BUILDING
DECARBONIZATION GUIDE



COMMERCIAL OFFICE

Class A

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HOW TO USE THIS GUIDE

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 sample **Class A commercial office** building to illustrate the typical characteristics and energy systems found in these properties. While your building may differ somewhat from this model, the key takeaways apply to most office buildings with similar features.

In this guide you will learn:

- Typical characteristics and energy systems in your building,
- How your building uses energy and produces emissions,
- Steps you can 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**.

CHARACTERISTICS OF CLASS A OFFICE BUILDINGS

Commercial office real estate is often grouped into different classes. These classes help describe a building's features, location, rent, age, and overall condition. In the City of Boston's Decarbonization Guides, we modeled two types of office buildings: Class A and Class B. This guide will cover Class A buildings, you can find our Class B Commercial Office Buildings guide at **boston.gov/berdo**.

CLASS A
BUILDINGS

Class A buildings usually feature central heating and cooling systems that provide heating and cooling that serve all.

For these Building Decarbonization Guides, we assume Class A buildings were built more recently, any time between 1970 and today. Our sample Class A commercial office building heating system uses a **central heating and Domestic Hot Water (DHW) system** that relies on a natural gas boiler. **Cooling** is provided by a central electric chiller plant with cooling towers, owned and operated by the building owner. **Ventilation** is provided through centralized air handling units.

Given that the building already supports large electrical loads for cooling, electrical service in the building may already be strong enough to upgrade to electric heating.

CLASS B
BUILDINGS

Class B buildings often have a central heating system that provides heat for the whole building. Cooling is usually the responsibility of each tenant, so cooling systems can vary from space to space. For these Building Decarbonization Guides, we assume these buildings were built between 1900 and 1930.

BUILDING FEATURES AND RELATED CHALLENGES

In this guide, we will walk you through the types of energy upgrades and decarbonization measures you can make in a typical Class A office.

A Class A office 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 size characteristics of the building we modeled, as well as some of the common challenges found in each major building element.

115,000

SQUARE FOOTAGE

EXTERIOR WALLS



Steel frame with glass curtain wall.

Challenges:

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

WINDOWS



Aluminum frames, double glazing with and without thermal breaks.

Challenges:

- Average insulative performance

HEATING



Hydronic loop heating system with hot water supplied by gas boiler. Perimeter fan coil units or induction units.

Challenges:

- Limited savings opportunities for induction unit systems
- System type requires simultaneous heating and cooling to meet varying temperature needs

COOLING



Centralized chiller plant with electrically operated water cooled chillers, cooling towers.

Challenges:

- Meeting low cooling loads with large equipment
- Unoptimized chilled water plants
- Older chiller equipment does not respond well to typical optimization strategies

DOMESTIC HOT WATER (DHW)



Dedicated gas-fired hot water heater.

Challenges:

- Low DHW use, hot water production relies on fossil fuel systems
- High water flow rates at plumbing fixtures

VENTILATION



Centralized air handling units with a mix of ventilation controls.

Challenges:

- Equipment is oversized in most cases, using more energy than needed for small loads
- Delayed system improvements are common due to differing tenant lease lengths and terms
- Overventilation is common, using unnecessary energy

ELECTRIC CAPACITY



Likely in-unit electrical capacity of 220 volts present.

Challenges:

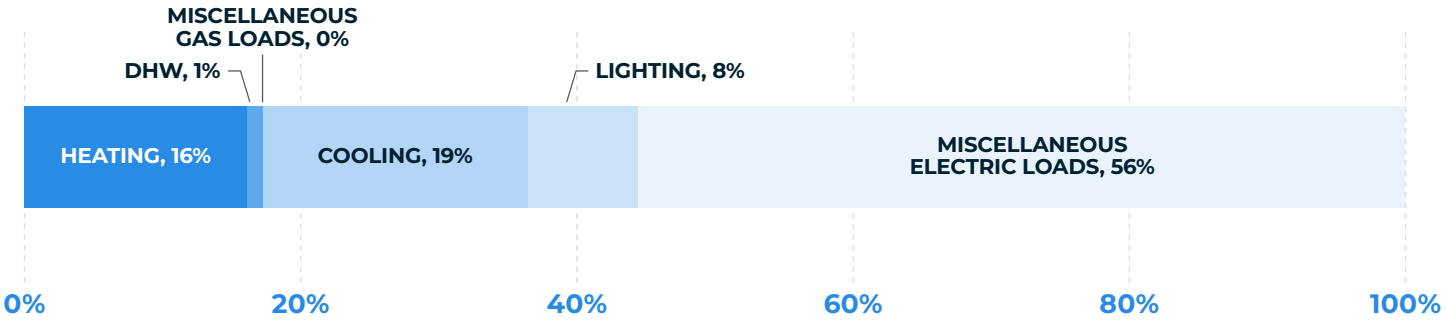
- A study of current capacity and future needs may be required to see if upgrades are needed

HOW THIS BUILDING USES ENERGY

Electricity use is the main energy use and source of GHG emissions in this building. Most electricity use is driven by tenant meters, which includes **miscellaneous electric loads** such as computers, lighting, and air conditioning. Tenants are generally responsible for and pay for their own electricity use, which cannot be controlled by the building owner. A smaller amount of electricity is used for common area lighting, central cooling, and other small needs.

Heating with natural gas is the second largest energy use and source of GHG emissions. The central heating system can be managed and upgraded by the building owner.

END USE BREAKDOWN ($kgCO_2e/sf$)

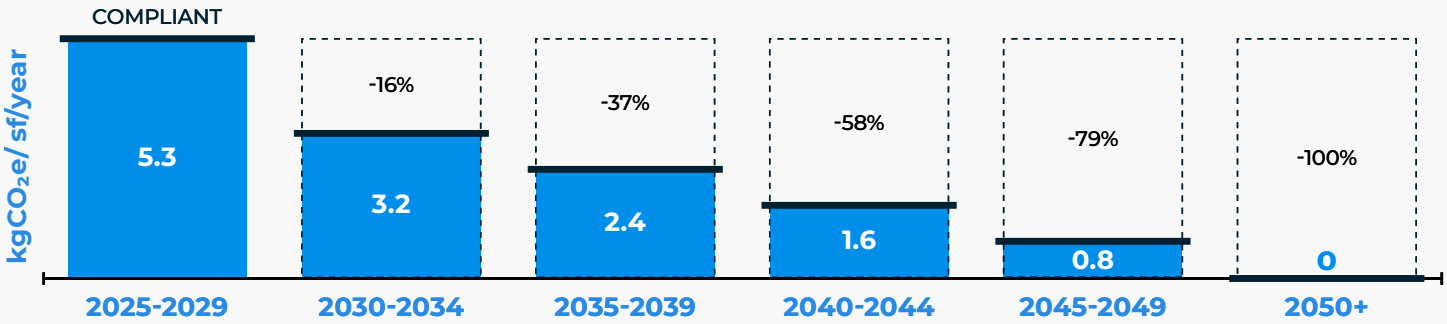


BERDO COMPLIANCE

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, an office building has an emissions limit of 5.3 kgCO2e/sf/yr. This modeled Class A commercial 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 $kgCO_2e/sf/yr$

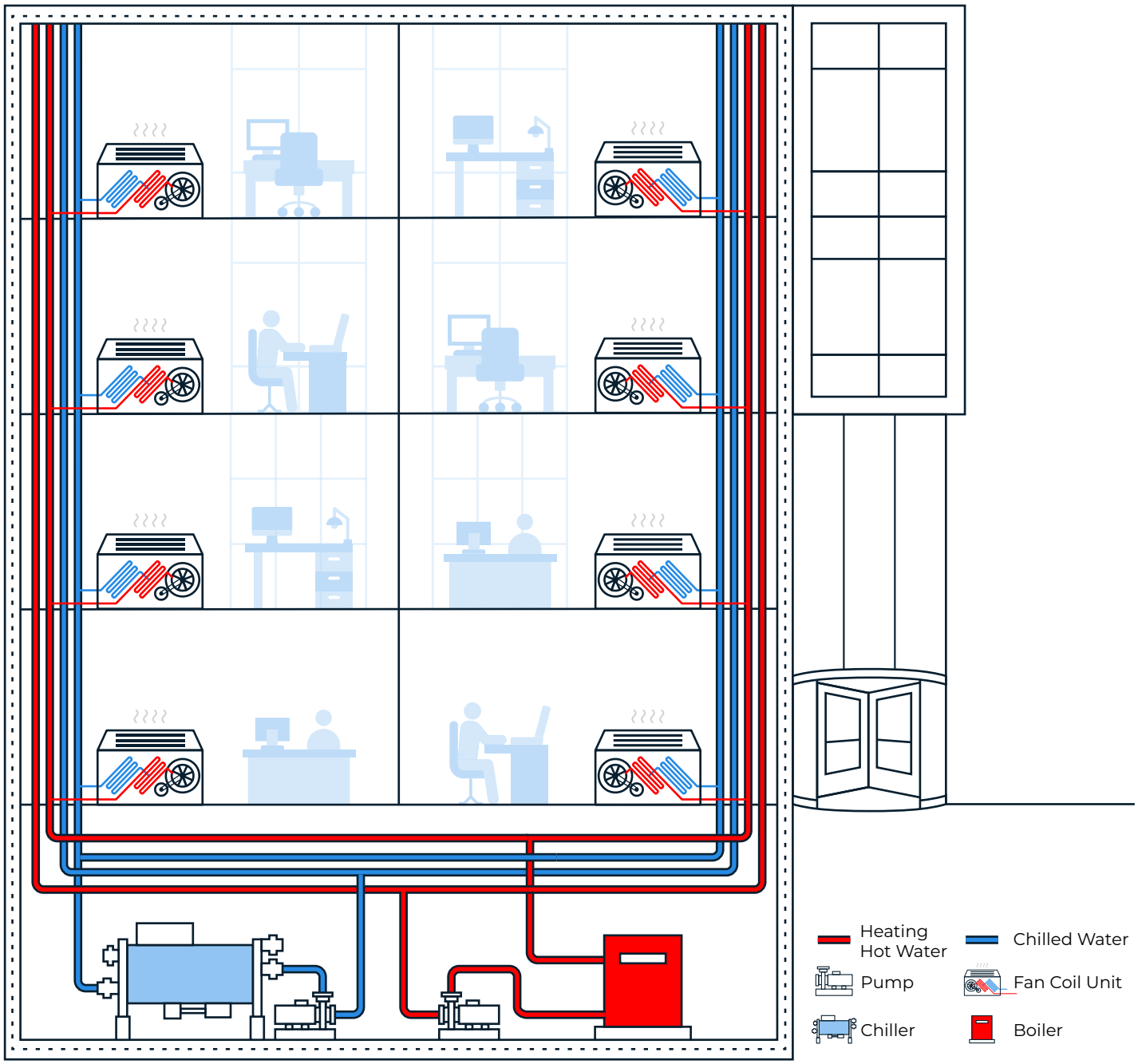
- *$kgCO_2e/sf/year$*
- *% emissions reduction needed to comply with each period*
- *Emissions limit*



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 HOT WATER BOILER



Hydronic loop system with hot water boiler in a Class A office building.

A hydronic loop with a hot water boiler system is a common heating setup in commercial buildings.

In this example, natural gas boilers are used to produce hot water. Central pumps move this hot water through a hydronic loop (a closed-pipe water loop) to reach central air handling units and small heating units located in different rooms.

The most common heating units in commercial buildings are fan coil units (depicted above) and induction units.

Fan coil units contain a small fan that forces air to pass through the heated loop. A thermostat can be used to increase or decrease the speed of the fan, which determines how much heat is blown back into the room after it passes through the heated loop.

Induction units receive high-pressure outside air from the central air handling unit. This creates a pressure difference that pulls indoor air from a room into the unit. The two air sources mix and pass through the heated loop before venting back into the room for heating. These induction units can also be controlled by a local thermostat.

Central air handling units deliver ventilation and conditioning through constant or variable air volume. Variable air volume boxes are controlled by local thermostats with minimum flow requirements set to meet the ventilation requirements of the space.

Cooling is provided by a chiller plant powered by electricity. In this case, a different set of pumps move cold water to the same central air handling and small heating units. This allows the building to have cooling and heating at the same time. The same thermostats used for heating also control the cooling in each unit.

NEAR TERM OPPORTUNITIES FOR IMPROVEMENT

There are cost-effective, proven improvements to increase efficiency and comfort that should always be considered as part of any improvement plan. Further detail on these steps are provided in the last section of this guide



DEMAND CONTROLLED VENTILATION *(P. 15)*

Ventilation requirements are determined based on the design floor area and occupancy of the conditioned space. However, occupancy rates are often much lower than the original design values. Installing demand-controlled ventilation controls allows for measurement of indoor air conditions to determine the necessary level of ventilation based on the current conditions.



INSTALL VARIABLE FREQUENCY DRIVES (VFDS) ON HYDRONIC PUMPS *(P. 17)*

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 or cooling needs in the building.



INSTALL VARIABLE FREQUENCY DRIVES (VFDS) ON AIR HANDLING UNIT FANS *(P. 17)*

VFDs allow fans to speed up and slow down as needed, based on the pressure within the distribution ductwork. This greatly reduces electricity usage in contrast to systems where fans may operate at constant speeds regardless of heating or cooling needs in the building. Note, this requires variable air volume terminal units to maintain balance and operate effectively.



RETRO-COMMISSIONING *(P. 16)*

A central heating plant, central cooling plant, air handling units, and controls need regular tuning and adjustments for optimal performance.

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 Commercial and Industrial 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.***

PERFORMANCE-BASED LEASES: ENCOURAGING ENERGY EFFICIENCY

The way most commercial leases are set up can make it difficult to invest in projects that lower emissions. Building owners are usually responsible for central HVAC systems and the building envelope, while tenants often handle the interior build-out and upgrades of their office spaces. Because of this, tenants and owners don't always have shared goals around energy efficiency. This creates what's called a **split incentive**, where the owner pays for new equipment, but the tenant benefits from lower energy bills.

One way to approach this is by using **Performance-Based Leases.** These leases include terms that support carbon reduction efforts. They set clear building performance targets, outline which party is responsible for costs and performance, and require regular tracking of energy use. They also include steps for ongoing monitoring and retrocommissioning (making sure building systems are working efficiently) and describe what happens if either the owner or tenant doesn't meet their goals.

For additional details on green leasing practices, visit greenleaseleaders.com.

GREEN LEASE LEADERS

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 should 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 misses the opportunity to combine efforts or does not address interactive building systems holistically. A long-term plan allows for coordinated efforts that will increase the efficiency of doing a deep energy retrofit.

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.

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 be different based on your building and its systems, market costs for equipment and labor, and the work that is needed.

COMPONENT	TERM	MEASURE	% REDUCTIONS	COST LOW	COST HIGH
LIGHTING & LOADS	Immediate	LED Upgrades + Controls	1.1%	$44,500	$57,400
ENVELOPE	Immediate	Roof Insulation	0.3%	$287,000	$328,000
VENTILATION	Long	Energy Recovery Ventilation (ERV) System	4.3%	$290,000	$340,000
HEATING & COOLING	Immediate	Retro-commissioning	5.0%	$40,200	$57,400
	Immediate	Controls + Distribution Improvements	3.6%	$114,800	$229,600
	Long	Heating Electrification	10.2%	$4,000,000	$8,600,000

EMISSIONS REDUCTIONS MEASURES BY SYSTEM TYPE

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 tenant spaces where possible, and all exterior fixtures.
- Tenant hard-wired fixtures can be upgraded to LED but requires coordination with tenants.

ACCESS NEEDED TO MAKE IMPROVEMENTS

Common Areas: Access to lighting fixtures, minimal disruption.

Tenant Spaces: Access to hard-wired fixtures, minimal disruption.

ADDITIONAL RESOURCES

- LED lighting retrofits
- Chapter 5 of the ASHRAE Energy Efficiency Guides for Commercial Office Buildings
- US Department of Energy Advanced Energy Retrofit Guide for Office Buildings

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

EMISSIONS REDUCTIONS 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 light and 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.
- **Tenant Spaces:** Not applicable.

ADDITIONAL RESOURCES

- Roof Insulation
- Chapter 5 of the ASHRAE Energy Efficiency Guides for Commercial Office Buildings
- US Department of Energy Advanced Energy Retrofit Guide for Office Buildings

RECOMMENDED SPECIFICATIONS

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

ENERGY SAVINGS

2% of heating load

CAPITAL COST

$35–$40 / SF of roof area

EMISSIONS REDUCTIONS 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.

Combining an ERV with Demand Control Ventilation (DCV) can further reduce energy usage by adjusting your building's ventilation rates. A DCV can ramp up or slow down the amount of fresh air supplied to a space based on how that area is being used. This is monitored through carbon dioxide and other occupancy sensors. If a room is empty or at low occupancy, air supply is reduced. If a room is fully occupied, the system will increase airflow to make sure the space is healthy and comfortable.

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, kitchens, etc 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.
- **Tenant Spaces:** 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)
- Chapter 5 of the ASHRAE Energy Efficiency Guides for Commercial Office Buildings
- US Department of Energy Advanced Energy Retrofit Guide for Office Buildings

RECOMMENDED SPECIFICATIONS

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

ENERGY SAVINGS

6% of heating usage and ventilation usage

CAPITAL COST

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

EMISSIONS REDUCTIONS 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).
- **Tenant Spaces:** Not applicable.

ADDITIONAL RESOURCES

- Operations and Maintenance Guide
- Chapter 5 of the ASHRAE Energy Efficiency Guides for Commercial Office Buildings
- US Department of Energy Advanced Energy Retrofit Guide for Office Buildings

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 REDUCTIONS MEASURES BY SYSTEM TYPE

IMMEDIATE TERM

HEATING & COOLING

CONTROLS + DISTRIBUTION IMPROVEMENTS

Install Variable Frequency Drives (VFDs) on hydronic pumps: Systems that rely on large central pumps can benefit from 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.

Install VFDs on air handling unit fans: Improved controls in central HVAC systems can also reduce run times for air handler fans, and better manage temperatures for chillers and cooling towers.

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.
- The heating or cooling supply must be shut off to complete this work.

ACCESS NEEDED TO MAKE IMPROVEMENTS

- **Common Areas:** Access to central pumps.
- **Tenant Spaces:** Plumber/ technician access at all terminal units.

ADDITIONAL RESOURCES

- Hydronic Heat Upgrade
- Chapter 5 of the ASHRAE Energy Efficiency Guides for Commercial Office Buildings
- US Department of Energy Advanced Energy Retrofit Guide for Office Buildings

RECOMMENDED SPECIFICATIONS

- Specifications must be designed by engineers.

ENERGY SAVINGS

Estimated 4% of heating load

CAPITAL COST

Estimated $1.00–$2.00 / building SF

EMISSIONS REDUCTIONS 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.

Water-Source Heat Pumps (WSHPs) are a great electrification option because they can continue to use many of the heating and cooling components that your building already has as part of its existing hydronic loop with boiler system (**see page 7**).

While WSHPs would replace the chillers your building currently uses for cooling, they can continue to use the following components from your existing system:

- **Cooling Tower:** WSHPs would use your existing system's cooling tower to get rid of any extra heat inside the building. When the building needs more cooling than heating, the cooling tower releases heat to the outside.
- **Condenser Water Pumps:** Instead of moving water between the cooling tower and the chillers, these pumps would move water between the cooling towers and the WSHPs.
- **Chiller Water Pumps:** Instead of moving cool water between the chillers and the building, these pumps would now send water cooled by the WSHPs to air-handling units and other equipment.
- **Boilers:** Instead of sending hot water directly to the building, the boilers would add heat to the main water loop connected to the WSHPs. While the boilers would not run as often after the upgrade, they would still provide backup heat when needed.
- **Hot Water Pumps:** The existing hot water pumps would need to be reconfigured to pull from the supply side of the WSHPs, instead of the boilers. Much of the current piping could still be used.

Since Class A office buildings often need heating and cooling at the same time, the WSHP system must be designed to support both loads. Maintaining your building's chilled-water loop and the hot-water loops allows this flexibility. In this setup, some WSHPs can operate in heating mode while others operate in cooling mode. To make this work, each WSHP must be properly isolated so the heating and cooling processes don't interfere with each other. When configured correctly, the water-source loop can function as a heat-recovery system, transferring heat from areas that need cooling to areas that need heating.

In addition to WSHPs, there are a few main types of electric heating systems that you can consider:



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 hot water heaters 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 buildings have maximum length limitations and must be placed appropriately.
- Installation requires penetrations for refrigerant lines between condensers and the in-unit mini-splits.

- **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 buildings 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.
- **Tenant Spaces:** Required, except in the case of PTHP installation in existing, appropriately sized sleeves. Window Heat Pump technology is also a simple installation option.

ADDITIONAL RESOURCES

- Mini-Splits
- Packaged Terminal Heat Pumps

RECOMMENDED SPECIFICATIONS

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

ENERGY SAVINGS

Estimated 73% 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.