# Sustainable. Resilient. Affordable.

*Residential and Mixed-use Sustainable Building Design Guidelines*
Published April 2023

**What are these guidelines?**
These design guidelines are intended for residential and mixed-use new development or retrofit projects. The guidelines serve as part of a toolkit for advancing the stock of energy-efficient, affordable, and resilient living spaces. Housing developers should use these guidelines, in tandem with local ordinances and state building codes, in coordination with local building and sustainability departments. These guidelines were developed by the Metropolitan Area Planning Council (MAPC) in collaboration with the cities of Melrose, Malden, and Medford with support from a Municipal Vulnerability Preparedness Action Grant from the Massachusetts Executive Office of Energy and Environmental Affairs.

**Why are they important?**
Greater Boston is experiencing a housing crisis. Simultaneously, our built environment is increasingly exposed to extreme heat, urban flooding, and extreme weather and must be built to withstand and recover quickly. It is critical that our housing contributes to the long-term health and wellbeing of our community.

These guidelines were developed with input from community members through a series of interviews, focus groups, and workshops. Residents told us that they value living spaces with outdoor access that are close to community resources like transit, groceries, and health centers. They also told us that there is an interest in seeing more green space in their communities. This includes more gardens as well as green roofs and decks. Green spaces not only beautify the community but can reduce the effects of pollution and urban heat islands.

They also told us that affordability is a key concern, as they have seen the price of housing increase rapidly in recent years, pricing out many friends, neighbors, and family members. Utility costs are a growing concern. They want to make sure affordable housing is climate resilient, including addressing concerns related to flooding, water drainage, and fire hazards. Making sure that affordable housing is built with sustainable material and considerations around retrofitting old buildings instead of demolishing and wasting material is also a concern. Community members also stressed the importance of making sure that when building housing, it is inclusive to residents of all ability levels.

Creating incentives for developers to instill these practices will be key to encouraging implementation.

# Energy Measures

Many building design elements can help residents reduce energy use or save on energy costs. In turn, these energy saving measures can help reduce greenhouse gas emissions and may provide other co-benefits as well such as improved health and comfort.

**Energy Efficiency**

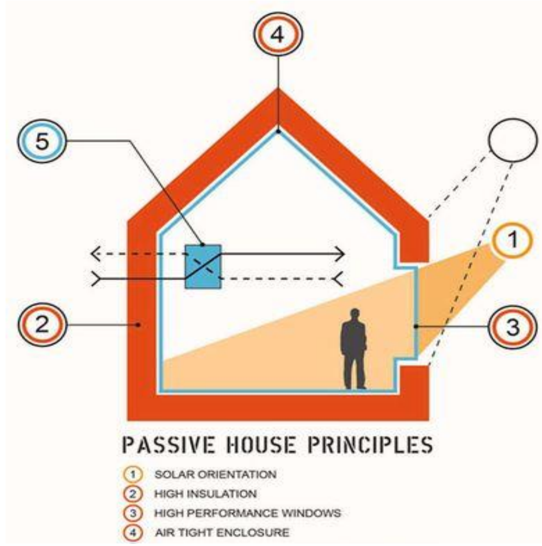
The Massachusetts Building Energy Code sets requirements for the energy consumption of buildings. Project teams can also make smart choices about building design and components that help minimize energy waste and make buildings healthier and more comfortable for residents while complying with the energy code. These elements include the thermal envelope (e.g., insulation and air sealing), doors and windows, lighting, and appliances. Specific design best practices for energy efficiency include:

- Passive House certification for building envelope and Heating, Ventilation, and Air Conditioning, or HVAC (see below)
- Home Energy Rating System (HERS) Index provides scoring for a home's level of energy efficiency on a scale of 0 to 100
- LED lighting with controls such as occupancy sensors
- ENERGY STAR-certified appliances

The Mass Save program offers incentives for energy efficiency measures for new construction, renovations, and retrofits. Learn more at www.masssave.com.

**Green Building Certification**

A well-designed building reduces energy waste and helps maintain comfortable and healthy indoor temperatures for residents. Project teams are encouraged to pursue a green building certification such as Passive House, Enterprise Green Communities, or LEED to help maximize energy performance and minimize waste while creating a healthy indoor environment. There are health, energy efficiency, and climate resilience benefits of these certifications. Certification costs money but can also be used to market to potential residents and the energy savings can reduce operating costs. There may also be incentives available to help offset the cost of certification such as Mass Save's Passive House incentive program.




Passive House Principles.
Source: Richard Pedranti Architect

**Is there a cost premium?**
Buildings can be built to green building standards with little-to-no additional upfront cost. Research by the Massachusetts Clean Energy Center shows that multi-family buildings are being built to Passive House standards with a minimal incremental cost ranging from 1% to 4.1% with an average incremental cost of 2%.[1] Passive House buildings typically use 40%-60% less energy, significantly reducing utility costs.[2]

**Heating, Ventilation, and Air Conditioning (HVAC)**
A well-designed and energy efficient HVAC system is one of the best ways to create healthy and comfortable living spaces for building residents while minimizing energy costs and environmental impacts. Heat pump (air-source or ground-source) or variable refrigerant flow (VRF) systems provide both heating and cooling at efficiency rates that are three times higher than other systems without requiring climate polluting fossil fuels. Heat recovery ventilation (HRV) or energy recovery ventilation (ERV) systems can help provide adequate fresh air while reducing energy usage. Project teams are encouraged to install HVAC systems that efficiently provide both heating and cooling and to explore the feasibility of systems that do not require the combustion of fossil fuels such as natural gas. Depending on the building size and compliance pathway in the Massachusetts Stretch Energy Code (Stretch Code), an all-electric building, including heating and cooling, may help meet energy efficiency goals.

**Utilities**
Energy cost burden, the percentage of household income spent on energy, is an important component of overall housing affordability. Energy cost burden can be minimized by making smart decisions about the design and operations of a building. Project teams are encouraged to consider how the project will minimize energy costs burdens for residents.

**Water Conservation**

[1] MassCEC Passive House Design Challenge.
[2] PHIUS. What is Passive Building?

As climate change accelerates, prolonged droughts will likely be more common in New England. Conserving water is a good way to lower operating costs and to ensure that buildings are not contributing to water scarcity. Project teams are encouraged to consider water consumption and water conservation in design and to prioritize the use of water-efficient appliances and systems. Learn more about water conservation from ENERGY STAR.

**Renewable Energy**

The Stretch Code requires new construction to be solar ready. Projects are encouraged to evaluate the feasibility of on-site renewable energy systems such as solar photovoltaic (PV) systems to be installed at time of construction. Solar PV may be installed on flat roofs, pitched roofs, or on parking canopies. Solar PV generates electricity which can be used on-site to cover a portion or all the on-site energy usage. Excess electricity may be sold back to the electricity grid for credit.

Many federal and state incentives exist to support the installation of solar PV and other renewable energy. For information about what incentives are available for renewable energy systems refer to the Database of State Incentives for Renewables and Efficiency.


*A solar PV system installed at the Melrose Highlands Church.*
*Source: City of Melrose.*

**Energy Resilience**

There are several site-level actions that improve energy resilience in the face of extreme weather or electrical grid outages. If a building is within the flood plain (FEMA flood zone or future flood zones), it is recommended to relocate or elevate utilities, electrical, and mechanical equipment to above the design flood elevation. If relocation is not an option, then protecting utilities from potential flooding is critical through dry floodproofing. If located in a FEMA flood zone V, elevating mechanical equipment is required to receive a reduction on National Flood Insurance Program (NFIP) premiums.

Backup power becomes critical in medium to high-rise residential buildings where people rely on electricity and mechanical equipment for elevators, safety, and potable water. Generators reliant on delivery fuel like propane, gasoline, or diesel may face supply chain disruptions during a large-scale outage or emergency. State incentives exist to install battery storage along with solar energy, which may be able to sustain operation during a grid outage if appropriate smart inverter equipment is installed and permits from the utility are obtained. There is also renewed interest in "passive survivability" under the LEED and Passive House certification programs. A common area for cooling refuge should also be included in the critical load when calculating size of generator or battery storage capacity.

- Overview of FEMA P-312, 2014 Edition, Homeowner's Guide to Retrofitting
- FEMA P-348, Protecting Building Utility Systems from Flood Damage
- Maintaining Backup Power to Critical Systems | Climate Safe Housing

# Mobility and Transit Access Measures

The transportation sector is the largest single source of carbon pollution in many communities and about 30% of emissions statewide.[3] Designing buildings to provide access to and promote the use of transit and other mobility solutions such as walking and biking infrastructure can reduce energy consumption and greenhouse gas (GHG) emissions as well as boosting resilience to climate change and extreme weather. Development should consider the pedestrian first, then bicyclists and transit, and then the automobile.

**Walkability, Mobility, and Connectivity**
Projects are encouraged to provide convenient pedestrian access and information about the proximity of key community sites and resources such as transit hubs, grocery stores, downtown districts, and recreation areas.

*Multi-family development near Oak Grove MBTA station.*

**Universal Design for Accessibility**
Universal Design principles aim to maximize usability by individuals with a wide variety of characteristics. These principles include:

- Equitable Use
- Flexibility in Use

[3] GHG Emissions and Mitigation Policies | Mass.gov

- Simple and Intuitive
- Perceptible Information
- Tolerance for Error
- Low Physical Effort
- Size and Space for Approach and Use

Projects are encouraged to incorporate Universal Design principles and can learn more from the Universal Design Institute.

**Transit Accessibility**
Connections to transit are crucial for new housing developments to reduce residents' need for private car ownership. If new housing is within a walkable distance (approximately 1/2 mile), safe, enjoyable walking infrastructure should be prioritized between the building and the transit stop.

ADA-accessible transit stops, covered bus shelters, and seating at bus stops all contribute to a safer and more enjoyable experience for transit riders. In addition to contributing towards these infrastructure changes, project teams are encouraged to consider providing a one-time monthly MBTA pass for new residents, and information about transit options available to them.

**Bike parking**
Providing on-site parking such as outdoor bike racks and protected indoor storage for bicycles makes it much easier for residents to own and store bikes safely. A significant barrier to biking for many residents in dense, urban areas is a lack of space to store bikes. Providing a bike room that is accessible and can be accessed only by residents allows more people to own a bike for personal use. Projects are strongly encouraged to provide ample bike racks and protected storage for residents and visitors.

**Bike share**
Bike share programs like metro-Boston's public Bluebikes system make biking a more accessible form of transportation and recreation for residents. The Bluebikes system has developed into a vital form of public transportation for the greater Boston region and has experienced record ridership year after year, with over three million rides taken in 2022 alone. Project teams are encouraged to partner with bike share companies to provide access to residents.

**Automobile Parking**
MAPC's perfect fit parking analysis found that 30% of the off-street parking in multifamily developments in Greater Boston went unused, with some areas having up to 50% of parking vacant. With more people working from home, walking, riding transit, replacing car trips with e-bikes, and online shopping, project teams are encouraged to evaluate parking needs and minimize automobile parking. Providing housing with fewer parking spaces in a transit rich location is essential so as to not attract residents that own cars, which will increase traffic congestion, and to minimize the amount of impervious surface and land area devoted to parking. Parking adds significant costs to a development which correlates to increased housing costs so building unnecessary parking should be avoided when transit alternatives exist.

**EV charging**
Electric vehicles such as cars, bikes, and scooters are becoming increasingly popular in Massachusetts. Electrification of private vehicles as well as public transit and municipal fleets are

important strategies to meet GHG emissions goals as well as for combating climate change and improving air quality. Access to electric vehicle charging is a key factor in determining whether to purchase an electric vehicle.

The Stretch Code requires that wiring be installed to allow for future electric vehicle charging, also known as "EV ready," in at least one space per dwelling for 1-2 family homes and a minimum of 20% of spaces in new multifamily parking lots or parking lots for business use. It is worth noting that the City of Boston has a policy for new development projects to have electric vehicle charging equipment installed at 25% of parking spaces and the remaining 75% of parking spaces be electric vehicle ready for future installation.

Programs that offer rebates and incentivize the purchase of electric vehicles and charging equipment are available for individuals, businesses, and non-profits. These programs include the Massachusetts Offers Rebates for Electric Vehicles (MOR-EV), Massachusetts Electric Vehicle Incentive Program (MassEVIP), and National Grid's Make-Ready program.

**Car share**
Car share programs such as Zipcar and Boston's Good2Go program provide shared vehicles to residents and make it easier to get around for those who don't own their own vehicles. Projects are encouraged to add parking for car share vehicles and to work with car share companies to host vehicles on-site.

# Resilience Measures

Many building and site design elements can reduce and withstand the impacts of extreme weather and increase resilience to climate change. This includes addressing challenges around stormwater runoff, flooding, and urban heat island effect. These elements may also provide additional co-benefits for the building tenants and neighborhood such as recreation, improved aesthetics, reduced air and water pollution, ecological benefits, and decreased cooling load requirements.

Project teams are encouraged to evaluate the vulnerability of the project to extreme weather and climate change impacts (heat, flooding, etc.). Tools for assessing vulnerability include:

- Resilient MA Climate Change Clearinghouse for the Commonwealth
- Climate Resilience Design Standards Tool
- Resilient MA Mapping Tool
- MAPC's Climate Vulnerability Index
- LISC Boston and New Ecology's Resilient Design Brief

**Urban Forest and Trees**
The trees that line our streets, parks, open space, and private property throughout the City are considered our urban forest. Trees reduce solar gain and provide cooling benefits, filter the air and convert $CO_2$ to oxygen, reduce urban heat islands, and provide habitat for wildlife. Trees planted near the public right-of-way, such as the front yard of a property, also provide critical shade for pedestrians and can improve community aesthetics. Trees can also be a challenge to manage, including ensuring they are adequately watered and maintained so that they can provide these benefits for decades to come. If shade trees are not possible in certain areas, consider constructed shade elements such as canopies, overhangs, and awnings to provide shade, reduce solar gain, and improve the public realm.

Site plan design should consider:

- Protecting and preserving existing trees whenever possible
- Type of appropriate species including height at maturation, spread and growth of the canopy, drought tolerance, and ability to withstand climate change
- Adequate size of tree bed or tree box to allow for root growth and watering, permeable surfaces above the tree box may be used to maximize water infiltration or tree box filters that can help capture stormwater
- Maintenance and watering plan for young trees to ensure they are well-established
- Efforts to reduce damage to new trees caused by foot traffic, parking, garbage collection, or other activities

Resources:

- Tree species and climate change | USDA Climate Hubs
- Landscape: North American Plants for New England Gardens | Center for Agriculture, Food, and the Environment at UMass Amherst

**Sustainable Roofs**

A building's roof space provides additional opportunities to enhance sustainability and resilience. There are several different options for roofs ranging in benefits, costs, and considerations.

| Roof type | Definition | Considerations |
|---|---|---|
| Green roof or Eco-Roof | A roof that includes plants/vegetation and soil in order to reduce stormwater runoff and/or reduce urban heat impacts. Also, sometimes referred to as a "blue roof" if for the purposes of stormwater retention or rainwater harvesting. Green roofs can also reduce the solar gain of the building and reduce summer cooling needs of the occupants. | Often requires additional weight for soil and planting. Plants should be well suited to the typical climate. |
| Cool Roof | A roof that is painted white or made of highly reflective material to reduce urban heat impacts. Cool roofs also reduce the solar gain of the building and reduce summer cooling needs of the occupants. | Low-cost and low maintenance project that is appropriate for retrofitted or new construction.<br><br>May be paired with solar arrays. |
| Solar Roof *see renewable energy section above | A roof that includes solar photovoltaics (PV) or solar hot water/thermal equipment to provide energy for on-site use. Recent technological advances include building integrated solar PV for roofs and other building materials. | Often requires additional weight for solar panels. However, new technologies are lighter and more efficient. There are State and Federal incentives available for installing solar panels. |
| Rooftop Garden | A publicly accessible space on the roof that includes opportunities for | Most appropriate for flat roofs in areas where there is |

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|---|---|---|
| | recreation, as well as many benefits of a green roof. | limited open or recreation space at the ground level. The design should strive to include sustainability benefits, alongside the opportunities as a recreational amenity. |

**Site Level Stormwater Management**

There are several site level interventions available to help reduce stormwater runoff, infiltrate precipitation where it falls, reduce water pollution, and reduce flooding. This suite of practices may be referred to as "Green Infrastructure" (GI), "Low Impact Development" (LID), or "Best Management Practices" (BMP) and often utilizes engineered or natural systems to mimic natural processes. Many of these interventions can be used together on a single site and combined with other natural elements like trees and plantings or engineered elements like underground stormwater storage.

**Permeable Surfaces**

There are a wide range of permeable surfaces that can be used at the site level including permeable pavement, permeable pavers, and loose aggregate (gravel). Permeable surfaces allow water to filter through into the ground, can reduce the load on storm sewers and drains during storms and flooding events, and can help recharge ground water. Some permeable surfaces, like pavement, require special maintenance or be best utilized on certain surfaces, such as for parking, foot traffic, or bike traffic.

**Rain Gardens and Bioswales**

Rain gardens and bioswales utilize natural elements like rocks, mulch, and plants rather than the stormwater systems to capture stormwater, slow it down, filter it, and absorb it into the ground.

*Diagram from Center for Urban Waters*

Bioswales help channel and convey stormwater from a street, parking lot, or walkway and can absorb low flows or carry runoff from heavy rains to storm sewer inlets or rain garden. Bioswales improve water quality by infiltrating the first flush of storm water runoff and filtering the large storm flows they convey. When not raining, a bioswale may look like a stream bed.

Rain gardens provide holding space for storm water during large rain events, averting flooding and run off in adjacent spaces such as sidewalks and roadways. When filled with water-tolerant grasses and plants, they provide a visual amenity and additional capacity during storm events. Resources:

- Soak Up the Rain: Rain Gardens | US EPA
- Massachusetts Watershed Coalition (2011) A Community Guide to Growing Greener (commonwaters.org)
  Massachusetts Clean Water Toolkit

# Project Resources and Incentives

There are incentive programs designed to encourage the adoption of energy efficiency and climate-smart building design. These include:

- Mass Save's Passive House incentives and Residential High-Rise New Construction Incentives. Solar PV projects may be eligible for incentives through the Solar Massachusetts Renewable Target (SMART) program.
- For more information about available incentives, check out MAPC's matrix of clean energy programs for low- and moderate-income residents in Massachusetts.
- In addition to these state-level incentives, the federal government also provides incentives for green building practices, especially for affordable housing development. For a summary of the incentives established under the 2022 Inflation Reduction Act, see the National Housing Trust's Policy Brief and this summary.