) of 2021** includes billions of dollars in funding to modernize the electric grid, invest in energy transmission systems, increase funding for building energy efficiency and weatherization, and expand clean transportation infrastructure. Additional funding is also provided for research, development, and deployment of clean technologies in the energy generation sector, including battery and other storage technologies.
- **The Inflation Reduction Act (IRA) of 2022** includes hundreds of billions of dollars to support the adoption of new construction codes and building performance standards, clean or low-carbon procurement, the development of environmental product declarations (EPDs) and other labeling activities, decarbonizing steel and cement production, and other support specific to decarbonizing federal facilities.[22]
- **Executive Order 14057**[23] directed a "Whole-of-Government" approach to decarbonization. The Order establishes embodied carbon as a priority for the federal government, and sets the goal of achieving net-zero GHG emissions from federal procurement by 2050. This includes developing low-embodied-carbon material procurement pilot programs, collecting and disclosing environmental performance data for materials, standardizing emissions reporting across the federal government, and establishing an interagency Buy Clean task force to expand consideration of embodied carbon and pollutants in federal procurement and federally-funded projects.[24]
- **The Federal Building Performance Standard**,[25] released in December 2022, requires agencies to cut energy use and electrify equipment and appliances to achieve zero Scope 1 emissions in 30 percent of the building space owned by the federal government by square footage by 2030. Simultaneously, DOE has proposed a rulemaking to electrify new or newly renovated federal buildings.



Decarbonization Policies and Programs at the State and Local Level

Many new state initiatives prioritize decarbonizing buildings, including all-electric or electric-preferred building codes as well as incentives to encourage fuel switching from fossil fuel-fired heating equipment to electric heat pumps, among others.[26] Some cities and states are also developing or have begun implementing building performance standards (BPS) for existing, large commercial buildings, and/or have enacted Buy Clean programs. For example:

- Boulder, CO: The City of Boulder offers residential rebates for the purchase and installation of heat pump water and space heating equipment, with additional rebates available to incentivize fuel switching for these end uses from natural gas to electricity. City rebates can be stacked with similar incentives offered by Boulder County.[27]
- Montgomery County, MD: In late 2022, the Montgomery County Council passed a bill requiring the County Executive to issue all-electric building standards for new construction by the end of 2026.[28] Earlier in 2022, the County amended its existing building energy benchmarking program (i.e. BPS) to lower the benchmarking square footage threshold for commercial buildings and expand the types of buildings that are subject to the requirement.[29]
- California: The Buy Clean California Act (BCCA), first passed in 2017, requires that four classes of materials used in California public works projects (structural steel, concrete reinforcing steel, flat glass, and mineral wool board insulation) must meet GHG emissions targets in their production.[30]

Decarbonizing the Built Environment: Recommendations from the Consultative Council

The task of decarbonizing the building sector will be difficult, but there are multiple achievable, scientifically-proven pathways to doing so. Drawing on the latest research and industry best practices, the recommendations below are designed to promote collaboration and information exchange, as well as the sharing of costs and benefits, to continue the important process of decarbonizing the built environment. These recommendations supplement, and should not replace, other necessary actions to adapt the built environment to a changing climate and make our buildings and communities healthier and more resilient to natural hazards.

Coordination Across the Building Sector

- The **Federal Government** should leverage the significant experience of the design and construction industries, prioritizing private sector input in ongoing Council on Environmental Quality coordination of federal actions around decarbonization. This public-private sector exchange is particularly important for relevant agencies with regulatory missions and substantial private sector impact, like the U.S. Environmental Protection Agency, U.S. Department of Energy, and the U.S. Department of Housing and Urban Development.
- **Building Industry Trade Associations** should continue to collaborate, align, and harmonize activities in the realm of building decarbonization. Together, they should use their collective market power and professional membership to align under common definitions, metrics, and practices for their respective members, as well as develop messaging and communications that promote building decarbonization to targeted and relevant stakeholders and constituents.
- The **Administration** and **Federal Agencies** should continue to engage with building owners and portfolio managers to discuss and identify the most effective incentives that can drive action to reduce operational emissions and embodied carbon in buildings leased by the federal government. This is essential to complement federal decarbonization portfolio planning for government-owned buildings.

Embodied Carbon Accounting and Data Transparency and Disclosure

- The **Administration** and **Federal Agencies** should ensure that all proposed action and mandates are working from a common definition of decarbonization, with commonly shared, publicly available performance data, to ensure shared progress and tracking.
- **Building Component and Materials Manufacturers** should continue to develop EPDs verified by an accredited EPD Program Operator to support informed decision making across a building's lifecycle.
- **Federal Agencies** should directly provide, or provide funding for, tools and resources to support manufacturers and trade groups—particularly small businesses—to expand the availability of EPDs to more products and manufacturers.
- **Federal Agencies** should provide technical assistance and funding to support development of a generally-accepted and widely available lifecycle approach to evaluating whole-building environmental impacts, one that balances operational GHG emissions and embodied carbon considerations.
- Once developed, **Building Designers, Owners, and Developers** should use this whole-building, lifecycle approach to evaluate projects, determine their embodied carbon and operational GHG emissions, and support development of baselines for common building types.

Market Transformation

- **Federal, State, and Local Governments** should provide a continuum of policy support to facilitate decarbonization efforts at every stage of the building lifecycle, including design and construction (e.g. building energy codes), operation (e.g. benchmarking, disclosure, and performance standards), renovation (e.g. incentivize or subsidize energy efficiency and/or decarbonization retrofits), and end-of-use (e.g. facilitate building rezoning and/or re-use or incentivize recycling of building materials).
- The **Federal Government** should continue to coordinate with industry trade associations and other private sector actors to leverage funding from the Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA) to further stimulate and grow a private sector marketplace for low-embodied carbon building products, which Agencies can then specify for construction and renovation projects as part of "Buy Clean" programs.

Codes & Standards

- **Federal, State, and Local Governments** should increase investment in understanding the current landscape of energy code compliance; developing tools, resources, and best practice compliance methods for all building types; and continuing education and training for both current code officials as well as the next generation of code officials.
- **Codes and Standards Developers** should review existing codes and standards for their potential contributions to building decarbonization and whether they are aligned with the urgency of the challenge.

Existing Buildings

- **Federal, State, and Local Governments** and the **Building Industry** should increase investment in understanding and overcoming the challenges to decarbonization posed by the existing building stock. A significant portion of the existing buildings will continue to operate for decades, but extreme variability in the age, design, and construction of these buildings constrains the implementation and widespread applicability of many technologies and approaches that can drive decarbonization.

Workforce

- The **Federal Government** should increase investment in continuing education and training for the current workforce on low-emission building technologies and low-embodied-carbon products, as well as continued investment in developing a next-generation building sector workforce that can help to address the shortage of skilled and unskilled laborers in the building trades.

Equitable Decarbonization

- **Federal, State, and Local Governments** should allocate dedicated funding for disadvantaged or low-income communities to support decarbonization efforts. This includes funding for technical assistance, energy-efficiency renovations or the purchase of high-efficiency and/or low-emissions equipment or appliances in residential and commercial buildings, as well as increased utility bill support for disadvantaged residents or communities who remain on legacy energy distribution systems.
- In implementing federal decarbonization goals, including the Federal Building Performance Standard, **Federal Agencies** should critically examine at whether closures of buildings or facilities not in compliance with the Federal Building Performance Standard would harm disadvantaged or low-income communities in areas where those facilities provide a substantial number of jobs

Consultative Council Leadership and Current Activities

NIBS and Consultative Council members continue to make tangible commitments to demonstrably reduce the carbon footprint of the built environment, and are matching this intent by developing and disseminating educational materials and technical resources, driving industry engagement, reporting on progress to drive accountability and inform future strategies, and advocating for appropriate regulations and policies at the local, state, federal, and international levels.

National Institute of Building Sciences (NIBS)

In 2022, the NIBS Board of Directors developed a new three-year strategic plan to guide the organization under the following cultural value: collaboration, innovation, inclusion, and accountability. Through two of its four strategic goals, NIBS seeks to improve communities by accelerating collaboration between public and private stakeholders and advancing transformational technologies across the built environment.

1. **Climate Adaptation, Mitigation, and Resiliency**

   The goal of climate adaptation, mitigation, and resilience requires advancing climate solutions and their adoption in the built environment. Building alliances with public and private sector organizations to develop and deploy innovative solutions is critical to this mission. NIBS also must drive interdisciplinary and interorganizational collaboration resulting in the development of policies, codes, and standards and share knowledge to advance resilient and sustainable communities.

2. **Transformational Building Sciences and Technologies**

   NIBS aims to promote convergent research and transformational technologies. Strategies to this goal involve nurturing and promoting creativity and innovation to advance technology. NIBS also aims to remove barriers to accelerate technology acceptance and adoption and advance innovative technology awareness and implementation.

American Institute of Architects (AIA)

In 2021, the AIA Board of Directors adopted a five-year Strategic Plan (2021-2025) to bring deliberate focus to two overarching goals:

a. Climate action for human and ecological health
b. Advance racial, ethnic, and gender equity

AIA's Strategic Plan is supported by organizational imperatives that include:

- **Emphasizing climate action:** Focusing efforts on climate action and positioning architects as community leaders to drive widescale adoption of practical design solutions that will rapidly address and mitigate the impacts of climate change. This includes the AIA 2030 Commitment, a climate strategy for reaching net zero emissions in the built environment.
- **Optimizing the role of the architect:** Amplifying architects' presence and impact by equipping and preparing them to serve as conveners, collaborators, civic leaders, and change agents to deliver solutions to society's most pressing needs. This includes the development of The Architecture & Design Materials Pledge, a framework for intentional product specification focused on ecological and human health.

- **Emphasizing justice & catalyzing equity:** Working to eradicate racial and gender inequity within the built environment and profession to better reflect society, and advancing the health, safety, and welfare of our communities through design and advocacy.

AIA will continue to seek opportunities and connections that will help define their stewardship of the built environment.

American Society of Civil Engineers (ASCE)

ASCE's commitment to decarbonization starts with its Code of Ethics, under which engineers (i) adhere to the principles of sustainable development, (ii) consider and balance societal, environmental, and economic impacts, along with opportunities for improvement, in their work, (iii) mitigate adverse societal, environmental, and economic effects; and (iv) use resources wisely while minimizing resource depletion. Building on the foundation of these ethical principles, ASCE has confirmed this commitment through its policy on the Role of the Engineer in Sustainable Development; its SE 2050 Commitment to Net Zero, which includes an embodied carbon estimator, and intensity diagrams and trends; as well as dozens of published papers, books, manuals of practice and training programs, including ASCE Manuals of Practice on (i) Sustainable Procurement of Infrastructure and (ii) Climate-Resilient Infrastructure, Adaptive Design and Risk Management. ASCE is also a signatory of the Sustainable Development Goals Publishers Compact, with additional ASCE research supporting the Sustainable Development Goals available at https://ascelibrary.org/sdg.

Associated General Contractors of America (AGC)

In 2021, AGC released the Final Report & Recommendations from the AGC of America Climate Change Task Force. The report highlights the task force's discussions on the top impacts associated with climate change for construction markets and construction firms (see Sections IV and V). The report provides details on opportunities and challenges specific to many of the projects that AGC members build, spanning all major construction markets. Finally, the report explores the many ways contractors have demonstrated environmental leadership on projects (see Section VI). It also candidly discusses some of the challenges that members may face related to climate policies and trends.

ASTM International

Several ASTM International technical committees have published and continue to develop voluntary consensus standards related to reducing the carbon footprint of the built environment, including embodied carbon in buildings. ASTM committees cover most of the building material categories cited in RMI's analysis of cradle-to-gate embodied carbon emissions and have standards related to material durability. Moreover, approaches being used by committees that are actively working in carbon-related areas include several of the steps to reducing embodied carbon that are identified in AIA's work. In addition, separate cross-cutting technical committees on building performance and sustainability generate relevant standards.

For example, ASTM Committee C01 on Cement and Committee C09 on Concrete and Concrete Aggregates have and are developing standards that address lifecycle carbon; recycled content; enhancing durability, longevity, and service life; and new materials and technology. For example, C01 is developing a standard with new test methods for determining carbon dioxide directly or indirectly in cements and concretes.

In the area of product design, ASTM Committee E60 on Sustainability is developing a standard guide for principles of circular product design, which could support reuse of materials, use of high-recycled content materials, and minimizing waste. E60 also has an existing standard for modeling recycling scenarios for building

materials, including copper, glass, plastics and gypsum.

In the area of reducing resource use, Committee E06 on Performance of Buildings formed a new subcommittee in October 2022 to develop standards related to “tiny houses”. Committee F42 on Additive Manufacturing is actively developing standards for additive construction.

Committee E50 on Environmental Assessment, Risk Management and Corrective Action has developed standards for entities and building owners to assist in managing their GHG emissions and for developing strategies that address GHG associated with a facility’s operations. For example, ASTM E2725, Standard Guide for Basic Assessment and Management of Greenhouse Gases provides a uniform framework for identifying management options and steps that may be beneficial to evaluate (GHG) solutions. It provides basic management strategies for existing corporations, commercial businesses, and government facilities, even those currently outside of various voluntary and regulatory schemes. The work of E50 guides building owners in establishing a baseline of current emissions, objectives for reducing or managing those emissions, monitoring progress in meeting the objectives, and reporting the results of these efforts.

ASHRAE

ASHRAE is committed to achieving net zero energy by 2030, and reaffirmed this commitment in a Position Document on Building Decarbonization, published in July 2022. As the standards authority for energy usage in buildings, ASHRAE recognizes that long-standing initiatives in energy efficiency should be expanded to building decarbonization. In Spring 2021, ASHRAE formed a Task Force for Building Decarbonization (TFBD) composed of dedicated experts who are updating its energy conservation standards to include carbon; developing training and education resources; and facilitating research on operational and embodied carbon, the grid-building intersection, and more. In January 2023, the ASHRAE TFBD with support from DOE released a new guide, Building Performance Standards: A Technical Resource Guide, to provide technical basis for policymakers, building owners, facility managers, and design professionals involved in developing and implementing BPS for existing buildings. Other resources expected in 2023 include a guide for grid-interactive buildings, a whole life carbon guide for building systems, and an embodied carbon standard adapted for North America from CIBSE TM65.

Recognizing the need for consistency in the quantification of GHG emissions associated with buildings across their lifecycle, ASHRAE and the International Code Council are jointly developing Standard 240P: Evaluating Greenhouse Gas (GHG) and Carbon Emissions in Building Design, Construction and Operation. This standard will establish how to measure and verify the GHG and carbon emissions of a building or group of buildings over the entire lifecycle, providing consistent procedures and data to be referenced by other standards that address new and existing building performance.

BOMA International

BOMA International’s Carbon Reduction Challenge offers building owners and managers the opportunity to pledge their dedication to reducing carbon emissions and saving the planet, one building at a time. The commitment is simple: track a building portfolio’s carbon output using BOMA’s tracker. BOMA International has also developed a Carbon Reduction Resource Center to collect and then make available decarbonization strategies proven to reduce carbon emissions. These strategies can be applied to a building and on-going data collection can be used to illustrate progress in overall reductions. BOMA International has also established an annual Symposium to work-shop and present new building technologies, focused on decarbonization for 2023.

BOMA International is also continuing to build its building certification and recognition programs to identify High-Performance Buildings by advancing BOMA 360 (high-performance) and BOMA BEST (reduced environmental

impact). These programs are essential in assisting building owners in implementing, and demonstrating the positive impact, that innovative carbon reduction technologies and strategies have on buildings across the globe. Additionally, BOMA International continues to work with DOE and EPA on several projects, including DOE's Better Buildings Challenge and Summit and EPA's Energy Star Program, where BOMA has just received its 16th Energy Star Partner of the Year Award.

Finally, in education, BOMA International continues to lead with educational offerings and trainings that focus on highly efficient building operations, including Foundations of Property Management and Facilities Operations courses. These courses improve the ability of the CRE workforce to achieve the efficient operation of all types of Commercial Real Estate.

Green Building Initiative (GBI)

GBI is developing criteria within Green Globes for New Construction and Green Globes for Existing Buildings that drive projects toward net zero as part of the holistic sustainability and resilience approach of Green Globes. Net zero energy and net zero carbon will be featured prominently in the 2023 editions of GBI's New Construction Standard and GBI's new standard on Existing Buildings. Of the standards' total points, 18% can be awarded for a completion of a Net Zero certification for New Construction Energy Performance and 12% of the standard's total points being awarded for Existing Buildings Energy Consumption.

In addition, GBI has developed an entire tool specific to net zero: The Green Globes Net Zero Accelerator™. The Accelerator™ and validation tool, launching in 2023, gives project teams and building owners specific guidance to advance their projects towards net zero carbon and net zero energy via a user-friendly system that is customizable to the needs of the project. The Accelerator helps projects demystify carbon and energy emissions accounting at the building and portfolio level, and will work in tandem with the GBI Towards Net Zero awards program, providing technical support to get more buildings where they need to be.

International Association of Plumbing and Mechanical Officials (IAPMO)

IAPMO continues to find innovative ways to innovate plumbing systems, which includes decarbonization. In the 2021 Uniform Plumbing Code, Appendix M, the Water Demand Calculator (WDC) was released. The WDC is the first time in 80 years plumbing water system sizing methods have been updated. This new pipe sizing methodology leads to right-sizing of plumbing systems in residential occupancies and an overall reduction of pipe sizes in the built environment. This not only leads to improved water efficiency, but also an overall reduction in carbon footprint in the built environment of plumbing systems. IAPMO is continuing to expand this tool which will impact commercial buildings such as schools, offices, and other building types.

International Code Council (ICC)

ICC is developing a comprehensive set of solutions to assist communities and the building industry in achieving a decarbonized building stock. In October 2022, ICC released "Decarbonization of the Built Environment: Solutions from the International Code Council" The report outlines how codes like the International Energy Conservation Code (IECC) and International Green Construction Code (IgCC) have reduced operational energy use and are driving toward zero energy buildings. Reductions in embodied GHGs are supported by EPDs verified by the ICC Evaluation Service and the resilience provisions in codes like the International Building Code (IBC) and International Residential Code (IRC).

In 2021, ICC released "Leading the Way to Energy Efficiency: A Path Forward on Energy and Sustainability to Confront a Changing Climate" to assure future editions of the IECC continue to reduce energy use and that

communities have resources they need to achieve their energy and climate goals. Currently available resources include "Electric Vehicles and Building Codes: A Strategy for Greenhouse Gas Reductions" and "Energy Codes and Building Performance Standards: Supporting Energy Use and Emissions Reductions in Buildings."

Please see above regarding ICC's co-development with ASHRAE of Standard 240P.

International Institute of Building Enclosure Consultants (IIBEC)

IIBEC is addressing decarbonization from a policy and an education front. Given that its members play a key role in the design and construction of sustainable and high-performance enclosures, IIBEC has developed an online course to facilitate education of its members on these topics. "Tools to Grow Your Sustainability Consulting Practice" consists of three modules: Sustainability 101: Basics in the World of Green Buildings, Sustainability in U.S. National Codes, Standards, and Rating Systems, and Embodied Carbon and Its Role in a Sustainable Future.

On the advocacy side, IIBEC's efforts has focused on supporting the update and adoption of building and energy code and standards, and issuing policy statements related to Environmental Commitment and Sustainability and Building Enclosures.

New Buildings Institute (NBI)

In March 2022, NBI released the Cost Study of the Buildings Decarbonization Code, which analyzes first costs for both all-electric and mixed-fuel paths for single-family and medium office prototypes. It also includes life cycle cost analysis for the single-family scenario. Ultimately, the cost study found that all-electric homes achieve construction savings and mixed-fuel buildings households are only nominally more expensive. Additionally, researchers determined that life cycle cost analysis (LCCA) for the single-family prototypes produced both economic and societal benefits of reduced emissions that contribute to climate change.

In September 2022, NBI released the Existing Building Decarbonization Code, a new way for jurisdictions to reduce carbon emissions and meet Climate Action Plan and public health and equity goals. The Existing Buildings Decarbonization Code is an overlay to the 2021 International Energy Conservation Code (IECC) and covers residential and commercial retrofits. The new model language covers both residential and commercial buildings including all-electric and mix-fuel energy use pathways.

In April 2022, NBI released the Decarbonization Roadmap Guide for School Building Decision Makers. The Guide is written for those interested in healthy, efficient, carbon neutral school design, construction and operation.

Other activities related to NBI's efforts on decarbonization can be found in NBI's Annual Report for Fiscal Years 2021 & 2022.

Royal Institution of Chartered Surveyors (RICS)

In November 2017, RICS released the first edition of the professional standard and guidance entitled Whole life carbon assessment for the built environment.[31] It has now become the world-leading standard for carbon measurement in the built environment. The professional standard is being revised with the aim of releasing the second edition in the summer of 2023.

RICS, as part of the International Cost Management Standard (ICMS) Coalition,[32] has developed the world's first integrated taxonomy for life cycle cost and life cycle carbon emissions to contribute positively to efforts to decarbonize the construction sector in the most cost-effective way. Through the third edition of ICMS, professionals will, for the first time, be empowered to deliver a globally consistent method for carbon life

cycle reporting across construction projects, from buildings and bridges to ports and offshore structures. This collaborative development aims to make consistent construction carbon and cost management reporting to the public advantage. The solution will support sustainable investment strategies by bringing much-needed transparency and cross-border comparability of embodied and operational carbon across the life cycle of construction projects.

RICS, with a consortium of professional bodies, is also developing a Built Environment Carbon Database (BECD). BECD consists of data at the entity level and the product level. The schema of this database can be used to develop a national benchmarking database for early cost and carbon advice on new and existing assets. In November 2022, RICS released "Decarbonising UK Real Estate: Recommendations for Policy Reform." The report outlines the main policy reforms needed to accelerate the reduction of both embodied and operational carbon emissions arising from real estate in line with national decarbonization targets.

To present a holistic picture of the integrated life cycle costing and life cycle carbon emissions process and practice, RICS has developed the RICS Carbon Toolkit[33] that allows RICS members to use globally accepted principles for decarbonization.

U.S. Green Building Council

The U.S. Green Building Council (USGBC) has been working since 1993 to reduce the negative environmental, health, and community impacts of building design, construction, and operations. USGBC works with partners from all sectors of the building industry with a focus on reducing GHG emissions including operational carbon, embodied carbon, refrigerants, mobility options, and carbon sequestration. USGBC continues to refine its tools to guide, drive, and validate achievement of more ambitious building decarbonization goals to meet the urgency of the climate crisis.

USGBC's LEED rating systems incentivize energy efficiency optimization, whole building lifecycle assessment, environmental product declarations, and other measures that raise awareness of building impacts and guide better decision-making during design, construction, and operations.

In 2022, USGBC:

- Introduced new alternative compliance paths in LEED to provide metrics supporting goals, including beneficial electrification, low peak heating and cooling loads, reduction of other energy loads, and investments in renewable power: EApc160—Electrification ACP: Prescriptive Path and EApc161—Electrification ACP: Energy Simulation Performance Path.
- Published "The Future of LEED", guiding principles to align more closely with the targets in the Paris Agreement and move the market further on critical imperatives including equity, health, biodiversity, and resilience.
- Recognized more than 100 projects representing over 23 million gross square feet under its LEED Zero program. Each project serves as a showcase for proven emissions reduction strategies, clean energy technologies, and decarbonization commitments made real.
- Developed a Carbon Badge to award individuals who complete a set of courses on carbon avoidance and decarbonization, nearly 2,500 Carbon Badges have been earned to date.
- Convened local events focused on building decarbonization; released dozens of resources and articles related to building decarbonization and beneficial electrification.
- Actively advocated for federal, state, and local policies to drive building decarbonization, such as incentives for net zero buildings and funding for public building retrofits. USGBC issued a sample resolution to convene an Infrastructure Task Force to coordinate efforts to ensure that federal funding is used to advance climate,

resilience, and equity goals.
- Featured an in-depth look at the embodied carbon tool EC3.
- Released a new resource: "Synergies between LEED and the SDGs."

The next version of LEED will continue to move the market forward, transforming our bwuildings and communities for greatest impact in decarbonizing the built environment.

Consultative Council Members

American Institute of Architects
American Institute of Steel Construction
American Society of Civil Engineers
ASHRAE
Associated Builders and Contractors
Associated General Contractors of America
ASTM International
Building Owners and Managers Association International
ConnexFM
Construction Management Association of America
Construction Specifications Institute
Design-Build Institute of America
EPDM Roofing Association
Green Building Initiative
Insurance Institute for Building and Home Safety
International Association of Plumbing and Mechanical Officials
International Code Council
International Institute of Building Enclosure Consultants
Modular Building Institute
National Building Museum
National Ready Mixed Concrete Association
New Buildings Institute
Royal Institution of Chartered Surveyors
U.S. Green Building Council

References

[1] Blanco, Jose Luis; Engel, Hauke; Imhorst, Focko; Ribeirinho, Maria João; Sjödin, Erik. "Call for Action: Seizing the Decarbonization Opportunity in Construction." McKinsey and Company. July 2021. https://www.mckinsey.com/industries/engineering-construction-and-building-materials/our-insights/call-for-action-seizing-the-decarbonization-opportunity-in-construction

[2] US EPA. "Overview of Greenhouse Gases." https://www.epa.gov/ghgemissions/overview-greenhouse-gases

[3] UN Environment Program. "2022 Global Status Report for Buildings and Construction." https://globalabc.org/our-work/tracking-progress-global-status-report

[4] Ibid.

[5] Architecture 2030. "Why the Buildings Sector." https://architecture2030.org/why-the-building-sector/

[6] Cleary, Katherine; Palmer, Karen. "Federal Climate Policy 106: The Buildings Sector." Resources for the Future. April 6, 2021. https://www.rff.org/publications/explainers/federal-climate-policy-106-the-buildings-sector/

[7] Cortese, Amy. "The Embodied Carbon Conundrum: Solving for All Emissions Sources from the Built Environment." New Buildings Institute. https://newbuildings.org/embodied-carbon-conundrum-solving-for-all-emission-sources-from-the-built-environment/

[8] New Buildings Institute. "Embodied Carbon." https://newbuildings.org/code_policy/embodied-carbon/

[9] Cortese, Amy. "The Embodied Carbon Conundrum: Solving for All Emissions Sources from the Built Environment." New Buildings Institute. https://newbuildings.org/embodied-carbon-conundrum-solving-for-all-emission-sources-from-the-built-environment/

[10] Anish Tilak, Connor Usry, and Victor Olgyay, Roadmap to Reaching Zero Embodied Carbon in US Federal Building Projects, RMI, 2022, https://rmi.org/insight/roadmap-to-reaching-zero-embodied-carbon-in-federal-building-projects/

[11] Strain, Larry. "10 Steps to Reducing Embodied Carbon." American Institute of Architects." https://www.aia.org/articles/70446-ten-steps-to-reducing-embodied-carbon

[12] Carbon Leadership Forum. "What is a Buy Clean Policy." https://carbonleadershipforum.org/what-is-a-buy-clean-policy/

[13] U.S. Green Building Council. "Benefits of Green Building." https://www.usgbc.org/press/benefits-of-green-building

[14] New Buildings Institute. "Existing Building Decarbonization Code." September 2022. https://newbuildings.org/resource/existing-buildings-decarbonization-code/

[15] National Institute of Building Sciences. "Moving Forward: 2018 Findings and Recommendations from the Consultative Council." 2018. https://www.nibs.org/files/pdfs/NIBS_CC_MovingForward_2018.pdf

[16] International Code Council. "IECC Compliance and Enforcement." https://www.iccsafe.org/advocacy/iecc-compliance/

[17] International Code Council. “Workforce Development for Energy Code Enforcement.” https://www.iccsafe.org/advocacy/energy-code-workforce-development/

[18] National Institute of Building Sciences. “2019 Moving Forward Report: Findings and Recommendations from the Consultative Council.” 2020. https://www.nibs.org/reports/2019-moving-forward-findings-and-recommendations-consultative-council

[19] National Institute of Building Sciences. “2021 Moving Forward Report: Findings and Recommendations from the Consultative Council.” 2022. https://www.nibs.org/reports/2021-moving-forward-report

[20] Committee on Accelerating Decarbonization in the United States. “Accelerating Decarbonization of the U.S. Energy System.” National Academies of Sciences. 2021. http://nap.nationalacademies.org/25932

[21] Boyce, Amy. “How Does the First Federal BPS Measure Up?” Institute for Market Transformation. December 2022. https://www.imt.org/news/how-does-the-first-federal-bps-measure-up/

[22] Olgyay, Victor; Tilak, Anish; Usry, Connor. “Roadmap to Reaching Zero Embodied Carbon in Federal Building Projects.” Rocky Mountain Institute. 2022. https://rmi.org/insight/roadmap-to-reaching-zero-embodied-carbon-in-federal-building-projects

[23] White House Council on Environmental Quality. “Executive Order 14057. Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability. Implementing Instructions.” August 2022. https://www.sustainability.gov/pdfs/EO_14057_Implementing_Instructions.pdf

[24] The White House. “Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability.” December 2021. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/12/08/executive-order-on-catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability/

[25] Federal Building Performance Standard. https://www.sustainability.gov/federalbuildingstandard.html

[26] Takahashi, K., Frost, J., Goldberg, D., et al. (2020). Survey of U.S. State and Local Building Decarbonization Policies and Programs. Proceedings from the ACEEE 2020 Summer Study on Energy Efficiency in Buildings. Web. https://www.aceee.org/files/proceedings/2020/event-data

[27] EnergySmart. “EnergySmart Rebates and Financing.” https://energysmartyes.com/rebates-financing/

[28] Melton, Britney. “New construction in Montgomery County to be 100% electric energy equipment starting in 2026.” WUSA9. November 30, 2022. https://www.wusa9.com/article/news/local/maryland/montgomery-county-passed-marylands-comprehensive-building-decarbonization-legislation/65-6b9a05c5-1c85-4791-93fa-adc5f4d6f638

[29] Department of Environmental Protection, Montgomery County, Maryland. “Building Energy Benchmarking.” https://www.montgomerycountymd.gov/green/energy/benchmarking.html

[30] Department of General Services, State of California. “Buy Clean California Act.” https://www.dgs.ca.gov/PD/Resources/Page-Content/Procurement-Division-Resources-List-Folder/Buy-Clean-California-Act

[31] RICS Whole Life Carbon Assessment for the Built Environment https://www.rics.org/profession-standards/rics-standards-and-guidance/sector-standards/building-surveying-standards/whole-life-carbon-assessment-for-the-built-environment

[32] ICMS Standard https://www.rics.org/profession-standards/rics-standards-and-guidance/sector-standards/construction-standards/icms-international-cost-management-standards

[33] RICS Carbon Toolkit https://www.rics.org/content/dam/ricsglobal/documents/standards/rics_carbon_toolkit_infographic_landscape.pdf

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