Shaping Tomorrow's Built Environment Today

180 Technology Parkway, NW • Peachtree Corners, GA 30092-2977 • Tel: 404.636.8400 • Fax: 404.321.5478

Ginger Scoggins
2023-2024 ASHRAE President

Engineered Designs, Inc.
1151 SE Cary Pkwy., Ste. 200
Cary, NC 27518
Phone: (919) 851-8481
Email: gscoggins@engineereddesigns.com

May 2, 2024

The Honorable Nilsa Cruz-Perez
Chair
Senate Economic Growth Committee
New Jersey State Senate
State House Annex
P.O. Box 068
Room B50
Trenton, NJ 08625

Sent via email to: sencruzperez@njleg.org

Re: S. 249, "Requires BPU to establish beneficial building electrification program and requires electric public utilities to prepare and implement building electrification plans."

Dear Chair Cruz-Perez and Members of the Senate Economic Growth Committee:

I am writing on behalf of ASHRAE, the American Society of Heating, Refrigerating, and Air Conditioning Engineers, to support the goals of Senate Bill 249, which proposes to mandate the Board of Public Utilities to establish beneficial building electrification programs. ASHRAE, founded in 1894, is a global professional society of more than 54,000 members, including nearly 1,000 in New Jersey. ASHRAE focuses on building systems, energy efficiency, indoor air quality, refrigeration, and sustainability. Through research, standards writing, and continuing education, ASHRAE shapes tomorrow's built environment today.

This legislation would require the Board of Public Utilities to establish a beneficial building electrification program with greenhouse gas emission reduction targets, filing requirements in line with the state's energy master plan, cost recovery and performance incentives for these programs, and incentives for the installation of heat pumps. Furthermore, the legislation would mandate that these plans be cost effective both in terms of dollars and cents, as well as in terms of the environmental benefits of reducing greenhouse gas emissions (GHG).

ASHRAE supports building decarbonization, including through beneficial electrification. Considering that the buildings we live and work in are responsible for 40% of global energy related GHG emissions, building decarbonization is imperative for global climate stability, energy security, and the general well-being of communities. The benefits of building decarbonization include improved indoor air quality, energy efficiency, community health, and social equity.

Operational energy-related greenhouse gas emissions can be reduced by implementing energy efficiency measures and building electrification. We also recognize there are electric grid infrastructure challenges in achieving building decarbonization goals, which is why it's important that utilities are brought into the planning framework. Widespread electrification of building heating and domestic hot-water systems could require a substantially larger electrical grid infrastructure, unless there is a substantial reduction in building energy use through energy efficiency. Supplementing energy efficiency with demand flexibility and storage strategies can reduce the grid impact.

We also recommend this legislation be amended to include language directing the Board of Public Utilities to consult with technical societies such as ASHRAE as they develop their building electrification programs. ASHRAE can offer subject matter expert advice on developing electrification programs that are economically feasible and accomplish the goal of greenhouse gas emission mitigation. ASHRAE's Position Document on Building Decarbonization, enclosed, makes recommendations on how to pursue building decarbonization that is in line with this legislation, such as the necessity of energy efficiency retrofits. ASHRAE can also offer training courses on building energy audits, high-performance buildings and smart grid systems, in addition to other topics relevant to these building electrification programs. ASHRAE would be pleased to provide technical assistance to the New Jersey Board of Public Utilities as it implements this legislation, if passed.

Again, thank you for your consideration of S. 249 and its proposed building electrification programs. On behalf of the nearly 1,000 ASHRAE members in New Jersey, we support the goals of this legislation. I am enclosing a copy of the ASHRAE Position Document on building decarbonization, which more thoroughly discusses this matter. ASHRAE would be happy to address any questions you might have. Please feel free to contact me or have your staff contact GovAffairs@ashrae.org.

Sincerely,

Ginger Scoggins
ASHRAE President

Enclosure: ASHRAE Position Document on Building Decarbonization, June 26, 2022.

Shaping Tomorrow's Built Environment Today

ASHRAE Position Document on

Building Decarbonization

Approved by the ASHRAE Board of Directors June 26, 2022

Expires June 26, 2025

ASHRAE is a global professional society of over 55,000 members, committed to serve humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration and their allied fields (HVAC&R). ASHRAE position documents are approved by the Board of Directors and express the views of the Society on specific issues. These documents provide objective, authoritative background information to persons interested in issues within ASHRAE's expertise, particularly in areas where such information will be helpful in drafting sound public policy. The documents also clarify ASHRAE's position for its members and building professionals.

Building Decarbonization is a Public Interest Issue

Building decarbonization is imperative for global climate stability, energy security, and the general well-being of communities. As the building sector accounts for significant global greenhouse gas (GHG) emissions, prioritizing decarbonization action directly serves the public interest. Addressing this issue has the potential not only to help mitigate climate change in the short term but also to provide a stable environment for future generations. The benefits of building decarbonization include improved indoor air quality, energy efficiency, community health, and social equity.

For building decarbonization to be successful, it requires robust research and development, industry standardization, effective government policies, and workforce development. R&D programs must focus on strategies that reduce GHG emissions without compromising occupant safety and indoor environmental quality. Collaboration between energy, transportation, and building sectors is essential to cost-effectively optimize GHG reductions. Moreover, equipping the future workforce with the skills to support building decarbonization is crucial.

Building decarbonization is a public interest issue because it directly impacts climate stability, public health, economic well-being, and the broader societal goal of sustainability. Addressing this issue is pivotal for current and future generations, making it a collective responsibility. Embracing it is not just an industry priority, but a move in the best interest of the public at large.

Why ASHRAE Takes Positions on Building Decarbonization

ASHRAE underscores the urgency of decarbonizing buildings due to their contribution to global GHG emissions. With the global building stock projected to double by 2060, ASHRAE commits to a holistic approach encompassing research, design, technical guidance, regulations, and education.

The buildings we live and work in are responsible for roughly 40% of energy-related greenhouse gas (GHG) emissions. As jurisdictions across the planet confront climate change, the term decarbonization is being used to describe practices or policies that reduce GHG emissions. The standard metric used to quantify GHGs is carbon dioxide equivalent (CO2-eq). Using a common metric helps evaluate different sources of GHGs in terms of their potential to impact the atmosphere—also referred to as their global warming potential (GWP).

This position document presents ASHRAE's position on decarbonizing buildings and recommendations for moving forward. ASHRAE membership has the expertise, mission, and vision to directly address decarbonization in existing and future buildings while providing a healthy and sustainable built environment for all.

The global policies and commitments driving the transformation in building design and performance are broadly motivated by climate change, and the global building stock is expected to double by 2060. In response to this call for action, many countries' public and corporate entities have set goals to be carbon neutral prior to 2050. Now is the time to turn these commitments and goals into action. By 2050, at the latest, all new and existing assets must have net zero GHG emissions across their whole life cycles.

Building decarbonization encompasses a building's entire life cycle, including building design, construction, operation, occupancy, and end of life. Building construction, energy use, methane, and refrigerants are the primary sources of GHG emissions. Building life-cycle assessment involves consideration of operational and embodied emissions. Operational emissions are generally from energy use. Embodied emissions include GHG emissions associated with building construction, including extracting, manufacturing, transporting, and installing building materials, as well as the emissions generated from maintenance, repair, replacement, refurbishment, and end-of-life activities. Embodied emissions also include refrigerant releases across the building life cycle.

As new technologies develop and our understanding of the environmental effects of technology grows, ASHRAE is committed to continued efforts relating to building decarbonization in the following areas:

- **Research and standards development:** Creating a foundation for decarbonization efforts.
- **Design and equipment applications:** Promoting innovations in building infrastructure.
- **Technical guidance and training:** Equipping the workforce with updated knowledge.
- **Regulatory guidelines and measures:** Establishing a regulatory framework for industry compliance.
- **Educational resources and outreach:** Educating stakeholders and the public on the importance of decarbonization.

This position document recommends embracing building decarbonization strategies to reduce building greenhouse gas (GHG) emissions. Buildings benefit society but have a significant worldwide environmental impact due to their GHG emissions. The building industry accounts for roughly 40% of global GHGs, and the global building stock is expected to double by 2060.

As society faces the challenge of mitigating climate change, ASHRAE's position is that decarbonization of buildings and their systems must be based on a holistic analysis including healthy, safe, and comfortable environments; energy efficiency; environmental impacts;

sustainability; operational security; and economics. By 2030, the global built environment must at least halve its 2015 GHG emissions, whereby

- all new buildings are net zero GHG emissions in operation,
- widespread energy-efficiency retrofits of existing assets are well underway, and
- embodied carbon of new construction is reduced by at least 40%.

Positions and Recommendations

ASHRAE Takes the Positions that:

- Eliminating GHG emissions from the built environment is essential to address climate change.
- By 2030, the global built environment must halve its 2015 GHG emissions, whereby
  - all new buildings must be net zero GHG emissions in operation,
  - widespread energy-efficiency retrofits of existing assets must be well underway, and
  - embodied carbon of new construction must be reduced by at least 40%.
- By 2050, at the latest, all new and existing assets must be net zero GHG emissions across the whole life cycle.
- Building decarbonization provides benefits beyond reducing GHGs, including reduced indoor and outdoor air pollution, energy savings, improved community health and well-being, enhanced social responsibility, and increased property valuation.
- Operational energy-related GHG emissions can be reduced by implementing efficiency measures and building electrification; improving O&M; using low-GWP refrigerants and minimizing refrigerant volume while maintaining energy efficiency; improving refrigerant management; and increasing use of renewable energy sources both on site and off site, energy storage, and building-grid integration.
- Building design and operations should be able to respond to real-time carbon signals from the power grid to reduce GHG emissions.
- Increasing stringency and enforcement of energy codes are critical for decarbonization.
- Whole-building life-cycle assessment (WBLCA) must be considered in future building codes to reduce embodied and operational GHG emissions related to buildings and their HVAC&R systems.
- Building performance standards (BPS) should be considered as a policy tool for existing building decarbonization.
- Decarbonization policies must consider and mitigate impacts on disadvantaged communities and less-developed nations.
- Building decarbonization strategies and policies must consider healthy, safe, and comfortable environments; environmental and social impacts; sustainability; resilience; and economics.

ASHRAE Recommends that:

To support global building decarbonization, ASHRAE recommends that governmental and nongovernmental institutions focus on the following areas:

Research, Standards, and Guidelines Development

- Promote research and development programs that investigate and adopt building decarbonization strategies that lower GHG emissions and increase grid flexibility without compromising indoor environmental quality and safety.
- Promote research and development of heat pump technology.
- Support the development, update, and adoption of relevant standards and guidelines that facilitate the whole-life-cycle reduction of GHG emissions from new and existing buildings.
- Encourage standardization of measurement and labeling of embodied carbon in building materials, systems, and equipment.

Improved Design and Equipment Applications

- Balance safety, energy efficiency, cost, and environmental impacts to achieve building decarbonization.
- Advance the design, development, and application of HVAC&R equipment and systems that minimize GHG emissions during the life of the equipment.
- Encourage greater collaboration and the development of standards and guidelines among the energy, transportation, and building sectors to improve secure building-grid integration, data communication, and optimization of energy performance (generation, use, and storage).
- Develop tools, equipment, methodologies, and practices to minimize or prevent GHG emissions during installation, operation, maintenance, retrofit, and decommissioning of buildings and their systems.
- Develop the data and methods needed for calculating practical, repeatable, and verifiable procedures for estimating embodied carbon in HVAC&R equipment and mechanical systems.

Workforce Development

- Work in partnership with industry to increase the capacity and opportunities for a skilled workforce supporting building decarbonization.
- Support funding for building decarbonization training and curriculum development.

ASHRAE commits to the following:

- Develop technical guidance, standards, training, and other tools to support building decarbonization policy goals.
- Support research that develops and advances technologies and practices to minimize building GHG emissions.
- Develop policies and recommendations based on the global science related to the building sector's impact on the environment.
- Take a leadership role in determining and harmonizing one set of aligned definitions and terminology for all building-related carbon terms.
- Strengthen the decarbonization components of ASHRAE standards every three to five years, consistent with achieving a fully decarbonized built environment by 2050.
- Provide resources to support building performance standards (BPS) development, implementation, and compliance.

- Develop and revise guidelines and standards to reduce building GHG emissions while maintaining or improving building indoor environmental quality, sustainability, and resilience.
- Promote whole-building life-cycle assessment (WBLCA).
- Collaborate with other organizations to promote and advance global building decarbonization.
- Advance HVAC&R technologies and practices that minimize refrigerants' impact on the environment while enhancing performance, cost-effectiveness, and safety.
- Mobilize ASHRAE grassroots members around the world to encourage sound, balanced, and innovative carbon reduction strategies and become involved with policy-setting entities.
- Support beneficial electrification of heating through education, information dissemination, and focused training.
- Educate and train the future workforce for building decarbonization.

Appendix A—Background

Building decarbonization encompasses a building's entire life cycle, including building design, construction, operation, occupancy, and end of life. Building construction, energy use, methane leakage, and refrigerants are the primary sources of GHG emissions. Building life-cycle assessment involves consideration of operational and embodied emissions. Operational emissions are generally from energy use. Embodied emissions include GHG emissions associated with building construction, including extracting, manufacturing, transporting, and installing building materials, as well as the emissions generated from maintenance, repair, replacement, refurbishment, and end-of-life activities. Embodied emissions also include refrigerant losses across the building life cycle.

The primary means for reducing building GHG emissions are the following:

- Reduce building energy use through energy efficiency
- Reduce building embodied carbon
- Eliminate refrigerant releases, minimize leakage, and use low-global-warming-potential (low-GWP) refrigerants
- Energy-efficient electrification of building energy needs
- Design buildings to optimize grid flexibility
- Provide on-site renewable energy
- Decarbonize the electrical grid

While decarbonized combustion fuels and on-site carbon capture use and storage (CCUS) are not mainstream building solutions today, they may play a larger role as the technologies are improved.

Keys to reducing embodied carbon GHG emissions are to minimize refrigerant leakage and the quantity of materials used on site, reduce energy for transportation by sourcing local materials, reuse existing buildings and materials, choose new low-carbon materials, and minimize end-of-life carbon impacts.

ASHRAE Relevance

ASHRAE has a long history of improving building design and operation and advancing HVAC&R technologies and applications. ASHRAE's robust building energy standards continue to drive improvements in efficiency and long-term energy costs (ASHRAE 2019e). Energy efficiency directly reduces energy-related GHG emissions. ASHRAE has been a driving force behind global reductions in refrigerant-related emissions from buildings through guidance in its research, handbooks, and standards (2020b). ASHRAE also facilitates decarbonization through educational opportunities and the development of guidance materials such as the new Chapter 36, "Climate Change," in the 2021 ASHRE Handbook—Fundamentals (2021c) and the book Smart Grid Application Guide: Integrating Facilities with the Electric Grid (2020c). ASHRAE's additional focus on occupant health and safety within the built environment is expressed in continuously updated design guide documents, handbooks, standards, and other publications.

For more than a century, ASHRAE has been a leader in building design, operations, and technology. ASHRAE is advancing strategies toward reduction of life-cycle GHG emissions in the built environment including embodied carbon. Many ASHRAE standards address decarbonization and others are quickly evolving to address the issue. Table 1 lists ASHRAE standards that address energy efficiency, GHG emissions, refrigerant emissions, and/or renewables or may include such references in future updates.

Table 1 ASHRAE Standards Addressing Energy Efficiency, GHG and Refrigerant Emissions, and Renewables

	Topic				
Standard/Code	**Energy Efficiency**	**Operational GHG Emissions**	**Embodied GHG Emissions**	**Refrigerant Emissions**	**Renewables**
ANSI/ASHRAE Standard 34-2019, *Designation and Safety Classification of Refrigerants*				✓	
ANSI/ASHRAE/IES Standard 90.1-2019, *Energy Standard for Buildings Except Low-Rise Residential Buildings*	✓	✓			✓
ANSI/ASHRAE/IES Standard 90.2-2018, *Energy-Efficient Design of Low-Rise Residential Buildings*	✓	✓			✓
ANSI/ASHRAE Standard 90.4-2019, *Energy Standard for Data Centers*	✓				
ANSI/ASHRAE/IES Standard 100-2018, *Energy Efficiency in Existing Buildings*	✓				

Table 1 ASHRAE Standards Addressing
Energy Efficiency, GHG and Refrigerant Emissions, and Renewables *(Continued)*

	Topic				
Standard/Code	**Energy Efficiency**	**Operational GHG Emissions**	**Embodied GHG Emissions**	**Refrigerant Emissions**	**Renewables**
ANSI/ASHRAE Standard 105-2021, *Standard Methods of Determining, Expressing, and Comparing Building Energy Performance and Greenhouse Gas Emissions*	✔	✓			✔
ANSI/ASHRAE Standard 147-2019, *Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems*				✔	
International Green Construction Code® and **ANSI/ASHRAE/ICC/USGBC/IES Standard 189.1-2020,** *Standard for the Design of High-Performance Green Buildings*	✔	✔	✔		✔
ANSI/ASHRAE/ASHE Standard 189.3-2021, *Design, Construction, and Operation of Sustainable High-Performance Health Care Facilities*	✔	✔	✔	✓	✔
Proposed ASHRAE Standard 227P, *Passive Building Design Standard*	✅			✅	
Proposed ASHRAE Standard 228P, *Standard Method of Evaluating Zero Net Energy and Zero Net Carbon Building Performance*		☑		☑	☑
Proposed ASHRAE Standard 240P, *Evaluating Greenhouse Gas (GHG) and Carbon Emissions in Building Design, Construction and Operation*	✅	✅	✅	✅	✅

Legend:
- ✔ Included in standard
- ✓ Carbon calculation methodology included in standard
- (✓) Under consideration for inclusion in next update of standard
- ✅ Included in proposed standard
- ☑ Carbon calculation methodology included in proposed standard

Note: Energy efficiency directly contributes to operational GHG emission reductions.

Decarbonizing the Built Environment

The #BuildingToCOP26 Coalition (UNEP 2021) set the following global goal:

> By 2030, the built environment should halve its emissions, whereby 100 percent of new buildings must be net-zero carbon in operation, with widespread energy efficiency retrofit of existing assets well underway, and embodied carbon must be reduced by at least 40 percent, with leading projects achieving at least 50 percent reductions in embodied carbon. By 2050, at the latest, all new and existing assets must be net zero across the whole life cycle, including operational and embodied emissions.

This implies that global building sector emissions must drop by approximately 6% per year from 2020 to 2030. Achieving this goal requires rapidly renovating existing buildings in addition to improving new building designs. While top priority should be given to implementing energy efficiency, electrification, and renewable energy measures, any residual whole-life-cycle emissions may need to be offset through off-site carbon reduction or storage projects, certified via independent third-party verification (WorldGBC 2021).

Both operational and embodied carbon are significant sources of a building's life-cycle carbon impact. Energy-related embodied GHG emissions account for approximately 25% of the total annual global energy-related GHG emissions of buildings and are locked in place as soon as a building is built, even before its operation. With the built environment floor space forecast to double from 2020 to 2060, it is imperative that the building industry create embodied carbon strategies to reduce the environmental impact from buildings (UNEP 2021). Figure 1 (NBI 2022) illustrates the importance of embodied carbon across a building's life cycle.

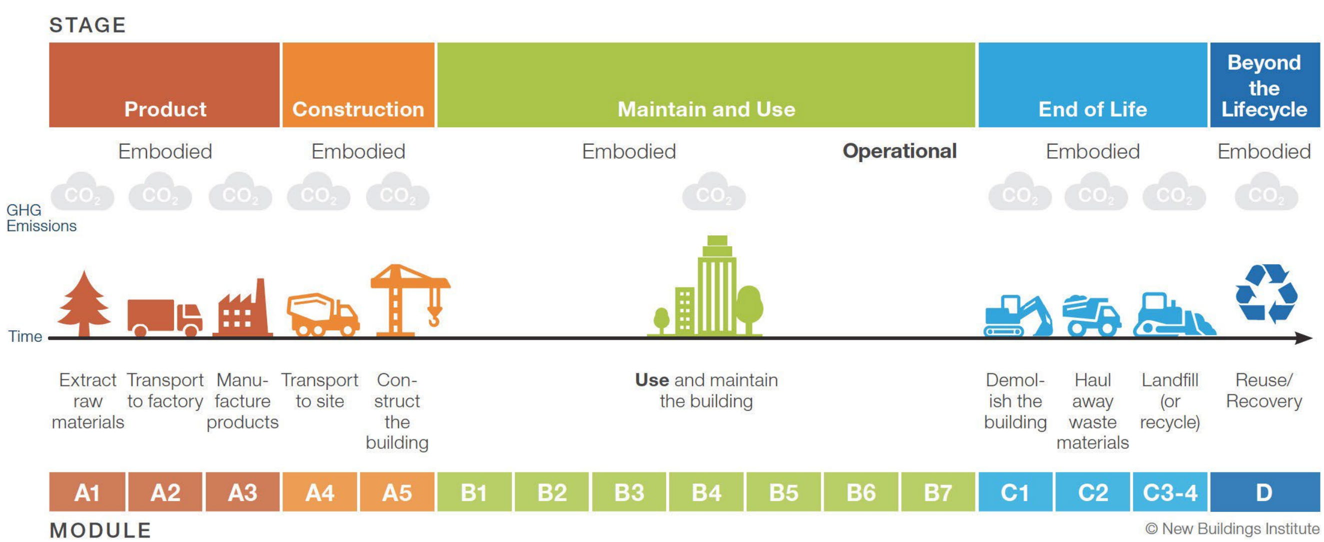

Figure 1 Building carbon life-cycle stages.
NBI 2022

The following building decarbonization design measures can help guide early decision making:

- Reuse existing buildings, structures, and materials whenever possible.
- Optimize building envelope, orientation, and geometry to reduce energy use and maximize solar potential.
- Implement passive and active energy-efficiency measures.
- Use waste energy streams.
- Minimize embodied carbon in new construction materials and construction.
- Use energy-efficient electrification of space and water heating.
- Use low-GWP refrigerants and minimize refrigerant volume while maintaining energy efficiency.
- Use grid-integrated control systems to optimize building energy storage and increase demand flexibility.
- Use renewable energy resources on site and/or off site.
- Provide for effective long-term O&M.

Carbon Reduction Principles

Building design must prioritize high-performance practices. Design changes become increasingly challenging and costly the later in a project they are made. Early integrated design processes can optimize carbon reduction strategies. Design-phase life-cycle assessments can provide designers with the information to minimize whole-life-cycle GHG emissions.

Building design and procurement decisions must account for embodied carbon. Building architects and engineers can have a direct impact on reducing embodied carbon through informed design decisions using life-cycle assessment for new buildings and retrofits. Building embodied carbon can be reduced by 25% or more by reusing materials, specifying alternative low-carbon materials, and limiting carbon-intensive materials. More research is needed to determine the embodied carbon impact of various building components and systems.

Building metrics are an important tool for minimizing GHG emissions. Effective design decisions depend on prioritizing the metrics used to make the best decisions to achieve project goals. A strategy of minimizing GHG emissions means that using energy-efficient electric options, such as heat pumps, should be considered, even when fossil fuel prices are low. This approach can be driven through a GHG emissions metric to evaluate building performance, particularly in energy code compliance.

Increased energy efficiency and building-grid demand flexibility will be required to reduce the impact of building electrification. The growth of building and transportation electrification could require a significant increase in electrical grid capacity. This emphasizes the need for energy efficiency, energy storage, and alignment of consumption with carbon-free generation to minimize the needed increases. Worldwide, the buildings sector accounted for roughly 50% of the annual total electricity consumption between 2010 and 2020. The building sector electricity consumption increased by 24% from 2010 to 2019, an average annual growth rate of 2.7% (IEA 2021c). The least-cost solution is to aggressively improve a building's electrical efficiency and operation with intelligent controls and load flexibility based on minute-by-minute variations in grid carbon intensity.

For the building sector to decarbonize, global electric grids must decarbonize. Electricity generation and delivery are currently major contributors to global GHG emissions. Combustible fuels account for roughly 65% of global gross electricity production. The Net Zero by 2050 scenario (IEA 2021a) shows a path for the electric grid to achieve zero emissions: global generation from renewables must triple by 2030 and grow eightfold by 2050, as shown in Figure 2.

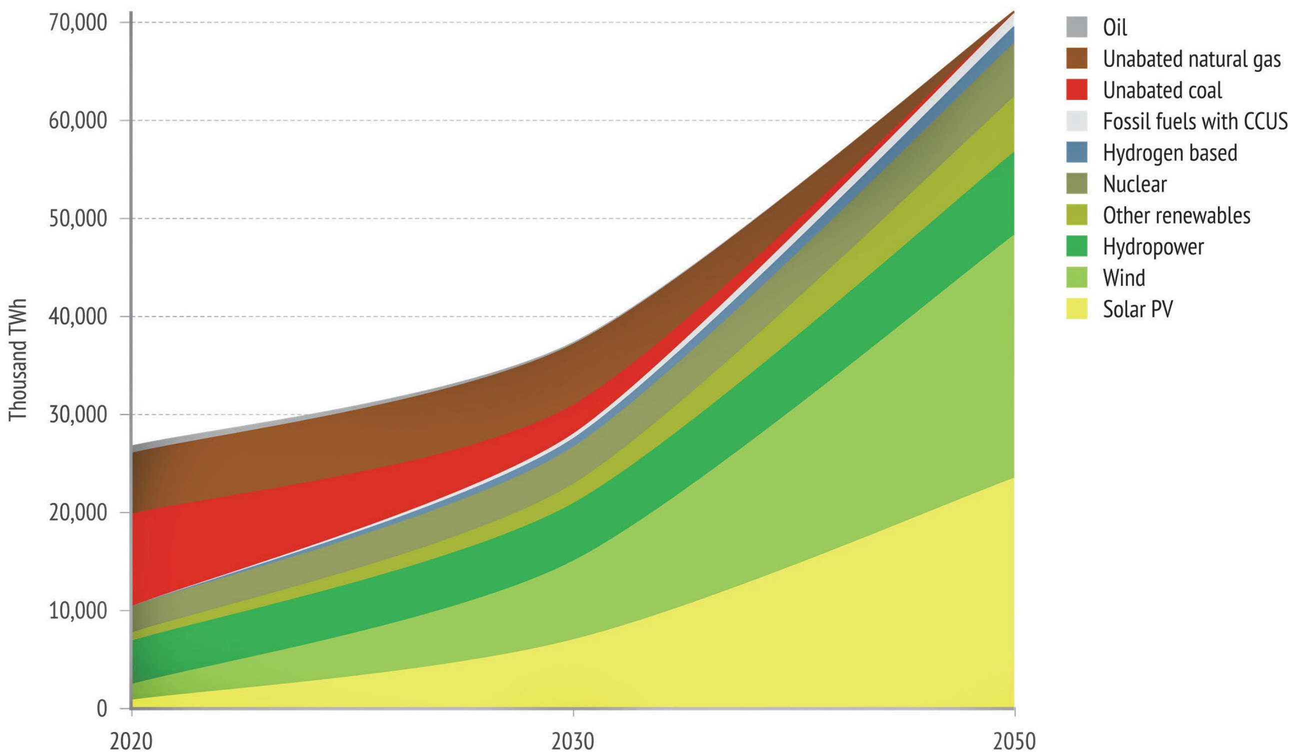

Figure 2 Global electricity generation forecast by source in the Net Zero by 2050 scenario. *Data source: IEA 2021a*

Decarbonization Strategies

Decarbonization can happen at any building. Often, decarbonization is simpler with smaller buildings, including residential and small commercial buildings. While the individual impact can be small, widely applied turnkey solutions can have a large impact. Heat pump equipment and other decarbonization strategies are readily available for a wide range of applications. Campuses and district systems often provide opportunities for larger-scale decarbonization. Geothermal systems can be designed to service an entire district, while heat recovery from wastewater, data centers, refrigeration, and industrial processes can supply heat to other buildings.

Whole-building life-cycle assessment (WBLCA) is an important tool for minimizing the environmental impact of buildings and their HVAC&R systems. WBLCA includes assessment of embodied and operational GHG emissions in addition to other environmental impacts.

New buildings provide the opportunity to set decarbonization goals while in the design phase. They can use architectural and engineering techniques that minimize energy consumption and integrate renewable energy with energy storage to shift loads to align with lower carbon periods on the grid. Dispatchable building loads, which allow curtailment or load shifting, can use machine learning to understand each building individually and anticipate when it will hit peak load. Building codes are the primary policy instrument to foster widespread adoption of decarbonization practices into new construction. Existing buildings are more complex, as each one is unique, but up-front analysis and design choices can have dramatic long-term decarbonization payoffs.

Retrofitting large numbers of existing buildings for decarbonization is critical. This may be most effectively accomplished at major building life-cycle events such as periodic audits and inspections, changes in ownership or tenancy, renewals of licensure, changes of building use, and permitting of additions, alterations, and end-of-life equipment replacement. Existing building policies such as existing building construction codes, mandatory upgrades, appliance emission standards, and building performance standards (BPS) are oriented around such triggers (ASHRAE 2021d). A report by the U.S. Environmental Protection Agency (EPA 2021) found that

> [s]everal jurisdictions have turned their attention to BPS policies to reduce GHG emissions from existing commercial and multifamily buildings. BPS policies require these buildings to meet a specific performance target, such as GHG emissions, site energy use intensity, weather normalized energy use intensity, or an ENERGY STAR score above the local median.

ANSI/ASHRAE/IES Standard 100 is the only ANSI standard that sets energy performance targets for existing buildings and provides a strong technical framework for assessing current energy performance levels (ASHRAE 2018b).

Best practices in building O&M can significantly impact emissions reduction, reducing energy use by 10% or more while extending the lives of building systems and equipment. Increasing the efficiency of O&M is also cost-effective, with a much shorter payback than building retrofits or other major improvement projects. Effective building O&M starts by installing an effective energy submetering and monitoring system and implementing a structured commissioning process followed by periodic or continuous building retuning and retrocommissioning. Note that although extending equipment life can reduce embodied GHG emissions from premature equipment replacement, the lives of inefficient equipment should not be extended, as this can result in greater operational emissions over the building life cycle.

Building decarbonization policies will have wide-ranging impacts. At a time when the world is in social transition, ASHRAE and building industry professionals are well-positioned to encourage community leadership to permanently improve the built environment in previously underserved communities. While not all decarbonization benefits may be directly measured, consideration of all impacts—economic, affordability, equity, health, comfort, security, safety, and environmental—is required to develop appropriate decarbonization policies and investments. Corporate financial disclosures increasingly evaluate environment, social, and governance (ESG) criteria to manage asset, financial, reputation, and legal liability risks. These criteria disclose compliance with local, state, national and international government requirements, environmental stewardship, and future climate readiness. Corporate ESG criteria increasingly mandate the adoption of low-carbon-emission infrastructure and technology shifts by property management and design consultants.

Reputation, social standing, and investor influence play increasing roles in corporate decision-making regarding sustainability and climate change mitigation. ASHRAE members can play a critical role in global decarbonization as expert advisors on the built environment within their personal and professional lives.

Decarbonized buildings must maintain, if not improve, healthy and resilient indoor environments. Designers and operators of decarbonized buildings must contemplate the challenges that ongoing and future climate change pose to buildings and the public's general health and safety.

Decarbonization Challenges

Cold climates present building equipment challenges in achieving decarbonization goals. Air-source heat pumps have limitations for heating in very cold climates. More research and development is needed to advance heat pump technologies for very cold climates. Using fossil-fuel boilers and furnaces as backups may need to be considered until cold-climate technologies and grid capacities can cost-effectively meet heating loads. Emerging technologies should be considered as they become viable.

There are electric grid infrastructure challenges in achieving building decarbonization goals. Widespread electrification of building heating and domestic hot-water systems could require a substantially larger electrical grid infrastructure, unless there is a substantial reduction in building energy use through energy efficiency. Supplementing energy efficiency with demand flexibility and storage strategies can reduce the grid impact.

Uncertain return-on-investment projections for building construction and remodeling, manufacturing, and selection of building systems pose challenges to the building industry's decarbonization progress. Potential changes in key cost parameters include future local and national mandates, future availability of nontraditional energy sources or systems, existing utility incentives and rate structures, and existing utility system capacities and future reliability. Changing climate conditions further complicate the reliable return-on-investment estimations. Ongoing climate change and infrastructure transitions make it increasingly difficult to reliably project energy costs, GHG emission savings, and return on investment.

Historic buildings present unique challenges in decarbonization. Historic buildings need to be included in the decarbonization of existing buildings, with ensurances that retrofits maintain their historic characteristics. Historic building technical challenges will also increase as the objective moves from energy efficiency to decarbonization. Additional challenges include undersized electrical infrastructure; steam heat distribution systems that are difficult to decarbonize; and interior spaces, envelope assemblies, and exterior surfaces that cannot easily accommodate new electrical and thermal designs.

Two-thirds of countries have no mandatory or voluntary codes for minimum energy performance requirements of new buildings. Increased adoption of building codes and policies is necessary to move the world toward net zero operational emissions. Current energy codes are focused on efficiency and energy cost metrics but not GHG metrics. While energy efficiency reduces GHG emissions, some energy codes are beginning to directly address GHG emissions.

Buildings that can modify their electric loads to match the availability of low-carbon electricity can maximize carbon reductions. This requires real-time information regarding the carbon content of grid-supplied power. However, real-time information describing GHG emissions associated with electricity delivered to the building is not often available. Power-grid carbon emissions are dynamic, varying locally, seasonally, and by time of day.

References

ASHRAE. 2019a. ANSI/ASHRAE/IES Standard 90.1-2019, *Energy standard for buildings except low-rise residential buildings*. Peachtree Corners, GA: ASHRAE.

ASHRAE. 2019b. ANSI/ASHRAE Standard 34-2019, *Designation and safety classification of refrigerants*. Peachtree Corners, GA: ASHRAE.

ASHRAE. 2019c. ANSI/ASHRAE Standard 90.4-2019, *Energy standard for data centers*. Peachtree Corners, GA: ASHRAE.

ASHRAE. 2019d. ANSI/ASHRAE Standard 147-2019, *Reducing the release of halogenated refrigerants from refrigerating and air-conditioning equipment and systems*. Peachtree Corners, GA: ASHRAE.

ASHRAE. 2019e. *ASHRAE position document on energy efficiency in buildings*. Peachtree Corners, GA: ASHRAE. www.ashrae.org/file%20library/about/position%20documents/pd_energy efficiencyinbuildings_2020.pdf.

ASHRAE. 2020a. ANSI/ASHRAE/ICC/USGBC/IES Standard 189.1-2020, *Standard for the design of high-performance green buildings*. Peachtree Corners, GA: ASHRAE.

ASHRAE. 2020b. *ASHRAE position document on refrigerants and their responsible use*. Peachtree Corners, GA: ASHRAE. www.ashrae.org/file%20library/about/position%20documents/pd_refrigerants-and-their-responsible-use-pd-6.29.2020.pdf.

ASHRAE. 2020c. *Smart grid application guide: Integrating facilities with the electric grid*. Peachtree Corners, GA: ASHRAE.

ASHRAE. 2021a. ANSI/ASHRAE/ASHE Standard 189.3-2021, *Design, construction, and operation of sustainable high-performance health care facilities*. Peachtree Corners, GA: ASHRAE.

ASHRAE. 2021b. ANSI/ASHRAE Standard 105-2021, *Standard methods of determining, expressing, and comparing building energy performance and greenhouse gas emissions*. Peachtree Corners, GA: ASHRAE.

ASHRAE. 2021c. Chapter 36, Climate change. In *ASHRAE Handbook—Fundamentals*. Peachtree Corners, GA: ASHRAE.

ASHRAE. 2021d. *Using building performance standards to address carbon emissions*. A product of the ASHRAE Task Force for Building Decarbonization. Peachtree Corners, GA: ASHRAE. www.ashrae.org/file%20library/about/building-performance-standards-overview-2021-9-16---staff-review.pdf.

CEN. 2011. EN 15978:2011, *Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method*. Brussels: European Committee for Standardization (CEN).

EPA. 2021. *Understanding and choosing metrics for building performance standards and zero-carbon recognition*. Washington, DC: U.S. Environmental Protection Agency. www.energystar.gov/sites/default/files/asset/document/BPS-White_paper_v14May 2021.pdf.

ICC. 2021. *International Green Construction Code*©. Washington, DC: International Code Council.

IEA. 2021a. *Net zero by 2050: A roadmap for the global energy sector*. Paris: International Energy Agency. https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf.

IEA. 2021b. *Tracking buildings 2021*. Paris: International Energy Agency. www.iea.org/reports/tracking-buildings-2021.

IEA. 2021c. *World energy outlook 2021*. Paris: International Energy Agency. www.iea.org/reports/world-energy-outlook-2021.

IPCC. 2021. *Climate change 2021: The physical science basis*. Geneva: Intergovernmental Panel on Climate Change. www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/.

NBI. 2022. Figure 1 adapted from EN 15978. *Lifecycle GHG impacts in building codes*. Portland, OR: New Buildings Institute. https://gettingtozeroforum.org/wp-content/uploads/sites/2/2022/01/NBI_Lifecycle-GHG-Impacts-in-Codes_Jan2022.pdf.

UNEP. 2021. *2021 Global status report for buildings and construction: Towards a zero-emissions, efficient and resilient buildings and construction sector*. Nairobi: United Nations Environment Programme. https://globalabc.org/sites/default/files/2021-10/GABC_Buildings-GSR-2021__BOOK.pdf.

WorldGBC. 2021. *Advancing net zero whole life carbon: Offsetting residual emissions from the building and construction sector*. London: World Green Building Council. https://www.worldgbc.org/sites/default/files/WorldGBC%20Advancing%20Net%20Zero%20Whole%20Life%20Carbon_PUBLICATION.pdf.

DOCUMENT COMMITTEE ROSTER

The ASHRAE Position Document on Building Decarbonization was developed by the Society's Building Decarbonization Position Document Committee, formed on July 20, 2021, with Kent Peterson as its chair.

Kent W. Peterson (Chair)
P2S Inc.
Long Beach, California, USA

Constantinos A. Balaras
National Observatory of Athens (NOA)
Athens, Greece

Drury B. Crawley
Bentley Systems, Inc
Washington, D.C., USA

Jim Edelson
New Building Institute
Portland, Oregon, USA

Roger Hedrick
NORESCO
Boulder, Colorado, USA

Clay Nesler
World Resources Institute
Washington, D.C., USA

Elizabeth K. Tomlinson
Stantec
Saint Paul, Minnesota, USA

Paul Torcellini
National Renewable Energy Laboratory
Golden, Colorado, USA

DOCUMENT HISTORY

Publication and Revision History

ASHRAE's Technology Council and the cognizant committee recommend revision, reaffirmation, or withdrawal every 30 months. The history of this position document is described below:

6/26/2022*—BOD approves Position Document titled Building Decarbonization*