BUILDING DECARBONIZATION GUIDE

LARGE MULTIFAMILY HOUSING

Post-2000 Construction with District Steam

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WHAT IS BERDO?

Boston's **Building Emissions Reduction and Disclosure Ordinance** (BERDO) is a local law that aims to reduce air pollution and greenhouse gas emissions (GHG) from Boston's largest buildings, which account for 40% of the city's carbon emissions. Building owners subject to BERDO are required to report their buildings' annual energy and water consumption as well as comply with building emissions standards. These emissions standards decrease over time, with all BERDO buildings expected to reach net-zero emissions by 2050.

Reducing carbon emissions means cleaner air, improved public health, and fighting the climate crisis, but also makes our buildings healthier and more comfortable.

HOW TO USE THIS GUIDE

The City of Boston's Building Decarbonization Guides are a resource for building owners and property managers to get to know their buildings, understand how their buildings use energy, and identify the most impactful building upgrades that can improve energy efficiency, reduce emissions, and help with BERDO compliance.

In this guide, we model a **large multifamily building that has been built after 2000 and is connected to a district steam network**. In this case, **district steam is used to produce hot water for heating.** While your building may look a bit different from the sample model, the takeaways from this guide are relevant for any large multifamily housing building that uses hot water for heating.

In this guide you will learn:

- Typical characteristics and energy systems in your building,
- How your building uses energy and produces emissions,
- Steps can you take to reduce your building's energy use and emissions, and
- Technical and financial resources available for building upgrades.

This guide can be a starting point to familiarize yourself with key aspects of building decarbonization, but all buildings will require their own assessment to select the right equipment, repairs, or electrical service that may be needed for specific upgrades. Always consult a qualified service provider before undertaking any building upgrades.

Is this not your building?

Explore other Building Decarbonization Guides we prepared for typical Boston buildings at **boston.gov/berdo**.

SAMPLE LARGE MULTIFAMILY BUILDING

POST 2000 CONSTRUCTION WITH DISTRICT STEAM

In this guide, we will walk you through the types of energy upgrades and decarbonization measures you can make in a typical large multifamily building connected to district steam in Boston. In this example, the building was built after 2000. The building uses district steam from a provider for heating and domestic hot water.

Below are common features found in this building style.

Heating is provided by a hydronic loop that is heated by district steam. The hydronic loop sends hot water to fan coil units inside the apartments. District steam is used in place of a hot water boiler.

Cooling is provided by air-cooled chillers which feed chilled water to the same fan coil units in the summer.

Ventilation is provided through central ventilation for baths or kitchens. Corridors receive conditioned supply air.

Domestic Hot Water (DHW) is provided by heat exchangers using the district steam supply.

NOTE:

In this example, the building uses district steam from a provider to produce hot water. That hot water flows through the building to provide heat.

- Any building that uses hot water for heating can follow the same steps mentioned in this guide, no matter how the hot water is made. However, if a building produces its own hot water through a boiler, this boiler system will also need to be taken care of.
- Buildings that get district steam and use it directly for heating (instead of using steam to produce hot water) will have similar needs to two-pipe steam buildings. If your building uses district steam directly for heating, please visit our Building Decarbonization Guide for *Large Multifamily Housing: Pre 1971 Construction with Two-Pipe Steam System instead.*

BUILDING FEATURES AND RELATED CHALLENGES

A large multifamily building has many ways to save energy and lower emissions over time. The first step is to understand the building's current systems and the challenges they face. Below are characteristics of the building we modeled, as well as some of the common challenges found in each major building element.

200,000
SQUARE FOOTAGE

210
APARTMENTS

EXTERIOR WALLS

Steel framed window wall with code-level insulation.

Challenges:

- Air leakage
- Minimal to no insulation
- Thermal bridging/ heat loss at roofs and floorplates

WINDOWS

Double-hung aluminum or fiberglass framing, double pane glass with thermal breaks.

Challenges:

- Average insulative performance

ELECTRIC CAPACITY

In-unit electrical capacity of 110/120 volts or 220 volts may be present.

Challenges:

- A study of current capacity and future needs may be required to see if upgrades are needed
- Switchgear and feeder cables at the building level, and panel and wiring upgrades likely needed within apartments to provide 220/240 volt service – dependent on the electrification upgrade

VENTILATION

Kitchen and bath mechanical exhaust with vertical risers. Corridors are supplied with conditioned air.

Challenges:

- Both low and high ventilation in the building can cause poor indoor air quality and unnecessary energy use

HEATING

Hydronic loop heating system with district steam, serving fan-coil units.

Challenges:

- Minimal temperature control

COOLING

Chilled water loop provided by air-cooled chillers, serving fan-coil units. A dual temperature loop is switched over to cooling in the summer.

Challenges:

- Minimal temperature control

DOMESTIC HOT WATER

District steam heat exchanger.

Challenges:

- Requires use of district steam during summer and periods with mild outdoor temperatures
- High water flow rates at plumbing fixtures

HOW THIS BUILDING USES ENERGY

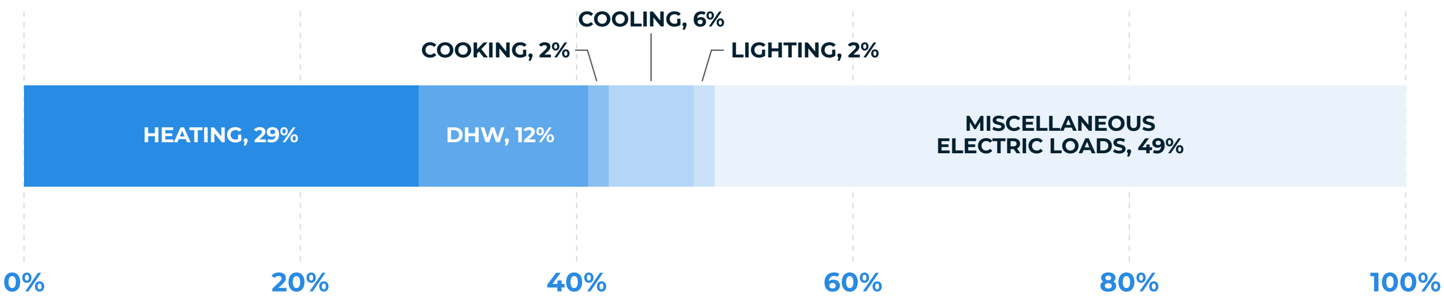
Most of the energy in this building is used for **miscellaneous electric loads**, including residents' appliances and in-unit cooling. Lowering this electricity use is the biggest opportunity to reduce emissions in this building. However, if each unit has its own meter, residents generally pay and are responsible for their own electricity use, which cannot be fully controlled by the building owner.

A smaller amount of electricity is used for common area lighting and other small needs in shared areas.

District steam heating and **Domestic Hot Water (DHW)** are the second and third largest energy uses in this building.

District steam and DHW are usually produced through central systems, which building owners can access more easily when building upgrades are needed.

END USE BREAKDOWN ($kgCO_2e/sf$)



BERDO COMPLIANCE

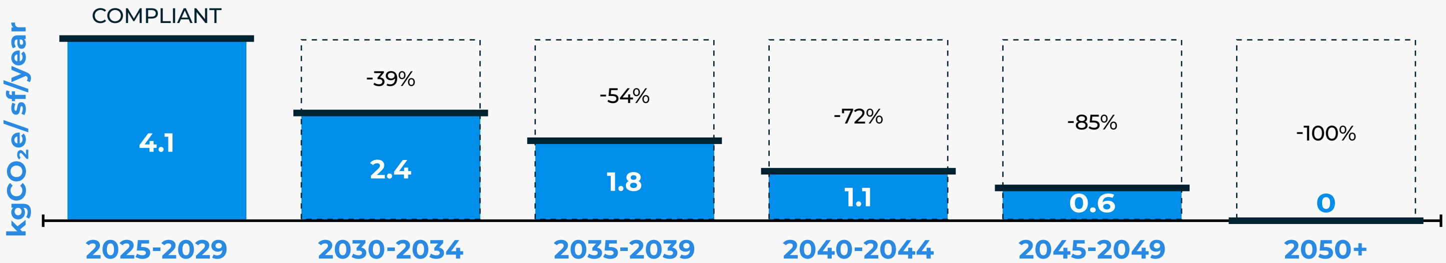
BERDO requires the amount of kilograms of carbon dioxide a building releases per square foot every year (kgCO2e/sf/yr) to stay under the limit set for its building type. From 2025 to 2029, a residential building has an emissions limit of 4.1 kgCO2e/sf/yr. This modeled multifamily building is under the emissions limit for 2025-2029 but will need to lower its emissions by the percentages shown in the figure below for each period of time to remain compliant with BERDO.

BERDO EMISSIONS STANDARDS (LIMITS) IN $kgCO_2e/sf/yr$

$kgCO_2e$/ sf/year

% emissions reduction needed to comply with each period

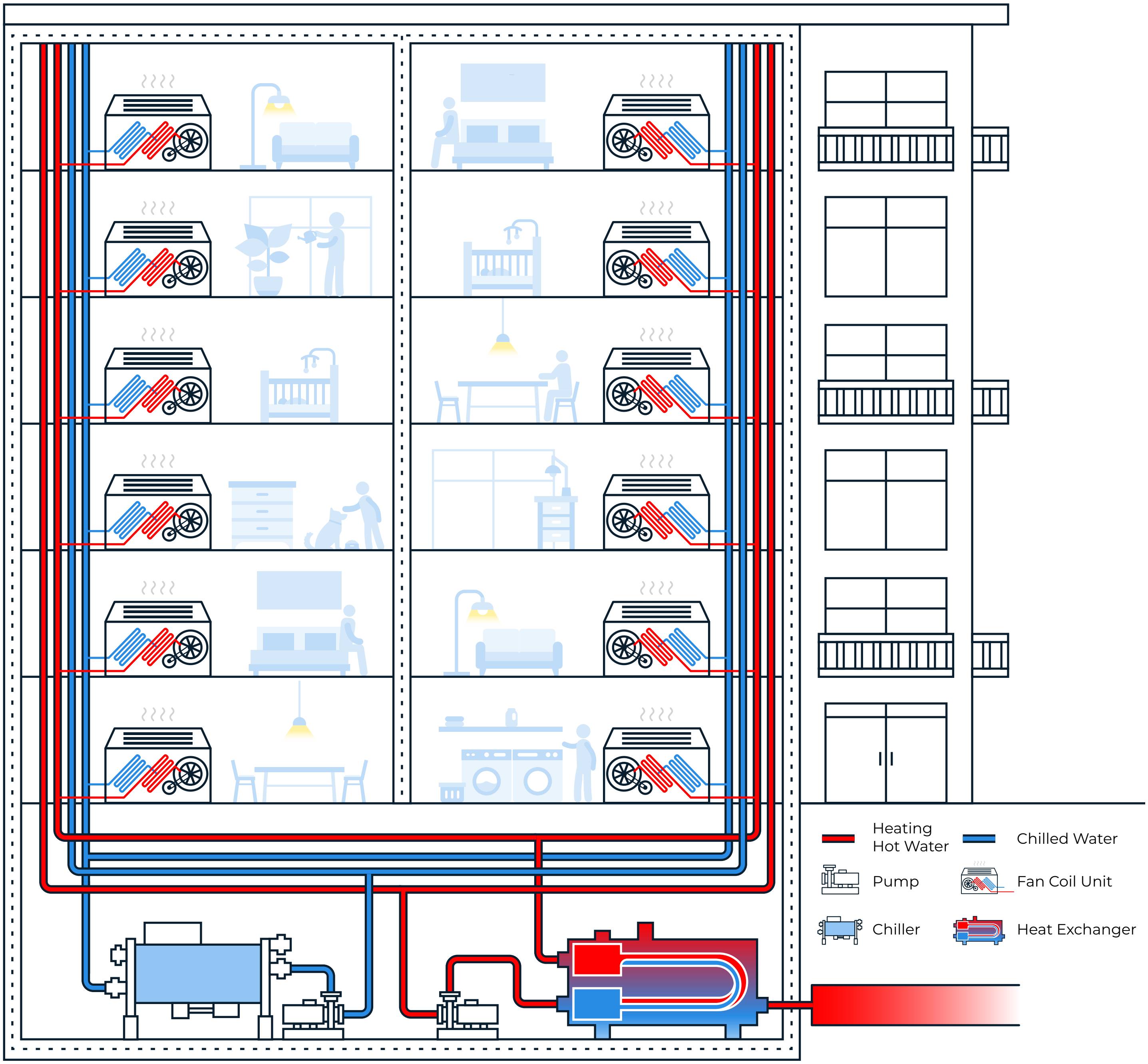
Emissions limit



These estimates are based on a typical building of this size. Emissions reductions can change from building to building and should be calculated for each one separately.

UNDERSTANDING YOUR HEATING SYSTEM

HYDRONIC LOOP SYSTEM WITH DISTRICT STEAM



Hydronic loop system with district steam in large multifamily building

Hydronic loop systems with district steam are a common heating setup in large multifamily buildings. In this example, a hydronic loop (a closed-pipe water loop) circulates hot water to fan coil units (terminal units) located in each apartment.

This hot water is produced with district steam. The building receives district steam directly from a provider at high pressures. When entering the building, the steam is reduced in pressure and then sent into a heat exchanger to produce hot water.

Central pumps help circulate the hot water through the hydronic loop until it reaches the fan coil units in each room. Fan coil units consist of a small fan which can be controlled by residents. Residents can increase or decrease the speed of the fan and determine how much heat is blown off of the heated loop into the room.

Cooling is provided by an air-cooled chiller plant powered by electricity. In this case, a dual temperature loop circulates chilled water in the summer to the same fan coil units located inside the apartments. The entire system is manually switched from heating to cooling and back each season.

NEAR TERM OPPORTUNITIES FOR IMPROVEMENT

There are cost-effective, proven improvements for hydronic loop systems with district steam to increase efficiency and comfort. These should always be considered as part of any improvement plan. Further details on these steps are provided in the following sections:

RETRO-COMMISSIONING *(P. 20)* ↗

A central heating plant and controls need regular tuning and adjustments for optimal performance.

INSTALL VARIABLE FREQUENCY DRIVES (VFDS) ON HYDRONIC PUMPS *(P. 21)* ↗

VFDs allow pumps to speed up and slow down as needed, based on pressure within the loop piping.

This greatly reduces electricity usage in contrast to systems where pumps may operate at constant speeds regardless of heating needs in the building.

INSTALL CONTROL VALVES AT FAN COIL UNITS *(P. 21)* ↗

Control valves ensure that the hot water supply to each fan coil unit can be closed off when not needed. This allows the pump VFDs to vary pump speeds as needed.

ELECTRICAL SERVICE CONSIDERATIONS FOR BUILDING ELECTRIFICATION

Switching to electric heating, hot water, and cooking systems is one of the main ways to reduce emissions, and it can be a big project. For example, **heat pump systems** need enough electrical power to work. Older buildings may need **electrical upgrades** to increase their electrical capacity. The cost of these upgrades depends on the building's current capacity and power use, so they should be carefully reviewed.

Electrical service upgrades can be broken down into these basic components:

ELECTRIC SERVICE FROM THE LOCAL GRID

First, the utility company must supply enough power to the building. Building owners need to work with the utility and review the building's current and future power needs to confirm there is enough capacity or to request an upgrade.

- An analysis is needed to figure out how much electricity a building will need from the utility.
- A mechanical engineer designs the heating and cooling systems and chooses the size of the equipment, which affects how much electricity the building will use.
- An electrical engineer then looks at the building's current electricity use and estimates how much more will be needed. This helps determine if the building has enough electrical capacity.

If the current supply is enough, the upgrades can move forward. If not, the utility will need to add more capacity. The utility decides what work is required and whether the building owner will need to pay for any of it. This can take anywhere from months to years, however, the timing and process can vary for each building.

BUILDING CENTRAL INFRASTRUCTURE

Electricity enters the building through a main connection and goes to a switchgear. The switchgear can turn the power on or off for the whole building when needed. This helps isolate the building from the main electrical supply. The switchgear must be large enough to handle all incoming electricity. Some equipment, such as large chillers, might also need a special transformer to provide extra voltage to operate.

DISTRIBUTION AND METERS

Next, electricity goes to the building's main meter or a group of meters for apartments or businesses. The cables that bring electricity must be the right size. Large equipment like a heat pump water heater usually connects at this point.

INDIVIDUAL UNIT SERVICE

Electrical risers carry power to each unit's electrical panel. The panel controls electricity for the unit and provides safety shut-offs. Power flows from the panel to outlets and equipment. For equipment such as heat pumps, condenser units, water heaters, dryers, and refrigerators, the wiring and panel must provide enough amperage, usually 220 or 240 volts. This is often where electrical capacity is too low and a load study is needed to understand what upgrades are required. In some cases, new wiring can run directly from the equipment to a central location, bypassing panels, either through chases within or exterior to the building without going through the unit's panel.

The electrical infrastructure in your building should be evaluated to see if upgrades are needed to support new equipment installation.Evaluating your electrical infrastructure can sometimes be as simple as having an electrician inspect your panels, but more complex cases may require a full electrical feasibility study by a qualified firm or contractor.

TIMING YOUR BUILDING UPGRADES

Building systems impact each other. For example, better insulation can reduce heating and cooling loads. The timing of construction projects can impact installation costs and disruption. Using incentives or rebates that may be available in the short term frees up capital to invest in incremental improvements further into the future.

Poor sequencing can lead to missed chances to combine work or to retrofit building systems that work with each other and improve your building's performance in the long run. A long-term plan helps organize building upgrades so that a deep energy retrofit can be done more efficiently.

TIMING CONSIDERATIONS

EXISTING BUILDING SYSTEM OPTIMIZATION

Prioritize carrying out measures that reduce heating and cooling loads, such as air sealing, heating system controls, and distribution repairs, lighting and appliance upgrades as soon as feasible. These measures reduce heating and cooling needs, allowing for purchase of smaller and less expensive equipment when the time comes for future system upgrades. These measures also tend to improve comfort and health for occupants through improved air quality, temperature control, and safety.

The energy cost savings from reduced heating and cooling loads in the short term can also be applied toward capital expenses for future, larger-scale measures.

TENANT TURNOVER

Building owners and staff have the opportunity to make energy efficiency improvements in addition to repairs or aesthetic upgrades when tenants vacate spaces. This includes air sealing in places that may be hard to reach when spaces are occupied, standardizing equipment, and replacing or upgrading equipment such as air conditioners or packaged terminal units.

EXISTING BUILDING SYSTEM END OF LIFE

Upgrades to building systems are often most cost-effective at the time when major equipment is at the end of its useful life and due for replacement. Capitalize on these times where investments are already required to upgrade key systems, or choose additional systems that can easily be completed at the same time. While the exact time for replacement may not be known, it is good practice to plan around the equipment's expected useful life. This also helps minimize the risk of expensive emergency repairs or replacements.

Between now and 2050, there may be only one chance to replace major systems like heating and cooling. It's important to plan ahead so you can make upgrades that save the most energy and money.

RESOURCES FOR BUILDING UPGRADES

There are many resources available to you to help you decarbonize your building:

Retrofit Resource Hub ↗

The City of Boston maintains a resource with the most up-to-date incentives, rebates, tax credits, and loans that can help you throughout your decarbonization journey.

Mass Save Multi-Family Program ↗

If you are ready to begin exploring decarbonization options for your building, start by identifying what upgrades your building needs. You can contact Mass Save for a no-cost energy assessment and to explore possible incentives and financing options.

Hire a Building Science Firm ↗

The City of Boston maintains a list of Building Science Firms that have responded to a request for information for BERDO-related services. This can serve as a helpful starting point for finding a vendor, but is not an exhaustive list of companies that offer these services. These firms can:

- Assess your building
- Recommend energy improvements
- Obtain incentives on your behalf, and
- Find the right contractors for the job.

TIP: ***It is best practice to request quotes from multiple providers to make sure that you are getting the right services for your situation at the best price.***

BUILDING UPGRADES TO LOWER GREENHOUSE GAS EMISSIONS

This section guides you through the measures you can take to upgrade your building systems. Each upgrade overview is based on the modeled building and includes cost ranges, estimated energy savings, key considerations, and other helpful information. Depending on your building's condition, the age of your systems, and your available budget, you can decide which energy-saving measures can be made right away and which should be planned over time.

The City of Boston's BERDO team is here to help you. Visit **boston.gov/berdo** to learn about our program offerings, get in touch, and access our latest resources and guides.

GREENHOUSE GAS EMISSIONS REDUCTIONS AND COSTS

All emissions reductions and cost numbers in this document are estimates for the example building presented in this guide. Actual results may differ based on your building and its systems as well as market costs for equipment and labor.

COMPONENT	TERM	MEASURE	% REDUCTIONS	COST LOW	COST HIGH
LIGHTING & LOADS	Immediate	LED Upgrades + Controls	0.3%	$77,600	$100,000
	Immediate	Appliance Upgrades	3.8%	$841,207	$1,261,810
ENVELOPE	Immediate	Air Sealing	0.7%	$50,000	$100,000
	Immediate	Roof Insulation	1.0%	$444,500	$508,000
	Long	Recladding/Wall Insulation	7.4%	$1,767,500	$2,272,500
	Long	Window Replacement	2.0%	$4,907,900	-
VENTILATION	Long	Energy Recovery Ventilation (ERV) system	1.1%	$384,000	$434,000
HEATING & COOLING	Immediate	Retro-commissioning	2.9%	$70,000	$100,000
	Immediate	Controls + Distribution Improvements	1.3%	$25,000	$75,000
	Long	Heating Electrification	18.5%	$7,000,000	$15,000,000
DOMESTIC HOT WATER	Immediate	Low-flow Water Fixtures/Aerators	0.3%	$4,206	$10,515
	Long	Central/Partial/Full Heat Pump	6.4%	$1,000,000	$8,000,000

IMMEDIATE TERM

LIGHTING & LOADS

LED UPGRADES + CONTROLS

LED light bulbs use 90% less energy than traditional lighting options and have the longest lifespan of all bulb options. Automatic lighting controls such as motion sensors can reduce lighting energy use even further.

CONSIDERATIONS

- Beyond common areas (stairwells, corridors, back of house), address in-unit/tenant spaces where possible, and all exterior fixtures.
- Residential tenant lamps can be upgraded through tenant LED hand-outs.

ACCESS NEEDED TO MAKE IMPROVEMENTS

Common Areas: Access to lighting fixtures, minimal tenant disruption.

In-Unit: Access to hard-wired fixtures, minimal disruption.

ADDITIONAL RESOURCES

LED lighting retrofits

RECOMMENDED SPECIFICATIONS

- Target 50% reduction in watts per square foot in common areas to reduce wasted energy use.
- ENERGY STAR labeled fixtures and lamps.

ENERGY SAVINGS

About 14% of the building's lighting load

CAPITAL COST

Estimated to be between $0.37–$0.50 / SF

IMMEDIATE TERM

LIGHTING & LOADS

APPLIANCE UPGRADES

Install ENERGY STAR labeled washing machines, dishwashers, and refrigerators.

Consider electrifying gas-fired ranges and stoves. Gas stovetops are a significant contributor to air quality problems in residences and often the final barrier for buildings that wish to fully electrify their systems. Electric induction stoves and cooktops also reduce the risk of gas leaks and fire, as well as carbon monoxide poisoning.

CONSIDERATIONS

- Where equipment is not owned by residents, replace equipment at unit turn-over, end of useful life.
- If you're switching from a gas stove to an electric induction stove, you may need to upgrade your electrical wiring and install a new 240 Volt outlet. Expect to hire an electrician for electric panel upgrades.

ACCESS NEEDED TO MAKE IMPROVEMENTS

- **Common Areas:** Not applicable.
- **In-Unit:** Equipment replacement causes minimal disruption. Electric service upgrades may require more extensive access to the panel in-unit and in the building.

ADDITIONAL RESOURCES

Induction Cooking

RECOMMENDED SPECIFICATIONS

- ENERGY STAR certified equipment.

ENERGY SAVINGS

About 8% of plug loads

CAPITAL COST

$4,000–$6,000 / apartment

EMISSIONS REDUCTION MEASURES BY SYSTEM TYPE

IMMEDIATE TERM

ENVELOPE

AIR SEALING

Making a building airtight can lower energy use and improve indoor air quality. It also helps ventilation systems work more efficiently. You should consider airtightness in any building upgrade. All parts of the building envelope, including windows, walls, insulation, and doors, contribute to air tightness.

CONSIDERATIONS

- It's also important to seal up areas like stairwells, elevator shafts, duct risers, and roof bulkheads to stop air from leaking out.
- Different parts of the building need different materials to seal properly. For example, caulk works well for small cracks, while spray foam or weatherstripping may be better for larger gaps.
- Fresh air systems should be added or upgraded to keep the indoor air clean and healthy.

ACCESS NEEDED TO MAKE IMPROVEMENTS

- **Common Areas:** Not applicable.
- **In-Unit:** Minimal. Access to air conditioners, window frames, and exterior facing walls may be required. Most in-unit air sealing is done with conducted caulk, weather stripping, or dedicated covers and gaskets.

ADDITIONAL RESOURCES

Air Sealing At Room Air Conditioners

RECOMMENDED SPECIFICATIONS

- Reduce Air Leakage: Recommended airtightness = 1.0 ACH.

ENERGY SAVINGS

Estimated 2.5% of heating load

CAPITAL COST

Estimated $0.25–$0.50 / SF

EMISSIONS REDUCTION MEASURES BY SYSTEM TYPE

IMMEDIATE TERM

ENVELOPE

ROOF INSULATION

Upgrading roof insulation helps extend the building's lifespan and lowers energy costs by reducing the load on heating and cooling systems.

If your building has a flat roof with some or no existing insulation, consider installing insulation above the existing roof deck. This should include solid insulation boards such as polyisocyanurate (Polyiso), extruded polystyrene (XPS), or expanded polystyrene (EPS), covered by a protective layer. This type of installation provides more continuous insulation and often delivers better thermal performance.

CONSIDERATIONS

- Any plan to add insulation to the exterior of a building must be carefully coordinated with any zoning or lot line restrictions, as well as any potential oversight by local authorities such as historic preservation ordinances.
- Roof insulation is governed by minimum code requirements; adding insulation must comply with other regulations such as roof height, parapet height, etc.
- Insulation improvements are most cost effective at the time of roof replacement.
- Consider reflective cool roof materials when resurfacing.
- Consider improvements alongside rooftop equipment installation to phase work appropriately.
- Blown-in cellulose or mineral wool are preferred for their reduced health risks. Fiberglass is also used but should be properly sealed to limit exposure.

ACCESS NEEDED TO MAKE IMPROVEMENTS

- **Common Areas:** Roof access only.
- **In-Unit:** Not applicable.

ADDITIONAL RESOURCES

Roof Insulation

RECOMMENDED SPECIFICATIONS

- Minimum of R-30, or local code minimum (higher R-value is better).

ENERGY SAVINGS

3.5% of heating load

CAPITAL COST

$35–$40 / SF of roof area

EMISSIONS REDUCTION MEASURES BY SYSTEM TYPE

LONG TERM

ENVELOPE

RECLADDING/WALL INSULATION

Upgrading exterior insulation is one of the most effective ways to reduce energy use and maintain a comfortable indoor temperature. Products like External Insulation and Finishing Systems (EIFS) can be added to the outside of a building and include all parts of the exterior wall system in one product.

CONSIDERATIONS

- Unlike masonry and glass façades, products like EIFS do not have ongoing maintenance costs. Buildings that already budget for façade maintenance can repurpose this money to install EIFS. Well-made products are designed to handle weather better than older materials and often include a drainage layer to reduce moisture damage. Brick facades, for example, need regular maintenance and re-pointing bricks to stay in good shape and remain structurally safe.
- Before upgrading your façade, make sure a structural engineer reviews whether your building's structure can support the changes, especially if your building is an older masonry building.
- EIFS may not be allowed in certain landmark districts or on buildings with historic designation.

ACCESS NEEDED TO MAKE IMPROVEMENTS

- **Common Areas:** Building may need exterior protection or scaffolding.
- **In-Unit:** External insulation requires minimal in-unit access, but noise and scaffolding may disrupt tenants.

Interior insulation requires access to units and may require tenants to temporarily relocate for a limited time. Thoughtful planning is important to minimize disruption and keep things comfortable for tenants.

Most in-unit air sealing is done with conducted caulk, weather stripping, or dedicated covers and gaskets.

ADDITIONAL RESOURCES

Wall Insulation

RECOMMENDED SPECIFICATIONS

- R value = Minimum R-22

ENERGY SAVINGS

26% heating energy savings

CAPITAL COST

$35–$45 / SF of wall area

LONG TERM

ENVELOPE

WINDOW REPLACEMENT

Choosing the right windows is important to keep indoor spaces comfortable and reduce heating and cooling needs. Triple-pane windows are often recommended for better comfort. Passive House certified windows are a great choice because they are well-sealed and energy efficient.

Window styles like awning, tilt-turn, and casement are better than double-hung or sliding windows because they let in less air and last longer thanks to stronger locks and seals.

CONSIDERATIONS

- Start by identifying windows that are old or damaged, since replacing them at the right time can save money.
- How the windows are installed matters just as much as the kind of window you choose. Make sure you hire a reputable contractor who's familiar with proper window sealing during installation to avoid air leaks.

ACCESS NEEDED TO MAKE IMPROVEMENTS

- **Common Areas:** Access to common area windows may need exterior protection and scaffolding.
- **In-Unit:** Full access is needed to make improvements to schedule and replace windows. Thoughtful planning is recommended to minimize tenant disruption during this time.
- **ADDITIONAL RESOURCES**

High Performance Windows

RECOMMENDED SPECIFICATIONS

- U value = 0.167 Btu/hr.ft2.F (lower U-value is better)

ENERGY SAVINGS

Estimated 7% of heating load

CAPITAL COST

Estimated $23,000 / apartment

EMISSIONS SAVINGS MEASURES BY SYSTEM TYPE

LONG TERM

VENTILATION

ENERGY RECOVERY VENTILATION (ERV) SYSTEM

An Energy Recovery Ventilator (ERV) is a type of ventilation system that brings fresh air into a building while using less energy. It helps improve indoor air quality and keeps people healthy.

An ERV works by using the air that's leaving the building to warm or cool the fresh air coming in. This means your heating and cooling systems don't have to work as hard, which saves energy and reduces pollution.

CONSIDERATIONS

- **Mechanical Exhaust System:** If there is space available, ERVs can work with existing mechanical exhaust systems
- **Ductwork Modifications:** Some buildings may need added or modified ductwork to distribute fresh air effectively.
- **Exhaust Riser Condition:** Cleaning and sealing of exhaust risers is important for the best performance. Exhaust risers help remove stale, or contaminated air from different parts of the building and push it up to the roof or an upper-level vent where it's released outside.
- **Fan Replacement:** Existing exhaust fans in common areas, bathrooms, and other spaces may need to be replaced.
- **Electrical Capacity:** Installing an ERV may require increased electrical capacity both at the unit level and in the building's main electrical panel.

ACCESS NEEDED TO MAKE IMPROVEMENTS

- **Common Areas:** Access to exhaust risers and rooftop access.
- **In-Unit:** Access needed to make improvements to clean and seal ductwork, some through all access may be necessary to repair damaged risers.

ADDITIONAL RESOURCES

Enhanced Ventilation with Energy Recovery Ventilators (ERV)

RECOMMENDED SPECIFICATIONS

- Sensible Heat Factor: 80%
- Max fan power: 0.76 W/cfm

ENERGY SAVINGS

4% of heating usage

CAPITAL COST

Costs vary depending on the type of mechanical ventilation risers currently installerd in the building, as well as the materials and labor used to install new ERV euipment. There are additional costs for cleaning, sealing, and balancing risers.

EMISSIONS SAVINGS MEASURES BY SYSTEM TYPE

IMMEDIATE TERM

HEATING & COOLING

RETRO-COMMISSIONING

Retro-commissioning (RCx) is a crucial process for maintaining existing building performance and is generally recognized as the first stage in the building upgrade process. RCx focuses on optimizing and improving the performance of existing building systems.

RCx starts with an assessment from an energy engineer and/or commissioning agent to evaluate if the building's systems are designed, installed, functionally tested, and capable of being operated and maintained according to the owner's operational needs. Following the assessment, the owner must complete the study's recommendations to achieve energy savings. This can range from simple setpoint adjustments and scheduling improvements, to repairing or replacing sensors, dampers, or other non-functioning components of an HVAC system.

RCx can be done for any building, but is particularly useful for older buildings where systems may have changed from their original design specifications. RCx covers the performance of HVAC equipment, distribution efficiency, controls settings, and any operational settings that affect the system's energy efficiency.

CONSIDERATIONS

- Have equipment documentation available for consultant review and inventory all systems before assessment.

ACCESS NEEDED TO MAKE IMPROVEMENTS

- **Common Areas:** Access to mechanical systems and building automation system (if installed).
- **In-Unit:** Not applicable.

ADDITIONAL RESOURCES

Operations and Maintenance Guide

RECOMMENDED SPECIFICATIONS

- Follow best practices set by manufacturer or designer.

ENERGY SAVINGS

Estimated 5% of whole building usage (conservative estimate based on federal research indicating up to 30%)

CAPITAL COST

$0.39–$0.50 / SF

EMISSIONS SAVINGS MEASURES BY SYSTEM TYPE

IMMEDIATE TERM

HEATING & COOLING

CONTROLS + DISTRIBUTION IMPROVEMENTS

Systems that rely on large central pumps can benefit from installation of Variable Frequency Drives (VFDs). VFDs allow pumps to speed up or slow down as needed, when more or less water pressure is needed in the system. Pumps without VFDs waste energy because they run at full speed when they are on.

CONSIDERATIONS

- Pumps must feature the appropriate insulation class in order to accommodate VFDs, existing pumps must be surveyed for suitability, or replaced.
- Terminal units must have control valves that allow water flow to stop and start, which then permits the VFDs to respond to changes in loop pressure. If terminal units contain three way valves as opposed to two-way valves, valve replacement and some re-piping may be required.

ACCESS NEEDED TO MAKE IMPROVEMENTS

- **Common Areas:** Access to central pumps.
- **In-Unit:** Plumber/ technician access at all terminal units.
- The heating or cooling supply must be shut off to complete this work.

ADDITIONAL RESOURCES

Hydronic Heat Upgrade

RECOMMENDED SPECIFICATIONS

- Specifications must be designed by engineers.

ENERGY SAVINGS

Estimated 2.7% of electrical loads

CAPITAL COST

$25,000–$75,000

EMISSIONS SAVINGS MEASURES BY SYSTEM TYPE

LONG TERM

HEATING & COOLING

HEATING ELECTRIFICATION

Heating electrification is a major project that involves completely replacing the heating system and its related equipment and connections. Switching to electric heating is one of the best ways to lower emissions because it replaces one of the biggest sources of fossil fuel use in buildings. There are a few main types of electric heating systems:

Mini-Split Heat Pumps

These are small systems with one outdoor unit (compressor) connected to the indoor unit (mini split) that condition the air in the room. They don't use ducts and are good for heating and cooling single rooms.

Package Terminal Heat Pumps (PTHPs)

These are single units usually found under windows in through-wall penetrations in bedrooms or living rooms. They heat and cool one room at a time and can be plugged in or hard wired.

Central Air to Water Heat Pump (AWHP) Plant

A bank of AWHPs can replace district steam service and heat the hot water loop for the building.

CONSIDERATIONS

- **Mini-Split Heat Pumps:** This is a well-established technology you can trust. Space is needed for exterior condensing units – usually roofs or ground level space. You should consider your building's structural integrity, your roof's replacement schedule, and placement of refrigerant lines.
    - Best suited for smaller buildings – refrigerant lines connecting condensing units to mini-splits within the apartments have maximum length limitations and must be placed appropriately.
    - Installation requires penetrations for refrigerant lines between condensers and the in-unit mini-splits. Connection is somewhat straight forward once equipment location is identified.
- **Package Terminal Heat Pumps (PTHP):** This is a well-established technology you can trust. PTHP requires through-wall penetrations. This can result in increased air movement, unless properly gasketed and installed.
    - Good for building of any size, especially where through-wall penetrations for package terminal air conditioners (PTACs) already exist.
    - Installation is low maintenance where penetrations already exist. PTHPs will likely need power supply in the unit. PTHPs require moisture drainage which may be difficult if an existing pathway isn't already present.
- **Central Air to Water Heat Pump (AWHP) Plant:** This is a technology already available in the market.
    - The number of heat pumps you need depends on your heating load.
    - Space is needed for equipment and adequate venting.
    - Replacing your building's heating source for AWHP may require little to no adjustment to the existing distribution system or terminal units.
- Your building and local utility must have enough electrical capacity to support heat pump systems. Always check electrical loads first, as electric service upgrades can have high costs depending on your building's existing capacity.
- Regulations for refrigerants can change over time. You should always confirm that the equipment you are installing is permissible under upcoming code requirements.

- A new technology uses window-based air-source heat pumps that can be placed directly in a window opening, similar to a standard air conditioner. This option doesn't require special installation, just enough electrical power for the wall outlet. Pilot projects in New York City are currently testing this technology.

ACCESS NEEDED TO MAKE IMPROVEMENTS

- **Common Areas:** Required.
- **In-Unit:** Required, except in the case of PTHP installation in existing, appropriately sized sleeves, and central AWHP installation requires no in-unit access. Window Heat Pump technology is also a simple installation option.

ADDITIONAL RESOURCES

- Mini-Splits
- Packaged Terminal Heat Pumps
- Can Heat Pumps Work for Renters?
- Public Housing Sees Gains from Heat Pumps

RECOMMENDED SPECIFICATIONS

- Heating: 3.3 COP @ 47°F Cooling: 4.4 COP
- Cold climate certified equipment

ENERGY SAVINGS

Estimated 70% reduction in heating loads

CAPITAL COST

Cost can range from $35 / SF to over $100 / SF, depending on the system type and capital constraints.

Electric service upgrades can have high costs depending on your building's existing conditions, but they are not always necessary. Electric service upgrades must be identified on a site-by-site basis.

IMMEDIATE TERM

DOMESTIC HOT WATER (DHW)

LOW-FLOW WATER FIXTURES/AERATORS

You can install low-flow, tamper-proof aerators or restrictors on most sinks and showerheads to reduce water usage. This will also reduce the energy needed to heat your building's DHW.

CONSIDERATIONS

- Installing these systems requires some coordination and buy-in from residents, since they may notice a different experience when using the fixtures.

ACCESS NEEDED TO MAKE IMPROVEMENTS

- **Common Areas:** Not applicable.
- **In-Unit:** Minimal—installation can take place within minutes.

ADDITIONAL RESOURCES

WaterSense

RECOMMENDED SPECIFICATIONS

- WaterSense labeled products
- Max Water Flow: Gallons Per Minute (GPM): Showerheads: 1.5, Kitchen Sink, 1.5, Bath Sink: 1.0

ENERGY SAVINGS

Estimated 3% of DHW load

CAPITAL COST

Minimal—packages of aerators and restrictors can cost less than $20 per apartment unit.

EMISSIONS SAVINGS MEASURES BY SYSTEM TYPE

LONG TERM

DOMESTIC HOT WATER (DHW)

CENTRAL HEAT PUMP WATER HEATERS

Heat pump technologies are also available for DHW production. You can electrify your building's central DHW system while keeping existing distribution systems in place. You can also choose to complement your existing DHW system with modular heat pumps to handle part of your building's DHW loads.

CONSIDERATIONS

- Your building and local utility must have enough electrical capacity to support heat pump systems. Always check electrical loads first, as electric service upgrades can have high costs depending on your building's existing capacity.
- Regulations for refrigerants can change over time. You should always confirm that the equipment you are installing is permissible under upcoming code requirements.
- Systems must be designed for Boston's cold weather.If your heat pump evaporators are installed outside, you may need to add more electrical power or use a backup DHW source such as electric resistance heating.
- Before electrification, DHW loads should be reduced by fixing leaks, installing low-flow fixtures and aerators, and making sure the pumping and piping systems are properly designed for efficient water distribution.
- Partial electrification needs advanced equipment controls to manage two systems working together.

ACCESS NEEDED TO MAKE IMPROVEMENTS

- **Common Areas:** Acces to Mechanical and electrical spaces is needed.
- **In-Unit:** Not applicable.

ADDITIONAL RESOURCES

Air to Water Heat Pumps (AWHPs)

RECOMMENDED SPECIFICATIONS

- Air to Water Heat Pump: Min. COP: >2.2, Water to Water Heat Pump: Min. COP: >3.1
- AWHPs that use a carbon dioxide (CO_2) based refrigerant are recommended. CO_2 refrigerant is more efficient and has a significantly smaller global warming impact compared to conventional refrigerants.

ENERGY SAVINGS

Estimated 63% of DHW load

CAPITAL COST

$5–$40 / SF