Building Resilient Communities: Enhancing Building Energy Resiliency Through Building Performance Standards and Energy Codes

Key Takeaways

As buildings face increasing risks due to climate change, policymakers are increasingly looking to building energy codes and building performance standards to incorporate resilience metrics.

- The 2021 International Energy Conservation Code (IECC) and the Zero Energy Appendices address passive survivability and grid reliability by specifying metrics such as insulation, air sealing, and on-site renewable energy.
- The 2024 IECC includes metrics that are more stringent than those of the 2021 IECC and includes new appendices such as Electric Energy Storage Provisions (Appendix RD).
- Building performance standards and energy codes can take into consideration community needs and risks when addressing building resiliency. For example, a review board overseas the implementation of BERDO, Boston's building performance standards, to ensure that communities experiencing environmental injustices receive the substantial benefits of decarbonization.

Introduction to Building Resiliency

Buildings are confronting heightened vulnerabilities due to the shifting climate, resulting in amplified risks such as extreme weather events, rising temperatures, and energy supply fluctuations. States and jurisdictions can leverage building standard metrics and integrate community considerations to bolster resilience in new and existing structures. This resource provides strategies that enhance building energy resiliency through building performance standards and building energy codes to effectively harmonize building performance objectives with broader community needs. The primary objective of these ordinances is to elevate the overall performance of buildings. By assessing building resiliency, incorporating community-specific needs, and proposing implementation strategies, this resource seeks to empower state energy offices, policymakers, communities, and advocates to build and retrofit structures that can withstand, adapt, and thrive in the face of ongoing climate risks.

Building performance standards establish mandatory energy consumption or greenhouse gas emissions performance targets for existing large commercial and multifamily buildings. Targets often get more aggressive over time to set buildings on a path to net zero.

Building energy codes outline the minimal energy efficiency criteria for constructing or renovating buildings, aiming to curtail energy waste.

Resiliency, often referred to as resilience, encompasses the capacity to not only withstand the impact of an event but also to swiftly return to an acceptable level of functionality following such an event's occurrence (Better Buildings, Resilience). However, it's important to emphasize that resiliency is not a static quality; rather, it's a dynamic concept that necessitates ongoing innovation and adaptability to effectively mitigate and manage the ongoing consequences of climate change.

Building Resiliency in the Face of Climate Risks

The importance of building resiliency in the context of expanding the built environment cannot be overstated, particularly considering the growing number and cost of disasters caused by extreme weather events. The vulnerability of buildings and energy systems to climate risks has been prominently underscored by a recent study Enhancing Resilience in Buildings Through Energy Efficiency (U.S. Department of Energy, July 2023). Over the past two decades, the United States has grappled with an alarming increase in the frequency and severity of weather and climate disasters, exceeding $1 billion in damages. Notably, the year 2017 stands out as the costliest, with $320 billion in losses. This troubling trend is further exacerbated by the anticipated escalation in the occurrence of extreme temperature events, such as heat waves, impacting previously unaffected regions. The ramifications of extreme weather events, which include prolonged power outages, have been witnessed in events like Hurricane Maria, where Puerto Rico endured 328 days (about 11 months) without full power.

As the built environment continues to expand, the need for resiliency measures becomes increasingly pressing. Approximately 13.9 million new buildings are projected to be added to the U.S. inventory between 2016 and 2040. The implementation of adequate resiliency measures is pivotal considering these numbers. Not only does it serve to safeguard lives and assets in the face of escalating climate disasters, but it also promises substantial cumulative financial savings, estimated at $132 billion[1] average annualized losses avoided (AALA) by 2040 (compounding to at least $3.2 billion AALA per year). This underscores the necessity of integrating resiliency considerations into building performance standards and energy codes to ensure that these structures not only meet the present needs but can also withstand the future challenges posed by an increasingly unpredictable climate. (Federal Emergency Management Agency, Building Codes Save: A Nationwide Study of Loss Prevention, 2020).

Resiliency Measures: Enhancing Building Energy Efficiency

In the context of extreme weather events or disasters, the merits of energy-efficient buildings transcend mere economic benefits. Energy-efficient building designs, particularly those equipped with on-site energy storage or production capabilities, provide an elevated level of protection for both occupants and critical operations. When compared to structures adhering to lower building energy and performance standards, energy-efficient buildings furnish a more robust defense against the adverse impacts of climate events, ensuring a higher degree of protection and continuity in essential functions. There are three integral components to realizing the benefits of resiliency in energy-efficient buildings:

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[1] The cumulative financial savings were calculated via the average annualized losses avoided or AALA analysis.

- **Equitably Assessing and Incorporating Community Needs** requires recognizing that resilience extends beyond individual buildings; it entails consideration of the needs and capabilities of the surrounding community. This encompasses collaborative planning, the sharing of resources, and the development of coordinated response strategies to ensure resilience at a community-wide level. This approach underscores the importance of defining and addressing community resilience.
- **Increasing Passive Survivability** involves enhancing a building's capacity to maintain habitable conditions during disruptions through the implementation of passive measures. Such measures decrease the reliance on active energy systems during emergencies. These measures include thermal control, radiation control, moisture control, and air control.
- **Continuity/Reliability in Energy Services/Grid Resiliency** encompasses the assurance of consistent and reliable energy supply to buildings, even in the face of disturbances such as power outages. To achieve this, various strategies are employed such as incorporating backup power sources like on-site renewables and battery storage systems as well as incorporating demand response controls.

Assessing Building Resiliency

Assessing building resilience requires the development of tools and metrics aimed at evaluating building resilience on a community-wide scale, taking into consideration infrastructural risks and social vulnerability. Building resiliency assessments should examine the intricate components that contribute to a building's ability to withstand and recover from disruptive events, encompassing structural integrity, passive design strategies, and resource availability, and the specific needs and priorities of the community. This requires state energy offices, communities, and other stakeholders to establish a comprehensive understanding of the specific needs of the community and integrate these considerations into resilience planning and implementation.

When assessing the resilience of a building, it is imperative to consider several essential components. A National Institute of Building Sciences' report, Building Resilience, aims to identify different aspects of resilience management to mitigate and help control the rapidly escalating costs associated with hazardous events while ensuring that the impacted infrastructure demonstrates a high degree of resilience. This resource emphasizes four critical components of building resilience as determined by the National Infrastructure Advisory Council (NIAC):

- **Robustness** refers to the building's ability to keep essential functions going, even in the face of a crisis. This component assesses the building along with the design of the infrastructure that supports it, such as power generation, distribution structures, and more. Robustness also includes existing infrastructure such as secondary power sources, transportation alternatives, and other backup resources, which may serve as a contingency resource in the case of an extreme event. This is referred to as redundancy and is further discussed below.
- **Resourcefulness** involves the skillful preparation for, response to, and management of a crisis or disruption as it happens. This includes things like identifying courses of action, providing training, prioritizing actions to minimize damage, responding to community needs, and effectively communicating decisions.

- **Rapid Recovery** assesses how quickly a building can resume normal operations after a disruption. This involves having well-prepared contingency plans, competent emergency response operations, and the ability to swiftly deploy essential resources as needed, such as electricity, heating and cooling, etc.
- **Redundancy** refers to the existence of backup resources in place to support primary systems in case of failure. Redundancy is an integral component to assess when planning for resilience and ensures that there are alternative options to rely on as the need arises.

Enhancing Resilience in Buildings Through Energy Efficiency: Standardized Methodology and Resulting Analysis Demonstrating the Value of Codes and Above Code Measures to Hazard Resilience

This study's methodology lays the foundation for a standardized analysis that quantifies the resilience benefits of improved building efficiency, evaluating thermal resilience (code measure and or improvement), mortality (Gasparrini rate model), and investment (benefit cost ratio estimate).

Conducting Risk Assessments

A risk assessment is a fundamental aspect of a comprehensive risk management strategy, playing a vital role in introducing control measures to either eliminate or mitigate potential risks and their associated consequences. The primary purpose of conducting a risk assessment is twofold:

To steer clear of unfavorable outcomes linked to risks and explore potential opportunities that may arise. This process involves a collective effort, encompassing the identification and analysis of potential future events that could negatively impact individuals, assets, processes, or the environment, which is referred to as risk analysis.

Making informed judgments about how to manage and tolerate risks, guided by the results of a risk analysis and considering various influencing factors, known as risk evaluation. In essence, risk assessment is a pivotal tool for anticipating and addressing risks and opportunities in a structured and systematic manner.

Risk Assessments: Social Vulnerabilities and Community-Specific Needs

Climate-related hazards like wildfires, flooding, and severe storms are on the rise due to climate change, posing increasingly severe threats. Among those affected, marginalized communities and vulnerable groups have borne a disproportionate burden.

Certain segments of the population face heightened disaster and climate change risks due to their geographical location and limited resources for mitigation or adaptation. Some groups, such as low-income communities, also struggle with lower preparedness and coping abilities because of restricted access to economic and social support networks. Effective climate change adaptation and risk management strategies necessitate a deep understanding of the social vulnerability profiles within a community. While various methodologies exist to assess the impact on vulnerable populations, they are often not systematically integrated into overall climate and disaster risk management processes. As a result, many studies intended as “risk assessments” often fall short, due to a lack of standardized, comparable, and quantifiable social dimensions of vulnerability. This presents several challenges, as vulnerability depends on multiple factors like income disparities, gender, age, disability, language, literacy, and family status. Personal characteristics can contribute to vulnerability but do not fully define it.

Policymakers and state energy offices can work to identify social vulnerabilities when conducting risk assessments by employing the following strategies:

- **Data Analysis**: Utilize data sources to identify communities and building types that are most susceptible to the impacts of climate change and extreme weather events. Analyze current and historical data related to demographics, economic disparities, housing disparities, and access to critical infrastructure to pinpoint areas in need of resilience improvements.
- **Community Engagement**: Engage with local communities and stakeholders to gather insights into their specific needs and vulnerabilities related to building resilience. Conduct surveys, host community meetings, and establish advisory groups to ensure the voices of vulnerable communities are heard.
- **Expert Consultation**: Collaborate with experts in social sciences, public health, and disaster management. These experts can provide valuable insights into identifying vulnerable populations and understanding the complex social dynamics that contribute to vulnerability.

Incorporating Community Needs Equitably

Identifying and addressing social vulnerabilities in building resilience efforts is paramount for equitable, effective, and cost-efficient interventions. By placing vulnerable populations and high-risk building types at the forefront of resilience planning, policymakers can ensure that all members of the community have fair access to safe and resilient structures. Targeted interventions that address the specific needs of at-risk areas maximize the impact of resources, ultimately strengthening both individual building and community resilience. This community-centered approach not only safeguards local structures but also bolsters the overall resilience of the entire community, making it better prepared to face disasters. Ultimately, the identification of social vulnerabilities empowers policymakers to allocate resources efficiently, prioritizing investments where they will have the most substantial and positive effect on building resilience, ensuring the safety and security of the broader community.

Incorporating Community Needs Equitably in Energy Codes

States and jurisdictions often inadvertently exclude communities from the code development process due to limited outreach, communication, and resources. Language and cultural barriers further impede participation, especially for marginalized groups. It’s vital to address these challenges continuously and promote transparency to ensure equity in code development.

To foster equity, it’s essential to involve a diverse range of stakeholders who can provide varied perspectives and expertise. This approach leads to more informed and effective building energy codes that better address community needs and challenges. By enabling communities to contribute actively to the code development process, it builds trust and ownership in the finalized codes. Additionally, transparent and inclusive engagement can streamline code adoption, clarify code language, and ultimately reduce delays and confusion for builders, code officials, and designers.

Incorporating Community Needs Equitably in BPS

Ensuring equitable adoption of a building performance standard (BPS) policy entails engaging communities affected by climate risks and energy disparities at an early stage. This approach promotes meaningful community participation, enabling collaborative policy development. When communities take a lead role in the process, it becomes pivotal in shaping an equitable BPS policy that incorporates their unique priorities and requirements. This collaborative effort results in more robust and sustainable solutions. Community engagement should guide research endeavors and risk assessments, providing essential lived experiences and perspectives necessary to comprehensively address the needs of all residents. As delineated in IMT's model BPS ordinance summary, the Community Accountability Board (CAB) assumes the responsibility of formulating a strategy for disbursing assistance funds to marginalized communities. Furthermore, it evaluates the equity impacts of the ordinance and recommends measures to rectify the historical disinvestment in low-income and minority communities. The CAB, aligned with community-driven priorities, may opt to invest in expansive projects that enhance overall community resilience rather than channeling resources into individual buildings. The selection of these community priority actions is decided on by the community and expressed through the CAB; priority actions may encompass a range of localized social concerns, including but not limited to public health, equity, affordable housing, sustainability, access to transportation, and resilience to climate-related challenges.

Boston's Building Emissions Reduction and Disclosure Ordinance (BERDO) mandates emissions reductions for large buildings, aiming to steadily decrease greenhouse gases with the ultimate objective of achieving net zero emissions by 2050. The BERDO Review Board oversees the implementation of BERDO to ensure that communities experiencing environmental injustices receive the substantial benefits of decarbonization. The review board consists of nine nominated volunteers, of which six are nominated by community-based organizations.

Integrating Resilience into Building Performance Standards and Building Energy Codes

To enhance the resilience of both new and existing construction projects, it's crucial to elevate resilience-related components within the framework of building performance standards (BPS) and building energy codes. This entails infusing these standards with the criteria mentioned above: passive survivability, energy service continuity, and adaptability to extreme weather conditions.

Increasing Passive Survivability

During extreme weather events, essential services like heating, cooling, and water supply may be compromised, putting occupants in jeopardy. Extreme indoor temperatures resulting from energy and service loss can lead to various health issues, including hypothermia, hyperthermia, elevated blood pressure, and heat strokes. Additionally, poor ventilation and filtration systems can result in indoor air quality problems, increasing the risk of respiratory ailments and exacerbating symptoms for individuals with pre-existing conditions. Considering these risks, there is a growing recognition of the importance of passive survivability.

Passive Survivability Metrics

The Department of Energy's Building Technologies Office (DOE BTO) collaborated with national research labs to create a standardized method for assessing the impact of energy efficiency on a building's ability to withstand temperature extremes. The study, Enhancing Resilience in Buildings Through Energy Efficiency, analyzes both new and existing single-family and multifamily apartment buildings across six U.S. cities. The study demonstrated that enhancing passive efficiency in residential buildings, by meeting or surpassing current energy codes, significantly extends occupant habitability and ability to shelter in place. This methodology utilized three metrics to assess a building's passive survivability, standard effective temperature (SET), heat index (HI), and SET degree hours.

These metrics provide quantifiable benchmarks for a building's passive survivability during extreme weather conditions. By setting clear compliance thresholds based on these metrics, state and local governments can ensure that structures remain habitable during severe weather events. Encouraging builders and designers to exceed these resilience benchmarks through incentives or credits, tailoring metrics to regional climate variations, and collecting data on building resilience are strategies that can help states and jurisdictions effectively enhance resilience in their building standards.

SET (standard effective temperature) evaluates indoor comfort by considering factors like temperature, humidity, radiant temperature, air movement, occupant activity, and clothing choices.

SET degree hours calculate the cumulative hours of indoor comfort during extreme weather based on specific standards.

HI (heat index) measures how hot it feels based on air temperature and humidity, helping assess indoor resilience to extreme heat.

While these metrics offer valuable insights into a building's passive survivability, they are based on specific assumptions and parameters. These metrics rely on certain calculations and models to evaluate thermal performance, and their accuracy may be influenced by factors like climate conditions, building design, and occupant behavior. States and jurisdictions should consider these limitations when implementing these metrics into building energy codes and BPS. It is important to periodically review and update these metrics to reflect changing climate patterns and evolving building practices.

Enhancing Passive Survivability Measures in Building Energy Codes

States and jurisdictions can strengthen the requirements for these elements in building codes, including adopting the 2021 International Energy Conservation Code (IECC) and above. Elements that dictate passive survivability in building energy codes include:

- **Insulation** plays a pivotal role in passive survivability by efficiently regulating indoor temperature.
- **Solar Heat Gain Coefficient** quantifies solar radiation for better indoor climate control.
- **Roof Solar Reflectance** reduces heat absorption, promoting passive survivability.
- **Reduced Air Leakage** enhances thermal resilience and energy efficiency.
- **Duct and Pipe Insulation** prevent heat loss, ensuring access to essential services like hot water.
- **On-site Renewable Energy Sources** provide backup power, fortifying passive survivability during disruptions. (2021 IECC Zero Energy Appendices)

Passive design is a construction concept that can be applied to all buildings, whether residential or commercial. The voluntary standards are performance-based, with a limited prescriptive option for certain scopes. States in the NEEP region such as New York and Massachusetts incorporate Passive House standards as alternative compliance pathways and/or requirements in their stretch energy codes, and other states are considering this approach as one strategy for achieving their carbon reduction goals and improving resilience.

Programs like Passive House Institute (PHI) or PHIUS offer tested, standardized approaches for achieving passive survivability. Integrating these programs into building codes as alternative compliance pathways provides a nationally recognized way for builders and designers to meet these higher standards. Additionally, promoting the adoption of stretch energy codes, which are voluntary standards with more stringent requirements, can further encourage the implementation of passive survivability measures in construction practices. Passive survivability strategies may vary based on regional climate conditions. Therefore, building energy codes can integrate region-specific guidelines to optimize resilience outcomes.

Enhancing Passive Survivability Measures in Building Performance Standards

Enhancing passive survivability in building performance standards involves incorporating specific resilience-focused criteria and metrics into broader building standards. This expansion goes beyond energy efficiency and focuses on measures that improve a building's capacity to endure and function during extreme conditions, especially when critical infrastructure services like energy supply are disrupted. Some key considerations within building performance standards to enhance passive survivability include:

- **Building Envelope Resilience** standards address building envelopes with advanced insulation, weatherproofing, and durable materials for effective temperature control without active heating or cooling.
- **Ventilation and Indoor Air Quality** standards mandate proper ventilation systems that can operate without constant energy supply. Passive ventilation and air filtration may be required.
- **Thermal Comfort Metrics** introduce metrics like SET, SET degree hours, and HI to evaluate a building's

ability to maintain safe indoor conditions during extreme events. Limits on indoor temperature ranges in performance standards ensure occupant safety and comfort.

- **Testing and Evaluation Protocols** include provisions for testing a building's passive survivability under disaster scenarios to ensure compliance.
- **Strengthening Building Structures** establish measures to bolster the resilience of existing structures, enabling them to withstand extreme conditions better.
- **Resource Conservation** strategies conserve resources and minimize waste.

The U.S. Green Building Council's LEED rating system has introduced a pilot credit, known as Passive Survivability and Back-up Power During Disruptions, that offers a blueprint for integrating resilient building criteria into BPS (IMT, Building Performance Standard Module: Resiliency). The LEED pilot credit delineates three distinct metrics to show a building's inherent capability to sustain safe thermal conditions without relying on active systems. These metrics encompass psychrometry,[2] SET, and Passive House certification. The LEED pilot program for passive survivability includes a provision for supplying backup power to vital systems, quantified with a time-based metric indicating the duration of backup power, to assure safe thermal conditions.

The IMT policy brief explores the expansion of BPS policies beyond energy efficiency and carbon emissions to address resilience and social concerns. To incentivize building owners to invest in resilience measures through BPS, the brief suggests BPS programs allow for Building Performance Action Plans (BPAP). The BPAP allows building owners to propose customized compliance strategies, including adjustments to performance standards and commitments to community priority actions. Jurisdictions can incorporate passive survivability benchmarks, retrofit requirements, and other enhancements within the BPAP framework.

Reliability in Energy Services/Grid Resiliency

The importance of grid reliability becomes evident when reflecting on climate events such as the Texas winter storms in January 2021. These storms resulted in widespread power grid failures, leaving many residents without power in below freezing temperatures, and those who still had power faced high utility bills. Nearly 250 lives were lost due to the extreme cold and power outages. Unreliable grid services and energy infrastructure can jeopardize occupant health and safety during extreme weather conditions. These issues also have economic impacts by directly impacting businesses and industries—grid instability can cause financial losses and economic disruption. Grid instability also hinders long-term resilience by limiting a community's ability to withstand future extreme weather events. Highly energy-efficient and electrified buildings assume a crucial role in enhancing resiliency. Their significance lies in the fact that electrification, coupled with advanced building energy management systems, can facilitate grid interactivity, and provide backup power, including the establishment of virtual microgrids during severe weather conditions.

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[2] Psychrometry is the study of air and its properties, focusing on temperature and humidity. It plays a pivotal role in the design and operation of environmental control systems, like air conditioning, to maintain precise indoor conditions. Psychrometry entails a comprehensive analysis of diverse air characteristics, facilitating the engineering of comfortable and controlled atmospheres within buildings.

Enhancing Reliability in Energy Services/Grid Resiliency in Building Energy Codes

Following a year of extensive deliberations, the residential provisions of the 2024 IECC are nearing their finalization for publication. Notable among these provisions are measures that strengthen grid resiliency, such as:

2024 IECC Draft #2 for Residential[3]

- **Renewable Energy Infrastructure (R404.6)** mandates solar-ready zones on residential building roofs to enhance grid resilience.
- **Minimum Efficiency Requirements for Appliances (R408.2.8)** requires that thermostats for primary heating and cooling systems have demand-responsive controls, enabling occupant participation in utility demand response programs.
- **On-Site Renewable Energy (Appendix RI)** requires on-site renewable energy systems for residential and commercial buildings, aiding grid resilience and providing guidance on performance.
- **Electric Energy Storage Provisions (Appendix RD)** introduces guidelines for electrical energy storage systems in different building types, ensuring readiness for new construction, particularly where solar readiness is required.

Demand response is essential for grid resiliency, balancing electricity supply and demand during peak periods, like extreme weather events, to prevent overloads and blackouts. It prioritizes power supply to critical infrastructure in emergencies, ensuring electricity access. Moreover, it helps integrate renewable energy sources by adjusting consumption during shortages, reducing stress on the grid, and enhancing reliability, contributing to overall grid resiliency.

2024 IECC Draft #2 for Commercial[4]

- **Demand Responsive Controls for Heating and Cooling Systems (C403.4.6-C403.4.8)** mandates controls that adjust temperature based on occupancy, reducing energy use.
- **Mandatory Requirements for On-Site Renewable Energy Generation (C405.15)** requires that new buildings generate on-site renewable energy.
- **Mandatory Requirements for On-Site Energy Storage Systems (C405.16)** requires that new buildings include energy storage or have infrastructure for it.

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[3] International Code Council, *The International Energy Conservation Code Residential, Public Comment Draft #2*, July 2023.

[4] International Code Council, *International Energy Conservation Code Commercial, Public Comment Draft #2 Update, July 2023*

Enhancing Reliability in Energy Services/Grid Resiliency in BPS

Building Performance Action Plans can serve as a valuable mechanism empowering building owners to submit tailored compliance strategies, including commitments to essential community actions. Building owners can proactively retrofit their properties to bolster resilience when confronting climate-related disasters. This approach ensures that critical community assets, such as local community centers, maintain consistent access to reliable energy resources during power outages. Consequently, this strategy not only fortifies the resilience of individual buildings but also contributes to the broader grid's robustness by alleviating stress during emergency situations.

Conclusion

Enhancing building resiliency through building performance standards (BPS) and energy codes is a multifaceted and imperative approach to addressing the escalating climate-related challenges we face. Building resiliency is not merely about withstanding the immediate impact of a disaster but ensuring that structures can swiftly recover and continue functioning to meet the needs of communities. To achieve this, various strategies are outlined, including integrating passive survivability measures, enhancing grid reliability, and incorporating community-specific needs equitably. The latter can ensure that all communities, especially vulnerable and marginalized populations, have a voice in the code development process, promoting transparency and fostering trust and ownership in the resulting standards. These strategies, collectively, contribute to more resilient buildings and communities that can better withstand and adapt to the challenges of an increasingly unpredictable climate, ultimately safeguarding lives, assets, and the well-being of our society.