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Wisconsin Housing Preservation Corp.

ELEVATE

Building System Energy Action Plan

About WHPC and Elevate

Wisconsin Housing Preservation Corp (WHPC), a 501(c)(3) nonprofit, is the largest owner of affordable housing in the State of Wisconsin. With a diverse portfolio of over 8,400 units located in more than 450 buildings across 58 of Wisconsin's 72 counties, WHPC provides safe, affordable housing for low- and moderate-income families, seniors, veterans, and persons with disabilities.

WHPC's Green Team is an internal team of asset and construction managers focused on identifying the needs and opportunities to make energy and water efficiency upgrades, utilize new technologies, and install renewable energy generation systems, such as solar photovoltaic (PV) and battery storage, throughout our portfolio to lower property operating costs, including maintenance and utility costs, and reduce greenhouse gas emissions.

Elevate is a 501(c)(3) nonprofit that seeks to create a just and equitable world in which everyone has clean and affordable heat, power, and water in their homes and communities — no matter who they are or where they live. Elevate centers equity in the climate conversation.

Acknowledgements: *Funding for the development of this plan was made possible by the Public Service Commission of Wisconsin Office of Energy Innovation - 2021 Energy Innovation Grant Program.*

Table of Contents: Building System Energy Action Plan

Introduction

Goals

As Wisconsin's largest provider of affordable housing, **WHPC is a leader and innovator in providing safe, affordable housing** for low- and moderate-income families, seniors, veterans, and persons with disabilities.

With grant funding from the WI Public Service Commission, WHPC launched a portfolio-wide energy planning process to inform and guide energy-related investments across the portfolio in Summer 2021.

The goals of the portfolio-wide energy planning process are to develop tools that centralize property information and inform decision-making to:

- **Preserve and provide high-quality affordable housing** by incorporating clean energy, healthy building, and resiliency solutions
- **Prioritize rural communities** that are historically underserved by energy efficiency programs
- **Minimize utility cost burden on residents**
- **Provide a roadmap** for other affordable housing portfolio owners

Portfolio-wide Energy Planning Process Overview

Step 1: Aggregate Portfolio Data (Property Characteristics, Utility & Asset Management Data)

Step 2: Analyze Trends and Map Properties

Step 3: Develop an Energy Action Plan to Inform Upgrades

Step 4: Pilot Implementation of the Plan

Step 5: Share Process & Learnings

These steps build a comprehensive package of tools to support decision-making.

Tools Developed

- ✓ Comprehensive Database of WHPC's Properties
- +
- ✓ Interactive Map of WHPC's Properties
- +
- ✓ **Building System Energy Action Plan**
- +
- ✓ Property Case Studies

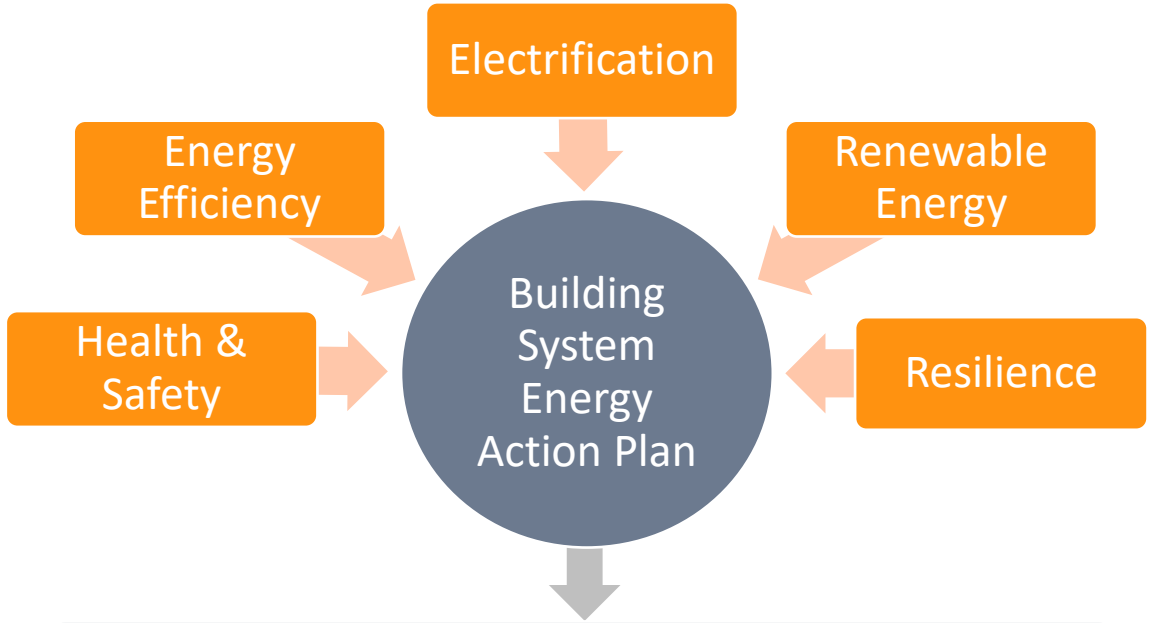
↓

- ✓ Overview Presentation for Affordable Housing Owners & Managers

About the Building System Energy Action Plan

- The Building System Energy Action Plan is a roadmap of recommended energy upgrades for each building system to inform property-level decision making over time, such as:
  - Asset managers planning property investments
  - Property managers evaluating annual property needs, participation in efficiency programs, and contractor scopes
- Recommendations are organized by the three major points of a building life cycle:
  - Regular Operations & Maintenance
  - Equipment Replacement
  - Major Renovation (or New Construction)

Energy-Related Goals & Considerations



Outcomes of the Recommended Upgrades

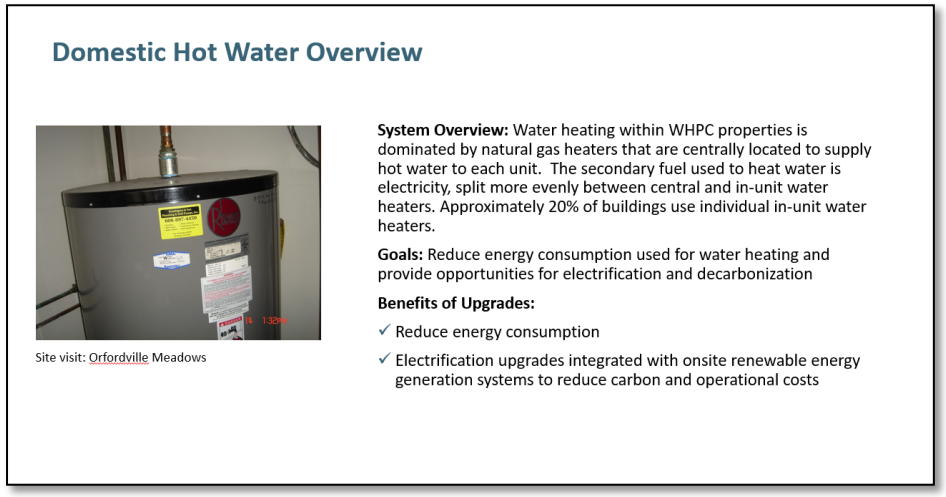
- ✓ Improved & efficient building systems
- ✓ Increased tenant comfort & lower utility costs
- ✓ Lower building operating and utility costs
- ✓ Increased access to clean energy technology and lower building carbon emissions

Note: For property acquisitions, if no upgrades are planned, property and asset managers should explore the opportunities under "Regular Operations & Maintenance". If minor upgrades are planned, consider opportunities under "Equipment Replacement". If major upgrades are planned, explore opportunities under "Major Renovation".

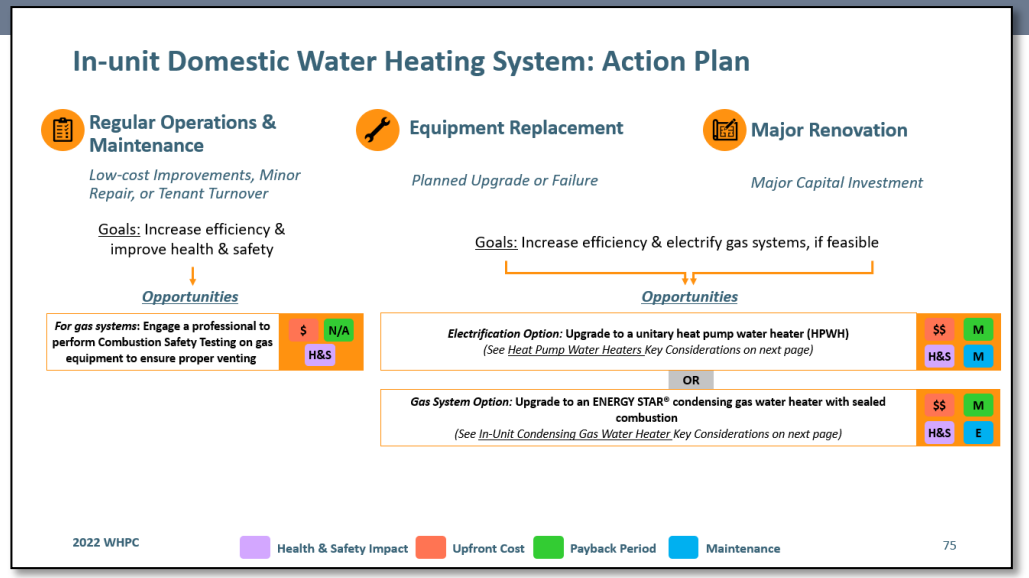
About the Building System Energy Action Plan

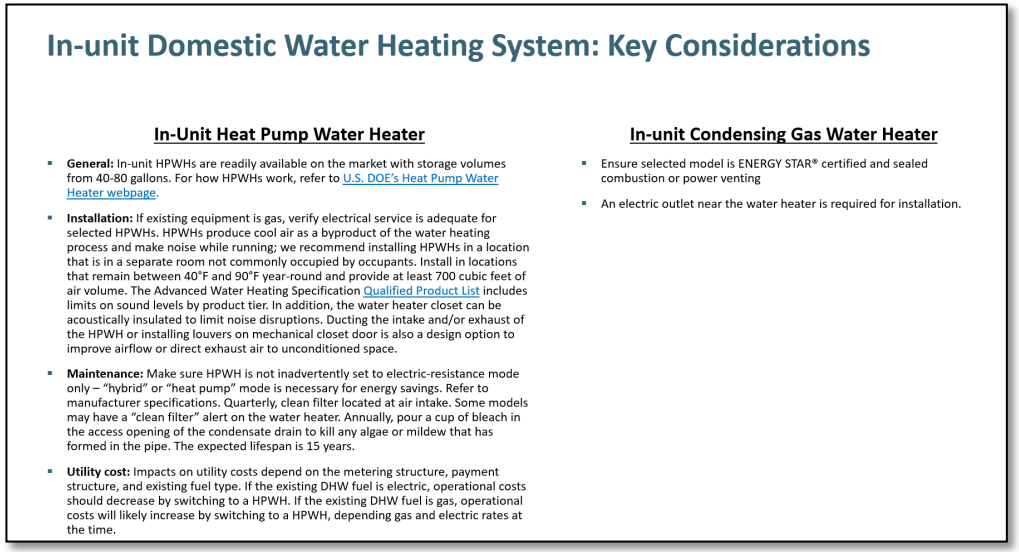
Each major building system section (e.g., Heating & Cooling, Lighting, etc.) includes:

- Building System Overview
- Action Plans + Key Considerations



Note: Domestic Hot Water and Heating & Cooling sections have actions plans for each current type of equipment (e.g., Central, In-Unit). Building Envelope section has action plans for each component (e.g., attic, foundation, windows & doors).





How to Use this Energy Action Plan

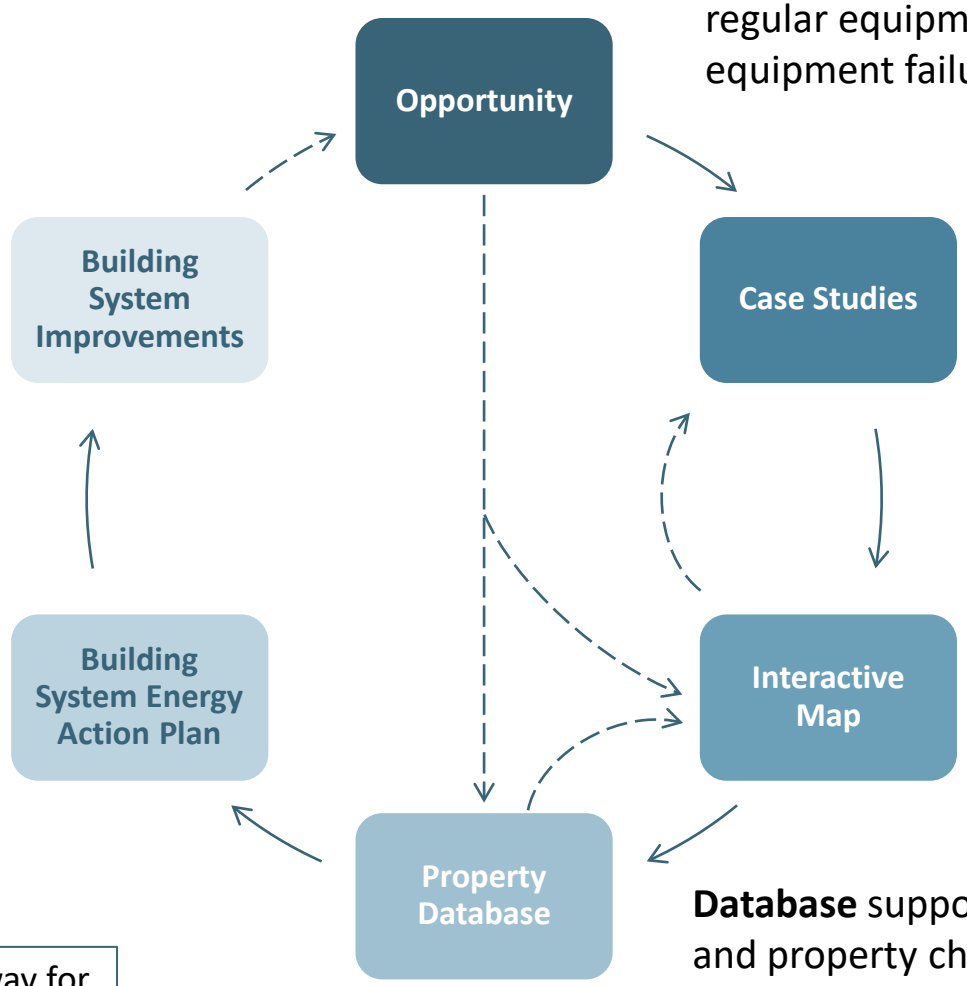
Opportunity (e.g., acquisitions, new funding source, regular equipment maintenance, tenant turnover, equipment failures, etc.) prompts utilizing the tools.

Building System Improvements are the implementation of the planning process.

Case Studies demonstrate how the planning process translates into implementation for other asset/ property managers.

Building System Energy Action Plan provides recommendations for energy-related improvements.

Map serves as a data visualization to locate buildings based on geographic parameters (e.g., county, utility service territory, etc.)



Database supports mapping and provides building and property characteristics and equipment, affordable housing subsidies, annual owner paid utility costs, whole-building utility data, when available to inform action needed.

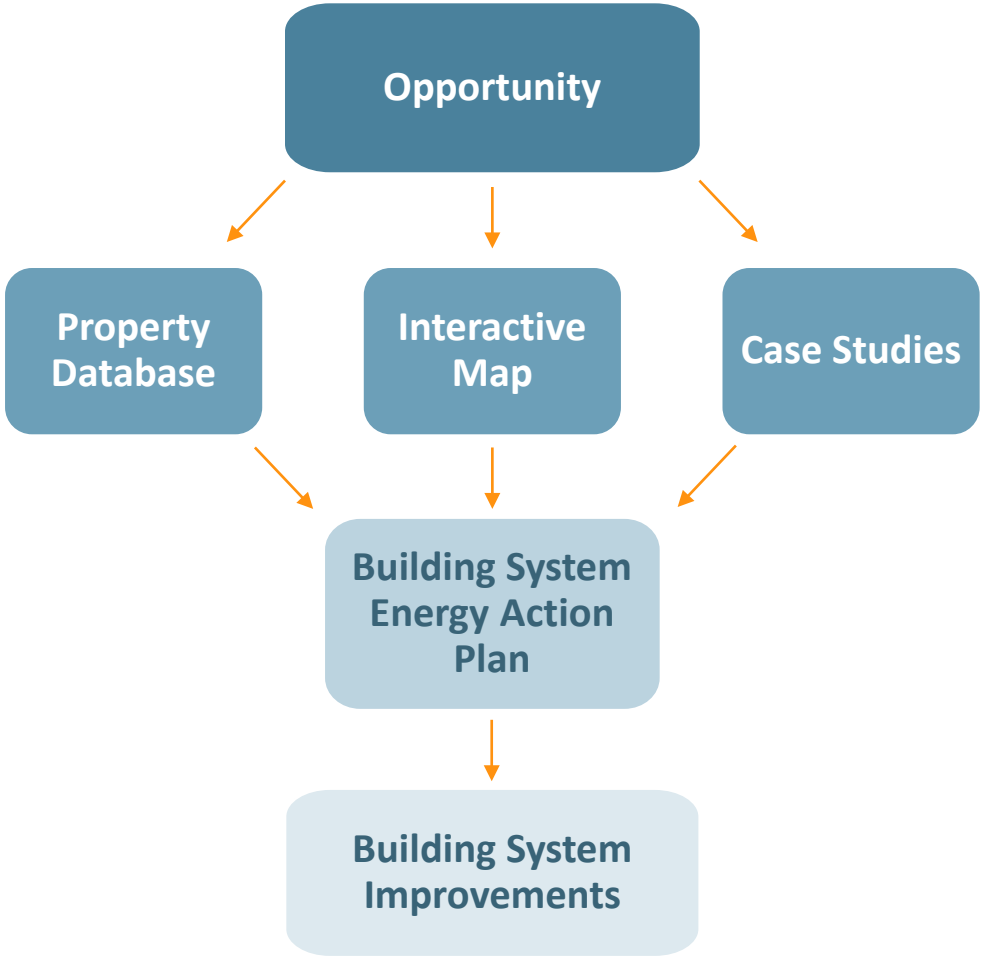
How to Use This Energy Action Plan

Opportunity (e.g., acquisitions, new funding source, regular equipment maintenance, tenant turnover, equipment failures, etc.) prompts utilizing the tools.

Databases, maps, and case studies inform the property/asset manager and demonstrate how the opportunity can benefit them.

Building System Energy Action Plan provides recommendations for energy-related improvements.

Building System Improvements are the implementation of the planning process.



How to Use this Energy Action Plan

Use the Action Plan <u>when</u>:

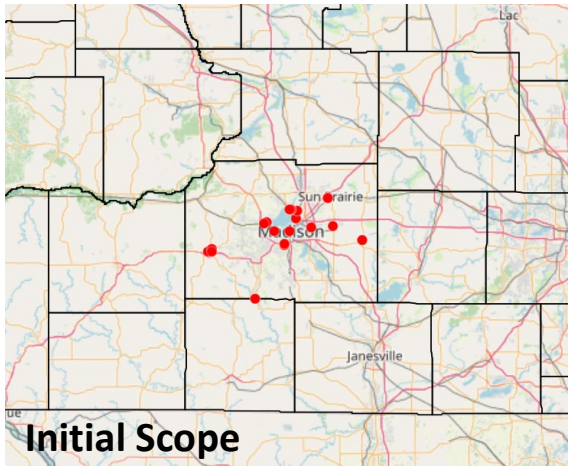
- Acquiring a new property
- Planning a rehab
- Planning for equipment replacement
- Equipment or component fails
- Property experiences high operating or utility costs
- Concerns about indoor air quality or other energy related health & safety issues

Use the Action Plan <u>to</u>:

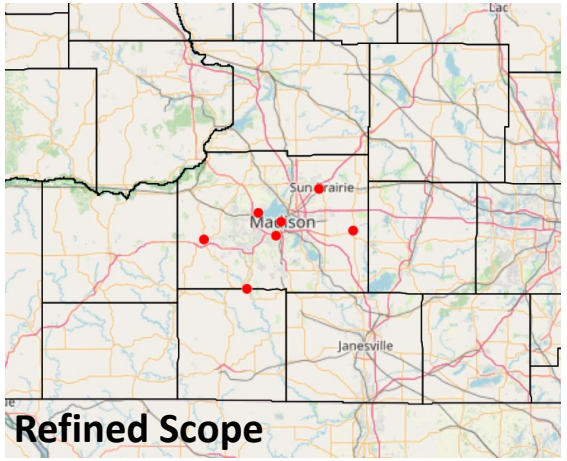
- Avoid missed opportunities for increased energy efficiency during planned upgrades and renovations
- Identify high efficiency and electrification options when replacing equipment
- Identify strategies to improve health & safety for residents
- Identify buildings with the most solar exposure to install solar PV

Example Use Case: Grant Funding Opportunity

- **Opportunity:** Grant funding for health and safety related building improvements in a specific county
- **Initial Scope:** All buildings within the county *(Map or Database)*
- **Refined Scope:** All buildings within the county with in-unit gas equipment *(Map or Database)*
- **Action:** Electrify in-unit gas equipment *(Action Plan)*



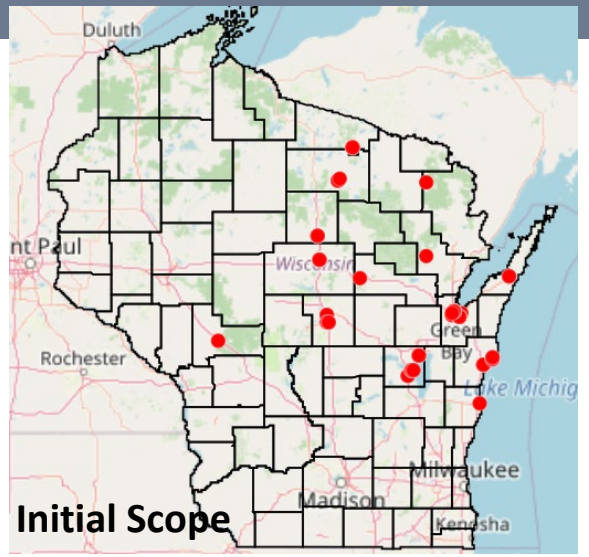
Initial Scope

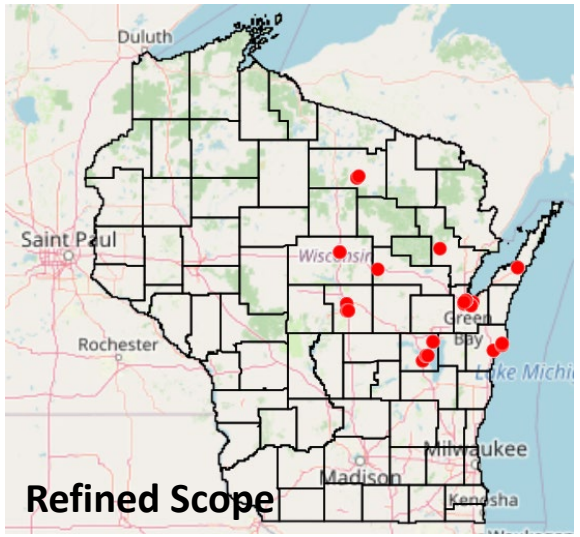


Refined Scope

Example Use Case: Increase In Natural Gas Costs

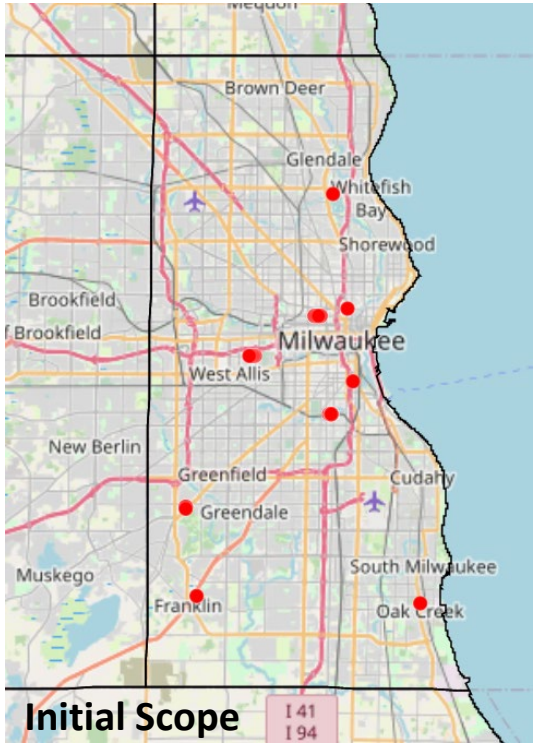
- **Opportunity:** Utility increases natural gas costs
- **Initial Scope:** Properties within the Wisconsin Public Service gas service territory *(Map or Database)*
- **Refined Scope:** Properties with gas space heating systems served by Wisconsin Public Service *(Map or Database)*
- **Action:** Upgrade gas space heating equipment to air source heat pumps *(Action Plan)*

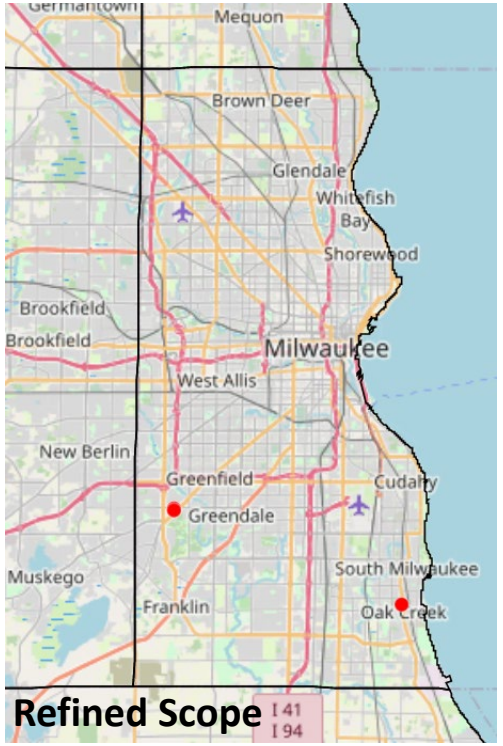




Example Use Case: Solar PV Panel Bulk Purchase in Iowa County

- **Opportunity:** Solar PV panel bulk purchase opportunity in Milwaukee County
- **Initial Scope:** Properties within Milwaukee County *(Map or Database)*
- **Refined Scope:** Properties with electric space heat in Milwaukee County *(Map or Database)*
- **Action:** Install Solar PV *(Action Plan)*





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Building System Action Plans: A Roadmap for Improvements

Contents

Jump to specific Building System Energy Action Plans by clicking the hyperlinks!

Overarching Considerations

- Building systems are interrelated, therefore prioritize upgrades that increase tenant health and safety and consider a whole-building approach, when possible.
- A building performance consultation is extremely important at the time of envelope and/or mechanical system upgrades to evaluate the impact of the envelope on the mechanical system requirements and indoor air quality. Existing systems should be tested for functionality and performance (such as ventilation and exhaust system airflow), where applicable.
- During system upgrades, prepare for future electrification investments by reviewing:
  - Electrical service capacity to the building
  - Electrical load center to ensure adequate capacity for electric space conditioning, water heating, and cooking
- While electrification can require a larger initial investment and have a longer payback period, consider projected increases in gas costs, impact on indoor air quality, and the opportunity for longer-term carbon reductions.
- For buildings identified with good solar exposure take steps to prepare the building for a future solar PV system by making it renewable ready anytime work is being done in the attic or on the roof.
- When electrifying equipment, consider opportunities to install solar PV to defray increases in electric utility costs, especially for tenants.
- Research city, county, state and federal energy and water saving programs and understand the latest offerings and criteria. Such as the Focus on Energy program for energy savings and the Madison Metro Sewage District for water saving measures.

System Legend for Each System Action Plan

Health & Safety Impact: opportunity if undertaken can impact health & safety of residents

Upfront Cost

- **$** = can be paid out of annual operating budget
- **$$** = most likely requires using reserves
- **$$$** = most likely requires external funding

Payback Period

- **S** = short payback period (0-5 years)
- **M** = medium payback period (6-15 years)
- **L** = long payback period (15+ years)

Maintenance

- **E** = maintenance staff can easily & quickly accomplish
- **M** = requires additional time and knowledge for maintenance staff to accomplish
- **H** = requires contacting and/or hiring a professional

Building Envelope

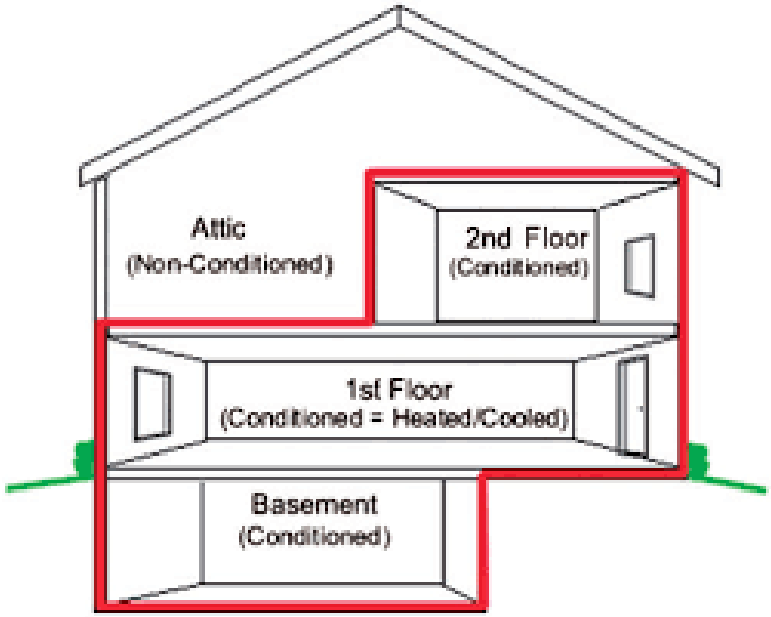
Building Envelope Overview

System Overview: The building envelope consists of the roof and attic, exterior above grade walls, foundation and below grade walls, windows, and doors. It creates an air, moisture, and thermal barrier between the exterior and interior spaces.

Goals: Increase airtightness, insulation, and compartmentalization, which is the robust separation between different spaces within a building.

Benefits of Upgrades:

- ✓ Improve occupant comfort and indoor air quality
- ✓ Reduce risk of mold, mildew, fungal growth, and pest infestations
- ✓ Prevent airborne contaminants, smoke, and odors from moving between units
- ✓ Reduce heating and cooling loads
- ✓ Increase effectiveness of ventilation, heating, cooling, and dehumidification systems to maintain comfortable temperatures and levels of humidity



Attic/Roof: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Equipment Replacement

Planned Upgrade or Failure

Major Renovation

Major Capital Investment

Goals: Increase efficiency, prevent and/or solve for moisture damage and ice dams

Opportunities

For vented, unconditioned attics: **Air seal and insulate vented attic to levels that meet or exceed the current adopted building and energy codes (R-49 to R-60)**

(See Key Considerations on next pages)

$ M H&S

Opportunities

For unvented attics, roof cavities, and vaulted ceilings: **Install closed cell spray foam insulation to underside of roof decking**

(See Key Considerations on next pages)

$ M H&S

OR

During roof replacement (flat roofs and roofs over conditioned attics)**: Install above deck rigid foam insulation**

(See Key Considerations on next pages)

$ M

Attic/Roof: Key Considerations

Insulating & Sealing Vented, Unconditioned Attics

- Hire a professional building analyst to perform a blower door test with thermal imaging to locate all holes allowing conditioned air to escape.
- Air sealing between the conditioned space and unconditioned attic space must be completed prior to adding insulation.
- Adequate attic ventilation, in conjunction with air-sealing measures, is needed for moisture control and to prevent ice dams from forming. Continuous ridge vents and soffits vents are the preferred attic venting system. A good time to replace attic vents is at the same time as roof replacement.
- Inspect the roof and attic; repair any leaks, remove active knob and tube wiring, and remediate any hazardous materials prior to air sealing and insulating. Learn more about these health and safety considerations at Pre-Retrofit Assessment of Attics, Ceilings, and Roofs | Building America Solution Center (pnnl.gov)
- Consult building professionals during envelope upgrades to ensure proper building ventilation is achieved, which may require the addition or improvement of mechanical ventilation strategies.
- Attic insulation must be returned to maximum levels after any work is done in the attic to maximize efficiency.
- Air sealing and insulating the building envelope affects building ventilation as well as heating and cooling system performance. Consult building professionals during envelope upgrades to ensure proper building ventilation is achieved, which may require the addition or improvement of mechanical ventilation strategies.
- More information about Air Sealing Attics; more information about Insulating Attics

Attic/Roof: Key Considerations

Air Sealing & Insulating Unvented Attic, Roof Cavities, and Vaulted Ceilings

- Inspect the existing roof shingles or roofing membrane for any deficiencies. If there is any history or evidence of leakage, correct the leaks and repair the damage before proceeding.
- If the roof is at or near the end of its service life, consider replacing the roof to ensure the roof will provide acceptable water control.
- Seal any penetrations from the home into the attic through the attic floor.
- Air sealing and insulating the building envelope affects building ventilation as well as heating and cooling system performance. Consult building professionals during envelope upgrades to ensure proper building ventilation is achieved, which may require the addition or improvement of mechanical ventilation strategies.
- More information about insulating unvented attics.

Above Deck Roof Insulation

- Consider installing above deck roof insulation during planned roof replacement for flat roofs and roofs above conditioned attics, unvented roof cavities, and vaulted ceilings.
- Ensure proper air and vapor barriers are installed.
- Assess roof construction for ability to support solar PV arrays and consider installing solar-ready roof assembly.
- More information about above deck roof insulation.

Walls & Floors: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Equipment Replacement

Planned Upgrade or Failure

Major Renovation

Major Capital Investment

Goals: Increase efficiency & improve thermal comfort

Opportunities

Air seal penetrations in exterior walls such as space around window AC units, AC wall sleeves, windows and door frames, and receptacles.

$ S

Opportunities

Add cavity insulation to exterior walls in wood framed buildings
(See Key Considerations on next page)

$$ M

AND

Insulate overhangs, bays, and cantilevered floors to R-30 or fill to capacity
(See Key Considerations on next page)

$$ M

Opportunities

Air seal and add continuous insulation to exterior walls
(See Key Considerations on next page)

$$$ L H&S

Health & Safety Impact | Upfront Cost | Payback Period | Maintenance

Walls & Floors: Key Considerations

Add Cavity Insulation to Exterior Walls

- Have an insulation professional assess need for additional cavity insulation.
- Cavity insulation is typically dense-packed to capacity to obtain highest achievable R-value.

Air Seal and Insulate Overhangs, Bays, and Cantilevered Floors

- Floor overhangs and cantilevered floors are often uninsulated and not well air sealed, interrupting the continuity of home's thermal and air barriers and reducing comfort levels for occupants.
- Air sealing and insulating floor overhangs and cantilevered floors requires the exterior barrier (siding, soffits, etc.) to be removed.

Air Sealing and Continuous Wall Insulation

- This option is best utilized when replacing siding or exterior cladding of the building.
- Hire a building professional to conduct a blower door test and use thermal imaging to locate all penetrations to be sealed.
- Hire an insulation professional to install continuous insulation to maximum achievable levels.
- Given the increased airtightness associated with this retrofit, combustion safety testing and controlled mechanical ventilation upgrades may be required to maintain acceptable indoor air quality.
- Inspect the walls and remediate any hazardous materials or mold issues prior to air sealing and insulating. Learn more about these health and safety considerations at Pre-Retrofit Assessment of Walls, Windows, and Doors | Building America Solution Center (pnnl.gov)

Foundation: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Equipment Replacement

Planned Upgrade or Failure

Major Renovation

Major Capital Investment

Goals: Increase efficiency & control moisture

Opportunities

Air Seal and insulate crawlspace or basement rim joists *(See Key Considerations on next page)*	$$ M H&S	

Opportunities

Air Seal and insulate crawlspace or basement walls to R-15 *(See Key Considerations on next page)*	$$$ M H&S	
AND		
Install Slab Edge Insulation for slab on grade foundations *(See Key Considerations on next page)*	$$$ L	

Foundation: Key Considerations

Air Seal & Insulate Crawlspace and Basement Walls

- Before air sealing and insulating basements and crawlspaces, it is critical to examine several health and durability factors including structural integrity of foundation, combustion safety, moisture management, pests, and radon. Learn more about these health and safety considerations at Pre-Retrofit Assessment of Crawlspaces and Basements | Building America Solution Center (pnnl.gov)
- Contractors may recommend one of several approaches for full-height basement insulation. The best option is continuous foam board, which provides better moisture and thermal barriers compared to other methods of foundation insulation.
- For crawlspaces, ensure that the access hatch is insulated with foam board and fully air-sealed with a gasket seal.
- If HVAC equipment or ductwork is located in the basement or crawlspace, the area should be treated as a conditioned space and fully air sealed and insulated.

Slab Edge Insulation for Slab on Grade Foundations

- Moisture control issues must be remediated before installing insulation.
- Requires excavation around building perimeter to install insulation.
- Consult a professional to conduct energy modeling scenarios to ensure this is a cost-effective measure.

Air Seal & Insulate Crawlspace/Basement Rim Joists

- Two-part/closed cell spray foam best product because it provides air sealing and insulation in one step.

Windows & Exterior Doors: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Equipment Replacement

Planned Upgrade or Failure

Major Renovation

Major Capital Investment

Goals: Increase efficiency & occupant comfort

Opportunities

Air Seal Around Windows and Exterior Doors
(See Key Considerations on next page)

$ S H&S

Opportunities

Replace windows with ENERGY STAR®/National Fenestration Rating Council certified products
(See Key Considerations on next page)

$$$ L H&S

AND

Replace exterior doors with ENERGY STAR®/National Fenestration Rating Council certified products

$$ L

Health & Safety Impact | Upfront Cost | Payback Period | Maintenance

Windows & Exterior Doors: Key Considerations

Air Seal Around Windows and Exterior Doors

- Learn more about health and safety considerations at Pre-Retrofit Assessment of Walls, Windows, and Doors | Building America Solution Center (pnnl.gov)
- Air sealing and insulating the building envelope affects building ventilation as well as heating and cooling system performance. Consult building professionals during envelope upgrades to ensure proper building ventilation is achieved, which may require the addition or improvement of mechanical ventilation strategies.

Replace Windows

- Learn more about health and safety considerations at Pre-Retrofit Assessment of Walls, Windows, and Doors | Building America Solution Center (pnnl.gov)
- Air sealing and insulating the building envelope affects building ventilation as well as heating and cooling system performance. Consult building professionals during envelope upgrades to ensure proper building ventilation is achieved, which may require the addition or improvement of mechanical ventilation strategies.
- Ensure that a high-quality window installer is hired. Installation methods are key to proper air sealing of new windows.
- An excellent time to replace windows is when replacing siding or exterior cladding material

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Domestic Hot Water

Domestic Hot Water Overview

Site visit: Orfordville Meadows

System Overview: Water heating within WHPC properties is dominated by natural gas heaters that are centrally located to supply hot water to each unit. The secondary fuel used to heat water is electricity, split more evenly between central and in-unit water heaters. Approximately 20% of buildings use individual in-unit water heaters.

Goals: Reduce energy consumption used for water heating and provide opportunities for electrification and decarbonization

Benefits of Upgrades:

- ✓ Reduce energy consumption
- ✓ Electrification upgrades integrated with onsite renewable energy generation systems to reduce carbon and operational costs

Central Domestic Water Heating System: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Goals: Increase efficiency & improve health & safety

Opportunities

Install demand-controls to recirculation pumps to reduce unnecessary water heating	$ S
AND	
Insulate hot water pipes with R-4 insulation	$ S
AND	
For gas systems: **Engage a professional to perform Combustion Safety Testing on gas equipment to ensure proper venting**	$ N/A H&S

Equipment Replacement

Planned Upgrade or Failure

Major Renovation

Major Capital Investment

Goals: Increase efficiency & electrify gas systems, if feasible

Opportunities

Electrification Option: **Install central heat pump water heater (HPWH) appropriate for cold climates** *(See Central Heat Pump Water Heaters Key Considerations on next page)*	$$$ L M
OR	
Gas System Option: **Install condensing ENERGY STAR® gas water heater with sealed combustion** *(See Central Condensing Gas Water Heater Key Considerations on next page)*	$$ L E
OR	
If space heating is also central: **Combine water heating and space heating with one boiler system by installing condensing, modulating high-efficiency ENERGY STAR® boilers** *(See Central Combination Boiler Key Considerations on next page)*	$$$ L M

Central Domestic Water Heating System: Key Considerations

Central Heat Pump Water Heaters

- **General:** HPWHs in central configurations can be done in two ways: (1) using several in-unit HPWHs or (2) a commercial central HPWH. For the second configuration, this application is in it's infancy for specifically cold-climates. The application of HPWHs in central configurations for cold climates is in its infancy. Solutions on the market may be available for smaller multi-family buildings. Commercial HPWHs are recommended for larger central applications. The storage capacity for HPWH systems may need to be larger than the gas-equivalent in order to handle the peak hot water demand and ensure sufficient recovery times and hot water supply. Consider this solution when the technology has matured, or if confirmed the solution can meet peak building hot water demand.
- **Installation:** If existing equipment is gas, verify electrical service is adequate for the selected HPWH system. Split HPWHs can accommodate larger scale systems; for split units, freeze protection for outside water lines should be addressed. Commissioning a central HPWH after installation is critical to minimize tenant disruption.
- **Maintenance**: Make sure HPWH is not inadvertently set to electric-resistance mode only – "hybrid" or "heat pump" mode is necessary for energy savings. Refer to manufacturer specifications. Generally, clean filter located at air intake quarterly. Some models may have a "clean filter" alert on the water heater. Annually, pour a cup of bleach in the access opening of the condensate drain to kill any algae or mildew that has formed in the pipe. The expected lifespan is 15 years.
- **Utility cost:** Impacts on utility costs depend on the metering structure, payment structure, and existing fuel type. If the existing DHW fuel is electric, operational costs should decrease by switching to a HPWH. If the existing DHW fuel is gas, operational costs will likely increase by switching to a HPWH, depending gas and electric rates at the time.

Central Condensing Gas Water Heater

- Ensure selected model is ENERGY STAR® certified and has sealed combustion.
- High-efficiency DHW boilers have additional design considerations compared to conventional DHW boilers (e.g., condensate lines).
- Commissioning a new central high-efficiency condensing gas boiler after installation is critical.
- *Partial electrification option*: Consider adding an ASHP to preheat water before going to high-efficiency boiler (existing or new). For this option, HVAC designers would be required to ensure controls are sequenced correctly for pre-conditioning water.

Central Combination Boiler

- Multiple fully modulating smaller boilers staged to meet building load increases operational efficiency.
- The boilers should prioritize domestic hot water heating
- An integrated control strategy that adjusts water flow and water temperature with both indoor and outdoor temperatures increases efficiency.

In-unit Domestic Water Heating System: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Goals: Increase efficiency & improve health & safety

Opportunities

***For gas systems*: Engage a professional to perform Combustion Safety Testing on gas equipment to ensure proper venting**	$	N/A
	H&S	

Equipment Replacement

Planned Upgrade or Failure

Major Renovation

Major Capital Investment

Goals: Increase efficiency & electrify gas systems, if feasible

Opportunities

***Electrification Option:* Upgrade to a unitary heat pump water heater (HPWH)** *(See Heat Pump Water Heaters Key Considerations on next page)*	$$	M
	H&S	M

OR

***Gas System Option:* Upgrade to an ENERGY STAR® condensing gas water heater with sealed combustion** *(See In-Unit Condensing Gas Water Heater Key Considerations on next page)*	$$	M
	H&S	E

In-unit Domestic Water Heating System: Key Considerations

In-Unit Heat Pump Water Heater

- **General:** In-unit HPWHs are readily available on the market with storage volumes from 40-80 gallons. For how HPWHs work, refer to U.S. DOE's Heat Pump Water Heater webpage.
- **Installation:** If existing equipment is gas, verify electrical service is adequate for selected HPWHs. HPWHs produce cool air as a byproduct of the water heating process and make noise while running; we recommend installing HPWHs in a location that is in a separate room not commonly occupied by occupants. Install in locations that remain between 40°F and 90°F year-round and provide at least 700 cubic feet of air volume. The Advanced Water Heating Specification Qualified Product List includes limits on sound levels by product tier. In addition, the water heater closet can be acoustically insulated to limit noise disruptions. Ducting the intake and/or exhaust of the HPWH or installing louvers on mechanical closet door is also a design option to improve airflow or direct exhaust air to unconditioned space.
- **Maintenance:** Make sure HPWH is not inadvertently set to electric-resistance mode only – "hybrid" or "heat pump" mode is necessary for energy savings. Refer to manufacturer specifications. Quarterly, clean filter located at air intake. Some models may have a "clean filter" alert on the water heater. Annually, pour a cup of bleach in the access opening of the condensate drain to kill any algae or mildew that has formed in the pipe. The expected lifespan is 15 years.
- **Utility cost:** Impacts on utility costs depend on the metering structure, payment structure, and existing fuel type. If the existing DHW fuel is electric, operational costs should decrease by switching to a HPWH. If the existing DHW fuel is gas, operational costs will likely increase by switching to a HPWH, depending gas and electric rates at the time.

In-unit Condensing Gas Water Heater

- Ensure selected model is ENERGY STAR® certified and sealed combustion or power venting
- An electric outlet near the water heater is required for installation.

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Plumbing Fixtures

Plumbing Fixtures Overview

System Overview: Plumbing fixtures at WHPC's properties include bathroom faucets, kitchen faucets, shower heads, and toilets. At least half of these fixtures throughout the portfolio are not low-flow fixtures.

Goals: Reduce water consumption and waste

Benefits of Upgrades:

- ✓ Reduced water waste and costs
- ✓ Reduce impact of unexpected water leaks

Plumbing Fixtures: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Goals: Reduce water waste

Opportunities

Install low-flow bathroom faucets, kitchen faucets, and shower heads

(See Low-flow faucets & shower heads Key Considerations on next page)

$ S E

AND

Monitor water use for leak detection

(See Water Monitoring Key Considerations on next page)

$$ S M

Equipment Replacement

Planned Upgrade or Failure

Goals: Reduce water waste

Opportunities

Replace toilets with low-flow toilets

(See Low-flow toilets Key Considerations on next page)

$$ M E

AND

Install low-flow bathroom faucets, kitchen faucets, and shower heads

(See Low-flow faucets & shower heads Key Considerations on next page)

$ S E

AND

Monitor water use for leak detection

(See Water Monitoring Key Considerations on next page)

$$ S M

Major Renovation

Major Capital Investment

Plumbing Fixtures: Key Considerations

Low-flow Faucets & Shower Heads

- Install bathroom faucet aerators that are WaterSense rated and ≤ 1.0 GPM (Gallons Per Minute)
- Install kitchen faucet aerators that are WaterSense rated and ≤ 1.5 GPM
- Install shower heads that are WaterSense rated and ≤ 1.5 GPM

Low-flow Toilets

- Install toilets that are WaterSense rated and 0.8 GPF (Gallons Per Flush) ultra-high-efficiency.

Water Monitoring

- Products are readily available that monitor building water consumption and send alerts for leaks and abnormally higher water use. These products typically have an initial cost for sensor(s)/hardware installed and ongoing data access (e.g., dashboard) fees. Sensors can indirectly measure water use (i.e., non-invasive sensor installed at the utility water meter) or directly measure use (i.e., water piping is cut to install the sensor).

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Ventilation and Filtration

Ventilation and Filtration Overview

Site visit: Chapel Terrace

System Overview: Ventilation is the movement of air between inside and outside of the building for improved indoor air quality (IAQ) and general building and occupant health. Air filtration is the removal of particulate matter from the airstream. Some common substances captured by filtration are spores, pollen, dander, dust, smoke, and some pathogens.

Goals: To reduce levels of carbon dioxide, humidity, odors and indoor air pollutants such as secondhand smoke, radon, formaldehyde and other volatile organic compounds (VOCs).

Benefits of Upgrades:

- ✓ Improve indoor air quality
- ✓ Reduce odors
- ✓ Reduce excess moisture

Ventilation: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Equipment Replacement

Planned Upgrade or Failure

Major Renovation

Major Capital Investment

Goals: Improve indoor air quality

Opportunities

Replace/install new bathroom exhaust fans with ENERGY STAR products rated for continuous use	$ H&S
AND	
Replace recirculating kitchen exhaust fans with ENERGY STAR fans that exhaust to outdoors	$$ H&S
AND	
Properly vent exhaust fans to outside *(See Key Considerations on next page)*	$ H&S
AND	
Install continuous operation controls for bath fans and measure airflow to verify performance	$

Goals: Improve indoor air quality

Opportunities

Install whole house/supply driven ventilation system *(See Key Considerations on next page)*	$$ H&S E
OR	
Install a Heat Recovery Ventilation (HRV) or Energy Recovery Ventilation (ERV) system *(See Key Considerations on next page)*	$$ H&S M

Note: Ventilation systems don't have a payback compared to nonexistent or insufficient ventilation systems.

Ventilation: Key Considerations

Properly Vent Exhaust Fans to Outside

- Fans must be vented outdoors, not into an attic, crawlspace, or space between floors.
- Choose a smooth metal duct with the diameter specified by the fan manufacturer.
- Install the duct with the most direct route to the outside with as few bends as possible.
- Seal all seams and around ceiling and wall or roof penetrations with mastic or spray foam.

Install Whole House/Supply Driven Ventilation System

- Often this type of system utilizes an existing forced air duct system to provide “fresh” outdoor air.
- Combined with a high quality and properly installed bathroom fan, this system removes moisture, odors, and other pollutants better than an exhaust fan alone.
- Routine Maintenance:
  - Clean fresh air intake screen at least annually
  - Check damper operation during HVAC tune-ups (1-5 years depending on equipment age)

Install HRV or ERV

- Requires regular inspection and cleaning of filters, fans, drains, and heat exchanger.
- Best configuration is to have fully dedicated duct system for ventilation that is separate from the heating/cooling ducts.
- Commissioning and balancing can be challenging. System should be recommissioned every 3-5 years.
- Routine Maintenance:
  - Clean fresh air intake screen at least annually
  - Check filter condition monthly. Clean and replace as needed.
  - Annually inspect and clean the condensate drain, fans, and heat exchanger
- Definitions:
  - Heat Recovery Ventilation (HRV) transfers heat between incoming supply air and outgoing exhaust air. The two air streams do not mix, only heat is transferred via conduction.
  - Energy (or Enthalpy) Recovery Ventilation (ERV) transfers both heat and humidity between incoming supply air and outgoing exhaust air.

Note: Always follow manufacturer installation and maintenance instructions and measure airflow to verify adequate fresh air to living spaces.

Filtration: Key Considerations

- Filter performance is standardized by the MERV rating (Minimum Efficiency Reporting Value). Filters with higher MERV ratings capture smaller particles from the air more efficiently. It's recommended to assess the conditions of existing filter(s) (if applicable) and record the type(s) of filters and the MERV rating, if documented on the filter.
- Systems typically come with factory provided filters, which have MERV ratings of 8 or less. Some filters do not have a MERV rating, such as washable filters that commonly come with mini-split heat pumps. However, manufacturers often provide filter upgrade package options which can be included as a selection during design. This is applicable when retrofitting an existing system or installing a new system.
- MERV 13 filters are often recommended as an indoor air quality best practice, but each system needs to be assessed to determine if MERV 13 filters are feasible for existing or new conditions; for example, some existing systems may not be able to provide the same amount of airflow, if a higher MERV filter is added.
- Filters come in a variety of types and configurations. In addition to standard fiberglass media or pleated filters, other technologies available include electronic filters or electrostatic filters, bipolar ionization, and UV. It's recommended to always consult with a professional and to only use validated solutions which provide evidence that the proposed technology is effective and safe for the application. **Resource:** https://www.ashrae.org/technical-resources/filtration-disinfection

Note: Always follow manufacturer installation and maintenance instructions for filter cleaning and/or replacing schedules and procedures.

Heating and Cooling

Heating & Cooling Overview

Site Visit: Brookstone Homes

System Overview: Space heating and cooling is provided by either natural gas or electric fuel types. Existing space heating equipment includes natural gas furnaces, natural gas boilers, or electric resistance. Existing space cooling equipment includes central air conditioners and window unit air conditioners. The "balance of system" components include hot water pipes, ductwork, refrigerant lines, pumps, and fans.

Goals: Reduce energy consumption used for heating and cooling and provide opportunities for electrification and decarbonization

Benefits of Upgrades:

- ✓ Improve occupant comfort
- ✓ Electrification upgrades integrate with onsite renewable energy generation systems
- ✓ Electrification reduces carbon emissions over time

Forced Air Gas Furnace: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Goals: Increase efficiency

Opportunities

Annual Furnace Tune Up *(See Key Considerations on next page)*	$ L H&S
AND	
Air seal and insulate ductwork *(See Key Considerations on next page)*	$ S

Equipment Replacement

Planned Upgrade or Failure

Major Renovation

Major Capital Investment

Goals: Increase efficiency & electrify gas system, if feasible

Opportunities

Electrification Option: **Replace gas furnace with ducted, inverter driven, variable speed, cold-climate air-source heat pump (ccASHP)** *(See Ducted ccASHP Key Considerations on next page)*	$$ L H&S E
OR	
Gas System Option: **Replace gas furnace with a high-efficiency (95%+ AFUE), ENERGY STAR® rated condensing gas furnace**	$$ M H&S E

Forced Air Gas Furnace: Key Considerations

Annual Furnace Tune-up

- Ensure combustion safety testing for atmospherically vented furnaces is included at the time of furnace tune-up

Air Seal and Insulate Ductwork

- If ductwork is located in a *condition spaces*, duct sealing and insulation is likely unnecessary, unless there are major holes, cracks, or disconnects.
- If ductwork is located in *unconditioned spaces*, it is recommended to convert the space to a conditioned space following recommendations in the Building Envelope section.
    - If it is not possible to locate duct work in a conditioned space, then advanced duct sealing and insulation by a professional is recommended.

Ducted ccASHP

- **General:** Ducted cold-climate air source heat pumps provide both heating and cooling and can operate at temperatures as low as -13°F. The selected ccASHP should be inverter driven and variable speed. The existing duct system can be reused with a ducted ccASHP. See NEEP's ccASHP list for recommended models.
- **Design & Installation:** The building envelope and existing ductwork should be air sealed and insulated before ccASHP installation. The size of the ccASHP should be designed to heating/cooling loads after it is weatherized. Talk with your heating contractor about supplemental heat sources and system control options to maximize operational cost and carbon savings. Consider a MERV 13 upgrade or higher filtration system (if available) with the new unit. Also, electrical capacity will need to be assessed to ensure there is enough capacity for moving from a gas to an electric heating system.
- **Maintenance:** Check and assess filters monthly; clean and replace as needed.
- **Utility cost:** Operational costs of heat pumps in WI is currently more expensive than natural gas alternatives because of the price of electricity compared to the price of natural gas. Resident education on optimal thermostat operations is important to minimize utility costs.
- *Partial electrification option:* the existing gas furnace can be kept and used as a dual-fuel system, where the ASHP operates until it is not able to provide enough heat. In this case, the ASHP may not need to be rated for cold-climates, saving on costs.

Electric Baseboard & Ceiling Heat: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

None

Equipment Replacement

Planned Upgrade or Failure

Goals: Increase efficiency

Opportunities

Electrification Option: **Upgrade to ductless mini-split heat pumps (one system per apartment)**
(See Ductless mini-split heat pumps Key Considerations on next page)

$$$ L M

OR

Electrification Option: **Upgrade to Variable Refrigerant Flow (VRF) system with heat recovery**
(See VRF with heat recovery Key Considerations on next page)

$$$ L H

Major Renovation

Major Capital Investment

Electric Baseboard & Ceiling Heat: Key Considerations

Ductless mini-split heat pumps

- **General:** Ductless mini-split heat pumps provide both heating and cooling and have an outdoor and indoor unit connected by refrigerant lines through the wall. The indoor unit can be ceiling or wall mounted. Each apartment has a sperate system. The selected model should be rated for cold-climates and inverter driven. See NEEP's ccASHP list for recommended models.
- **Design & Installation:** Air sealing and insulation upgrades should be completed prior to installing new heat pumps[1]. The size of the system should be designed to heating/cooling loads after it is weatherized. Consult the heat pump installer for best location of indoor and outdoor units. Integrated back-up heat is not available for ductless mini-split heat pumps, but back-up heat is likely required. Existing electric resistance heating system can be used for supplemental or emergency heat. Talk with your heating contractor about supplemental heat sources and system control options to maximize operational cost and carbon savings. Consider a filter upgrade option (if available) with the new unit.
- **Maintenance:** Check and assess filters and fans monthly; clean and replace as needed.
- **Utility cost:** Switching from electric baseboard to heat pump heat will reduce utility costs. Residents should be given education to keep thermostat at the same temperature (rather than applying a setback) to improve comfort and efficiency.

[1]Exception**:** if attic access is required for heat pump installation, attic insulation should be completed after heat pump installation.

VRF with heat recovery

- **General:** These systems allow for simultaneous heating and cooling of indoor units connected to the same outdoor unit, moving unneeded heat from one apartment into another apartment where heat is necessary. Heat recovery greatly improves efficiency and zonal control in buildings with mixed uses and/or loads. Unlike mini-split systems, the VRF system is connected between multiple apartments.
- **Design & Installation:** A VRF system requires full redesign of the building's HVAC system. There is currently no standard for defining cold-climate VRF systems. Also, VRF systems require significantly more refrigerant than other heat pump options. Air sealing and insulation upgrades should be completed prior to installing new VRF system. The size of the system should be designed to heating/cooling loads after it is weatherized. Consult the heat pump installer for best location of indoor and outdoor units. Consider enhanced filtration (MERV 13 or higher) when possible as part of the system design.
- **Maintenance:** Check and assess filters and fans monthly; clean and replace as needed.
- **Utility cost:** Switching from electric baseboard to heat pump heat will reduce utility costs. VRF systems are central systems and most often building owners pay operational costs. Residents should be given education to keep thermostat at the same temperature (rather than applying a setback) to improve comfort and efficiency.

Central Boiler: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Goals: Increase efficiency

Opportunities

Install outdoor air temperature-based reset control	$	S
AND		
Install variable speed pumps	$	S
AND		
Add zone control valves if not present	$	S
AND		
Insulate Hot Water Pipes	$	S

Equipment Replacement

Planned Upgrade or Failure

Goals: Increase efficiency & electrify gas system, if feasible

Opportunities

Gas System Option: **Replace existing boiler with a high efficiency (95%+ AFUE), ENERGY STAR rated Gas Boiler(s)** *(See Key Considerations on next page)*	$$	M, E
OR		
Electrification Option: **Upgrade to ductless mini-split heat pumps (one system per apartment)** *(See Key Considerations on next page)*	$$$	L, M
OR		
Electrification Option: **Install new Variable Refrigerant Flow (VRF) system with heat recovery** *(See Key Considerations on next page)*	$$$	L, H

Major Renovation

Major Capital Investment

Opportunities

Electrification Option for Hydronic boilers only: **Reutilize existing water distribution system and install new Air-to-Water or Water-to-Water Centralized Heat Pump** *(See Key Considerations on next page)*	$$	L
OR		
Electrification Option: **Install Ground-Source Heat Pumps (GSHPs)** *(See Key Considerations on next page)*	$$$	L

Health & Safety Impact | Upfront Cost | Payback Period | Maintenance

Central Boiler: Key Considerations

High-Efficiency Gas Boiler

- Stage multiple boilers whenever possible to improve combustion efficiency
- *Partial electrification option*: Consider adding an ASHP to preheat water before going to high-efficiency boiler (existing or new). For this option, HVAC designers would be required to ensure controls are sequenced correctly for pre-conditioning water.

Variable Refrigerant Flow (VRF) with Heat Recovery

- **General:** These systems allow for simultaneous heating and cooling of indoor units connected to the same outdoor unit, moving unneeded heat from one apartment into another apartment where heat is necessary. Heat recovery greatly improves efficiency and zonal control in buildings with mixed uses and/or loads. Unlike mini-split systems, the VRF system connects between multiple apartments.
- **Design & Installation:** A VRF system requires full redesign of the building's HVAC system. There is currently no standard for defining cold-climate VRF systems. VRF systems require significantly more refrigerant than other heat pump options. Air sealing and insulation upgrades should be completed prior to installing new VRF system. The size of the system should be designed to heating/cooling loads after it is weatherized. Consult the heat pump installer for best location of indoor and outdoor units. Also, electrical capacity will need to be assessed to ensure there is enough capacity for moving from a gas to an electric heating system.
- **Maintenance:** Check and assess filters and fans monthly; clean and replace as needed.
- **Utility cost:** Operational costs of heat pumps in WI is currently more expensive than natural gas alternatives because of the price of electricity compared to the price of natural gas. Residents should be given education to keep thermostat at the same temperature (rather than applying a setback) to improve comfort and efficiency.

Ductless Mini-Split Heat Pumps

- **General:** Ductless mini-split heat pumps provide both heating and cooling and have an outdoor and indoor unit connected by refrigerant lines through the wall. The indoor unit can be ceiling or wall mounted. Each apartment has sperate systems. The selected model should be rated for cold-climates and inverter driven. See NEEP's ccASHP list for recommended models.
- **Design & Installation:** Air sealing and insulation upgrades should be completed prior to installing new heat pumps[1]. The size of the system should be designed to heating/cooling loads after it is weatherized. Consult the heat pump installer for best location of indoor and outdoor units. Integrated back-up heat is not available for ductless mini-split heat pumps, but back-up heat is likely required. The central boiler may be able to be configured to supply supplemental heat. Talk with your heating contractor about supplemental heat sources and system control options to maximize operational cost and carbon savings. Also, electrical capacity will need to be assessed to ensure there is enough capacity for moving from a gas to an electric heating system. Consider a filter upgrade option (if available) with the new unit.
- **Maintenance:** Check and assess filters and fans monthly; clean and replace as needed.
- **Utility cost:** Switching from a central boiler to ductless mini-splits can shift utility costs to tenants. Consider early on if this is an acceptable outcome, or ideally, if owner can still pay heating costs. Residents should be given education to keep thermostat at the same temperature (rather than applying a setback) to improve comfort and efficiency.

[1]Exception: if attic access is required for heat pump installation, attic insulation should be completed after heat pump installation.

Central Boiler: Key Considerations (continued)

Air-to-Water or Water-to-Water Centralized Heat Pump

- Air-to-Water and Water-to-Water heat pumps are emerging technologies in the U.S. market. It is recommended to talk with manufacturers to identify top tier contractors that are factory trained.
- It is necessary to have an experienced professional to evaluate the current system and create an appropriate system design. Working closely with the manufacturer engineers is recommended.

Ground-Source Heat Pumps (GSHPs)

- Ground-source heat pumps (sometimes referred to as 'geothermal') are a proven, high efficiency technology
- GSHPs can be cost-prohibitive and are not suitable for every site. Contact a ground-source heat pump professional to assess your site for sufficient size to accommodate the ground loops, thermal conductivity, and heating and cooling needs of the building.

Window AC or None Provided: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Goals: Increase efficiency & thermal comfort

Opportunities

Check filter monthly and clean as needed	$
AND	
Ensure condensate drips away from building	$
AND	
Ensure window units are air-sealed around opening	$

Equipment Replacement

Planned Upgrade or Failure

Goals: Increase efficiency & thermal comfort

Opportunities

If heating system is ducted: **Replace with ducted, inverter driven, variable speed, cold-climate air-source heat pump (ccASHP)** *(See Ducted ccASHP Key Considerations on next page)*	$$ H&S E
OR	
If heating system is <u>not</u> ducted: **Install ductless mini-split heat pumps (one system per apartment)** *(See Ductless mini-split Key Considerations on next page)*	$$$ H&S M

Major Renovation

Major Capital Investment

Window AC or None Provided: Key Considerations

Ductless mini-split heat pumps

- **General:** For this project, the project owner can choose whether the ductless mini-splits will be designed for only cooling, or to also supplement/replace the existing heating system. Ductless mini-splits have an outdoor and indoor unit connected by refrigerant lines through the wall. The indoor unit can be ceiling or wall mounted. Each apartment has sperate systems. If also used for heating, the selected model should be rated for cold-climates and inverter driven. See NEEP's ccASHP list for recommended models.
- **Design & Installation:** Air sealing and insulation upgrades should be completed prior to installing new heat pumps[1]. The size of the system should be designed to cooling loads and heating loads (if applicable) after it is weatherized. Consult the heat pump installer for best location of indoor and outdoor units. If using for heat as well, integrated back-up heat is not available for ductless mini-split heat pumps, but back-up heat is likely required. Talk with your heating contractor about supplemental heat sources and system control options to maximize operational cost and carbon savings. Consider a filter upgrade option (if available) with the new unit.
- **Maintenance:** Check and assess filters and fans monthly; clean and replace as needed.
- **Utility cost:** If switching from window units to mini-splits, cooling costs are expected to decrease. If no cooling was previously used, cooling costs will increase with mini-splits. Depending on the existing heating system, switching to ductless mini-splits may shift utility costs to tenants. If this is the case, consider early on if this is an acceptable outcome, or ideally, if owner can still pay heating costs. Residents should be given education to keep thermostat at the same temperature (rather than applying a setback) to improve comfort and efficiency.

Ducted ccASHP

- **General:** This project is applicable to projects wishing to add central cooling in conjunction with replacing the existing ducted heating system. Ducted cold-climate air source heat pumps provide both heating and cooling and can operate at temperatures as low as -13°F. The selected ccASHP should be inverter driven and variable speed. The existing duct system can be reused with a ducted ccASHP. See NEEP's ccASHP list for recommended models.
- **Design & Installation:** The building envelope and existing ductwork should be air sealed and insulated before ccASHP installation. The size of the ccASHP should be designed to heating/cooling loads after it is weatherized. Talk with your heating contractor about supplemental heat sources and system control options to maximize operational cost and carbon savings. Consider a MERV 13 upgrade or higher filtration system (if available) with the new unit. Also, electrical capacity will need to be assessed to ensure there is enough capacity for moving from a gas to an electric heating system.
- **Maintenance:** Check and assess filters and fans monthly; clean and replace as needed.
- **Utility cost:** Operational costs of heat pumps in WI is currently more expensive than natural gas alternatives because of the price of electricity compared to the price of natural gas. Resident education on optimal thermostat operations is important to minimize utility costs.
- *Partial electrification option:* the existing gas furnace can be kept and used as a dual-fuel system, where the ASHP operates until it is not able to provide enough heat. In this case, the ASHP may not need to be rated for cold-climates, saving on costs.

[1]Exception: if attic access is required for heat pump installation, attic insulation should be completed after heat pump installation.

Central AC: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Goals: Increase efficiency

Opportunities

Annual AC tune-up	$ L
AND	
Air seal and insulate ductwork in unconditioned spaces *(See Key Considerations on next page)*	$ M

Equipment Replacement

Planned Upgrade or Failure

Goals: Increase efficiency & thermal comfort

Opportunities

If replacing heating system: **Replace with ducted, inverter driven, variable speed, cold-climate air-source heat pump (ccASHP)** *(See Ducted ccASHP Key Considerations on next page)*	$$ L H&S E
OR	
If not replacing heating system: **Install central AC with a high SEER (>15) ENERGY STAR® certified model** *(See High-efficiency Central AC Key Considerations on next page)*	$$ L

Major Renovation

Major Capital Investment

Central AC: Key Considerations

Air Seal and Insulate Ductwork

- If ductwork is located in *condition spaces*, duct sealing and insulation is likely unnecessary, unless there are major holes, cracks, or disconnects.
- If ductwork is located in *unconditioned spaces*, it is recommended to convert the space to a conditioned space following recommendations in the Building Envelope section.
    - If it is not possible to locate duct work in a conditioned space, then advanced duct sealing and insulation by a professional is recommended.

High-Efficiency Central AC

- **General:** This project is for upgrading a central AC system to a high-efficiency system.
- **Design & Installation:** Ensure the AC unit is ENERGY STAR® certified and variable speed. Have contractor check duct design and capacity and make sure system is sized appropriately. Seal ducts and insulate if in unconditioned space. Relocate ducts to conditioned space if possible. Locate condensing unit where no nearby objects will block airflow to it. Automatic-delay fan switch to turn off the fan a few minutes after the compressor turns off. Locate the thermostat away from heat sources, such as windows or supply registers. Consider a MERV 13 upgrade or higher filtration system (if available) with the new unit.
- **Maintenance:** Filter check light reminder to change filter after a predetermined number of operating hours
- **Utility Cost:** Utility costs are expected to decrease by switching to a higher efficiency central AC system.

Ducted ccASHP

- **General:** This project is applicable to projects wishing to add central cooling in conjunction with replacing the existing ducted heating system. Ducted cold-climate air source heat pumps provide both heating and cooling and can operate at temperatures as low as -13°F. The selected ccASHP should be inverter driven and variable speed. The existing duct system can be reused with a ducted ccASHP. See NEEP's ccASHP list for recommended models.
- **Design & Installation:** The building envelope and existing ductwork should be air sealed and insulated before ccASHP installation. The size of the ccASHP should be designed to heating/cooling loads after it is weatherized. Talk with your heating contractor about supplemental heat sources and system control options to maximize operational cost and carbon savings. Consider a MERV 13 upgrade or higher filtration system (if available) with the new unit. Also, electrical capacity will need to be assessed to ensure there is enough capacity for moving from a gas to an electric heating system
- **Maintenance:** Check and assess filters and fans monthly; clean and replace as needed.
- **Utility cost:** Operational costs of heat pumps in WI is currently more expensive than natural gas alternatives because of the price of electricity compared to the price of natural gas. Resident education on optimal thermostat operations is important to minimize utility costs.

Lighting

Lighting Overview

https://www.lrc.rpi.edu/programs/solidstate/assist/multifamily.asp

System Overview: Lighting in common areas, individual units and the exterior

Goals: Increase energy efficiency, light spaces only when needed and improve safety while minimizing any negative impacts on health.

Benefits of Upgrades:

- ✓ Lower energy consumption and costs
- ✓ Improve light quality
- ✓ Decrease maintenance frequency and costs
- ✓ Reduce outdoor light pollution

Lighting: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Equipment Replacement

Planned Upgrade or Failure

Major Renovation

Major Capital Investment

Goals: Increase efficiency & improve safety

Opportunities

Upgrade to Energy Star® or DLC listed bulbs and fixtures *(See Key Considerations on next page)*	$ M H&S
AND	
Install lighting controls to dim or turn off lights when not needed *(See Key Considerations on next page)*	$ S H&S

Lighting: Key Considerations

Upgrade to LED Bulbs & Fixtures

- Lighting efficiency should be balanced with color rendering (lighting reflects object's true color) and color temperature (warmth or coolness of the lighting, measured in kelvin) as the amount of as these can impact tenants mental and physical health. For larger projects, we recommend testing several different lights with vendors to decide on the preferred lighting temperature.
- For outdoor lighting, consider Dark Sky compliant fixtures or shielding to minimize light pollution.
- Wisconsin's *Focus on Energy* program offers free kits including LED bulbs (as of 2022).

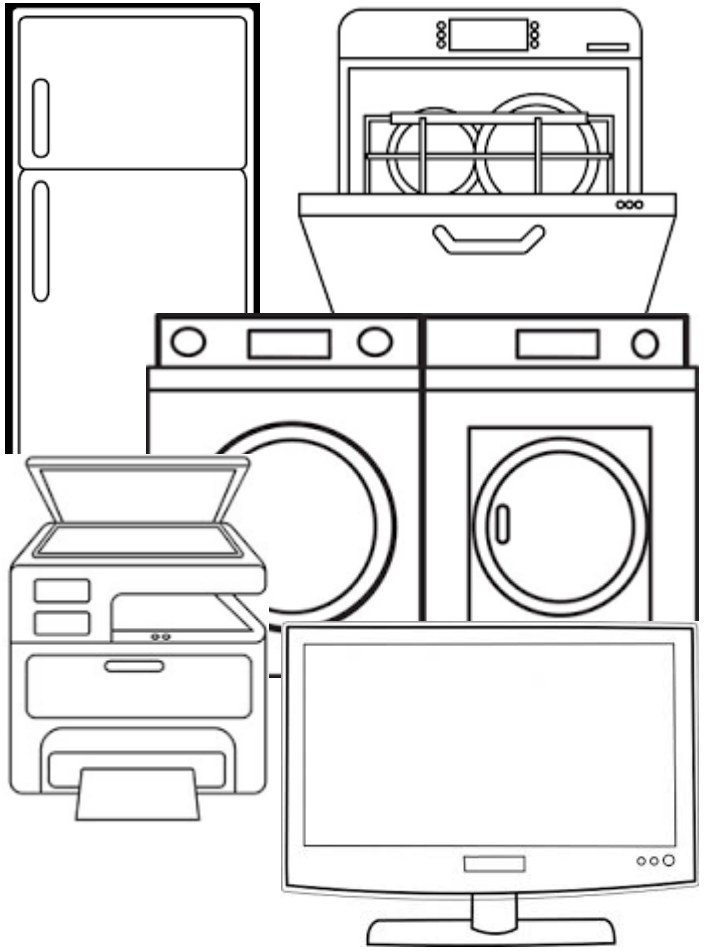
For more information read:
The Lighting Field Guide: Upgrading to LEDs for Multi-Family Housing
Sensor Controlled Lighting in Multi-Family Corridors (Delta Field Test Snapshots Issue 10)

Install Lighting Controls

- Fail on, dimming and auto on/off should be considered for each lighting context given any safety and/or security concerns and the amount of ambient light during daylight hours.

Appliances

Appliances Overview



System Overview: Appliances in the building may include refrigerators, dishwashers, clothes washers, clothes dryers, stovetops, ovens and plug loads.

Goals: Increase energy efficiency and draw power only when in use.

Benefits of Upgrades:

- ✓ Lower energy consumption and costs
- ✓ Increased awareness of usage behavior

Appliances: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Equipment Replacement

Planned Upgrade or Failure

Major Renovation

Major Capital Investment

Goals: Increase efficiency & improve safety

Opportunities

Replace refrigerators, dishwashers, clothes washers, and clothes dryers with ENERGY STAR® models *(See Appliances Key Considerations on next page)*	$ M E
AND	
***Electrification option for gas dryers*: Replace gas dryer with electric model, preferably a heat pump model** *(See Electrify Appliances Key Considerations on next page)*	$$ M M H&S
AND	
***Electrification option for stoves*: Replace gas stovetops and ovens with electric model** *(See Electrify Appliances Key Considerations on next page)*	$$ M E H&S
AND	
Use smart power strips to turn off electronics when not in use *(See Power Strips Key Considerations on next page)*	$ S E

Health & Safety Impact | Upfront Cost | Payback Period | Maintenance

Appliances: Key Considerations

Appliances

- Use the ENERGY STAR® product finder to find the equivalent ENERGY STAR® rated model.
- Maintenance:
  - **Refrigerators**: clean coils at the back of the refrigerator during client turnover
  - **Dryers**: Clean vents on a regular basis

Smart Power Strips

- Wisconsin's *Focus on Energy* program offers free kits including smart power strips (as of 2022).

Electrify Appliances

- Electric service capacity may need to be increased when switching appliances from gas to electric and should be evaluated as part of the project scope.
- Gas Dryers
  - If in unit, convert to ENERGY STAR® certified ventless heat pump dryer.
  - If in common areas, convert to standard electric resistance dryer.

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Solar and Solar + Storage

Solar and Solar + Storage Overview

System Overview: Solar modules on roof or ground of property, inverters to convert DC electricity output to AC, and sometimes battery systems for storing excess electricity from the solar.

Goals: To reduce electricity costs by offsetting electricity being used at the property with electricity from solar PV. For battery storage, to provide backup power in case of grid outages.

Benefits of Upgrades:

- ✓ Lower electricity costs
- ✓ Can offset increased electricity use from electrification
- ✓ Can provide some backup power in case of grid outages

Solar and Solar + Storage: Action Plan

Regular Operations & Maintenance

Low-cost Improvements, Minor Repair, or Tenant Turnover

Equipment Replacement

Planned Upgrade or Failure

Major Renovation

Major Capital Investment

Goals: Decrease electricity costs and add resiliency

Opportunities

Install Solar *(See Key Considerations on next page)*	$$$ M M
AND	
Install Battery Storage *(See Key Considerations on next page)*	$$$ H M

Solar and Solar + Storage: Key Considerations

Solar Photovoltaics (PV)

To understand if solar is right for a specific property, a formal cost-benefit analysis is best. Even if funding is paid for fully, start with understanding how much solar energy can be produced to offset the electricity use at that property.

- How much solar energy can be produced at this property? The **solar capacity** will take into consideration shading and installation options
- How much of the building's electrical load will be **offset** by the amount of solar you can install? The greater the percent offset typically means the better payback.
- Is this site good for a **solar installation**? Is the roof flat or pitched, oriented toward the sun, does it have at least 15 years of life remaining? Is ground mount or carport possible?
- How is the **building metered**? Master-metered buildings offered greater potential savings and lower costs.

When planning for new construction or roof upgrades, review the NREL Solar-Ready Checklist. Ensure south-facing roofs have minimal obstructions (e.g., vents) and can accommodate the additional load from the PV system. Confirm electrical panels have enough space for a Solar PV circuit breaker.

Battery Storage

Battery storage can store energy produced from solar to provide power when solar panels are not producing, like at night or during power outages. Battery storage can also provide opportunities for reducing energy costs by managing when electricity is used, although savings from battery storage is not common.

- Resiliency, or providing **backup power**, is usually the key consideration when looking at battery storage.
- Consider what you want to keep powered during an outage (the **critical load**), and for how long (**duration**).
- Larger loads and longer backup durations mean **larger batteries** and more costs.
- Meters with measurable demand charges may offer opportunities for savings using your battery and controllers to shift load in a way that reduces **peak demand**.
- Not having enough **solar capacity** as a percentage of load may limit the feasibility of battery storage.

Solar and Solar + Storage: Other Considerations

Costs

- Solar capacity is typically measured in Kilowatts (KW) and costs as $ per watt. Solar costs for multifamily properties can range greatly, from $2.00 per watt for large, flat roofs or ground mounted arrays, to as high as $5.00 per watt for complicated roofing and metering or for carport arrays.
- Battery storage is commonly measured by kilowatts (KW) which indicates the size or capacity of the battery, and kilowatt hours (kWh), which indicates the length of time or duration the battery can deliver the energy. Storage costs are typically measured as $ per kWh. Industry standard costs as of August 2022 range from about $900/kWh to $1,200 per kWh, depending on configuration, brand or geography, etc.
- During new construction or significant renovations, and when implementing solar is realistic, consider a construction scope that makes the property solar ready. This can significantly lower cost for implementation later. See NREL's solar-ready checklist for more information.

Finding Solar Vendors

- The ability to analyze your property and understand the optimal solar and/or storage design before seeking industry costs and proposals will make it easier to compare costs and services across vendors and ensure the system proposed is right for the property. This potentially means costs for upfront technical work. But saves time on the back end.
- Solar and storage vendors can also provide system design work as part of the proposal process. This approach does not require upfront technical work and can leave options open for approaches that may be more optimal than initial designs and assumptions.
- Whether you seek industry input with or without design and analysis upfront, have a clear plan for reviewing and assessing proposals, and then communicating with vendors. Providing as much detail as possible about electricity usage and metering will allow for more realistic and robust designs and performance analysis.

Other Issues When Engaging the Solar/Storage Industry

- As of August 2022, supply chain issues have made managing cost difficult. Consider adding additional cost contingencies in your budgets whenever possible. Consider a milestone approach to vendor contracting to allow more payment upfront so vendors can lock in equipment costs early.
- While solar racking and panels will last 25 years or more, inverters need to be replaced between 12 and 26 years after installation. It is typically more economical to replace those inverters rather than install a new system or discard the currently installed system.
- Maintenance can be done by property managers, or you may look for a maintenance contract from the installer. Maintenance is usually considered on an annual basis, and includes cleaning the panels, checking for loose electrical connections, and servicing power electronics like inverters.

Solar Rating Analysis: Definitions and Process

Definitions

- Shading
  - Are there trees, other buildings, or other objects that cause the roof to be in shade for part or all of the day?
- Rooftop Obstructions
  - Are there rooftop vents, different aspects, dormers, or other obstructions that will make placing panels on the roof difficult?
- Orientation
  - What direction are the roof aspects facing?
- Carport Potential
  - Does the property have space available in the parking lot that isn't heavily shaded, and could be used for a carport solar array?

Ratings Process

- Shading and Rooftop Obstructions are rated on a good, fair, poor scale. A "good" property would have minimal shading and a large amount of available roof space.
- For orientation, if a building had any roof aspects facing south, it was considered "good". All other configurations, such as east/west would be considered "fair". Orientation, while important, has less impact on solar potential than shading or obstructions.
- Carport Potential is either yes, there is available space for a carport array, or no.
- Overall buildings scores are based on a summation of these four criteria.

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Additional information and definitions provided in the Database.

Case Studies

NOAH Acquisition Case Study: Brookstone Townhomes – Fitchburg, WI

Property Details

- 28 Townhomes
- ~1975 Construction
- Tenant – Electric
- WHPC – Gas
- Central gas boiler + electric baseboard
- Central gas DHW

Reasons to use the action plan for this property

- Recently acquired, naturally occurring affordable housing (NOAH)
- Upgrades planned
- Higher cost intensity for space and water heating compared to other properties

Photo Credit: Elevate

NOAH Acquisition Case Study: Brookstone Townhomes – Fitchburg, WI

- **Opportunity:** Planning for upgrades at Brookstone Townhomes
- **Additional Information**: Top quartile of energy cost intensity amongst properties where WHPC pays for tenant space heating and DHW *(Database)*
- **Action**: Engage a professional to conduct a site assessment and identify opportunities to address high costs in planned upgrades
- **Outcome:** Opportunities identified will inform the scope of planned upgrades with additional guidance from the system sections of the Action Plan
  - Air seal and insulate the attic in conjunction with roof replacement
  - Air seal and insulate the cantilevered floors, rim joists, overhangs and add continuous insulation in conjunction with siding and soffit replacement
  - Install low-flow showerheads, bathroom aerators, and toilets
  - Install outdoor boiler reset controls on the and replace recirculation pumps
  - Replace bulbs and fixtures with energy efficient LEDs and lighting controls
  - Replace refrigerators with ENERGY STAR® refrigerators

Action Plans

- ✓ Building Envelope: Attic/Roof
- ✓ Building Envelope: Walls & Floors
- ✓ Building Envelope – Foundation
- ✓ Plumbing Fixtures
- ✓ Heating – Central Boiler
- ✓ Lighting
- ✓ Appliances

Note: Deeper retrofit considerations include adding exterior insulation if siding is replaced, upgrading windows, and insulating the foundation. See action plans for more details.

HUD Section 8 Case Study: River Grove – Black River Falls, WI

Property Details

- 40 units, 3-story masonry
- Built in 1978
- All-electric, all electricity WHPC-paid
- Electric baseboard heat, no A/C provided, central electric DHW
- Flat roof, no shading

Reasons to use the action plan for this property:

- HUD Section 8 property
- No rehab planned in next 10 years
- High owner-paid costs, older systems
- Good candidate for electrification – needs cooling, utilities WHPC paid, electric baseboard heat, good solar rating

Photo credits: Rentals.com

HUD Section 8 Case Study: River Grove – Black River Falls, WI

- **Opportunity:** Public Service Commission of Wisconsin Office of Energy Innovation - 2022 Energy Innovation Grant Program
- **Initial Scope:** All-electric properties WHPC-paid properties with flat roofs for high solar rating for potential onsite renewable energy generation (Map)
- **Refined Scope:** Properties high electric costs *(Database)*
- **Action:** Application submitted and awarded to upgrade to heat pump technology with future consideration for installing solar PV *(Action Plan)*

Action Plans

- ✓ Heating – Electric Baseboards: Action Plan
- ✓ Cooling – Window A/C or None Provided: Action Plan
- ✓ Renewable Energy: Solar / Solar + Storage Action Plan

For More information

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Appendix

Opportunities by Timing – Regular Operations & Maintenance

System	Opportunity	Health & Safety Impact	Upfront Cost	Payback Period	Mainten-ance
Building Envelope – Attic/Roof	For vented, unconditioned attics: Air seal and insulate vented attic to levels that meet or exceed the current adopted building and energy codes (R-49 to R-60)	Yes	$	Medium	
Building Envelope – Walls & Floors	Air seal penetrations in exterior walls such as space around window AC units, AC wall sleeves, windows and door frames, and receptacles.		$	Short	
Building Envelope - Foundation	Air Seal and insulate crawlspace/basement rim joists.		$$	Medium	
Building Envelope – Windows & Exterior Doors	Air Seal Around Windows and Exterior Doors	Yes	$	Short	
Central Domestic Water Heating	Install demand-controls to recirculation pumps to reduce unnecessary water heating		$	Short	
Central Domestic Water Heating	Insulate hot water pipes with R-4 insulation		$	Short	
Central Domestic Water Heating	*For gas systems:* Engage a professional to perform Combustion Safety Testing on gas equipment to ensure proper venting	Yes	$	N/A	
In-Unit Domestic Water Heating	*For gas systems*: Engage a professional to perform Combustion Safety Testing on gas equipment to ensure proper venting	Yes	$	N/A	
Plumbing Fixtures	Install low-flow bathroom faucets, kitchen faucets, and shower heads		$	Short	E
Plumbing Fixtures	Monitor water use for leak detection		$$	Short	M

Opportunities by Timing – Regular Operations & Maintenance

System	Opportunity	Health & Safety Impact	Upfront Cost	Payback Period	Mainten-ance
Ventilation	Replace/install new bathroom exhaust fans with ENERGY STAR products rated for continuous use	Yes	$	NA	
Ventilation	Replace recirculating kitchen exhaust fans with ENERGY STAR fans that exhaust to outdoors	Yes	$$	NA	
Ventilation	Properly vent exhaust fans to outside	Yes	$	NA	
Ventilation	Install continuous operation controls for bath fans and measure airflow to verify performance		$	NA	
Heating – Forced Air Gas Furnace	Annual Furnace Tune Up	Yes	$	Long	
Heating – Forced Air Gas Furnace	Air seal and insulate ductwork		$	Short	
Heating – Central Boiler	Install outdoor air temperature-based reset control		$	Short	
Heating – Central Boiler	Install variable speed pumps		$	Short	
Heating – Central Boiler	Add zone control valves if not present		$	Short	
Heating – Central Boiler	Insulate Hot Water Pipes		$	Short	

Opportunities by Timing – Regular Operations & Maintenance

System	Opportunity	Health & Safety Impact	Upfront Cost	Payback Period	Mainten-ance
Cooling – Window or None	Check filter monthly and clean as needed		$	NA	
Cooling – Window or None	Ensure condensate drips away from building		$	NA	
Cooling – Window or None	Ensure window units are air-sealed around opening		$	NA	
Cooling - Central	Annual AC tune-up		$	Long	
Cooling - Central	Air seal and insulate ductwork in unconditioned spaces		$	Medium	
Lighting	Upgrade to Energy Star® or DLC listed bulbs and fixtures	Yes	$	Medium	
Lighting	Install lighting controls to dim or turn off lights when not needed	Yes	$	Short	
Appliances	Replace refrigerators, dishwashers, clothes washers, and clothes dryers with ENERGY STAR® models		$	medium	E
Appliances	*Electrification option for gas dryers*: Replace gas dryer with electric model, preferably a heat pump model	Yes	$$	Medium	M
Appliances	*Electrification option for stoves*: Replace gas stovetops and ovens with electric model	Yes	$$	Medium	E
Appliances	Use smart power strips to turn off electronics when not in use		$	Short	E

Opportunities by Timing – Equipment Replacement

System	Opportunity	Health & Safety Impact	Upfront Cost	Payback Period	Mainten-ance
Building Envelope – Attic/Roof	For unvented attics, roof cavities, and vaulted ceilings: Install closed cell spray foam insulation to underside of roof decking	Y	$	Medium	
Building Envelope – Attic/Roof	During roof replacement (flat roofs and roofs over conditioned attics): Install above deck rigid foam insulation		$	Medium	
Building Envelope – Walls & Floors	Add cavity insulation to exterior walls in wood framed buildings		$$	Medium	
Building Envelope - Walls & Floors	Insulate overhangs, bays, and cantilevered floors to R-30 or fill to capacity		$$	Medium	
Building Envelope - Foundation	Air Seal and insulate crawlspace or basement walls to R-15	Yes	$$$	Medium	
Building Envelope – Windows & Exterior Doors	Replace windows with ENERGY STAR®/National Fenestration Rating Council certified products	Yes	SSS	Long	
Building Envelope – Windows & Exterior Doors	Replace exterior doors with ENERGY STAR®/National Fenestration Rating Council certified products		$$	Long	
Central Domestic Water Heating	*Electrification Option:* Install central heat pump water heater (HPWH) appropriate for cold climates		$$$	Long	M
Central Domestic Water Heating	*Gas System Option:* Install condensing ENERGY STAR® gas water heater with sealed combustion		$$	Long	E
Central Domestic Water Heating	*If space heating is also central:* Combine water heating and space heating with one boiler system by installing condensing, modulating high-efficiency ENERGY STAR® boilers		$$$	Long	M

Opportunities by Timing – Equipment Replacement

System	Opportunity	Health & Safety Impact	Upfront Cost	Payback Period	Mainten-ance
In-Unit Domestic Water Heating	*Electrification Option:* Upgrade to a unitary heat pump water heater (HPWH)	Yes	$$	Medium	M
In-Unit Domestic Water Heating	*Gas System Option:* Upgrade to an ENERGY STAR® condensing gas water heater with sealed combustion	Yes	$$	Medium	E
Plumbing Fixtures	Replace toilets with low-flow toilets		$$	Medium	E
Plumbing Fixtures	Install low-flow bathroom faucets, kitchen faucets, and shower heads		$	Short	E
Plumbing Fixtures	Monitor water use for leak detection		$$	Short	M
Ventilation	Install whole house/supply driven ventilation system	Yes	$$	NA	E
Ventilation	Install a Heat Recovery Ventilation (HRV) or Energy Recovery Ventilation (ERV) system	Yes	$$	NA	M
Heating – Forced Air Gas Furnace	*Electrification Option:* Replace gas furnace with ducted, inverter driven, variable speed, cold-climate air-source heat pump (ccASHP)	Yes	$$	Long	E
Heating – Forced Air Gas Furnace	*Gas System Option:* Replace gas furnace with a high-efficiency (95%+ AFUE), ENERGY STAR® rated condensing gas furnace	Yes	$$	Medium	E
Heating – Electric Baseboard & Ceiling	*Electrification Option:* Upgrade to ductless mini-split heat pumps (one system per apartment)		$$$	Long	M
Heating – Electric Baseboard & Ceiling	*Electrification Option:* Upgrade to Variable Refrigerant Flow (VRF) system with heat recovery		$$$	Long	H

Opportunities by Timing – Equipment Replacement

System	Opportunity	Health & Safety Impact	Upfront Cost	Payback Period	Mainten-ance
Heating – Central Boiler	*Gas System Option:* Replace existing boiler with a high efficiency (95%+ AFUE), ENERGY STAR rated Gas Boiler(s)		$$	Medium	E
Heating – Central Boiler	*Electrification Option:* Upgrade to ductless mini-split heat pumps (one system per apartment)		$$$	Long	M
Heating – Central Boiler	*Electrification Option:* Install new Variable Refrigerant Flow (VRF) system with heat recovery		$$$	Long	H
Cooling – Window or None	*If heating system is ducted:* Replace with ducted, inverter driven, variable speed, cold-climate air-source heat pump (ccASHP)	Yes	$$	NA	E
Cooling – Window or None	*If heating system is not ducted:* Install ductless mini-split heat pumps (one system per apartment)	Yes	$$$	NA	M
Cooling – Central	*If replacing heating system:* Replace with ducted, inverter driven, variable speed, cold-climate air-source heat pump (ccASHP)	Yes	$$	Long	E
Cooling – Central	*If not replacing heating system:* Install central AC with a high SEER (>15) ENERGY STAR® certified model		$$	Long	
Lighting	Upgrade to Energy Star® or DLC listed bulbs and fixtures	Yes	$	Medium	
Lighting	Install lighting controls to dim or turn off lights when not needed	Yes	$	Short	

Opportunities by Timing – Equipment Replacement

System	Opportunity	Health & Safety Impact	Upfront Cost	Payback Period	Mainten-ance
Appliances	Replace refrigerators, dishwashers, clothes washers, and clothes dryers with ENERGY STAR® models		$	medium	E
Appliances	*Electrification option for gas dryers*: Replace gas dryer with electric model, preferably a heat pump model	Yes	$$	Medium	M
Appliances	*Electrification option for stoves*: Replace gas stovetops and ovens with electric model	Yes	$$	Medium	E
Appliances	Use smart power strips to turn off electronics when not in use		$	Short	E

Opportunities by Timing – Major Renovation

System	Opportunity	Health & Safety Impact	Upfront Cost	Payback Period	Mainten-ance
Building Envelope – Attic/Roof	For unvented attics, roof cavities, and vaulted ceilings: Install closed cell spray foam insulation to underside of roof decking	Yes	$	Medium	
Building Envelope – Attic/Roof	During roof replacement (flat roofs and roofs over conditioned attics): Install above deck rigid foam insulation		$	Medium	
Building Envelope – Walls & Floors	Air seal and add continuous insulation to exterior walls	Yes	$$$	Long	
Building Envelope - Foundation	Air Seal and insulate crawlspace or basement walls to R-15	Yes	$$$	Medium	
Building Envelope - Foundation	Install Slab Edge Insulation for slab on grade foundations	-	$$$	Long	
Building Envelope – Windows & Exterior Doors	Replace windows with ENERGY STAR®/National Fenestration Rating Council certified products	Yes	SSS	Long	
Building Envelope – Windows & Exterior Doors	Replace exterior doors with ENERGY STAR®/National Fenestration Rating Council certified products		$$	Long	
Central Domestic Water Heating	*Electrification Option:* Install central heat pump water heater (HPWH) appropriate for cold climates		$$$	Long	M
Central Domestic Water Heating	*Gas System Option:* Install condensing ENERGY STAR® gas water heater with sealed combustion		$$	Long	E
Central Domestic Water Heating	*If space heating is also central:* Combine water heating and space heating with one boiler system by installing condensing, modulating high-efficiency ENERGY STAR® boilers		$$$	Long	M

Opportunities by Timing – Major Renovation

System	Opportunity	Health & Safety Impact	Upfront Cost	Payback Period	Mainten-ance
In-Unit Domestic Water Heating	*Electrification Option:* Upgrade to a unitary heat pump water heater (HPWH)	Yes	$$	Medium	M
In-Unit Domestic Water Heating	*Gas System Option:* Upgrade to an ENERGY STAR® condensing gas water heater with sealed combustion	Yes	$$	Medium	E
Plumbing Fixtures	Replace toilets with low-flow toilets		$$	Medium	E
Plumbing Fixtures	Install low-flow bathroom faucets, kitchen faucets, and shower heads		$	Short	E
Plumbing Fixtures	Monitor water use for leak detection		$$	Short	M
Ventilation	Install whole house/supply driven ventilation system	Yes	$$	NA	E
Ventilation	Install a Heat Recovery Ventilation (HRV) or Energy Recovery Ventilation (ERV) system	Yes	$$	NA	M
Heating – Forced Air Gas Furnace	*Electrification Option:* Replace gas furnace with ducted, inverter driven, variable speed, cold-climate air-source heat pump (ccASHP)	Yes	$$	Long	E
Heating – Forced Air Gas Furnace	*Gas System Option:* Replace gas furnace with a high-efficiency (95%+ AFUE), ENERGY STAR® rated condensing gas furnace	Yes	$$	Medium	E
Heating – Electric Baseboard & Ceiling	*Electrification Option:* Upgrade to ductless mini-split heat pumps (one system per apartment)		$$$	Long	M
Heating – Electric Baseboard & Ceiling	*Electrification Option:* Upgrade to Variable Refrigerant Flow (VRF) system with heat recovery		$$$	Long	H

Opportunities by Timing – Major Renovation

System	Opportunity	Health & Safety Impact	Upfront Cost	Payback Period	Mainten-ance
Heating – Central Boiler	*Electrification Option for Hydronic boilers only:* Reutilize existing water distribution system and install new Air-to-Water or Water-to-Water Centralized Heat Pump		$$	Long	
Heating – Central Boiler	*Electrification Option:* Install Ground-Source Heat Pumps (GSHPs)		$$$	Long	
Cooling – Window or None	*If heating system is ducted:* Replace with ducted, inverter driven, variable speed, cold-climate air-source heat pump (ccASHP)	Yes	$$	NA	E
Cooling – Window or None	*If heating system is not ducted:* Install ductless mini-split heat pumps (one system per apartment)	Yes	$$$	NA	M
Cooling – Central	*If replacing heating system:* Replace with ducted, inverter driven, variable speed, cold-climate air-source heat pump (ccASHP)	Yes	$$	Long	E
Cooling – Central	*If not replacing heating system:* Install central AC with a high SEER (>15) ENERGY STAR® certified model		$$	Long	
Lighting	Upgrade to Energy Star® or DLC listed bulbs and fixtures	Yes	$	Medium	
Lighting	Install lighting controls to dim or turn off lights when not needed	Yes	$	Short	
Appliances	Replace refrigerators, dishwashers, clothes washers, and clothes dryers with ENERGY STAR® models		$	Medium	E
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Appliances	*Electrification option for stoves*: Replace gas stovetops and ovens with electric model	Yes	$$	Medium	E
Appliances	Use smart power strips to turn off electronics when not in use		$	Short	E