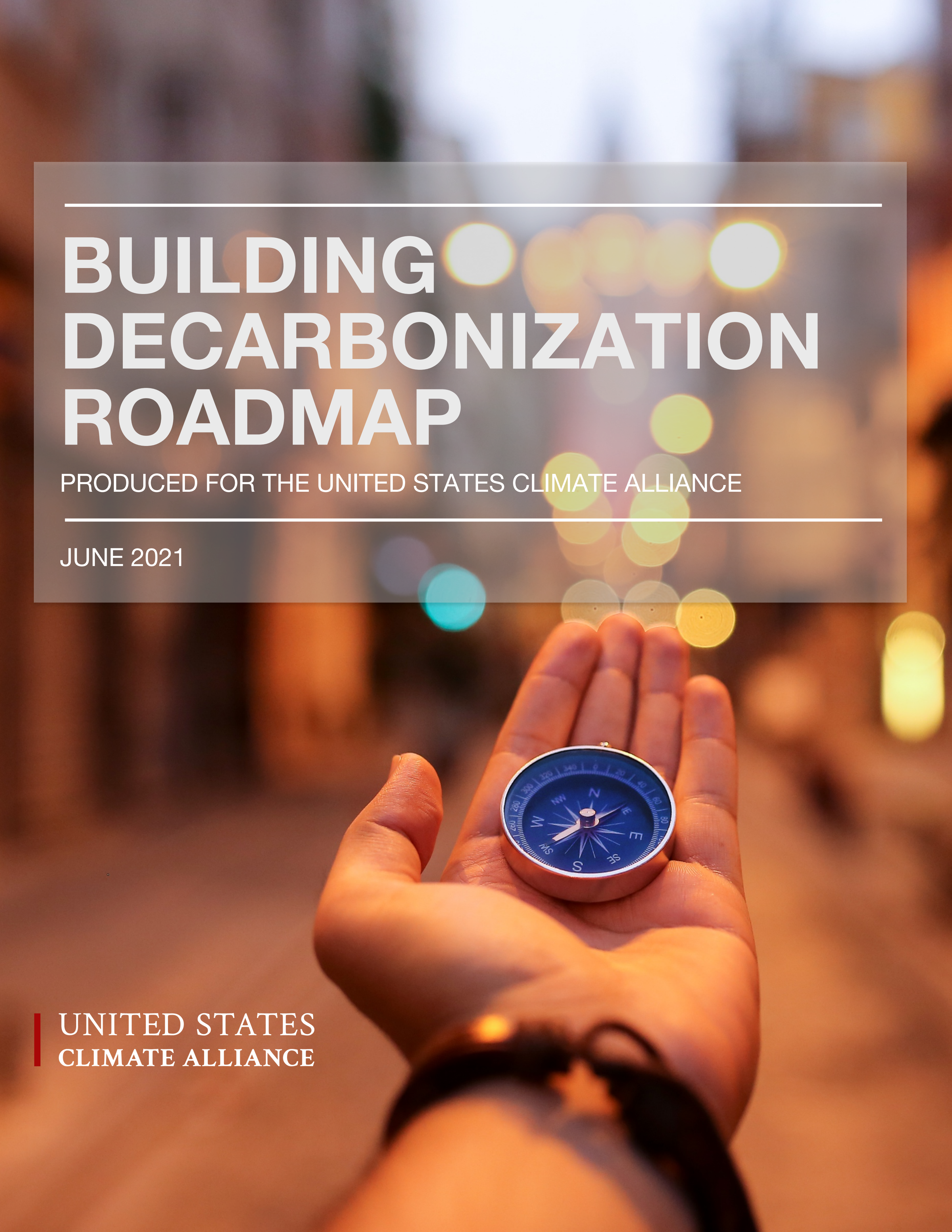

BUILDING DECARBONIZATION ROADMAP

PRODUCED FOR THE UNITED STATES CLIMATE ALLIANCE

JUNE 2021

UNITED STATES
CLIMATE ALLIANCE

The United States Climate Alliance (USCA) commissioned RMI to produce the following Building Decarbonization Roadmap. It was prepared with guidance and significant contributions from the USCA Building Transformation Working Group, which includes staff from various state government agencies and offices. Not all states in the Alliance participated in this process. This Roadmap is not meant to represent a policy plan for the Alliance or any Alliance states but is rather a tool designed to summarize the highest-impact actions that states can take to decarbonize buildings.

In support of a clean energy future, RMI engages in multiple change models, ranging from direct consulting for state agencies to supporting grassroots efforts. RMI staff supporting this document are a dedicated team focused on meeting the technical needs of USCA states.

ACKNOWLEDGMENTS

We are grateful to the organizations who lent their time and expertise to this work through an independent external review panel. Among others, these included the Building Electrification Initiative, the Institute for Market Transformation, and the New Buildings Institute.

Images are courtesy of iStock unless otherwise noted.

RMI

ENERGY. TRANSFORMED.

About RMI

RMI is an independent nonprofit founded in 1982 that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and NGOs to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing.

UNITED STATES
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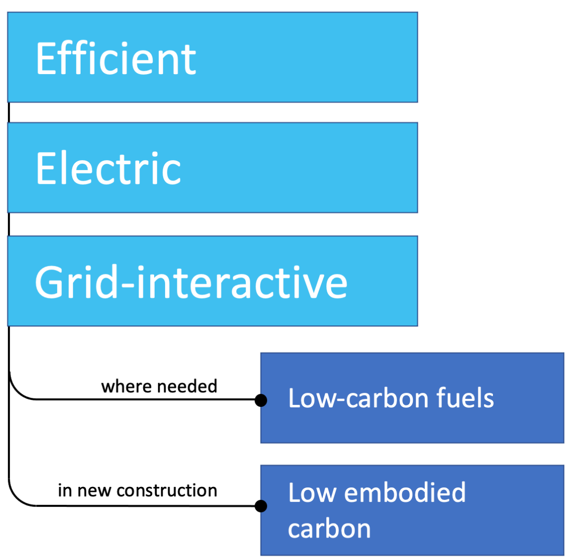
EXECUTIVE SUMMARY

Governors in the United States Climate Alliance (USCA) have committed to implementing policies that advance the goals of the Paris Agreement, aiming to reduce greenhouse gas (GHG) emissions by at least 26%–28% below 2005 levels by 2025. Representing more than 55% of the US population, 60% of the US gross domestic product, and just under 40% of US GHG emissions, these states and territories have the potential to drive substantial progress while helping lead the way for states and territories that are not USCA members.[1]

The buildings sector represents about 40% of global carbon dioxide (CO_2) emissions and a similar portion of US emissions.[2] This substantial impact necessitates attention and action, and it also brings with it a wide array of opportunities for decarbonization policy. Many of these policies are worth pursuing in their own right, emissions impacts aside, because of their benefits to human health, equity, economic development, resilience, and more.

This roadmap was created through collaboration with staff from various state offices as well as industry experts. It is not meant to represent a policy plan for the Alliance or any Alliance states, but it is rather a tool designed to summarize the highest-impact actions that states can take to decarbonize buildings. The document provides information to help states prioritize and sequence those actions—depending on the state's circumstances, climate, and other factors, not all options will be appropriate or immediately possible.

Exhibit ES-1: Key Principles of Building Decarbonization



Building sector decarbonization hinges on five core principles:

- **Efficient**: Ensure new buildings are designed and constructed to be highly efficient and that existing buildings realize deep efficiency benefits.
- **Electric**: Electrify fossil fuel-based end uses (e.g., space and water heating) where possible. Immediate opportunities in each state will differ based on available technology, economic feasibility, climate, and other context considerations. The benefits of electrification will continue to increase as the grid becomes cleaner.
- **Grid-interactive**: Enable grid-interactivity with appliances and energy management systems that can receive and respond to grid signals. Grid-interactive buildings can also serve as a distributed energy resource to minimize grid impacts, support variable renewable generation, and maximize consumer value.

- **Low-carbon fuels**: Determine the role of low-carbon fuels, which may support decarbonization of certain geographies or hard-to-electrify end uses.
- **Low embodied carbon:** Use low-carbon materials in new construction and major retrofits, and reuse carbon-intensive materials and structures where possible.

These strategies are high impact and applicable to any state interested in decarbonizing its building sector, with different variations possible for each strategy. In any case, by selecting policies customized to their needs, states can take advantage of the widespread opportunities for progress in the building sector to meet decarbonization goals and other policy objectives.

THE OVERALL STRATEGY

Decarbonizing the Building Sector

Decarbonizing buildings offers many benefits for economic productivity, human health, resilience, and equity while improving the value of the building stock itself. Conversely, failure to pursue building decarbonization introduces many risks. The impacts of climate change are significant and increasing, and they will continue to bring about many simultaneous and interwoven economic, social, and environmental crises if not addressed at the necessary speed and scale. In recent years, climate impacts have occurred in tandem with the COVID-19 pandemic and protests for racial equity. Communities with high levels of air pollution—which also tend to be low-income communities and communities of color—have been hit hardest by COVID-19.[3]

Because climate change presents numerous human health risks and exacerbates inequity,[4] these problems are interlinked, and mitigating climate change in a just and equitable way is essential to avoid a downward spiral of constant crisis management—and to achieve the many benefits of decarbonization. Building sector decarbonization is a critical component of avoiding this climate disaster.

The Intergovernmental Panel on Climate Change (IPCC) is the transnational body of the United Nations focused on science-based research regarding human impacts on the global climate. IPCC research widely supports keeping global temperature rise to less than 1.5°C above pre-industrial levels, as opposed to 2°C, to substantially lower the risk of climate disaster.[5] To keep warming below 1.5°C, society must rapidly decarbonize across all economic sectors, including addressing emissions from buildings.

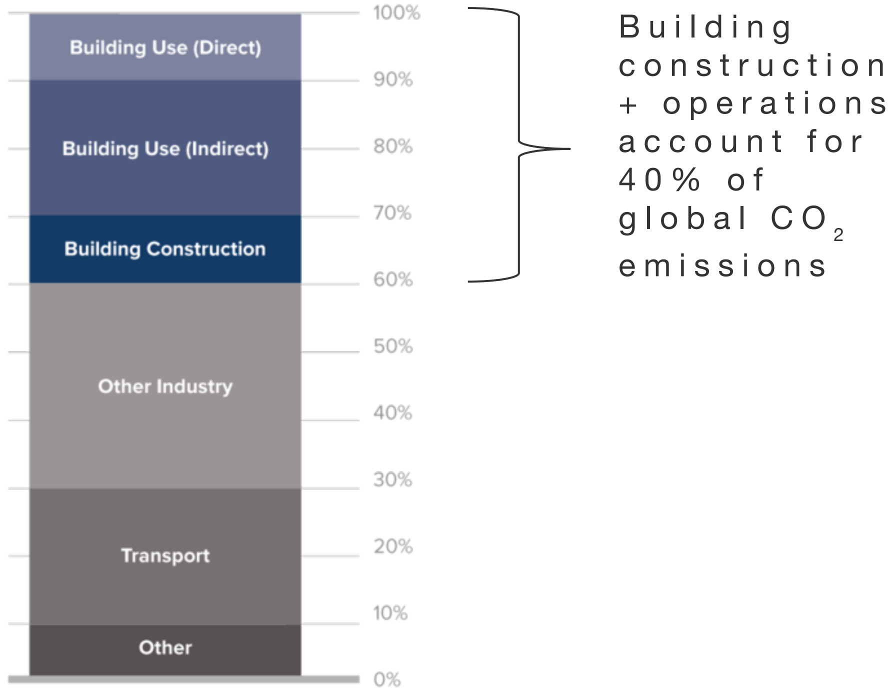
Greenhouse gas (GHG) emissions from buildings fall into several categories:

- **Operating emissions**, which come from building energy consumption and include:
    - **Direct (on-site) emissions**, which come from the burning of fossil fuels in buildings (e.g., emissions from natural gas (gas) water heating, propane space heating, etc.).
    - **Indirect emissions**, which come from electricity consumed in buildings and include emissions from energy losses during electricity generation, transmission, and distribution.
- **Embodied emissions**, which represent the life cycle emissions associated with building materials—such as concrete, iron, and steel—from resource extraction to end-of-life.
- **Refrigerant emissions**, attributable to commonly used refrigerants in refrigeration equipment; heating, ventilation, and air conditioning (HVAC) appliances; and heat pump water heaters (HPWHs) are potent GHGs and contribute to global warming when leaked into the atmosphere. Refrigerant emissions can be categorized as either direct or embodied emissions.

In the United States, indirect emissions represent roughly 60% of total annual building sector emissions, direct emissions represent about one-quarter, and embodied emissions represent about one-eighth.[6]

Buildings represent the largest single contributor to global carbon dioxide (CO_2) emissions: about 40%. Exhibit 1 shows this contribution in detail. A dramatic reduction in global emissions will be difficult without a strong focus on reducing emissions from the building sector.

Exhibit 1: Global CO_2 Emissions by Source



Source: IEA 2019

Indirect emissions from buildings have been dropping since the mid-2000s due to changes in the electricity sector as coal consumption has declined and been replaced by gas and renewables. However, direct and embodied emissions have been flat for decades;[7] despite improvements in equipment efficiency and embodied emissions intensity, the number of buildings and building sizes have both increased. States will therefore have trouble meeting climate targets without seriously addressing the building sector.

__Embodied carbon__ refers to the life cycle emissions associated with building materials, from resource extraction to end of life. Solutions to embodied carbon tend to focus on procuring low-embodied-carbon materials. However, holistic solutions focus on a systems-wide approach that limits or avoids the need for new material entirely (e.g., through providing services without new buildings, renovating existing buildings, limiting the overspecification of materials, reusing materials, etc.).

Fortunately, decarbonizing the building sector is a strong investment, offering tremendous benefits that make it attractive independent of the need to avoid the climate crisis and its impacts. Benefits include:

- **Supporting job creation and economic recovery and development:** Decarbonizing buildings through energy efficiency, renewable energy, and electrification helps create jobs. Investing in energy efficiency, for example, creates nearly three times more jobs per dollar than investing in the fossil fuel sector.[8] Decarbonizing the building stock will also require local labor; construction jobs cannot be outsourced in the same way that manufacturing or other sectors' jobs may be.
- **Improving health and safety:** Decarbonized buildings can help improve indoor environmental quality. For example, electrification can improve indoor air quality and reduce asthma, especially important during the COVID-19 pandemic.[9] All-electric buildings also eliminate the risk of carbon monoxide poisoning and reduce the risk of fires from combustion.

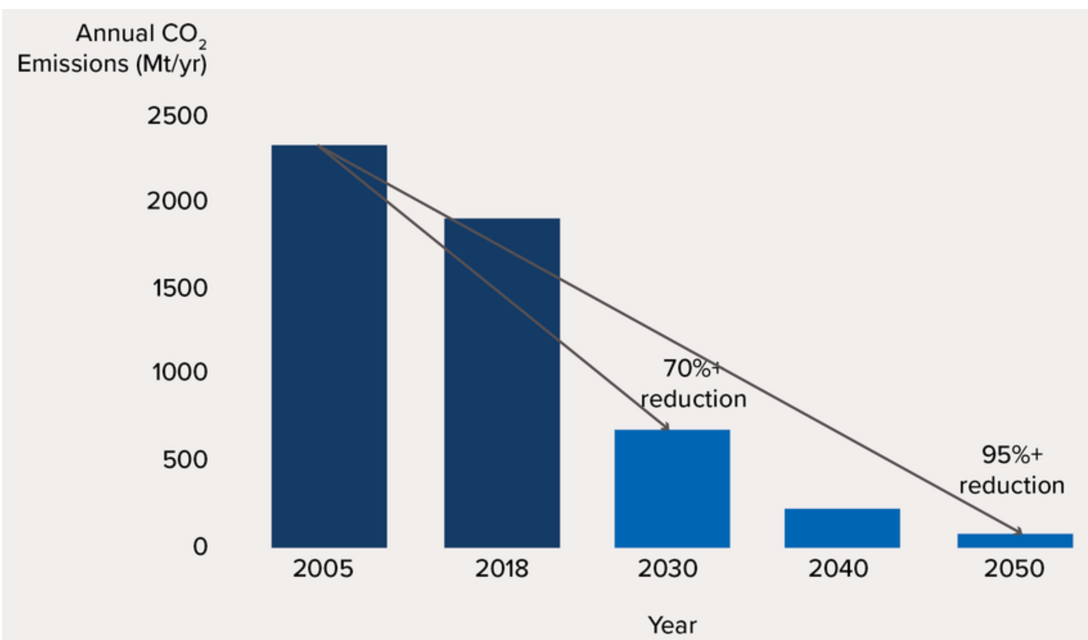
- **Enhancing equity:** Efficiency and electrification programs can provide targeted support specifically for low- to moderate-income (LMI) households. LMI households face higher energy burdens and higher rates of energy insecurity than higher-income households, and they also may be disproportionately affected by buildings-related health issues, such as indoor air pollution from gas stoves.[10]
- **Increasing resilience and security:** Building envelope improvements, such as insulation and air sealing, can help keep homeowners safe during extreme heat or cold weather events and associated power outages.
- **Improving the condition and value of the building stock:** Upgrades improve the building stock as essential infrastructure for families and businesses. These upgrades act as investments in the future of the communities that they are in and create a foundation for other continued improvements.

Setting the Goal

The scale of the problem at hand necessitates ambitious action. Climate scientists have said that complete decarbonization of the economy by 2050 is necessary to avoid the worst impacts of climate change. Meanwhile, emissions have been holding flat or increasing in nearly all major economic sectors—only emissions from electricity generation have declined substantively.[11] Rapid decarbonization therefore requires a rapid scaling up of state action.

Exhibit 2 below shows, based on climate model outcomes, how both direct and indirect emissions may decrease in order to align with a pathway that stays below 1.5°C. This analysis suggests that staying below 1.5°C could mean a 70% reduction from a 2005 baseline in operating (direct and indirect) emissions by 2030 and nearly a 100% reduction by 2050. Though changes in the electricity sector will help decarbonize buildings, immediate action to upgrade buildings and transform the buildings industry is needed to meet these emissions targets.

Exhibit 2: 1.5°C Scenario for US Buildings Sector Operating (Direct and Indirect) Emissions

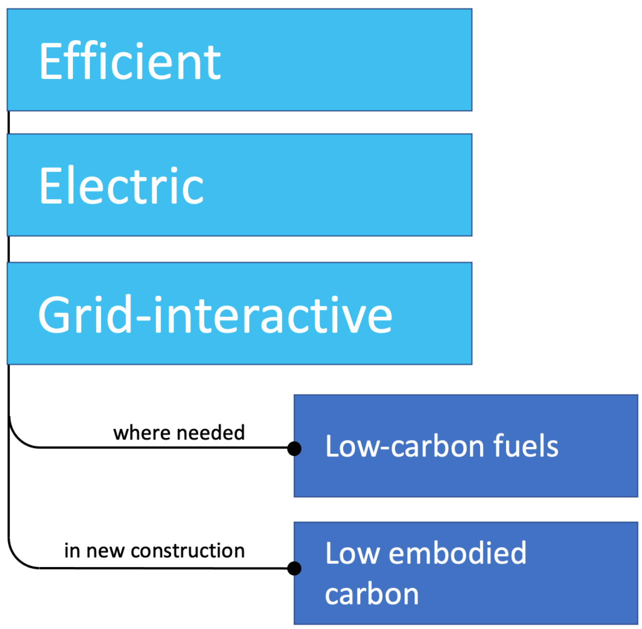


Source: RMI analysis

New York State, for example, is taking bold action in this spirit, aiming for an 85% to a 93% reduction in building sector emissions by 2050 to meet its economy-wide decarbonization target. This goal will require strong, specific targets in the near term, such as 50% to 70% of all new heating equipment sales to be electric by 2030.[12] States that align on a 1.5°C goal will not get there without quickly pursuing these sorts of specific, actionable, near-term targets.

State-level action must be ratcheted up significantly. If states only pursue solutions deemed cost-effective using today's methodologies, the scale of action will be inadequate to reach the necessary emissions reductions. Therefore, cost compression, aggregate purchasing of key equipment, a longer-term accounting of costs and benefits, securing the economic value of non-energy benefits, and other strategies are necessary to drive costs down and help meet these emissions targets.

The Process of Decarbonization



Building sector decarbonization hinges on five core principles:

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- **Low embodied carbon:** Use low-carbon materials in new construction and major retrofits, and reuse carbon-intensive materials and structures where possible.

Decarbonization of the built environment also means taking action to address emissions from both new construction and existing buildings.

New buildings: All new structures and equipment must be built to align with emissions targets and should be highly efficient and all-electric to the extent possible. About one-third of the building area that will exist globally in 2050 will be built between now and then.[13] Building carbon-intensive structures today is incompatible with the aggressive timeline required to limit warming to 1.5°C. Building inefficient buildings today would effectively “lock in” emissions far into the future. In other words, we should avoid constructing new buildings that will immediately require retrofits to meet climate goals.

Clean Power Generation
Through its Power Sector Working Group, Climate Alliance states are working together to overcome barriers to a zero-carbon power system. This collaboration includes sharing best practices, lessons learned, and model policies related to accelerating grid modernization; using regional markets in a way that helps achieve state climate and clean energy priorities; and integrating state climate priorities into regulatory frameworks and rate design.

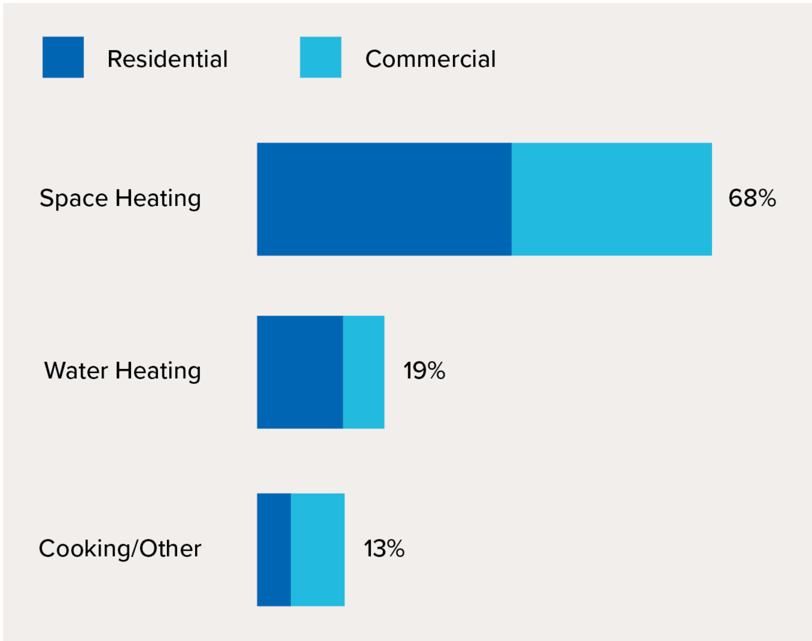
All-electric construction can save money by avoiding the cost of gas infrastructure in buildings, and in some instances avoiding the costs of distribution lines in new developments, whereas existing dual-fueled buildings have already incurred the costs of gas pipelines and appliances. Some states may pursue a building sector decarbonization pathway that also includes low-carbon fuels, such as hydrogen or biomethane(i.e., purified biogas). As these fuel sources are likely to be expensive and limited in supply at the scale required to decarbonize the building sector, their use should most often be prioritized for hard-to-electrify sectors, such as industry and manufacturing.

Existing buildings: Minimizing emissions requires retrofitting the existing building stock. Given capital improvement cycles, most buildings will have only one opportunity for major retrofits before 2030, and policies should be designed to ensure that significant retrofits are aligned with climate goals.

Buildings are large investments, and, in addition to undertaking minor repairs and ongoing maintenance, each one needs to repair or replace major components to preserve the value of its investment. Structural changes or those that involve effectively replacing a major, integral component of the building are considered “capital improvements.” Major systems (like heating) and many structural components (like roofs) are expected to need major repair or replacement on a periodic schedule: “capital improvement cycles.” For example, if a particular cooling system is expected to last 15 years, the building would be on a 15-year capital improvement cycle for its cooling equipment and can set aside reserve funds and time to plan for that need. Policies addressing existing buildings should allow adequate time for compliance so that building owners can align these improvements with their capital improvement cycles. Given these long cycles, there will likely be only one or two opportunities to improve the emissions performance of a building, so it is crucial to ensure that the correct new equipment is installed in the next capital improvement cycle.

Emissions reduction policies should target the largest sources of emissions. For example, Exhibit 3 shows that direct emissions in US buildings primarily come from space and water heating. These end uses are clear targets for reducing direct emissions, which, in total, represent 10% of total US GHG emissions.[14]

Exhibit 3: Direct Emissions in US Buildings (2017)



Source: RMI analysis

Other end uses (e.g., plug loads and appliance) also offer significant indirect emission reduction potential through efficiency improvements. Plug load and appliance efficiency standards are being addressed by USCA states through appliance efficiency standards.[15]

Incorporating Equity

Building decarbonization efforts should incorporate equity from the beginning of planning and design processes, rather than as an afterthought to avoid inequitable outcomes. Actively supporting positive, equitable solutions will improve lives and can build wider public support. Racial equity should be considered in addition to affordability, as racial equity is distinct from purely socioeconomic equity and often tied to both geography and real estate history. Without careful design and thoughtful planning, building decarbonization could have unintended consequences and worsen inequity by increasing energy burdens and providing inequitable access to new technologies. However, with forethought, states can enact policies, structures, and safeguards to support equitable outcomes, including lowering costs, improving health and comfort, and supporting job creation.

Equity considerations arise in many aspects of building decarbonization, and procedural equity—that is, the process by which decisions are made—is a crucial first step. Procedural equity can include working with front-line communities to pilot and develop solutions through, for example, innovative public processes and active outreach, as seen in the electrification pilots in California's San Joaquin Valley.[16] Processes that empower communities to make their own decisions, rather than simply informing communities of decisions that impact them, support procedural equity and can help ensure distributional equity, where the benefits and burdens of a policy are equitably distributed.

Building decarbonization policies must address affordability. If transformation in the rental housing market, for example, happens without attention to affordability, capital improvement costs could be passed on to renters, translating to higher living costs for those who can least afford them. Regulators, utilities, and program administrators must ensure affordability by reducing upfront installation costs and ongoing operating costs through new rate designs, program incentives, financing offerings, or other programs.

Best practices suggest meeting early with affordable housing stakeholders to support the design of equitable solutions. Positive outcomes can include, for example, well-designed electrification programs that reduce energy costs for low-income customers, especially for those currently heating with heating oil or propane.[17]

Reducing costs and capturing the potential benefits of building decarbonization can happen in a number of ways. Creating a value stack from other benefits—for example, demand flexibility and peak reduction—can offset increased costs of electrification. Supporting inclusive financing solutions can also spread the costs of upgrades over time, and, in some cases, over multiple residents and owners. Expanded financing options with appropriate consumer protections make decarbonizing solutions more accessible, allowing more customers and households to achieve the benefits of building decarbonization.

Building decarbonization can affect equity in a variety of other ways, offering both problems to be avoided and opportunities for better outcomes. Beyond affordability, some negative impacts to be carefully avoided are:

- **Green gentrification:** Displacement, rent increases, or inappropriate property tax increases could result from decarbonizing the building stock in a particular area.
- **Inequitable rate burdens:** If vulnerable populations become the last to electrify, those households could end up paying for the rate base of the remaining gas distribution system. Solutions for affordable building upgrades must be sequenced to avoid this outcome.
- **Net loss of high-quality, family-sustaining jobs:** As economies and supply chains shift, job losses could result. Maintaining skilled, high quality, family-sustaining jobs is important as the building sector evolves.

Some of the additional equity benefits that could be realized include:

- **Investing in underserved housing:** Building sector transformations offer an opportunity to correct for historic institutional disinvestment in specific communities.
- **Health and safety improvements:** Decarbonization policies and programs can prioritize unhealthy or unsafe housing for upgrades—addressing ventilation, lead, mold, and structural or electrical issues. Some buildings may require these upgrades before decarbonization solutions can be implemented.
- **Equitable workforce development:** States can provide accessible training and certifications to support a transition of the building sector. States can also create specific job opportunities for marginalized communities.
- **Neighborhood stabilization:** By reducing energy burdens, unhealthy living conditions, and safety concerns, building transformations can help stabilize existing neighborhoods and decrease mortgage foreclosures.[18]

The Policy Roadmap

This policy roadmap was created through collaboration with various state agency staff and industry experts. It outlines opportunities for change, highlighting key design options and examples for each strategy. The roadmap is organized around five strategies, with specific options for action underneath them. The two key and three supporting strategies are described below.

Key Strategies. Successful pathways to substantive building decarbonization require action around these first two strategies:

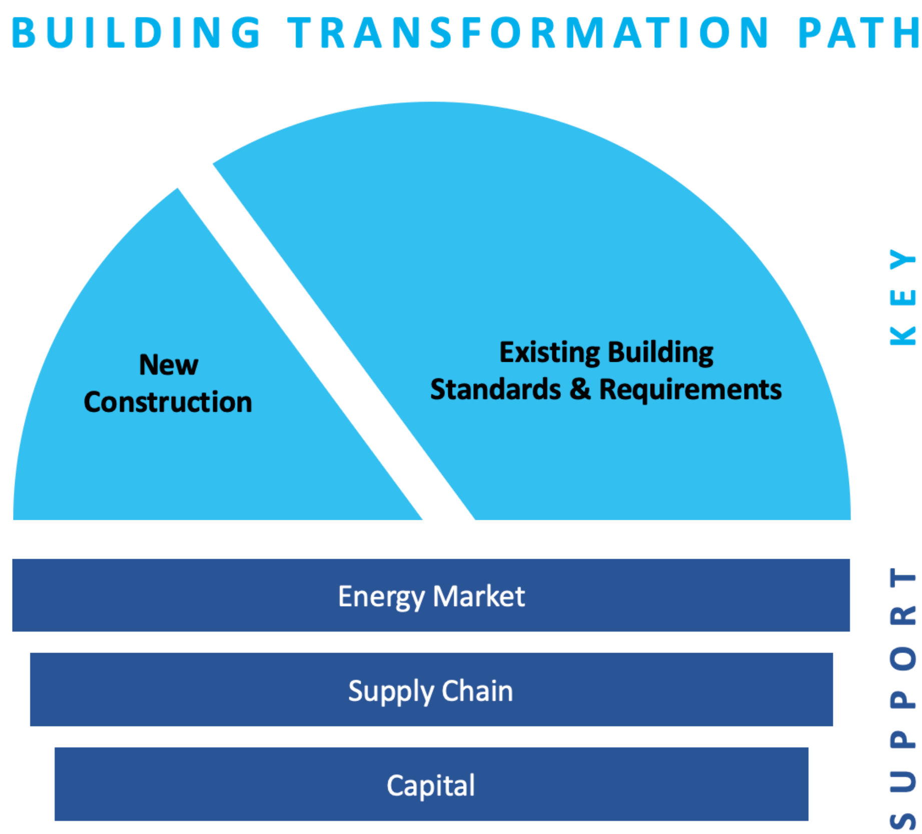
- **Fostering zero-carbon new construction** to ensure that new buildings support, rather than hinder, decarbonization efforts
- **Establishing building or equipment requirements** to decarbonize the existing building stock and building equipment

Supporting Strategies. These strategies include supporting, market-building policies that help accelerate decarbonization, and their implementation can be more varied and context-specific:

- **Transforming the energy market** to scale decarbonization
- **Strengthening the supply chain** to support low-carbon approaches
- **Expanding access to capital** to help remove barriers to low-carbon solutions

Exhibit 4 summarizes these strategies in a hierarchy of implementation—the two key strategies are in light blue, and the three supporting strategies are below in dark blue.

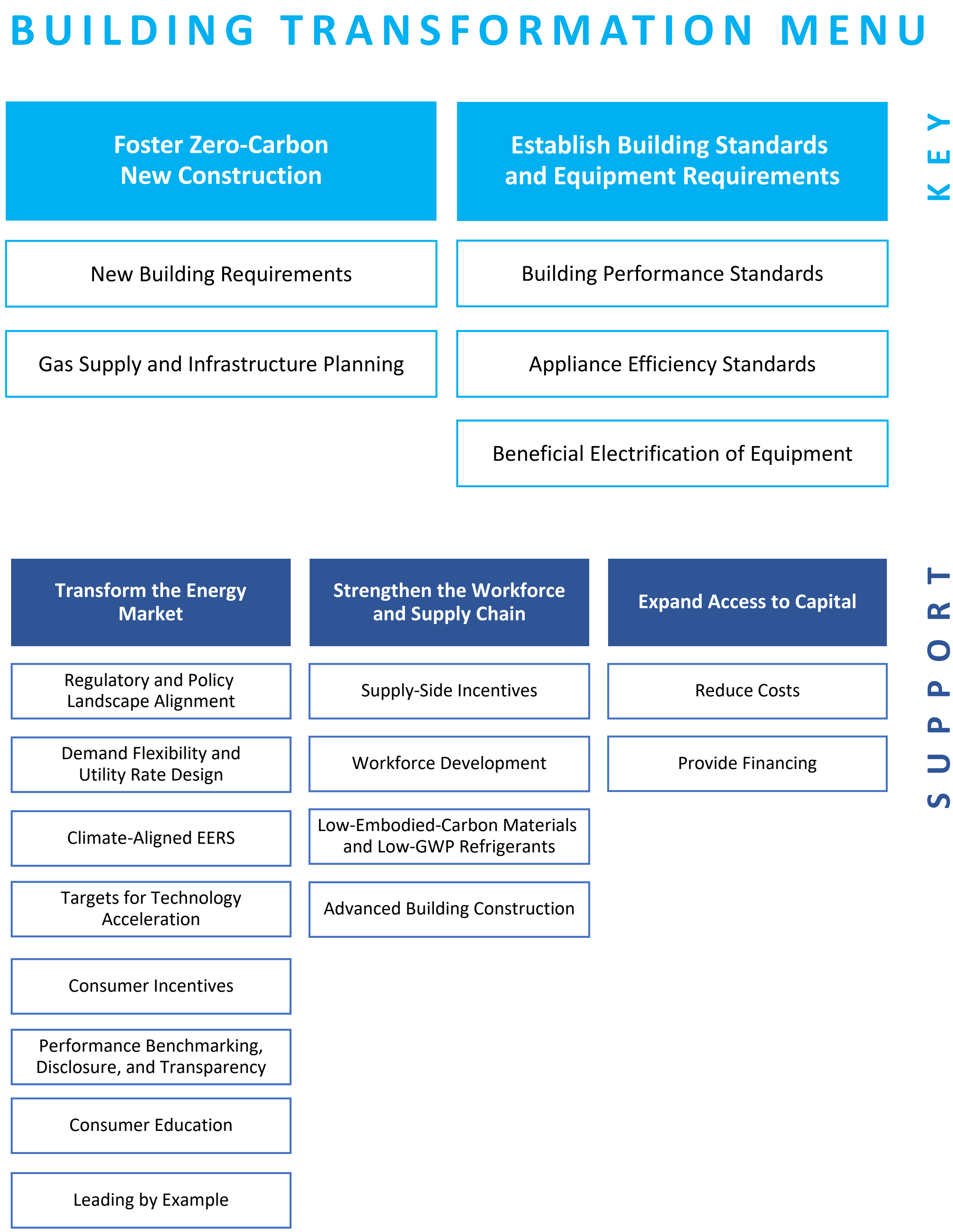
Exhibit 4: Strategies for Building Decarbonization



Source: RMI

This document explores a few key policy actions under each of these five strategies. Exhibit 5 shows these policies and strategies together.

Exhibit 5: Policies for Building Decarbonization



Source: RMI

States will vary in how they implement these policies, and not all options will be appropriate or immediately possible for all states. To meet decarbonization goals, states can consider policies most applicable to their circumstances, picking and choosing to customize to their needs while carefully sequencing opportunities for impact. In some cases, a few highly transformative policies might be easier to implement as a single package, while other states may introduce a series of policies over time.

For illustrative purposes, below are three different potential implementation pathways:

1. **Electric Equipment Requirement:** A single policy that requires all new space and water heating equipment to be efficient and electric for both new and existing buildings. This would, by itself, set the state on a path toward near decarbonization of its building sector if states and utilities work together to ensure the continued decarbonization of the electricity grid. Given federal preemption law, a strict electric equipment requirement would likely be difficult. States would best pursue this through other sources of authority through, for example, air quality or health and safety laws.

2. **"Key Policies" Approach:** States could implement a suite of policies over several years, anchored on new construction requirements and building performance standards. Supporting policies for incentives, training, regulatory alignment, and financing could ease the path for those key policies.

3. **Market-First Strategy:** States without the context to follow the "Key Policies" approach could start with a series of supporting strategies to get the market moving, learn more, and prepare for the later adoption of the key policies. A market-first approach alone is not likely to achieve the necessary emissions reductions, but transforming the market can make it easier to pass future requirements or other policies.

While there are many avenues for change, having a clear, state-level vision for building decarbonization can help to ensure success. Policies and programs must not be at odds with each other and must work together to optimize benefits and create lasting, systemic change. For example, a stringent building energy code that fosters efficient heat pumps can be much more impactful when coupled with utility demand flexibility programs and time-varying utility rates that capture cost and carbon savings. Efforts to improve community health, in particular through health and safety interventions in LMI housing, should synergize with efficiency and electrification programs that bring about their own health benefits. Programs that improve home resilience in the face of worsening storms should align with efficiency and electrification work to ensure homes are less vulnerable to extreme weather events.

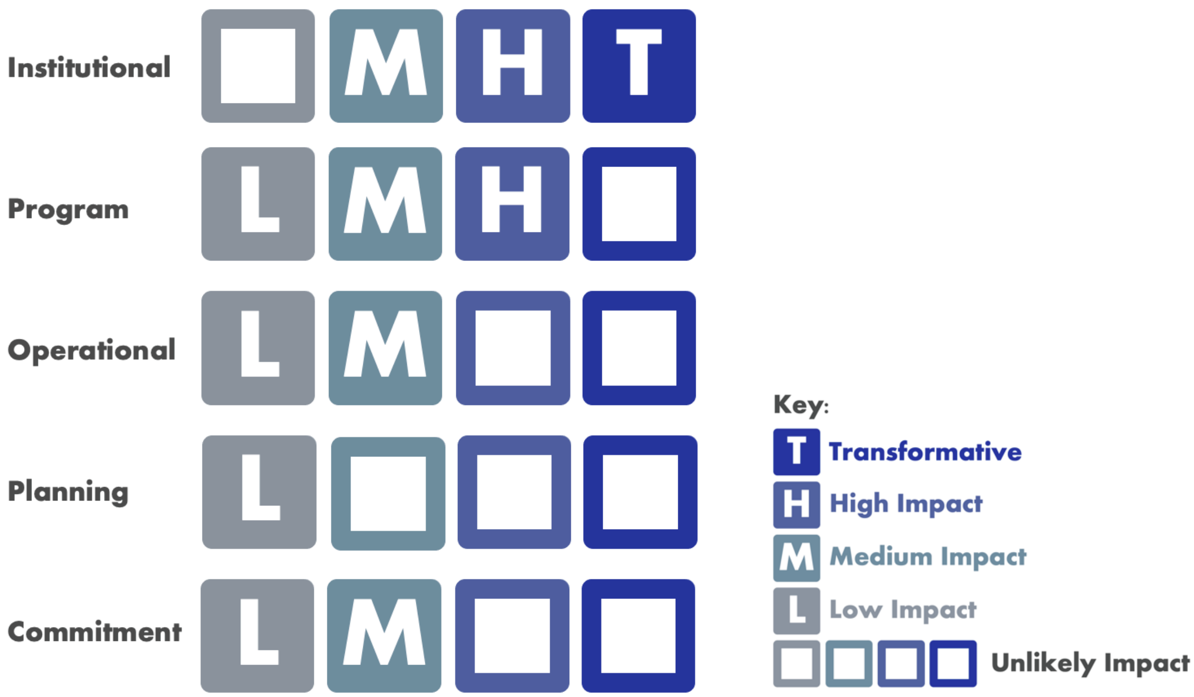
State governments can also coordinate with local governments and other states to maximize impact. This may include showcasing ambitious local government action and building state-level action based on that progress or soliciting local government input into state action (like performance standards, codes, or public utilities commission [PUC] proceedings). It may also include updating and streamlining the local permitting process to lower costs and enable policy implementation at the necessary speed and scale. Some beneficial local government actions are prohibited by the state, so states may consider removing these barriers (e.g., through enabling legislation for stretch codes or other policies that are not feasible at the state level).[19] States should also understand how federal preemption limits state action around certain policies, such as appliance and code requirements. Though some strategies already exist to address these barriers, innovative actions, such as new multistate collaborations and joint advocacy at the federal level, may be necessary to achieve progress at the scale required.

Some categories of buildings should be prioritized for decarbonization—for example, buildings heated by delivered fuels (i.e., propane, fuel oil, etc.) or electric resistance appliances are strong candidates for rapid switching to heat pumps because of the potential for carbon and cost savings.[20] Different types of buildings will require different solutions and technologies. Solutions for residential buildings may be easier from a technology perspective, but in some geographies, they may be more challenging than multifamily or commercial buildings in terms of market deployment. The types of programs and incentives required for decarbonization may be different in a state with a significant portion of large buildings as opposed to one with more single-family homes.

Pathways for Implementation

States can take action through a number of pathways, each with different challenges and opportunities for impact. No type of action is necessarily better than another, but some have more resilience or more directly drive tangible emissions reductions than others. Some actions may fit into more than one category (e.g., an institutionalized action that establishes a plan). These pathways are outlined in more detail below. Exhibit 6 shows the typical impact of each of these five pathways.

Exhibit 6: Expected Impact of Pathways



Source: RMI

Institutional

Institutionalized actions are legally enforceable steps that come through three main avenues:

- **Legislative action:** State legislatures can pass laws that establish commitments or require specific actions, codifying the actions beyond a single administration. For example, Senate Bill (SB) 1477 in California required the California Public Utilities Commission to establish programs that support building decarbonization.[21] New York passed the Climate Leadership and Community Protection Act in 2019, legally establishing economy-wide carbon reduction targets.[22] In June 2019, Maine legislation established a target of 100,000 heat pumps to be installed in the state by 2025.[23]
- **Regulatory action:**
  - **PUCs** can reform utility business models and require utilities to meet efficiency standards, offering penalties for noncompliance and rewards for strong performance. Energy efficiency resource standards (EERS) establish targets for utilities to reduce their demand and can be used for gas and electric utilities. As of 2020, twenty-two USCA member states had an EERS standard or goal in place. PUCs can also establish regulation that supports building decarbonization in other ways through, for example, rate design, performance incentive mechanisms, or other utility business model reforms.

    - **Energy codes** are adopted by states and local jurisdictions and are part of a package of codes that address the built environment (including fire, electrical, and structural codes). In some cases, state law automatically adopts the latest energy code, such as the IECC. In others, states review options and determine a path forward. For example, the California Energy Commission updates Title 24 building energy efficiency standards every three years through an extensive public process.[24] CEC is resetting the Title 24 performance pathway to strongly favor efficient heat pump technologies.
- **Executive order:** Governors can set targets, establish programs, and create a number of other changes through an executive order though subsequent administrations could reverse orders if desired. Both California and New York established emissions targets through executive order before codifying the targets through legislation.

Program

Programs are administrative frameworks with dedicated funding and staff. Well-designed programs can provide a powerful leadership role to move the market, drive local government or utility action, and prompt larger-scale federal or regional change. Because funding sources and administrations change, programs may not be permanent, but in as much as they launch independent, private sector action, they can provide some level of resilient progress over time.

Operational

Internal operations offer an opportunity to drive change within a state's own sizable portfolio of buildings. Often called "leading by example," this opportunity can involve demonstrating new solutions, showcasing best practices, developing local contractor experience regarding decarbonization solutions, or anchoring aggregate purchasing benefits that can enhance private sector action. For example, states could require public buildings to meet a specific standard, like the Leadership in Energy and Environmental Design (LEED) Zero standard, Passive House Institute US (PHIUS) 2018+, standards from the International Living Future Institute, or a net zero emissions standard.

Planning

Planning can take commitments toward more tangible action through, for example, a climate action plan or a decarbonization roadmap. Developing such a plan takes a target or a goal one step closer to impact, but it may still not result in near-term action.

Commitment

Commitments can send a market signal and may require less effort to achieve than other pathways to action. However, a commitment without funding, planning, or legal enforcement may not result in tangible impact.

Considering the urgency of climate change, it is important to not view these policy options as sequential, moving, for example, from a commitment to a plan to a program. Whenever possible, these components should move forward in parallel to ensure expedient action and change. Plans and commitments should serve to lay the foundation for action rather than to delay it.

Image courtesy of Alamy.

PLANNING YOUR ROUTE

Foster Zero-Carbon New Construction

New construction must be highly efficient and zero carbon where possible to drive deep building sector decarbonization. These policies address two main components: buildings themselves and the gas infrastructure serving them. Land use planning, which governs the broader built environment, is also important but is not discussed in this roadmap.

The first action below is essential for decarbonization. **High-efficiency building codes** help to propagate low-carbon technologies and ensure that all new residential and commercial construction, as well as major renovations and building additions, are built to a low-carbon standard. To further drive down emissions, codes should also incorporate other elements that further lower indirect and embodied emissions. Examples include requiring or incentivizing demand-flexible appliances and low-carbon construction materials. Relevant code interventions may occur through a number of avenues beyond just the building energy code, (e.g., through health and safety codes). In addition, **new construction should be all-electric where possible**, which can be accomplished through codes, incentives, and other legal requirements as applicable to the jurisdiction.

Gas supply and infrastructure planning is an essential, related action. States can explore policies that support all-electric construction and disincentivize or limit the further buildout of the gas distribution system while also considering the role of alternative fuels in decarbonization. Minimizing the installation of new gas distribution pipes and service lines avoids stranded assets and costs to ratepayers in the future.

These policies limit the installation of new fossil fuel equipment and infrastructure while other policies can work to decarbonize the existing built environment simultaneously. In contrast, constructing inefficient new dual fuel buildings, which will have to be retrofitted at additional cost later on, increases the cost of achieving decarbonization goals. When implemented carefully, these policies do much more than decarbonize. They help build communities of the future, provide health benefits, advance affordability and housing justice, and more.

New Building Requirements

Requiring highly efficient construction through building codes is a powerful decarbonization tool and should be prioritized early to avoid locking in emissions from inefficient buildings and new fossil fuel infrastructure for decades to come. In addition, fostering all-electric construction where possible, through various policy and programmatic levers, furthers the decarbonization potential of the building sector. As all-electric buildings do not burn fossil fuels on-site, once electricity generation is carbon-free, the associated building operating emissions decline to zero. Building highly efficient, all-electric buildings from the outset can be dramatically more cost-effective than retrofitting buildings once they are already built.[25]

Highly efficient buildings require less energy, whether from onsite renewable energy or the grid. Energy efficiency is typically the lowest cost energy resource and is most cost-effective when installed during construction. Retrofits can be very difficult and expensive, particularly for envelope measures (doors, windows, walls, roofs, and floor insulation). Envelope efficiency measures must be prioritized as they can last the life of the structure, which may be 50 to 100 years, and continue to provide benefits for every resident or business that uses the structure over its lifetime.

Code requirements for buildings should provide a mix of prescriptive measures, performance requirements, and additional requirements that vary based on state context, climate zone, and building type. Prescriptive measures include specific HVAC, fenestration (i.e., doors and windows), or lighting requirements. Performance requirements set building energy use intensity (EUI) limits that can approach zero emissions once renewable energy and other measures are incorporated. To provide flexibility, and to meet federal preemption requirements for state energy codes, states must allow buildings to "meet an energy conservation objective" through either a performance or prescriptive pathway.

Additional design options should also be incorporated into the code, each of which could be incentivized, encouraged, or required. These design options, including embodied carbon and electric vehicle (EV) charging, are discussed in more detail below. Codes could also consider exceptions or different sets of requirements for affordable housing (e.g., cost-effective prescriptive rather than performance requirements), and these policies should be developed with adequate input from communities and affordable housing providers.

State governments can choose to adopt their own state-specific code or to modify one of the national model energy codes. ASHRAE develops the commonly used model commercial energy code, known as 90.1, among other standards. The International Codes Council develops the IECC, which contains chapters for both residential and commercial buildings. Model codes are updated every three years though states often lag in their adoption of updated codes. Note that these model codes have been designed, either entirely as in the IECC or substantially as in ASHRAE 90.1, to be fuel neutral. States will have to move past those model codes to encourage heat pump technologies.

Federal law pre-empts states from creating more efficient requirements for many key equipment types, including, for example, space and water heating equipment. This law creates a real barrier to setting efficiency standards in state energy codes, requiring that states establish performance or prescriptive pathways to work with this law (e.g., a "multi-path" approach that is in place in multiple jurisdictions).[26] This law does allow the state to establish high efficiency performance standards that could strongly favor efficient heat pump technologies over fossil fuel equipment. High efficiency performance standards that strongly incentivize electrification may represent an important legal path. States could also possibly utilize non-energy parts of the building code to limit combustion appliance use by enacting requirements for combustion safety, indoor air quality, or fuel specifications. Additional innovative strategies to advance codes in the face of federal preemption may be required.

Though local code compliance and enforcement is often challenging, states can play a role in supporting local governments in this endeavor. This support should include energy code-specific trainings for building professionals through utility programs, workforce development, or other means.

Strong codes can provide valuable non-carbon benefits, such as improving the insurance ratings of jurisdictions and enhancing disaster resilience. States can consider how building code adoption fits into other priorities (e.g., emergency planning, preparedness, and response while coordinating with state and local emergency management agencies as appropriate).

Codes can include provisions for specific technologies or needs as detailed below.

Renewable Energy

- States can consider encouraging, incentivizing, or requiring on-site renewable energy generation and/or off-site renewable energy procurement.
- Where feasible, on-site energy sources, such as photovoltaic panels, can be required on all
- new buildings.
- Financing options for these provisions may include direct purchase, leasing, power purchase agreements, or community solar subscriptions.

EV Charging Infrastructure

- States can consider supporting EV adoption by requiring charging infrastructure or equipment to be installed as part of code compliance. Alternately, states can consider EV-ready codes to require the paneling and wiring necessary for EV charging.

- Installing EV infrastructure in new construction is generally much cheaper than installing it after the fact, meaning that codes can help speed the transition to EVs and help meet upcoming climate targets.
- The amount and type of EV charging infrastructure and equipment required can vary by building type (e.g., single-family homes, multifamily buildings, hotels, and commercial structures).

Demand Response and Load Flexibility

- Demand response programs and load flexibility technologies can significantly reduce emissions and customer costs while improving system reliability by addressing peak loads. Demand-flexible appliances can shift loads from times of high-cost electricity to times with lower costs and lower emissions.
- Load flexibility technologies can also help integrate renewables and will become increasingly important as variable renewable energy becomes a larger percentage of the electricity sector.
- States can consider requiring all new buildings to install technologies that have the ability to participate in automatic opt-out demand response programs.
- States can require PUCs to adopt time-of-use electricity rates and offer demand response programs.
- Codes can require pre-wiring for battery storage or distributed energy resources, which can make load flexibility more cost-effective for building owners to install.

Low-Embodied-Carbon Materials

- Though embodied carbon accounts for 11% of annual global emissions, it is largely unregulated.[27] Codes offer a key mechanism to minimize the amount of embodied carbon without compromising building strength and durability.
- Codes can require the use of low-carbon materials and features. These requirements can incorporate the inclusion of reused materials by establishing limits on embodied carbon for certain materials or buildings (e.g., material-specific standards, such as environmental product declarations, or performance-based approaches, such as whole-building life cycle analysis), the removal of restrictions on low-carbon materials (e.g., mass timber), or the adherence to existing low-embodied-carbon standards and certifications (e.g., LEED, Envision, Zero Carbon Certification).

Stretch Codes

- Stretch codes, whether voluntary or required, are a level of stringency above the state's base code and can better reflect new advances in technology and design practices.
- States can consider enabling and encouraging local governments to adopt stretch codes and pairing these stretch codes with other mechanisms, such as incentives. Options could include third-party green building standards, such as Passive House standards.[28]
- States can consider whether a single statewide stretch code (e.g., Massachusetts) is appropriate or whether allowing individual jurisdictions to adopt a unique stretch code (e.g., California) is preferable.

Examples

- **California:** Title 24 significantly advances energy efficiency and building decarbonization.[29]
- **California:** Berkeley utilized its police powers to require all-electric new construction.[30] Several dozen other cities have adopted local ordinances favoring all-electric construction in various ways, generally by increasing code stringency for dual-fuel construction.
- **San Jose, California:** Ordinance No. 30311 modifies the building code to advance efficiency and solar readiness, and it provides the strongest EV charging requirements of any large US city.[31]
- **Seattle, Washington:** the 2015 Commercial Energy Code achieves energy efficiency improvements designed to help keep the city on track with its goal to achieve a 70% EUI reduction in new construction from 2006–2031.[32]
- **Washington:** EV-Readiness Code requires certain new buildings to install EV infrastructure.[33]

Gas Supply and Infrastructure Planning

As buildings decarbonize, gas supply and infrastructure planning will need to change. Today's gas distribution system is not well-aligned with climate goals. The regulated gas utility business model is based on planning, building, maintaining, and operating infrastructure to deliver gas. This business model will not be viable in the future; continuing to invest in infrastructure to distribute and burn fossil gas as we do now is incongruous with a decarbonized world. It is necessary to carefully consider further investment in gas infrastructure and associated stranded asset risk and to establish a plan for the climate-aligned future of gas distribution systems.

Alternatives to fossil gas must be considered and explored carefully. The supply of gas is a key consideration in planning for the future of gas infrastructure. Low-carbon fuels, such as biomethane and hydrogen/methane blends, are often discussed as ways to drive building decarbonization. These fuels are likely to be limited in availability and expensive and will also be required to decarbonize sectors that are hardest to electrify, such as aviation, industry, manufacturing, and shipping.[34] Multiple state-level decarbonization studies, including studies from California and New Jersey, have found that building electrification, rather than biomethane, offers the lowest-cost pathway to eliminate carbon emissions.[35] Other states, including Rhode Island, see a role for low-GHG fuels in some hard-to-electrify scenarios and are pursuing multiple pathways to heating sector decarbonization.[36]

When states are considering alternative fuels because electrification is not feasible or cost-effective, the following questions can help determine the optimal gas supply mix for that state. For example:

- How much alternative fuel will be available, and what will it cost?
- What other end uses, such as industry and aviation, might require a supply of alternative fuel in order to decarbonize?
- How can states ensure that biomethane production does not cause environmental justice issues?
- What percentage of hydrogen can safely be blended into natural gas, and what safety concerns would have to be addressed?
- How much carbon reduction is possible through the use of biomethane or hydrogen blending?
- How can we verify the carbon reductions of these approaches?

Some of these questions may have answers today while others will require additional research and attention.

In addition to determining future gas supply, states may need to plan for the gas infrastructure of a decarbonized future. While alternative fuels may play a role in overall decarbonization strategies for some states, in any highly decarbonized future, gas throughput is likely to significantly decline, resulting in much smaller gas infrastructure needs. Planning for a future with markedly different demand and a different customer base requires rethinking business-as-usual infrastructure investments.

Slowing the installation of new infrastructure is a key step in moving away from a reliance on fossil fuel infrastructure. The expected lifetime and amortization of gas distribution lines range from 30 to 60 years or more. Gas lines built today pose an unnecessary cost, which will either be borne by ratepayers or become a stranded asset risk, as the timeline of necessary action to achieve a 1.5°C pathway does not align with the lifetime of new pipelines. States can consider a number of actions to avoid this risk, including reevaluating or eliminating gas line extension allowances, requiring consideration of non-pipes solutions, and developing a plan for a managed transition away from gas. Multiple states, including California, New York, Colorado, and Massachusetts, as well as D.C., have opened proceedings focused on the future of natural gas planning and the gas utility business model in a decarbonized future. A transparent public process is important to ensure that ongoing gas investment is in the continued public interest, rather than continued business as usual.

Rather than building both gas and electric infrastructure for new buildings, all-electric buildings only require electric wiring, representing a potential savings opportunity for developers. In addition, as the costs of new line extensions are typically spread across all gas ratepayers, gas customers can also benefit from these avoided costs. Traditionally, the utility ratepayer pays for most of the cost of new gas lines with the homeowner or developer paying the remaining cost.

Reducing or eliminating the line extension allowance better reflects the true costs of new gas lines and can help to incentivize all-electric construction and reduce stranded asset risk. Reducing this risk is especially important to avoid equity issues where LMI and disadvantaged communities are left supporting a gas system with diminished use.

Determining the long-term future of the gas distribution, transmission, and storage systems is crucial. As different users transition to all-electric buildings, hard to electrify uses, such as industry, will be responsible for the financial viability of gas systems. The gas distribution utility will need to transition to a new business model to accommodate the reduced demand for fossil fuels. Even in states that pursue low-carbon fuels as a solution, gas distribution systems will have to shrink relative to today's levels. Such a managed transition will require a clear vision from state government so that a robust plan, which protects public safety, ratepayers, and workers, can be put in place. Gas utility workers will also need clear protections and job transition opportunities, which will be more available in a managed transition than in a chaotic collapse of the gas utility. As customers leave the gas system, protections and plans must be in place to ensure that low-income and disadvantaged customers are not disproportionately burdened or bearing the cost of the entire gas distribution system. Enabling an orderly, equitable transition may require additional government funding to ensure ratepayers are not bearing the full cost.

As communities transition to electrified buildings, the existing gas infrastructure system must be managed in a manner that protects the public and the environment, ensuring safety and reliability throughout. The transition to electrified buildings will proceed at different paces in each community, but the gas system serving remaining customers will need to be maintained to ensure safety during each stage in the process.

Examples

- **California:** A study from Gridworks shows pathways with a proactive approach to gas transition will be more equitable and less costly than "reactive" pathways. [37]
- **New York, Massachusetts, Colorado, and California:** Gas planning dockets in these states explore the long-term future of gas planning and the role of gas in decarbonization.[38]

Zero-Carbon New Construction: Key Considerations

Energy and Emissions Impacts

- **Reductions in energy consumption:**[39] From 2005 to 2017, building sector energy use decreased by 4.5% even though the country added about 30 billion square feet to the building stock over that time period.[40]
- **Carbon reductions:** In 46 out of 48 states, electrifying today is carbon-reducing over the lifetime of a heat pump device, compared to using gas appliances.[41]
- **Long-term impact:** Building all-electric while decarbonizing the electricity sector, rather than installing new gas lines, avoids locking in emissions for decades to come and reduces emissions significantly.
- **Market development:** Codes are a principal avenue for mitigating emissions from embodied carbon, and requiring low-embodied-carbon materials in new construction can help develop that market.

Cost and Economic Considerations

- **Avoiding costly retrofits:** Building a highly efficient, all-electric building is generally cheaper than retrofitting an existing building. Energy codes and new construction requirements and incentives are often a cost-effective way to drive down building sector emissions.
- **Job creation and innovation:** The construction sector is ripe for technology innovation and productivity improvements, and these changes would drive significant job creation.

- **Avoiding stranded assets:** Given that gas distribution system usage will decrease due to energy efficiency and all-electric construction, limiting the expansion of the gas distribution system avoids the risk of stranded assets and increasing utility costs for fewer customers. Without careful planning, the cost of maintaining and operating the gas system will increase as customers leave the system.
- **Lower overall utility costs:** Beneficial electrification can increase system load factors and lower volumetric rates (dollars per kilowatt-hour [kWh]) for customers. Electrification programs should consider potential grid impacts and be designed to support the grid as much as possible.
- **Infrastructure cost savings:** Building gas infrastructure is expensive, and choosing all-electric construction helps developers and homeowners avoid these high costs.[42] All-electric buildings eliminate the cost of new gas infrastructure. Studies in California and New Jersey have shown that electrifying with efficient heat pump technologies is, including the costs of increased electric load, the lowest-cost pathway to decarbonization.[43]

Equity Considerations

- **Procedural equity.** Affordable housing advocates and groups focused on equity and environmental justice should be deeply involved throughout the code development and adoption process.
- **Affordability.** Adequate care must be taken to ensure that low-carbon homes are more, rather than less, affordable, especially for marginalized or vulnerable populations. Thoughtful land-use planning can support affordable housing by allowing developments other than single-family homes.
- **Gas infrastructure costs.** Continuing to expand the gas distribution system risks disadvantaged communities shouldering the burden of assets that depreciate at rates over a 60+ year timeline, well beyond the necessary timeline for emissions reductions. Avoiding new investments lessens that burden.
- **Health.** Indoor air pollution from gas stoves poses serious health risks.[44] By avoiding gas infrastructure build-out and requiring new homes to be all-electric, the risk of asthma decreases significantly. Health impacts from gas stoves disproportionately impact lower-income and Black communities.[45]
- **Just transition.** Gas utility workers must have a just transition path to alternate employment or retirement.

Cross-Sectoral Considerations

- **Cross-policy and cross-sectoral synergies:** Building codes, land use planning, and gas infrastructure planning should be implemented in ways that complement each other and support larger policy goals. These policies should work hand-in-hand with plans and policies focused on infrastructure, economic development, and transportation.
- **Hard-to-electrify end uses:** Critical facilities, such as hospitals and emergency response centers, may require backup generation in the event of an electrical outage. These types of facilities may still require some kind of gas whether through new line extensions or other methods.

State Authority

- Legislatures, or regulatory agencies with legal authority, generally adopt building codes at the state level. In many cases, however, “home rule” applies, and local governments have a greater role in code development and adoption. States with home rule should consider incentivizing local governments to adopt zero-carbon codes and consider opportunities to implement baseline codes through alternative mechanisms, such as clean air laws, as Texas has done. Home rule states could also limit the age of baseline codes that may be adopted. For example, Colorado requires any jurisdiction adopting a code to adopt an edition that is no more than three editions old.
- States (including staff in building departments, sustainability offices, housing departments and others) should provide input into model code development, such as the development of the IECC and ASHRAE standards, emphasizing the need to move away from fuel neutrality toward highly efficiency codes that favor decarbonized technologies. If model codes are slow to make these changes, states can develop their own efficiency standards or make major modifications to the model codes to enable those approaches.
- In order for gas utilities to stop installing new service lines, their “obligation to serve” may need to be modernized, likely requiring legislative or executive action.

- The shift toward all-electric requirements in cities across America can support state efforts by expanding markets for efficient electric technologies and providing a state-level vision for the future of utilities.

Potential Challenges

- **Industry opposition:** Strict building codes are often opposed by developers and professionals who work in construction and installation. Adequate care must be taken to provide the right encouragement and incentives to the building industry, and industry representatives should be involved throughout the code development process to ensure that their interests are taken into account where appropriate. Gas-only utilities are also likely to view electrification as an existential threat to their business. Since these companies will need to remain financially sound until the very last day customers require gas, policymakers should consider how to maintain the financial integrity of gas-only utilities during the transition, both as a practical matter and to decrease their opposition to decarbonization measures.
- **Support for gas:** Attachment to gas stoves for cooking and the current low cost of gas remain a key barrier to widespread support for all-electric codes. In Berkeley, California, the restaurant association is suing the city over its ban on gas in new construction. Public support for gas, while shifting, is still strong, and changing public opinion will require awareness and education programs.
- **Obligation to serve:** As discussed above, the "obligation to serve" has been legally interpreted to require that utilities provide just and reasonable service to customers that request and pay for gas service; no state has explicitly modernized this obligation yet.

Key Partners

- **Organizations that developed low-emissions codes and standards** are key partners. Many of these templates already exist, and states should consider incorporating them into their zero-carbon code. Standards include:
  - PHIUS 2018+[46]
  - International Living Future Institute: Zero Energy, Zero Carbon, and Living Building Certifications[47]
  - US Green Building Council: LEED Zero[48]
  - US Department of Energy (DOE): Zero Energy Ready Home[49]
  - US Environmental Protection Agency (EPA): EnergyStar Certification[50]
- **Utilities and public utility commissions** can work together to analyze the impact of building decarbonization policies on fuel consumption, distribution infrastructure, and the gas system transition.
- **Affordable housing advocates** are necessary partners to ensure that upfront costs for buildings do not result in higher bills or higher rent for LMI residents. Many states (e.g., Pennsylvania) have also found that low-income housing tax credit qualified allocation plans that incorporate Passive House standards are no more expensive than plans that pursue traditional construction methods.
- **City planners** are key partners, especially during land use and gas infrastructure planning.
- **Developers** in gas infrastructure planning can work with states to help them manage and understand the cost implications of these policies. Often, because developers can save money by not installing the infrastructure, they could serve as key advocates for a low-carbon transition.

Policy Variants

- **Code variants:** Though zero carbon codes achieve decarbonization most directly, other variants can provide some amount of progress (e.g., net-zero-energy codes). Exceptions could be made for gas stoves (which have minimal carbon impacts but have negative human health impacts). Policies should consider either updating gas line extension allowances, as discussed in the below section, or requiring the disclosure of the cost to install gas lines and monthly charges to provide a true cost comparison.
- **Density bonuses:** Developers could be allowed to build more densely than would traditionally be allowed in exchange for providing a public good—for example, incorporating a certain percentage of affordable housing into their projects.
- **Inclusionary zoning:** These requirements stipulate that new projects include a certain percentage of affordable housing, which can benefit low-income communities and communities of color.

- **Gas line allowance calculations:** Modernizing gas line extension allowance calculations would more accurately reflect the true costs of the service line and make gas service less economically attractive for the developer.

State Context Considerations

- **Strength of existing codes:** States that have not updated their building codes to at least the penultimate edition of a model code (without weakening amendments) should consider adopting stricter codes with particular urgency.
- **Strength of gas industry:** The influence of the gas industry in a particular state should inform the state's approach to gas infrastructure planning. In addition, gas planning may look different in jurisdictions with combined gas and electric utilities, as opposed to jurisdictions with gas-only utilities.
- **Hard-to-electrify end uses:** Some end uses, such as those in industry and manufacturing, may be difficult to electrify. States undertaking gas infrastructure planning can work with these sectors to develop economical decarbonization solutions.

Resources[i]

- American Council for an Energy Efficient Economy (ACEEE)
- National Association of State Energy Officials (NASEO)
- New Buildings Institute (NBI)
- Regulatory Assistance Project
- RMI
- Pacific Northwest National Laboratory (PNNL)
- Urban Land Institute (ULI)
- US DOE Building Energy Codes Program

[i] Resources described further in Appendix.

Establish Building Standards and Equipment Requirements

Building standards and equipment requirements limit the emissions from building technologies and existing buildings themselves. Either or both types of policies are critical for deep building sector decarbonization. Key policies under this umbrella include:

- **Building performance standard (BPS):** mandatory performance-based standards that set limits on energy or GHG emissions intensity for certain building types
- **Equipment requirements:** appliance efficiency standards and the beneficial electrification of equipment

Setting BPS and equipment requirements is perhaps the most effective way to rapidly reduce emissions in the building sector as a whole. Existing buildings must be decarbonized to meet climate goals—the majority of the buildings that will need to be decarbonized by mid-century have already been built. Equipment requirements ensure that the actual source of building emissions—the essential technology inside of them—is ratcheted down. Equipment requirements are more likely to target time-of-replacement triggers, which complement the more regular interval timeline of building standards. In addition to their carbon benefits, both approaches also provide a variety of economic and health benefits.

Building Performance Standards

A BPS places limits on energy use or GHG emissions from energy consumption in buildings. Rather than prescriptive standards that require specific energy measures or types of equipment, performance standards set limits on energy use or emissions per square foot and let building owners choose how to comply. Non-compliance typically results in a penalty, and variances should be provided for financial hardship. A BPS allows multiple pathways for achieving the standard, which supports end use appliance electrification, energy efficiency, demand flexibility, and energy storage approaches.

Initial energy or emissions limits are typically high, covering only the worst-performing buildings first before tightening limits incrementally over time (e.g., every five years) toward a deeper decarbonization goal. Currently, four cities (St. Louis, Missouri; New York City, New York; Reno, Nevada; and Boulder, Colorado), the District of Columbia, and the state of Washington have some sort of BPS in place. Five are based on energy use, and New York City's is an emissions standard, based on carbon dioxide equivalent (CO_2e) per square foot.

A BPS should consider two components—on-site energy use/direct emissions (e.g., gas, diesel, and propane) and electricity use/indirect emissions. A BPS can be designed so that these components can be adjusted independently to achieve energy reductions, drive GHG emission reductions, and encourage electrification, depending on state priorities. A BPS policy must be carefully designed as in some cases a single energy or emissions standard can lock in sources of emissions that impede deep decarbonization. For example, a more efficient gas furnace may reduce energy and GHG emissions in the short term compared to an electric heat pump, but it would not achieve necessary emissions reductions over the longer term.

A BPS should take into account grid decarbonization and the long lifetime of certain products. For example, in certain states, grid projections may show gas heating to be less carbon-intensive than electric heating over the next five years but more carbon-intensive after that. Because heating systems can last 25 years or more, states should carefully design standards to ensure that they do not incentivize installing equipment that is less carbon-intensive in the short term but more carbon-intensive over the product's expected lifetime.

Furthermore, the carbon intensity of electricity can vary throughout the day as different generation sources meet changes in demand. In states, such as California, that have deployed smart metering infrastructure and have grid GHG emissions data available, accurately calculating a building's GHG emissions can be completed in almost real time using software. In states without smart metering infrastructure and grid GHG emissions data, monthly data and the annual average estimate of emissions per unit of electricity consumed is the most accurate metric to use in the calculation.

Although US energy-related building emissions have been declining somewhat over the last decade or more, this decline has been gradual. While US electric power sector emissions have declined by about one-third since 2007, driving much of the decline in the building sector, direct emissions from building fuel combustion have increased by about 10% over that same period.

As a result, the pace of building retrofits needs to increase dramatically. Research shows that retrofitting 80% of US buildings by 2050, for example, would require increasing the current retrofit rate by about 15-fold for residential buildings and by about two-fold for commercial buildings.[51] A BPS can help reach these rates by driving both electrification and efficiency retrofits much faster than voluntary market-based mechanisms have proven capable of doing.

While performance standards in the United States have thus far been used mostly in commercial and multifamily buildings, some single-family home applications are worth considering. Single family homes may be best addressed through equipment requirements, but a BPS may be a good pathway for targeted segments, such as publicly subsidized housing or rental homes, which could be regulated as business-based emissions. Requirements for small- and medium-sized buildings may need different compliance schedules, funding, and support than requirements for larger buildings. Certain existing policies also provide prescriptive options (i.e., a set of low-cost energy conservation measures) for rent-regulated, public, and affordable housing to lower the financial burden on these buildings.

Passing a BPS typically comes with, or follows, a building energy benchmarking and disclosure policy. States that pass a BPS can effectively achieve two things—both a standard and benchmarking (which facilitates the necessary data collection and ongoing measurement/tracking); Washington took this approach. In some cases, however, benchmarking comes first and provides important lessons for the later design of performance standards. To be accurate, a BPS must also have rigorous measurement and verification standards that leverage available smart meter data.

In addition to enacting their own BPS, states should also consider allowing local governments to set their own standards. This is particularly important in Dillon Rule states, where local governments generally have more limited authority than they do in Home Rule states and enabling legislation may need to be enacted to allow local jurisdictions to adopt these regulations. These standards can be enacted in the absence of statewide standards or be set as “stretch standards,” which would be stricter than state-level standards already in place.

Examples

- **Boulder, Colorado:** SmartRegs program creates efficiency standards for rental properties with over 90% compliance and no discernable effect on rent increases.[52]
- **District of Columbia:** Clean Energy DC Omnibus Amendment Act of 2018 (Title III) sets ENERGY STAR® score standards for commercial and multifamily buildings over 10,000 square feet.[53]
- **New York City, New York:** Local Law 97 sets CO_2e intensity limits for commercial and multifamily buildings over 25,000 square feet.[54]
- **Reno, Nevada:** Ordinance 7068 established the Energy and Water Efficiency Program, which, among other things, sets building energy performance requirements for commercial and multifamily buildings.[55]
- **St. Louis, Missouri:** Building Energy Performance Standard sets EUI limits for commercial and multifamily buildings over 50,000 square feet.[56]
- **Washington:** House Bill (HB) 1257 sets EUI limits for commercial buildings over 50,000 square feet.[57]

Equipment Requirements

Equipment requirements fall under two categories: appliance efficiency standards and policies to support the beneficial electrification of equipment. The latter are important because the lifetime carbon emissions of heat pumps are lower than those of gas systems in nearly all states, according to the National Renewable Energy Laboratory's (NREL's) projections for the US electricity mix.[58] In the near term, places with cold climates and fossil fuel-heavy electric grids may not see an immediate carbon reduction from electrification.

Appliance efficiency standards *mitigate building emissions by targeting the devices that drive the majority of them—appliances such as furnaces, air conditioners, water heaters, and lighting—both in residential and commercial buildings. The US DOE has promulgated federal standards for appliance energy efficiency for decades, which cover more than 60 categories of appliances and generally preempt states from setting more stringent standards. At the same time, states can request a waiver from the DOE to implement stricter appliance standards, and they can also set standards for appliances that are not yet covered by the DOE.*[59]

Through the Appliance Standards working group, USCA states are working to adopt a suite of consensus standards where feasible, to develop coordinated strategies to assure compliance with state standards, and to encourage the development of policies that promote the continued advancement of standards. Alliance states have been using a model bill customized to each state's circumstances, deploying shared implementation resources (e.g., factsheets and analysis), and strategizing on how to engage with industry.

Examples:

- *As of 2020, 15 states and the District of Columbia were enforcing energy efficiency standards for appliances not covered under federal standards.*[60]
- ***California****: SB 49 sets demand flexibility standards for appliances.*[61]
- ***California****: Health and Safety Code 19881 regulates unvented appliances.*[62]
- ***Washington****: HB 1444 requires new electric water heaters to be grid-interactive.*[63]

Beneficial electrification of equipment represents a key strategy that should work in parallel with appliance efficiency standards. Beneficial electrification generally means that electrification must meet at least one of the following criteria without adversely affecting the others:

1. Reduces emissions
2. Reduces consumer costs
3. Supports the electric grid[64]

Sales or installations of new equipment should be all-electric and efficient, with a particular focus on space and water heating equipment, which account for nearly 90% of direct (i.e., on-site) building emissions. Heat pumps for space and water heating can achieve far higher levels of efficiency than fossil fuel devices or electric resistance devices. Federal law preempts states from adopting state appliance efficiency standards that are more stringent than federal standards, and it establishes an exception for state energy codes with several rules that must be carefully followed to allow "an energy conservation objective" approach to performance or prescriptive standards. To further limit combustion appliance use, states could also consider adopting requirements in non-energy parts of the building code to accomplish combustion safety or air quality goals.

Beneficial electrification requirements apply to all new appliances in the state, whether tracked by sales or installations. States can consider implementing them through different means, either as requirements for individual appliances or as a more portfolio-based approach. For the latter, states can consider an approach similar to federal Corporate Average Fuel Economy Standards, which require manufacturer fleets to meet an overall efficiency threshold, or California's Zero Emissions Vehicle (ZEV) program, which requires manufacturers to have EVs as a certain percentage of sales in California. Electrification requirements should not just exist within the code compliance process; triggered only during construction or major renovations, these processes do not cover all appliance installations, missing equipment upgrades or end-of-life replacements.

In many states, appliances are already regulated by air quality agencies—for example, the California Air Resources Board has been regulating emissions standards for years. Similarly, New York City phased out certain oil appliances by prohibiting their use in boilers through the Air Code, based on fine particulate matter ($PM_{2.5}$) emissions. While the structure and authority of air quality agencies will vary, these agencies may have the opportunity to effectively require appliance electrification by adopting low or zero $PM_{2.5}$, nitrogen oxide (NO_x), or CO_2 emissions standards for specified equipment.

Efficiency requirements for appliances will face obstacles as a result of federal preemption. However, a multistate collaboration could work together with the DOE or trade industry groups to establish updated standards for products currently covered by federal law. Other strategies, such as “multi-path” state energy code approaches, can be used to pursue deep efficiency that favors efficient electric technologies, such as heat pumps.[65] These approaches would not ban gas appliances, so states would have to look to other authorities to accomplish this.

States can also consider electrification requirements that incorporate demand flexibility standards for these appliances. When paired with time-of-use pricing and demand response programs, demand-flexible appliances can further reduce GHG emissions, improve grid reliability, reduce customer costs, and help integrate renewables.

Technical potential studies can help states understand the role of electrification in their geography and how it may change over time. Some states (e.g., Colorado) have already completed such studies.[66] When implemented appropriately based on state context, equipment requirements—appliance efficiency standards and beneficial electrification—can save consumers money, improve health, create jobs, and substantially reduce building sector emissions.

Examples

- **California:** ZEV program requires automakers to sell EVs and has been adopted in 10 other states (Colorado, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont).[67]

Building Standards and Equipment Requirements: Key Considerations

Energy and Emissions Impacts

- **Large-scale benefits:** New York City’s first round of existing building emissions limits is set to reduce emissions by about 26% by 2030 from today’s levels—roughly equivalent to the total emissions of San Francisco (including buildings, waste, and transportation). Relatedly, Colorado found that the technical potential for annual emissions reductions from equipment electrification is roughly 30% of the forecasted emissions from electricity production, gas consumption, and propane consumption in the state.
- **Household benefits:** For nearly all US households,[68] replacing a gas furnace with a heat pump reduces lifetime carbon emissions, given NREL projections of electricity mix. In the near term, states should also consider the short-term emissions impact of electrification as well as the actual performance and efficiency of heat pumps in various climates and geographies.

Cost and Economic Considerations

- **Job creation:** Retrofitting buildings can be a strong driver of job growth. For example, in 2019, 2.38 million Americans worked in energy efficiency, more than in all of fossil fuel extraction.[69] Equipment requirements drive job creation in research, manufacturing, and installation. According to ACEEE, federal appliance standards led to the creation of 340,000 jobs as of 2010, with that number expected to grow to 380,000 by 2030. State standards could serve to further increase these numbers.[70]

- **Incremental costs through time-of-replacement focus:** Focusing requirements at time of replacement greatly reduces costs to building owners because the costs are incremental to existing equipment replacement costs, rather than equal to the gross cost of new equipment.
- **Electrical panel upgrades:** electric appliances contribute to a building's electric load and may therefore require an upgrade of a building's electrical panel. These upgrades can be expensive to building owners, and programs, incentives, and regulation may be needed to reduce or mitigate these costs.
- **Energy cost savings:** Federal energy efficiency standards for appliances and equipment currently save households about $320 per year on their energy bills.[71] Bill savings to consumers in the entire building sector, as a result of these standards, are expected to reach nearly $1 trillion by 2020 and $1.7 trillion through 2030.[72] State efficiency standards would drive further savings for customers. Potential annual savings in 2025 from new, recommended state appliance standards are 16 billion kWh of electricity and 46 trillion British thermal units of gas.[73]
- **Grid infrastructure costs:** When standards drive electrification, states should also consider measures that reduce peak demand on the grid and avoid the need for the expansion of costly grid infrastructure. As smart metering technology proliferates, states should consider setting BPSs that manage peak demand at the system and substation level.

Equity Considerations

- **Health impacts:** Combustion emissions ($PM_{2.5}$ and ozone) from the buildings sector contribute to more premature deaths associated with outdoor air pollution (over 28,000 annually) than any other sector—transportation, industry, or power generation.[74] In 2018, residential and commercial buildings were responsible for an estimated 37% of the total early deaths attributable to combustion emissions. Gas appliances can also lead to unsafe indoor air quality. Both indoor and outdoor air quality issues disproportionately affect households of color and low-income communities. Building standards and equipment requirements can mitigate these problems, and policies can be designed to benefit the communities most affected by health problems.
- **Procedural equity:** Policy design should involve stakeholders, particularly those from disadvantaged communities, to ensure policies maximize benefits and minimize unintended harm to these communities.
- **Using non-compliance fines:** States can consider redirecting non-compliance fines from a BPS toward affordable housing retrofits, other low-income retrofit programs, or incentives that specifically benefit LMI households.
- **Impact on LMI customers:** As buildings electrify, states face a risk that low-income households will be left carrying the remaining rate-base for gas infrastructure, creating an unfair burden. As such, dedicated funds and program support to help LMI households electrify should be prioritized. Depending on resources available, states can support LMI households in early adoption to help drive and scale the market, ensuring that LMI households benefit first and are not left behind. On the other hand, many vulnerable communities may not want to be the test-case for electrification programs. Another approach is to scale the market in other sectors, creating lessons learned and reducing costs through scale, therefore reducing the costs for LMI household retrofits.
- **Protecting LMI customers:** Cost increases that affect housing or appliances should be paired with measures that protect LMI consumers and building occupants from unfair burdens, provide renter protections that prevent landlords from passing these costs onto their renters, and/or ensure LMI consumers have access to low-carbon technologies. For example, a "feebate" could be put in place to benefit LMI households by imposing a fee on certain high-emitting equipment. Revenue from this fee could be used for rebates to LMI households to purchase low-emissions equipment. LMI households also often have difficulty taking advantage of rebate-style incentives in the first place and do not participate as widely in utility programs. Therefore rebate-style programs should be paired with turnkey technical assistance programs for LMI communities. Additional financing options are discussed in more detail later in this roadmap.
- **Providing career opportunities:** States should consider pairing building standards and equipment requirements with workforce development programs. For example, these could specifically allow

disadvantaged communities to take advantage of new work opportunities and provide just transition opportunities and high quality, family-sustaining jobs for gas industry workers. These opportunities should provide living wages that help mitigate income inequality.

- **Managing energy burdens:** Landlords installing cheapest-cost electric equipment to meet requirements could create a cost burden for renters. For example, switching from a gas device previously paid by the landlord to an electric device that the customer is responsible for could increase a resident's energy bills. If paired with overall efficiency upgrades, those new energy costs may be balanced out, but by themselves, they may increase energy burdens. To address this issue, new approaches may be needed to address the "split incentive" between the landlord and tenant.

Cross-Sectoral Considerations

- **Utilities:** Development of building standards and equipment requirements should involve significant utility coordination and a comprehensive stakeholder engagement process to ensure that utilities can effectively manage impacts to the electric grid and the gas distribution infrastructure.
- **Measuring emissions:** Building standards should be implemented in tandem with benchmarking that measures building energy consumption at the outset of the program and then monitors to ensure that targets are met. States should also consider building sector-wide or economy-wide energy use and emissions monitoring if not already in place.
- **Technology integration:** States and utilities should consider supporting EV charging infrastructure, energy storage, smart meters, and solar installation where appropriate to support grid integration and mobility goals. EV-readiness and solar-readiness upgrades, at a minimum, may be appropriate to incorporate when loads are electrified. In many cases, these technologies can be incentivized within performance standards themselves (e.g., through credits).

State Authority

- Building standards are typically established through legislation, with implementation led by the relevant state agencies.
- Executive orders may be used as part of emergency management or to align resources that, for example, guide a stimulus program; this has occurred as part of the COVID-19 response. Executive orders may allow for enacting statewide building standards and equipment requirements. They also may allow for targeted efforts to decommission gas lines and electrify homes in response to aging infrastructure risks, methane leaks or explosions, or ventilation and health issues. They also could focus on aligning resources to avoid efficiency investments in gas equipment, etc. (See article on using executive orders for public health.[75])

Potential Challenges

- **Program Costs:** Performance standards may require the purchase of materials or technologies with high upfront costs or a switch to more expensive energy sources. When upfront costs are a barrier, financial assistance can be critical to achieve compliance.
- **Technical understanding:** Building owners, property managers, and maintenance workers will need substantial support to understand what is required of them and how to implement changes to their buildings. Standards would likely face strong political pushback without adequate technical assistance.
- **Supply chain laggards:** Supply chain professionals may see building decarbonization as a threat to their business and oppose standards. On the other hand, building standards and equipment requirements can be powerful job creation tools.

  Measuring emissions: Because of variability and long-term changes in electricity-related emissions, and in the absence of smart metering infrastructure and an electricity grid GHG emissions signal, it can be challenging to accurately measure the emissions reductions achieved by an electric appliance or to properly measure building emissions. Demand flexible appliances or energy management systems can provide more accurate usage data, which can be used to calculate GHG emission reductions.

Key Partners

- **Utilities** should be engaged during BPS development to ensure that standards take into account utility needs and impacts. Understanding current energy system emissions and future emission projections also requires collaboration with utilities.
- **Supply chain professionals,** such as manufacturers, vendors, designers, and installers—in addition to affected building owners—should be educated about building standards and equipment requirements and ideally be part of the development process.
- **Organizations focused on equity and environmental justice** are important partners to ensure that building standards and equipment requirements adequately benefit disadvantaged communities and that any increased costs are paired with mitigating measures (e.g., incentives) available to these communities.

Policy Variants

- **Supply chain focus.** Equipment requirements could be accomplished through several mechanisms, including at the building level (e.g., permitting requirements), at point of sale (e.g., only allowing sales of electric equipment), or at installation (e.g., not allowing licensure of installers of new gas equipment).
- **Timeline.** Building standards can be set at the time of sale, at the time of lease, or at a set time and frequency, such as every five years.
- **Building type.** Buildings standard requirements and timelines often vary by type of building. To date, standards mostly apply to larger commercial and multifamily buildings. In most states, electrifying single family homes may be more technologically simple today than electrifying high-rise commercial facilities, suggesting different calendars for policy requirements.
- **Other mechanisms.** Targets, incentives, supply chain development, and a number of other measures can increase the adoption of low-carbon technologies—in addition to standards (see other sections below). It may be possible to accomplish the goals of a standard through other means (e.g., a state target for low-emitting HVAC appliances rather than state standards for HVAC appliance emissions). However, past experience suggests that a market-led approach is unlikely to accomplish the same level of GHG reductions unless the effort is deeply coordinated and well-resourced.

State Context Considerations

- **Energy mix.** Building standards and equipment requirements should be designed to consider the electricity mix and the heating fuel mix, which differ substantially by state, and how they are expected to change over time. This will affect the math of emissions intensity calculations and targets. These standards should be designed to factor in other relevant policies, such as a clean electricity standard or an economy-wide emissions reduction target.
- **Building stock and climate.** The economics of electrification retrofits vary based on the building stock and climatic conditions in each state; the specifics of incentives and program design should reflect the economics of specific geographies.

Resources

- American Council for an Energy-Efficient Economy (ACEEE)
- EPA: Benchmarking and Building Performance Standards Policy Toolkit
- Greenlining Institute
- Institute for Market Transformation (IMT)
- New Buildings Institute (NBI)
- RMI

Transform the Energy Market

To speed the decarbonization of buildings, the energy market and utilities will need to transform to allow for rapid electrification and efficiency improvements at scale. States can pursue actions to transform the energy market, especially when strict building standards or appliance requirements may not yet be possible. Ensuring that stakeholders have the necessary incentives and information can help to "grease the wheels" to both support and create rapid market transformation. Policies and regulation that deepen reliance on fossil fuels, including incentives for gas appliances, must be reconsidered to clear the path for decarbonization as well as direct limited funds to the right goals.

In order to scale, distributed energy resources, such as rooftop solar and other clean energy solutions, have required policy and regulatory changes as well as customer-focused programs. Likewise, in the absence of adequate policy support, decarbonized building technologies may face low market adoption and eventual discontinuation.[76] Similarly, building decarbonization will be more successful and effective if incentives, policies, and information support the market together. States can consider the actions below:

- **Regulatory and policy landscape alignment:** Removing barriers to fuel substitution and fuel switching and rethinking efficiency incentives for fossil fuel-based appliances are key actions to drive market transformation.
- **Utility rate design and demand flexibility:** Thoughtful rate design and demand flexibility programs can help to incentivize energy efficiency, capture the full value of electrification, reduce negative grid impacts, and support the integration of variable renewables. Customers can also see savings through well-designed programs.
- **Climate-aligned efficiency standards:** Rather than designing energy efficiency resource standards separately for gas and electric consumption, standards can be established on the basis of total energy, avoided GHG emissions, or total system benefits (i.e., value of avoided energy and GHG emissions) helping to align utility incentives.
- **Targets for technology acceleration:** Setting a target for a particular technology can send a powerful market signal and spur adoption.
- **Consumer incentives:** Well-designed incentives can speed uptake and help to transform the market when costs remain high and consumer awareness is low.
- **Building performance benchmarking, disclosure, and transparency:** Measuring energy-related emissions and making that information accessible can arm key decision-makers with the knowledge needed to reduce emissions.
- **Consumer education:** Educating consumers on the clean, efficient options and incentives available to them is crucial to influence decision-making. States can improve consumer awareness of the air quality risk posed by gas stoves, for example.
- **Lead-by-example standards:** Emissions limits, or other measures, applied to state government buildings drive modest decarbonization for the building sector statewide but can pave the way for nongovernment buildings to follow their lead.

Regulatory and Policy Landscape Alignment

Existing energy policies and regulations often reflect the priorities of a different time with different circumstances. Regulation was designed to incentivize gas heating when it was the more efficient and cost-effective option. Historically, many states placed restrictions on fuel switching, preventing homeowners from receiving incentives to switch from gas appliances to electric appliances. These policies were put in place for several reasons. One reason was that electric appliances, especially electric resistance-based appliances, were inefficient, and the electric grid was far dirtier than it is today. Gas appliances were more efficient and often the more cost-effective and carbon-reducing option at the time.

Now, however, the benefits are in favor of electrification, but many states still have fuel substitution or fuel switching prohibitions on the books. Meeting climate goals requires changing restrictions that prevent access to carbon-reducing technology. States and PUCs can lift these restrictions and can go further: making clear that utility programs should consider encouraging fuel substitution or fuel switching to electricity, especially where it can save cost and carbon.

Funding for utility energy efficiency programs for any fuel is based on different cost tests; it is important to consider whether these cost tests accurately reflect the benefits sought by the program and the urgency of addressing climate change. Cost tests should consider the social cost of carbon as well as other environmental and health considerations over the lifetime of the device. Cost tests should consider the cost savings possible through fuel-switching, including savings from switching away from nonregulated fuels like propane or heating oil. The cost of avoided gas infrastructure, including new gas line extensions, should also be quantified and considered as part of the cost tests for an electrification program.

Regulators and policymakers should also consider how the concept of cost-effectiveness impacts policy goals. In some cases, it may be worthwhile to implement programs that support policy goals, even if they do not satisfy traditional cost-effectiveness tests. For example, how should the benefits of a heat pump, which will save carbon over the lifetime of the device, be compared with a higher-efficiency gas furnace, which may be cheaper but locks in fossil fuel emissions for the lifetime of the device?

Finally, both gas and electric utilities' revenue should be decoupled from sales volume. Decoupling is common in many states and is an important tool to eliminate the profit incentive for utilities to increase load.

Examples

- **Colorado:** Legislation requires programs, including electrification programs, to incorporate the social cost of carbon into decision-making.[77]
- Regulatory Solutions for Building Decarbonization,[78] a report from RMI.

Demand Flexibility and Utility Rate Design

Utility regulation, including demand flexibility and rate design, can support building electrification and efficiency. Demand flexibility programs and time-varying rates can help to capture the full value of electric loads, supporting the grid through load shedding, load shifting, or ancillary services and helping customers save money. Utilities can offer "bring your own device" programs, where customers purchase their own smart thermostat, for example, and become part of a demand flexibility or demand response program. Smart devices should allow customers to participate in programs that lower costs and support the grid with minimal effort and without any discomfort. For example, water heaters can provide thermal energy storage by preheating water before it needs to be used; as long as a customer can take a hot shower at any time, the timing of water heating does not matter to the customer.

Rate design should be carefully considered to incentivize customers to shape their load in a way that both benefits the grid and reduces GHG emissions. At the same time, rates need to be easily understandable and should not penalize customers with inflexible loads or without smart devices. States should consider expanding time-varying rates, whether as time-of-use rates or real-time pricing.

Utilities can also consider specific rate classes for all-electric buildings, perhaps with lower costs per kWh. Inclining block rates, in which customers pay more per kWh as they consume more electricity, should be avoided in most cases as they disincentivize electrification even when it is emissions-reducing or could provide grid services. Demand charges encourage higher customer load factors (e.g., flatter load profiles), rather than the load profiles strategically shaped to match grid needs; these types of rate designs should therefore be avoided. Non-coincidental demand charges may also penalize customers for spikes in energy use, regardless of whether those spikes actually occur during costly times for the grid or times of high-emissions generation.

Examples

- **Michigan:** Great Lakes Energy offers a $0.03/kWh seasonal discount on heating costs when customers utilize an efficient air source heat pump.[79]
- **Vermont:** Green Mountain Power provides a free smart control device to anyone who enrolls in their eControl demand flexibility program.[80]

Climate-Aligned Energy Efficiency Resource Standards (EERS)

EERS are traditionally designed for single fuels, with separate load reduction goals for gas and electric utilities. If a utility helps a customer to shift from a fossil fuel appliance to an electric appliance, there is often little opportunity for any GHG emissions savings to be counted toward energy efficiency targets. States should therefore consider defining targets and accounting in a way that includes the total reduction in carbon, either through accounting for savings compared to a fossil fuel baseline or by considering total fuel savings or total avoided GHG emissions.

Given that space heating equipment is likely to only be upgraded once or twice between now and 2050, states should carefully consider when to stop incentivizing fossil fuel appliances. In many places where oil and propane are primary heating sources, utilities offer significant incentives for customers to shift to gas appliances. Incentives for gas appliances with improved efficiency are also common, especially as states consider affordability—heat pumps may be cost-prohibitive for low-income customers. However, these incentives for gas appliances lock in emissions for years to come when building systems already need to be shifting to meet long-term climate goals.

Examples

- **New York** efficiency targets are based on total energy savings;[81] utilities, including ConEdison, also have specific incentives based on heat pump installation.[82]
- **Sacramento Municipal Utility District (SMUD)** recently changed its efficiency metric to focus solely on avoided carbon, rather than energy savings.[83]

Targets for Technology Acceleration

States should consider setting targets for the acceleration of beneficial technology—for example, Maine passed a bill establishing a target of 100,000 heat pumps installed by 2025. Setting a target sends a market signal; technology providers and contractors know that Maine is expected to have a large customer base for heat pumps on a specific timeline. Setting targets for building decarbonization technologies, especially for grid-interactive technologies that can support grid balancing, is an important tool to support market development. Targets can also serve to align state-run programs with the overall market signal. States can convene market actors so they can coordinate action; such convening can be less resource-intensive than incentives.

States have established targets for renewable energy technologies for years and should consider setting similar targets for building technologies, such as heat pumps, efficient LED lighting, and on-site energy storage. As is true for renewable energy goals, targets for beneficial technology should be coupled with enforcement mechanisms that make clear who is responsible for meeting the target.

Example

- **Maine:** Legislative Document (LD) 1766, signed in 2019, sets a goal of 100,000 heat pumps installed by 2025.[84]

Consumer Incentives

Efficiency and electrification projects may not always be immediately cost effective or may have a long payback period. This is especially true given that the market for heat pumps has not yet fully matured, which means that costs can still be high while consumer demand is low. Incentives that lower the cost of new technologies for consumers can help them to choose products they otherwise might not choose. Incentives can bridge the difficult part of the cost curve, allowing rapid electrification as overall costs decline. They may be offered through utilities, through state-level efficiency programs, or through other state agencies.

As the market matures, incentives may be phased out for some populations but can be retained as a crucial tool for equitable electrification. While market forces may make technologies affordable for some populations, low-income and disadvantaged communities will still need incentives to ensure equity and affordability. States can consider a “targeted universalism” approach to guide equitable outcomes.[85]

Given that most appliance replacements are emergency, end-of-life replacements, incentive programs can offer ways to encourage off-cycle replacements. States can consider “Cash-for-Clunkers”-like programs to incentivize the early replacement of highly inefficient or fossil-based appliances, providing direct financial incentives to consumers to make the swap. To avoid limiting access to affordable equipment, a Cash for Clunkers approach is likely best for heaters, air conditioners, and water heaters, which are the largest energy users in buildings and have a minimal secondary market. However, stoves and dryers may be worse candidates for this kind of replacement program. Programs with “instant rebates,” as seen in Maine, can significantly increase the uptake of efficient electric devices for emergency replacement.[86]

Though they may have long payback periods, incentives can provide a high rate of return. New York State, for example, announced an additional $2 billion in utility-administered incentives for energy efficiency and building electrification in the beginning of 2020. This initiative will cost $2 billion but save ratepayers more than $13 billion in utility bills over the life of the program.[87]

Examples

- **New York:** NYS Clean Heat offers a variety of incentives to both consumers and contractors, and the program also offers on-bill recovery loans and smart energy loans.[88]
- **California:** SMUD offers significant incentives, up to $10,000, to households converting to electric appliances.[89]
- *Driving the Heat Pump Market: Lessons Learned from the Northeast* is a report from the Vermont Energy Investment Corporation and Natural Resources Defense Council.[90]

Building Performance Benchmarking, Disclosure, and Transparency

Targeted actions to decarbonize buildings require a comprehensive understanding of building energy use and emissions — “you can’t manage what you don’t measure.” Depending on a state’s goals, benchmarking can apply to different building types and can occur against different types of baselines. Benchmarking can provide data with varying levels of disclosure and transparency.

The greater the transparency, the more these data can reduce information gaps and drive investments in energy efficiency and electrification upgrades. Transparency and disclosure should include energy labeling and rating systems such that building performance is intuitively understood by occupants; examples include “report cards” and physical building labels that present energy consumption information.[91]

To be effective, these policies must be coupled with targeted energy- and emissions-reducing actions. Benchmarking, disclosure, and transparency policies are most effective when implemented as part of policies—such as BPSs or commissioning, auditing, and tune-up policies—that mandate real emissions reductions.

Benchmarking can also be administered by municipalities, with states helping streamline the process by implementing a Shared Energy Manager program. As discussed under the Building Performance Standards section above, Dillon Rule states should consider allowing local governments to require benchmarking and transparency through enabling legislation. States can also streamline disclosure and transparency by providing a standardized platform as seen in Minnesota.

Examples

- **Austin, Texas:** Energy Conservation Audit and Disclosure Ordinance.[92]
- **California:** Assembly Bill (AB) 802 requires commercial and multifamily benchmarking.[93]
- **California:** AB 1103 requires nonresidential performance disclosure at time of sale, lease, and financing.[94]
- **California:** Executive Order S-20-04 requires benchmarking and emissions reductions for state-owned buildings.[95]
- **Massachusetts:** An Act Relative to Consumer Access to Residential Energy Information (House Bill 4371) provides homeowners and prospective homebuyers with access to energy efficiency information.[96]
- **New York City, New York:** Local Law 33 of 2018 requires owners of certain large buildings to publicly display energy efficiency ratings.[97]
- **Portland, Oregon:** Home Energy Score Ordinance requires energy disclosure at time of listing[98]
- *Map: U.S. City, County, and State Policies for Existing Buildings: Benchmarking, Transparency and Beyond* is a resource from the Institute for Market Transformation that shows the US jurisdictions that have implemented mandatory benchmarking and transparency policies.[99]
- Shared Energy Manager programs.[100]

Consumer Education

Programs that educate consumers about low-carbon technologies help speed the decarbonization of the building sector as a whole. Building owners, tenants, and landlords can benefit from programs that tout the environmental, health, and economic benefits of low-carbon homes and appliances. Education efforts should focus in particular on disadvantaged communities, providing access to information for stakeholders that can most benefit, helping them to make informed choices and to participate in policy discussions that impact their lives. In all cases, programs should aim to not just educate consumers about options but to inspire them to make new choices and change behavior in beneficial ways.

Customers often resist building decarbonization due to often high upfront costs and consumer inertia. However, strong educational messages from credible sources can convince consumers that envelope upgrades, low-emissions equipment, or behavioral changes are worth the investment. On the residential side, evidence shows that education programs can help consumers cut their energy use by 20%.[101] Providing tours of all-electric, efficient buildings, or other demonstration projects can also provide valuable hands-on experience.

Almost all home improvement projects are not cost-effective from a “payback” perspective, but people invest in them because they see other value in undertaking them. Consumer education can help make these other values clearer for energy upgrades and inspire “social norming” around these changes.

Education campaigns will often influence a wider array of consumers when they expand their focus beyond the environmental benefits of a consumer choice. For example, research shows that gas stoves can lead to levels of indoor air pollution that would be illegal outdoors. This pollution leads to significant respiratory risks, especially for children, making electric cooking a safer option.[102] Understanding the benefits of electric cooking may influence consumers who were not aware that gas stoves posed health risks, even if they are not compelled by climate impacts.

Public education regarding these technologies is particularly important in places where they are not very popular, such as the Northeast. Campaigns should focus on the technologies appropriate to the particular state context. For example, cold-climate heat pump education may be more helpful in northern states than elsewhere. To increase access for all communities, language and accessibility services, along with delivery through various media (such as electronic, print, and in-person), should be considered when designing educational campaigns.

Examples

- **Boulder, Colorado:** Comfort365 program[103]
- **New York:** Consumer Education Program for Residential Energy Efficiency (CEPREE)[104]
- Numerous utilities lead efficiency education, such as Michigan's Consumers Energy[105]

Leading by Example

State governments can lead by example by decarbonizing the buildings under their control through the implementation of a BPS or other measures. These policies can occur through legislation or executive order and can apply to leased space, government-owned buildings, or publicly financed buildings—encompassing all or a subset of a state's buildings and/or building operations.

Lead-by-example standards may be a higher priority for certain states based on their unique conditions (e.g., large and/or inefficient building stock, high energy costs, budget constraints, and/or political challenges with implementing standards that cover a larger swath of the state's buildings). States should also work to provide adequate financing options for a lead-by-example program, which may require changing rules to provide state agencies with access to these options.[106]

There is significant potential for both carbon savings and cost savings here: state and local governments spend about $11 billion on building energy costs annually.[107] In addition to increasing energy efficiency, reducing air pollution, and lowering GHG emissions, targeting public buildings promotes public awareness that decarbonizing existing buildings works, can help jumpstart the market, and can save taxpayers money through reduced energy spending.

Examples

- **Minnesota:** Buildings, Benchmarking, and Beyond (B3) requires benchmarking and energy savings that have cut state building energy use by nearly 30%.[108]
- **Montana:** 20 x 10 Initiative required a 20% reduction in executive branch building energy use by 2010.[109]
- **North Carolina:** SB 668 requires emissions reductions of 20% by 2010 and 30% by 2050 for all state buildings against a fiscal year 2003–2004 baseline.[110]

The Energy Market: Key Considerations

Energy and Emissions Impacts

- **Reducing peak and supporting renewables:** Appropriate demand flexibility programs and rate designs can leverage buildings as grid assets. For example, flexible hot water loads in particular can help integrate renewables and shift energy consumption away from peak periods. Demand flexibility could reduce renewables curtailment by 40% and lower peak demand net of renewables by 24%.[111] Energy efficiency is also a crucial component to meeting emissions targets, with especially strong opportunities available in new construction.
- **Eliminating gas emissions:** Decommissioning gas systems would have significant emissions impacts, effectively eliminating emissions from the gas distribution system and associated methane leaks. Including the leakage from drilling to delivery, gas delivered to buildings is responsible for between 90

and 470 million metric tons of CO_2e, depending on the estimate and global warming potential (GWP) timeframe used.[112]

- **Fuel-substitution and fuel switching reduces carbon:** There are significant savings possible through fuel substitution and fuel switching to heat pumps; heat pumps are carbon-reducing in 46 of the lower 48 states over their lifetime.[113] Supporting programs should not incent electric resistance space and water heating, which are highly inefficient and unlikely to be carbon-reducing. ACEEE has outlined the status of fuel substitution and fuel switching policies in each state.[114]
- **Benchmarking can lead to action:** Even though simple benchmarking policies do not have emissions reduction "teeth," studies suggest that benchmarking alone makes building owners more attentive to their buildings' energy use and often leads them to reduce energy use. For example, a recent analysis found that benchmarked buildings reduced energy consumption by 3%–8% over the first few years of policy implementation.[115] In the residential sector, energy labelling has shown energy reduction impacts from 7%–22% across various jurisdictions internationally. When benchmarking is paired with other strategies to reduce emissions, the impacts are generally much greater.
- **Lead-by-example standards drive energy savings:** EPA and DOE studies have shown that energy efficiency improvements in government buildings can generally cut energy use by 35% in existing buildings and 50% in buildings undergoing significant renovation, driving reductions in associated GHG emissions.[116]
- **Education has significant impact:** One case study from New York State provides evidence related to the impact of residential education efforts. In 2006, hundreds of energy efficiency outreach presentations reached more than 17,000 people. Evidence showed that about 70% of participants implemented recommended practices, reducing average annual home CO_2 emissions by 2.5 metric tons and energy bills by $400, saving about 15 million kWh in energy use, nearly $5 million in energy bills, and about 30,000 metric tons of CO_2 emissions in total.[117]

Cost and Economic Considerations

- **Market competition:** Benchmarking emissions enables market competition; evidence shows that tenants are willing to pay more for green buildings than similar but less efficient buildings, green buildings sell for higher prices, and tenants are more likely to rent and remain in green buildings.[118]
- **Cost savings:** Education that reduces building emissions and energy use can save consumers money overall, even when these savings require modest upfront investments. For states that import most of the energy consumed in their state, efficiency minimizes the amount of money leaving the state through energy bills.[119]
- **Job creation:** Market interventions that speed efficiency projects support the creation of jobs; the US energy efficiency industry supports nearly 2.4 million jobs, more than all jobs in fossil fuel extraction. Job creation from energy efficiency can happen both directly (e.g., in manufacturing and installation) and indirectly (e.g., through increased disposable income). Investing in energy efficiency measures can create 380 jobs per terawatt-hour (TWh) of electricity saved, whereas investing in fossil plants creates only 110 jobs per TWh of electricity generated.[120]
- **Appliance cost:** While electrification can be cost-effective today in many scenarios, retrofitting with heat pumps is often more expensive than installing replacement gas appliances. Lowering the cost to customers through incentives will be a crucial component of rapid decarbonization.
- **Improved state budgets:** Many states have the goal of reducing energy use in government buildings by at least 20%. This would, on average, cut annual energy bills by about $16 million.[121] Since energy expenditures can account for as much as 10% of a government's annual operating budget, these savings can provide valuable budget flexibility.

Equity Considerations

- **Disclosure provides visibility and consumer protection benefits:** Energy affordability is a major challenge for many families and disproportionately affects households of color.[122] Required energy and emissions disclosure provides important information (including ongoing energy cost information) to families buying and/or renting a home before they move in, informing their budgeting, decision-making, and selection processes.

- **Heat pumps provide efficient space cooling:** Space cooling is a growing need, and the urban heat island effect disproportionately affects vulnerable communities. Heat pumps offer efficient space cooling, and their installation should be prioritized for the most at-risk residents.
- **Programs should benefit the most vulnerable:** For example, 75% of funding for California's Building Initiative for Low Emissions Development (BUILD) new construction program must be spent in low-income communities.[123] Communities of color, which often have higher rates of asthma made worse by poor indoor air quality, should receive educational services that discuss the health benefits of electrification as well as the technical and financial support to electrify their homes.
- **Design programs with LMI communities:** Utility programs and market offerings should be designed with specific attention to and involvement from LMI and disadvantaged communities.
- **Rate design should carefully consider equity implications:** For example, while time-varying rates can support electrification, they should not cause bill spikes on the coldest day of the year.
- **Protect renters:** Strong renter protections are needed to prevent building owners from passing along the costs of upgrades to their tenants and avoid undue harm on renters, particularly low-income families.

Cross-sectoral considerations

- **Health:** States should consider coordinating public health initiatives with building decarbonization and electrification campaigns that benefit human health to further leverage funding and ensure cohesion.[124]
- **Broad energy education:** States should consider opportunities to combine building-related educational programs with education and outreach on other related topics (e.g., educating consumers about the cost and carbon benefits of zero carbon homes, on-site generation, demand flexibility, and EV use).
- **Transportation electrification:** Any utility business model changes or utility programs should consider how the change or program will impact transportation electrification.
- **Resilience and disaster-preparedness:** Preventative actions are far more cost-effective than disaster response. Dual benefits for both decarbonization and disaster preparedness may be possible by pairing the former with funding sources for the latter, driving improvements in, for example, building envelopes, roofs, and windows.

State Authority

- Educational campaigns are often run by a state agency in conjunction with external partners. For example, New York State's residential consumer-facing education program, CEPREE, exists as a partnership between the New York State Energy Research and Development Authority and the Cornell Cooperative Extension. State agencies could also delegate education responsibilities to utilities.
- To support a managed transition away from today's gas distribution system, states would need to establish a clear, legally enforceable vision for a climate-aligned future of utilities.

Key Partners

- **Public health groups** can be critical allies in customer awareness and market transformation.
- **Organizations focused on equity and environmental justice** are key stakeholders and should be meaningfully incorporated into decision-making, including regulatory proceedings.
- **Utilities** are crucial stakeholders throughout this transition; they are the key interface for building owners and tenants and can offer efficiency programs and education. Utility incentives should align with larger state policy goals.

Resources

- American Council for an Energy Efficient Economy (ACEEE)
- Gridworks: *Rate Design and Decarbonization: Social Equity Considerations in Rate Design*[125]
- National Association of State Energy Officials (NASEO)
- Regulatory Assistance Project: *Making Basic Service More Affordable: Electricity Rates for Low- and Moderate-Income Ratepayers*[126]
- RMI

Strengthen the Workforce and Supply Chain

A skilled clean energy workforce is critical to enabling decarbonization. Targeting market actors that are "upstream" from consumers can help accelerate adoption of newer technologies. Key policies to strengthen the supply chain include:

- **Supply-side incentives:** financial mechanisms that motivate market actors, such as manufacturers, distributors, and contractors, to develop the market for low-carbon building technologies
- **Workforce development:** initiatives that ensure everyone upstream of consumers, from building designers to installing contractors, understand the benefits of low-carbon technologies, have the skills and training to deploy them, and can play their part in accelerating sector decarbonization
- **Low-embodied-carbon materials and low-GWP refrigerants:** complementing declines in operational emissions by pursuing decarbonization through these two less-discussed avenues
- **Advanced building construction:** supporting off-site manufacturing and other supply chain innovations to make building construction faster and cheaper

Supply-Side Incentives

Building decarbonization requires a rapid transition to low-carbon appliances and equipment, and upstream market actors are generally unprepared to facilitate this transition at the pace required. Incentivizing original equipment manufacturers (OEMs), distributors, retailers, wholesalers, and contractors to embrace these new technologies appeals to their bottom line and can help move the market to meet the scale of the progress needed.

OEMs, distributors, retailers, wholesalers, and contractors have an outsized role in determining the equipment and appliances installed in homes and used by customers. Even if other technologies might be more cost-effective or environmentally friendly, customers are likely to go with the products that contractors recommend and have available. Many incumbent market actors are less familiar with critical low-emissions technologies and have little incentive to learn about them.

At the same time, they can be disincentivized to install modern, lower emissions appliances that require less maintenance or less frequent replacement. In addition, low-carbon appliances are too often installed improperly, and fossil-based heating systems are sometimes still used by building occupants after heat pumps have been installed. As a result, the supply chain does not produce, procure, or properly install the right equipment at the pace needed. Once installed, occupants and building managers are often not trained on how to use the equipment optimally.

Supply-side incentive programs can fill this critical gap. In general, incentive programs should first identify which supply-side actors in the state will be incentivized and how (e.g., manufacturers, based on their level of retail equipment sales). The program should market its benefits to the target audience and educate them about qualifying equipment. Successful incentives can directly increase the amount of low-carbon equipment sold and help ensure proper installation. Incentives can also ensure the equipment is properly used; for example, programs can incentivize contractors whose installations meet benchmarked energy savings within a particular time period. In addition to providing these direct emissions benefits, incentives often lead the targeted market actors to promote low-carbon technologies throughout other parts of the supply chain.[127]

Examples

- **California:** The proposed Technology and Equipment for Clean Heating (TECH) program allocates a $120 million budget to midstream incentives as well as contractor training and consumer education.[128]
- **Georgia:** Georgia Power provides incentives to heat pump salespeople, dealers, and owners.[129]
- **Maine:** Efficiency Maine provides a heat pump water heater rebate to plumbers.[130]
- **New York:** Consolidated Edison allocates distributor incentives.[131]

Workforce Development

The full potential of building decarbonization is generally not understood by building sector decision-makers. Unless these supply-side stakeholders become part of the solution, they will drive business-as-usual activities and create incumbent inertia. In the current economic crisis, there is a big opportunity to use workforce development, education, and training programs to provide career opportunities to unemployed people. There is also a need to consider existing fossil fuel workers, including oil and propane workers, and provide opportunities for a just transition of that workforce. In all cases, policymakers should aim to provide high-quality (i.e., "high-road"[132]) work opportunities, helping grow an equitably compensated and well-trained workforce.

These programs can take numerous forms, including workshops, media campaigns, appliance-lending libraries, specific-audience presentations (e.g., for homebuilders), and online resources. Education and training help ensure that building decarbonization solutions are implemented at a high quantity and are high quality. This work is often most effective when paired with other policies discussed in this roadmap, including incentives. Education and training will also drive more progress when they are required—for example, mandating particular courses as a requirement to receiving or renewing a contractor license.

These supply-side policies can focus on the technical job skills necessary for decarbonization, including understanding how various types of equipment work as well as how to construct, retrofit, and repair low-carbon building technologies. Currently, much of this work occurs through technical and vocational high schools, technical colleges, community colleges, state college systems, and union apprenticeship programs, which should receive appropriate policy support.

Developing business skills, in addition to technical skills, is also necessary, especially for general contractors. Business training focuses on the business opportunities in a decarbonizing economy and on the skills necessary to take advantage of these opportunities. This type of training provides existing professionals with the knowledge needed to play a leading role in implementing low-carbon solutions.

Workforce development can focus on students, designers, contractors, technical sales staff, real estate actors, and other professional service workers. In any case, these programs can serve as powerful tools to advance equity and workforce diversity and should focus explicitly on expanding the representation of groups such as women and racial minorities in building-related professions. For technical training, this can include, for example, supporting vocational high schools in communities of color, fostering and connecting with pre-apprenticeship programs for disadvantaged youth, and working with construction trade union locals that are committed to racial and gender equity.

Examples

- **Massachusetts:** Massachusetts Clean Energy Center helps LMI women enter the clean energy workforce by partnering with local nongovernment organizations.[133]
- **New York City, New York:** Envirolution's Win-Win Campaign provides skills, mentoring, and training for young adults related to green jobs.[134]
- **Oakland, California**: Oakland Green Jobs Corps helps residents in disadvantaged communities find green career opportunities.[135]
- **Tennessee:** Tennessee Energy Education Initiative, a collaborative led by the state government, provides workforce-related education to students.[136]

Low-Embodied-Carbon Materials and Low-GWP Refrigerants

Policies that address building decarbonization tend to focus on the majority of building emissions: operating emissions. However, focusing only on operating emissions ignores two important, often cost-effective solutions—supporting low-embodied-carbon strategies and low-GWP refrigerants. Both of these topics are often addressed as components within other strategies (e.g., code requirements) but deserve specific attention.

For a typical building, embodied carbon may equal 10 to 15 years of operating emissions; with contemporary, high-efficiency buildings, it can equal 50 years of operating emissions. Low-embodied-carbon strategies address the life cycle carbon emissions associated with building materials, from resource extraction to end-of-life. Solutions include embodied carbon limits in new buildings, waste handling requirements, financial instruments (e.g., low-embodied-carbon loans or incentives), and more. Design decisions that minimize the amount of material needed and limit the overspecification of materials can also substantially lower the amount of embodied carbon associated with a project.

Products that sequester carbon in the material itself (e.g., low-emissions concrete) may also represent an important emerging strategy and could make net-negative-carbon buildings possible in the future. At the same time, while many people think of using low-carbon or carbon-sequestering products as the primary method for decreasing embodied carbon, a much wider array of strategies is available. Policies can generally achieve earlier and more impact by focusing on pathways such as refurbishing buildings or finding ways to avoid the need for new construction entirely.[137]

Reducing embodied carbon reduces the acoustic, $PM_{2.5}$, and health harm caused by machinery and dust, manufacturing, and road transport. It can also lead to less area destroyed by resource extraction, more job creation, and less congested landfills.[138] Particular low-embodied-carbon strategies can also provide their own specific benefits. For example, mass timber, a low-carbon alternative to certain steel and cement applications, is safer during fires than these other materials can be. It is also often faster to assemble on-site, which shortens construction schedules and saves costs. Some concrete admixtures can reduce the amount of carbon-intensive cement needed while improving the product's workability and strength.

USCA's Short-Lived Climate Pollutant Working Group has also developed a roadmap to reduce these emissions, including those used in space conditioning.[139]

Many refrigerants are climate super-pollutants, and reducing their use and leakage is often a particularly cost-effective emission mitigation strategy. As they do for embodied carbon, solutions vary widely; states may consider the following:

- The emissions savings from heat pumps vastly outweigh the potential GHG emissions from refrigerant leakage; concern around refrigerant leakage should not prevent immediate heat pump deployment. For example, the Natural Resources Defense Council (NRDC) estimates that in the worst-case scenario, heat pump water heater refrigerant leakage offsets less than 10% of the lifetime emissions savings.[140]
- States can support or require low-GWP refrigerants, especially in larger commercial systems like VRFs, a type of heat pump technology that circulates refrigerant throughout a building. States can also support better installation and servicing of equipment to reduce leakage. Refrigerant policies or bans should be sure to cover all key technologies, including heat pumps.
- States that pursue low-GWP refrigerant alternatives should consider the tradeoffs related to flammability, cost, toxicity, or efficiency that many of these alternatives present. When leaked, many refrigerants used today break down to environmentally toxic substances. Many low-GWP refrigerants do not have this problem.
- States can support the recovery and destruction of high-GWP refrigerants at appliance end-of-life.
- States can examine opportunities to modify outdated fire codes or influence national model codes, which currently limit the use of certain natural refrigerants, such as propane refrigerant (R290), due to flammability concerns.
- States can support passive construction, which can dramatically reduce or eliminate the need for central heating and cooling and dramatically decrease the need for refrigerants.

A systems-wide view is necessary for complete building sector decarbonization, which necessitates a focus on reducing embodied carbon as well as high-GWP refrigerants. Both produce GHG emissions during parts of their life cycle that are often less visible to building occupants. These sources of emissions are significant and will only become more salient as operational carbon is reduced.

Examples

- EPA's Significant New Alternatives Policy (SNAP) Rules 20 and 21 mandated the phaseout of certain high-GWP refrigerants and were struck down but subsequently adopted by California, New Jersey, Vermont, and Washington.[141] Colorado, Hawaii, and Oregon have also recently announced that they intend to adopt the rules.
- The American Innovation and Manufacturing Act (AIM) Act, which passed in December 2020 as part of an omnibus bill, authorizes the US EPA to regulate a group of around 20 HFCs.
- **California**: Buy Clean Act.[142]
- **California**: Refrigerant Management Program.[143]
- **Marin County, California**: low-embodied-carbon concrete code.[144]
- **Quebec**: Wood Charter.[145]
- Numerous embodied carbon policies exist at the city level in the United States.[146]

Advanced Building Construction

The construction sector's productivity, the average value produced by employees in a given amount of time, has not improved over the past 70 years, unlike in most other industries.[147] This lagging productivity often leads to prolonged and more costly new construction and building retrofits. At the same time, cost-effective energy efficiency solutions are too often omitted from building construction.

Advanced building construction techniques mitigate these two problems by using off-site manufacturing of building components—as well as innovative installation and delivery practices—to increase building energy efficiency and project productivity. These solutions can decarbonize the building sector while improving building quality, price, resilience, and safety.

Example

- DOE's Advanced Building Construction Initiative[148]

The Workforce and Supply Chain: Key Considerations

Energy and Emissions Impacts

- **Embodied carbon impacts:** Building sector embodied carbon represents nearly 6% of US emissions, roughly one-seventh of the emissions from the building sector as a whole. This slice of emissions is key to sector-wide emissions reductions.
- **Refrigerant impacts:** In 2018, US air conditioner and heat pump emissions from leaking hydrofluorocarbons (HFCs), widespread and potent GHGs, were equal to the emissions of about 8–10 coal-fired powerplants.[149] However, this problem is still small compared to the overall benefits of heat pumps and should not in any way inhibit their adoption. Even in a worst-case scenario, leakage offsets less than 10% of the emissions benefits of a heat pump.
- **Alternative refrigerants:** Evidence suggests that HFC emissions could be reduced by 40% by 2030 using measures for certain refrigerants that are cost-effective or have a break-even price today.[150]

Cost and Economic Considerations

- **Market growth:** Supply-side incentives help to develop the market for key low-carbon technologies, bringing job creation and consumer savings as markets for new materials expand and costs decline.
- **Circular economy:** Turning waste into profit can lower embodied carbon emissions through, for example, reusing waste products such as slag, glass, rice husks, and sawdust for new processes or materials.

- **Workforce equity:** Workforce development, done right, can create career opportunities for people facing employment barriers.[151]
- **Lowered costs:** Reducing embodied carbon also often reduces costs because fewer materials are needed.[152]

Equity Considerations

- **Incentive allocation:** How incentives are allocated across stakeholders can have implications for equity. For example, some programs require that the full incentive be passed downstream to the customer while others let the market allocate it among supply chain actors.[153]
- **Equitable access:** Education and access to incentive programs should be equitable and should consider, for example, taking specific measures to ensure that women- and minority-owned businesses are able to participate. States could also consider pairing these incentives with targets for installations by women- and minority-owned businesses, for example.
- **Workforce diversity:** Workforce education and training programs should target communities that have historically lacked access to quality employment opportunities and can provide an opportunity to diversify the workforce, which, at least for energy efficiency, is currently dominated by white male employees. Women make up only 23% of this workforce, and Black workers are underrepresented as well.[154]
- **Financial solutions:** Solutions that require certain materials, technologies, or building types to reduce emissions from refrigerants and embodied carbon should be paired, when necessary, with financial mechanisms that align incentives and reduce inequitable effects of any cost increases that may result.

Cross-Sectoral Considerations

- **Aligning goals:** Supply chain initiatives should align with other goals. For example, incentives for heat pumps could be implemented in tandem with EV charging equipment initiatives since both may require panel upgrades and rewiring. Education initiatives could focus in particular on utility service territories that are trying to avoid costly demand-related grid infrastructure improvements.
- **Ensuring a broad focus:** Supply chain education should cover low-embodied-carbon materials and refrigerant leakage in addition to operational emissions.
- **Addressing upstream opportunities:** Any initiative aiming to lower embodied carbon emissions should not limit its focus to only the building sector. Effective strategies should also focus upstream in the industrial sector (e.g., incentivizing GHG reductions in steel manufacturing).

State Authority

- States can consider the implementation of supply-side incentives through three primary avenues.[155]
    1. State agencies, utilities, or other third parties may administer programs that are paid for by ratepayers and authorized through legislation or existing regulatory authority.
    2. Utilities may administer programs that are paid for by ratepayers through bundled rates.
    3. State agencies may administer incentives that are paid for by tax revenue.
- Supply-side education programs are often run by a combination of state agencies, utilities, and/or external partners. Programs can be enacted through legislation or implemented through existing executive or regulatory authority.
- Refrigerant management programs could be enacted through legislation or through existing regulatory or executive agencies, including building code or air quality agencies.
- State agencies governing education, economic development, housing, energy, or climate may all be sources of workforce training funds and authority, and coordination could potentially occur between these agencies to develop policies and programs.

Potential Challenges

- **Demand-side focus:** Education to improve the supply side will only succeed if paired with efforts to increase demand.
- **Established industries:** Many high-embodied carbon materials, such as concrete, steel, and aluminum, are extremely common, and targeting them could generate opposition from entrenched industries.

- **Rural access:** Providing workforce training in rural areas can be difficult as it may not be cost-effective to send a trainer to places where a low number of individuals will attend. At the same time, those same individuals may lack broadband internet access and may be unable to easily receive online training services as a result.

Key Partners

- **Industry practitioners** and supply chain representatives, especially those representing community-based organizations, to ensure that regulations effectively achieve emissions goals
- **Utilities**, not just in situations where utilities will be administering incentive programs
- **Organizations focused on equity and environmental justice** to help ensure that disadvantaged communities are able to experience the benefits of programs and to address potentially inequitable effects of price changes in housing, appliances, or materials
- **Financial institutions** to provide critical support to emerging low-embodied-carbon products
- Education is often accomplished through **implementing partners**, such as utilities, civil society organizations, or industry representatives

Policy Variants

- **Workforce development.** A variety of strategies fall under workforce development. Any or all of these should be implemented where appropriate:[156]
    - *Workforce training* provides skills to new or existing workers to help meet market demand.
    - *Job placement* programs help qualified workers enter the workforce.
    - *Job access* supports hiring equity.
- **Innovation.** Policies to accelerate the adoption of certain embodied carbon and refrigerant strategies could be broadened to accelerate technology innovation in other sectors.

State Context Considerations

- **Building stock:** Supply-side incentives are critically important in places with high levels of equipment installation, such as those with significant new construction or upgrade activity.
- **New construction rate:** States experiencing construction booms should consider investing in workforce development that focuses on more upstream portions of the supply chain, such as building design and construction. Embodied carbon considerations should be prioritized here as well.
- **Existing funding mechanisms:** States should consider how supply-side incentives could take advantage of existing funding pools or programs, streamlining their establishment.
- **Industry:** The industries present in a state may also determine the focus of embodied carbon policies. For example, states containing significant upstream portions of the market, such as manufacturing of carbon-intensive products, should consider supply-side policies that reduce emissions during the manufacturing process. Supporting mass timber may be particularly beneficial in states with significant sustainable forestry resources.

Resources

- Architecture 2030
- Building Electrification Initiative (BEI)
- Building Transparency
- Carbon Leadership Forum
- Emerald Cities Collaborative
- Energiesprong
- EPA's EnergyStar program
- "How to Use Midstream Incentives to Promote ENERGY STAR® Certified Consumer Electronics"[157]
- Inclusive Economics
- materialsCAN
- REALIZE[158]
- Urban Green Council's GPRO trainings[159]

Expand Access to Capital

Capital constraints represent a major barrier to the implementation of energy upgrades, and a variety of mechanisms can help manage upgrade costs and overcome split incentives between building owners and tenants. To make the efficiency improvements necessary for decarbonization, building owners must have access to capital to pay for those upgrades. States can support this access to capital through several mechanisms, including providing state funding, allowing for new funding mechanisms with appropriate consumer protections, and more. Capital solutions fall into two main categories: strategies that reduce costs and strategies that provide financing. In addition, states may want or need to provide additional public investment for building decarbonization, given the scale of transformation required.

Financing institutions may also need education to better understand efficiency, electrification, and energy storage. Lenders need to better understand the economics of new types of projects, including the opportunities that can arise from savings or the ways that green multifamily buildings can lead to more stable tenancy and higher performing buildings.

Reduce Costs

- **Aggregate purchasing:** Aggregate purchasing can reduce costs in several ways. State governments can organize bulk purchasing to secure lower prices and create a time-bound trigger to spur action as well as bulk purchase through their own procurement processes. States can support aggregate purchasing through making bulk procurement pools available to local entities, like local governments or utilities, as seen in the Michigan Municipal League.[160]
- **"Thermalize" programs:** Like solarize programs, "thermalize" programs allow a group of homes or businesses to make upgrades together through local community outreach. By working as a community to gather interested buyers, the community can secure lower costs from service providers. The providers, in return, reduce their lead-generation expenses and gain the benefits of a larger volume of contracts. States can support thermalize programs by providing education and partnerships to deliver thermalize program to local communities.
- **Improve service delivery:** Supply-side improvements, discussed above, can reduce installation costs.
- **Leverage other funding sources:** States can consider other sources of funding that may be applicable to building decarbonization, like health and resilience funding. For example, states could leverage health funding for efficiency improvements or stove replacements that improve public health. States should also align low-income energy assistance programs and weatherization programs with decarbonization goals. Money from the Low Income Home Energy Assistance Program has historically been used primarily for bill assistance, and states can explore opportunities to use these funds for efficiency improvements that would offer ongoing bill savings, rather than simply cash assistance paid directly to the utility. Low-income housing tax credits might also be expanded for efficient new construction. Community Reinvestment Act funds could also be aligned with these goals.

Provide Financing

- **Public investment:** In some cases, states may want or need to provide direct public investment to upgrade buildings, given the scale and speed of building decarbonization required. Such investment could be funded through tax revenues and could begin with a focus on affordable housing.
- **Inclusive financing:** States can allow utilities to offer on-bill financing programs, such as Pay-As-You-Save® (PAYS), where the utility invests upfront in cost-effective energy upgrades at customer sites, and customers repay over time through a fixed line-item on their utility bills. This type of model can enable significant uptake of energy efficiency projects and can greatly improve access to lower-income and underserved market segments. Financing from public or private sources can be provided to bill-payers

through the utility, allowing customers to see savings on their bills and pay for efficiency upgrades and energy costs in one place. Inclusive financing can also ensure that customers do not need to have a specific credit score or meet income thresholds to qualify, and the obligations would stay with the properties. Beyond on-bill financing, states can also offer other low-cost financing options, such as Colorado's RENU program.[161]

- **Energy Savings Performance Contracts (ESPCs):** ESPCs are contracts with private energy service companies for efficiency upgrades (typically in municipal, university, school, and hospital buildings), to pay for today's upgrades with tomorrow's savings. This approach also removes upfront costs for customers and guarantees savings. States can pass legislation to allow and encourage ESPCs as well as use them to upgrade publicly owned buildings. States can also support these programs through funds from a green bank or through subsidized loans.
- **Green banks:** Using public funds to stimulate private investment in strategic projects can help to overcome market barriers, especially for immature markets. Green banks can be used to support a variety of clean energy technologies and have historically supported projects focused on solar, EVs, building upgrades, and more. Product offerings may include credit enhancement, loan loss reserves, guarantees, term loans, or direct project finance. States can provide public funding and a mandate to establish a green bank, leveraging public funding with private capital to support specific building decarbonization strategies.
- **Property-assessed clean energy (PACE) financing:** PACE is a solution that allows building owners to finance clean energy improvements through a special property tax assessment. This approach ensures that repayment of the loan transfers with building ownership. PACE must be authorized by state legislation, and once passed, states can convene a decision-making body to design and run a PACE program. PACE programs should be expansive enough to offer financing for a wide range of projects, including those focused on resilience, energy efficiency, and renewable energy, for both new construction and existing buildings. Thirty-seven states already have PACE-enabling legislation, twenty-two of which have active programs.[162] Most of these are for commercial buildings only, referred to as C-PACE. Only three states have an active residential (R-PACE) program at this time. As of 2020, R-PACE programs are awaiting new rulemaking from the Consumer Financial Protections Bureau, which may determine how these programs function in the future.
- **Green leases:** Green leases allow tenants and owners to share the costs and benefits of energy upgrades by addressing split incentives. For example, rather than a landlord paying upfront for building upgrades when the savings would accrue to tenants (who commonly pay energy bills), amortized capital costs for energy upgrades can be passed through to tenants under a green lease such that the landlord is gradually reimbursed over time. Green leases can also include other considerations—for example, efficiency requirements for tenant fit-outs and appliances and commitments to energy management and other sustainable building operations. To support green leases, states can provide education and model green leases to the real estate community. States could also require multitenant commercial buildings to offer green lease options to tenants.
- **Green mortgages:** Green mortgages can provide financing for efficiency upgrades when buying or refinancing a home, rolling the upfront project costs into mortgage loans and spreading repayment over typical 30-year schedules at among the lowest costs of capital available. While single-family green mortgage products exist (e.g., offered by Fannie Mae, Freddie Mac, Federal Housing Administration, etc.), consumer awareness and adoption remain low. States could require lenders to make homeowners aware of green mortgage product options.
- **Social investing and concessionary capital:** Philanthropic organizations and other investment organizations can provide more favorable terms for mission-aligned or program-related investments. States can provide support with legislation that allows for social investing, or they can consider a requirement that banks invest a percentage of their portfolio in carbon-neutral technologies.

Access to Capital: Key Considerations

Energy and Emissions Impacts

- **Financial accessibility:** Availability of capital increases the feasibility of decarbonization projects and policies. Lowering costs or expanding access to capital alone will not in itself lower emissions, but making projects financially accessible will ensure that efficiency upgrades and efficient construction actually happen.
- **Technology adoption:** By enabling access to capital, financing solutions can support clean energy technologies that would not otherwise be installed. The Connecticut Green Bank, for example, has avoided more than 8.7 million tons of CO_2 through its investments.[163]

Cost and Economic Considerations

- **Equitable sharing of benefits:** For measures funded by taxes, the benefits of the program should be equitably shared, and low-income customers should not be paying more than their fair share.
- **Bill savings:** Enabling efficiency improvements that do not require large upfront costs yet provide ongoing bill savings to customers can be especially important for LMI customers who face disproportionate energy burdens.

Equity Considerations

- **Enabling access:** On-bill financing solutions like PAYS® and reducing or eliminating credit requirements can ensure that low-income and disadvantaged communities are able to access clean energy improvements. Without financing solutions that are designed with low-income communities in mind, these households may be excluded from clean energy opportunities.
- **Affordable housing:** PACE financing can be an effective source of funding for affordable housing that might otherwise not attract financing. Low-income customers can then see bill savings from improved efficiency.

State Authority

- States can use legislation to establish green banks and enable social investing.
- Executive orders can establish new sources of funding.
- PACE needs to be enabled legislatively, which allows local governments to launch programs, but a department-led program to create consistent PACE efforts can accelerate adoption.
- Regulatory powers may be needed to enable on-bill financing or on-bill tariff solutions.

Potential Challenges

- **COVID-19:** Given the economic downturn as a result of COVID-19, states may have to make difficult choices regarding budgeting and funding. When determining how to fund building decarbonization efforts, states should consider the job opportunities and other co-benefits that can come by funding clean energy projects—including increased comfort and indoor air quality during prolonged stay-at-home periods.
- **Education:** Green leases, PACE financing, green banks, ESPCs, and other financing tools are often not well-understood and therefore are not yet common outside of the Class A commercial office sector.
- **Budgeting systems:** Aligning different funding streams can be challenging, as state budgets for different departments are not always designed with collaboration in mind.

Resources

- Affordable housing providers
- Clean Energy Works (PAYS®)
- Coalition for Green Capital (CGC)
- Fannie Mae and Freddie Mac
- Green Lease Leaders program
- Inclusive Prosperity Capital

- PACENation
- Tenant associations

Examples

- **Connecticut:** The Connecticut Green Bank was established in 2011 and has been providing funding for clean energy projects since.[164]
- **Maine:** low-income weatherization funding is used for heat pump incentives, expanding available funding.[165]
- The **PAYS**® model uses tariffed on-bill financing for energy efficiency upgrades. This model is being implemented successfully through utilities across the country.[166]

CONCLUSION

Rapid decarbonization is necessary to ensure that our economy, environment, and communities are healthy and resilient; targeted, comprehensive policy action is needed to drive this decarbonization at the appropriate pace. Fortunately, the buildings sector presents many opportunities for progress. The extensive menu of policy options outlined in this roadmap provides states with a variety of paths to suit each specific context and helps states realize these opportunities.

Building decarbonization policies provide widespread benefits. Low-carbon construction practices and retrofits can improve indoor and outdoor air quality, benefitting human health. Innovations in buildings can also help to protect occupants from extreme temperature swings and strong storms, both of which are increasing as a result of climate change. Decarbonization in the building sector can help accelerate the adoption of new technologies and new practices, driving economic development and job growth. Well-designed policies also provide important benefits, such as energy affordability improvements and technology access, to marginalized or disadvantaged communities. They can even be used to correct for historic inequities.

Policies to achieve these benefits range widely and include building codes, performance standards, energy market policy and regulation, developing equipment supply chains, and supporting innovative financing models. Now is the time for state policy to pave the way to progress.

APPENDIX

Below are descriptions of organizations with expertise regarding the strategies discussed in this roadmap. While organizations may have expertise beyond the bulleted strategies, bullets highlight key areas where organizations may be able to offer support. Organizations without bullets have a wide focus and can offer support across several strategies.

American Council for an Energy Efficient Economy (ACEEE): ACEEE, a nonprofit, 501(c)(3) organization, acts as a catalyst to advance energy efficiency policies, programs, technologies, investments, and behaviors. ACEEE aims to build a vibrant and equitable economy—one that uses energy more productively, reduces costs, protects the environment, and promotes the health, safety, and well-being of everyone.

- Transform the energy market

Architecture 2030: Architecture 2030's mission is to rapidly transform the global built environment from the major contributor of GHG emissions to a central part of the solution to the climate crisis. Architecture 2030 pursues two primary objectives: (1) to achieve a dramatic reduction in the energy consumption and GHG emissions of the built environment; and (2) to advance the development of sustainable, resilient, equitable, and carbon-neutral buildings and communities.

- Foster zero-carbon new construction

Building Electrification Initiative (BEI): BEI builds on the work of leading cities, supported by the Urban Sustainability Directors Network and the Carbon Neutral Cities Alliance, to pilot strategies to scale up the electrification of building heating and cooling systems. Over the past four years, a growing number of cities have become active in this work to equitably transition their buildings away from fossil fuels. BEI provides guidance around three main topics: local and regional market development, including workforce development; state and regional partnerships and strategy development; and equitable transition and inclusive decision-making.

Building Transparency: Building Transparency's core mission is to provide the open access data and tools necessary to enable broad and swift action across the building industry in addressing embodied carbon's role in climate change. The Embodied Carbon in Construction Calculator tool, allows benchmarking, assessment, and reductions in embodied carbon per material category.

- Transform the energy market

Carbon Leadership Forum: The Carbon Leadership Forum propels knowledge through its embodied carbon research and resources, collaboration through its robust network of architects, engineers, contractors, material suppliers, building owners, policymakers and associations, and action by supporting and empowering its members to advance new ideas and approaches through impactful initiatives.

- Foster zero-carbon new construction
- Strengthen the workforce and supply chain

Clean Energy Works: PAYS® harnesses a proven utility investment model to offer virtually all consumers cost-effective energy building upgrades through tariffed on-bill financing. The utility invests in cost-effective energy upgrades at customer sites, without upfront costs to customers. Instead the utility pays the installer. Using a tariff, the utility puts a fixed charge on the customer's monthly bill that is less than the estimated savings generated by the upgrade, allowing the customer to enjoy immediate and sustained cash flow. Until the investment is recovered, the tariff for the PAYS charge automatically transfers to future customers at that site.

- Transform the energy market
- Expand access to capital

Coalition for Green Capital (CGC): CGC is a nonprofit with a mission to halt climate change by accelerating investment in clean energy technologies. CGC achieves this mission by advocating for, creating, and implementing Green Bank finance institutions. Green Banks are a proven finance model that uses public and philanthropic funds to mobilize private investment in renewable energy, energy efficiency, and other decarbonization technologies. For over a decade, CGC has led the Green Bank movement, working at the federal, state and local level in the United States and in countries around the world.

- Expand access to capital

Emerald Cities Collaborative (ECC): ECC is a national nonprofit network of organizations working together to advance a sustainable environment while creating high-road—sustainable, just, and inclusive—economies with opportunities for all. ECC develops energy, green infrastructure, and other sustainable development projects that not only contribute to the resilience of metropolitan regions but also ensure an equity stake for low-income communities of color in the green economy. This includes developing the economic infrastructure for family-supporting wages and career paths for residents of such communities, as well as contracting opportunities for women, minority, and other disadvantaged businesses.

ENERGY STAR®: ENERGY STAR®, a program of the EPA, is the government-backed symbol for energy efficiency, providing simple, credible, and unbiased information that consumers and businesses rely on to make well-informed decisions. Thousands of industrial, commercial, utility, state, and local organizations—including about 40% of the Fortune 500®—partner with the EPA to deliver cost-saving energy efficiency solutions that improve air quality and protect the climate.

- Establish building standards and equipment requirements

Fannie Mae: Fannie Mae's mission is to provide a stable source of liquidity for mortgage lending, supporting greater access to affordable home and rental housing finance in all markets, at all times. Fannie Mae helps facilitate the flow of capital into the US housing market by issuing and guaranteeing mortgage-related securities. This work helps make the 30-year fixed-rate mortgage—a mainstay of the US mortgage market—possible.

- Expand access to capital

Freddie Mac: Freddie Mac makes homeownership and rental housing more accessible and affordable. Operating in the secondary mortgage market, Freddie Mac keeps mortgage capital flowing by purchasing mortgage loans from lenders so they in turn can provide more loans to qualified borrowers. Freddie Mac's mission to provide liquidity, stability, and affordability to the US housing market in all economic conditions extends to all communities from coast to coast.

- Expand access to capital

Green Lease Leaders: Launched in 2014 by the DOE's Better Buildings Alliance and the IMT, Green Lease Leaders is a national program that sets standards for what constitutes a green lease and recognizes cross-sector landlords and tenants for creating and implementing those leases. Resources include reference guides, online lease assessments, and case studies.

- Expand access to capital

Greenlining Institute: The Greenlining Institute is a policy, research, organizing, and leadership institute working for racial and economic justice. Greenlining works on a variety of major policy issues, from the economy to environmental policy, health care, and many others. Greenlining's approach connects community leaders with policymakers, researchers and private sector leaders. Through the design and support of policies designed to open doors to opportunity, Greenlining recognizes that America's racial wealth gap was created by deliberate policy choices, and it will take deliberate, race-conscious choices to end it.

- Transform the energy market

Gridworks: Gridworks' mission is to convene, educate, and empower stakeholders working to decarbonize electricity grids. Gridworks facilitated a series of discussions between key consumer, labor, equity, utility, and environmental stakeholders and authored the report *California's Gas System in Transition: Equitable, Affordable, Decarbonized, and Smaller*. This report shows how a suite of local and state-wide policies resulting from California's commitment to 100% clean electricity and carbon-neutrality are set to cause a significant reduction in gas demand in coming decades.

- Transform the energy market
- Foster zero-carbon new construction

Inclusive Economics: Inclusive Economics conducts research on the employment, economic, equity impacts of energy transitions, and climate policies. Services also include advising on policies to improve workforce outcomes from climate and clean policies and programs.

- Strengthen the workforce and supply chain

Inclusive Prosperity Capital: Inclusive Prosperity Capital, Inc. is a not-for-profit investment fund scaling energy financing solutions that channels investment capital to program partners in communities that need it most. The green energy economy is growing, but Inclusive Prosperity Capital discovered that there is a financing gap that prevents equal access. Inclusive Prosperity Capital addresses this gap by increasing access to capital for LMI communities and nontraditional credits like nonprofits, faith-based organizations, housing authorities, schools, and smaller businesses. Through its suite of financing products and network of partners, Inclusive Prosperity Capital will reduce the energy burden on residents, improve the health and resiliency of homes and multifamily properties, and help businesses and nonprofits in distressed communities.

- Expand access to capital

Institute for Market Transformation (IMT): IMT catalyzes demand for high-performing buildings in three main ways. IMT creates paths to broad and deep whole-building energy reductions across a wide selection of geographies and building types. IMT crafts and activates local networks to deploy efficiency faster and deeper in all stages of building use, from financing, design, and construction, through occupancy, tenant turnover, renovation, and disposition. IMT works to enable efficiency in buildings and regions where it would otherwise not be a priority.

- Establish building standards and equipment requirements

materialsCAN: materialsCAN includes members of the global building industry that are ready to act on the smart prioritization of embodied carbon in building materials. MaterialsCAN provides specific and practical strategies for selecting products and materials that reduce embodied carbon emissions and move the industry toward making carbon-storing products the rule, rather than the exception.

- Low-embodied-carbon materials and low-GWP refrigerants

National Association of State Energy Officials (NASEO): NASEO is the only national nonprofit association for the governor-designated energy officials from each of the 56 states and territories. Formed by the states in 1986, NASEO facilitates peer learning among state energy officials, serves as a resource for and about state energy offices, and advocates the interests of the state energy offices to Congress and federal agencies.

New Buildings Institute (NBI): NBI is a nonprofit organization pushing for better energy performance in buildings. NBI works collaboratively with industry market players—governments, utilities, energy efficiency advocates and building professionals—to promote advanced design practices, innovative technologies, public policies, and programs that improve energy efficiency. NBI also develops and offers guidance and tools to support the design and construction of energy efficient buildings.

- Foster zero-carbon new construction

PACENation: PACENation's mission is to promote PACE financing by providing leadership and support for a growing universe of PACE market participants. PACENation is movement of people and organizations who are joined in their support for PACE financing. Members may have different individual goals, but they share a desire to create energy and resource-efficient communities.

- Expand access to capital

Regulatory Assistance Project (RAP)®: RAP is an independent, non-partisan, non-governmental organization dedicated to accelerating the transition to a clean, reliable, and efficient energy future. RAP crafts innovative, practical, and forward-looking policy and market solutions designed to meet local needs and, through the network, can quickly share lessons learned across the globe.

- Transform the energy market

RMI: RMI's mission is to transform global energy use to create a clean, prosperous, and secure low-carbon future. RMI engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. RMI employs rigorous research, analysis, and whole-systems expertise to develop breakthrough insights. RMI then convenes and collaborates with diverse partners—business, government, academic, nonprofit, philanthropic, and military—to accelerate and scale solutions.

US DOE Building Energy Codes Program: The US DOE Building Energy Codes Program is conducting a series of research studies investigating energy code implementation in residential and commercial buildings. The goal of the study is to help document baseline practices, target areas for improvement, and quantify related savings potential. This information is intended to assist states in measuring energy code compliance and to identify areas of focus for future education and training initiatives.

- Transform the energy market

Urban Green Council GPRO: GPRO is a comprehensive national training and certificate program developed by Urban Green Council. The program teaches the principles of sustainability and trade-specific green construction knowledge to people who build, renovate, and maintain buildings. GPRO is designed for the experienced building professional who seeks to integrate green practices into the core knowledge of their trade.

- Strengthen the workforce and supply chain

Image courtesy of Alamy.

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