Reframing Energy Efficient Buildings as Heat-Resilience Infrastructure for Maintaining Safe Indoor Temperatures

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ABSTRACT

Extreme heat is one of the fastest-growing climate hazards in the United States, driving rising mortality, increasing electricity demand, and placing strain on buildings and energy systems. Much of the health risk associated with extreme heat occurs indoors, where building characteristics, cooling access, and power reliability determine whether buildings can maintain safe temperatures for occupants. Maintaining safe indoor temperatures is the primary defense against extreme heat, making buildings a critical form of heat-resilience infrastructure. This paper examines the role of energy efficiency in enabling buildings to protect public health while strengthening energy system resilience. It first outlines key determinants of indoor temperatures during extreme heat, including building envelope performance, cooling equipment efficiency, solar heat gain, power outages, and neighborhood heat exposure, and links them to interventions that improve indoor thermal safety. These interventions include building energy codes and retrofit programs that strengthen building envelopes, initiatives expanding access to efficient cooling technologies, urban heat mitigation strategies, and distributed energy resources that maintain cooling during grid disruptions. Drawing on examples from utility programs and local governments, this paper illustrates how these strategies reduce heat exposure, lower peak electricity demand, and improve resilience for vulnerable households. The analysis highlights how indoor thermal safety outcomes are shaped by decisions across the built environment, energy systems, and community planning. As a result, aligning planning and policy across these domains can help decision makers better target efficiency investments to reduce heat-related health risks, expand equitable access to cooling, and strengthen community resilience.

Introduction

Extreme heat is among the fastest-growing climate hazards in the United States, posing significant risks to public health, energy systems, and community resilience. Between 1999 and 2023, more than 21,500 heat-related deaths occurred in the United States, and in recent years, annual mortality rates have remained at or above the long-term average (Howard et al. 2024). Extreme heat is also becoming more frequent and intense. U.S. cities now experience up to 10 extreme heat events[1] per year, and heat-wave seasons last about 46 days longer than in the 1960s. Projections suggest that much of the country could see 15–30 additional days above 95°F annually, with dangerously hot days above 100°F or 105°F becoming increasingly common (Center for Climate and Energy Solutions (C2ES), n.d.). For example, in Washington State, average summer temperatures could rise 3.7°F by 2049 and as much as 10.5°F by the 2080s,

[1] Extreme heat is defined as a period of high heat and humidity with temperatures above 90°F for at least two to three days (https://heat.gov/learn-about-extreme-heat/).

while some locations in King County (greater Seattle) already experience temperatures up to 20°F hotter than surrounding areas due to urban heat islands and limited shade (King County 2024).

Importantly, much of this mortality occurs indoors, where building energy performance, access to efficient cooling, neighborhood heat exposure, and power reliability determine whether buildings can maintain safe temperatures for occupants. Maintaining safe indoor temperatures is the primary defense against extreme heat; buildings should therefore be treated as essential heat-resilience infrastructure. A range of strategies influences whether buildings can fulfill this role, including improvements to building envelopes, high-efficiency cooling equipment, and weatherization that reduces indoor heat exposure. These measures improve the effectiveness and affordability of cooling and reduce peak electricity demand during extreme heat events (Franconi et al. 2023). Other measures—such as passive design strategies[2] like shading and cool surfaces, distributed energy resources, and public education and awareness—can further strengthen buildings' ability to maintain safe indoor conditions during extreme heat. By enabling buildings to maintain safer indoor temperatures while reducing strain on the electric grid, these strategies can simultaneously protect public health and strengthen community resilience. Recognizing buildings as heat-resilience infrastructure requires utilities, policymakers, and other decision-makers to reflect this role in the policies and programs that enable these strategies.

National Weather Service data show that nearly half, about 45%, of heat-related deaths recorded in the United States with a known location over the past two decades occurred in homes, more than outdoors (41%), in vehicles (12%), or any other setting (Kim, 2024). Many people who die during heat waves lack air conditioning or have health conditions that make them especially vulnerable to extreme heat. City-level data reinforce this pattern: New York City's 2025 Heat-Related Mortality Report estimates an average of 525 heat-related deaths each summer (2018–2022) and identifies lack of home air conditioning as the most important risk factor for heat-stress death (New York City Government 2025). Among people exposed to dangerous heat at home, deaths most often occurred in non-air-conditioned homes. Without air conditioning, indoor temperatures can remain significantly higher than outdoor temperatures, especially overnight and for days after a heat wave, prolonging exposure and increasing risk (New York City Government 2025). While passive cooling strategies such as opening windows may help in some contexts, their effectiveness can be limited by factors such as outdoor air quality, noise, and security concerns, which may discourage their use.

This burden is not evenly distributed. In New York City, Black residents experience heat-stress death rates twice as high as white residents, and mortality rates are higher in neighborhoods with greater poverty. These disparities reflect structural inequities in housing quality, income, health care access, and the affordability of air conditioning. As a result, extreme heat both reflects and reinforces existing social inequities, making equitable access to safe, affordable cooling and resilient housing central to reducing heat-related mortality.

Extreme heat also threatens communities by straining the energy systems that households depend on to stay safe. As temperatures rise, demand for air conditioning surges, increasing the

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[2] Passive design is defined as building and site design strategies that use natural climate forces to reduce heating, cooling, and lighting loads without relying on active mechanical systems (https://aiacalifornia.org/news/things-you-can-do-right-now-passive-design/).

risk of grid stress, rolling outages, or equipment failures during the very moments when cooling is most important (U.S. Climate Resilience Toolkit 2025). When the power goes out during a heat wave, indoor temperatures can rise quickly—especially in poorly insulated buildings—placing older adults, people with chronic health conditions, and occupants of older, inefficient buildings at immediate risk.

This paper examines how energy-efficient buildings and the systems that support them can function as a tool for protecting communities from extreme heat. In this paper, *heat-resilient buildings* refers to structures whose design, equipment, and operation enable them to maintain safe indoor temperatures under extreme heat, even when the broader energy system or neighborhood conditions are stressed. It focuses on interventions that directly influence indoor thermal safety, including building codes and high-performance design, household access to efficient cooling technologies, neighborhood heat-mitigation strategies, and energy system reliability. Unlike many hazard-specific resilience investments whose benefits are realized primarily during extreme events, energy efficiency measures provide continuous co-benefits such as lower energy costs and improved comfort under normal conditions, while also enhancing protection during heat extremes. Through these examples, this paper highlights how energy efficiency policies and programs can play a central role in reducing heat-related risk while strengthening the resilience of buildings, communities, and energy systems.

Factors Shaping Indoor Temperature During Extreme Heat

Indoor temperatures during extreme heat are influenced by a combination of building characteristics, cooling systems, occupant behavior, and neighborhood conditions. This section introduces the primary factors that shape indoor temperatures and the interventions that can improve heat resilience, while reducing energy costs, lowering peak electricity demand, and improving health and comfort outcomes. Table 1 summarizes many of these measures, their interactions, and the populations or systems that benefit from each, highlighting how integrated approaches maximize heat resilience at multiple scales.

Building Envelope Performance

Improving building envelope performance can significantly reduce the amount of heat entering a building and help maintain safer indoor temperatures during extreme heat. Measures such as adding insulation to walls and attics; installing continuous exterior insulation; sealing air leaks around windows, doors, ducts, and other openings; and improving window performance limit heat transfer, reduce unwanted heat gain and prevent hot outdoor air from infiltrating the building. These improvements not only stabilize indoor temperatures and reduce reliance on mechanical cooling, but also reduce energy costs. Air sealing and insulation can reduce heating and cooling costs by about 15% on average (or roughly 11% of total household energy costs) (ENERGY STAR, n.d.). Because envelope improvements provide passive thermal protection, they continue to moderate indoor temperatures even during power outages or cooling system failures, making them a foundational heat resilience strategy.

Mechanical Cooling System Performance and Access

Properly sized and maintained mechanical cooling systems—such as air conditioners and heat pumps—play a key role in keeping homes safe and comfortable during extreme heat. Cooling accounts for a significant portion of household energy use, representing about one-fifth of home electricity consumption (U.S. Energy Information Administration, n.d.). The average U.S. household is projected to spend $792 on electricity this summer, with cooling costs up more than 39% since 2020 (National Energy Assistance Directors Association (NEADA) 2026). ENERGY STAR®–certified central air conditioners use approximately 25% less electricity than standard units (ENERGY Star, n.d.), providing meaningful savings for households while reducing peak electricity demand.

Access to functional cooling is equally important, particularly for vulnerable populations such as low-income households, seniors, and people with pre-existing health conditions. Programs that provide financial support for access to high-efficiency cooling technologies, maintenance, replacement, or utility bill assistance can help ensure that all households can stay cool during heat waves. Unlike passive building measures, mechanical cooling directly controls indoor temperatures during extreme heat, making access to efficient cooling equipment essential for preventing heat-related illness and death.

Solar Gains and External Heat Exposure

Solar gains—the heat energy entering a building from sunlight—can significantly raise indoor temperatures during extreme heat events. Windows account for 25–30% of residential heating and cooling energy use, making glazing and shading strategies essential (U.S. Department of Energy, n.d.-b). High-performance windows with low-emissivity coatings can reduce heat loss by up to 50%, lowering reliance on mechanical cooling and heat exposure risk (U.S. Department of Energy, n.d.-c). Highly insulating windows with a whole-window R-value of 5 (U-factor ~0.2) represent the top tier for cold and mixed climates, compared with typical ENERGY STAR windows (R-value 3). Even more modest upgrades beyond standard windows can improve thermal performance and reduce heat transfer. Upgrading from R3 to R5 reduces average heat loss by around 40% (U.S. Department of Energy Office of Energy Efficiency and Renewable Energy 2010), and low-E glass has been proven cost effective, with payback periods of just 2–5 years across all climates and window types (Pacific Northwest National Laboratory 2015).

Shading and window orientation further reduce solar heat gain, often more affordably than replacing windows. While window orientation is primarily determined during new construction or major renovations, overhangs provide strong protection for south-facing windows, and awnings can block up to 65% of solar heat on south-facing windows and 77% on west-facing windows (U.S. Department of Energy, n.d.-a). Exterior roller screens, shades, or shutters block sunlight before it reaches the glass, and deciduous vegetation provides seasonal shading. Interior solutions like blinds or insulated curtains also limit solar heat gain, with temporary coverings—sheets or foil—available for urgent situations.

Cool roofs, which reflect sunlight and shed absorbed heat efficiently, can lower roof-surface temperatures by 50–90°F and reduce indoor heat gains by 10–20% (Environmental and Energy Study Institute, 2010). In air-conditioned homes, they can cut peak cooling demand by up to 27% and total cooling costs by 7–15%, while reducing strain on AC systems and the electricity grid (U.S. Environmental Protection Agency, n.d.). In non-air-conditioned buildings, cool roofs can lower maximum indoor temperatures by 2–6°F and help mitigate the urban heat island effect (Cool Roof Rating Council, n.d.).

Together, efficient windows, shading strategies, and cool roofs reduce solar heat gain, lowering indoor temperatures and cooling demand during extreme heat. Policies and programs such as building codes, above-code standards, and retrofit incentives can help accelerate adoption of these strategies across both new and existing buildings.

Reliable Power Supply

A reliable electricity supply is essential for keeping homes and communities safe during extreme heat events. Power outages that leave residents without air conditioning and refrigeration create serious health risks: a U.S. study found that each additional hour of outage measurably increases mortality, and heat-related deaths are substantially worse when outages coincide with hot days (Ai et al. 2023). In cities like Atlanta, Detroit, and Phoenix, multi-day blackouts overlapping with heat waves have more than doubled heat-related mortality, with up to 50% of the population potentially requiring medical attention under some scenarios. Large blackout events in the United States—affecting more than 50,000 customers—have more than doubled in recent years, most occurring during summer peak demand periods (Stone et al. 2023). This underscores the importance of reducing both the likelihood and the consequences of power outages. Distributed energy resources such as rooftop solar paired with battery storage can maintain essential services and safe indoor temperatures during blackouts while also helping reduce peak demand under normal grid conditions. Energy efficiency complements these resources by reducing electricity demand, relieving stress on the grid to lower outage risk, and reducing the amount of backup power needed to maintain safe indoor conditions. As a result, battery systems can operate longer, reducing reliance on backup generators and the associated fuel costs and emissions.

Occupant Behavior

Occupant behavior plays an important role in managing indoor temperatures and reducing energy use during extreme heat events. Simple actions, such as closing blinds or curtains during the hottest parts of the day, using ceiling or portable fans effectively, and shifting energy-intensive activities to cooler periods, can significantly reduce indoor heat exposure and lower cooling costs. In homes with air conditioning, setting thermostats to moderate temperatures and properly maintaining systems help limit energy use while maintaining comfort. These behaviors are particularly important for households with limited resources, as they provide low- or no-cost opportunities to improve comfort and reduce utility bills. While occupant actions alone cannot fully address extreme heat, they can significantly enhance the effectiveness of energy efficiency measures. Behavioral measures cannot overcome severe heat exposure on their own, but they can enhance the effectiveness of physical building improvements and provide immediate, low-cost actions that households can implement during extreme heat events.

How Heat-Resilient Buildings Benefit People, Communities, and the Grid

Energy efficiency and resilient building design do more than just lower energy bills—they create interconnected benefits across households, communities, and the energy system. By reducing heat gain, improving envelope performance, and supporting reliable mechanical systems, these measures ease grid stress, enhance occupant comfort, and improve passive survivability during outages. The following table illustrates how different heat-resilience interventions interact and highlights who benefits from each, from individual households to utilities and broader communities. The previous section describes the primary factors that influence indoor temperatures and interventions to address them. Table 1 summarizes these measures and illustrates how they improve heat resilience and benefit households, communities, and energy systems.

Table 1. Interventions to Enhance Indoor Comfort and Energy System Resilience[3]

Intervention Category	Example Measures/Programs	Heat Resilience Benefits	Primary Beneficiaries
Energy Efficiency Retrofits	Insulation upgrades, air sealing, high-performance windows, efficient air conditioning and heat pumps, reflective roofing	Improves building thermal performance and reduces cooling loads	Residents, renters, building owners; utilities through reduced demand
Building Energy Codes & Above-Code Standards	Modern building energy codes, stretch codes, passive design requirements, cooling efficiency standards	Ensures new construction and renovations meet efficiency and cooling standards	Future building occupants, communities, utilities through lower system demand
Utility & Public Efficiency Programs	Utility rebate programs, weatherization assistance, income-qualified efficiency programs, efficiency financing programs	Expands access to upgrades that lower indoor temperatures and peak electricity demand	Residents (especially low-income households), utilities, communities
Community Resilience Infrastructure	Cooling centers, resilience hubs, community facilities with backup power and efficient cooling systems	Provides safe, cooled spaces and services during heat events	Vulnerable populations, communities, local emergency response systems

[3]Program examples are illustrative rather than comprehensive. Some intervention categories are supported by multiple programs discussed in the following sections, while others do not have a single dedicated case study. The table is intended to present a typology of intervention approaches rather than a complete mapping of programs.

Distributed Energy Resources & Demand-Side Grid Programs	Rooftop solar, battery storage, demand response programs, virtual power plants, thermal energy storage	Reduces peak demand and supports backup power during outages	Utilities/grid operators, residents, community facilities

Together, these categories of heat-resilience interventions—energy efficiency retrofits, building codes and above-code standards, utility programs, community resilience infrastructure, distributed energy resources, and public outreach—support buildings in functioning as heat-resilience infrastructure. Through measures such as insulation upgrades, efficient cooling systems, cooling centers, and demand-response programs, these interventions improve indoor thermal conditions, reduce energy demand, and strengthen the energy system's resilience during extreme heat. By enabling buildings to maintain safer indoor temperatures while reducing strain on the grid, they deliver tangible benefits to households, communities, and utilities, particularly for populations most vulnerable to extreme heat, and can reduce reliance on emergency cooling centers, shelters, and health care services during extreme heat events, especially when heat waves coincide with power outages or other disaster conditions.

Programs Supporting Buildings as Extreme-Heat Resilience Infrastructure

This section highlights programs in action, building from examples in Table 1and the discussion of the factors impacting indoor temperature during extreme heat. These examples show how utilities, local governments, and community partners can implement initiatives that enhance resilience to extreme heat—not only at the building and individual level, but also across communities and the energy system. The programs fall into several categories: building design requirements (including energy codes, specialty codes, and above-code standards for new construction), access to mechanical cooling and equipment in homes, strategies to reduce neighborhood and urban heat exposure, and energy system reliability and backup capacity. Across all categories, these programs demonstrate how interventions can be structured to deliver community-wide benefits, with particular attention to heat-vulnerable and disadvantaged populations.

Codes and Above-Code Building Design

Research shows that stronger codes improve passive survivability during power outages. A 2023 modeling study conducted by three U.S. Department of Energy (DOE) National Laboratories found that homes built to IECC 2021 or Passive House standards remain habitable far longer during extended outages than typical homes. For instance, during a modeled 7-day extreme heat event in Atlanta, typical homes remained habitable for 1.4 days, code-compliant homes for 2.3 days, and Passive House homes for the full 7 days—a 409% improvement over existing stock. A second study also found that Passive House standards can reduce excess deaths during heat events by up to 93% while lowering property damage risks, such as mold growth, burst pipes, and foundation damage (Franconi et al. 2023).

Utility-led code readiness. Utility-driven code readiness programs provide technical support that helps jurisdictions prepare for, adopt, and implement energy-efficient building codes that enhance resilience to extreme heat. Building codes shape energy demand and influence occupant comfort and utility costs, leading to utilities having a strong interest in accelerating their adoption. Utility-led programs can target measures that reduce peak loads during heat events, align with long-term grid planning, and provide technical and financial assistance to speed adoption. Through these efforts, utilities can reduce the technical, financial, and implementation barriers to stronger energy codes, helping local governments and building owners incorporate high-performance building practices that improve long-term heat resilience. Effective code readiness programs incorporate several key strategies:

- Stakeholder engagement: Align utilities, state agencies, and local governments on shared goals such as peak load reduction, passive survivability, and grid reliability during extreme heat events.
- Implementation support: Provide technical guidance, compliance tools, and incentives to accelerate adoption of high-performance envelope measures, efficient HVAC, and demand-flexible technologies.
- Capacity building and training: Equip designers, inspectors, and officials with the tools and skills needed to implement updated standards effectively.
- Equity-focused approaches: Prioritize adoption in affordable housing and high-heat, high-vulnerability communities, leveraging incentives to reduce costs and construction risks while improving project economics.

Program in action: PG&E Code Readiness Program. Pacific Gas & Electric's (PG&E) Code Readiness Program accelerates the integration of advanced energy-efficiency, electrification, and grid-interactive technologies into California's building codes and appliance standards. The program conducts research and field demonstrations evaluating technologies such as high-efficiency electric HVAC and grid-interactive, solar- and EV-ready construction practices (Pacific Gas and Electric Company 2023a). For example, as part of its research informing building code development, a field study of dedicated outdoor air systems (DOAS) and variable refrigerant flow (VRF) heat-recovery systems in four commercial buildings showed that ventilation heat recovery reduced summer peak electricity demand by up to 0.5 W/sf, while advanced control strategies maintained comfortable indoor temperatures. These findings informed new Title 24 code provisions and compliance guidance, helping reduce grid stress during peak heat demand. With a five-year budget of $35–40 million under California Public Utilities Commission oversight, the program demonstrates how utilities can strengthen heat resilience and grid reliability through technical assistance, market transformation, and codes-focused innovation (Pacific Gas and Electric Company 2023b).

State and local code initiatives. State and local governments are also advancing code-based heat resilience strategies. Examples include New York State's Extreme Heat Action Plan and the Connecticut Climate-Resilient Energy Code for Multifamily Affordable Housing (CT-CRE Code). The CT-CRE Code, a voluntary overlay for existing multifamily energy codes, requires high-performance insulation and windows, efficient ventilation with heat recovery, resilient HVAC and essential systems capable of operating on emergency power or in resilience modes, solar panels with battery storage, reflective and shaded surfaces, and backup power for critical functions. Modeling shows these measures would reduce electricity use by more than 36,000 kWh annually for a typical 30-unit building, cut greenhouse gas emissions by nearly 15 metric tons per year, and deliver tenant savings of approximately $2,800 per unit over 20 years (Clean Energy Group 2025).

Voluntary above-code programs. Voluntary standards such as LEED v5 can further strengthen building resilience and are especially useful in jurisdictions without code authority, where they can be adopted locally to improve efficiency and resilience outside formal code adoption processes. LEED projects assess climate hazards, including extreme heat, and encourage heat-island mitigation strategies—like reflective surfaces, shading, and vegetation—to reduce exposure and improve indoor and outdoor conditions (U.S. Green Building Council 2025)

Mechanical Cooling and Access to Equipment in the Home

Energy-efficient cooling technologies help maintain safe indoor temperatures during extreme heat by lowering building energy demand and improving comfort. Their effectiveness, however, depends on equitable access—particularly for populations that face financial, physical, or informational barriers. Low-income, elderly, and medically vulnerable households often cannot purchase efficient cooling equipment on their own and struggle to navigate conventional programs. Targeted initiatives that prioritize these residents maximize both individual and community heat resilience (Schaaf et al. 2022).

These barriers can be addressed through locally led programs that are especially effective because they combine knowledge of community needs with trusted delivery networks. By partnering with community-based organizations, tailoring equipment to specific housing conditions, and integrating outreach with existing social services, these programs can overcome participation barriers and ensure that efficient cooling technologies reach those at highest risk.

Program in Action: Cooling Portland Program. Launched in 2022 with support from the Portland Clean Energy Community Benefits Fund (PCEF), Cooling Portland was created in response to the June 2021 heatwave, which highlighted disparities in in-home cooling access. The program provides energy-efficient portable heat pumps and AC units to eligible households within Portland city limits with incomes at or below 60% of the Area Median Income (AMI), prioritizing residents age 60 or older, living alone, or with medical conditions that increase heat illness risk (City of Portland 2024).

Cooling Portland tailors equipment to each home's electrical capacity and physical constraints and distributes units through 15 Community Distribution Partners (CDPs)—trusted local organizations that identify eligible households, perform installations, and provide education. This community-centered approach increases cultural relevance, reduces participation barriers, and ensures equipment reaches those who need it most. By the end of 2024, 13,182 households had received equipment—nearly 90% of the original goal—with 31% of units going to people living alone and 48% to residents over 60. In December 2024, $10.3 million in new funding expanded the program goal to 25,000 units by 2026 (Earth Advantage 2024).

The program also connects residents with affordability and efficiency resources, such as utility bill assistance and simplified application pathways via the city's 311 system, further expanding access for underserved populations. Cooling Portland demonstrates that expanding cooling access requires more than providing equipment alone. By pairing efficient cooling technologies with bill assistance, streamlined enrollment pathways, and community-based support, the program helps ensure that residents can afford to operate and benefit from the equipment during extreme heat events.

Similar approaches are being implemented elsewhere. In San Antonio, the city partnered with philanthropic foundations, the housing authority, and the local utility (CPS Energy) to provide 2,400 air conditioners to public housing residents, with energy credits to cover operating costs (Wang 2019). In Orange County, Florida, the Senior Climate Efficiency Program offers free air conditioner replacements, repairs, and efficiency upgrades—including smart thermostats and duct sealing—to low-income seniors aged 60 and older, with eligibility coordinated through programs such as Low-Income Home Energy Assistance Program (LIHEAP) and Weatherization Assistance (Orange County Florida 2024).

These examples illustrate that the effectiveness of efficient cooling depends on program delivery structures that intentionally connect vulnerable households to equipment through trusted partners and existing assistance infrastructure.

Reducing Community and Urban Heat Exposure with Passive Heat Reduction Measures

Local governments play a vital role in advancing nature-based and passive strategies that reduce heat exposure and help buildings maintain safer indoor temperatures. Regulatory tools and public investments—such as zoning reforms, tree canopy expansion, urban design measures, and improvements to public spaces—can lower surrounding ambient temperatures and reduce heat absorbed by buildings, helping limit indoor heat buildup during extreme heat events (Environmental Protection Agency, n.d.). Unlike many utility-led resilience interventions, these strategies rely on local planning authorities, long-term stewardship, and coordination across agencies. Because these strategies unfold over decades, they depend on institutions that can manage public assets and respond to community priorities.

Nature-based and smart surface solutions, such as tree planting, green and cool roofs, reflective pavements, reduced surface parking, and expanded green spaces, can substantially lower ambient temperatures and help buildings maintain safer indoor temperatures during extreme heat. Smaller-scale interventions, like shade trees and passive building features, primarily reduce direct heat exposure for individuals in homes and public spaces, while broader canopy expansion and green infrastructure moderate neighborhood-scale temperatures and mitigate urban heat island effects. Streetscape designs with shade corridors, planted medians, and other cooling features further enhance comfort and reduce heat exposure for residents.

Because tree canopies take years to mature, expanding and protecting urban greenery is a long-term investment in heat resilience. Sustaining these benefits also requires workforce development, including arborists, foresters, and maintenance staff. Building-level strategies such as shading, reflective surfaces, and improved envelopes provide more immediate cooling benefits while reducing building energy demand.

Local-led strategies are often strengthened by collaboration with utilities and regional partners. For example, Con Edison supported New York City’s Urban Forest Agenda, which aims to increase tree canopy cover to 30% by 2035. As of 2021, tree canopy covered 23.4% of the city, with the hottest and most heat-vulnerable neighborhoods—often low-income and communities of color—having the least coverage. Prioritizing these areas helps lower temperatures, prevent heat-related deaths, and reduce building energy use, generating millions of dollars in community benefits annually (Climate Central 2023; City of New York 2025).

Program in action: King County, Washington, Extreme Heat Mitigation Strategy. Following the 2021 Pacific Northwest Heat Dome, King County, Washington, developed an Extreme Heat Mitigation Strategy to expand passive and nature-based cooling across the region. With summer maximum temperatures projected to rise 3.7°F by the 2030s and some neighborhoods already 20°F hotter due to urban heat islands, the county prioritized interventions that shape public spaces and the built environment where residents are most exposed to heat.

Developed through partnerships among local and state governments, community organizations, and frontline residents, the strategy builds on countywide heat-island mapping supported by public utilities. Seattle City Light and other utilities contribute technical expertise, conduct outreach, and help connect residents with efficiency and bill-assistance programs. Key actions include:

- **Private property tree care:** Financial incentives, water bill subsidies, renter-landlord agreements, and workshops to support planting and maintenance.
- **Maximizing tree survival:** Best practices for planting and watering, with training for city staff and community members.
- **Tree code toolkit:** Guidance for jurisdictions to adopt stronger tree protection policies and integrate heat resilience into development regulations.
- **Tracking equitable canopy cover:** Countywide LiDAR mapping to guide investments in high-heat, high-vulnerability neighborhoods.
- **Open space and stormwater parks:** Infrastructure projects that expand shaded areas, depaved surfaces, and stormwater parks to cool neighborhoods while improving drainage.
- **Heat-smart parks and playgrounds:** Community upgrades including shade structures, splash pads, and mobile cooling stations with multilingual signage.
- **Passive cooling measures:** Expanded access to home-level strategies such as shading devices, window films, cool roofing, air sealing, and insulation upgrades.

To complement these strategies, the county also provides near-term support, including portable ACs, bill assistance, high-efficiency heat pumps, and cooling centers, ensuring that vulnerable residents can stay cool affordably during extreme heat events (King County 2024).

Other jurisdictions are pursuing similar locally led strategies. In Phoenix, reflective cool pavement is integrated into street maintenance to lower surface temperatures, and zoning codes require new developments to provide at least 50% shaded open space (City of Phoenix, n.d.; Wickerson et al. 2025).

These examples demonstrate that because heat mitigation through the built environment requires long-term planning, land-use decisions, and public investment, local governments are uniquely positioned to lead and sustain these strategies over time.

Energy System Reliability and Backup Capacity

Extreme heat drives up electricity demand and stresses grid infrastructure, increasing the likelihood of power outages that can disrupt cooling systems and lead to unsafe indoor temperatures. To protect residents, particularly vulnerable populations, utilities can invest in strategies, including demand-response programs, distributed energy resources, and targeted grid upgrades, that strengthen grid reliability, manage peak demand, and enable buildings to continue cooling during periods of high load or unexpected outages.

Flexible demand technologies, such as smart thermostats, managed water heaters, and bidirectional electric vehicle charging, help reduce and shift electricity demand during periods of grid stress. Community- and customer-sited distributed energy resources, including rooftop solar paired with battery storage, provide homes and buildings with the electricity needed to maintain safe indoor temperatures during outages. When deployed together, these measures reduce peak electricity demand, provide dispatchable capacity during periods of grid stress, and help prevent outages that would compromise safe indoor temperatures, preserving the ability of buildings to function as heat-resilience infrastructure.

Utilities can complement these measures with targeted grid upgrades, including heat-tolerant equipment, upgraded transformers, and advanced monitoring systems. These upgrades strengthen the distribution system to ensure that flexible resources and distributed energy can operate effectively under extreme heat conditions, maintaining reliable service to buildings and supporting indoor cooling.

Program in action: Green Mountain Power Resiliency Zone Program. Green Mountain Power (GMP) in Vermont demonstrates how utilities can use flexible demand programs to coordinate thousands of distributed customer resources, including rooftop solar, batteries, and bidirectional electric vehicle chargers, to operate as a dispatchable grid resource during extreme heat events. The value of this approach became clear during a June 2025 heat wave in New England, when record electricity demand coincided with unexpected generation outages. By strategically dispatching these resources during the period of greatest grid stress, GMP reduced demand on the grid and maintained reliable electricity service, allowing homes and businesses to continue operating cooling systems and maintain safe indoor temperatures.

GMP's network began in 2015 with a 3.4 MWh solar-battery installation and expanded through home battery programs, electric school bus battery storage, and community-scale storage. Today, this network provides 72 MW of dispatchable capacity across more than 5,000 participants, making it GMP's largest flexible resource (Giles 2025). During the June 2025 heat wave, customer-sited solar supplied approximately 4.4 GW across ISO-NE, reducing reliance on fossil-fuel generation and avoiding costly peak power interruptions for Vermont residents (Berman and Dickerson 2025).

Distribution-system investments through GMP's Zero Outages Initiative, including undergrounding lines, reinforcing overhead equipment, and advanced monitoring, further strengthen sections of the grid that support localized resources. By combining utility programs, customer-sited resources, and grid hardening, these coordinated investments improve both grid reliability and the ability of buildings to remain habitable during extreme heat.

Recommendations

Reframing buildings as frontline heat-resilience infrastructure has implications for how policy, program design, and regulatory decisions are structured across the built environment and energy system. Maintaining safe indoor temperatures during extreme heat depends on multiple interacting factors—including building design and performance, access to mechanical cooling, neighborhood heat exposure, and the reliability of the electricity system. Because these factors span multiple sectors and levels of governance, approaches that address them separately may fail to maximize the effectiveness and cost-effectiveness of investments in heat resilience.

First, state and local governments should explicitly treat buildings as core heat-resilience infrastructure in policy and program design, particularly in shaping new construction and major retrofit decisions. Building energy codes, above-code standards, and utility-supported code-readiness programs influence not only new buildings but also the long-term performance trajectory of the existing building stock through retrofit pathways and equipment turnover. Strengthened envelopes, improved ventilation, and efficient cooling systems reduce energy demand and help maintain habitable indoor temperatures, even during power disruptions. Integrating heat-resilience considerations into codes and efficiency programs ensures that both new and existing buildings contribute to long-term protection against extreme heat.

Second, utilities, program administrators, and local policymakers should expand access to efficient cooling technologies in existing buildings, where the majority of exposure to extreme heat occurs today. As demonstrated by programs like Cooling Portland, the effectiveness of efficient cooling depends not only on the technology itself but also on how it is deployed, supported, and maintained over time. Targeted deployment strategies that prioritize low-income households, elderly residents, and medically vulnerable populations can significantly increase program impact by ensuring efficient cooling reaches those most at risk, while also improving the effectiveness of public and utility investment in these programs.

Third, planning and program design should integrate building systems, community-level resilience strategies, and energy system planning, recognizing that indoor thermal safety is shaped jointly by decisions across these domains. Fragmented approaches that treat these systems separately can underutilize investments and miss opportunities for compounding benefits, while coordinated strategies can improve both everyday performance and extreme-event resilience by reducing peak demand, lowering heat exposure, and improving system reliability when it is most needed.

Finally, resilience investments should be designed to deliver value under normal operating conditions while also maintaining performance during extreme heat events and grid disruptions, ensuring that investments remain cost-effective across both everyday and emergency conditions. This dual-benefit framing helps ensure that heat-resilience strategies provide continuous returns while also functioning as foundational protective infrastructure during periods of elevated risk.

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