Green Building Operations and Maintenance Manual

A GUIDE FOR PUBLIC HOUSING AUTHORITIES

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Green Building Operations and Maintenance Manual

A GUIDE FOR PUBLIC HOUSING AUTHORITIES IN THE NORTHERN CLIMATE REGION

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Table of Contents

Foreword v
Acknowledgments vii
Contributing Authors ix

SECTION ONE. MAINTENANCE IN COMMON AREAS

1. Cleaning Procedures and Products 3
2. HVAC in the Northern Climate Region 49
3. Landscaping 103
4. Lighting 127
5. Parking Garage and Surface Lot Maintenance 161
6. Purchasing 165
7. Recycling and Special Waste Programs 175
8. Roofing Maintenance 187
9. Snow Removal and De-Icing 193
10. Water Fixtures and Conservation 197

SECTION TWO. UNIT MAINTENANCE AND TURNAROUND

11. Unit Maintenance 205
12. Unit Turnaround 215

SECTION THREE. RESIDENTIAL INITIATIVES FOR A GREENER PHA

13. Resident Education and Special Programs 227

Foreword

In 2009, the U.S. Department of Housing and Urban Development (HUD) set aside $4 billion for facility improvements at public housing authorities (PHA) across the country. As a requirement for receiving funding, PHAs had to commit to implementing a series of specific actions to create energy-efficient, green communities. One requirement was to create a Green Building Operations and Maintenance Manual. With the help of Siemens Industry, Inc., nine public housing authorities took on this challenge.

The nine PHAs, Siemens Industry, Inc., and Green Seal are proud to have joined forces to create this manual. The purpose of the manual is to serve as a guide for PHA staff and residents to operate their facilities in a sustainable manner by reducing the use of energy, water, and toxic chemicals, as well as by increasing the quality of life for residents and employees. Our hope is that the manual will serve as a tool to help PHAs become green communities that lead the way in the use of environmentally preferable products and more sustainable operations. We hope, too, that the manual provides a catalyst for building staff and residents to work together to improve the environment and the quality of life in their communities.

Many aspects of public housing facilities affect the health of residents and staff, and of the environment in general. Heating and ventilating systems have implications for total energy usage, as does the choice of lighting fixtures and appliances. Many types of paint, floor finishes, and cleaning products can result in toxic air pollution and harm the health of staff and residents. Choices in maintenance of building grounds also have health and environmental implications. With the technology available today and the in-depth knowledge we have accumulated on environmental sustainability, we can reduce the negative impact that PHA operations and maintenance make on the environment. If followed, the recommendations in the manual would decrease the load of toxic or otherwise unhealthful substances on workers and residents, and conserve energy and water.

This manual covers a broad range of facility and maintenance operations. Recommendations for green operations address heating, ventilation, and air conditioning systems, water fixtures, and facility lighting—all of which can be altered to increase system efficiency and conserve energy. The manual also includes recommendations on sustainable landscaping, recycling, and green unit maintenance and unit turnaround procedures. In addition, HUD required all grantees to involve residents in creating more sustainable communities; as a result, this manual includes a resident education section with suggestions for setting up recycling programs, helping residents identify and purchase environmentally preferable products, and creating community gardens.

By adopting these guidelines and policies, PHAs can take a significant step towards a sustainable society.

Please email any comments or suggestions about this manual to: greenbuildings@greenseal.org.

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- Watervliet Housing Authority, NY
- Jersey City Housing Authority, NJ
- Housing and Redevelopment Authority of Duluth, MN
- Metropolitan Development and Housing Agency, TN

Without their interest in taking the initiative to create more sustainable public housing, this manual would not exist.

We also want to thank the Commonwealth of Pennsylvania, for whom Green Seal created the *Pennsylvania Green Building Maintenance Manual* in 2002. The Commonwealth generously allowed Green Seal and Siemens to use the 2002 manual as a starting point for this new and greatly expanded publication titled *Green Building Operations and Maintenance Manual: A Guide for Public Housing Authorities.*

To create this manual, which covers many different substantive areas, we relied on a team of authors, identified in the contributing authors' page that

follows. We thank them for contributing their knowledge and expertise to this important effort.

The Green Building manual would never have come to completion without the dedicated efforts of the project managers at Green Seal and Siemens. We owe many thanks to Katherine Probst of Green Seal and Eng Kun Taing of Siemens for their tireless work attending to the quality of the manual, while staying within budget and on deadline. They were aided throughout the project by Justin Southwick of Wilmot, Inc., a sustainability consultant to Siemens who conducted the energy assessment at each of the PHAs, as well as the training on how to effectively use the manual. A special thanks is due to Andrew Beauchamp and Christine Chase of Green Seal, who reviewed and edited many sections, tracked down needed facts, and helped in many other ways throughout the project.

Finally, we wish to thank our outside editor, Paula Whitacre of Full Circle Communications, and our outside designer, Sally James of Cutting Edge Design. Paula's editing resulted in major improvements to the consistency and clarity of the text, while Sally's design expertise resulted in a manual that is much easier on the eye, and is therefore much more accessible to the user.

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SECTION ONE

Maintenance in Common Areas

Chapter 1 | Cleaning Procedures and Products

INTRODUCTION

Public housing authorities (PHAs) should provide a safe and healthy environment for residents and visitors, and cleaning of common spaces plays a vital role. Cleaning should be an environmental enhancement, not a source of unintended pollution. By definition, cleaning is the removal of unwanted matter, contaminants, or pollutants from the environment, or the prevention of soiling; thus, it is—or should be—green. Cleaning is about *removing* pollution, not *adding* to it.

The chapter covers two aspects of cleaning:

- **CLEANING PROCEDURES**, redefining the processes or the ways in which cleaning is performed, to enable the effective removal of contaminants without adding unwanted substances to the environment or otherwise causing harm;
- **CLEANING PRODUCTS**, using tools or agents that do not add or spread pollutants or cause other unintended effects.

CLEANING AT-A-GLANCE

Introduction

Cleaning Procedures
Improving and Standardizing the Way to Clean
Chemical Management
Entryways and Lobbies
Dusting, Dust Mopping, and Dry Floor Cleaning
Floor Care: Hard Floors and Carpets
Restrooms
Disinfection
OSHA Bloodborne Pathogen Standard
Spills
Food Areas
Reducing Solid Waste from Cleaning Operations
Pest Management
Indoor Plants
People with Special Needs

Cleaning Products

Appendices
Housing Complex-Specific Green Plan
Environmentally Preferable Cleaning Products and Suppliers
Powered Equipment Use and Maintenance Plan
Acronyms and Definitions in This Chapter
Toxicity Categories for Pesticide and Disinfectant Products

The chapter concludes with appendices on:

- Housing complex-specific green cleaning plans
- Environmentally preferable cleaning products and supplies
- Powered equipment use and maintenance plan
- Acronyms and definitions
- Toxicity categories for pesticide and disinfectant products.

Throughout the section on Cleaning Procedures, applicable cleaning products are mentioned, with their environmentally preferable selection criteria elaborated upon in the Cleaning Products section and in the Appendices.

The term "green cleaning" highlights the need to *clean up* the cleaning processes and products themselves, because many commonly used interventions contain, add, or leave environmental pollutants or may cause harm in other ways. Green cleaning benefits the environment and helps protect people, especially vulnerable populations such as the elderly, the infirm, children, and the chemically-sensitive (see Appendix D for a definition). Their long- or short-term exposure to toxic chemicals or harmful particles, gases, or vapors can have serious consequences such as asthma, allergies, depression, hormonal changes, or even cancer.

CLEANING PROCEDURES

Before starting to clean, read product and equipment labels and usage instructions. Wear recommended Personal Protective Equipment (PPE), which may include rubber or surgical-type gloves, goggles, dust mask or respirator, earplugs, or other equipment.

Improving and Standardizing the Way to Clean

Improving cleaning procedures involves changing the way—or the focus with which—cleaning is performed to better prevent or remove soils, contaminants, or pollutants, and to select and use less toxic products. These processes should be integrated into a system of Standard Operating Procedures (SOPs) that are part of the overall operations and maintenance plan for the building.

Building managers ideally should develop and maintain SOPs as a set of written guidelines that govern:

- Cleaning procedures
- Chemical handling and tracking requirements
- Equipment maintenance and operation procedures
- Communication protocols and requirements
- Training and inspection programs, and
- Reporting and record-keeping procedures.

These guidelines should be made available to all cleaning personnel and occupants. In addition, if desired, a more in-depth housing complex-specific Green Cleaning Plan (see Appendix A) may be developed for every building or building-set to be cleaned.

Chemical Management: Reducing Waste, Efficient Use

Minimizing the effects of toxic cleaning chemicals requires building managers to work and communicate with cleaning staff, the PHA management or owners, and occupants.

Suggested Activities in a Green Cleaning Program

Give clear guidance to cleaning staff on handling cleaning chemicals:

- Provide easily understood directions to cleaning staff in appropriate written languages or graphic representation for the dilution of chemical cleaning products.
- Track the quantities of cleaning chemicals used over time on at least a quarterly basis.
- Use a chemical measuring and dilution control system that limits worker exposure to chemical concentrates while facilitating the proper dilution of these concentrates (e.g., wall-mounted dispensing systems where concentrates are sequestered and dispensed remotely and cleaning chemical is automatically mixed with water for proper end-use dilution without the worker needing to touch concentrates).
- Use the appropriate technology (coarse spray or squirt bottles, automatic chemical dispensers on powered equipment, etc.) for applying the chemical product to avoid aerosolization, overuse, or waste.
- Provide directions for the proper rinsing and disposal of expended or empty chemical solution containers.

- Prevent other building areas from being adversely affected.
- Reduce, minimize, or eliminate the need for using cleaning chemicals if possible.

Train new and current employees:

- Provide employees with initial, on-site, site-specific, and annual in-service training. Training should be done in a manner that respects unique needs of the employee, such as limited English proficiency, physical challenges, or learning disabilities. All employees should receive training and/or education on an annual basis to maintain knowledge of correct procedures for safety, tools, techniques, and pertinent environmental standards.
- Train cleaning personnel in the proper handling of chemicals, proper use and maintenance of equipment, and proper cleaning procedures.
- Train purchasing personnel in the selection of green cleaning materials.
- Train management/supervisors through in-service training and/or education on an annual basis on policies and procedures.
- Train new cleaning personnel on standard operating procedures, the proper sequencing of cleaning steps, and the proper use of personal protective equipment. This training may occur before personnel are assigned to a facility or at the site before beginning independent work. Follow up with in-service training, continuing education, and/or professional development opportunities on an annual basis.
- Give all personnel standard safety training, including how to reduce and prevent ergonomic injuries and exposure to hazardous materials.
- Provide site-specific training focusing on standards for the facility to which workers will be assigned. This site-specific training should cover: facility-specific cleaning instructions, tailored procedural training (e.g., servicing areas for vulnerable populations) based on the needs of the facility and occupants, and hazardous communication standards.
- Maintain records of training on each employee. The documentation should include a general outline of information covered, the name and qualifications of the trainer, and the date(s) and duration of the training or courses. It is recommended that records be retained for two years from the hiring date of current employees, and one year for former employees. PHAs that contract green cleaning services may want to consider requiring GS-42 Certification (see Appendix D—Definitions) or evidence of GS-42 compliance from their service provider. Criteria from LEED-EBOM and CIMS-GB are also helpful guides (see Appendix D—Definitions).

Encourage communication with building management/owners, employees, and occupants:

- Develop a system for cleaning service employees to provide comments and suggestions about workplace issues and suggestions for improvements in the provision of services.
- Communicate to the public housing management or owners of the building the presence of pests and any maintenance issues discovered during cleaning operations.
- Provide materials to occupants that define opportunities to reduce the need for more intensive cleaning processes or treatments (e.g., reporting spills and making attempts to reduce clutter in common areas).
- Notify occupants about all cleaning products used in the facility. This should include a list of all chemicals that may be used. It also should include the name, address, and phone number of the PHA contact person; a statement that the contact person maintains the product labels and Material Safety Data Sheets (MSDSs) of each product used in the building; and that the labels or MSDSs are available for review upon request. The contact person should be available for additional information and comment.
- Provide product MSDSs in a timely manner upon request.
- Identify building occupants with special needs or sensitivities (to dust, chemicals, noise levels, etc.) and have a process in place to work with PHA management, cleaning staff, and individuals to mitigate the problem.

Highly Concentrated Products

Special care is needed for highly concentrated cleaning products. These products reduce environmental impacts from packaging and transportation, and typically reduce actual use-cost compared to less concentrated alternatives.

Products should always be diluted accurately according to manufacturers' directions. This can be achieved through a variety of methods including measuring cups, simple dispensing pumps, and more complicated automated dilution equipment. Dilution equipment should be periodically checked for accuracy (consult the manufacturer or supplier for assistance).

Cleaning personnel should understand that adding extra amounts of concentrated cleaning products generally does not make the work go better or faster; on the contrary, it

ACTION ITEMS

1. Use appropriate protective equipment as recommended by the manufacturer when mixing concentrated cleaning products.
2. Follow the manufacturer's dilution directions. Do not under- or over-dilute concentrated cleaning products.
3. Make sure spray or squirt bottles (and other secondary containers) have OSHA-compliant labels.
4. Never mix different cleaning products together.

can result in longer task times (e.g., removing residues), slippery floors and surfaces, and other complications. Overuse wastes product and raises the cost of chemicals. Finally, never mix cleaning products together.

See Products Section and Appendices for more information about:

- Dilution control units and proportioners.

Entryways and Lobbies

Entryways are the first line of defense against many contaminants. Thus, special effort should be focused in these areas. Begin by cleaning outside walkways leading into the facility, especially during inclement weather.

Sweep outside entry walkways daily (weather permitting) with a mechanized sweeper for larger areas or with a wide push broom for smaller ones. Alternately, walkways may be cleaned using a backpack vacuum or blower. Outdoor areas should also be periodically cleaned with a pressurized water hose or a high-pressure power washer.

During snow and ice events, establish procedures to protect occupants and visitors from slips and falls (including placing of warning signs or caution cones). Select appropriate ice melting compounds (e.g., non-corrosive, non-phosphate) and use extra matting to help dry shoes and avoid excess tracking into the building.

Use walk-off mats outside entryways, immediately inside exterior doors, and in lobbies. Mats should be long enough so adults can take several steps on them. Walk-off mats should not just be used during inclement weather, but all year round. Matting inside and outside the entryways should, at a minimum, meet the following requirements: 6–10 feet of scraper/wiper matting, followed by 6–10 feet of wiper matting, for an overall total of 12–20 feet of matting for every entry point to the building.

Vacuum the matting daily or more frequently if required (e.g., in very high traffic areas or soiling conditions) to prevent migration of contaminants into the building. Use a vacuum with a beater bar, and vacuum in both directions. Walk-off mats should be wet-cleaned frequently as needed (e.g., indoors with a carpet extractor or outdoors with a hose or pressure washer and wet vac, and allowed to dry before being put back into service), including periodic cleaning of the underside.

Regularly sanitize or disinfect touch points (door handles, push plates, telephone receivers, etc.) to prevent cross-contamination and spread of germs.

Microfiber cloths enable cleaning entrance glass effectively using just water. A window-washing sleeve that fits over an applicator handle enables cleaning glass with just water mixed with a small amount of mild detergent, followed by use of a squeegee for drying the glass.

See Products Section and Appendices for more information about:

- Glass cleaners
- All-purpose cleaners
- General disinfectants
- Chrome cleaners/polish
- Gum remover
- Equipment

ACTION ITEMS

1. Clean entryways starting outside the building.
2. Use walk-off matting at the outside (bi-level, scraper mat construction to remove and trap soil) and inside entry (smooth carpet-like mat surface to dry and wipe shoes). Vacuum, sweep, clean, and replace mats frequently (weekly, daily, or as needed), especially during inclement weather.
3. Make sure floor-cleaning or mopping solutions are effective by using the correct amount of cleaning chemical (follow label directions) and by frequent solution changes. Do not overuse chemicals. Remake as necessary and dispose spent solution appropriately.
4. Use high-efficiency vacuums, such as those approved by the Carpet and Rug Institute (CRI). Dispose of captured material, or empty or change bags before half full.

Dusting, Dust Mopping, and Dry Floor Cleaning

Traditional dusting and dust mopping techniques frequently move dust and other contaminants from one area to another, such as from a countertop to the floor. It is important to recognize that moving the dust around is more than just an efficiency issue. Dusting and dust mopping activities that do not capture soils frequently stir them into the air where people can inhale the particles, creating a potential health hazard.

Dusting

It is preferable to dust with water-dampened lint-free or untreated microfiber cloths that are neatly folded like a handkerchief to expose multiple sides for absorbing dust, or to use a vacuum cleaner with high-efficiency filters and proper dusting attachments. For tight spots, lambs wool or flexible microfiber dusters are helpful substitutes for feather dusters.

Minimize dust-capturing treatments that contain petroleum products, high VOCs, or solvents, and select a water-based treatment instead. Consider a vacuum cleaner fitted with a brush or hard floor attachment rather than a treated cloth or dust mop. If a dust mop is used, choose the widest mop possible (based on the size of the area and the physical abilities of the custodial worker) to optimize productivity.

Dust Mopping

Each pass with a properly treated dust mop helps to remove dirt, dust, and abrasive particles, without leaving the floor dull or slippery. Cleaning staff should dust-mop as follows:

1. Fill a properly labeled (per OSHA requirements) trigger-spray bottle with a water-based dust mop treatment prepared according to label directions, and spray (using a course stream rather than a mist to avoid aerosolizing chemical) the treatment onto a clean dust mop. Follow the manufacturer's directions for application rate, and apply next to the backing at the base of the yarn, without overtreating it.

2. Roll the dust mop, treated side in. Place it in a plastic bag to help the mop head fibers absorb the treatment for at least 24 hours. After 24 hours, place the treated dust mop on the frame.

3. Dust mop the area, using a continuous motion, without lifting the mop from the floor. Begin at the perimeter (next to the wall) and walk to the other end of the work area. At the opposite end, rotate the dust mop so that the leading edge remains the same. Return to the opposite end and repeat. Overlap the previously mopped path by 2–4 inches to ensure complete coverage.

4. Sweep accumulated soil to a collection area, lightly shake the loose soil from the dust mop, and continue. Remove gum, tape, or other sticky residue with a scraper, using care not to mar or scratch the floor finish. Continue the dust-mopping process until the entire area has been dust mopped. When finished, pick up the collected debris using a counter brush and dustpan, or vacuum.

5. Clean excess dust from the mop head. Place the mop over a trash container. Brush with a stiff bristle brush in a firm, downward motion and/or vacuum.

6. Store the mop in a hanging position. Do not store the dust mop on the floor. The mop treatment may discolor the floor, and the mop fibers may become matted.

7. When the dust mop no longer attracts adequate soil, it may be re-treated. Spray the mop at the end of a work shift, and allow the treatment to be thoroughly absorbed.

8. Launder soiled dust mop heads monthly, weekly, or as needed. Soak mop heads overnight in a neutral pH cleaning solution. Rinse thoroughly, wring out, and hang them to dry. Machine washing and drying following manufacturer's recommendations is another option.

9. Re-treat as directed above for initial treatment.

Non-microfiber dust cloths may also be treated with some dust mop treatments. (See their label instructions.) Spray lightly and allow fibers to absorb the treatment for 24 hours before use.

Dry Floor Cleaning

Depending on the type of equipment (canister, backpack, wide-area sweeper, etc.), follow the manufacturer's recommendations for hard floor vacuuming. Typically, a canister or backpack vacuum cleaner equipped with a suction-only hard floor brush-tool may be used to remove dry dust and dirt from floors. In some cases, this method cleans more thoroughly than dust mopping, while removing more fine dust from the surface and debris from cracks and crevices.

ACTION ITEMS

1. Ensure dusters and dust mops are selected based on their ability to capture and remove dust, and are treated with a non-toxic water-based dust-removal treatment as warranted to capture dust.
2. Use vacuums with high-efficiency bags/filters.
3. Use lint-free wipes, microfiber cloths or tools, and/or properly filtered and sealed vacuums instead of feather dusters.

See Products Section and Appendices for more information about:

- Dusting treatments
- Furniture polish
- Janitorial equipment

Floor Care

The procedures for floor care in a green maintenance program are similar in most instances to those of a traditional program. Floor care in a green maintenance program addresses the selection of environmentally preferable products and equipment (see Products Section and Appendices), along with minor modifications of the procedures themselves.

In a green maintenance program, the primary effort should be a pollution prevention strategy, or one that minimizes the need to use strong chemicals, scrub, strip and recoat a floor, or extract (e.g., deep clean) a carpet. Thus, the focus is on preventative measures. As described above to keep outside entryways and mats clean and vacuumed, a dust mop or vacuum will clean resilient tile floors, especially those close to entryways and other sources of particulates (i.e., near copier rooms). Periodically cleaning underneath floor mats reduces the potential for moisture leading to bacterial and fungal growth. (Floor mats should be replaced with dry mats when saturated with moisture.) In summary, the goal is intensive cleaning of entryways to capture soils at the entries rather than to remove them after they have spread throughout the facility.

Hard Floor Maintenance

Hard floors include stone, tiles, resilient flooring, and other non-carpeted surfaces.

For routine hard floor maintenance, the cleaning staff should:

- Vacuum to remove and contain particulate matter from flooring surfaces, or alternatively, use mops equipped with reuseable/cleanable collection heads.
- Clean both on a predetermined schedule and as needed to restore floors to a clean condition. At a minimum, the schedule for cleaning should be:
    - Daily: heavy traffic areas, including entrances, corridors, community centers, break areas, congested areas, main passageways, and primary work or office areas.
    - Scheduled, as appropriate, to maintain cleanliness: gymnasiums, light traffic areas including conference rooms, administrative offices, limited access areas, and other areas or spaces with limited or periodic use.

For periodic hard floor maintenance, the cleaning staff should:

- Provide reasonable notice to building occupants prior to the commencement of non-routine floor cleaning operations. The timing and method of the notice should be established by building management in consultation with the cleaning crew.
- Perform periodic maintenance only if sufficient floor finish exists on the floor surface to protect the underlying flooring from being degraded during the restoration process.
- Apply floor restoration chemicals, when used, by mop, an automatic scrubbing machine, or autoscrubber, rather than by manual spray application (to avoid exposure to aerosol or vapors).
- Use burnishing or buffing equipment with controls or other devices sufficient for capturing and collecting particulates generated during the use of the equipment.

For restorative hard floor maintenance, the cleaning staff should:

- Perform restoration on an as-needed basis to maintain the cleanliness, appearance, and integrity of the floor finish, rather than on a rigid schedule.
- Ventilate the area, to the outside if possible, both during and after stripping or floor scrubbing and recoating operations to ensure adequate fresh air.

- Schedule floor stripping and refinishing to coincide with a period of minimum use or occupancy.
- Provide reasonable notice to occupants prior to the commencement of non-routine floor maintenance operations. The timing and method of the notice should be established by building management in consultation with the cleaning crew.

When floors need to be spray-buffed (or carpets, spot-cleaned), solutions should be applied from a sprayer in a course spray or stream rather than as a fine mist. This will minimize the amount of material that is atomized and potentially inhaled, as well as minimize over-spray. When floors need to be stripped and recoated or carpets extracted, it is important that occupants be notified. Use the least toxic products possible. Use the least amount of water and ventilate the area with fans if necessary for rapid drying to minimize both the possibility of mold growth and slip-fall incidents.

It is preferable to conduct major cleaning activities in a time period when traffic is minimal or the area can be closed off. This allows maximum time for the building to be ventilated (flushed with fresh air) prior to the return of the majority of occupants.

ACTION ITEMS

1. Consult with your janitorial supplier for newer finish or floorcare options that may or may not require stripping and are also environmentally preferable (check for green certification or recognition). Otherwise, select appropriate zinc- or metal-free floor finishes. Choose the most durable finish available to minimize the need for stripping and recoating.
2. If using a water-based polymer coating, build a solid base, which can be between 6 and 12 coats for a 20% solids floor finish.
3. Develop a system to maintain floors daily, using walk-off mats, dust mopping or vacuuming, and spot cleaning.
4. Develop an interim restoration program (e.g., scrubbing and recoating) to maintain adequate levels of floor finish (as applicable), cleanliness, and appearance.

Floor Stripping

Removing floor finishes is perhaps one of the most labor-intensive and hazardous of maintenance operations, placing both cleaning personnel and occupants at risk. Furthermore, frequent stripping can cause health, safety, and environmental impacts through the use and disposal of products.

The objective of a green floor maintenance program is to minimize the frequency of stripping/removing and maximize the longevity of coatings. In some cases, newer equipment that relies on special floor pads, high-speed oscillations, or wet orbital sander technology enables stripping floors without harsh chemicals, or in some cases, without the use of chemicals at all.

For chemical-based stripping, the cleaning staff should:

1. **PREPARE THE AREA.** Place "Floor Hazard" signs at entrances to the area being stripped. Move or work around heavy furniture or equipment that cannot be moved. Sweep the floor with a treated dust mop or vacuum.

Remove gum, tape, and other foreign matter with a scraper, taking care not to mar or scratch the surface of the floor.

2. **PREPARE THE EQUIPMENT.** Assemble two mop heads and handles. Label one "Strip Mop." Label the other "Rinse Mop." Assemble two mop buckets and wringers, labeling one "Strip Bucket" and the other "Rinse Bucket." Place a black or high-productivity stripping pad on the rotary floor machine. Fill the Strip Bucket with a solution of floor stripper (see Products Section and Appendices) following the manufacturer's recommendations for dilution rates and water temperature. Fill the Rinse Bucket with clean, cold water. Add a small amount of a neutral pH cleaner following the manufacturer's recommendations for dilution rates. Equip a wet vacuum with a floor squeegee tool. Place the equipment in the area where the work will begin.

3. **APPLY STRIPPING SOLUTION** to the floor, using the Strip Mop and Strip Bucket. Dip the mop in stripping solution. Lift the mop and allow excess stripper to drain back into the bucket. Fan out the mop head on the floor and initially apply stripping solution along the edges. Continue applying solution in other areas using an arc motion from right to left, covering the area between the edges. Apply sufficient solution to thoroughly wet the floor, but *do not* flood it. Do not allow solution to dry on the floor. Immediately wipe off splashes from walls, baseboards, glass partitions, etc. with a damp cloth. Allow the solution to remain on the floor 5–10 minutes. Re-apply as necessary to keep the floor wet.

4. **SCRUB THE FLOOR** with the rotary floor machine and stripping pad. Overlap the strokes made by the machine. Again, keep the floor wet, re-applying the solution as necessary.

5. **REMOVE THE STRIPPING SOLUTION** from the floor with the wet vacuum and floor squeegee tool. Examine the floor for complete finish removal. Re-strip any areas that have finish remaining on them.

6. **RINSE THE FLOOR.** Apply rinse solution using the Rinse Mop and Rinse Bucket. Apply sufficient water to thoroughly wet the floor, but *do not* flood it. Remove the rinse solution from the floor using the wet vacuum and floor squeegee tool.

7. **DAMP MOP THE FLOOR WITH CLEAN WATER.** Empty the Rinse Bucket and refill it with clean water. Rinse the Rinse Mop with clean water, and use it to damp mop the floor. Remove floor hazard signs only when floor is completely dry.

ACTION ITEMS

1. Notify occupants beforehand if a strip-out is scheduled.
2. Select the least toxic products available (see Products Section and Appendices). Mix and use products according to the manufacturer's directions.
3. Use the appropriate personal protective equipment. Gloves, goggles, and non-slip footwear may be required. Aprons and respirators may be necessary depending on products and methods selected.
4. Ventilate both during and after stripping.

Note: An automatic scrubbing machine or autoscrubber, which applies cleaning and rinse solutions, scrubs, and vacuums/squeegees away soiled solutions, can be used in place of manual or rotary scrubber methods.

Floor Restoration, Buffing, and Burnishing

Select products for restoration that are water-based or low in VOCs (see Products Section and Appendices). Consult the finish manufacturer or janitorial supplier for product and procedural assistance. When applying the restorer from a spray bottle, use a stream or coarse spray. Do not use a fine mist as this increases the potential for fine particles to enter the breathing zone and to over-spray walls, furniture, carpets, and other objects.

Some floors do not require a separate finish applied by the owner or cleaning service. Check with your supplier to determine the maintenance requirements of the type of floor you have. Do not apply finish to a surface not intended for it.

Many options in finishes are available. Some newer coatings require very little maintenance. However, the cleaning and restoration process is a huge factor in the longevity of most coatings.

To maximize the life of finishes and floors, make sure there is a solid foundation of water-based finish (as applicable) on the floor. Dry buffing and burnishing is slightly abrasive and increases the appearance level by removing thin layers of finish to smooth out the surface—the smoother the surface, the shinier its appearance. However, if too much floor finish is removed, dry buffing and burnishing can damage floor tile and send flooring particles into the air, which may be harmful if inhaled. Important: Dry buffing on asbestos tile should only be performed when there is an adequate coat of intact floor finish to prevent abrading the floor itself. Non-buffable coatings (those that shine to a certain degree without buffing) may be a better choice for asbestos-containing tile.

Match the appropriate pad to the equipment and floor finish. Especially when using high-speed burnishers, it is important to use vacuum attachments to minimize particles in the air. If machine floor or pad pressure is adjustable, set the level to achieve appearance goals while minimizing the amount of finish removed from the floor.

See Products Section and Appendices for more information about:

- Floor finishes
- Floor strippers

ACTION ITEMS

1. Make sure adequate finish is on the floor. Determine if it is time for a scrub and recoat. Consult the finish manufacturer or janitorial supplier for procedural assistance.
2. Select the appropriate restoration product. Water-based or low-VOC products are recommended (see Products Section and Appendices). Consult the finish manufacturer or janitorial supplier for assistance.
3. Select appropriate equipment (see Products Section and Appendices). If burnishing, use a vacuum attachment to prevent particles from becoming airborne where they can be inhaled. Use recommended buffing/burnishing pads (overly aggressive pads will abrade the finish and create more dust).

- Wood floor finishes
- Janitorial equipment

Carpet Maintenance

In a green maintenance program for carpets, the primary effort should be a pollution prevention strategy, or one that minimizes the need to extract a carpet. Thus, a specific focus should be on preventative measures, as described earlier, such as:

1. Frequently vacuuming entryway mats and entry grating systems.
2. Frequently dust mopping or vacuuming hard floors, especially close to entryways and other sources of particles (e.g., near copier rooms) to reduce tracked soiling on surrounding carpeted areas.
3. Establishing a specific daily routine for vacuuming and spotting carpets.
4. Establishing an interim cleaning process to address the needs of high traffic areas.
5. Minimizing the need for large-scale extraction or deep cleaning of carpet.

For routine carpet maintenance, the cleaning staff should:

- Vacuum carpets on a predetermined schedule of frequency, and as needed, to keep them clean and restore appearance. At a minimum, the schedule for vacuuming should be:
  - Daily: heavy traffic areas, including entrances, corridors, community rooms, break areas, congested areas, main passageways, and primary work or office areas.
  - Scheduled, as appropriate, to maintain cleanliness: light traffic areas including conference rooms, administrative offices, limited access areas, and other areas or spaces with limited or periodic use.

Periodic light carpet cleaning is necessary to clean the tops of carpet fibers and maintain the appearance of carpeted floors. Restorative deep carpet cleaning is needed to extract embedded and sticky soils.

For periodic and restorative cleaning, the building manager should:

- Provide reasonable notice to building occupants prior to the commencement of non-routine carpet cleaning operations. The timing and method of the notice should be established by building management in consultation with the cleaning crew.
- Perform carpet extraction (see below) on an as-needed basis, rather than according to a rigid schedule.

- Remove sufficient water from the carpet and provide sufficient airflow (e.g., use of blowers, increased outdoor air exchange) so that the carpet will dry in less than 12 hours when interim cleaning carpets or performing carpet extraction.
- Schedule carpet extraction to coincide with a period of minimum building occupancy.

When carpets require spot cleaning, apply solutions from a sprayer in a stream or coarse spray, not a fine mist. This minimizes the amount of material that is atomized and potentially inhaled, as well as over-spray.

It is preferable to conduct major cleaning activities when common area occupancy is low. This allows maximum time for the building to be ventilated (flushed with fresh air) prior to the return of the majority of occupants.

See Products Section and Appendices for more information about:

- Carpet cleaners
- Solvent spot removers
- Equipment

ACTION ITEMS

1. Select appropriate vacuums and ensure they are in good working order by changing belts as needed, having the vacuums professionally serviced by authorized repair centers at regular intervals, and using and maintaining the correct bags and/or filters.
2. Empty or replace vacuum bags when half-full or less to maintain vacuum airflow. Dispose of dust and bags properly. Bagless vacuums also have filters that need cleaning or changing to maintain performance. Consult the supplier for assistance.
3. Clean up spills while they are still fresh.
4. Minimize the amount of moisture used during cleaning.

Carpet Extraction Cleaning

Carpets act as a "sink" that allows particles and other unwanted material to filter down to the base of the fibers and sometimes into the carpet backing. Once deep in the carpet and walked on, gritty soil can damage carpet fibers and backing, causing excess wear, degraded appearance, and ultimately the need to replace carpets prematurely.

Moisture provides an opportunity for unwanted biological contaminants in carpet—such as mold spores and bacteria—to become active, multiply, and contaminate the indoor environment.

Extraction is a carpet-cleaning process in which a water-based cleaning solution is applied to the carpet and vacuumed (extracted) from the carpet nap, taking soil with it. Extraction helps remove unwanted contaminants deep in the carpet before they cause problems. But extraction cleaning can also add large amounts of water to the carpet, especially if the equipment is not functioning properly. Care must be taken to service equipment regularly by an authorized maintenance and repair center and to ensure adequate passes during use to remove the most water from the carpet.

For carpet extraction, the cleaning staff should:

- **MIX CLEANING SOLUTION PROPERLY.** Using too much concentrated cleaner not only wastes product, but also can lead to more rapid resoiling of the carpet. Do not apply too much solution.
- **MAKE SURE THAT THE VACUUM PICK-UP IS WORKING PROPERLY** and no holes or leaks in wands, hoses, or other attachments are decreasing suction. When vacuuming spent solution, repeat the process multiple times in both directions.
- **USE INCREASED VENTILATION AND AIRFLOW** to help dry carpets. This can be accomplished by opening windows when weather permits, increasing building ventilation, turning on air conditioning or heating systems, and using floor-level drying fans. Carpets should dry within 12 hours to minimize the potential for mold and other microbes to grow.
- **NOTIFY OCCUPANTS** before a large-scale extraction procedure as this activity can affect sensitive individuals. Proper scheduling is recommended to ensure minimum traffic. The building should also be ventilated or flushed with fresh air prior to being reopened.

ACTION ITEMS

1. Correctly dilute and use the proper amount and type of cleaning chemicals. Excess or incorrect use of chemicals may result in rapid resoiling and other issues.
2. Use equipment that will maximize the amount of water or solution extracted from carpet, such as equipment approved by the Carpet and Rug Institute, to minimize moisture and potential for mold and bacterial growth.
3. Increase ventilation, run the HVAC unit, or open windows if weather allows and use fans to dry carpets quickly. Carpets should be completely dry within 12 hours.
4. Dispose of cleaning solutions properly.

Restrooms

While procedures for cleaning restrooms in a green maintenance program are similar to those in a traditional cleaning program, restrooms should be cleaned frequently using appropriate products because of their heavy use and moisture.

The cleaning must be done thoroughly, including hard-to-reach areas such as behind toilets and around urinals. Periodically deep- or machine-scrub restroom floors with a disinfectant, following the label directions for appropriate dilution and recommended dwell time to enable thorough germ-kill. Dwell time for many disinfectants is from several to 10 minutes.

Many restroom cleaning products are hazardous, such as drain cleaners and toilet bowl cleaners, although less toxic alternatives are available (see Products Section and Appendices). Make sure that appropriate personal protective equipment recommended by product manufacturers is used. Never mix chemical products.

Paper dispensers and trash cans used in restrooms to dispense or dispose of paper hand towels should be "touch free," which reduces the potential for cross-contamination of bacteria and other potentially harmful pathogens. Large trash cans can minimize overflow and reduce the frequency for policing the area.

For a restroom cleaning process, staff should clean from high to low, towards the doorway, and do dry work before wet work, through a process such as the following:

- Check the supply cart for proper equipment and supplies.
- Prepare the area. Place a "Restroom Closed" sign at the door, if applicable.
- Re-stock supplies and clean the exterior of all dispensers including paper towel, feminine hygiene, toilet tissue, and hand soap dispensers.
- Remove trash from waste receptacles. Clean receptacles with a disinfectant cleaner, and replace the liners.
- Dust mop, sweep, or vacuum the floor, and pick up collected debris with a dustpan.
- Clean sinks using a disinfectant cleaner and abrasive sponge, first making sure they safe for surfaces including chrome. Leave disinfectant on surfaces according to the manufacturer's dwell-time directions.
- Clean mirrors with glass cleaner and soft, clean cloths, or use an applicator and squeegee. Microfiber cloths enable cleaning glass and mirrors with water only and without chemicals.
- Clean and disinfect toilets and/or urinals. Remove urinal screens. Using a bowl swab, force the water level down in urinals and toilet bowls by repeatedly pushing the swab down the throat or flush path. Apply bowl cleaner to the exposed interior surfaces of the bowls and urinals, especially under the rim. Allow time for the chemical to work, while cleaning partitions and showers (several to 10 minutes, based on the manufacturer's directions).
- Remove graffiti from walls and stall partitions. Clean stall partitions and walls as needed with disinfectant cleaner.
- Clean both sides of entrance/exit doors with a disinfectant cleaner, paying special attention to hand contact areas.
- Return to scrub the inside of the bowls and urinals with a bowl swab or brush. Use a brush or abrasive sponge for difficult soils. Clean the exterior of the bowls and urinals with disinfectant cleaner. Clean both sides of the toilet seat. Clean the walls around the bowls or urinals with disinfectant cleaner. Flush bowls and urinals. Polish all chrome surfaces with a dry cloth after cleaning with a disinfectant cleaner.

- Scrub the floor with a disinfectant cleaner using a wet mop, bucket, and wringer. If needed, scrub the floor grout with a tile and grout brush. Rinse with clear water. Squeegee or vacuum up water, if necessary. Note: Floors, since they are not considered to be hand touch points, may not need to be disinfected if properly maintained.
- Treat sink, shower, or floor drains with drain maintainer, if necessary.

- Inspect the work. If satisfactory, allow the floor to dry and re-open the restroom. Return the cart to the supply area and restock.

The following additional requirements apply:

- On surfaces touched by hands (e.g., door knobs, light switches, handles, etc.), clean and disinfect more frequently as traffic requires.
- Control and remove standing moisture from floor and restroom surfaces in a timely manner.
- Use equipment specifically for restroom cleaning. Restroom cleaning equipment, except for powered equipment, should not be used to clean any other areas of the building.
- Pull restroom trash liners daily at a minimum and disinfect the trash receptacle. Fill all drain traps on a regular basis.

Non-chemical interventions are also available to assist with sanitizing or disinfecting restrooms (see Products Section and Appendices).

ACTION ITEMS

1. Make sure sanitizing and disinfecting solutions are prepared and used properly (e.g., dwell time) and remix as required.
2. Frequently clean surfaces that hands touch (touch points) to eliminate the spread of germs (such as door knobs, light switches, and handles).
3. Eliminate moisture buildup through good cleaning practices and by ensuring that adequate exhaust ventilation is supplied.
4. Keep floors as dry as possible to eliminate slips and falls and the build-up of bacteria, mold, and mildew.

See Products Section and Appendices for more information about:

- Lime and scale remover
- Restroom cleaners
- Restroom disinfectants
- Urinal deodorizers
- Graffiti removers
- Janitorial equipment

Disinfection

Disinfection is particularly important on touch points in restrooms, community rooms, gymnasium and workout areas, daycare / preschool surfaces (e.g., desktops and toys), and other high-touch locations.

Cleaning staff should:

- Perform disinfection in areas or on surfaces where pathogens collect and breed, such as in restrooms, on door handles, exercise and playground equipment, and other fomites (inanimate surfaces that can harbor and transmit germs). However, use disinfectants only where required to minimize their use.
- Disinfect using only disinfectants or devices that can document disinfecting properties.
- Follow product label directions for preparation of chemical disinfecting solutions (e.g., dilution rate), and the appropriate disinfecting and cleaning method for the area to be cleaned (e.g., dwell time and pre-cleaning as required).

See Products Section and Appendices for more information about:

- General disinfectants
- Janitorial equipment

OSHA Bloodborne Pathogen Standard

As part of its mission to protect employees from hazardous work environments, OSHA maintains standards that cover safe handling of bloodborne pathogens for people who encounter bodily fluids on the job. Bloodborne pathogens are disease-causing microbes transmitted by blood or other body fluids.

OSHA recommends the use of a disinfectant that is tuberculocidal (kills TB) and proven effective against the Hepatitis B virus (HBV) to disinfect surfaces potentially contaminated by bloodborne pathogens. Check disinfectant labeling for EPA registration to determine whether or not the product is tuberculocidal. In certain instances, products that kill HBV may serve this purpose, but using an EPA-registered tuberculocide is safer in most cases. Certain hydrogen peroxide-based products are effective but less toxic disinfectants, and make tuberculocidal claims (check for EPA registration) that may meet OSHA requirements for bloodborne pathogen cleanup.

Careful attention should be given to the use and application of these federally required products under a green maintenance program. Chemicals reserved for compliance with OSHA's Bloodborne Pathogen Standard should be clearly separate from those used for general disinfecting/sanitizing. This dedicated use and special focus will help meet OSHA requirements, differentiate the procedures for the different types of disinfecting/sanitizing, reduce the potential for confusion, and minimize overall health and environmental impacts.

ACTION ITEMS

1. Use safety cones or other means to make sure that occupants do not come in contact with a spill that might contain bloodborne pathogens.
2. Use proper personal protective equipment (i.e., gloves, goggles).
3. Disinfect the area with appropriate solution.
4. Dispose of cleanup materials properly in a red bio-hazard bag.

See Products Section and Appendices for more information about:

- Disinfectants

Spills

It is generally preferable to address spills as soon as possible to minimize impacts on both health and the environment. Work with building occupants so they communicate quickly about spills.

ACTION ITEMS

1. Clean spills while still fresh.
2. Use the proper cleaning solutions and only the amount that is necessary.
3. Dispose properly.
4. Ensure that occupants know whom to contact in case of spills.

See Products Section and Appendices for more information about:

- Solvent spot removers/absorbents

Food Areas: Cafeterias, Breakrooms, and Other Areas

Particular attention should be paid to sanitizing touch points in food areas. It is also important to manage and remove food waste and to sanitize trash receptacles containing food debris, recyclables such as soda cans, and other objects that contain food residues, which can attract pests. Making every effort to eliminate wastes and residues that attract pests is critical to protecting occupant health by reducing or eliminating the need for pesticides inside the building. Ask occupants to rinse out food and drink containers before placing them in recyclable

collection areas. Occupants should empty and clean refrigerators to avoid food going bad. Integrated Pest Management (IPM) should be followed.

Cleaning food areas, such as dining areas and break rooms, should include the following:

- Clean and sanitize surfaces in food preparation and consumption areas on a daily basis or as required to protect human health.
- Clean and sanitize daily surfaces that hands touch (e.g., faucet handles, drinking fountains, and cafeteria lines).
- Equip waste containers likely to collect food waste with a cover, and empty once per day or when full; clean and sanitize daily.

See Products Section and Appendices for more information about:

- Sanitizers
- General degreasers

ACTION ITEMS

1. Clean and sanitize tables, floors, and other surfaces.
2. Separate recyclables from trash and make sure recyclable areas are kept clean (i.e., rinse soda cans) to prevent attracting pests.
3. Make sure occupants understand how to properly separate trash and recyclables and dispose of each.
4. Make sure waste containers are covered and emptied at least daily.

Reducing Solid Waste from Cleaning Operations

Another aspect of a green maintenance program is to reduce solid waste throughout the building, including in cleaning operations.

To reduce solid waste while cleaning, staff should:

- Purchase chemical products and supplies in quantities that minimize the amount of packaging and container waste generated.
- Use reusable cleaning cloths or microfiber technology, whenever practicable, in lieu of paper products. Within 2 hours of use, rinse and/or place cleaning towels, cloths, and other reusable cleaning materials in a sealable container (e.g., metal flammable rag canister, locking plastic bag, etc.) to minimize evaporation of the cleaning product. Reusable cleaning cloths or microfibers should be cleaned or laundered prior to reuse.

ACTION ITEMS

1. Purchase products in quantities that minimize packaging and waste.
2. Use reusable cleaning cloths or microfiber instead of paper.
3. Segregate all waste from cleaning operations and dispose of properly.

- Segregate and recycle all waste items from cleaning operations, including paper, glass, plastics, cardboard, other packaging materials, empty chemical containers, and worn equipment, that are acceptable for recycling in the community.

The chapters on Resident Education and on Recycling and Special Waste Programs contain information on setting up a recycling program.

Pest Management

Traditional pest management practices are being replaced by an "integrated pest management," or an IPM, approach. As defined by the EPA, IPM is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices.

Two keys to IPM are removing the food supply of pests via effective cleaning and housekeeping, and sealing up places where pests can enter the public housing complex or migrate between buildings.

Bed bugs are a particular concern in many complexes. Although they can cause itchy bites on people and pets, according to the EPA, they are not known to transmit or spread diseases, unlike most public-health pests. Pesticides are only one tool to get rid of bed bugs. A comprehensive approach that includes prevention and non-chemical treatment of infestations is the best way to avoid or eliminate a problem. (See also chapter on Unit Turnaround.) A few examples of non-chemical methods of control (which may serve as advice to residents) include:

- Removing clutter where bed bugs can hide
- Using mattress covers designed to contain bed bugs
- Sealing cracks and crevices
- Vacuuming rugs and upholstered furniture thoroughly and frequently, as well as

ACTION ITEMS

1. Store trash in covered receptacles outside and away from buildings.
2. Caulk holes and cracks to prevent pests from entering or moving between buildings.
3. Seal openings around pipes under sinks (pests are attracted to water).
4. Cover exhaust or vent openings exposed to the outside with wire mesh.
5. Establish rules for food cleanup and storage in community centers.
6. Remove clutter so pests have fewer hiding places.
7. Use sticky or mechanical traps rather than pesticides where possible.
8. Hire only trained, licensed, and certified pest control professionals experienced with IPM.
9. Use pesticides only where infestations occur and never as a "just-in-case" measure.
10. Use a targeted (pest-specific) EPA-registered pesticide and the least toxic product that will do the job (see Appendix E). Follow label directions carefully and use sparingly.
11. Avoid fogging or broadcast spraying of pesticides.
12. Provide clear advance notice to building occupants of scheduled pesticide use and apply pesticides when areas are closed or occupancy is low.

vacuuming under beds (taking the vacuum bag outside immediately and dispose in a sealed trash bag)

- Washing and drying clothing and bed sheets at high temperatures (heat can kill bed bugs)
- Placing clean clothes in sealable plastic bags when possible
- Being alert and monitoring for bed bugs so they can be treated before a major infestation occurs.

If pesticides are used to control pests, follow these tips to ensure safety and product effectiveness:

- *Read the product label first*, then follow the directions for use.
- Any pesticide product label without an EPA registration number has not been reviewed by EPA to determine how well the product works.
- Make sure that the pesticide has been approved for indoor use.
- For control of bed bugs in particular, check the product label. If bed bugs are not listed on the label, the pesticide has not been tested for bed bugs and it may not be effective.

Indoor Plants

Indoor plants are a wonderful addition to any facility. Building staff charged with watering and caring for plants may also be called upon to address spills from watering, mold growth in carpets from dampness, pest control, and other problems. Use of indoor pesticides and fertilizers should be managed with care because these products can impact health. Thus, the staff should be educated on the proper and appropriate care for plants. Plants on carpets should be placed on stands to keep moisture from building up in carpeting. Unit ventilators should not be used as plant stands.

Maintenance of indoor plants includes the following:

- Collect and dispose of plant debris, such as fallen leaves and flower petals.
- Ensure that plants are not in direct contact with carpet.
- Move plants away from HVAC vents.

ACTION ITEMS

1. Educate workers on appropriate care guidelines for indoor plants.
2. Ensure that plants are not in direct contact with carpets and unit ventilators.

If indoor plant care is not the responsibility of the onsite manager, the manager should notify the responsible party when indoor plants are interfering with or compromising cleaning, or when other issues such as those noted above require attention.

People with Special Needs

One of the primary goals of a green cleaning and maintenance program is to protect the health of building occupants. This is done in many ways, including the identification and removal of harmful contaminants, such as particulates, mold spores, bacteria, and viruses.

While the cleaning process is intended to reduce exposure to these and other harmful contaminants, improper methods and cleaning products themselves can cause adverse health impacts. This is especially true for people sensitive to fragrances, those with asthma and allergies, and those with impaired immune systems because of cancer and other health conditions.

For these individuals, accommodations should be made relative to byproducts of cleaning activities, such as VOCs, dust, noise levels, and other factors. Pet dander is often carried on clothing and by other means throughout facilities, affecting people with sensitivities to pet allergens

Understanding these sensitivities is essential for accommodating occupants. In some cases, different product selection may be necessary, the time of day that cleaning takes place may need to be altered, occupants who are reacting to substances may need to be relocated or diverted to other areas within the building, or other interventions may be required, such as vacuuming with HEPA-filtered vacuums to remove or reduce pet dander and other particulates.

In most cases, effective accommodations cannot be achieved by the cleaning staff alone, but require everyone, including the affected individuals, to work together to achieve the best outcome.

In situations where cleaning operations have the potential to adversely affect members of a vulnerable population, the building manager should:

- Schedule daily cleaning activities to avoid their exposure to the cleaning process.
- Adopt alternative cleaning practices that minimize or make unnecessary the use of cleaning chemicals.
- Use cleaning chemicals in areas only where sufficient ventilation is present to allow airborne substances to dissipate before the area becomes repopulated.

ACTION ITEMS

1. Identify building occupants with specific needs or sensitivities.
2. Develop a plan to address these issues.
3. Change products and/or cleaning schedules as necessary to accommodate them.
4. Address ventilation requirements to help mitigate problems related to indoor air quality (IAQ).

- Provide additional ventilation through the use of blowers to enhance the rate of chemical dissipation.
- Conduct cleaning operations in a manner that prevents the transfer of impacts to other areas of the building that may contain vulnerable populations.

CLEANING PRODUCTS

In addition to cleaning procedures, the selection and use of cleaning products is important in a green maintenance program. General guidelines for purchasing decisions include:

- **pH:** Prefer cleaners that have a neutral pH (closer to 7) compared to those with extreme pH (closer to 1 or 14).
- **BIODEGRADABILITY:** Prefer cleaners that are readily biodegradable (check for green certification or recognition) compared to those that are slower to degrade. Unfortunately, many older formulations use excellent performing ingredients that have been found to have serious environmental and health concerns.
- **DYES AND FRAGRANCES:** Prefer those with no or low levels of dyes and fragrances compared to those products that are heavily dyed or fragranced (check for green certification or recognition). If dyes are necessary, use those that are approved for foods and cosmetics (F&C).
- **VOCS:** Prefer those that have no or low VOCs. These requirements will vary depending on the product type, usage, actual outgassing rates, and other factors (consult recognized green guidelines in Appendix B) compared to those with higher levels.
- **BIO-BASED/RENEWABLE RESOURCES:** Prefer products that use materials derived from renewable resources compared to those from non-renewable resources (check for green certification or recognition).
- **FLASHPOINT:** Prefer products that have a high flashpoint compared to those with a low flashpoint (see the product's MSDS).
- **HMIS (HAZARDOUS MATERIALS IDENTIFICATION SYSTEM) RATING:** Look for a product with a zero hazard rating (see Appendix B).

The final component in selecting products is consideration of the supplier. The supplier plays an important role as part of the green cleaning and maintenance team and may be intimately involved in training. Therefore, consideration should be given to suppliers' ability to train cleaning personnel and their expertise

with green janitorial products and cleaning, in addition to price, reputation, and other traditional considerations.

Below are additional considerations related to 21 product categories:

1. All-purpose cleaners
2. Restroom cleaners
3. Restroom disinfectants
4. Carpet cleaners
5. Chrome cleaners/polish
6. Dusting treatments
7. Floor finishes
8. Floor strippers
9. Furniture polish
10. General degreasers
11. General disinfectants
12. Glass cleaners
13. Graffiti remover
14. Gum remover
15. Lime and scale remover
16. Sanitizers
17. Solvent spot removers / absorbents (for spill cleanup)
18. Urinal deodorizers
19. Wood floor finishes
20. Choosing disposable paper and plastic bags
21. Selecting and using janitorial equipment

1. All-Purpose Cleaners

All-purpose cleaners consist of a broad array of possible formulations. Select products that have been recognized by green certification or recognition programs, such as DfE, EcoLogo, Green Seal, and others (see Appendix B). The following are some of the specific issues to compare in this product category:

- Consider detergent-based products versus those containing solvents.
- Preferable ingredients include surfactants containing terms such as lauryl, amides, and glycosides.

- If possible, do not purchase cleaners containing Nonyl Phenol Ethoxylates, NTA, EDTA, glycol ethers, sodium hydroxide, potassium hydroxide, sodium metasilicate, or phosphates.

2. Restroom Cleaners

Restroom cleaners often contain strong acids because of the need to remove mineral deposits from sinks, bowls, and urinals. Frequently, they are heavily dyed and strongly fragranced. Select products recognized by green certification or recognition programs (see Appendix B). The following are some specific issues to look for:

- Preferable ingredients include surfactants containing terms such as lauryl, amides, glycosides; citric acid; acetic acid as found in vinegar; and lactic acid.
- If possible, avoid purchasing products containing nonyl phenol ethoxylates, NTA, EDTA, hydrochloric acid, phosphoric acid.

3. Restroom Disinfectants

Restroom disinfectants are similar to general disinfectants, but typically may have an acidic pH (closer to 1) to remove hard water deposits in sinks, bowls, and urinals. The selection issues include both those under General Disinfectants and Restroom Cleaners. Care in selection and use is important. The following are some of the specific issues to compare in this product category:

- See Restroom Cleaners for similar attributes.
- Antimicrobial ingredients: Prefer antimicrobial ingredients that have a lower potential for persistence in the environment and accumulation in living tissue compared to those with a greater potential (check for DfE recognition* [1]if available).
- Preferable active ingredient: hydrogen peroxide.
- If possible, avoid purchasing products containing sodium hypochlorite (chlorine bleach), quaternary ammonium compounds, alcohols, or phenolic compounds.

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[1] Currently, the U.S. EPA does not permit disinfectants to be certified as green. However, the EPA Design for the Environment (DfE) program has launched a pilot program that may lead to certain disinfectant products being permitted to carry the DfE logo on their labels as recognition of environmental preferability under new rules.

- Look for disinfectants in Toxicity Category IV (see Appendix E).

Non-chemical interventions, such as steam vapor devices, can also help sanitize or disinfect restrooms. In larger restrooms, using water-only spray-and-vac type equipment that applies water under pressure and then vacuums off the solution has been demonstrated to effectively clean and sanitize both floor and above-floor surfaces by removal of soil and germs rather than by chemical intervention. Ionized or activated water devices have also shown effectiveness in sanitizing surfaces without added chemicals. Check with your janitorial supplier for these and other options.

4. Carpet Cleaners

See also All-Purpose Cleaners. Select products that have been recognized by green certification or recognition programs (see Appendix B) and have received a Green Label or Seal of Approval (SOA) for soil removal effectiveness and other attributes by the Carpet and Rug Institute (CRI).

5. Chrome Cleaner/Polish

Chrome cleaners and polishes frequently use petroleum distillates, which are poisonous and derived from a non-renewable resource. Select products recognized by green certification or recognition programs (see Appendix B). The following are some of the specific issues to compare for in this product category:

- Preferable ingredients: essential plant oils and non-toxic abrasives such as baking soda.
- If possible, avoid purchasing products containing petroleum distillates or ammonia.

6. Dusting Treatments

Dusting treatments often contain petroleum distillates and solvents. Select products recognized by green certification or recognition programs (see Appendix B).

- Preferable ingredients or attributes: water-based, non-flammable.
- If possible, avoid purchasing products containing petroleum distillates, high-VOCs, or that leave slippery residue.

7. Floor Finishes

Floor finishes should be durable and appropriate for the prescribed maintenance method, but they typically contain heavy metals such as zinc. Importantly, floor finishes should be compatible with the stripping solution. Select products recognized by green certification or recognition programs (see Appendix B). The following are some of the specific issues to compare in this product category:

- Durability: Prefer finishes that are more durable (require less maintenance such as buffing, restoring, and recoating) than less durable finishes that require more frequent maintenance.
- Heavy metals: Prefer non-metal cross-linked polymers (e.g., zinc-free) as compared to those containing heavy metals. Another significant benefit of non-metal polymer formulas is that frequently they can be removed with less hazardous floor strippers.
- Preferable ingredients: metal-free polymers.
- If possible, avoid purchasing products containing metal-crosslinked (containing heavy metal) polymers.

8. Floor Strippers

Floor strippers typically have extreme (alkaline) pH, solvents, and ammoniated compounds to remove metal cross-linked floor finishes. Floor strippers should be compatible with the floor finish. Select products recognized by green certification or recognition programs (see Appendix B). The following are some of the specific issues to compare in this product category:

- pH: Prefer those with a pH closer to neutral (in the range of 10 to 12) as compared to those with extreme pH (closer to 14).
- Preferable ingredients: d-Limonene (citrus solvent) and methyl esters. If possible, avoid purchasing products containing ethylene glycol mono butyl ether (butyl cellusolve), 2-butoxyethanol, ammonia, and sodium hydroxide.

9. Furniture Polishes

Furniture polishes frequently use petroleum distillates, which are poisonous and derived from a non-renewable resource. Select products recognized by green

certification or recognition programs (see Appendix B). The following are some of the specific issues to compare for in this product category:

- Preferable ingredients: citrus (lemon and orange) oils.
- If possible, avoid purchasing products containing petroleum distillates.

10. General Degreasers

General degreasers are typically heavy-duty cleaners that include solvents for removing oil-based soils. Traditional solvents are typically derived from a non-renewable sources (e.g., petroleum), can be flammable, and have high VOC levels that can cause respiratory irritation and contribute to environmental pollution; some cause severe health impacts. Select products recognized by green certification or recognition programs. The following are some of the specific issues to compare in this product category:

- See All-Purpose Cleaners for additional considerations.
- Preferable ingredients: d-Limonene (derived from citrus fruits) and methyl esters from soy and corn.
- If possible avoid purchasing products containing glycol ethers in general, ethylene glycol mono butyl ether (butyl cellusolve), and sodium hydroxide.

11. General Disinfectants

General disinfectants are similar to cleaners (see All-Purpose Cleaners) with additional ingredients to kill bacteria and other unwanted organisms (see Restroom Disinfectants). Because disinfectants kill organisms, they are toxic by definition. Some are persistent in the environment and accumulate in living tissue. Care in selection and use is important. The following are some of the specific issues to compare in this product category:

- See Restroom Disinfectants for similar attributes.
- Antimicrobial ingredients: Prefer antimicrobial ingredients that have a lower potential for persistence in the environment and accumulation in living tissue compared to those with a greater potential (check for DfE recognition[2]).

[2] Currently, the U.S. EPA does not permit disinfectants to be certified as green. However, the EPA Design for the Environment (DfE) program has launched a pilot program that may lead to certain disinfectant products being permitted to carry the DfE logo on their labels as recognition of environmental preferability under new rules.

- Preferable active ingredient: hydrogen peroxide.
- If possible, avoid purchasing products containing sodium hypochlorite (chlorine bleach), quaternary ammonium compounds, and phenolic compounds.
- Look for disinfectants in Toxicity Category IV (see Appendix E).

Non-chemical interventions, such as steam vapor devices, are also available to assist with sanitizing or disinfecting. Floors, since they are seldom touched by hands, may not need to be disinfected if properly maintained. Cleaning in shower areas using water-only spray-and-vac type equipment that applies water under pressure, then vacuums off the solution has been demonstrated to effectively clean and sanitize both floor and above-floor surfaces by removal of soil and germs rather than by chemical intervention. Ionized or activated water devices have also shown effectiveness in sanitizing surfaces without added chemicals. Check with your janitorial supplier for these and other options.

12. Glass Cleaners

Glass cleaners have ingredients added to reduce streaking and to evaporate quickly. Traditional glass cleaners can contain alcohol and other solvents (typically glycol ethers) or ammonia. The following are some of the specific issues to compare in this product category:

- Preferable ingredients: surfactants containing terms such as lauryl, amides, and glycosides.
- If possible, avoid purchasing products containing ammonia, alcohols, propylene glycol, ethylene glycol, and other glycol ethers.

Microfiber cloths enable cleaning glass effectively using just water. A window-washing sleeve that fits over an applicator handle cleans glass with water mixed with a small amount of mild detergent, followed by use of a squeegee for drying the glass.

13. Graffiti Removers

Graffiti Removers used to be formulated with chlorinated solvents (e.g., methylene chloride) before those solvents were banned due to their environmental impact. Many graffiti removers are packaged in aerosols that often contain hydrocarbon propellants (e.g., propane, butane), are highly flammable, and can

contribute to indoor air quality problems. The following are some of the specific issues to compare in this product category:

- Preferable ingredients: n-Methyl-2-Pyrolidone, d-Limonene.
- If possible, avoid purchasing products containing methylene chloride, petroleum distillates, propane, butane, isobutene, and sodium hydroxide.

14. Gum Removers

Gum removers used to be formulated with chlorinated solvents (e.g., Freon) before those solvents were banned due to their environmental impact. Dry ice and carbon dioxide are preferable replacements. Degreasers can be used in some situations (see section on General Degreasers). The following are some of the specific issues to compare in this product category:

- Preferable ingredients: dry ice, carbon dioxide.
- If possible, avoid purchasing products containing Freon, dichloro-difluoro-methane, trichloro-fluoromethane.

15. Lime and Scale Removers

Lime and scale removers are acids because of the need to remove mineral deposits from sinks, bowls, and urinals. The following are some of the specific issues to compare in this product category:

- Environmentally preferable lime and scale removers fall more in the range of pH 4 as compared to traditional products that have a pH below 1 (check for green certification or recognition).
- Preferable ingredients: citric, acetic, or lactic acid.
- If possible, avoid purchasing products containing hydrochloric or phosphoric acid.

16. Sanitizers

Sanitizers are used to reduce, but not necessarily eliminate, microorganisms from the inanimate environment to levels considered safe as determined by public health codes or regulations. Sanitizers include:

- Food contact products: These products are important because they are used on sites where consumable food products are placed and stored. Sanitizing rinses are used for dishes and cooking utensils, including those in eating and drinking establishments.
- Non-food contact products: Non-food contact surface sanitizers include carpet sanitizers, air sanitizers, laundry additives, and in-tank toilet bowl sanitizers.

The following are ingredients to compare:

- Antimicrobial ingredients: Prefer antimicrobial ingredients that have a lower potential for persistence in the environment and accumulation in living tissue compared to those with a greater potential.
- Preferable active ingredient: hydrogen peroxide.

17. Solvent Spot Removers/Absorbents (for spill cleanup)

Solvent spot removers may be necessary for oily spot removal, particularly on carpets. Use detergent-based spotters if possible, followed by extraction or other method to remove/absorb the detergent).

Select products that have been recognized by green certification or recognition programs and/or have received a Green Label or Seal of Approval (SOA) for soil removal effectiveness and other attributes by the Carpet and Rug Institute (CRI). The following are some of the specific issues to compare in this product category:

- Preferable ingredients for spot removers: d-Limonene (derived from citrus fruits) and methyl esters from soy and corn.
- Preferable ingredients for absorbents: recycled corncobs, kitty litter.
- If possible, avoid purchasing products containing mineral spirits or 2-butoxyethanol.

18. Urinal Deodorizers

Urinal deodorizers are blocks placed in urinals to reduce odors. Preferably, these deodorizers should be eliminated altogether through more frequent cleaning and other methods of deodorizing (eliminating the source of the odor is best).

However, if urinal deodorizers are still required, preference should be given to those with the safest ingredients:

- Preferable ingredients: surfactants containing terms such as lauryl, amides, glycosides.
- If possible, avoid purchasing products containing nonyl phenol ethoxylates, paradichlorobenzene.

19. Wood and Stone Floor Coatings

Wood and stone floor coatings have traditionally been solvent-based. While extremely durable to protect flooring materials that are expensive to replace, these coatings can be hazardous during the drying and curing period. It is preferable to use zero or low-VOC-containing materials to address indoor air quality concerns (check for green certification or recognition). Unfortunately, lower VOC formulas often have lower product durability and flooring protection, and raise product and application costs. Also, many janitorial firms lack specific expertise in application of these types of finishes. Thus, supplier support (e.g., instruction and training) is very important. The following are some of the specific issues to compare in this product category:

- Durability: Prefer durable finishes that require less maintenance (e.g., recoating) than less durable finishes that require more frequent recoating.
- Preferable ingredients: water- or epoxy-based finishes.
- If possible, avoid purchasing products containing xylene, stoddard solvent.

20. Choosing Disposable Paper and Plastic Bags

The issues associated with selecting paper products, compared to cleaning products, are simpler. Whereas cleaners may have more than a dozen individual ingredients that can vary significantly between and within categories, concerns related to paper are primarily focused at the manufacturing stage of the product. Paper has less emphasis on health issues during the product-usage stage or environmental impacts as a result of disposal.

The three basic issues of concern for paper are total recovered material (recycled content), post-consumer recycled content, and the bleaching process. Environmentally preferable (check for green certification or recognition) paper products should meet the following standards for each of the following product categories:

- Restroom tissue—100% recovered materials and 20% post-consumer content.
- Toilet seat covers—100% recovered materials and 40% post-consumer content.
- Paper towels and general-purpose industrial wipes—100% recovered materials and 40% post-consumer content.

Two further recommendations for paper:

- No use of de-inking solvents containing chlorine or any other chemicals listed in the Toxics Release Inventory in the manufacture of paper products.
- No use of chlorine or chlorine derivatives in bleaching processes for paper products.

When selecting plastic trash bags, look for a minimum of 10% post-consumer content.

21. Selecting and Using Janitorial Equipment

Powered janitorial equipment includes powered floor scrubbers, burnishers, carpet extractors, vacuum cleaners, power washers, and other powered cleaning equipment.

Building managers should select equipment that, at a minimum, meets the following specifications:

- Vacuum cleaners should meet, at a minimum, the Carpet and Rug Institute (CRI) Green
- Label or Seal of Approval (SOA) Program requirements and should operate at a sound level of less than 70 dBA.
- Carpet extraction equipment should meet at a minimum the Carpet and Rug Institute (CRI) Bronze Seal of Approval.
- Powered floor maintenance equipment should be equipped with controls or other devices for capturing and collecting particulates and should operate at a sound level less than 70 dBA.
- Propane-powered floor equipment should have low-emission engines certified by the California Air Resources Board under the Small Off-Road Engines or Equipment (SORE) program, and should be equipped with catalytic and exhaust monitoring systems in addition to other requirements for floor equipment set out in the section.

- Current in-use propane-powered equipment should only be used when the building is unoccupied, and under conditions allowing for as much air circulation and exchange as possible.
- Powered scrubbing machines should be equipped with a control method for variable rate dispensing to optimize the use of cleaning fluids.

Other considerations for equipment selection include the following:

- To accommodate people with sensitivities, consider vacuums with High Efficiency Particulate Air (HEPA) filtration capable of trapping 99.97% of all airborne particles 0.3 micron and larger entering the vacuum. In some cases, it is preferable to use vacuums with a beater bar to increase the amount of soil removal on certain carpet types.
- Floor machines should have guards and filters.

In selection of all equipment, it is preferable to select those that are durable, energy-efficient and quiet, as compared to less durable, less efficient, and noisier alternatives. Appendix C also discusses powered equipment.

APPENDICES

Appendix A: Housing Complex-Specific Green Cleaning Plan

The building manager may wish to develop a written housing complex-specific Green Cleaning Plan that comprehensively describes the methods by which a particular facility is cleaned effectively while protecting human health and the environment. In addition to typical cleaning concerns, the Green Cleaning Plan should:

- Define a comprehensive communications plan established with occupants. The plan should describe procedures for cleaning personnel to communicate with building occupants, as well as a system for providing feedback from building occupants.
- Develop and implement a floor cleaning and maintenance plan, consistent with manufacturers' recommendations, to extend the life and appearance of flooring through routine, periodic, and restorative cleaning operations.
- Determine schedules of routine cleaning operations, activities performed periodically, equipment operation and maintenance, cleaning inspections, and accident preparedness plans.
- Schedule cleaning operations to ensure the minimum frequency required to clean and maintain the area to a level that adequately protects human health and the environment.
- Include a review of cleaning operations at least twice per year to adjust the program as needed in response to the changing needs of the building/complex and its occupants.

The Green Cleaning Plan may also provide a detailed description of how green cleaning operations address:

- Cleaning procedure requirements for such special areas as entryways, lobbies, community centers, daycare and preschools, gymnasiums, workout rooms, and playgrounds.
- Storage and use of chemicals within the facility, including consideration of proper ventilation, dilution control procedures, adequate security, and proper management of the area.
- Vulnerable populations such as children, asthmatics, the elderly, and pregnant women.

- Indoor sources of contaminants or pollution, both temporary and permanent, such as building renovations, indoor plants (e.g., potential for mold growth), and new carpet or flooring installations.
- Special requirements for operations involving potentially hazardous materials such as the maintenance of floors containing asbestos or compliance with the OSHA Bloodborne Pathogen Standard.
- Cleaning in areas with special engineering concerns such those with inadequate ventilation, poor lighting, and restricted access.
- Seasonal or periodic conditions and periods of increased or decreased use.
- Requirements of the building Integrated Pest Management (IPM) System.
- Special cleaning requirements or conditions that may affect the frequency of cleaning or negatively impact human health or the environment.

Appendix B: Environmentally Preferable Cleaning Products and Supplies

The building manager should strive to use environmentally preferable products, which are defined as "products that have a lesser or reduced harmful effect on human health and the environment compared with products or services that serve the same purpose" (Source: U.S. Executive Order 13101).

The majority of products are not yet *certified* as environmentally preferable by a credible body. This does not mean that they are necessarily harmful or bad, but that a reliable third party has not validated them. In these cases, check product labels for undesirable ingredients (see the section on Cleaning Products), ask the manufacturer for full disclosure of ingredients and proof that they are safe, and/or whether product ingredients were selected using EPA's Design for the Environment (DfE) safer ingredient criteria (located at http://www.epa.gov/dfe/pubs/projects/gfcp/index.htm#GeneralScreen).

Products may include:

- General or all-purpose cleaners, floor cleaners, restroom cleaners, glass cleaners, and carpet cleaners
- Floor finishes and floor strippers
- Liquid hand soap
- Toilet tissue and facial tissue
- Paper towels and napkins
- Plastic trash can liners.

Ideally, to determine which products are environmentally preferable, look for established green certification, recognition, and/or health and safety labels on the product packaging. Some of these programs and their criteria are described below.

Recognized Products— EPA's Design for the Environment (DfE)

- The EPA DfE Program is for product formulators.
- DfE screens each ingredient for potential human health and environmental effects; the product must contain only those ingredients that are least harmful in their class.
- DfE provide formulators information on safer substitutes for chemicals of concern.
- The program will be strengthened by annual desk or paper audits and on-site audits.

Certified Products—EcoLogo

The EcoLogo™ program, under Canada's Environmental Choice, is a North American multi-attribute, lifecycle environmental standard and certification. EcoLogo is a Type I eco-label (see Appendix D, Abbreviations and Definitions), as defined by the International Organization for Standardization (ISO).

- Environmental Choice CCD-110, for cleaning and degreasing compounds
- Environmental Choice CCD-146, for hard surface cleaners
- Environmental Choice CCD-148, for carpet and upholstery care
- Environmental Choice CCD-112, for biological digestion additives
- Environmental Choice CCD-113, for drain or grease trap additives
- Environmental Choice CCD-115, for odor control additives
- Environmental Choice CCD-147, for hard floor care
- Environmental Choice CCD-82, for toilet tissue
- Environmental Choice CCD-86, for hand towels
- Environmental Choice CCD-104, for hand cleaners and hand soaps

Certified Products—Green Seal

The Green Seal® program is a North American multi-attribute, lifecycle environmental standard and certification. Green Seal is a Type I eco-label, as defined by the International Organization for Standardization (ISO).

Green Seal® provides environmental standards and certification for cleaning products including bathroom cleaners, carpet cleaners, general purpose cleaners, glass cleaners, hand soaps, floor-care products, and a variety of jansan paper products. Green Seal has also established a standard and certification process for environmentally preferable cleaning services (GS-42).

- GS-37, for cleaning products for industrial and institutional use
- GS-40, for floor care products (floor strippers, finishes) for industrial and institutional use
- GS-41, for hand cleaners for industrial and institutional use
- GS-9, for paper towels and napkins
- GS-1, for tissue paper

Certified Products—GREENGUARD

The GREENGUARD Environmental Institute (GEI) was founded in 2001 and seeks to protect human health through programs that reduce chemical exposure and improve indoor air quality.

GEI oversees third-party certification programs that identify acceptable product emission standards and certify low-emitting products. GEI also establishes building standards designed to control mold and moisture.

- GREENGUARD Indoor Air Quality Certified®: A product certification program for low-emitting building materials, furniture, furnishings, finishes, cleaning products, electronics, and consumer products.
- GREENGUARD Children & Schools(SM) Certified: A certification program for low-emitting building materials, furniture, finishes, cleaning products, electronics and consumer products in environments where children and sensitive populations spend extended periods of time.

Certified Products—Information-Based Environmental Labeling (IBEL)

The cleaning association ISSA's Information-Based Environmental Labeling (IBEL) program will serve as a single environmental label that embraces existing labels while filling gaps that exist. It will:

- Help purchasers make informed decisions
- Harmonize product data gathering and how it appears on labels
- Expand third-party verification to products not represented in current third-party labeling systems
- "Reward continuous improvement by innovative manufacturers producing leadership products that continue to reduce potential adverse health and environmental impacts" (Source: ISSA).

Certified Products—UL®

UL Environment (ULE) offers Environmental Claims Validation™ (ECV), a service for testing and validating manufacturers' self-declared environmental claims, and Sustainable Products Certification™ (SPC), a service for testing and certifying products to accepted industry standards for environmental sustainability. A partial list of claims it will test and validate:

- Recycled content
- Rapidly renewable materials
- Volatile organic compound (VOC) emissions
- Volatile organic compound (VOC) content
- Energy efficiency
- Water efficiency
- Hazardous or toxic substances
- Mold resistance
- Degradability

Health and Safety Rating—HMIS

HMIS (Hazardous Materials Identification System) is a hazard rating system using a label with four color-coded bars representing hazard categories (Blue-Health, Red-Flammability, Orange-Physical Hazard, White-Personal Protection). Each category is assigned a numerical value from 0–4, with 4 being the most hazardous.

Certified Performance—CRI Seal of Approval

The CRI Seal of Approval (SOA) program identifies effective carpet-cleaning equipment and solutions:

- Vacuum cleaners
- Extractors and truck mounts
- Cleaning solutions/carpet-spotting products
- Carpet cleaning systems (solutions and equipment)

Recognized Performance—IEHA High Performance Cleaning Product (HPCP) with UMass Lowell TURI Lab

The High Performance Cleaning Product (HPCP) recognition is the International Executive Housekeepers Association's (IEHA's) voluntary fee-based program, which tests green hard surface cleaning product performance on real-world soils.

Appendix C: Powered Equipment Use and Maintenance Plan

The building manager should develop, adopt, and maintain a plan for the use of powered janitorial equipment that maximizes the effective reduction of building contaminants with minimum environmental impact. Building managers should determine that the janitorial equipment currently used is functioning properly (as validated by the equipment manufacturer or by a reputable third-party service organization) or that it is tagged out of service.

A component of this plan should include a quarterly maintenance program that inspects and maintains the performance of janitorial equipment, as defined by the equipment vendor and records results in a maintenance log.

The following requirements apply to the use of vacuum cleaners:

- Vacuums should be equipped with the proper filter or bag; the filters should be changed or cleaned consistent with the manufacturer's recommendations. Bagless vacuums may be acceptable (even if they do not have Carpet and Rug Institute approval) if they are able to remove and capture particles efficiently (ask for independent test data), and if care is exercised in the emptying of dust bins.
- Vacuum bags or canisters should be inspected at least every 2 hours and changed or replaced when half-full or less or when indicated by a bag sensor, if the vacuum is so equipped.

- Precautions should be taken to limit worker exposure to dust and particulate matter when cleaning and replacing bags and filters, or emptying dust bins.

Appendix D: Acronyms and Definitions in This Chapter

Definitions

CHEMICAL SENSITIVITY: Chemical sensitivity is hypersensitivity or intolerance to many chemicals at very low exposures or concentrations. Chemical sensitivity differs from an allergic reaction because while medical tests can confirm allergies, effective tests are not available for chemical sensitivity. Physicians hold a wide range of views about the causes, diagnosis, and treatment of this condition; also referred to as "Multiple Chemical Sensitivity" or MCS.

CIMS-GB: To help meet the growing demand for green and "Leadership in Energy and Environmental Design" (LEED) certification, the ISSA's Cleaning Industry Management Standard & Certification Program has expanded to include "Green Building" (GB) criteria and an optional GB designation. (Excerpted and adapted from ISSA.com.)

ACRONYMS IN THIS CHAPTER

CRI	Carpet and Rug Institute
dBA	Decibels
EPA	Environmental Protection Agency
F&C	Food and cosmetics
HMIS	Hazardous Materials Identification System
HVAC	Heating, ventilation, and air conditioning
IPM	Integrated pest management
LEED	Leadership in Energy and Environmental Design (U.S. Green Building Council)
MSDS	Material safety data sheet
OSHA	Occupational Safety and Health Administration
PHA	Public Housing Authority
PPE	Personal protective equipment
SOP	Standard operating procedure
VOC	Volatile organic compound

CONCENTRATE: A product that should be substantially diluted with water to form the appropriate solution for use (typically at least 1:8, or as appropriate for the particular product category).

DISINFECT: A process for hard inanimate surfaces undertaken to destroy or irreversibly inactivate infectious fungi and bacteria, but not necessarily their spores.

ENVIRONMENTALLY PREFERABLE PRODUCT: A product certified as such by a Type 1 (i.e., third-party) environmental label that was developed in accordance with the ISO 14024 Environmental Labeling Standard. Alternatively, a

product may be designated as environmentally preferable by an established and legitimate, nationally recognized program developed with the purpose of identifying environmentally preferable products. The program should not have any financial interest or stake in sales of the product, or other conflict of interest. Such designation should be based on consideration of human health and safety, ecological toxicity, other environmental impacts, and resource conservation, as appropriate, for the product and its packaging, on a life cycle basis. Product criteria should distinguish market leadership for that product category, and be publicly available and transparent.

GS-42 CERTIFICATION: Green Seal, a non-profit certification body, has established GS-42, the environmental practice standard for commercial cleaning services. The program involves onsite audits and other criteria for certification of a service as environmentally preferable.

INTEGRATED PEST MANAGEMENT (IPM): An integrated approach to controlling pests—and keeping populations at an acceptable level using prevention, observation, and intervention—with the goal of reducing or eliminating pesticide use.

LEED-EBOM: The LEED for Existing Buildings Operations and Maintenance (LEED-EBOM) Rating System helps building owners and operators measure operations, improvements and maintenance on a consistent scale, with the goal of maximizing operational efficiency while minimizing environmental impacts. LEED for Existing Buildings addresses whole-building cleaning and maintenance issues (including chemical use), recycling programs, exterior maintenance programs, and systems upgrades. It can be applied both to existing buildings seeking LEED certification for the first time and to projects previously certified under LEED. (adapted from LEED)

Example Credits

- Credit 3.1 Green Cleaning—High Performance Cleaning Program 1
- Credit 3.2 Green Cleaning—Custodial Effectiveness Assessment 1
- Credit 3.3 Green Cleaning—Purchase of Sustainable Cleaning Products and Materials 1
- Credit 3.4 Green Cleaning—Sustainable Cleaning Equipment 1
- Credit 3.5 Green Cleaning—Indoor Chemical and Pollutant Source Control 1
- Credit 3.6 Green Cleaning—Indoor Integrated Pest Management

MATERIAL SAFETY DATA SHEET (MSDS): MSDS forms are required for a wide range of products, mainly chemicals, under the laws of the U.S., Canada, and several other nations, to promote occupational health and safety. Material Safety Data Sheets are specific to each applicable product. They contain manufacturer contact information, hazardous ingredients, fire safety, explo-

sion and reactivity data, health hazards, precautions for safe handling, and use and control measures, such as protection for skin, eyes, or lungs.

SANITIZE: A process intended to reduce, but not necessarily eliminate, microorganisms from the inanimate environment to levels considered safe as determined by public health codes or regulations.

TYPE I ECO-LABEL: Defined by the International Organization for Standardization (ISO) as a certification program that compares products/services with others in the same category, applies stringent scientific criteria reflecting the full life-cycle impact of the product, and identifies products or services in compliance with the criteria as verified by an independent third party.

VULNERABLE POPULATIONS: Vulnerable populations represent people who are more susceptible than the general population to chemicals and products that might pose a risk to human health. These populations include but are not limited to children, pregnant women, the elderly and infirm, people sensitive to chemical exposures (e.g., fragrances), and other occupants, customers, or employees that may have a higher susceptibility to cleaning operations.

Appendix E: Toxicity Categories for Pesticide and Disinfectant Products

The U.S. Environmental Protection Agency has established four Toxicity Categories for acute hazards of pesticide or disinfectant products. Category I is the highest toxicity category.

Signal words such as Danger, Poison, Warning, or Caution designate the level of toxicity. Most human hazard, precautionary, and human personal protective equipment statements are based upon the Toxicity Category of the pesticide or disinfectant product as sold or distributed.

In addition, toxicity categories may be used for regulatory purposes other than labeling, such as classification for restricted use and requirements for child-resistant packaging. In certain cases, statements based upon the Toxicity Category of the product as diluted for use are also permitted.

A Toxicity Category is assigned for each of five types or routes of acute exposure:

1. Oral
2. Inhalation
3. Dermal toxicity
4. Skin irritation
5. Eye irritation

Toxicity Category I

Any pesticide or disinfectant product meeting the criteria of Toxicity Category I for any route of exposure must bear on the front panel the signal word ''DANGER.'' In addition, if the product is assigned to Toxicity Category I on the basis of its oral, inhalation, or dermal toxicity (as distinct from skin and eye irritation), the word ''Poison'' must appear in red on a background of distinctly contrasting color, and the skull and crossbones symbol must appear in immediate proximity to the word ''Poison.''

Toxicity Category II

Any pesticide or disinfectant product meeting the criteria of Toxicity Category II as the highest category by any route of exposure must bear on the front panel the signal word ''WARNING.''

Toxicity Category III

Any pesticide or disinfectant product meeting the criteria of Toxicity Category III as the highest category by any route of exposure must bear on the front panel the signal word ''CAUTION.''

Toxicity Category IV

A pesticide or disinfectant product meeting the criteria of Toxicity Category IV by all routes of exposure is not required to bear a signal word. If a signal word is used, it must be ''CAUTION."

Chapter 2 | HVAC in the Northern Climate Region

INTRODUCTION

Heating, ventilation, and air conditioning (HVAC) are the equipment and systems that control the conditions and distribution of indoor air. Indoor air must be comfortable, healthy, and safe. HVAC systems address these needs by controlling indoor temperature and relative humidity (RH), and by filtering air and providing ventilation air to improve air quality. HVAC systems also control ancillary effects such as building pressure and direction of airflow, which can affect the growth of mold inside a building and can impact the correct operation and venting of combustion equipment. Installing efficient HVAC equipment, scheduling and operating it in optimum fashion, and maintaining the systems and controls will achieve a comfortable and healthy indoor environment in an energy-efficient manner. ASHRAE Standard 180-2008 "Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems" provides guidance regarding inspection and maintenance practices for HVAC systems.

HVAC AT-A-GLANCE

Introduction
Maintenance Considerations
Regional Climate Demands

Operations and Maintenance Practices
Cooling Systems
Heating Systems
Air Distribution Systems
Air Handler Units
Ventilation
Comfort Controls

Health and Safety
Mechanical Rooms
Combustion Safety

Limiting Loads from Devices Brought in by Employees

Equipment Replacement or Upgrades

Acronyms in this Chapter

Heating, ventilating, and air conditioning maintenance practices have a significant effect on a building's energy use and the comfort of its occupants. HVAC systems are typically the largest users of energy in most buildings—about 45% of a typical office building's energy use, compared with about 23% for lighting and 32% for internal equipment.

This chapter discusses operation and maintenance practices of common types of HVAC equipment employed in the common (non-residential) spaces of public housing authority (PHA) buildings in the northern United States. Common spaces include offices, meeting rooms, laundry rooms, and community gathering areas. The size and arrangement of common areas within public housing buildings varies significantly from one PHA site to another. They range from small single-zone detached buildings to large multi-story buildings with common space areas distributed throughout the building. These spaces may be served by a variety of HVAC systems.

Public housing office and common space may be designed and operated so that occupants cannot meet individual comfort needs through access to operable windows for ventilation and thermostats to adjust temperature. Sometimes the cooling and heating system strictly maintains a "comfort zone" without regard to whether or not occupants feel hot or cold, or even if anyone is present. Complaints that areas are too hot or too cold can plague facility managers. These factors point to the difficult tasks that the building HVAC engineer and the maintenance staff must carry out in order to balance occupant comfort with building and equipment efficiency, while keeping maintenance costs low. It is a challenging task because comfort problems that affect employee productivity may outweigh the cost of cooling, heating, or ventilating the building.

After discussing maintenance considerations and regional climate demands, this chapter summarizes operation and maintenance practices of specific HVAC equipment used in public housing. Due to the wide variety of building types and of common spaces found in PHAs, the information is organized by primary type of equipment. Within each section, a discussion with some tips for improved HVAC operation is followed by maintenance guidance or a checklist. Later sections in this chapter cover recommendations on how to limit energy consumption from devices brought in by employees, and issues to consider when planning equipment replacement or upgrades.

Maintenance Considerations

A good maintenance program maximizes equipment performance and life expectancy in the most cost-effective manner. Good communication between people familiar with the equipment and with management will help to establish realistic budgets. There are generally three ways to consider maintenance: Reactive, Preventative, and Predictive.

REACTIVE MAINTENANCE is the practice of repairing or replacing equipment only after operation is impaired or has ceased. Also referred to as "run-to-failure," this practice can diminish HVAC performance, resulting in more complaints about comfort and reduced air quality control. Waiting until total equipment

failure can also cause additional component damage and higher costs, especially if the repairs must be made when emergency or overtime rates apply.

PREVENTATIVE MAINTENANCE is performed according to a schedule or based on actual equipment operation runtime. While more efficient than reactive maintenance, preventative maintenance may also result in inefficiencies. For example, an air filter is often changed according to a calendar schedule, but this type of activity may actually "waste" some of the useful life of the filter.

PREDICTIVE MAINTENANCE is based on the actual condition of equipment, but it goes further than preventative maintenance. Predictive maintenance tracks fault frequency and costs, and uses this information to predict when maintenance should be implemented. While upfront costs to start and maintain a predictive maintenance program can be high, the U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP) claims this is a very cost-effective approach that yields savings that are ten times the cost of a predictive maintenance program. This program should also provide energy savings of 8–12%, reduced maintenance costs of 25–30%, reduction in breakdowns by 70–75%, and reduction in downtime by 35–45%.

The HVAC maintenance team must balance system efficiency and occupancy comfort, which at times seems incompatible. This balance may be achieved by considering the following, arranged from a broad to narrow focus:

- **HUMAN FACTORS:** Focusing on individuals' comfort zones instead of maintaining buildings at prescribed conditions may achieve both energy efficiency and occupant comfort.
  - Operate space conditioning and ventilation systems for occupant comfort during work periods.
  - Establish a policy of providing conditions within a range that occupants can depend on so they can adjust clothing as needed. For instance, those for whom an air conditioning setpoint of 75°F is too cold can plan to wear long sleeves. Consider ASHRAE Comfort Standard 55 for guidance.
  - Allow occupants to self-regulate temperature within a predetermined range through better access to supply vents and thermostats.
- **LOCATION, TEMPERATURE, AND LOAD FACTORS:** Focus on providing temperature for spaces according to their function. Where possible, reduce HVAC loads by establishing temperature setpoints for different spaces (e.g., hallways can be cooler in the winter and warmer in the summer than office areas).
- **EXTERNAL FACTORS:** Occupant comfort is often affected by factors such as leaky or low-performance windows, heat gain or loss through poorly insulated walls, and thermal stratification within the space. Energy savings can be achieved through building envelope improvements such as reflective

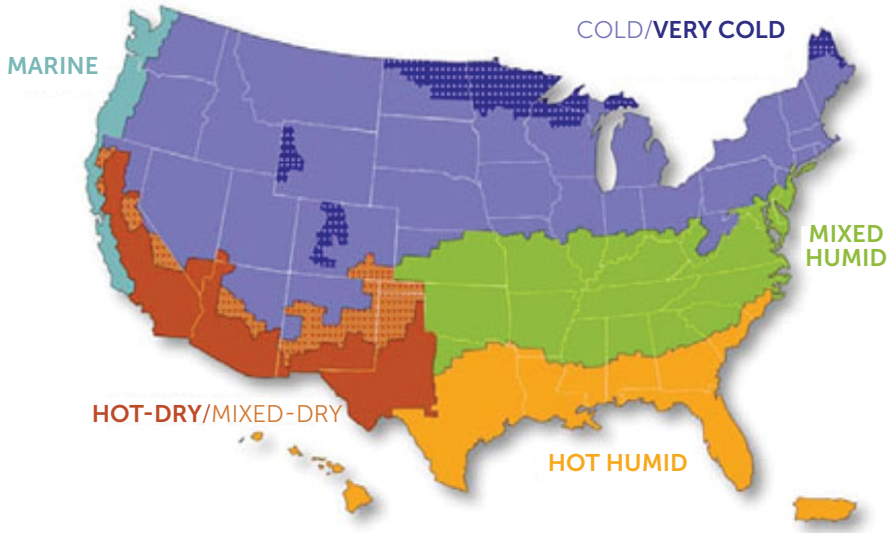
window blinds, exterior shading of walls and windows, and improved thermal performance of windows and walls.

- **LOW-COST OR NO-COST SYSTEM MODIFICATIONS:** In addition to operation and maintenance practices, a number of relatively low-cost or no-cost, quick-return measures can reduce energy consumption. They include sealing ductwork, adjusting thermostat settings, improving operating procedures, and automating system controls. Consider, for example, that raising cooling setpoints can reduce cooling energy consumption by about 8% per degree change, while lowering heating setpoints can reduce heating energy consumption by about 4% per degree change, depending upon the climate zone.

Regional Climate Demands

This chapter addresses the northern climate zone, which includes the cold and very cold portions of the United States (Figure 1). This climate zone, which covers about one-half of the lower 48 States, is a heating-dominated region. Throughout most of this zone, heating is required for about five to six months, and generally there are only intermittent periods when space cooling is required. Heating degree days (HDDs) vary from about 5,000 to about 10,000; the largest population centers of the northern climate zone are typically located in areas with 5,000 to 6,000 HDDs (see Box 1). Cooling degree days (CDDs) are generally in the range of 700 to 1,000. Therefore, the guidance provided in this chapter focuses primarily on heating, but will include some cooling issues.

FIGURE 1. DOMINANT U.S. CLIMATE REGIONS



There is also a general division between cold/moist winters from Iowa and Minnesota eastward and cold/dry winters to the west. In the eastern half, winter days are often cloudy with little sun. Temperature swings between day and night are often on the order of 15–20°F. In the western half, winter days are often clear and sunny, with daily temperature swings of 30°F to 40°F. With greater sunshine, buildings in the

west warm considerably during the daytime and cool down more at night. While solar radiation on horizontal surfaces in January averages only 510 Btu/ft^2/day in Cleveland, it averages 750 Btu/ft^2/day in Denver and 1010 Btu/ft^2/day in Albuquerque. The opportunity to implement passive or active solar is thus much greater in the western portions of the northern climate zone.

The heating season generally begins in October and ends in April. During this lengthy winter season, occupants depend upon HVAC systems to provide comfortable indoor temperatures and adequate ventilation. It should also be noted that when outdoor temperatures are low, outdoor dew point temperatures are also very low. Therefore, high levels of ventilation or infiltration have the potential to produce very low indoor RH, which can affect occupants and equipment.

As can be seen in Box 1, there are cooling loads in northern portions of the United States. Periods of hot weather occur, but generally do not persist, and are interrupted by cold fronts that lower both temperature and humidity. In most of the northern climate zone, summer dewpoint temperatures do not rise above 70°F except for short periods although occasional "heat storms" have occurred. In July 1995, for example, approximately 700 people died in Chicago from a five-day heat wave with daytime temperatures reaching over 105°F. This heat was also accompanied by dew point temperatures above 80°F. Those living in the northern United States are more susceptible to heat illness because they are less likely to have air conditioning. Most of the victims in Chicago were elderly poor in the city center without access to air conditioning. While unusual, these infrequent heat waves must be factored into considerations for good HVAC design, and precautionary measures should be considered for such events.

BOX 1. HEATING DEGREE DAYS AND COOLING DEGREE DAYS

Heating degree days (HDDs) and cooling degree days (CDDs) are useful tools to understand the amount of heating and cooling required for a specific climate.

HDDs and CDDs are defined relative to a base temperature: the outside temperature at which a building needs neither heating nor cooling. In most cases, the base temperature is 65°F.

Two examples will show how HDDs and CDDs are calculated. Consider a winter day in Columbus, Ohio, where the average temperature over a 24-hour period is 30°F. To obtain HDDs, subtract 30°F from 65°F to yield 35 HDDs for that day.

Consider a summer day in Columbus, where the average temperature over that 24-hour period is 80°F. To obtain CDDs, subtract 65°F from 80°F to yield 15 CDDs for that day.

Following are HDDs for various cities in the northern climate zone, based on weather from the period 1971–2000.

	HDDs	CDDs
Boston	5630	777
New York	4654	1151
Cleveland	6121	702
Chicago	6498	830
Denver	6128	696
Reno	5600	493
Missoula	7622	256
Indianapolis	5521	1042
Minneapolis	7876	699

OPERATIONS AND MAINTENANCE PRACTICES

This section covers the operations and maintenance of the following equipment:

Cooling Systems
Condenser Units, Chillers, Cooling Towers

Heating Systems
Electric Resistance; Heat Pumps; Gas Furnaces; Central Steam, Hot Water, and Radiator Space Heating Systems

Air Distribution Systems

Air Handler Units

Ventilation

Comfort Controls
Thermostats and Ventilation Sensors

HVAC maintenance practices vary depending on the type of equipment, building, and existing envelope measures, as well as building location, size, use pattern, and purpose. Thus, it is impossible to identify specific maintenance practices that fit all circumstances. Rather, use the following guidelines to develop a combination of practices and schedules that will best serve the occupants' needs, maintain good indoor air quality, reduce energy consumption, and lessen environmental impacts.

An energy audit is highly recommended as an initial step to improve energy efficiency. Various levels of audits, from preliminary to comprehensive, can be obtained from energy service companies, architecture and engineering firms, or utilities. (Note to government facility managers: the Federal Energy Management Program (FEMP) can also provide this technical support on a reimbursable sub-contract basis).

Cooling Systems

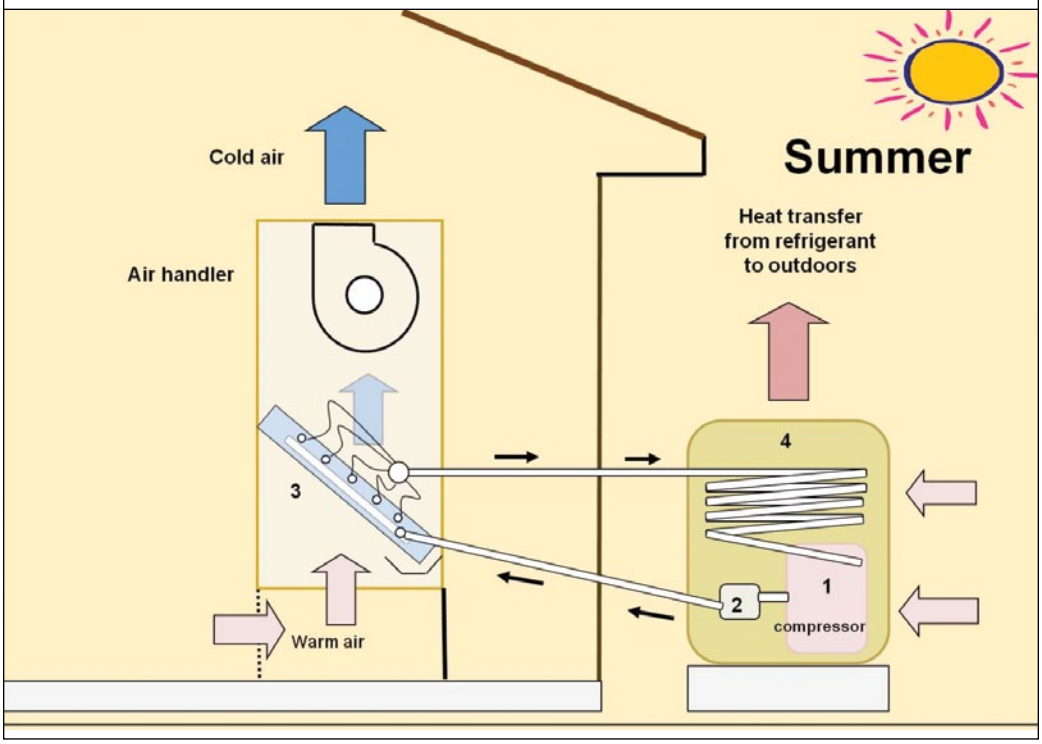
The cooling systems primarily used in northern public housing can generally be classified as **DIRECT EXPANSION** or **CHILLED WATER** systems. Most are direct expansion systems that require an outdoor condenser unit to exchange heat to the outdoor air. The condenser unit will be discussed here and the indoor air heat exchange of this system will be discussed in the Air Distribution System section below. While not as common, some multi-story public housing buildings use chilled water systems.

Condenser Unit Operation

Air conditioners that use direct expansion (DX) cooling circulate refrigerant in a circuit between two heat exchange surfaces (see Figure 2). The process begins with pressurized refrigerant at the compressor (#1 in the figure) that is transferred through an expansion valve (#2) before entering the evaporator coil (#3). The evaporator is located inside the AHU where a fan blows air through it to pick up cooling. The refrigerant then travels back to the condenser unit (#4) located outdoors. Refrigerant gives up heat to outdoors then the cycle begins again.

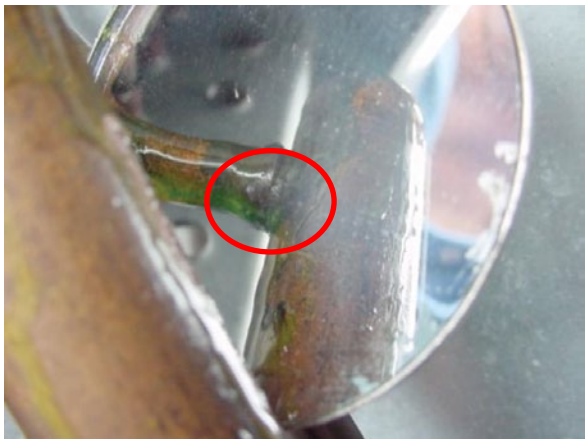
FIGURE 2. HEAT EXCHANGE IN A DIRECT EXPANSION SYSTEM IN SUMMER

1) compressor 2) expansion valve 3) evaporator 4) condenser



All illustrations and photographs in this chapter are courtesy of Jim Cummings and Charles Withers, unless otherwise noted.

Service technician using sensor to locate refrigerant leak around condenser coil.



Mirror and dye used to locate leak.

The condenser unit (or outdoor unit) contains the compressor, condenser, a fan that moves air across the condenser coil, and electronic components. Because this equipment is outdoors, it can become dirty and will be exposed to corrosive environmental factors over time. Heat transfer relies upon the coil surfaces remaining fairly clean. Therefore, the condenser coil must be protected from anything that interferes with airflow around and through it.

CONDENSER UNIT MAINTENANCE GUIDANCE

Maintenance	Description
	Annually
Outdoor coil	Clean the outdoor coil and remove any debris such as leaves or dirt from around or near the outdoor unit. Repair damaged fins. Place protective cover over top of unit at the end of cooling season if it is located under a roof edge where ice can fall onto it during winter.
Refrigerant leaks	Inspect tubes and coil for evidence of leaks. Have a leak test done and seal leak on system that requires refrigerant to be added.
Fan	Lubricate fan motor bearings according to manufacturer's recommendation. Inspect fan for damage or unusual vibration or noise. Tighten and adjust fan mounts as needed.
Electric power	Inspect wiring and electric connections. Tighten loose wires and replace weathered or nicked wiring. Measure heat pump amperage under operation and verify it is within manufacturer's specifications. Repair or replace equipment operating outside specifications.

Chiller Operation

A chiller uses a refrigeration process to cool water that is transported into the building to provide space cooling. How the chillers are operated and the method used to "condition" water significantly affects operating efficiency. Historically, chillers have worked most efficiently when operating at full-load rather than part-load. Buildings, however, produce full-load only a fraction of the time. In recent years, a new generation of variable-speed, variable-capacity chillers have entered the marketplace. Some of these units operate with magnetic bearings, allowing very high-speed, variable-capacity operation with very low noise and very high efficiency at part-load (as low as 320 Watts per ton at 40% load factor).

A chiller operates with two water loops. One loop takes water through the evaporator, which lowers the temperature of the chilled water. The other loop takes water through the condenser, which discharges waste heat to ambient air. A number of measures can increase chiller efficiency:

- **LOWER ENTERING CONDENSER WATER TEMPERATURES** will yield higher chiller efficiency. Decrease condenser water temperature by running it through a cooling tower. Operate the chilled water system to provide a relatively large temperature difference (of water delivered to the evaporator) from supply to return: Return water should be 15°F warmer than the supply water. If this differential drops to 10° or even 5°, the system efficiency will decline substantially. Careful balancing of the chilled water system flow rates through the various AHUs is important to maintaining the desired supply-to-return temperature differential. Replacement of standard chilled water valves with pressure independent valves can be a very cost-effective

means to achieve and maintain balanced chilled water flow and the target 15°F temperature differential.

- **VARIABLE FREQUENCY DRIVES** (VFDs) vary the flow rate of chilled water through the building loop. This can save substantial pump energy use and help to achieve the 15°F temperature differential. During colder weather, water can be taken directly from the cooling tower to feed the chilled water loop and thus provide "free cooling" without the use of the chiller.
- **A SIMPLE AND ECONOMICAL CHILLER PLANT CONTROL NETWORK** for the chillers, pumps, and tower fans that automatically operates and sequences all equipment is a cost-effective way to optimize the energy efficiency of large complex systems. Designing and implementing such a network can save $20 to $100 per installed ton per year.

The following table provides guidance on important chiller maintenance practices that should occur at least annually in early spring in preparation for cooling season.

CHILLER MAINTENANCE GUIDANCE

Maintenance	Description
	Follow Manufacturer's Recommended Schedule or At Least Annually
Evaporator and condenser	Clean the evaporator and condenser. Indications that cleaning is needed include poor water quality, excessive fouling, and age of chiller. Eddy current testing may be done to assess tube condition.
Refrigerant level and condition	Add refrigerant as required. Record amounts and address leakage issues.
Compressor oil system	Conduct analysis on oil and filter and change as needed. Check oil pump and seals, oil heater and thermostat, and strainers, valves, and any other significant components.
Compressor motor	Check all alignments to specification. Check all seals and provide lubrication where necessary. Consider vibration analysis. Check temperature per manufacturer's specification.
Motor load limit control	Check settings per manufacturer's specification.
Electrical connections	Check all electrical connections and terminals for contact and tightness.
Control functions	Verify proper control functions including hot gas bypass and liquid injection.
Compressor leak testing	Conduct leak testing on all compressor fittings, oil pump joints and fittings, and relief valves.
Insulation	Check for damaged or missing areas. Remove wet insulation and replace after surface is dry.
Chilled water reset	Check reset settings per manufacturer's specification.
Water	Assess proper water flow in evaporator and condenser. Test and inspect water quality to verify no biological fouling and make adjustments as needed. Test for appropriate levels of additives to water, such as glycol, if they are used.

Cooling Tower Operations

Cooling towers transfer heat from the condenser to the atmosphere using evaporative cooling. Their primary maintenance issues are scaling, corrosion, and biological growth that reduce heat transfer capacity and contribute to system "fouling."

Following are practices for more efficient cooling tower operations:

- **LOWER THE COOLING TOWER DISCHARGE TEMPERATURE** to the lowest manufacturer recommended setting.
- **IMPLEMENT A CONDENSER DISCHARGE TEMPERATURE RESET** to help optimize tower operation based on outdoor conditions. When using this method, the operator should set a cooling tower leaving temperature setpoint at least 5°F above the ambient wet-bulb temperature.
- **CLOSE THE BYPASS VALVE BEFORE STARTING THE COOLING-TOWER FANS** to avoid short-circuiting of hot water returning directly back to the chiller, which would lower chiller efficiency.
- **USE THE TREND-LOGGING CAPABILITY OF THE DIRECT DIGITAL CONTROL (DDC)** to track the temperature of the water leaving the tower. Higher than normal temperatures may indicate that the tower is not operating properly.

Cooling towers create environments conducive to biological growth. Pathogenic organisms such as *Legionella Pneumophila* (Legionnaires' disease) can develop in circumstances where the water is warm (95°F–99°F) and has a high concentration of minerals. Although awareness of this issue has helped reduce the incidence of sickness from cooling towers, **locating outdoor air intake vents far from the cooling tower plumes is critical to avoid entrainment of these pathogens into ventilation air.**

The most common treatments for scaling, corrosion, and biological/bacterial growth are the use of chemical additives and significant over-use of water. Most system operators use chemical biocides to inhibit biological growth, and allow a significant amount of "blow down" or deliberate water overflow to introduce fresh water into the system, thereby reducing the concentration of contaminants and the buildup of scale. These water treatment practices, however, can have significant impacts on the environment and should be considered and implemented carefully.

Blow down helps clean the tower, but should be limited since it requires more make-up water. In addition, spillage transports chemicals, such as chlorides, chromates, corrosion inhibitors, high concentrations of sulfides (if the water is treated for pH), and elevated concentrations of salt, into the external environment.

There are a number of alternative options to chemical treatment of water; however, they tend to require additional investments in the chilled water system. **Ozone treatment and mechanical cleaning are two viable alternatives to the use of chemical biocides.** Both have advantages and disadvantages, and both can have high initial costs. Ozone treatment has a higher first cost, but it lowers lifecycle costs and water consumption. The labor costs for both chemical and ozone systems are about the same. Ozone may be the best option in municipalities with strict blow down water disposal regulations.

COOLING TOWER MAINTENANCE GUIDANCE

Maintenance	Description
	Daily
Overall visual inspection	Complete overall visual inspection to be sure all equipment is operating and that safety systems are in place.
	Weekly
Vibration	Check for excessive vibration in motors, fans, and pumps.
Fan motor condition	Check the condition of the fan motor through temperature or vibration analysis and compare to baseline values.
Check belts and pulleys	Adjust all belts and pulleys as needed.
Check tower structure	Check for loose fill, connections, leaks, etc.
Clean suction screen	Physically clean screen of all debris.
Test water samples	Test for proper concentrations of dissolved solids, and chemistry. Adjust blow down and chemicals as necessary.
Operate make-up water float switch	Operate switch manually to ensure proper operation.
	Monthly
Check lubrication	Ensure all bearings are lubricated per the manufacturer's recommendation.
Check motor supports and fan blades	Check for excessive wear and secure fastening.
Motor alignment	Align the motor coupling to allow for efficient torque transfer.
Check drift eliminators, louvers, and fill	Look for proper positioning and scale buildup.
	Annually
Clean tower	Remove all dust, scale, and algae from tower basin, fill, and spray nozzles.
Check bearings	Inspect bearings and drive belts for wear. Adjust, repair, or replace as necessary.
Motor condition	Check the condition of the motor through temperature or vibration analysis to ensure long life.

Refer to the *Operations and Maintenances Best Practices Release 3.0* guide, available through the DOE website, for more information on operating and maintaining efficient cooling plants.

Heating Systems

Heating systems commonly used in northern-climate public housing include electric resistance heat; heat pumps; gas furnaces; and central steam, hot water, and radiator space heating systems. Each system is discussed with general guidance on operations followed by a maintenance guidance chart. Central steam and hot water have more components requiring specific maintenance, so some of these components have maintenance guidance charts of their own.

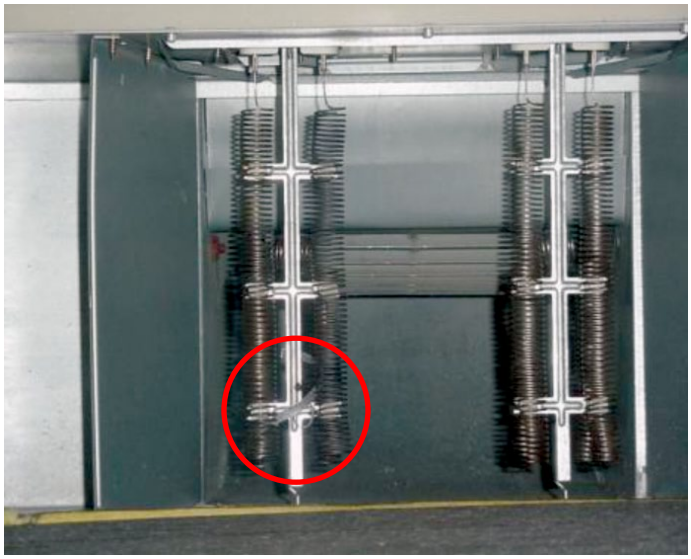
Electric Resistance Heat

Electric resistance heat is the simplest but least efficient type of heating system, and may be found in the form of either baseboard or forced-air electric resistance heat.

Baseboard Heating Operation

Units located on exterior walls along the baseboards are known as "baseboard" heating units and rely on convection and radiation to transfer heat. They do not rely on air distribution fans and have little to maintain. Solid furniture should not be placed in front of baseboard heaters since doing so will limit both convective and radiative heat exchange to the room and create uneven space temperatures.

Forced Air Electric Resistance Heat Operation



View of strip heat at top of an air handler. A metal shaving fell onto a strip during careless duct construction.

Electric heating elements, or strip heat, are generally located inside an air handler unit, package terminal unit, or rooftop package unit. This form of heat can be designed to provide all of the heating. Alternatively, the strip heat may act as a supplement or back-up to a heat pump. Care should be taken to protect the heating elements from falling debris during service work. Airflow should be operated within the specific range designed for the heat strip. Cold supply air temperature complaints may be due to an airflow rate that is too high for the strip heater. When strip heat elements are first activated at the beginning of the heating season, a burning odor may be detected as dust and spider webs are burned off.

ELECTRIC RESISTANCE HEAT MAINTENANCE GUIDE

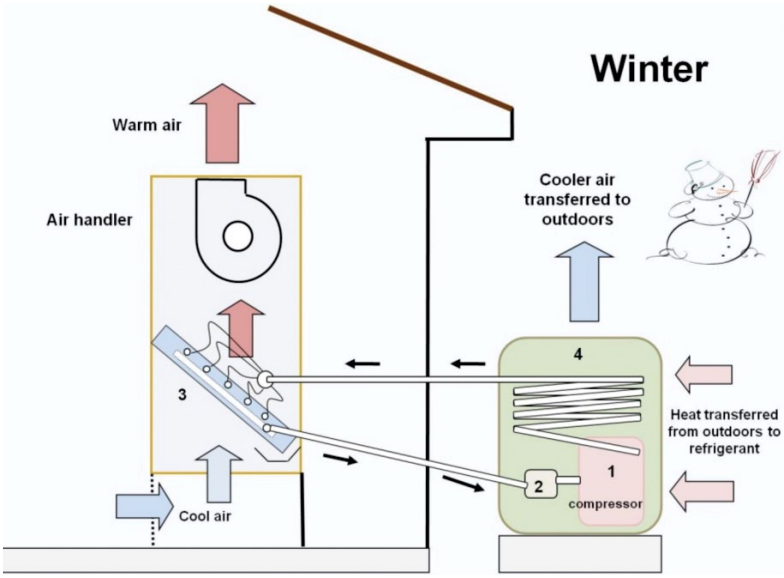
Maintenance	Description
	Annually
Heating elements	Inspect heat elements for corrosion or damage. Replace bad elements. Carefully vacuum dirty elements if needed and inspect duct system and filter assembly for entry points of dirt.
Heat stage	Test proper activation of various stages of heat in multi-stage heater.
Electric power	Inspect wiring and electric connections. Tighten loose wires and replace weathered or nicked wiring. Measure electric heat amperage under operation and verify it is within manufacturer's specifications. Repair or replace equipment operating outside specifications.

Heat Pump Operation

A heat pump is an air conditioner that can also operate in a reverse cycle to provide space heat. To achieve this, a reversing valve allows the refrigerant to flow in the opposite direction. In heating mode, the outdoor coil becomes the evaporator, discharging cold air outdoors; the indoor coil becomes the condenser, discharging hot air indoors (see Figure 3).

FIGURE 3. HEAT PUMP OPERATION IN WINTER

1) compressor 2) reversing valve 3) condenser 4) evaporator



Heating provided by heat pumps is about 2.5 to 3.5 times the efficiency of electric resistance strip heat, depending upon the outdoor temperature. The efficiency and capacity of a heat pump declines as outdoor temperature decreases. So, while a heat pump can still heat at 25°F, it does not deliver as much heat as when it is 40°F outside. For this reason, heat pumps have strip heat available for especially cold periods. Note that adjusting the heating setpoint by 2 degrees or more will activate the strip heat, which can lead to considerable energy waste. This problem is avoided by programming the thermostat to disable the strip heat above a specific outdoor temperature. If the thermostat does not have that capability, an outdoor thermostat can be installed to serve the same purpose.

Heat Pump Maintenance Guidance

Maintenance of the heat pump air handler will be the same as that performed for maintenance of AHUs (see AHU section below). Maintenance of the heat pump outdoor unit is similar to condensing units.

Heat transfer relies upon the coil surfaces remaining fairly clean. Therefore, the outdoor coil must be protected from anything that interferes with airflow around and through it, including snow and ice. Elevating the outdoor heat pump unit 4-8 inches above the surrounding grade will help keep snow from blowing up to and settling against the coils. Snow fence material can also be installed around heat pumps to protect them from wind-driven snow during storm events.

HEAT PUMP MAINTENANCE GUIDANCE

Maintenance	Description
	Annually
Outdoor coil	Clean the outdoor coil and remove any debris such as leaves or dirt from around or near the outdoor unit. Repair damaged fins. Keep snow and ice cleared away and make sure defrost water melt can drain away from the unit without harming building. DO NOT attempt to forcefully remove ice build up from any part of the heat pump. Do use the cooling cycle or warm water to melt ice build-up.
Refrigerant leaks	Inspect tubes and coil for evidence of leaks. Have a leak test done and seal leak on system that requires refrigerant to be added.
Fan	Lubricate fan motor bearings according to manufacturer's recommendation. Inspect fan for damage or unusual vibration or noise. Tighten and adjust fan mounts as needed.
Electric power	Inspect wiring and electric connections. Tighten loose wires and replace weathered or nicked wiring. Measure heat pump amperage under operation and verify it is within manufacture specifications. Repair or replace equipment operating outside specifications.

Gas furnace with panel removed. Cabinet and return duct leakage can interfere with natural draft appliances such as the gas water heater at left.

Gas Furnace Operation

PHA buildings commonly use gas furnaces for space heating. Any space where gas combustion appliances such as a furnace or water heater are located is referred to as a combustion appliance zone (CAZ). A gas furnace consists of a metal cabinet, combustion components, and an internal fan to circulate heated air to the building. Furnace maintenance should focus on 1) fuel delivery, 2) fuel ignition and combustion, 3) heat transfer to air, and 4) combustion venting. When properly installed and maintained, these furnaces operate safely. However, problems related to any one of these four processes can result in unhealthy and sometimes lethal consequences.

Some considerations related to safe furnace operations include the following:

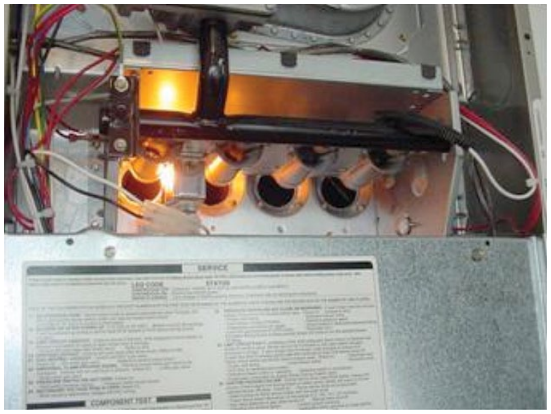
- **PILOT LIGHT:** Older furnaces have a pilot light that ignites gas once the gas valve opens. The pilot light should burn blue at the inner core of the flame and should also surround the thermocouple, causing it to glow red. A pilot light that has to be lit often may be a sign of building airflow imbalance. A building science expert familiar with unbalanced airflows and combustion systems should evaluate this circumstance.

- **ELECTRONIC IGNITION:** Newer furnaces have an electronic ignition that generates a spark to ignite fuel. The igniter should be aligned properly at the front of the burner. Furnaces with electronic ignition that fails to ignite after several attempts will go into a soft lock-out and will prevent further attempts to activate. Units that lock out often should be inspected by a qualified technician.

- **COMBUSTION CHAMBER:** Once the gas ignites, it burns inside the combustion chamber. The flame should appear blue. Improper air-to-gas ratios produce yellow in the flame. Inspections should also look for sooty areas within the combustion chamber. A qualified service technician should service the unit if evidence of soot or yellow flame is observed. Complete combustion requires an adequate amount of air. In many cases, dilution air is also required. This dilution air enters the atmospheric vent and flows out of the building along with the combustion gases to dilute the combustion byproducts and reduce moisture condensation in the vent. Vent openings are provided into the combustion appliance zone in order to provide the required combustion air and dilution air. These combustion/dilution vent openings should comply with the National Fuel Gas Code, known as standard NFPA 54, and applicable codes, and should be inspected periodically to verify that no blockage has occurred.

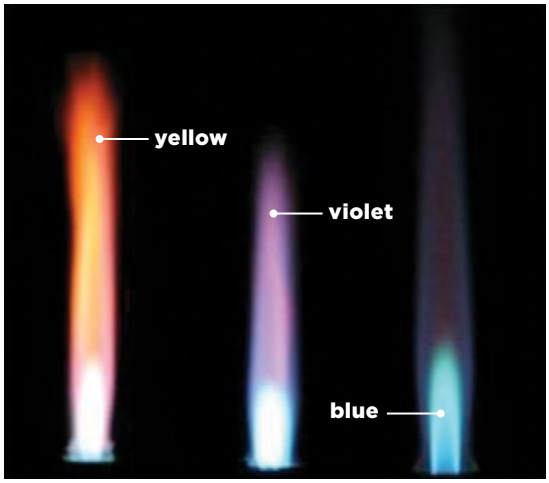
- **STORAGE:** As a safety precaution, the building policy should prohibit storage in either mechanical rooms or mechanical closets that contain combustion appliances.

- **HEAT EXCHANGE:** Heat is transferred from the combusted gas through the heat exchanger located inside the furnace. Generally, the heat exchanger requires no maintenance. However, older systems should be inspected



Furnace electronic igniter glowing brightly just before fuel is delivered.

Light blue flames indicate clean efficient combustion.



Three flames with varying fuel to oxygen ratio. The very yellow flame at far left needs more oxygen and will produce carbon monoxide and fine soot particles. The middle flame has improved oxygen supply, but still needs to produce complete combustion. The flame on the right produces clean and efficient combustion with no visible yellow and a clear blue tip.

for cracks that could allow carbon monoxide (and other combustion gases) to enter into the building.

- **VENTS:** Combustion gas is vented to the outdoors through a vent. Older systems often use a natural draft (or atmospheric draft) vent to carry the combustion gases outdoors. The buoyancy force of natural draft can easily be overcome by space depressurization (caused by exhaust fans, return duct leakage, or AHU leakage), resulting in air quality problems such as spillage, backdrafting, or, in severe cases, flame rollout. Higher efficiency furnaces have fan-powered exhaust since the exhaust temperature is cooler and the draft strength is lower than natural draft. More details on combustion safety can be found in the Health and Safety section of this chapter.

GAS FURNACE MAINTENANCE GUIDANCE

Maintenance	Description
	Monthly or As Needed
Combustion/ dilution air	Verify proper clearance of objects from vents that admit combustion/dilution air into the space.
Air filters	Inspect and change as needed.
Motors and fans	Tighten belts and lubricate bearings.
Combustion	Inspect ignition, pilot light, and burner flame. Verify effective exhaust.
	Annually Prior to Heating Season
Ignition	Inspect pilot light for proper flame and that the thermocouple sensor is within the pilot light. Consider having a building science expert determine if frequently blown out pilot lights are caused by zone depressurization. Inspect electronic igniters to verify proper ignition. Have qualified service technician determine causes of ignition problems.
Combustion	Inspect flames in burners for clear blue flame absent of yellow. Service technician should be used to adjust and clean equipment if yellow flame, soot, or oversized or undersized flames are observed. Inspect combustion vents for damage or blockage. Repair as needed and in compliance with NFPA54. Using a gas leak detector, determine if fuel leakage is occurring at valves and fittings.
Natural draft exhaust	Inspect combustion exhaust vent for damage or blockage. A smoke puffer can be used to verify complete draft up natural draft exhaust vents with the unit operating. Smoke that wafts or "blows" back into space from the entry of the vent indicates incomplete draft, also known as spillage.
Powered draft exhaust	Ensure that the fan operates quietly. Combustion vent duct should be tightly connected to the fan. Perform inspection to verify that the combustion vent is not damaged, leaking, or blocked.
Heat exchanger	Inspect for a cracked heat exchanger by observing for flame modulation or yellow flame. Heat exchanger should be replaced if cracked. Carbon monoxide can be detected in the central air distribution system (after the heat exchanger) if there is a crack in the exchanger.
Lubrication	Ensure all bearings are lubricated per the manufacturer's recommendations.
Motor supports	Check for excessive wear, secure fasteners, and adjust alignment if needed.
Belts	Adjust belts and replace worn or damaged belts.

Central Steam, Hot Water, and Radiator Space Heating System Operations

Central steam and hot water systems are commonly used in large public housing buildings. In simple terms, these systems consist of a boiler that heats water and piping to distribute hot water or steam to radiators located in areas to be heated. The system also has piping that returns the cooler water or condensed steam back to the boiler. In most hot-water systems, pumps move the hot water from the boiler to individual radiators. Thermostats modulate the flow rate of hot water or steam to individual spaces. The boiler burner is activated as needed to maintain an internal boiler temperature, which may be reset based on outdoor temperature.

Distribution Piping Operation

Pipes circulate heated water or steam through the building. Insulate the distribution pipes (especially where the pipes run through unconditioned spaces), and inspect the insulation at least annually or after any service that disrupts insulation. Insulation should not be compressed or have gaps between sections. Replace missing or damaged sections. Address dripping from pipes immediately. Discard and replace wet insulation after pipe surfaces have been repaired and dried. Infrared cameras or spot thermometers can be useful in finding areas that need replacement.

Boiler Operation

Boilers come in different sizes and styles, but all are designed to provide hot water or steam. Boilers are typically either water-tube or fire-tube style. Relatively small boilers operate fairly simply and do not require as much maintenance as large boilers with more complicated systems and controls. In fact, some of the information covered here may not apply to small hot water (also known as hydronic) heating systems.

Keeping daily records of boiler operation is important to boiler maintenance. As a baseline, measure fuel consumption, flue gas temperatures, and water pressures and temperatures during periods when equipment is known to operate as expected. The baseline allows the operator to identify substandard performance and take corrective action before larger problems develop. For example, flue gas temperatures that gradually increase over a period of time could signal a build-up of scale, reduced capacity, and diminished efficiency. Keeping the system clean helps maintain efficiency, durability, and reliability.

Maintenance and operations can affect boiler efficiency, according to the EPA report *Wise Rules for Industrial Energy Efficiency:*

- Optimizing air-to-fuel ratio, burner maintenance, and tube cleaning can save about 2% of a facility's total energy use with an average simple payback of 5 months.
- Tune-ups using precision testing equipment to detect and correct excess air losses, smoking, unburned fuel losses, sooting, and high stack temperatures can result in boiler fuel savings of 2–20%.
- Boiler fuel use can be reduced 1–2% for each 40°F reduction in net stack temperature (outlet temperature minus inlet combustion air temperature).
- Removing just a 1/32-inch deposit on boiler heat transfer surfaces can decrease a boiler's fuel use by 2%.
- For every 11°F that the entering feedwater temperature is increased, the boiler's fuel use is reduced by 1%.

Water Quality in Boiler Maintenance

Municipal water has dissolved minerals, oxygen, and chemicals that can shorten the life of a boiler. Water chemical treatment and softeners are important elements of boiler maintenance to remove dissolved solids and hardness. Deaerators remove oxygen from feedwater to protect the boiler from pitting and corrosion. **In a boiler steam system operating below 300 psi, it is recommended that feedwater have less than 3500 PPM total dissolved solids, maximum alkalinity of 700 ppm, and hardness less than 20 ppm.**

The blowdown system is designed to remove larger pieces of sediment from the boiler. In steam systems, the condensate return unit captures condensed steam to be used again. This conserves water and treatment chemicals, and prevents chemical discharge to the city sewage system. Make-up water should be supplied by nonpotable sources when possible. This would require a catchment system to collect precipitation that can be delivered into the feedwater.

Combustion Equipment

Take care to maintain the combustion part of the boiler. The air and gas must not only be in correct proportion, but also properly mixed to ensure complete combustion. Gas pressure is controlled through a pressure regulator, and a fan controls the volume of combustion air. Combustion fan problems can seriously affect combustion efficiency. Excessive fan noise or vibration is an indication of worn or damaged parts.

Some possible causes for inadequate combustion air:

- Incoming air limited by poorly adjusted dampers or inlet vanes
- Fan inlet or outlet is obstructed

- Air leaks within the system
- Damaged blower wheel or bearings
- Worn or broken fan mount.

The table on the following page provides general guidance for boiler maintenance. The DOE Federal Energy Management Program document *O&M Best Practices Guide, Release 3.0* is a good resource for details on boiler maintenance practices and inspection logs.

BOILER MAINTENANCE GUIDANCE

Maintenance	Description
	Daily
Water level	Inspect water level, test low water cut off. Consider metering feedstock water since this can help determine if system performance is dropping.
Blowdown	Perform blowdown to maintain clean boiler operations.
Visual inspection and record keeping	Make note of: Operating boiler pressure and temperature Feedwater pump operation Feedwater pressure and temperature Condensate temperature Flue gas temperature Gas pressure Oil pressure and temperature
Inspect combustion	Inspect the burner operation, look for signs of poor combustion such as soot, yellow flames, or over- or under-sized flames.
	Bi-Annually
Refractory	Clean and vacuum fireside surfaces as required. Inspect refractory for large cracks or missing pieces. Patch and wash coat as required. Inspect gasketing on doors and replace as needed.
Tubes	Inspect for soot deposits, pitting or deposits. Sooting can be an indication of a burner that needs adjustment. Pitting can be a sign of condensation of flue gas, which can occur due to short firing cycles. Increasing water temperature can produce longer cycles. White deposit on the ends of tube sheet can be a sign of leaks. A boiler service company may need to re-roll tubes.
Boiler / feedwater	Flush boiler with water to remove loose scale and sediment as needed. Check all hand hole plates and manhole plates for leaks at normal operating temperatures and pressures. Open feedwater tank manway, inspect and clean as required.
Combustion	Clean burner and burner pilot. Check pilot electrode and adjust or replace as needed. Clean air damper and blower assembly. Clean motor starter contacts and check operation. Make necessary adjustments to burner for proper combustion and record all results in service report. Perform all flame safeguard and safety checks and record results in service report.
Controls	Clean and inspect low water cut off controls. Remove plugs in control piping; inspect, clean and re-install.
Water treatment	Inspect chemical treatment tanks and pipes for leakage. Check water for proper quality per manufacturer recommendations.
Condensate return	Inspect condensate return pumps for leakage; inspect motor and measure motor amps.
	Annually
Blowdown piping	Inspect piping for obstructions.
Boiler tubes	Clean at least once a year or more often if needed.

Radiator Operation

The radiator transfers heat from the hot water or steam to the conditioned space. Some important things to address for good radiator operations include:

- **TRAPPED AIR IN A HOT WATER SYSTEM:** Over time, air can enter a hot water system, decreasing system efficiency, and should be removed.
- **TRAPPED WATER IN A STEAM SYSTEM:** A banging sound as the radiator begins to heat is a sign of trapped water in a steam system. Steam radiators should have appropriate tilt to allow all condensed water to drain. Tilt should be toward the drain in a one-pipe system and toward the steam trap in a two-pipe system.
- **STEAM TRAP:** A steam trap that needs to be replaced may cause poor temperature control.
- **INSULATION:** Placing insulation or reflective surface behind the radiator will minimize the heat loss to outside. The reflective surface should be durable and cleanable.
- **VENTS:** Steam radiator vents should also be maintained. Vents allow air in the radiator to exit as steam comes into the radiator. They should close once steam reaches the vent. Failure to close properly results in a loss of steam into the space, which can result in overheating of space and wasted energy. Prolonged whistling or air noise indicates that a vent should be cleaned or replaced.

RADIATOR MAINTENANCE GUIDANCE

Maintenance	Description
	Annually or As Needed
Hot water system water level	Bleed air from radiators in hot water systems before the heating season begins.
Zone control	Verify that zone controls work by manipulating thermostats and observing appropriate valve control response.
Steam radiator mounting	Verify proper tilt for draining condensate back to boiler.
Steam system air vents	Inspect vents during operation to verify the close properly and do not allow steam to escape. Clean or replace as needed.
Heat reflector surface	Clean reflective surfaces located behind radiators and secure loose mounts as needed.

Steam Trap and Valve Operation

As steam enters the radiators and releases heat into space, some water vapor condenses into water that must be removed from the steam system. Steam traps

are devices that allow condensed steam (condensate) to be released without releasing steam. Some systems release the hot water to a drain, which wastes water and energy resources. In contrast, better designed systems pipe the condensate back to a collection point to use as feedwater as needed.

Control valves are used to limit water or steam flow, and pressure relief valves maintain safe operating pressures. Various types of valves used in the water or steam distribution system rely on seals that can become worn over time and develop leaks.

The DOE reports that facilities lacking advanced steam plant maintenance programs can lose 20% of the steam generated through leaking steam traps (typically located in unconditioned space so that lost energy escapes to outdoors). Even small losses of steam should be taken seriously because so much energy is required to change water to steam. Programs that use the best equipment and programs can reduce steam leak losses to less than 1%.

STEAM TRAP AND VALVE MAINTENANCE GUIDANCE

Maintenance	Description
	Daily
High pressure steam traps (>250 psig)	Inspect for steam leakage. Short inspection interval is recommended since large quantities of steam can be lost at high pressure traps. Clean or repair as needed, replace when cleaning is no longer effective or about every 3-4 years. Verify that replacement traps are proper trap size.
Pressure relief valves	Inspect for chattering or water leaking. Repair seals or replace valves as needed. Valves rarely utilized in well-maintained systems may last several years before requiring replacement.
	Weekly
Pressure traps operating between 30-250 psig	Inspect for steam leakage. Clean as needed, replace when cleaning is no longer effective.
	Monthly
Pressure traps operating below 30 psig	Inspect for steam leakage. Clean as needed, replace when cleaning is no longer effective.

Air Distribution Systems

In most buildings, HVAC is distributed by means of an air distribution system (ADS). The *intended* goal of the ADS is to deliver air to various spaces in order to maintain desired temperature, RH, and air freshness. The ADS includes fans to move air, heating and cooling systems to condition the air, outdoor air and exhaust systems to control air exchanges with outdoors, and filters to control

particulate levels in the air. This section first discusses background and issues, then covers operations and maintenance priorities.

Background and Issues

Poorly designed or maintained air distribution systems also produce *unintended* effects. For example, air distribution leakage can diminish the heating and cooling capacity of the system, increase energy use, and cause poor indoor air quality.

Duct Leakage

Duct leakage is a large problem in commercial buildings. One study found air leakage from commercial building ducts to be 70 times greater than the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) standard for duct air-tightness. If the ducts are located outside the air and thermal boundary of the building, then these leaks create large energy losses. They also create unbalanced airflows, which produce positive or negative building pressure, which in turn moves air across the building envelope air boundary. If the duct leakage occurs inside the building air and thermal boundaries, then the effects of energy, airflow balance, and space pressure are greatly muted. Even relatively small portions of the air distribution system, such as the AHU, can have significant impacts on duct leakage. This can happen even if the rest of the duct system is very tight. One study of 69 AHUs in Florida found that more than 4% of the total system airflow was leaking into the cabinet of the AHU. Leaks in the AHU cabinet may be relatively small in terms of surface area, but because the operating pressures in the AHU are large, the resulting air leakage into the unit may be quite large.

Leakage in the ventilation ductwork can also occur. The air that leaks into outdoor air ducts from *within* the building air boundary diminishes the amount of "fresh" ventilation air, and may also draw contaminated air from attics, crawl spaces, and basements into the building. In the case of exhaust duct leakage, keep in mind that poorly conducted Test and Balance may add to the problem:

- The air drawn from the building through leaks will add to total building ventilation, but will not show up in measurements of exhaust at the grills.
- Test and Balance will typically measure exhaust only at the exhaust grills; therefore, part of their HVAC adjustments may increase total exhaust fan flow rates to achieve the target airflows at the grills.
- As a result, the building may become more depressurized as a result of Test and Balance work.

Unexpected Interactions

There can sometimes be other unexpected interactions between features of the ADS. For example:

- **LOCATION AND TYPE OF AIR FILTERS:** The location and type of filters can affect both the quantity and consequences of duct leakage. Air filters, which are typically intended to keep ducts, coils, and fans clean, are typically located at either the AHU or at grills. If filters are located at return grills, the return ductwork will operate under greater levels of negative pressure. Greater negative pressure, in turn, causes greater airflow through the return leak openings. Additionally, the air leaking into the return ductwork can carry dust into the system, which will not be filtered because the filter is upstream of the leak sites. By contrast, if the filter is located at the AHU, then the return ducts will be less depressurized, less return leakage will occur, and the dust entering those leaks will be filtered as it enters the AHU. Overall it is best to have a tight duct system with filtration at grills to keep the return duct cleaner.

- **RETURN AIR IMBALANCE:** Some buildings experience return air imbalance, which occurs when the amount of return drawn from a zone is greater or less than the amount of supply air delivered to that zone. This is especially common in buildings where the return(s) are located in the central space while supply air is delivered to rooms that can be closed. When doorways between the interior spaces are closed, the return versus supply imbalance can create either negative or positive pressure in that space, and this pressure can in turn move air across the building envelope. Unbalanced return air can increase the building infiltration rate and, during cold and dry weather, can decrease indoor RH below comfortable levels. In some cases, space depressurization increases the rate of soil gas into the building, such as radon. In other cases, this depressurization causes combustion safety problems (see the Health and Safety section below).

  Improve unbalanced return air by either adding ducted return air to each space that has a door and supply air, or by installing air transfer pathways from the closable room to the central space where return air is located. Transfers may be simple grills through a wall or door. Another method of transfer is to install a short section of duct in attic or ceiling space. The transfer duct is connected to a grill in the room ceiling with the other end connected to a grill in the central space ceiling.

In some cases, the amount of supply air delivered to a space is not proportional to the heating or cooling loads. This can lead to temperature variations and comfort complaints.

Air Distribution System Operations

Pressure Mapping

Pressure mapping can identify when the building or zones within it are operating at positive or negative pressure. This data can provide clues to duct leakage or unbalanced return air. Pressure mapping involves measuring pressures from one room compared to another. These measurements are made quickly using a micromanometer with the AHU operating. Pressures across closed doors should be less than 2.5 pascals (0.010 in WC).

Duct Air-tightness

Duct leakage is very common in light commercial buildings, such as PHA office and common spaces, where it has been found to be about three times greater than in residences. Testing for duct system air-tightness can be useful to understand the performance of HVAC systems and to correct energy waste. It can also help to understand high building infiltration rates or large building pressure differentials. A thorough duct tightness evaluation will involve a tightness test as well as visual inspection. The tightness test uses a special fan to depressurize the duct system to 25 pascals of pressure. The leakage airflow is measured as cubic feet per minute (cfm) at 25 pascals, so the test result is often noted as CFM25. Most ductwork in public housing would fall under the lower pressure classifications typically used in small commercial and residential construction.

A good duct tightness goal for existing ducts in public housing common spaces should be about 0.05 CFM25 / cfm of rated airflow. This would be total leakage of the system divided by the maximum rated airflow of the air handler unit on the duct system being tested. This goal can also be stated as follows: **The total duct leakage, CFM25, should not exceed 5% of the maximum rated airflow (cfm) of the heating/cooling system being tested**. It may be difficult for some systems to reach this goal if the duct system has limited access that prohibits sealing portions of the ducts. Visually small seams and cracks do not appear as significant leaks, and it can even be hard to feel leakage, but they may also have to be sealed to meet a 5% leakage goal.

To improve duct air-tightness:

- Start a visual inspection at the AHU.
- Inspect and seal seams, holes, and penetrations in the AHU cabinet.
- Pay special attention in reinstalling filter access panels after changing filters because such an opening can easily lead to serious depressurization of the mechanical room and perhaps cause backdrafting of combustion appliances.
- Inspect every connection and seam at least once, or after any duct alteration.

- Seal connections with duct mastic according to SMACNA and North American Insulation Manufacturers Association (NAIMA) standards.

Cooling and heating energy savings can vary depending on how much of the duct system is within the air and thermal boundaries of the building. Even duct systems within conditioned space should be reasonably tight to ensure better air quality control. Tighter ducts can result in energy savings from reduced fan power in variable air volume systems.

Filtration

Inspect filters regularly. Replace or clean filters when visual inspection indicates dirt build-up, or based on pressure drop across the filters, or on a pre-arranged schedule. In general, avoid replacing filters before they become dirty because this puts additional load on landfill. Filtration efficiency is classified by Minimum Efficiency Report Value or MERV. Generally, use filters with MERV ratings in the range of 5 to 8.

Filters located at the return grills will cause the ductwork to operate under a higher level of depressurization. Leaky return ductwork will not only lead to increased levels of air leaking into the ADS, but also the unintended airflow will be unfiltered. This entry of dust and particulates can lead to fouling of the heating or cooling coils, and of the ADS interior surfaces. This can foster the growth of mold within the ADS.

Temperature and RH Logging

Indoor temperature and RH can be tracked with logging devices. These logging devices are relatively inexpensive and yet provide powerful diagnostic assessment. The collected data identifies patterns of temperature or RH that can identify system performance problems.

Temperature and RH can be logged at returns and at supplies to identify whether the heating or cooling system is providing conditioned air within performance expectations. For example, the difference in temperature between the supply air and return air should be approximately 18°F–20°F for an air conditioner using direct expansion equipment. The temperature difference between supply and return is much higher for gas furnaces. Supply air temperatures for most furnaces are designed to be around 40–60 degrees higher than the return air. Temperatures outside manufacturers' specifications should prompt further investigation of the system. Causes of low temperature differences can be related to improper refrigerant charge or return duct leakage.

Occasionally, improper thermostat connections made during service allow cooling equipment and strip heat to come on at the same time, resulting in a difference of just a couple degrees between return and supply. Measuring amperage of AHU would determine if the strip heat is activated.

Other aspects to measure for potential improvements:

- **TEST AND BALANCE THE HEATING AND COOLING SYSTEMS:** Test and Balance can be performed to characterize and make adjustments of airflow rates to spaces and should be completed if no record exists or changes have been made to the building or to its HVAC systems. System performance testing can be a useful tool, especially for DX air conditioning and heat pump systems. Perform engineering calculations to convert the measured airflow rates, return and supply temperatures, and supply and return RH into cooling or heating capacity. Compare these calculated values to rated capacity (taking outdoor temperatures into account) to help determine if servicing of the units is warranted.
- **TEST AND BALANCE THE VENTILATION:** Test and Balance firms can also measure the airflow rate of outdoor air and exhaust systems, to confirm whether the required ventilation rates are being achieved. This should also be done if there are no records of previous work or changes have been made to the building or air distribution system. The best location to measure exhaust flows is where the airflow crosses the building envelope (e.g., at the roof). While this will not, in itself, verify that air is taken from each space as designed, it will provide the total airflow from the building. Testing of the exhaust ductwork can determine if significant leakage exists.
- **VARIABLE AIR VOLUME (VAV) SYSTEMS:** With chilled water systems (and some DX systems), the AHUs are often VAV with duct static pressure control. Individual VAV boxes adjust supply airflows to the spaces they serve to maintain the desired space temperature. The speed of the AHU fan is adjusted based on measurement of static pressure in the main duct. When VAV box dampers open to provide more heating or cooling, the AHU fan speed is increased to maintain this static pressure. Achieve energy savings by tuning the operation of the VAV boxes and implementing static pressure reset (e.g., lowering the duct pressure setpoint when airflow needs are reduced). Calibrate the static pressure control and inspect the VAV box damper control annually. Maintenance should include inspection for poor connections or cracked tubes of tubing connected to pressure sensors.

AIR DISTRIBUTION SYSTEM CHECKLIST

1. **PERFORM PRESSURE MAPPING** when any modifications affecting system airflow or distribution are made to the HVAC system, to the building envelope, or to interior partitions. Measure building pressure with the outdoor air (OA) normally open and with it sealed off, and with the AHUs on and off.
   - If the building or spaces within the building are found to be operating at negative pressure, look into the causes of these pressure differentials, including duct leakage, unbalanced return air, and exhaust fan operation.

2. **PERFORM DUCT LEAKAGE TESTING,** if it has never been done or after any HVAC duct modifications, especially:
   - if the ductwork is located outside the building air and thermal barrier,
   - if visual inspection yields suspicion of duct air leakage,
   - if pressure mapping finds the building pressure changing when the AHUs are turned on and the OA is sealed, or
   - if utility bills are larger than expected.

3. **ARRANGE FOR LEAKY DUCTS TO BE SEALED,** using mastic and embedded fabric. Seal cracks, openings, and penetrations in AHU cabinets.

4. **INSPECT FILTERS ON A REGULAR BASIS** (e.g., monthly). Replace or clean filters when visual inspection indicates dirt build-up or based on pressure drop across the filters. Filters with MERV ratings in the range of 5 to 8 will filter well and limit static pressure increase. While filters can be replaced on a pre-arranged schedule, avoid replacing filters before they become dirty because this wastes resources and puts additional load on land fill. If filters are located at return grills, take steps to ensure that the return ductwork does not have significant air leakage, since this can cause contamination of the ADS.

5. **IF HIGHER MERV FILTRATION IS CONSIDERED, CHECK DUCT STATIC PRESSURE** to verify system operation is within the air handler manufacturer's recommended values. If static pressure is too high, the filter surface area may need to be increased. Filter surface area can be increased by going to a deep-pleated filter or fabricating a larger filter rack. Deep pleated filters have a higher first cost, but last longer and may have a lower lifecycle cost.

6. **CONSIDER MEASURING SYSTEM AIRFLOW,** as well as temperature and RH, at returns and supplies as needed in zones with comfort complaints. This information can be used to characterize the performance of AC or heat pump systems and indicate whether servicing of these systems is required.

7. **CONSIDER PERFORMING TEST AND BALANCE ON THE HVAC SYSTEMS:**
   - If significant changes are made to the HVAC systems (e.g., AHU replaced, ducts added, or new building addition),
   - if pressure mapping finds significant pressure imbalances, or
   - if comfort problems are reported and not easily remedied.

   If airflows are found to be out of compliance with the design documents, make sure that these airflows are properly adjusted.

8. **WITH VAV SYSTEMS, PERIODIC COMMISSIONING OF THE AHU AND VAV BOX CONTROLS IS RECOMMENDED** (e.g., every 5 to 10 years). Consider implementation of static pressure reset (which would be implemented automatically through the building automation system when total heating or cooling load is reduced) to achieve energy savings. Check dampers and linkages to ensure that intended airflows are achieved in response to the automation system controls.

9. **INSPECT ALL REGISTERS FOR RESTRICTIONS TO AIRFLOW** such as covers over supply vents or furnishings placed in front of return or transfer grills.

Air Handler Units

Air handler units (AHUs) distribute conditioned air and are available in a wide range of sizes, depending upon the amount of air to be distributed throughout a zone. An AHU consists of a metal cabinet and an electric powered fan. The AHU may also contain cooling coils, heating coils, and electric resistance heating elements. Classifications of air handling units depend on where and how they are used. Three types are commonly used in PHAs:

Inside view of AHU with blower above evaporator coil. Electric heat element is located above the blower.

- **FAN COIL UNIT:** This unit is simply a cabinet with a fan and a heat exchange coil inside. Fan coil units are typically associated with chilled water systems.
- **ROOF TOP PACKAGE UNIT (RTU):** An RTU consists of a metal cabinet that contains not only the air distribution blower, cooling and heating exchangers, but also all of the components that would normally be in the outdoor unit of a split DX air conditioner (the compressor, the condenser, and the condenser fan). As the name implies, RTUs are designed to be located on rooftops requiring only a return and supply duct connection to be made to them. They vary significantly in size from 3 to well over 100 tons, serving areas of perhaps 1,000 to 50,000 square feet and more. Outdoor ventilation air is drawn into an opening in the side of the cabinet. Some RTUs are specially designed to condition 100% outside air.
- **PACKAGE TERMINAL AIR CONDITIONER (PTAC):** A PTAC is a self-contained unit like an RTU except it is generally much smaller and is designed to be installed through an exterior wall. PTACs may provide heating by means of electric resistance elements or heat pump. They are designed to distribute conditioned air into a small open area without a duct system.

PTAC unit was not tilted toward the drain correctly and water spilled from condensate pan onto carpet below.

Sealing AHU Panel Leakage and Penetrations

Air handler units (AHU) are not, by design, airtight. In most cases, they come from the factory with leaks at a variety of seams and penetrations. After an AHU has been installed, additional leakage may exist. Many AHUs used in common areas of PHA property are residential class units. Manufacturers rely on technicians to properly seal penetrations where wiring and refrigerant lines penetrate the cabinet. Relatively small holes or cracks may seem too small to have much impact. However, since the fan is located in the AHU, air pressure inside the AHU cabinet is higher than at any other location in the air distribution system. This powerful pressure differential can produce substantial air leakage through even very small holes. Many AHUs have a draw-through design, resulting in most of the cabinet under negative pressure, which means air leakage gets sucked into the cabinet instead of blown out. Even new AHU cabinets can leak about 4% of the total system airflow.

Roof top package unit leakage through loose panels.

The energy penalty of this leakage varies considerably depending upon the AHU location. If located inside the building, these leaks may cause little or no energy use increase. However, if located in an attic, system efficiency from AHU cabinet leakage alone during the hot hours of the day can decrease system capacity and efficiency by more than 10%.

This type of leakage can have two types of significant impacts in the Northern United States:

- **INCREASED ENERGY WASTE:** Depending upon unit location, AHU cabinet leakage can increase cooling energy costs by 10% or more in cold climates.
- **POOR AIR QUALITY:** Air leaking into the AHU cabinet carries unfiltered particles such as allergens, mold spores, and dust. These materials can build up on surfaces inside the AHU, including the cooling coil, insulation materials, fan motor and blades, and condensate drain pan. This build-up of dust and dirt can become the nutrient for mold growth, which can become widespread inside of AHU cabinets. Air handling equipment in locations such as garages, crawl spaces, attics, mechanical rooms, or shops will draw any pollutant present in those spaces, including carbon monoxide, into the conditioned space.

AHU cabinet leaks are generally easy and inexpensive to repair. Gasket material is best to seal panel seams, since it should not have to be replaced every time the access panels are opened. Tape is a temporary alternative, as it will not

hold well when exposed to rain or extreme temperatures. Tape adhesive also leaves a grimy residue on panels and has to be replaced every time service panels are opened. Penetrations should be sealed carefully using HVAC putty. While foil tape can be used to seal panel seams, it does not effectively seal around wire and pipe penetrations.

Evaluating Moisture Problems Inside the AHU

Even though the eastern part of the northern climate zone is dominated by cold weather, warm and humid weather may also occur for weeks when air conditioning may be used. Moisture can accumulate inside air handlers during hot and humid weather for various reasons.

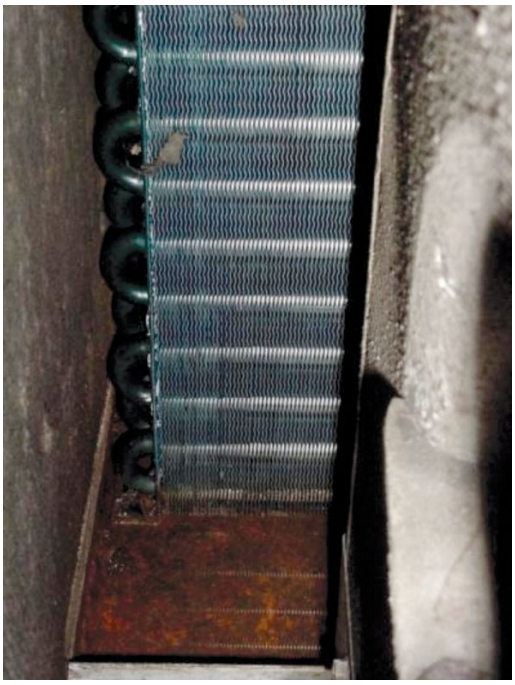
Sometimes clues are evident even before opening the access panels for routine inspections. Condensation on lower portions of the AHU exterior or water dripping from the AHU can indicate moisture problems.

As initial steps:

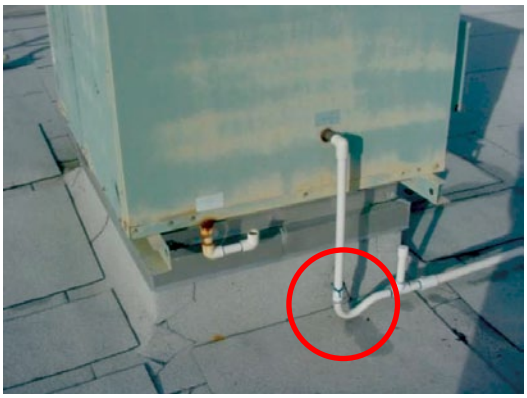
- **INSPECT THE INSIDE SURFACES OF THE BOTTOM PANEL** of the AHU for water or wet insulation. A section of panel insulation will likely have to be pulled back for this inspection. The panel surface and insulation should be dry. If wet, look first at the drain pan to ensure it is not full or spilling over.
- **INSPECT THE DRAIN PAN** to verify there are no leaks. The exterior sides of the drain pan should be dry with no evidence of watermarks.
- **LOOK FOR EVIDENCE OF MOISTURE BLOWN FROM THE COIL** onto surfaces downstream. This can occur when air velocity is too high for a particular coil, which might require duct or airflow modifications.

Wet building materials that cannot dry out also provide an excellent environment for mold growth. Proper condensate trap design is often overlooked. Traps should be deep enough to ensure that they do not dry out easily, that the traps do not leak water, and that air handler pressure cannot suck water back into the system.

Condensation at bottom of air handler caused by wet interior insulation, rendering the insulation useless.



Standing water in pan below a clean cooling coil. Corrosion or sludge can result in water spilling over pan.



A primary condensate trap (right) and secondary trap on a rooftop package unit.

Cleanout caps should remain closed to avoid air rushing into the drain line and restricting drain pan drainage. Open condensate lines act as a duct leak. In some draw-through type air handlers, this air has high enough velocity to splatter water collected in the drain pan onto interior surfaces. Maintenance programs should evaluate the traps to determine if modification is needed. (For more information on air conditioning condensate trap design, refer to an article in *Heating/Piping/Air Conditioning Engineering Magazine* at http://hpac.com/air-conditioning/condensate_traps_brusha/)

One last thing to consider is where the air conditioning condensation line ends. Termination points should be located in places that will not be exposed to toxic substances that could adversely impact air quality in the event the trap becomes empty. Condensate lines should never be terminated inside sewer lines, near combustion vents, or near the ground where pesticides may be applied.

AIR HANDLER MAINTENANCE GUIDANCE

Maintenance	Description
	Weekly
Unit inspection	Observe each unit to verify that it is operating as expected. Indications of problems should be recorded such as: • excessive vibration and uncharacteristic noise (squeak, rattle, hum), • loose access panels and unsealed cabinet penetrations, • surface condensation or dripping off of cabinet, and water leakage from the drain pan.
	Bi-Annually or As Needed
Vibration	Immediately inspect systems with excessive vibration in motors and fans.
Fan motor condition	If a problem with the fan motor performance is suspected, evaluate through temperature or vibration analysis compared to baseline values. Electric performance can also be measured using a power analyzer and compared to manufacturer specifications.
Check belts and pulleys	Adjust all belts and pulleys.
Bearing lubrication	Ensure all bearings are lubricated per the manufacturer's recommendation. Sealed bearings may not need maintenance. Elevated temperature at bearings is an indication of advanced wear.
Motor supports and alignment	Check for excessive wear, adjust and secure fastening as needed. Align the motor coupling to allow for efficient torque transfer.
Cabinet insulation	Inspect the condition of insulation inside the air handler to look for damaged or missing sections. Check to see if insulation is wet and determine cause. Repair or replace insulation as needed.
Clean interior air handler, coil and fan blades	Inspect the interior of the AHU. Clean as needed. A good filtration program will keep equipment clean and minimize the need for time-consuming cleaning. If filters are located at the return grill, then dust entry may be occurring through return duct leaks. Consider repairing the return leaks or locating an additional filter in the AHU. Also make sure that outdoor ventilation air is filtered prior to entering the AHU.

Maintenance	Description
Inspect blower drive	Inspect drive belts, pulleys, and bearings for wear. Adjust, repair, or replace as necessary. Some blowers are connected to a motor indirectly through a belt drive. Lubricate unsealed bearings.
Cabinet leakage	Check that panels fit tight with gaskets providing complete seal. Repair bent panels and replace damaged gaskets and missing screws. Make sure that filter access panels are put back into place and sealed tightly. All penetrations should be sealed.
Filter rack	Carefully inspect filter rack to see that it holds all filters tightly in place with no gaps either between filter sections or around the filter rack assembly. Repair deficiencies that permit air to bypass filters. Replace filters according to schedule or alternatively based on static pressure across the filters. Replace when pressure target is reached.
Condensate	Inspect drain pan for cracks or leaks. A system that properly drains condensate and is operated cleanly should not have the presence of sludge in the pan. Drain pan should slope towards drain and be free of any sludge. Clean and disinfect drain pan if there is evidence of microbial sludge. Flush out condensate drain traps and lines. Make sure the condensate drain line has a trap. Make sure traps are full of water and functioning properly.
Moisture inspection	Inspect during hot and humid weather. The interior of the air handler should be dry, with the exception of the cooling coil and the drain pan.
Electric	Verify that service power and control wire connections are tight. Replace wires that have damaged insulation jacket. Replace missing or damaged electric service cover plates.

Ventilation

Ventilation is the process of intentionally moving air between the indoors and outdoors to maintain acceptable indoor air quality. This section provides a fuller understanding of the issues related to ventilating PHA common spaces.

Background and Issues

Outdoor air (OA), introduced through the central heating and cooling system, dilutes indoor contaminants and produces pressurization of the space. Exhaust fans can capture air contaminants that are contained within a specific zone and also dilute contaminants. They produce space depressurization. The requirements for ventilation for specific types of buildings are listed in building codes and in applicable standards, such as ASHRAE Standard 62.1. Many jurisdictions have adopted the requirements of the ASHRAE standard.

Air Infiltration

Infiltration, which can be understood as the *unintended* introduction of outdoor air into a building, can contribute to space ventilation. Infiltration can occur either by means of natural infiltration (driven by the forces of wind or temperature

differential) or by mechanically driven forces (driven by duct leaks, unbalanced return air, etc.). In most cases, infiltration cannot be counted on to provide reliable and predictable ventilation. Several types of tests, performed by trained and qualified contractors, help the facility manager understand the amount of air exchange that is occurring because of infiltration or from operation of the ventilation systems:

- Blower door testing can measure the envelope air-tightness, which can predict "ballpark" natural infiltration.
- Duct air-tightness testing can help determine the levels of mechanically induced infiltration (especially if the ducts are located outside the envelope air boundary) that occur when the AHU fan is operating.
- Tracer gas decay testing can characterize the actual air exchange rate under specific operating conditions.

Ventilation from Outdoor Air

Unlike infiltration, ventilation is the *intended* introduction of outdoor air into a building. Ventilation can be implemented by introducing OA into the heating or cooling system, where it can be conditioned and distributed to the occupied space.

Scheduling of OA ventilation can create problems. In many systems, the AHU fan cycles on and off (fan AUTO) in response to the call for heating or cooling. When OA is introduced through the system and the AHU cycles, the amount of ventilation air delivered to the space is a function of the heating or cooling load. Periods of high load produce greater ventilation, while periods of little or no load lead to little or no OA introduced into the space. Alternatively, the AHU fan can be set to operate continuously (fan ON), thereby providing ventilation air continuously.

Drawbacks to continuous AHU fan operation include:

- Air leakage in the ductwork or AHU cabinet can create energy losses and lower indoor RH levels during cold weather.
- Conductive losses and air leakage losses from ductwork can increase heating loads, increase fan energy consumption, increase utility costs, and waste energy.
- During the cooling season, moisture remaining on the cooling coil can be evaporated back to the space when the compressor cycles off, raising indoor RH by as much as 20%.
- OA introduced when the heating source has cycled off can produce cold discharge air from registers and accompanying comfort complaints. It can even lead to freezing of hydronic coils .

Ventilation from Exhaust Systems

Exhaust systems can also create ventilation. While OA is introduced through the central space conditioning system and produces positive pressure in the building, exhaust fans draw air from the building and may create negative pressure (Figure 4). Negative pressure, or depressurization can create combustion safety problems discussed in the Health and Safety section below. Depressurization, may also result in over-ventilation that can cause excessively low indoor humidity during cold weather.

FIGURE 4. NEGATIVE PRESSURE CREATED BY OUTSIDE AIR

When exhaust air exceeds the air flow that is pumped into a building, the space can go to negative pressure. This can result in excessive infiltration rates and combustion safety problems.

Ventilation Operation

Filtration

The OA introduced into the central system should be filtered in order to avoid dust and particulate build-up on the heat exchange surfaces of the system (coils and heat exchangers) and internal surfaces of the distribution system. OA filters may need to be replaced or cleaned more frequently than circulation air filters.

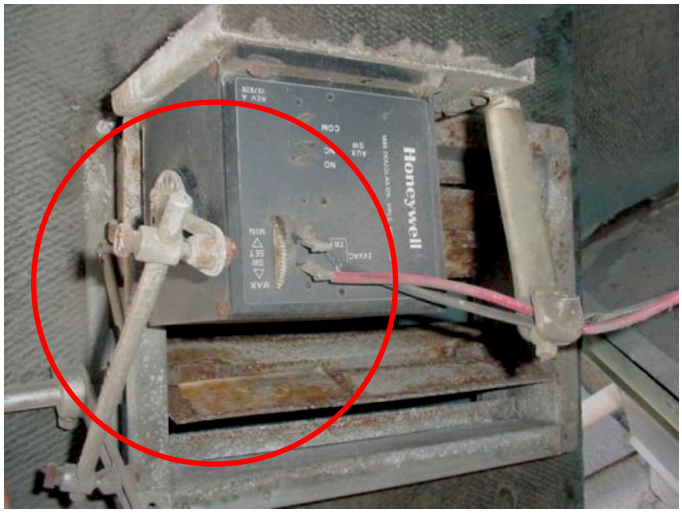
Outdoor Air Intake

Where to locate the OA intake is as much a matter of where **not** to locate it:

- The OA intake should not be located within 25 feet of contaminated sources such as the discharge of exhaust fans or plumbing stacks.
- OA should not be drawn from locations near garbage dumpsters or loading docks.
- Designated outdoor smoking areas should also not be located within 25 feet of air intake.
- Introduction of contaminated air during special events should be avoided. If a new roof (such as hot-mop asphalt roofing) is being installed, for example, seal off the OA during the period while chemical vapors are being emitted. Likewise, if outdoor smoke (such as from nearby forest fires) or smog exists, shut down the OA intake. It will be important to re-open the OA vents when the temporary air contamination event has passed.

Ventilation Requirements

Commissioning or retro-commissioning should be implemented for the HVAC systems to make sure that sufficient ventilation air is provided to the space.



Small ventilation damper showing signs of damper and linkage corrosion.

Damper settings, linkages, and control sequences should be checked and adjusted. It is common for OA dampers/linkages to lose functionality because of corrosion, especially in coastal areas because of air-borne salt. Once Test and Balance has been implemented, mark damper settings so that staff can verify proper damper position. Ventilation can be spot-checked by means of a portable carbon dioxide (CO_2) measurement device. People breathe out CO_2 as a byproduct of respiration. Thus, while CO_2 is not a pollutant at normal levels, it can be a flag to indicate if ventilation rates are sufficient. Indoor CO_2 levels significantly above about 1000 parts per million (ppm) after 3–4 hours into the work day indicate insufficient ventilation for an office space.

Table 1 shows the indicated ventilation rate per person for different measured indoor carbon dioxide concentrations after 3–4 hours into the work day (assuming an outdoor concentration of 400 parts per million).

TABLE 1. CO_2 THAT RESULTS FROM VARIOUS VENTILATION RATES AFTER A SEVERAL HOUR EQUILIBRIUM PERIOD

Carbon Dioxide Concentration (ppm)	cfm per person
2520 ppm	5
1460 ppm	10
1100 ppm	15
930 ppm	20
824 ppm	25

ASHRAE Ventilation Standard 62 recommends different ventilation rates for commercial property based on type of use and area of the space, as well as the design occupancy. Most PHA common areas can be ventilated effectively at about 15 cfm/person while occupied. While under-ventilation is a problem to avoid, excessive ventilation can create substantial problems as well, including the potential of not meeting space conditioning loads (comfort problems), energy waste, or low indoor RH during cold weather. Older buildings may have been built when recommended ventilation standards were much lower. This means that the air conditioning equipment may be sized for only 5 cfm/person.

Scheduling Ventilation

Since ventilation adds to heating and cooling loads, it should be turned off or modulated during periods when the building has no or reduced occupancy. Exhaust fans can be programmed to turn off during "after hours" periods, and OA dampers can be automatically closed. Operating this way avoids energy waste and low indoor humidity. Even when the building is occupied, occupancy may not be constant. More advanced ventilation control can "sense" the number of people in the space through measurement of CO_2 in the indoor air and adjust the position of the OA damper. Keep in mind that if OA is reduced but the exhausts

continue to run, then the space may go to negative pressure, which could create combustion safety problems. If the HVAC system uses CO_2 sensors to control ventilation, it will be important to check the calibration of these sensors on a yearly basis. New CO_2 sensors can be added to existing systems for about $1,100 each ($250 for the sensor and $800–$900 for installation). This can be cost-effective for zones with highly variable occupancy that are difficult to predict by schedule. If occupancy is reasonably predictable, then control of ventilation by a clock schedule is more cost-effective.

Avoiding Health and Safety Problems

High indoor RH and mold should be avoided. While there are many causes of moisture accumulation and mold growth in buildings, one common cause during cold weather is the internal generation of humidity within a tight building and low ventilation rates. Increasing the ventilation rate can correct this situation. It is even possible to control OA dampers or exhaust fan operation based on humidistat control. Winter mold growth can also occur when portions of the envelope are poorly insulated, causing portions of walls, ceilings, etc. to fall to temperatures below the indoor dew point temperature. Indoor relative humidity should generally be between 35%-65% RH. RH greater than 65% should prompt action to reduce internal sources of moisture if feasible, and consider increasing ventilation during the winter when air is dry. Low RH is more of a comfort problem so RH lower than 35% is not particularly bad unless occupants are expressing discomfort.

To avoid combustion safety problems related to ventilation and space depressurization:

- Make sure that exhaust air flows do not exceed OA flows for the building as a whole.
- Make sure that mechanical rooms and other zones with combustion appliances CAZs do not operate at negative pressure. If return leaks from air handlers or ducts are depressurizing that CAZ, then take steps to seal the return leaks or add supply air to bring the space to neutral or positive pressure.

VENTILATION MAINTENANCE GUIDANCE

Maintenance	Description
	Monthly or As Needed
Damper and drive	Inspect dampers and drive assemblies to verify damper stops are correct. Verify damper stop is 100% closed when no ventilation is required. Lubricate according to manufacture recommendations. Adjust drive actuator, linkage, and dampers as needed. For more details on HVAC O&M practices, refer to ASHRAE Standard 180-2008.
Filters and screens	Inspect air filters and replace based on inspection, or measured static pressure across filter. Intake screens should be clean and mechanically secure.
Rain louver	Inspect the louvers of OA intakes to be sure they prevent wind-driven rain from entering. If rain sometimes enters the OA intake duct, a section of sloped duct can be placed at the intake in a way that allows water to drain to the outside.
Exhaust operation	Help avoid building depressurization by turning off exhaust when not needed. Verify shutdown occurs as scheduled.
Ventilation effectiveness	Use handheld device to measure CO_2 in different zones and use as an indication of proper ventilation.
	Annually
Ducts	Inspect duct connections for leakage. Seal leaks with mastic. Inspect duct mechanical hangers. Repair as needed.
Measure outside air	A Testing and Balance firm should set OA amounts as required if no record exists, or after any system repairs, building modification, or change in occupancy has occurred. Damper position stops should be clearly marked.
Source contamination	Verify that the intake is at least 25 feet from any potential source of pollutant or odor source such as exhaust discharge, sewer vents, transportation loading areas, gas combustion vents, and cooling towers.
Building pressurization	Measure CAZ pressure compared to outdoors during typical building operations (with little or no wind) to verify that the CAZ does not operate under negative pressure. If CAZ depressurization exists, repair return leaks, add supply air, or otherwise bring CAZ to neutral or positive pressure.
Over/under ventilation	Consider building ventilation testing by a building scientist, or duct tightness tests when difficulty in controlling ventilation persists.

EXHAUST FAN MAINTENANCE GUIDANCE

Maintenance	Description
	Monthly or As Needed
Belts	Inspect and tighten or change as needed.
Motors and fans	Lubricate bearings according to manufacturer recommendations. Tighten motor mounts. Check pulley revolutions per minute (rpm).
	Annually
Duct	Inspect duct connection to exhaust unit. Inspect duct connections for leakage. Seal leaks with mastic. Inspect duct mechanical hangers. Repair as needed.
Fan housing	Inspect housing mounts for proper fastening to roof curbs or other structure.

Comfort Controls

Comfort controls are devices such as thermostats and ventilation controls intended to maintain a desired temperature and air quality. This section discusses sensors and their limitations in controlling comfort, followed by a brief summary of comfort controls operations and maintenance practices.

Background and Issues

Air is generally regarded as a simple invisible gas, but it is actually a complex mixture of gases, water vapor, and particles having thermal energy. The condition of air determines how comfortable and healthy the environment is for people. HVAC systems can and often do control a variety of indoor environmental factors including temperature, levels of air contamination, and ventilation rates.

Thermostats

Thermostats control space temperature. A key characteristic of thermostats is "dead band," which is also related to the cycling rate of the heating and cooling system. Dead band is the temperature range from when the system turns on to when it turns off. Thermostats commonly operate with a dead band of 2°F–3°F. For heating systems, this dead band may be an adjustable value, allowing the facility manager to select a cycling rate appropriate for the type of heating system. Hydronic radiator heating with water or steam, for example, may require considerably longer cycles, since the mass of the heat distribution system and heat transfer rate from the boiler to the room air is much longer than for systems that use air distribution. The thermostat then needs to anticipate that considerable heat is stored in the piping and radiators, increasing the potential for overheating the space if the system continues to provide heat to the space without proper anticipation.

Thermostats that control space cooling normally do not have adjustable dead bands or cycle rates. One major manufacturer designs thermostats to cycle the AC system three times per hour when operating at 50% of full load (10 minutes on, 10 minutes off, 10 minutes on, etc.). Some thermostats cycle the system more often, with five or more cycles per hour. This short-cycling can cause the AC system to not dehumidify as effectively, because it takes several minutes for the cooling coil to become fully cold.

Ventilation Control

Ventilation can be controlled based on schedule or occupancy detection. To save energy and improve control over indoor RH, it is good practice to shut off exhaust fans and close outdoor air dampers during unoccupied periods. Occupancy detection can be achieved by occupancy sensors or by carbon dioxide detectors,

either of which can activate the ventilation systems when it detects occupants in the building. Carbon dioxide control will save more energy because the ventilation will not activate until a sufficiently large number of people are in the building, raising indoor carbon dioxide levels to approximately 1000 parts per million (ppm).

Comfort Control Operation

Temperature Control

The following measures can help control temperature:

- **CONSIDER TURNING OFF THE HVAC SYSTEMS AFTER BUILDING OCCUPANTS HAVE LEFT FOR THE DAY.** This practice includes adjusting the temperature setpoints and shutting down the exhaust and OA flows.
- **ADJUST THE PROGRAMMING OF THE THERMOSTAT OR AUTOMATION SYSTEM** to initiate system start-up sufficiently early in the morning, so that the building can return to acceptable comfort conditions by the time the work day begins.
- **EXAMINE SOURCES OF HEAT OR COLD THAT MIGHT AFFECT CONTROL**, if temperature control complaints are reported. Re-calibrate thermostats in these areas.
- **AVOID LOCATING THERMOSTATS ON EXTERIOR WALLS**, where the sun can shine on the controller, or near heat-generating office equipment.
- **CONSIDER USING LOW-COST TEMPERATURE AND RH DATA LOGGERS** to track indoor conditions at the thermostat and at other locations within the space over a several-day or longer period. This will allow detection of temperature variations across the space and through time.

Control of Ventilation and HVAC

- **SHUT DOWN EXHAUST FANS WHEN THE BUILDING IS UNOCCUPIED**. Shut outdoor air dampers, to fully closed or mostly closed, during unoccupied periods.
- Use a **BATTERY BACK-UP** for clocks used to control HVAC equipment to maintain correct time during power outages.

COMFORT CONTROLS MAINTENANCE GUIDANCE

Maintenance	Description
	Daily
Sensor	Verify that space conditions are maintained within reasonable expectations. Investigate wall thermostats for exposure to sources of heat or cold.
	Quarterly
Clock schedule control	Check clocks and adjust time as needed.
Space condition trending	Record hourly temperature and relative humidity for a typical week during different seasons to verify conditions are maintained as expected. If building system doesn't have equipment to do this, small loggers can be purchased for this task (price about $80).
Heating/ cooling system performance	Use loggers placed at a return and one at a supply to evaluate temperature difference across heat exchangers, and the delivered supply air temperature.
	Annually
Thermostats, occupancy sensors, and CO_2 sensors	Calibrate control sensors according to manufacturer specifications. Replace or calibrate sensors that perform outside the manufacture specifications. Use high accuracy sensors when replacement is needed.

HEALTH AND SAFETY

Health and safety are the highest priority in any operations and maintenance program. Many aspects of HVAC operations and maintenance affect health and safety, either directly or indirectly, as discussed throughout this chapter. This section discusses two important areas of concern: mechanical rooms and combustion safety.

Mechanical Rooms

A mechanical room houses HVAC equipment. Sometimes, non-HVAC items are also stored in them, which, in some cases, detrimentally affects air quality. Mechanical equipment in this space can also have unintended impacts on air quality and safety. This section covers some of the complex interactions that may affect health and safety, and it concludes with operations and a chart on maintenance guidance.

Background and Issues

Field research has found that air distribution systems, including ductwork, plenums, and AHUs, experience large amounts of duct leakage, as discussed

previously. These leaks are often drawn from the mechanical room in which the AHUs are located.

Air distribution system leakage can create energy waste and indoor air quality problems through three ways that have implications for mechanical rooms:

- **AIR DISTRIBUTION SYSTEM LEAKAGE CAN TRANSPORT POLLUTANTS FROM A CONTAMINATED SPACE INTO THE CONDITIONED SPACE.** If zones that contain AHUs or ductwork contain air contaminants, those pollutants will almost certainly be delivered into the conditioned space. For this reason, mechanical rooms must be kept clean and dry. Standing water can lead to growth of mold, bacteria, or algae, especially if it comes into contact with dirt or soft building materials. Do not store chemicals, wet mops, or full mop buckets in mechanical rooms. These materials should be located in a janitorial closet with an appropriate sized exhaust fan. Mechanical rooms below grade may have mold and musty odors, because of contact with cold soil and elevated levels of radon, each of which can be transported to the conditioned space.

- **AIR DISTRIBUTION SYSTEM LEAKAGE CAN PRODUCE SPACE DEPRESSURIZATION THAT CAN CAUSE THAT SPACE TO DRAW CONTAMINANTS INTO THE BUILDING.** Return leaks can produce depressurization of the mechanical room, which can draw radon, sewer gases, and combustion gases into the mechanical room. These will, in turn, be drawn into the air distribution system and into the conditioned space. If the space pressure becomes sufficiently negative, sewer gases may be drawn from drain traps, especially if there is little or no water in the trap.

- **AIR DISTRIBUTION SYSTEM LEAKAGE CAN PRODUCE SPACE DEPRESSURIZATION THAT CAN ACTUALLY GENERATE AIR QUALITY PROBLEMS.** Return leaks may cause depressurization of the mechanical room or other spaces in the building. This depressurization can transport high moisture content air (especially during hot and humid weather) into interstitial cavities. Moisture build-up in building materials can lead to mold growth, and spores and mold odors can then be transported into the building. This depressurization can, if the level of depressurization is sufficiently aggressive, also cause large rates of carbon monoxide generation (see below).

Operations

To prevent health and safety problems related to mechanical room operations:

- **KEEP MECHANICAL ROOMS CLEAN:** Mechanical rooms that contain AHUs should be kept clean and dry, because the air in those rooms is also transported through leakage to the conditioned space.

- **MAKE SURE THAT AIR CONDITIONING CONDENSATE IS CAPTURED AND DRAINED:** Condensate pumps may be used to remove condensate from sealed combustion gas furnace and water heaters. Condensate pumps and lines should be inspected every three months to verify that lines are clean and clear, and that the pump is in good working order. Inspection of the pump should verify that it operates when water is present at its collection point. If the pump is not running at the time of inspection, some water could be added to the collection point to force the pump to operate. If pump does not operate, verify that there is electric power supplied to the pump and replace pump if needed. Inspection of condensate lines and pans should look for evidence of cracked or blocked lines indicated by drips, or by water backed up higher in pans or other collection reservoirs. The lines should be pulled and pressurized air or water forced through them at least once a year to keep lines cleared of debris.
- **CHECK MECHANICAL ROOM PRESSURE:** Using a manometer, measure the pressure in the mechanical room with reference to the interior spaces of the building and also with respect to outdoors. If the room is operating at a negative pressure compared to outdoors, take steps to bring the room to neutral or positive pressure. Sometimes mechanical rooms are built to be part of the return air system and are therefore intentionally depressurized. If depressurization is creating problems, it may be necessary to hard-duct the return directly to the AHU.
- **SEAL RETURN SIDE AIR LEAKAGE:** While sealing all duct leakage is good practice, it is especially important for mechanical rooms that may have mold and musty odors, vented combustion appliances, or radon in soil below a mechanical room.

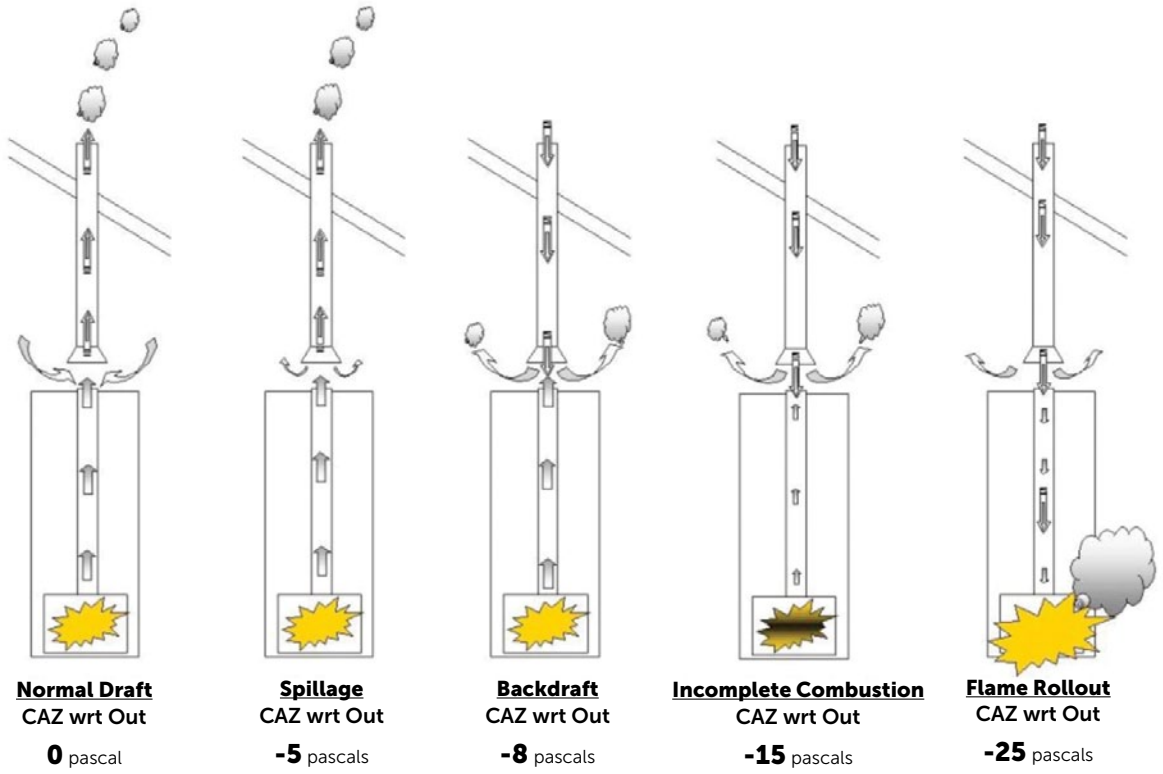
Combustion Safety

Background and Issues

Vented combustion devices, such as gas water heaters, gas or oil furnaces, and gas or oil boilers, produce combustion byproducts such as carbon dioxide, carbon monoxide, water vapor, nitrogen oxides, small diameter particulates, and other products. In large part, these effluents are dangerous to human beings. Therefore, it is important that they are vented to outdoors. In many cases, proper venting depends upon the buoyancy of the hot gases to move them upward through a vent and successfully deliver them to outdoors. This buoyancy is a relatively weak force and can be easily overcome by negative pressure in the combustion appliance zone (CAZ). Four stages of space depressurization impact should be considered and avoided (Figure 5):

- **SPACE DEPRESSURIZATION OF AS LITTLE AS -3 TO -5 PASCALS** can induce a phenomenon called "spillage," where only a portion of the combustion byproducts are captured by the venting system. In this case, a portion of the byproducts spills into the CAZ.
- **SPACE DEPRESSURIZATION OF AS LITTLE AS -5 TO -8 PASCALS** can produce "backdrafting," where the combustion appliance vent reverses direction of flow. In this case, all of the byproducts spill into the CAZ. With either spillage or backdrafting, the combustion gases and particulates will, in many cases, be drawn into the air distribution system (through leaks in return ducts and AHUs) and delivered to the conditioned space. With fuels such as natural gas or propane, there may be relatively little odor to alert building occupants to the presence of carbon monoxide and other dangerous combustion byproducts.

FIGURE 5. COMBUSTION SAFETY PROBLEMS CAUSED BY DEPRESSURIZATION OF THE COMBUSTION ZONE



Negative air pressure in combustion appliance zones interferes with drafting of atmospherically vented appliances. This can result in minor to dangerous conditions depending on the level of depressurization.

Source: Florida Solar Energy Center

- **SPACE DEPRESSURIZATION IN THE RANGE OF -15 TO -20 PASCALS** can create a particularly dangerous circumstance of "incomplete combustion." The relatively strong negative pressure in the CAZ causes air to flow downward through the vent at a high velocity. This airflow discharges from the vent onto the top of the water heater or other combustion device, impinging upon the discharge of the appliance flue (which is the vent inside the combustion appliance). The flue continues to vent upward into the room, but with reduced airflow. This reduced rate of airflow in turn slows the entry of combustion air into the combustion chamber of the water heater. With insufficient combustion air, the appliance that might otherwise produce little carbon monoxide (say, in the range of 10 ppm) might suddenly produce very large amounts of carbon monoxide (perhaps in the range of 50,000 ppm). These high levels of carbon monoxide can lead to carbon monoxide poisoning and even death to building occupants.
- **SPACE DEPRESSURIZATION IN THE RANGE OF -20 TO -25 PASCALS AND GREATER** can produce flame rollout. In this circumstance, the air velocity downward through the vent impinges on the appliance flue with sufficient force to reverse the direction of airflow in the flue itself. When the appliance cycles on, the gas ignites but the flame does not remain inside the combustion chamber. Rather, the flame is pushed out of the combustion chamber by the air moving down the flue. Some portion of the flame then burns outside the appliance, creating the likelihood that materials around the water heater will ignite.

Some combustion appliances have venting systems that resist the effects of space depressurization. Sealed combustion appliances are not atmospherically vented. Combustion air is delivered into the appliance from outdoors, which is not affected by the pressure field in the CAZ. Power draft equipment is also largely unaffected by space pressure. A fan is used to push the combustion gases from the building. In most cases, the fan has sufficient power to overcome the effect of CAZ depressurization.

As indicated in the Air Distribution System section of this chapter, duct leaks (especially return leaks) in mechanical rooms must be sealed to avoid depressurization. However, even when they are sealed, space depressurization is still possible.

For example, simply removing the filter access panel can produce substantial levels of space depressurization. If a maintenance person fails to replace that panel, a dangerous level of negative pressure could persist in the CAZ. It is also important that exhaust fans do not operate in mechanical rooms, unless it is verified that their operation does not significantly affect pressure in that space.

Combustion appliances typically require combustion and dilution air from the space. The National Fuel Gas Code, known as standard NFPA 54, defines requirements for venting to provide the necessary levels of combustion and

dilution air. The vents must remain unobstructed in order to allow the necessary air into the CAZ. Therefore, equipment, boxes, and other items should never be placed in front of the combustion and dilution air vent openings.

MECHANICAL ROOM AND COMBUSTION SAFETY MAINTENANCE GUIDANCE

Maintenance	Description
	Daily
Storage in mechanical room	Implement a policy of limited storage. Inspect and remove stored cleaning materials or other chemicals. Avoid storing combustible materials nearby any combustion appliance.
Mechanical room–clean and dry	Clean the mechanical room before dirt/dust levels build up. Remove wet materials immediately and determine cause and solution for wetness.
Carbon monoxide (CO)	Make sure CO detectors are located in CAZ and are functional. Designate responsibility to staff to be aware of alarms.
	Quarterly or After Any Service Work Done in Mechanical Room
Combustion/dilution air	Verify that combustion/dilution vents' size and installation comply with the construction building documents or with the National Fuel Gas Code (standard NFPA54) for all gas appliances located in the CAZ.
Avoidance of room depressurization	Measure mechanical room and CAZ pressure with reference to outside and take action to neutralize depressurization beyond -3 pascals. Inspect AHU panels for leakage. Seal leaks with UL approved tapes and putty. Seal return duct leaks in CAZ or mechanical rooms with mastic. If CAZ is still depressurized, add some supply air into the CAZ or replace natural draft appliances with sealed or forced-draft combustion appliances. Measure CO levels in CAZs or test CO monitor in room.
Wall moisture	Spaces below grade should have wall inspections to look for signs of moisture or mold. Damp external walls signify serious moisture control problems requiring immediately professional assessment.
	Annually
Radon	Conduct a radon test. Consult EPA guidelines on required action and frequency of follow-up testing based on initial test results. Generally seal all ground floor and below-grade penetrations. Note that some plumbing and electric penetrations are located inside wall cavities.
Review list of combustion appliances	Place all natural-drafted combustion appliances on list of equipment for high-priority replacement. Replace with sealed combustion or power-draft equipment. Energy Star gas appliances generally use sealed combustion venting, and yield reduced energy consumption and improved air quality control.
Carbon monoxide	Consider measuring CO in the combustion flue. Have appliances serviced by qualified person if vented CO concentration exceeds 50 ppm or if CO detector alarm is tripped. Replace CO detector batteries annually or at manufacturer's suggested schedule. Review with all staff or new hires, proper procedure for investigating alarms, alerting emergency professionals when needed, and evacuation.

LIMITING LOADS FROM DEVICES BROUGHT IN BY EMPLOYEES

Employees may bring electrical devices with a wide range of power usage into the facility. These devices may include desk lamps, table fans, and space heaters. Without a plan or policy in place, these devices can hamper energy conservation efforts and possibly create environmental hazards.

Impact of Devices

Some devices brought in by employees use relatively little energy, while others consume considerable energy and may also represent a fire hazard. Building operations and maintenance personnel often ignore such devices unless they interfere with the proper operation of the system. In general, these devices have the potential to significantly increase the building's energy consumption. Limiting use of unnecessary electric devices will not only conserve energy used by the device itself, but also reduce the space conditioning load.

Employee Personal Device Guidance

To deal with these devices:

- **CONDUCT A BUILDING SURVEY TO IDENTIFY HEATING OR COOLING DEVICES BROUGHT IN BY BUILDING OCCUPANTS**, which may indicate they have additional heating or cooling needs.
- **RECOGNIZE NO SINGLE SET OF INDOOR CONDITIONS IS COMFORTABLE FOR EVERYONE.** People have different metabolic rates and levels of clothing. Additionally, space conditions often vary from one location to another within a building or zone. Thus, some requests for supplemental space conditioning devices are valid.
- **IN THE CASE OF SUPPLEMENTAL SPACE CONDITIONING DEVICES (E.G., SPACE HEATERS), IDENTIFY THE CAUSE OF THE COMPLAINT THAT LEADS TO BRINGING THE DEVICE TO WORK.** If the space is too cold during the summer, try to adjust the space temperature at that workstation to accommodate the employee's or occupant's comfort needs. If the space is too cold during the winter, see if supply airflow can be increased to that work area. Alternatively, try to modify cold envelope features (e.g., nearby windows, poorly insulated walls, or drafts) to improve localized comfort.
- **SET GUIDELINES FOR SUPPLEMENTAL DEVICES** (maximum wattages, safety ratings, etc).

Table 2 provides examples of such devices and the relative amount of power each consumes. Keep in mind that some devices consume energy even when turned off or not in use. One clue that a device may be using energy even after it is turned off is to feel for warmth at the power supply or on device. Examples of policies to consider are in the far-right column, although it is generally more effective to obtain input from and buy-in by staff occupying the space before setting new policies.

TABLE 2. EXAMPLES OF PERSONAL DEVICES AND USAGE POLICIES

Equipment	Relative power (Approx. wattage)	Example Policy
Battery chargers (small electronics)	Low (15W–30W)	Unplug when not used.
Radio	Low (40W)	Unplug when not used.
Desk lamp	Low–medium (40W–100W)	Turn off when not used. Limit lamp to appropriate wattage and use high efficiency bulbs when practical.
Personal size floor fan	Low–medium (20W–60W)	Turn off when leaving space. Consider controlling by occupancy sensor. Limit fan size to that appropriate for space. (Example: 6"-8" diameter fan for single workspace at desk).
Oscillating circulation fan	Medium–high (30W–60W)	Turn off when leaving space. Limit to task areas more open that require movement within space or more than one person in area.
Personal space heater	High–very high (150W–>500W)	Discourage use, but allow in cases where existing heating is inadequate for personal needs. Permit only heaters with tip over safety shut-off. Have users sign a "safe- use" policy agreement that also establishes a max. watt limit appropriate for each space. (Example: small workspace limited to 300 watts). ALWAYS turn off when leaving space.
Small cooking appliances microwave, hot plates, toaster oven	Very high (>500W)	Limit to single appliances that can be shared.
Small personal space cooling (self-contained units or window AC)	Very high (>500W)	Low probability employee will bring in personal AC. If installed, make sure condensate can be properly drained without leaking or spilling. Waste heat must be properly vented to outdoors. Turn off when leaving space.
Small refrigerators	Medium (150W but cycles)	Encourage group sharing of one larger refrigerator, which consumes much less energy than several small units.

EQUIPMENT REPLACEMENT OR UPGRADES

Many public housing buildings were built more than 30 years ago when energy was still considered inexpensive. There is, therefore, great potential for energy conservation by upgrading to more efficient choices when replacing cooling and heating equipment or when considering alternative energy systems.

Replacing Heating Equipment

Whether replacing heating oil or gas heating systems, PHA buildings can become more energy efficient.

Electric Heating Systems

Electric resistance heating is common in northern PHAs. If electric resistance is used at your facility, a major opportunity to save energy and money is to switch to alternative space heating systems.

Heat Pumps

Heat pumps provide space heating about 2 to 3 times more efficiently than electric resistance heat. They are not widely used in the northern region of the United States because they generally do not perform efficiently below about 15°F. However, combination heat pumps with gas backup are becoming more widely available. They automatically switch over to gas heat when the heat pump is no longer the better choice. Heat pumps also provide the benefit that they operate as a cooling system during the summer months.

Gas Furnaces

Gas equipment efficiency is measured by the annual fuel utilization efficiency (AFUE). The minimum AFUE currently allowed for new equipment is 78%, which means 78% of the fuel energy gets transferred to useable space heat and the other 22% is lost up the chimney. The highest efficiency gas furnaces can achieve efficiency in the range of 90–95% because they extract energy from the water vapor contained in the combustion byproducts. They are also known as condensing furnaces. The exhaust of these systems must be vented according to manufacturers' guidelines since the condensed exhaust is acidic and will damage certain materials. Old unlined chimneys or metal vent systems of older equipment should not be used for condensing furnaces.

Replacing Cooling Equipment

Heating and cooling equipment will be replaced for various reasons from time to time. Some equipment will have reached the end of its useful life. Replacement could also be prompted by the need for improved system reliability. When replacing equipment, energy efficiency should be a major consideration, not only because of the environment, but also because it may be the most cost-effective choice.

In the past few decades, the energy efficiency of AC systems has increased dramatically. Units purchased prior to 1991 typically had SEER ratings in the range of 6 to 8. During the 1990s, AC system efficiency gradually increased. A major step forward occurred in 2006, when the minimum SEER rating that could be manufactured was raised from 10 to 13. The availability and cost of very high efficiency split DX equipment, in the 15–17 SEER range, has improved substantially with rebates available through manufacturers, utilities, and federal programs. The efficiency of chillers has also improved substantially. Variable-speed, variable-capacity chillers that can provide super high efficiency under part load are now on the market. Some chiller units have efficiency ratings as low as 320 Watts per ton at 50% or lower load factor, which is as much as 50% lower energy use compared to standard new chillers.

In most PHA buildings in the northern region, cooling systems operate for only a few months a year, and even during those months, total operation time may be limited. Therefore, it is unlikely that super high-efficiency AC systems or chillers will be a cost-effective choice, unless incentives are available through utilities or the government. In a majority of cases, standard efficiency cooling equipment is the best choice. The following example may provide assistance in making this decision.

Energy efficiency heavily influences the lifecycle cost of cooling systems. Consider the first cost and total energy cost of two AC systems (see Box 2). The cost of a replacement five-ton SEER 13 AC system might be $6,000, compared to $9,500 for a SEER 21 unit. In some cases, utility or government incentives may narrow the price differential. If the unit operates for 800 hours per year and the cost of electricity is $0.11 per kWh, it will take 23 years for the energy savings from the SEER 21 unit to pay for the added cost.

BOX 2. HOW TO ESTIMATE SAVINGS BETWEEN SEER 13 AND SEER 21 60,000 BTUH (5 TON) SYSTEMS

SEER 13: 60,000 Btuh/13 Btu/w = 4.615 kWh/hr x 800 hours x $0.11/kWh = $406 per year

SEER 21: 60,000/21 = 2.857 kWh/hr x 800 hours x $0.11/kWh = $252 per year

Difference = $154 per year

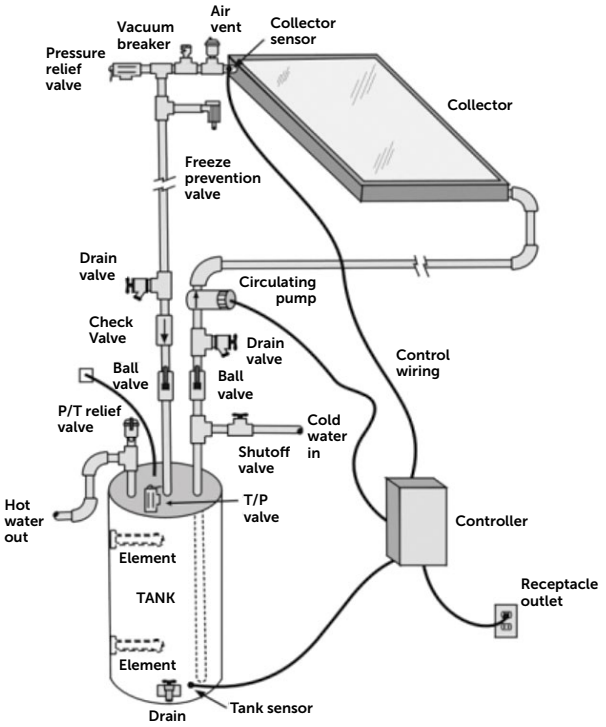
Installing Higher Efficiency AHUs, Fan Motors, and Variable Speed Drives

Energy efficiency improvements can also be achieved by means of higher efficiency fans and fan speed controllers. In the past decade, variable-speed AHUs (using electronically commutated fan motors) have become widely available. By themselves, these higher efficiency fan motors can increase AC and heat pump SEER rating by 1 point, e.g., from SEER 13 to SEER 14. They also save considerably on electricity costs of furnace operation. When installed with properly sized (or oversized) duct systems, they can achieve substantial energy savings in and of themselves compared to conventional shaded-pole motors.

AHU fans in larger commercial-sized systems can also be modified to operate much more efficiently using variable frequency drives (VFDs). VFDs adjust fans to a lower fixed airflow rate. They can also be used to vary AHU airflows in real time in response to temperature offset from thermostat setpoints or in response to VAV box damper settings. Benefits include 1) reduced fan power, 2) less potential for overcooling of the space and concomitant need for reheat, and 3) extended life of the air-moving equipment and filters.

Exhaust fans can also benefit from VFDs. If exhaust airflow rates are found to be larger than required, then an installed VFD can lower the exhaust fan airflow rate. This can reduce exhaust fan energy use and shrink ventilation-related heating and cooling loads.

FIGURE 6. ACTIVE SOLAR THERMAL SYSTEM



Source: Florida Solar Energy Center

Alternative Energy Systems

As energy costs and the awareness of limited fossil fuel resources increase, there is a growing desire to use alternative energy resources that have little or no carbon footprint. This section discusses solar thermal and solar electric systems, each of which can be used as a renewable energy source for buildings.

Solar Thermal Systems

Solar thermal systems use solar energy to heat domestic hot water (DHW). The system consists of a solar collector, piping to transfer hot water to a storage tank, and some form of back-up heat (Figure 6).

In PHA common areas, the systems can be sized for small applications that use very little hot water,

such as office or public restrooms. They can even be used in residential facilities but they are typically more cost-effective in large use applications, such as hot water for clothes washing. An engineer must first determine site suitability, which includes available space for collectors, orientation to the sun, potential for shading of collectors, and available space for hot water tanks. Maintenance will involve confirming that the circulation pumps are working (through weekly inspection), repairing plumbing leaks that may occur, and cleaning collector surfaces during extended periods without rain.

In the western portion of the Northern United States, where wintertime solar radiation is high, solar can provide cost-effective space heating as well. Systems that meet 100% of the DHW and perhaps 30–40% of the building's space heating needs can also be cost-effective, depending upon the cost of fuel and solar incentives. Space heat solar systems will be most effective in areas with high levels of winter sunshine (e.g., New Mexico, Colorado, Utah, Nevada, etc.) and where the collectors are tilted more steeply toward the south to optimize solar collection during winter months. Solar systems can also be cost-effective for pool heating.

Crystalline modules mounted on a sloped roof.
Source: Florida Solar Energy Center

Thin film modules mounted on a flat roof. This flat-roof type is generally less efficient and requires more roof area than a sloped system.
Source: Florida Solar Energy Center

Solar Electric Systems

Solar electricity is produced by photovoltaic (PV) panels commonly installed on a roof. In typical systems, the direct current produced by the panels is converted to alternating current using an inverter and then delivered into the utility grid. If the PV system is producing more energy than the building is consuming, then the electric meter in effect runs backward.

Just as in solar thermal systems, an engineer must evaluate the useable area of the roof and consider limiting factors such as shading and weight load imposed on the roof by solar collectors. PV system performance is drastically affected by shading, since shade over just 10% of the panel surface area can result in 90% reduction of power output in some configurations. In 2010, PV systems cost around $7–8 per installed Watt of capacity, and prices are expected to drop substantially in the coming years. State and federal sources may offer incentives to reduce system cost. While the life of the solar panels may be 20 years or longer, the inverter is likely to have a life of only 5–15 years. A replacement 4000W inverter may cost $2,000 to $3,000. Solar electric systems require little maintenance. The collector surfaces may need to be cleaned during extended periods without rain.

When comparing solar versus building efficiency, the best return on investment is improved building efficiency. This is especially true in the Northern region where annual solar radiation is considerably less than in the Southeastern and Southwestern regions of the country. The priority should be to optimize the energy efficiency of the building envelope and HVAC systems, and then consider implementing renewable energy production. As noted in the Regional Climate Demands section, the western portion of the Northern region has much greater solar radiation, especially during the winter. On the other hand, societal and environmental costs and consequences related to fossil fuel extraction and consumption are often not accounted for in building site financial analysis.

ACRONYMS IN THIS CHAPTER

AC	Air conditioning
ADS	Air distribution system
AFUE	Annual fuel utilization efficiency
AHU	Air handler unit
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BTU	British thermal unit
BTUH	British thermal unit per hour
CAZ	Combustion appliance zone
CDD	Cooling degree days
Cfm	Cubic feet per minute
DDC	Direct Digital Control
DHW	Domestic hot water
DOE	Department of Energy
DX	Direct expansion
EPA	Environmental Protection Agency
FEMP	Federal Energy Management Program
HDD	Heating degree day
HVAC	Heating, ventilation, and air conditioning
kWh	kilowatt hour
MERV	Minimum Efficiency Report Value
NAIMA	North American Insulation Manufacturers Association
NGFA	National Fuel Gas Code
OA	Outdoor air
PHA	Public Housing Authority
Ppm	Parts per million
Psig	pounds per square inch gauge
PTAC	Package terminal air conditioner
PV	Photovoltaic
RH	Relative humidity
RTU	Rooftop package unit
SEER	Seasonal energy efficiency ratio
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
VAV	Variable air volume
VFD	Variable frequency drive

Chapter 3 | **Landscaping**

INTRODUCTION

This chapter is intended to help resident managers of public housing authorities achieve healthful and sustainable landscaping practices. Sustainable landscaping produces an attractive landscape by incorporating native plants and maintaining them with minimal fertilizer and irrigation. Sustainable landscaping also creates conditions where humans and nature can healthily co-exist and conserve the landscape for current and future generations.

A vast variety of climates, soil, and native plants exist in the United States. Humans have reduced and altered the rich source of flora and fauna by drastically modifying the environment through clearcutting forestlands and draining wetlands to provide living space for human populations. As human impact and urban development spread across the landscape, biodiversity decreases and landscapes are threatened. The reintroduction of native plants and sustainable landscaping practices helps recreate a portion of the pre-developed landscape and reestablish the uniqueness of the land. Executive Order 13148, Section 207, Greening of

LANDSCAPING AT-A-GLANCE

Introduction

Sustainable Landscaping in a Nutshell

Site Inventory and Native Plant Selection
Inventory Natural Surroundings
Analyze Manmade Structures
Conduct a Landscape Survey
Identify Pre-existing Plants
Select Native Plants

Planting and Maintaining the Native Landscape
Regional Considerations
Planting Techniques
Maintenance Techniques

Soil and Plant Health
Knowing Your Soil
Mulching
Fertilization
Pest Management

Water Conservation
Reducing Lawn or Turf Grass
Impervious Services
Providing Water
Rain Gardens, Xeriscaping, and Rooftop Gardens

Residential Participation

Appendices
Recap of Selected Internet Resources
State-Level Resources

the Government Through Leadership in Environmental Management, promotes objectives for sustainable landscaping. This chapter is based on the executive order, university research, empirical evidence, and practical applications to save money, reduce waste and energy, and provide a healthful setting for employees and tenants.

SUSTAINABLE LANDSCAPING IN A NUTSHELL

- Use the natural surroundings and plants to your advantage. For example, plant trees on the south side of the building to protect the building from summer sun.
- Call 811 to locate underground utilities before you install any landscape.
- Ask for help from cooperative extension agencies and native plant societies in identifying the current species on the site and for suggestions of native plants to install. A list of cooperative extension agencies and plant societies for each state is included at the end of this chapter.
- Submit a soil sample to your extension agency before any plants are installed.
- Do not expect that going "native" means no landscape maintenance is involved. Native plants require watering for the first year of establishment and weeding, as necessary, for the duration of the landscape.
- Install plants, when possible, at the optimal time: fall is first choice, with spring as the second choice. Do not plant in the heat of the summer, except for vegetables.
- In the spring and fall (if necessary), apply no more than two inches of an organic mulch to your landscape.
- Fertilize, if necessary, by following best practices: for fertilizing a lawn, this would be at a rate of one pound or less of nitrogen per 1,000 square feet.
- Avoid chemicals for human and environmental well-being.
- Reduce the lawn area to conserve water and create a more sustainable landscape.
- Group plants of similar water needs together and close to a water source, such as a spigot.
- Consider planting drought-tolerant natives (xeriscaping) to conserve water.
- Reduce storm water run-off by reducing hard surfaces. Create rain gardens or get a rain barrel to collect water run-off.

SITE INVENTORY AND NATIVE PLANT SELECTION

The benefits of native plantings are numerous, from their intrinsic value to evolutionary balance. The use of drought-tolerant native plants eliminates the costly irrigation systems required of thirsty exotic grasses. A rain garden, which is an area planted with native plants to slow down and capture rain water, can reduce storm water runoff to save money. When trees are planted, air pollution is reduced, utilities costs are lowered, and shade is provided. No chemicals are necessary for the maintenance of native flora, which translates into no run-off of pesticides or fertilizers, reducing the pollutants added to our water systems. Sustainable landscaping also reduces the use of high-energy users, such as lawn mowers and irrigation systems.

Design dictates that the same plants be repeated throughout the landscape for a pleasing view; however, biodiversity is required to ensure the survival of any landscape and to reward the senses with a more varied landscape. Biodiversity refers to the diversity of living organisms in a given area. Reduced monoculture of plants, such as turf grass, minimizes maintenance and avoids having to replace large swaths of diseased plants. Native plants have much to offer building managers; planting varied groups of native plants ensures the landscape's existence and increases the site integrity.

Before selecting new plants to install, it is important to understand the natural and manmade features of the site.

Inventory the Natural Surroundings

Identify and use the natural conditions of the landscape, such as sun, wind, and soil, to lower utility costs, reap environmental benefits, and provide the best growing situation for the plant material.

SUN EXPOSURE. The amount of light defines suitable conditions for plant growth. A plant requiring full sun needs 6 hours of direct sunlight a day. A plant that survives in partial shade needs about 3–6 hours of sun, and a shade plant requires less than 3 hours of sunlight.

Erect a trellis to reduce sun exposure

- Locate the southern exposure. Ideal plants chosen for this area are deciduous trees (trees that lose their leaves in the winter) that will protect the building from the hot sun of summer and allow the sun to warm the building in the winter, reducing air conditioning and heating costs.
- If the property is small, vertical gardens in the form of a tall trellis planted with vines assist in controlling the amount of sun exposure. Build a trellis to keep the vines off the building, preventing the vines from compromising the

integrity of the building materials. Locate the trellis two feet from the foundation of the building. Cattle fencing panels attached to a wooden frame are easy building materials for a trellis.

WIND EXPOSURE AND NOISE ABATEMENT. Evergreen trees planted on the north and/or west side of a landscape make an excellent wind break and assist in reducing heating costs. Trees and shrubs can guide air movement, dampen noise, and provide a source of shade.

HABITAT CONDITIONS. Choose habitat conditions where the plant will best thrive. In addition to sun exposure, soil moisture and soil type also contribute to successful plant growth. If the region has little rainfall or the landscape has a dry slope or sandy soil, use drought-tolerant native plants or consider xeriscaping (covered later in this chapter). Moist soil conditions mean the area is damp and retains moisture for a period of time, and a wet landscape is saturated for most of the growing season. There are appropriate native specimens for all these site conditions. A state-by-state list of organizations that can help you pick these native specimens is provided at the end of this chapter.

- Before planting, determine the soil type and the nutrients in the soil by conducting a soil test (more information in the next section). Soil types are sandy or coarse-textured, clay, silt, or fine-textured, but are usually combinations intertwined with decaying organic matter, such as leaves. Let the soil determine the type of plant to be installed; do not amend the soil to suit the plant.

Analyze Manmade Structures

An important factor of site analysis is assessing the landscape for important manmade structures already in place, such as lighting for a parking lot, utility poles, and buildings. Avoiding damage to utilities and public security is paramount when planning a landscape.

UTILITIES need to be considered when landscapting. Know where the overhead and underground utilities are before planting. Call 811 to locate underground utilities before digging. The free 811 service is operated by the Common Ground Alliance, which will come to the site and mark underground utilities (see http://www.call811.com).

Look overhead before planting large trees or vines. It is essential to protect overhead wires from the weight of heavy vines or damage from falling branches. Trees planted too close to overhead lines will later require unhealthy pruning, which will shorten the life of the tree. Locate the gas and electric meter before planting. Do not obstruct these meters with shrubs or plants, in case the meter needs to be serviced.

SECURITY is another factor to consider when planning a landscape:

- How can you best protect residents near entryways? Shrubs located near a door or in front of windows could allow a person to hide behind them.
- Does the building entrance and parking lot have adequate nighttime lighting? Trees and shrubs should not obscure nighttime lighting.
- Will the planting obstruct a person's vision? For example, shrubs planted too close to a street can obstruct a driver's line of sight when making a turn.
- Can plants be safely used to create a barrier to a noisy or high-traffic area? Trees, especially evergreens, provide a buffer to noise and pollution.
- Are there unsightly areas to hide? Strategically planted shrubs can hide unsightly areas, such as dumpsters.

Will people and the building be safe if a large tree blows over in a storm? If not, small trees or shrubs can be used that would not cause damage if blown over in a storm.

Conduct a Landscape Survey

Conduct a survey of the landscape usage or pattern of use. Note areas that cannot be altered, such as permanent features like the building and parking lot. Note entrances to the building and the path taken to get from the building to the bus stop or parking lots.

Does an area for recreation and play space exist? A shade tree is a welcome benefit for parents to relax on the edge of any play area. Note service areas for deliveries, trash receptacles, and access to parking lots. These areas should not be blocked with plants.

Check the grade of the land. The soil should be the highest at the foundation and should direct the water away from the building.

Identify Pre-existing Plants

Accurate identification of plant species is crucial to initiating a healthy landscape and to planning. Protect native plants and eradicate non-native invasive species. Invasive species are introduced plants (non-native or alien) that spread rapidly and harm the environment.

Many online reference guides help managers identify and plan a course of action to remove invasive plants. Catching and removing the invasive species

saves money and time. Fighting invasive species, including plants, costs the United States $138 billion annually. *The Invasive Plant Atlas,* operated by the National Park Service and University of Georgia, is available online and is an excellent tool for identifying the species and determining a plan of action. (http://www.invasiveplantatlas.org). The U.S. Department of Agriculture also operates a helpful website for identifying invasive species (http://www.invasivespeciesinfo.gov/plants/). In addition, the University of Georgia Center for Invasive Species and Ecosystem Health's Invasive.org website (http://www.invasive.org/) supplies helpful pictures and guidelines to identify invasive plants. Good local sources for determining if the landscape has invasive plant species are a local native plant society or the cooperative extensive service (a state-by-state list is provided at the end of the chapter).

- If the plants are aggressive, invasive alien species, remove them as soon as possible and replace with them native species.
- If most of the species are non-invasive aliens, develop a long-term plan to replace them with native species; otherwise, non-invasive ornamental species that are not problematic can be left in place.
- If the plants are native species and well sited, leave them in place.

Identifying and finding native plant species can be challenging. Native plants are no longer as abundant in the landscape as in the past. The Lady Bird Johnson website run by the University of Texas at Austin has a searchable database for native species by state (http://www.wildflower.org/collections/). In addition, a state university-run cooperative extension agency or native plant society can provide assistance. (A state-by-state list is provided at the end of the chapter.) Virginia Tech also has a plant key for identification of trees and shrubs (http://www.dendro.cnre.vt.edu/dendrology/idit.htm).

Select Native Plants

SELECT PROPER NATIVE PLANTS FOR THE SITE LOCATION. Most plants will have to deal with a harsh urban environment and must be chosen appropriately. As in nature, every site location is different and has unique needs and requirements. Consider the function of the plant being planted. Will it serve as a windbreak, provide shade, or abate storm water runoff? Observe and note the environment. Will the plant serve to protect the soil from an eroding site? Is the tree in a location where residents can enjoy the shade on a hot summer day?

Tree planting is a cost-saving and environmental health plan. Shade trees lower soil and air temperature. Lower air temperature from trees helps counteract the heat-island effect created in urban areas. Trees also reduce air pollution,

collect rainwater to help prevent runoff, and provide a place to relax. The U.S. Forest Service Center for Urban Research provides information and statistics to promote trees in the urban environment (http://www.fs.fed.us/psw/programs/cufr/TreesInOurCity/).

- Be aware of trees that have fibrous roots, like sycamores and maples, which can get into the sewer system and block the flow. Be aware of tree roots from neighboring trees before you plant. Digging up tree roots not only is difficult to do, but also can harm the existing tree. Plant trees that will grow to be large at least 10 feet away from sidewalks, so the expanding tree roots cannot damage the walkway.
- Ground covers are a good choice for areas of the landscape that are hard to deal with. Low-maintenance native ground covers reduce soil erosion and benefit problem areas, such as slopes, shady areas under trees, and sidewalk borders.
- Select plants that are suitable for their eventual location and for your region. The resources in the state-by-state list at the end of this chapter can assist in determining suitable plants for a region.

PLANTING AND MAINTAINING THE NATIVE LANDSCAPE

Creating a sustainable landscape does not translate into having a site that requires no maintenance. Native plantings can take longer to establish and develop, 3–5 years in most cases. During the first year, the plant is establishing its root system and might not grow as rapidly above ground as expected. Native plantings require watering for the first year of establishment and weeding, as necessary, for the duration of the landscape. Landscapes surrounding buildings require maintenance; however, incorporating native plants and working with the lay of land make the upkeep job a great deal healthier and easier over the long term for the worker, the residents, and the environment.

Regional Considerations

The different climates of the United States have implications for sustainable landscaping. Choosing plants native to these different climate zones and taking advantage of seasonal variations will also benefit the PHA and the environment.

- **NORTHERN AND SOUTHEASTERN CLIMATE ZONES:** In the Northern and Southeastern climate zones, install native trees, shrubs, vines, and perennials in the fall for easiest maintenance. Fall is a healthier time to plant because the weather is usually cooler with more precipitation. In colder climates, planting in the fall allows the roots time to grow and get established before winter sets in. By the spring, the plant will be established and prepared for the stresses of summer. Planting in the heat of summer is not advisable, except for vegetable gardens.
- **SOUTHWESTERN CLIMATE ZONE:** Install native trees, shrubs, vines and perennials in fall (from September to December) for easiest maintenance. Fall is a healthier time to plant because the weather is usually cooler with more precipitation. By the spring, the plant will be established and prepared for the stresses of summer. Planting in the heat of the summer is not advisable, except for vegetable gardens.

Planting Techniques

Be prepared for planting on the day the plants arrive. It is easier to maintain the plants in the ground than in a container or burlap covering. Plants dry out faster and can be removed from the site if not planted in the ground as soon as possible. Before digging a hole, pull the plant out of the container and examine the root system. To plant in the ground:

- Dig a hole at least two times the width of the root ball or mass, which is of most benefit to the plant. The depth of the hole should be equal to the top of the root system; for instance, the top of the root ball should be level with the ground, so do not make the hole too deep.
- Shake out the roots. Plants that have been in containers or burlap for a long period of time usually have a congested root system. Gently rake the roots at the bottom of the container with your fingers or cut any encircling roots with pruners. This action entices the plant or tree to grow a proper root structure once free from its container.
- Remove all burlap, tags, wires, wire baskets, stakes, and plastic streamers attached to the specimen. These items will harm the plant as it grows and can cause its death.
- Do not stake trees, as staking trees is no longer considered necessary. Growing a tree without staking allows it to naturally develop a deeper root system and wider trunk, which will help protect it in storms.
- Water long and deeply. Monitor weekly to see if the plant needs additional water, but avoid overwatering. The first year of watering is critical. In sub-

sequent years, when the native specimen has established itself, it will need watering only in extreme drought.

GROUP PLANTS OF SIMILAR NEEDS TOGETHER, but do not plant all of a single type of species. Use an assortment of natives for easier long-term maintenance and survival of the species. As an example of the dangers of relying too heavily on a single species, Dutch elm disease, a foreign fungus, destroyed more than 75 million trees in U.S. towns and cities by the 1970s. If planners of the urban landscape had used 10 species of trees to line the streets instead of one, the outcome would not have been as devastating.

Hydrozoning is the term used for grouping plants that have similar watering requirements and is important to consider when locating the site and grouping the plants. Plant similar species together. For example, plants that require more water should be located in an area together. Drought-tolerant natives can be planted together farther from the water source. Hydrozoning creates less work for maintenance and saves water.

Maintenance Techniques

PRUNING. Reduce personal injury by pruning large, established trees until the lowest branch is 7–8 feet from the ground. If pruning for shape, never prune more than one-third of the mass of the shrub or tree.

As a general rule, shrubs that bloom in the spring benefit from pruning after they have flowered. When to prune also depends on climate location:

- **NORTHERN CLIMATE ZONE:** In the colder climates of the Northeast, shrubs that bloom in the summer can be pruned in the early spring.
- **SOUTHEASTERN AND SOUTHWESTERN CLIMATE ZONES:** In the warmer regions of the Southeast and Southwest, shrubs that bloom in the summer can be pruned in the winter.

MULCHING. Mulching protects soil moisture and helps discourage weeds. In the spring, apply 2 inches of organic mulch to conserve ground moisture for plant use. Mulch also discourages weeds and unwanted seedlings from growing. Apply mulch again in the fall if the spring mulch has decomposed and the bare ground is showing. More information on mulch is in the next section.

SOIL AND PLANT HEALTH

Soil health is a significant factor for plant growth. Soil is comprised of weathered rock fragments combined with organic matter and a vast number of microorganisms. In some cases, the soil includes sediment transported from other areas. Building construction tends to compact the soil by reducing the pore space, plus it changes the composition of soil by removing the top layer, making plant growth more challenging. The majority of soils are productive, however, especially for plants that are native to the area.

Knowing Your Soil

Know the type of soil that you are dealing with. Soil may contain sand, silt, or clay, usually in combinations. Course, sandy soils are light in appearance and drain water easily. Sandy soils do not hold nutrients well; however, native plants have adapted to these conditions. Clay is very fine textured and usually reddish in appearance, and clay soil does not drain readily. Loam is a combination of sand, silt, and clay and is a good texture for planting. A healthy soil contains about 50% pore space, with the pores containing air and water. When organic matter, such as shredded leaves, is used as a mulch, it feeds the microbes and earthworms in the soil, breaking down other organic matter and helping the soil to retain pore space for water, air, and nutrients for plant use.

TILLING is no longer recommended to improve the soil. Tilling breaks up the pore space and can damage existing root systems. In addition, tilling kills beneficial soil microbes and earthworms and can increase soil erosion. Instead of tilling, apply organic mulches to soil beds and allow them to improve the soil texture over time.

SUBMIT A SOIL SAMPLE for a professional soil assessment. A soil test is an easy way to assess the general health of the landscape and is essential before any purchases of plants or any planting. A list of university soil labs is provided at the end of this chapter. Soil should be analyzed for routine soil fertility, which includes pH, soluble salts, and organic matter. The soil pH scale is a measure of the acidity or alkalinity of the soil. The test measures the hydrogen (acid-forming) ion acivity of soil.

Regional considerations:

In the **East** and **South**, 5.0 to 7.0 is the common pH range of soils, which are considered acidic to neutral

In the **Midwest** and **arid** regions of the U.S., soils tend to be highly alkaline; in arid regions, they are also low in organic matter.

SOIL PH SCALE

5.0	Acidic
5.5	
6.0	
6.5	
7.0	Neutral
7.5	Alkaline
8.0	
8.5	
9.0	

Soil pH varies depending on the bedrock from which the soil was derived and the amount of rainfall.

Ideal conditions for growing vegetables in a community garden is 6.5 to 6.8

The major plant nutrients required for healthy growth are nitrogen, phosphorus, and potassium, along with carbon, hydrogen, and oxygen (which are derived from the air and water). These substances are used in the greatest quantities by plants. Currently, there is no soil test for nitrogen, because it is too mobile in the soil for an accurate reading; however, nitrogen plays a very important part in the development of leaves and stems. In general, plants use phosphorus for root growth and fruit production, while potassium helps the plant with cold hardiness, disease resistance, and general durability. Too much or too little of these macronutrients can cause problems. Besides the macronutrients, several micronutrients are required for successful plant growth: calcium, magnesium, zinc, manganese, copper, iron, and boron. Your extension agency will provide a list of recommendations of fertilizers to improve your soil if required.

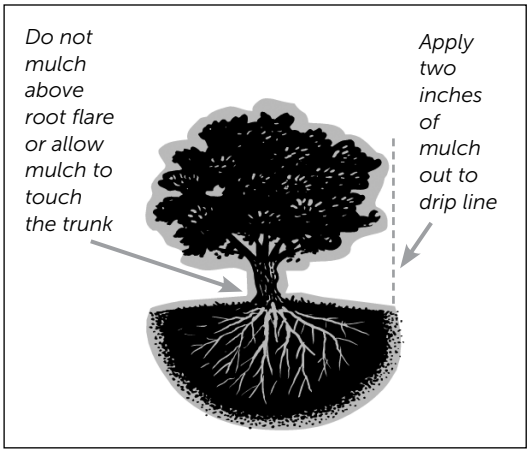
Mulching

Mulch absorbs water and releases it slowly to the plant roots, keeping the soil moist and conserving water. It helps keep water from evaporating from the soil surface, cools the soil, reduces erosion, and helps prevent weeds from germinating. Organic mulch is made up of material that was once part of the living world, such as leaves, bark, and pine needles; shredded hardwood or leaf mulch can be obtained free from many municipalities. In the Southwest, gravel and pebbles, which are inorganic, are useful in rock gardens or areas where forest fires are a great possibility.

Applying mulch is labor intensive but worth the effort for sustainable landscaping and beautifying the property. Consider a mulch-recycling program by mulching leaves and other landscape debris. After the leaf mulch has composted, use it in the landscape as organic mulch.

ESPECIALLY IF THE EARTH IS BARE, mulch should be applied to prevent soil erosion and keep in soil moisture. Apply 2 inches of mulch in the spring and again in the fall, if necessary, for a healthy landscape. The decomposition rate can be increased by the climate, rainfall, foot traffic, and runoff.

DO NOT OVER-MULCH: More than 3 inches of mulch can potentially kill the plant and is wasteful. Do not mulch above the root flare, and keep the mulch from touching the trunk of the plant. Mulch directly applied touching the stem or trunk of a plant promotes decay and invites insects, microbes, and rodents to do damage. Mulch a wide area, all the way to the drip line of trees and planting beds. Wide mulching prevents a lawn mower or string trimmer from getting too close to the plant and causing damage. If the landscape has a lawn, make sure the mulch edge is clearly defined and does not obstruct lawn mowers. A simple 2- to 3-inch angled trench dug out by a shovel will suffice as a garden edge. The edge also is effective in keeping mulch in place during a rain storm.



DO NOT USE BLACK PLASTIC AS A GROUND COVER. Black plastic does not make a good barrier for weeds and is also unsightly. The plastic overheats the soil, sometimes killing plants. A mesh landscape fabric is an improvement over plastic but is costly and still not desirable in sustainable landscaping. Weed seed will still find a way to germinate in the mulch, regardless of whether a covering has been placed on it, rendering the fabric or plastic useless. Do not use cocoa hulls for mulch; this newly popular landscape mulch can be toxic to dogs that ingest it. Organic mulch remains the best choice to protect soil and plants.

FIRES CAN START EASILY IN DRY MULCH. Keep alert for burning cigarette butts thrown into the mulch.

Fertilization

Fertilizers are usually not necessary for native plantings. If the soil is lacking in basic nutrients, use a slow-release pellet fertilizer to promote plant health. A soil test will determine whether the soil needs any necessary nutrients for your region.

A slow-release fertilizer provides the nutrients needed over an extended period of time. Most do not work when the weather is below 70 degrees. If a fertilizer is necessary to maintain turf grass, fertilize at a rate of one pound or less of nitrogen per 1,000 square feet. Apply no more than two to three times a year. Again, regional climate is a factor:

- **NORTHERN AND SOUTHEASTERN CLIMATE ZONES:** Apply lawn fertilizers only in the spring and fall, during the season when grass is actively growing. The grass is under stress in the summer, so fertilizing at that time is wasteful and not recommended.
- **SOUTHWESTERN CLIMATE ZONE:** Apply lawn fertilizers in the late spring, usually May, and again in fall, during the season when grass is actively growing. The grass is under stress in the summer, so fertilizing at that time is wasteful and not recommended.

If a pellet fertilizer is applied, target the application to the lawn and do not allow pellets to gather on hard surfaces such as parking lots and sidewalks. Fertilizers carelessly applied will run off into sewers and streams, which contributes to water pollution, in addition to being wasteful.

Pest Management

INTEGRATED PEST MANAGEMENT (IPM) is an environmentally responsible way to control pests. To prevent plant damage from pests, IPM incorporates prevention, monitoring, and the biology of the pests. Chemical pesticides are used in smaller amounts with this common-sense approach. A large variety of chemical pesticides are used to kill undesired plants, insects, and animals. Pesticides, however, also kill non-targeted organisms and cause human health issues. Chemicals are not necessary for a healthy native landscape. In general, it is best to avoid using pesticides on the landscape.

IDENTIFYING THE PEST AND ITS LIFE CYCLE is the first step toward understanding how best to treat an issue. Contact the local extension agency for safe methods of removal. Some levels of insect pests are acceptable and can even feed birds and other beneficial insects.

RATS ARE ALWAYS A PROBLEM IN URBAN AREAS, more attracted to human activities than plants, but rats cause damage to plants by destroying roots and uprooting plants. Anticoagulant rodenticides, commonly found in black boxes, can cause secondary poisoning to predators that consume the contaminated rats. If the neighborhood has predators such as hawks and foxes, take advantage of them for a more natural way to rid the property of rats, rather than using rat poison. Expose rat holes by removing leaf litter or mulch to allow the predators easy access, so they can capture the pests.

KEEP MULCH AND PLANTINGS TWO FEET FROM THE BUILDING to assist in keeping down the vermin. Mulching too close to the building can also encourage mice and voles to nest near the building.

PESTS ALSO TAKE THE FORM OF UNWANTED PLANTS. In sustainable landscaping, hand pulling weeds is the preferred method of removal, instead of using herbicides. Hand pull the undesired species before they have a chance to take hold in the soil. To perform the task efficiently, learn about the life cycle of weeds and how to properly identify them. The extension agencies and the invasive plant websites listed in this chapter are good resources. A good rainstorm softens the soil and makes the job easier. Hand pulling is labor intensive, but with a steady monitoring and extracting program, at least every two weeks during growing season, the task becomes efficient over time.

GIRDLING TREES is a means of removing unwanted trees and shrubs from the landscape. Girdling is a process that removes bark (cambium) from the trunk of a woody plant, which eventually results in killing the tree or shrub over time. By putting a deep notch through the bark all the way around the trunk or stem of a tree or shrub, you rob the plant of its ability to move valuable nutrients up to the leaves. The U.S. Department of Agriculture has a how-to guide online (http://www.fs.fed.us/eng/pubs/pdfpubs/pdf99242809/pdf99242809pt01.pdf).

AS A LAST RESORT, IF A PESTICIDE IS DESIRED, use a licensed state-certified specialist, and for good reason. The term "pesticide" refers to products that terminate animals, plants, or insects. Using a pesticide does not always create the desired effect of killing only the target. Innocent bystanders are affected, and all precautions need to be taken. For example, if exposed, butterflies and praying mantis, both of which are beneficial to a landscape, will also be killed when an insecticide is sprayed to treat aphids. More importantly, research is establishing a link between pesticide exposure and Parkinson's disease in humans, and pesticide poisoning affects nearly 3 million people worldwide annually. Small children and animals are most at risk. (See the National Coalition for Pesticide-Free Lawns, http://www.beyondpesticides.org/pesticidefreelawns/ for more information.)

WATER CONSERVATION

Water is a finite resource and, in most parts of the country, needs to be conserved. Population growth is placing demands on most water systems. Rainwater quickly leaves the property as storm water and is whisked away in drains, carrying pollution with it. (Storm water also refers to snow runoff and waste from irrigation systems, such as sprinklers.) Conserving water by slowing down the flow of water and keeping it on the landscape is a large part of sustainable landscaping.

To put a measurement to water conservation, if a half-inch of rain falls over a 1,000-square-foot-impervious surface, such as a rooftop, it generates about 310 gallons of water. If the average rainfall in the region is 32 inches, as in Michigan, the amount of water that could potentially be harvested or used in the landscape is nearly 10,000 gallons over the course of a year. Adopting sustainable landscape practices helps reduce the cost of water and conserves water for plant use in the landscape.

Reducing Lawn or Turf Grass

Turf grass is expensive to maintain, labor intensive, and a drain on natural resources. Lawns are one of the biggest crops in the United States, covering up to 40 million acres, and turf grass is not native. Units with large areas of lawn should reduce the lawn area by 30% over 3 years. Ideal conditions are to stop using pesticides on the lawn and maintain the turf grass without them. In addition to conserving water, other benefits to reducing the size of the lawn include noise and emission reduction from gas-powered lawn mowers, string trimmers, and leaf blowers. Lawns do have a place in landscape for athletic fields and recreation; however, unless turf grass has a specific purpose, the landscape should be returned to a healthful state by eliminating turf grass, creating a sustainable landscape and conserving water.

Trees, shrubs, and perennials are an excellent replacement for lawns. The possibilities and combinations are endless, and in the long run more cost-effective than maintaining a lawn. Native plantings add structure and diversity to the landscape. Begin with a small area and gradually add more or allow the plants to naturalize. A community garden can replace a lawn and benefit the residents as well. (For more information on community gardens, see the Residential Education chapter.)

Two methods to remove a lawn are as follows:

- Heat up the soil to the point of killing the grass and weed seed. Solarizing the soil uses the heat of the sun to kill the grass and weed seed. One method of solarizing is to cover the soil with heavy black plastic in the heat of the summer, allowing the plastic to work for 8 weeks to kill the grass and weed seed. At the end of the 8 weeks, remove the plastic and mulch the bare soil.

- Place several layers of biodegradable newspaper over the area. Spread 3–4 inches of soil over the paper, which is best done in the heat of the summer or fall, when the grass is dormant. Mulch over the soil with 2 inches of mulch and allow the soil and newspaper to smother the grass. A flat shovel can also be used to lift sod and remove it.

Reducing the size of the lawn will decrease the chemicals used to maintain the non-native grass. Research has shown that 70% of urban streams contain five or more lawn pesticides carried in storm water. In addition, when the lawn is reduced, so are the high costs of lawn fertilizers and chemicals. A natural way of putting nitrogen back into the lawn is to leave the grass clippings on the lawn after mowing. The decomposing clippings will slowly decompose, releasing nitrogen back into the ground.

Impervious Surfaces

Impervious surfaces, such as buildings, asphalt, and concrete, do not allow water to percolate into the ground. The heat-island effect, a problem in urban areas, is created when impervious surfaces heat up and dry the landscape, contributing to higher temperatures in the region. In addition, impervious surfaces create costly storm water runoff where water runs off into a street or sewer system, carrying with it pesticides, fertilizers, and other pollutants that harm the environment.

When concrete sidewalks need to be replaced or new paths for foot traffic created, consider installing pavers. Pavers are a more environmentally friendly building material made of porous asphalt that allows up to 95% of rainwater to percolate into the soil beneath them. Pavers reduce storm water and pollution runoff. If installing a paver path, consider the pattern of use in the landscape. Where do people walk the most? Are areas worn down in the landscape that would benefit from a paver path? Reuse the soil from the excavation to smother the turf grass and install native plants.

In addition to sidewalks, consider using pavers for parking lots and decreasing the amount of black asphalt. Include islands of vegetation in parking lots to retain rainwater and reduce the heat effect of asphalt. Areas planted with shrubs and small trees contribute to heat reduction and soak up rainwater.

Providing Water

Best practices for providing water for landscapes, in addition to supplemental hand watering, include soaker hoses for ground covers and perennials, irrigation bags for trees, and trickle irrigation for trees and shrubs. Watering techniques include the following:

- Know where your spigots and water sources are before you plant, and group plants of similar water needs together.
- Before watering, dig down about 12 inches to check the soil for water penetration.

- Hand-water deeply and infrequently to condition the plant to develop a deep root system, which is especially beneficial to the plant during droughts and storms.
- Irrigate during evening hours for the best use of water. Avoid watering during the hottest part of the day or during high winds. Heat and wind evaporate water quickly.
- If it is impracticable to hand-water, use soaker hoses placed close to the target plant. Discharging a water hose full force on a plant causes runoff and does not benefit the targeted specimen; on the other hand, allowing a hose to trickle for 20 minutes encourages the water to seep into the ground slowly. If budgeting allows, purchase irrigation bags for trees. These bags are easily filled with water that slowly hydrates the soil at the tree base.

Mechanical irrigation systems may seem like a good idea, but they are costly, and if installed improperly, can be difficult to maintain. Sprinklers are ineffective, because most of the water evaporates before benefiting the plants. If sprinklers or irrigation systems are used, avoid watering paved surfaces, like sidewalks and roads.

Rain barrels or cisterns can conserve water for later use. They collect roof runoff into large containers at the ends of a drain spouts. Although the water in rain barrels can get stagnant if not used in a timely fashion, stagnant water does not have an adverse reaction on plant life. Rain barrels do require some maintenance:

- In the North and Southeast where freezing occurs, the barrels **need to be disconnected, emptied, and stored during winter months.**
- In areas where mosquitoes are nuisances, have precautions in place. For example, Mosquito Dunks is an effective, nontoxic product that uses natural bacteria to eradicate mosquito larvae in standing water.

Rain Gardens, Xeriscaping, and Rooftop Gardens

RAIN GARDENS. A rain garden utilizes an area of the landscape and native plants to collect runoff from impervious surfaces, such as parking lots and buildings. Rain gardens provide an excellent water-filtration system, decrease flow to storm drains, and beautify the landscape. An advantage to rain gardens is that the root systems take up excess pollutants and filter the water before it seeps into the earth. Rain gardens also reduce storm water runoff costs.

Site a rain garden at least 10 feet from buildings and parking lots. This will avoid moisture around the building foundation. A flat area or an area with a slight slope away from the building is best. Dig out a shallow depth of 6–8 inches for

the rain garden. Place a pipe underground that directs the rainwater from rooftop gutters or parking lot curb openings into the rain garden. Plan the size of the garden based on the amount of water you are capturing. A simple study of the roof area or parking lot size will determine the size of the garden. The University of Vermont offers a helpful manual to calculate the drainage area in determining the size of a rain garden (http://www.vacd.org/~winooski/VtRainGardenManual.pdf).

Before finalizing the location for the rain garden, make sure the soil percolates properly for the garden to be most effective. A simple percolation test involves digging a 6-inch hole and filling it with water. Wait 24 hours; if the water has drained from the hole, it is a good site. If not, consider another location. Do not locate a rain garden over a septic tank or drinking well.

Choose native plants wisely. Plant hardy natives that can handle extreme rain garden conditions, such as wet roots during heavy periods of rain, along with dry periods during droughts. Monitor mulch for bare spots and replace it when needed. Contact your state university-run cooperative extension agency or native plant society for assistance.

XERISCAPING, or dry landscaping, conserves water by covering the landscape with drought-tolerant plants that can withstand the stresses of an arid environment:

- **NORTHERN AND SOUTHEASTERN CLIMATE ZONES:** Slopes, sandy soil, and other dry sites are perfect candidates for xeriscaping with native drought-resistant plants. Succulents and plants with deep roots, like native ornamental grasses, perform best in droughts and on areas such as slopes where water runs off.

- **SOUTHWESTERN CLIMATE ZONE:** Drought-tolerant planting is practical for western regions of the United States that do not have sufficient rainfall to maintain non-native plantings, such as turf grass. Semi-arid regions and regions prone to drought also benefit from xeriscaping. Xeriscaping in the Southwest uses rocks for mulch and native drought-resistant plants. Succulents, cacti, and plants with deep roots, like native ornamental grasses, perform best in droughts and in the desert-like conditions of the Southwest. Carefully consider children, however, when planting cacti, or choose cacti without spines to protect people and pets.

Your local cooperate extension agency can assist in choosing the best plants for xeriscaping.

ROOFTOP GARDENS or green roofs provide a space for gardening in urban areas that otherwise might not be available. Rooftop gardens can be complex or as simple as using containers to grow plants. The roof needs to be flat, accessible to people, and able to tolerate the weight load. Safety measures, such as railings, also need to be installed and a source of water provided.

Green roofs cool and insulate buildings, reducing the cost of air conditioning and heating and decreasing storm water runoff by retaining the rainwater on the roof for plant use. You may want to consider installing a rooftop garden if the building location offers no other alternative to gardening and water is easily accessible to the roof in periods of drought. **Always consult with a structural engineer to discuss the roof load before installing a rooftop garden.**

RESIDENTIAL PARTICIPATION

Two gardening programs are described in the Resident Education chapter: stewardship of native landscapes and community gardens. That chapter also notes the importance of indoor plants to help improve air quality.

Through stewardship, an individual or group of individuals cares about and safeguards the environment to create a healthier place. Education, both formal and informal, helps people understand the changes actively taking place around them and how they can help care for, as well as become ingrained in the process of, bettering the environment.

A community garden is an allotment of space or a plot of land divided into gardens to be shared by the inhabitants of the development. Community gardens greatly improve the quality of life for residents by supplying a sense of community through social interaction with other residents, providing exercise for gardening participants, and generating healthy organic produce. Gardens also provide a refuge from the hectic pace and noisy deluge of urban life.

APPENDICES

Appendix A: Recap of Selected Internet Resources

Call 811 to locate underground utilities
http://www.call811.com

Invasive Plant Atlas
http://www.invasiveplantatlas.org

USDA resource on invasive species
http://www.invasivespeciesinfo.gov/plants/

Center for Invasive Species and Ecosystem Health
http://www.invasive.org/

Searchable database for native plants
http://www.wildflower.org/collections/

Key for identifying woody species
http://www.dendro.cnre.vt.edu/dendrology/idit.htm

Tree benefits to urban areas
http://www.fs.fed.us/psw/programs/cufr/TreesInOurCity/

USDA guidelines for tree girdling
http://www.fs.fed.us/eng/pubs/pdfpubs/pdf99242809/pdf99242809pt01.pdf

National Coalition for Pesticide Free Lawns
http://www.beyondpesticides.org/pesticidefreelawns/

Rain garden manual
http://www.vacd.org/~winooski/VtRainGardenManual.pdf

Appendix B: State-Level Resources

The following chart lists state-level points of contact for assistance in sustainable landscape projects. Native plant societies are nonprofit organizations run by educated and passionate stewards and volunteers who are committed to preserving the flora specific to their state. They are very helpful in identifying plants in the landscape and aiding in suggestions of native plants.

Extension agencies, administered by land-grant universities, provide unbiased, researched information. With the latest information on landscaping specific to the state, most Extension websites include downloadable handbooks and pamphlets on gardening and the environment. Sites contain valuable tools such as instructions on how to create rain gardens, how to apply fertilizer to lawns, and how to create a vegetable garden, as well as information on classes

for continuing education. University-run soil testing labs are an inexpensive way to get soil tested and analyzed; however, because of financial constraints, not all land-grant universities run a soil-testing program.

	Native Plant Society	Cooperative Extension Agency	Soil Test
Alabama	http://www.alwildflowers.org/	http://www.aces.edu/homegarden/	http://www.aces.edu/anr/soillab/
Alaska	http://aknps.org/	http://www.uaf.edu/ces/	907/746-9482
Arizona	http://www.aznps.com/	http://extension.arizona.edu/	Does not offer a university-run program; contact the cooperative extension agent for a list of soil-testing companies
Arkansas	http://www.anps.org/	http://www.uaex.edu/	http://www.uark.edu/depts/soiltest/NewSoilTest/index.htm
California	http://www.cnps.org/	http://ucanr.org/	Does not offer a university-run program; contact the cooperative extension agent for a list of soil-testing companies
Colorado	http://www.conps.org/	http://www.ext.colostate.edu/	http://www.soiltestinglab.colostate.edu/
Connecticut	http://www.ct-botanical-society.org/	http://www.extension.uconn.edu/	http://www.soiltest.uconn.edu/
Delaware	http://www.delawarenativeplants.org/	http://ag.udel.edu/extension/	http://ag.udel.edu/other_websites/DSTP/
District of Columbia	Does not have a society; Maryland and Virginia's sites are useful	http://www.udc.edu/cooperative_extension/coop_ext.htm	202/274-7115
Florida	http://www.fnps.org/	http://solutionsforyourlife.ufl.edu/	http://soilslab.ifas.ufl.edu/
Georgia	http://www.gnps.org/	http://www.caes.uga.edu/extension/	http://aesl.ces.uga.edu/soiltest123/Georgia.htm
Hawaii	http://www.nativehawaiianplantsociety.org	http://www.ctahr.hawaii.edu/site/extprograms.aspx	http://www.ctahr.hawaii.edu/TPSS/research_extension/rxsoil/soilsample.htm
Idaho	http://www.idahonativeplants.org/	http://www.extension.uidaho.edu/	Does not offer a university-run program; contact the cooperative extension agent for a list of soil-testing companies
Illinois	http://www.ill-inps.org/	http://web.extension.illinois.edu/state/index.html	Does not offer a university-run program; contact the cooperative extension agent for a list of soil-testing companies
Indiana	http://www.inpaws.org/	http://www.ag.purdue.edu/Extension/Pages/ConsumerHorticulture.aspx	Does not offer a university-run program; contact the cooperative extension agent for a list of soil-testing companies

CONTINUED ON THE NEXT PAGE

	Native Plant Society	Cooperative Extension Agency	Soil Test
Iowa	http://www.public.iastate.edu/~herbarium/inps/index.php	http://www.extension.iastate.edu/	http://www.agron.iastate.edu/soiltesting/
Kansas	http://www.kansasnativeplantsociety.org/	http://www.ksre.k-state.edu/DesktopDefault.aspx	http://www.agronomy.ksu.edu/soiltesting/
Kentucky	http://www.knps.org/	http://ces.ca.uky.edu/ces/	http://soils.rs.uky.edu/index.php
Louisiana	http://www.lnps.org/	http://www.lsuagcenter.com/en/administration/about_us/extension/	http://www.lsuagcenter.com/en/our_offices/departments/spess/service+labs/soil_testing_lab/
Maine	http://www.newfs.org/	http://extension.umaine.edu/	http://anlab.umesci.maine.edu/
Maryland	http://www.mdflora.org/	http://extension.umd.edu/	Does not offer a university-run program; contact the cooperative extension agent for a list of soil-testing companies
Massachusetts	http://www.newfs.org/	http://www.umassextension.org/	http://www.umass.edu/soiltest/
Michigan	http://www.michbotclub.org/	http://www.msue.msu.edu/portal/	http://www.css.msu.edu/SPNL/
Minnesota	http://www.mnnps.org/	http://www.extension.umn.edu/	http://soiltest.cfans.umn.edu/
Mississippi	http://www.nrims.org/mysite2/	http://msucares.com/	http://msucares.com/crops/soils/testing.html
Missouri	http://www.missourinativeplantsociety.org/	http://extension.missouri.edu/	http://soilplantlab.missouri.edu/
Montana	http://www.mtnativeplants.org/Home	http://www.msuextension.org/	Does not offer a university-run program; contact the cooperative extension agent for a list of soil-testing companies
Nebraska	http://www.unl.edu/nebnps/NNPSindex.html	http://www.extension.unl.edu/	Does not offer a university-run program; contact the cooperative extension agent for a list of soil-testing companies
Nevada	http://www.nvnps.org/	http://www.unce.unr.edu/	Does not offer a university-run program; contact the cooperative extension agent for a list of soil-testing companies
New Hampshire	http://www.newfs.org/	http://extension.unh.edu/	http://extension.unh.edu/news/2006/05/time_for_a_soil_test_new_impro.html
New Jersey	http://www.npsnj.org/	http://njaes.rutgers.edu/	http://njaes.rutgers.edu/soiltestinglab/
New Mexico	http://npsnm.unm.edu/	http://extension.nmsu.edu/	http://swatlab.nmsu.edu/
New York	http://www.nyflora.org/	http://cce.cornell.edu/Pages/Default.aspx	http://cnal.cals.cornell.edu/

	Native Plant Society	Cooperative Extension Agency	Soil Test
North Carolina	http://www.ncwildflower.org/	http://www.ces.ncsu.edu/	http://www.ncagr.gov/agronomi/sthome.htm
North Dakota	Does not have a society	http://www.ag.ndsu.edu/extension/	http://www.soilsci.ndsu.nodak.edu/services/Testing/soiltesting/soiltesting.html
Ohio	http://nativeplantsocietyneohio.org/	http://extension.osu.edu/	http://www.dnr.state.oh.us/soilandwater/soils/soilsampling/tabid/9074/Default.aspx
Oklahoma	http://www.usao.edu/~onps/	http://www.oces.okstate.edu/	http://www.soiltesting.okstate.edu/
Oregon	http://www.npsoregon.org/	http://extension.oregonstate.edu/	http://extension.oregonstate.edu/catalog/html/ec/ec628/
Pennsylvania	http://www.pawildflower.org/	http://extension.psu.edu/	http://www.aasl.psu.edu/SSFT.HTM
Puerto Rico	Does not have a society	http://www.uprm.edu/agricultura/sea/newmap.html	Does not offer a university-run program; contact the cooperative extension agent for a list of soil-testing companies
Rhode Island	http://www.riwps.org/	http://cels.uri.edu/ce/	http://www.uri.edu/ce/factsheets/sheets/soiltest.html
South Carolina	http://www.scnps.org/	http://www.clemson.edu/extension/	http://www.clemson.edu/public/regulatory/ag_svc_lab/index.html
South Dakota	Does not have a society	http://sdces.sdstate.edu/	http://plantsci.sdstate.edu/soiltest/
Tennessee	http://www.tnps.org/index.html	http://utextension.tennessee.edu/Pages/default.aspx	http://soilplantandpest.utk.edu/
Texas	http://npsot.org/	http://texasextension.tamu.edu/	http://soiltesting.tamu.edu/
Utah	http://www.unps.org/index.html	http://extension.usu.edu/	http://www.usual.usu.edu/
Vermont	http://www.newfs.org/	http://www.uvm.edu/extension/	http://www.uvm.edu/pss/ag_testing/
Virginia	http://www.vnps.org/	http://www.ext.vt.edu/	http://www.soiltest.vt.edu/soiltest.html
Washington	http://www.wnps.org/	http://ext.wsu.edu/	http://www.puyallup.wsu.edu/soilmgmt/SoilTesting.htm
West Virginia	http://www.wvnps.org/	http://ext.wvu.edu/	http://www.caf.wvu.edu/plsc/side%20menu/wvu%20soil%20lab/soiltest.html
Wisconsin	http://wisplants.uwsp.edu/BCW/	http://www.uwex.edu/ces/	Depending on the county, the University of Wisconsin may or may not offer soil testing. Contact your extension agent.
Wyoming	http://uwadmnweb.uwyo.edu/WYNDD/wnps/	http://ces.uwyo.edu/	http://ces.uwyo.edu/Soil_Main.asp

Chapter 4 | **Lighting**

INTRODUCTION

This chapter discusses the overall goals of building lighting operation and maintenance (O&M). It provides a number of practices and tips that can reduce lighting energy consumption while maintaining users' visual comfort, productivity, and safety. Reducing lighting energy use can help reduce operating costs and the overall effects of electricity generation on the environment. Environmental benefits range from the local (lower pollution emissions from power plants), to the national (less dependence on fossil fuels and reduced impacts from their extraction and transportation), to the global (reduced emissions of carbon dioxide and other greenhouse gases).

Nationally, energy for lighting accounts for up to 22% of all U.S. electricity use. The lighting of offices, hallways, reception areas, and other spaces constitutes the largest use of energy in most office and commercial buildings—about 35%. This proportion increases even more when the energy needed to cool the heat generated by all the lighting systems and when electricity used for lighting outdoor parking and public areas are

LIGHTING AT-A-GLANCE

Introduction

Lighting Audits

Indoor Area Lighting Operations and Maintenance
Balancing Needs and Efficiency
Lighting Level Recommendations
De-Lamping

Lighting Controls
Lighting Schedules
Occupancy Sensors

Lamp Replacements and Bulk Purchasing of Lamps and Luminaires
Routine Replacement of Existing Lamps
Selecting Lamps for Efficiency

Fixture and Lamp Cleaning
Benefits of Regular Cleaning
Cleaning Methods

Devices Brought in by Occupants

Outdoor, Exterior, Garage, and Parking Lot Lighting Maintenance
Outdoor and Exterior Lighting Controls
Parking Lot and Garage Lighting Options

Lamp Disposal
Overview of Regulations
User Education, Lamp Collection, and Recycling

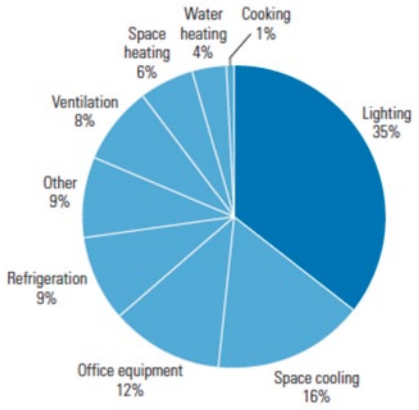
Refurbishing and Upgrading of Residential Units

Acronyms in this Chapter

factored in. Yet, good lighting is essential to provide worker productivity and occupant comfort indoors, as well as to ensure visibility and safety outdoors.

The design, commissioning, operation, and maintenance of a building's lighting need to be considered as an integrated, functional system to achieve maximum utilization and to control factors that affect system efficiency. Operation and maintenance practices for indoor and outdoor lighting systems must also be considered an important and integral part of the building energy efficiency equation. Newly available lighting and control technologies also require building lighting maintenance personnel to stay informed to get the most out of existing systems, as well as identify new technologies that can help improve O&M practices.

FIGURE 1. ENERGY USE IN COMMERCIAL BUILDINGS



Source: Adapted from ESource (2006)

Building maintenance engineers and maintenance staff face a difficult task in trying to keep costs low while balancing occupant lighting needs with equipment efficiency. A building's lighting quality has a direct impact on occupant satisfaction and may outweigh the cost of lighting, especially in public spaces. Similarly, a reduction in some public and outdoor area lighting may result in safety concerns, and can cast a negative light on all efficiency measures.

This chapter has guidelines to help you develop a combination of building O&M practices and schedules that works for your particular needs. Applying a combination of specific measures will best serve the building occupants' lighting needs, maximize energy efficiency, and maintain the proper lighting levels and light quality where needed.

LIGHTING AUDITS

Lighting operation and maintenance practices vary widely. It is almost impossible to come up with a set of specific O&M practices that exactly fit all operations or buildings. However, before embarking on any modifications or upgrade, the PHA should conduct a lighting audit.

Audits are essential because a systems approach is preferable to a piecemeal approach and can yield better results. A systematic approach helps to identify and take advantage of easy efficiency measures offering very short payback periods, depending on the age and type of lighting equipment in service. Energy service companies, architecture and engineering firms, or utilities can conduct audits. They can also be done by qualified internal staff or maintenance engineers. The PHA should:

- Conduct a preliminary energy audit of lighting usage in all the buildings, as well as the outdoor spaces (at a minimum, focus on the public spaces). The audit should note the number and type of fixtures in use, their light sources (and lamp type/model/wattage), the light levels in various areas, how long the fixtures are on per day (and variations during weekends), and what controls are in use. A good lighting auditor can also note the placement and light distribution of fixtures and suggest changes if needed.
- Use the audit as a baseline, if one is not available, to monitor building energy use. An audit also helps to identify the types and quantity of devices not connected to any control systems, and whether or not they should be.
- Use the results from the audit to assess the savings potential of various efficiency measures so that they can be properly considered before implementation.

INDOOR AREA LIGHTING OPERATIONS AND MAINTENANCE

Balancing Needs and Efficiency

The building maintenance team must strike a balance between system efficiency and occupants' visual and safety needs, which at times seem incompatible. This balance can be achieved by considering a range of factors, summarized below from broader to narrower focus:

- **LIGHTING NEEDS DIFFER ACCORDING TO TASKS OR AREAS:** Generally, the focus of lighting O&M should be to provide and maintain good, high-quality lighting for areas and tasks. Areas such as hallways require lower light levels than lobbies. Similarly, laundry areas require different light levels than corridors or stairs. Finding ways to provide occupants with comfortable light levels, instead of providing the same light level throughout the building, is the key to improving energy efficiency and maintaining comfort and safety. This practice not only can help to reduce a building's lighting loads, but also reduce

ACTION ITEMS

1. Provide good, high-quality lighting suitable to occupant needs, and maintain adequate levels for public spaces without over-lighting.
2. Keep up with "regular" system maintenance, such as inspections, light level checking, fixture cleaning, and bulb replacement.
3. Use the most efficient light sources and fixtures feasible, switch off or reduce the amount of light in lower use areas where appropriate, and incorporate daylight.
4. Consider external factors that affect lighting levels and comfort, such as direct sunlight and the layout and paint color of spaces
5. Review building energy performance and integrate user feedback on a regular basis to identify issues and ensure timely responses to them.

its cooling load substantially by reducing lighting heat build-up. It increases occupant comfort and reduces overall complaints regarding lighting levels.

- **"REGULAR" SYSTEM UPKEEP MANAGES ENERGY USE:** Maintaining "normal," routine maintenance practices, as required by the buildings' particular lighting systems and operation schedule, helps to manage energy use. Upkeep includes routine practices such as fixture cleaning, lamp replacement, and other measures such as testing and fine-tuning sensors. Generally, this is the best, simplest, and most conventional approach to maximizing energy efficiency in any building. Often, a poorly designed building with good O&M practices will outperform a well-designed building with poor O&M practices.

- **USING THE MOST EFFICIENT LIGHT SOURCES AND FIXTURES PROVIDES SAVINGS:** In addition to O&M practices discussed above, a number of relatively low-cost or no-cost, quick-return measures can help existing systems maximize their operating efficiency, increase efficiency, or reduce energy consumption. These measures range from using the most efficient light sources and fixtures available and affordable to you, to changes in operating procedures, to automating system settings. For example, installing occupancy sensors for low-use areas, automatic switching, activating day-light dimming, or de-lamping may yield additional savings.

- **EXTERNAL FACTORS AFFECT OCCUPANTS' VISUAL NEEDS:** Often, occupants' lighting levels and visual comfort needs are affected by other factors. For example:
  - Dark or dirty walls and floors reduce the amount of light available in any space.
  - Glare from south-facing windows affect occupants differently than occupants with north-facing windows during the latter part of the day.

These external factors will require different lighting strategies for public spaces such as lobbies and hallways. Blinds, window shades, film, timers or manual switches, and other measures may help to control the lighting loads in these different situations more effectively. Another consideration is that older occupants may require more light and need more individual or localized lighting solutions, such as reading lights.

Periodic or ongoing tracking and reviews of lighting (and building) energy performance complement routine O&M: Ongoing tracking and periodic reviews (monthly or quarterly) of lighting and building energy performance can complement routine O&M practices by providing both a feedback loop and an early-warning system, especially in mixed or residential areas, where systematic controls may not be possible or as easily accomplished. The tracking complements routine O&M practices by creating a baseline for building energy use to indicate

whether new or changes in routine affect energy use and user comfort. Tracking also identifies unusual changes in energy use pattern for further investigation.

Lighting Level Recommendations

As noted above different tasks and areas require differing light levels. It is better to provide high-quality light where needed, rather than high levels of light in all areas needlessly. The Illuminating Engineering Society of North America (IESNA) has determined a range of suitable light levels measured in foot-candles for certain indoor tasks. Nine categories cover typical office, institutional, and educational settings.

Five of the IESNA-recommended light levels for residential and mixed-use buildings are listed in Table 1.[1] Many states have also incorporated American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard 90.1 into their energy codes. ASHRAE 90.1 requires new and renovated spaces to meet strict power densities and lighting control measures. Similarly, California's Titles 20 (commercial buildings) and 24 (residential buildings) have very specific requirements for power densities and controls addressing various building areas.

Note that the IESNA recommended light levels do not distinguish the ambient light levels that are required for general illumination from the light level needed at the work surface. The opportunity for energy savings in some areas is that the ambient, or general, level of lighting can be lowered as long as there are sufficient light levels to meet the appropriate IESNA level.

TABLE 1. COMMON TASK CATEGORIES AND RECOMMENDED LIGHT LEVELS

Application or Task	Recommended Illumination Levels (range in foot-candles)	Notes
Public Spaces	2–5	General or ambient lighting
Short, temporary visits or short visual tasks (for example, bathrooms, closets)	5–10	General lighting
Occasional visual tasks (for example, lobby)	10–20	General lighting
Visual tasks of high contrast or large size (for example, reception areas)	20–50	Required at work surface. Can be met with a combination of ambient/general lighting and task lighting
Visual tasks of medium contrast or small size (most office work fall into this and the above category)	50–100	

Source: IESNA

[1] Chapter 10 of the IESNA Lighting Handbook contains a "Lighting Design Guide" that provides recommended levels for general application categories. The guide also provides a methodology for combining these recommended levels with other criteria to apply to light different tasks and locations.

Many fluorescent lighting systems put in place a decade or more ago provide too much light or provide low quality or inappropriate lighting for current use. For example, glare is a common complaint. These 10- to 15-year-old systems also tend to use more energy and produce excess heat. In addition, dark color walls and floorings, and dirt/dust in older or less well maintained buildings, "absorb" light levels, causing them to appear dark.

Strategies to bring these spaces into conformation with IESNA recommendations include:

- Bringing overlit areas to more comfortable levels through de-lamping
- Improving existing fixtures (through add-ons) to distribute and improve light quality
- Improving areas with poor quality lighting through re-lamping with appropriate lamp types
- Retrofitting or replacing existing systems with the most efficient luminaires
- Cleaning or painting interior walls with lighter colors to maximize the illumination level.

De-Lamping

Of the above measures, de-lamping is the simplest and yields improved energy savings along with visual comfort. This practice involves the removal of a lamp or lamps from multiple-lamp fixtures (for example, converting a 4-lamp 2 x 4 fixture to a 2 lamp 2 x 4 fixture). Areas that are typically overlit include public spaces, corridors with outside windows (in daytime), hallways, kitchens, storage areas, and meeting spaces. Even laundry areas can be overlit.

Following the IESNA recommendations also allows the ambient light levels in public areas to be reduced or turned off if sufficient daylighting levels are available. Where possible, lighting levels in areas such as interior hallways (where no natural light is available) can also be reduced, yielding additional savings. If you choose to practice de-lamping, remove lamps in a uniform fashion to eliminate "dark spots" and ensure that the remaining light levels are sufficient for the tasks or occupants. In addition, de-lamping is most effective when the remaining lamps and ballasts are still matched. Depending on the existing wiring, some ballast can consume as much energy with a partial load as with a full load. Additionally, de-lamping can be effectively combined with a campaign to clean or paint interior walls with a lighter color in order to maximize the illumination level and occupant comfort.

Applying measures other than re-lamping ideally requires the services of qualified lighting experts who can address both light distribution and quality

criteria.[2] In addition, depending on the scale, replacement of existing systems can also require compliance with energy codes governing energy use and lighting installations for new and retrofit facilities. Finally, user interaction and feedback provides some indication of light levels and quality. Complaints such as glare or flickering can indicate too much light or poor quality light. Working with users can help increase understanding and acceptance of implemented measures.

A NOTE ABOUT LEED: The U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program has certification programs for both new developments and existing buildings, including LEED O&M. If your building(s) have been LEED-certified, they need to be operated based on the operational procedures under which they were certified. Conversely, your existing building can earn LEED certification for its O&M practices. LEED O&M certification includes requirements for strict energy management practices and lighting controls, including manual and automatic switching requirements.

LIGHTING CONTROLS

Lighting Schedules

The implementation of regular building-specific or even area-specific lighting schedules saves energy in buildings where occupants keep fairly regular hours. The following strategies can also be incorporated in a building's lighting schedule to further increase lighting energy savings:

ACTION ITEMS

1. Use time scheduling to match lighting to usage hours.
2. Use natural daylight and dim or switch off interior lights as appropriate.
3. Set infrequent and less intensive use areas to lower lighting levels.

- **MANUAL SWITCHING:** The easiest way to save energy is to switch off energy-consuming equipment when not needed. Lights that can be shut off during unoccupied hours should be shut off promptly. Where zone control is available, lighting in unoccupied zones can be shut off with no loss to occupant comfort or safety. "Zoned" systems can provide better control of building lighting during both day and evening hours.
- **TIME SCHEDULING:** Large, open areas (for example, lobbies or public areas) tend to work well with simple time scheduling—regular, automatic switching of lights at fixed hours of the day (for example, off or dimmed during the day if daylight is available). Generally, maintenance crews can carry out time-scheduling if more sophisticated computer controls are not avail-

[2] Such services may be available from the local utility.

able. Time-scheduling controls should be set so that the switching times and intervals serve the needs of the occupants and usage pattern of the area. In addition, occupants need to be informed about the system and how to override the schedule when needed. Adjusting the on-off schedule to account for seasonal changes and available natural light can also yield incremental savings.

- **EMS:** Energy Management Systems (EMS) are often used to control HVAC systems but can also control lights. If lighting is not already integrated into your existing EMS, check whether or not it could be used in low-use or work areas (for example, loading docks). If you are in the process of purchasing a new EMS, consider the addition of lighting control options.
- **DAYLIGHTING:** Natural daylight can be used to great benefit and allows interior lights to be dimmed or switched off when appropriate. Natural daylight consumes no electricity and produces less heat than any electric light source, so the careful use of daylight can reduce air conditioning costs as well as lighting costs. Simple O&M practices can include such manual measures as adjustable blinds and individual light switches to maximize the use of daylight. Available automatic dimming systems can be used to maintain the proper light levels automatically. In addition, reflective film may be used to control intensity and glare, especially on east- and west-facing windows.

ACTION ITEMS

1. Use sensors to switch lights off or to lower light levels when and where possible.
2. Set sensors to avoid "false-offs," watch for non-human sources of motion that can trigger sensors, and inspect regularly for user overrides to the sensor settings.
3. Keep clear and accurate diagrams with marked areas of sensed zones, distinguishing high- and low-sensitivity areas.
4. Be aware of equipment that uses radio frequencies or emits infrared signals, which may affect sensor settings.
5. Set sensors to fail on the "on" position in dark areas.

Occupancy Sensors

Simple occupancy sensors are the most common lighting control measures in buildings today, and some state building codes (for example, Title 24 in California) require them. Sensors located throughout a building can help maximize the energy savings potential of infrequently used areas. Some sensors allow for both temperature and occupancy detection, and can be the basis of an automated setback system for both lights and HVAC in public spaces.

There are two main occupancy sensor technologies for lighting:

- **INFRARED (IR):** IR (also known as passive infrared, or PIR) sensors detect temperature changes in a room. PIR sensors are very resistant to false triggering, but tend to be reliable only within a short range.
- **ULTRASONIC (US):** Ultrasonic sensors use high frequency sound to detect motion, even around corners. US sensors can cover larger areas than PIR sensors and are more sensitive, but they are also more prone to false triggering.

There are also dual-technology sensors that combine both technologies or use acoustic sensors, increasing accuracy and flexibility, but they are more expensive.

Sensors work best in areas with low occupant densities, such as meeting rooms, hallway, laundry rooms, warehouses, loading areas, and storage spaces. Sensors pay for themselves through energy savings. Even though lamp life may be somewhat shortened by increased on-off switching, the overall life of lamps is usually extended by the reduced daily burn hours.

When setting up and using sensors, building staff should:

- Be aware of false sources of sensor triggers, such as air diffusers or curtained windows.
- Be aware, too, that radio frequencies such as remote controls or other emitters may affect sensor settings.
- Set sensors to fail to the "on" position in dark areas to avoid creating dangerous conditions.
- Inspect sensors on a routine basis to account for user overrides.
- Keep clear and accurate diagrams with marked areas of sensed zones, distinguishing high- and low-sensitivity areas.

As with any automated controls, maintenance practices must ensure that the sensor controls are operating properly. The proper installation and maintenance of daylight and occupancy sensors is an essential O&M task. Placement of sensors should take into account furniture placement and the geometry of the space as much as possible, as occupancy sensors need to sense all occupants to avoid turning off lights while the space is occupied. At the same time, "false-on" incidents can be triggered by an automatic on/off sensor that senses passersby in an adjoining hallway if the settings are too sensitive. Sensors with too low a sensitivity or too short a delay time can annoy occupants.

Lights in bathrooms or other infrequently used areas are frequently left on for extended periods, either due to forgetfulness or deliberately to serve as nightlights (especially by seniors and in living centers, nursing homes, etc., as well as residences with younger children). They can be a significant source of lighting

energy use. The nightlight function is generally useful in all residential housing, but especially critical for seniors, for whom tripping and falling is a serious concern. Managers have been reluctant to use occupancy sensors in these areas because the controls can switch off lights if occupants remain motionless for long periods.

For these cases, an option is a combination "nightlight" and occupancy sensor. Recently introduced from a concept developed by the California Lighting Technology Center, these systems combine LED-based nightlights with occupancy sensors. The LED-based lights provide sufficient illumination to assist occupants in the transition from light to dark, and then switch on the appropriate light when occupants enter the space or resume movement. These systems address concerns about lights turning off in areas where occupants tend to remain inactive for long periods, and can reduce lighting energy use in these areas by 50 to 75%.

LAMP REPLACEMENTS AND BULK PURCHASING OF LAMPS AND LUMINAIRES

ACTION ITEMS

1. Set a regular inspection schedule and a replacement schedule for lamp replacement in common areas (at a minimum).
2. Select replacement linear lamps with a minimum of 20,000 hours rated life.
3. Use fluorescent lamps with low mercury content (3.8 mg per 4-ft lamp or less).
4. Use CFLs (compact fluorescent lamps) instead of incandescent bulbs.
5. Replace existing lamps with more efficient equivalents.
6. Use specifications for bulk purchasing to obtain the appropriate lamps.

This section covers both routine replacement of lamps in service and replacement of existing lamps with more energy-efficient options. In addition to color rendering and color temperature (both of which can affect lamp/lighting system performance and user satisfaction), the two most important environmental characteristics of linear fluorescent lamps are:

- **LAMP LONGEVITY:** Most linear fluorescent lamps last for a long time. However, a number of factors affect system performance and reduce lamp life. The selection of a durable system not only ensures that less solid waste will be introduced into the environment, but also it means that the components have been tested for use as a system, thus ensuring user satisfaction and reducing failure incidents. Systems with rated lamp life of 20,000 hours or more should be considered.

- **LAMP MERCURY CONTENT:** All fluorescent lamps contain a small amount of mercury, which is necessary for their operation. We recommend that you select lamps with the lowest mercury content for your particular application. Maximum lamp mercury level should not exceed the State of California's requirements, which is 3.8 milligrams per 4-ft lamp. Manufacturers are required to state whether or not they meet this requirement, or indicate the amount of mercury contained in the lamps in both catalogs and consumer packaging information.

Routine Replacement of Existing Lamps

If your O&M practice involves individual replacement of fluorescent lamps (especially linear tubes) as they burn out, consider switching to replacement of all lamps or all lamps of the same type at once on a set schedule, based on the lamp types in use and their rated hours. However, if group replacement is not an option in your maintenance schedule, consider adopting or incorporating other maintenance tasks into the replacement routine, such as fixture cleaning and ballast inspection, to maintain light output and keep fixtures at peak performance.

ACTION ITEMS

1. Inspect building for lamp failures on a periodic basis (monthly or longer, depending on the types of lamps in use).
2. Do not wait for complaints from users.
3. Set up a maintenance request system for occupants to report lamp failure.
4. Inspect ballasts and perform other maintenance (such as cleaning) on a regular basis.

In general, it is best to develop specifications for replacement lamps to avoid having many different replacement lamp types in stock and/or different lamp types or color/performance in use at the same facility (or in the same fixture). Even if you replace lamps individually, it is better to purchase them in bulk with predetermined lamp specifications to obtain the best performing lamps for your needs, rather than depend on a distributor or dealer's stock at any moment.

Reasons to consider switching to group lamp replacement include the following:

- **COST:** Group relamping costs less on a per-lamp basis. To replace one individual fluorescent tube (or CFL) takes a maintenance worker as much as 30 minutes or longer from start to finish. Having materials on hand and systematically moving from one fixture to another reduces the per-lamp replacement time to about 3 to 5 minutes. The replacement process can be done at a suitable time for occupants to minimize disruptions.

- **SCHEDULING:** Group replacement is an easy task to schedule, and can even be handled by an outside contractor. This can reduce costs and the need for dedicated staff time for lamp replacement.
- **EFFICIENCY:** Other maintenance activities can be incorporated into the replacement process, such as ballast inspection, as well as reflector and diffuser inspection and cleaning. It also provides an opportunity to upgrade reflectors, install lenses, or other servicing tasks.
- **CONTROL:** Group replacement provides better control over replacement lamps, since the same types and color lamps will be used. It helps to reduce instances of incompatible lamps, or mixtures of lamps of different color temperatures and color rendering indices, which affect user comfort.
- **IMPROVED LIGHTING:** Group relamping can provide users with brighter and uniform light levels, because it reduces the chances of lamps reaching their end-of-life characteristics or lumen depreciation curve. It also reduces user complaints (flickering lamps) and on-the-spot maintenance calls.
- **BETTER SELECTION:** Group relamping allows for purchasing in bulk to obtain the best lamps for your needs, rather than purchasing individual replacement lamps and settling for what is available because they are needed immediately.

Note that you can typically calculate group relamping intervals, but the exact burn hours and lamp life usually are not known with enough accuracy. Thus, some organizations use a simple method of determining when to re-lamp: When group re-lamping, they buy 10% more lamps than are needed to re-lamp the area. The use of this 10% overstock is limited to spot relamping only. When they have depleted the 10%, this indicates that it is time to group re-lamp again. This method typically results in group relamping at about 70% rated lamp life.

Selecting Lamps for Efficiency

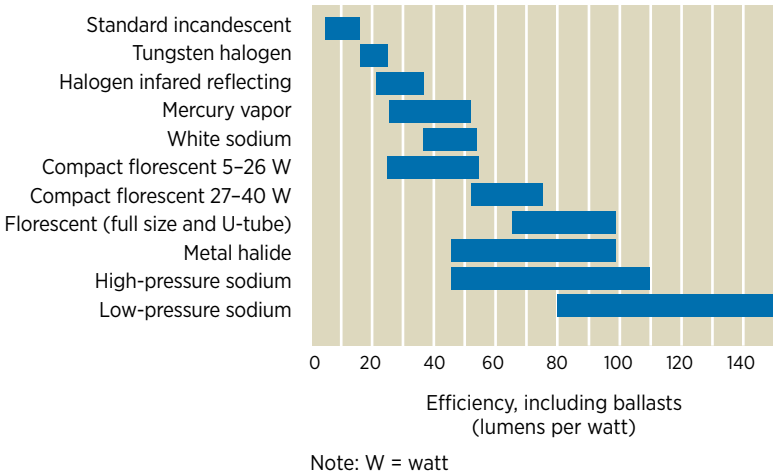
One of the most cost-effective lamp replacement strategies is to replace existing lamps or lamp systems with a more energy efficient (and longer lasting) equivalent or to take higher energy-consuming lamps or systems out of service.[3] As a rule, replacing both indoor and outdoor sources with the most efficient light sources possible without compromising user comfort and safety, while limiting the lighting operating hours, yields the most energy savings.

[3] Many utilities offer financial incentives for the replacement of lamps with more efficient equivalent, or for efficient upgrades of lamp-ballast combinations. Details can typically be found on the utility's website or other information venues.

For office and other commercial/institutional spaces, this strategy often involves replacing linear fluorescent lamps and lamp systems with more efficient alternatives (such as converting from T12 to T8 or T5 lamps and/or magnetic to electronic ballasts), and replacing incandescent lamps with CFLs, both of which are briefly covered below. Note that the most inefficient incandescent lamps are being gradually phased out of the market starting with the 100W incandescent lamp in 2011 in California and in 2012 for the rest of the country.

The efficiency measure of a light source is termed "efficacy" or "luminous efficacy" and is the ratio of luminous flux or light output (measured in lumens) to input power (measured in watts). Figure 2 compares the efficacy of various light sources available on the market today in terms of lumens per watt. Note that care must be taken to apply the most efficient sources to the right application. High pressure sodium, for example, is an extremely efficacious source, but provides very low light quality, especially for visually demanding tasks.

FIGURE 2. LIGHT SOURCES AND EFFICACIES



Note: W = watt

Source: MGE (2007)

CFLs

The cost of CFLs has dramatically dropped, as have lamp sizes, making CFLs the most cost-effective incandescent alternative today. CFLs are now available in a variety of shapes and sizes to fit most incandescent fixtures. Using the "1/3 or 1/5 to 1" rule for CFL replacement wattage (use CFLs that are 1/3 to 1/5 the wattage of the equivalent incandescent lamp, depending on lamp types) should provide the space previously served by incandescent lamps with the same, if not more, light. Replacement of incandescent lamps with CFLs will dramatically reduce the energy consumption of any space.

At a minimum, look for CFLs that carry the USEPA/DOE's ENERGY STAR label, which have met certain performance requirements such as efficacy, lamp life, and UL/safety testing. If you are able to specify CFLs through a PHA procurement contract, choose CFLs with:

- electronic ballast
- 10,000 hours rated life or more

- illumination within 1 second
- minimum color rendering index (CRI) of 80
- mercury content of 3 mg or less.

The chart below provides the most common incandescent equivalencies and minimum CFL efficacy (lumens per watt is defined as the amount of light output for the amount of power input) for bare lamps.

CFLS—BARE LAMPS

Incandescent watt	Equiv. Lumens	Equiv. CFL	Min. Efficacy Levels
40 watts	495 or more	11–13 watts	55 lpw or more
60 watts	900 or more	14–19 watts	65 lpw or more
75 watts	1200 or more	20–25 watts	65 lpw or more
100 watts	1750 or more	29+ watts	65 lpw or more

Another alternative is to take incandescent lamps out of service completely. If you have spaces where the ambient light levels are provided by incandescent downlights (also known as "cans" or "high hats"), such as hallways, meeting rooms, and bathrooms, consider taking these fixtures out of service and installing fluorescent fixtures in their place. While downlight fixtures can accept the newer generation of CFLs, the design of these fixtures tends to shorten the service life of CFLs due to heat build-up. CFLs used in these fixtures also suffer performance and optic problems such as glare, and can result in user discomfort. However, if you choose CFL reflector type bulbs, use the above criteria suggested for life, mercury content, and color quality. The chart at left will help with your selection.

CFLS—REFLECTOR-TYPE LAMPS

Incandescent watt	Equiv. Lumens	Equiv. CFL	Min. Efficacy Levels
40 watts	550 or more	17–19 watts	33 lpw or more
60 watts	675 or more	20–21 watts	40 lpw or more
75 watts	875 or more	22+ watts	40 lpw or more

One more consideration regarding CFLs is their use in enclosed fixtures. Ensure that the lamps intended for enclosed fixtures (with little or no ventilation options) are suitable for this application, by verifying with the distributors or manufacturers. CFLs not intended for use in enclosed fixtures can suffer significant light loss or shorter useful service life when used in these situations, leading to user complaints and frequent replacements.

Halogen Lamps

For applications that CFLs cannot fulfill, such as on a dimming circuit or spot lighting, replacing incandescent lamps with halogen equivalents yields modest savings in some applications. Where available, coated, infrared (IR) halogen lamps are typically the most efficient type available, and can be up to 20% or more efficient than incandescent lamps of the same type. However, rooms lit

with halogen lamps usually require more fixtures and use more energy than rooms lit with fluorescent lamps and can generate a lot of heat. Because halogen lamps are intended to be used as spotlights rather than for ambient lighting, they should not be the only illumination in a room, as they tend to have less even light distribution in addition to high energy usage.

Light-Emitting Diodes

Recently, light-emitting diode (LED)-based lighting products have appeared on the market, with a number of models specifically targeting incandescent or halogen reflectors. LED lighting technology produces light in a whole new way, and the market is rapidly evolving. LED is rapidly approaching the quality and efficiency of existing lighting technologies, such as fluorescent and incandescent—but not all LED lighting is created equal.

While these products may offer sizeable wattage reduction and possible energy savings, it is important to keep in mind that as of October 2010, testing by the U.S. Department of Energy's CALiPER program showed that many models on the market cannot deliver the light output, quality, and concentration (known as "center beam candle power") needed to adequately replace a halogen or incandescent reflector lamps (known as PAR or BR lamps) nor can they maintain their claimed output and lifetime. The testing also showed that very few models on the market now can deliver the light output, quality, and distribution to *adequately replace any halogen reflector lamps, nor can they match halogen reflector lamps' claimed output and even lifetime.*

The same selection rule for CFLs should be applied in selecting LED-replacement lamps: that is, at a minimum, the product must meet the requirements of the ENERGY STAR program for solid-state lighting (SSL) products. In addition, the high costs of the qualified replacement lamps currently available tend to make them more economic for new installations, not for retrofit or replacement.

Linear Fluorescents

LINEAR LAMPS. Fluorescent tubes have also seen steady technological improvement. Advances have added to the recent efficiency improvements made possible by electronic ballasts and better phosphor/lamp technologies. Lamp lifetimes have also improved. The more modern electronic ballast, matched with an efficient fluorescent tube, can reduce energy costs as much as 50% compared to older magnetic ballasted systems. The amount of mercury needed in each lamp has also been reduced significantly.

One of the most common ways to save significant lighting energy in most (older) buildings is upgrading existing T12 lamps with magnetic ballasts to T8

or "super T8" lamps with electronic ballasts.[4] The most common lengths for T8 lamps are 4 and 8 feet, although T8 lamps are available in 2, 3, 5, and 6 feet lengths as well. T8s lamps are also available as u-tubes. U-tube lamps are available in both 6–inch and 3-5/8–inch leg spacing and have an overall length of 22 inches. Where possible, lamps and ballasts should be selected as a matched set.

A new generation of fluorescent tube technology—the T5 lamp—has recently been introduced for general lighting use, but due to their unique size, length, and luminance, T5 lamps are better for new than retrofit installations. T5 lamps come in metric lengths, and the lamp holders are generally smaller and incompatible with T8 and T12 holders. T5 lamps are slightly more efficient than T8 lamps, but have substantially higher luminance, which can cause glare problems in existing installations. T5 lamps are often used for indirect lighting or in shielding or lensing applications, and are also ideal in high-ceiling applications, such as high-bay fixtures for maintenance shops, gymnasiums, and warehouses.

BALLASTS. Magnetic ballasts, found in a T12 fixture, are less efficient, noisier, and heavier than the electronic ballasts in T8 fixtures. The costs of electronic ballasts, like the cost of CFLs, have decreased dramatically, making them much more affordable. In selecting replacement ballasts, consider:

- **BALLAST FACTOR:** In applications, fluorescent lamps generate less light when operated on a commercial ballast than they do on the laboratory reference ballast used to establish the lamp lumen ratings listed in lamp manufacturers' catalogs. The ballast factor is the ratio of a lamp's light output for a given ballast and fixture combination, compared to the lamp's rated light output with a reference ballast. A lower ballast factor means less lumen output. Electronic ballast factors range from about 0.7 to 1.2, with a ballast factor around 0.9 being the most common.

  The ballast factor can be multiplied by a lamp's rated lumen output to determine actual light output. Note that a low ballast factor does not necessarily mean that the efficiency of a fluorescent fixture is worse, because the input power to a fixture will also decrease with a lower ballast factor. In retrofit applications, choosing the appropriate ballast factor can help achieve the desired lighting level without resorting to the replacement of the entire fixture.

- **STARTING METHOD:** Another important parameter of fluorescent systems is the starting method. T8s are typically equipped with rapid-start or instant-start ballasts. Rapid-start ballasts heat the electrodes quickly and then apply a starting voltage to create the arc and begin the illumination process. There is a slight delay of 1 second or less with rapid start ballasts before the lamp begins to illuminate. Rapid-start

[4] Linear fluorescent lamps are specified by diameter size in 1/8ths of an inch. A T8 lamp is a 1-inch diameter lamp and a T12 lamp is a 1.5-inch diameter lamp.

ballasts continue to heat the electrode even after the lamp has started, which typically results in a power loss of 1.5-2 Watts per lamp.

Instant-start ballasts allow the lamp to start without delay by applying a high initial voltage and instantly creating an arc across the electrodes. Instant-start ballasts have the lowest power losses but can decrease the life of the lamp because of degradation of the emissive coating on the electrodes from the high starting voltage. Typically, lamps operating with instant-start ballasts will withstand 10,000–15,000 switch cycles compared to 15,000–20,000 switch cycles for rapid-start ballast.

Generally, the selection of new lamps, especially replacement lamp-ballast systems, should be done in consultation with experienced assistance in order to maximize savings and performance potentials. Your facility's lighting use will determine the lighting levels required, and therefore the equipment you need. Below are some general guidelines to assist in the selection process. To ensure the efficient lighting energy performance, the fluorescent tube must match the ballast.

General Lamp/Ballast General Replacement Recommendations

- Choose T8 lamps and electronic ballasts where both lamp and ballast replacement is feasible. (Choose "super T8" for applications requiring higher lumen output for higher ceilings or dusty areas, for example).
- Choose replacement lamps with the lowest mercury content available for your application (3.8 mg of mercury or less per 4 foot lamp).
- Select replacement linear fluorescent lamps with 20,000 hours rated life or more.

Ambient Lighting General Replacement Recommendations

In addition to the general lamp/ballast recommendations, also consider:

- A 2-lamp in a 2-by-4 foot troffer (grid-like reflector) luminaire is suitable for most applications. Most 4-lamp fixtures can be de-lamped to this configuration.
- For areas where visual tasks are regularly performed (offices, reception areas), parabolic troffers are generally better than lensed troffers for better glare control, and should be kept in use where task lighting is not available.

Replacing linear fluorescent with LEDs

SELECTING LEDS REPLACEMENT LAMPS. As in the case of LED-based reflector lamps discussed earlier, LED-based linear fluorescent replacement lamps are

also available. And as in the case of LED-based reflector lamps, it is important to note that as of October 2010, testing by the US Department of Energy's CALiPER program has shown that very few models on the market can deliver the light output, quality and distribution needed to *adequately replace any linear fluorescent lamp, or can maintain their claimed output and lifetime.*

Note that some "replacement" lamps require disconnecting or bypassing the existing ballast, potentially adding to the installation costs and maintenance confusion. The same selection rule for CFLs and LEDs should be applied here—at a minimum, these product must meet the requirements of the ENERGY STAR program for SSL products, and demonstrate their lighting and lifetime performance qualities with test results rather than marketing claims.

Exit Signs and Emergency Lighting

EXIT SIGNS. While individual exit signs do not consume much electricity relative to other lighting fixtures, a building has many exit signs, and they are on 24 hours a day. As a category, they may account for a significant portion of building electricity use depending on how they are lit, and therefore deserve some consideration during a lighting survey or maintenance routine. Commercially available exit signs use incandescent bulbs, CFLs, or LED arrays as light sources.

Due to their low consumption, LED exit signs can be purchased with built-in back-up power supplies (i.e., batteries). With an estimated service life of 10 years or more, LEDs require significantly fewer lamp replacements than exit signs equipped with either incandescents or CFLs. Non-electrically powered photoluminescent (PL) exit signs utilize a glow-in-the-dark material to provide illumination. While PL exit signs do not require a direct connection to a source of electrical power to operate, they must be charged by another light source in order to function properly. Therefore, PL exit signs are not suitable for all applications.

The use of exit signs with incandescent light bulbs should be discontinued immediately. The Energy Policy Act of 2005 required a new minimum federal efficiency standard for electrically powered, single-faced exit signs with integral lights. All exit signs manufactured on or after January 1, 2006, must have an input power demand of 5 watts or less per face.

EMERGENCY LIGHTING. Safety product maintenance can be a time-consuming and expensive part of operation and maintenance, with codes requiring system testing every 30, 60, or 90 days. Energy-efficient and sources such as CFLs and LEDs can now provide long-lasting, energy-efficient emergency lighting that offers reliability and requires less maintenance and less battery draw from back-up sources. These new systems may also offer self-diagnostic features to monitor battery voltage, lamp continuity, incoming utility power, and unit performance on a regular basis.

FIXTURE AND LAMP CLEANING

O&M managers should consider developing and implementing a maintenance action plan that include both regular cleaning and relamping to achieve the full range of benefits generated by well-maintained lighting. Develop a lighting system maintenance policy and review it with your maintenance team to ensure they use the correct lamps and ballasts and that they clean and maintain lighting system and sensor components properly.

ACTION ITEMS

1. Clean fixtures and lenses at every relamping.
2. Replace lenses whenever ballasts are replaced.
3. Clean multi-celled, metal parabolic louvers with an ultrasonic machine (typically available from electronic repair shops).
4. A good maintenance plan that includes routine cleaning alone may justify the de-lamping of some fixtures.

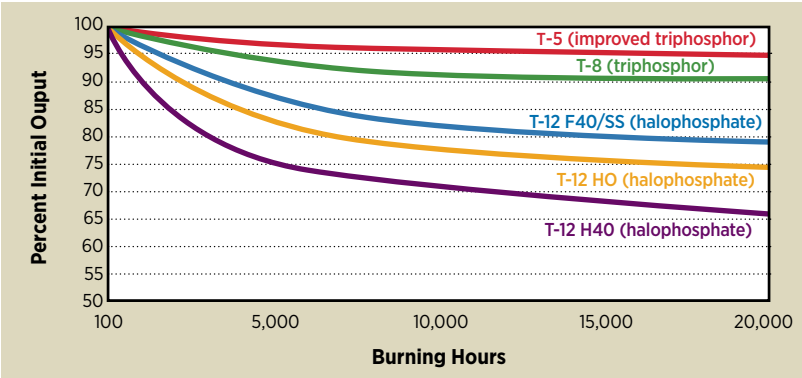
Benefits of Regular Cleaning

The routine cleaning of lamps and fixtures is one of the most important (and sometimes, most neglected) tasks in lighting O&M. All light sources used for interior lighting lose their ability to produce light as they age. Light levels from fluorescent systems can decline gradually over a period of months, due to dust accumulation and system decline. This condition is more noticeable with fluorescent systems due to their longevity. The term "lamp lumen depreciation" (LLD) describes this phenomenon. The values of LLD, also called lumen maintenance, vary between lamp types and manufacturers.

Generally, the LLD characteristics of T8 fluorescent lamps are better than those of T12 lamps, as the newer lamp types with rare-earth phosphor tend to lose less light output over time. The T8 lumen depreciation curve tends to level off as it reaches its low point at about 90%, instead of continuing to depreciate as the T12 does. In addition, new T8 HO (high output) lamps have especially good lumen maintenance. Figure 3 compares light output over time for different linear fluorescent lamp types.

Because of the light from both LLD and poor maintenance practices, lighting designers typically plan for more fixtures and

FIGURE 3. LUMEN MAINTENANCE COMPARISON: LINEAR FLUORESCENT LAMPS



Source: Electric Generating Authority of Thailand (2008)

bulbs than needed to ensure sufficient light levels. Therefore, a good maintenance plan that includes routine cleaning alone can justify the de-lamping of some spaces. Typically, the money saved in energy and lamp costs from de-lamping can more than pay for the regular fixture cleaning and relamping practices, depending on the size of the facility. Lamp cleaning practices are simpler today, as buildings tend to be less dusty, especially in facilities in which smoking is limited to designated areas.

A number of sources of dirt and dust remain even in non-smoking buildings, especially in kitchens and laundry areas. These areas are often overlooked, but they greatly contribute to the amount of dust and dirt generation. Clothes dryers release fine dust that can coat fixture surfaces. The most effective solution is to move these types of equipment to an area with a separate exhaust.

Replacing incandescent lamps with CFLs can significantly extend maintenance periods, but can allow more dust and dirt to accumulate on fixtures between replacements. Therefore, the routine cleaning of lamps and fixtures that have been retrofitted with CFLs should be part of the overall maintenance routine. At a minimum, fixtures, covers/reflectors, and lenses should be cleaned when lamps are replaced. Depending on where the CFLs are used, more frequent cleaning may be required for high use/high dust areas such as laundry areas, bathrooms, and kitchens.

Cleaning Methods

It is recommended that the lamp-replacement crew clean the interior reflecting surfaces of fixtures when lamps are changed. In some environments (such as offices), fixtures may need to be cleaned before the lamps are replaced, but in most interiors, cleaning at lamp change intervals (for group relamping) may prove to be adequate.

Generally, cleaning fixtures and lamps does not require harsh chemicals or volatile cleaning solutions. Fixtures usually require a simple dusting of the interiors, as well as the dusting of lamps, depending on your cleaning and re-lamping schedule. Below are recommended environmentally safe fixtures and lamp cleaning practices:

- Clean fixtures and lenses at every relamping, and replace lenses whenever ballasts are replaced.

ACTION ITEMS

1. Turn off all lamps before cleaning. Turn off power to the whole circuit where possible.
2. Clean lamps and fixtures with a soft, moist (to prevent static) cotton cloth.
3. Keep turning the cloth to present a clean surface as the cloth becomes dirty.
4. Avoid using disposable cleaning materials such as paper towels. Other acceptable re-useable cleaning devices include soft-bristled brushes with anti-static material or a low-powered hand vacuum.
5. Clean both sides of acrylic lenses with a mild solution of dishwashing detergent and allow to air-dry.
6. Use an environmentally safe laundry fabric-softener in the rinse water to reduce static electricity where needed.

- Unusually dirty fixtures or multi-celled, metal parabolic louvers may need to be professionally cleaned with an ultrasonic machine.
- Lamp and fixture cleaning can typically be done with soft, moist cotton cloth, which needs to be continually turned to present a clean surface as the cloth becomes dirty. Care should be used to keep the cloth moist, thereby avoiding the building up of static electricity, which will re-attract dust. Other re-useable cleaning devices (such as a soft-bristled brushes with anti-static material or low-powered hand vacuum) can and should be used instead of disposable materials.
- Most fixtures' acrylic lenses can come clean with a mild solution of dish-washing detergent, while glass covers can be clean with diluted vinegar or other mild glass cleaners. Both sides of the lens should be rinsed and allowed to air-dry. (A dirty lens can reduce a fixture's light output up to 50%).
- Static electricity can be a problem in attracting airborne dirt for some fixtures. The use of an anti-static material, such as an environmentally safe laundry fabric-softener in the rinse water, is a possible solution where static electricity is a problem.

There can be some resistance to cleaning practices when electricians or maintenance crews are asked to clean lamps and fixtures instead of custodial workers. Usually, electricians can be put towards more productive tasks than changing lamps or cleaning fixtures. In addition, custodians who are tasked with relamping may be more likely to clean fixtures properly.

DEVICES BROUGHT IN BY OCCUPANTS

High on the list of "external factors" that affect lighting and energy use are devices brought in by building occupants to help them deal with variable lighting conditions at their locations. These devices range from desk lamps to incandescent and halogen torchieres (up-lights) and other lighting fixtures for lighting larger areas. At best, these devices help provide occupants with the additional light needed for their tasks, and at worst, become

ACTION ITEMS

1. Pay attention to the presence of extra lighting brought by occupants, which indicates additional lighting needs.
2. Watch for fire hazards (and energy wasters) in the form of halogen torchieres (up-lights) and other high-wattage lamps.
3. Negotiate an agreement with all occupants where they can choose from a variety of energy-efficient desk, task, or general lighting options to meet their needs.
4. Set guidelines for supplemental fixtures (maximum wattages, safety ratings, lumen output, etc.).
5. Consider providing CFLs for most of occupants' devices.

a nuisance, if not a fire hazard, as in the case with halogen torchieres.[5] In general, most people require more light as they age.

However, if the goal of O&M practices is to minimize building energy use, these additional fixtures have the potential to wreak havoc with system settings and other reduction measures, resulting in an increase in the building's energy consumption, instead of reducing it.

To maximize savings, one approach is to negotiate an agreement with building occupants, where they can choose from a variety of energy-efficient desk, task, or table lighting to meet their needs. In exchange, the building's lighting levels can be set to take these devices into account. A pilot program can identify the devices that work well for occupants and the lighting levels that they need. Guidelines can also be set for supplemental fixtures (maximum wattages, safety ratings, lumen output, etc.) during these pilots. If needed, the pilot program can also familiarize occupants with CFLs before wholesale replacement.

Overall, there are opportunities in reducing energy consumption if these devices are taken into account, rather than ignored. In addition, the involvement of the building occupants in the pilot and decision-making process often makes the process work better, resulting in maximum energy savings.

OUTDOOR, EXTERIOR, GARAGE, AND PARKING LOT LIGHTING MAINTENANCE

ACTION ITEMS

1. Use daylight controls or photo sensors to turn off lights whenever adequate daylight is available. Inspect and test sensors regularly. Turn off all unnecessary lights.
2. Use energy management systems and time clocks to limit operating hours.
3. Check system setting and adjust time clocks with time of year to minimize operating hours and maximize savings.
4. Adjust timer switches and sensor to turn on non-essential or non-security lights for only short duration (loading docks, for example).
5. Clearly label all switching devices to save time and help employees identify which lights should be shut off at specific times.
6. Check and adjust fixtures so that lights are aimed where needed
7. Use incandescent sources only if they are integrated with a control mechanism that significantly limits the time that they operate.

Effective outdoor and exterior lighting design incorporates careful consideration of many variables, such as overall visibility, safety and security, and energy efficiency. Other outdoor lighting concerns may also need to be evaluated depending on the location and type of application. Most often, there will be concerns with a combination of issues, listed in Table 2, which arise from a combination of poor design and overuse of outdoor and exterior lighting.

[5] Note that the Energy Independence and Security Act (EISA), as well as other federal and state regulations, banned halogen/incandescent greater than 190W.

TABLE 2. OUTDOOR AND EXTERIOR OVER-LIGHTING ISSUES

Issue	Description and Cause	Ways to Minimize
Glare	Glare occurs when a bright source causes the eye to continually be drawn toward the bright image, or the brightness of the source prevents the viewer from adequately viewing the intended target. Glare may create a loss of contrast or an afterimage on the retina of the eye reducing overall visibility.	Equip luminaires with louvers and/or exterior visors to prevent viewing a bright source at lower angles. Luminaire shielding, or "cut off" luminaires (luminaires with specific light output patterns), can prevent the direct image of a bright source and lower the intensity of the light at high angles and direct more light downward. The use of quality prismatic or opaque lens materials can reduce the brightness of the source.
Light trespass	Light trespass occurs when neighbors of an illuminated space are affected by the lighting system's inability to contain its light within the area intended. The inappropriate selection, tilting, or aiming of outdoor luminaires for the particular lighting task causes light trespass.	Minimize light trespass through careful selection of lamp wattage, luminaire type, and placement. Appropriate reflector selection, aiming, and shielding of the luminaires can keep the projection of the light within property boundaries.
Sky glow	Sky glow is the haze or "glow" of light that surrounds highly populated areas and reduces the ability to view the nighttime sky. It results from: • Light emitted from a luminaire in a direction above the plane of the horizon. • Light emitted from a luminaire in a direction below the plane of the horizon but reflected from the surrounding surface towards the sky.	Turn off non-critical lighting late at night. Limit the use of non-cutoff luminaires. Ensure that luminaires emit little to no light above the plane of the horizon. Utilize internal or external shielding that minimizes the component of light above horizontal. Note: Non-cutoff luminaires, such as post lamps, have no shielding or are open at the top, allowing light to shine upward as well as downward.

Many states and municipalities have developed outdoor lighting codes to reduce sky glow, minimize light trespass onto adjacent properties, and limit glare and energy consumption. These legislative efforts may include requirements such as use of specific light source types or wattages, pole height limitations, or requirements for full-cutoff luminaires. (More information is available in the chapter on Parking Garage and Surface Lot Maintenance and on the website of the International Dark-Sky Association at http://www.darkskyorg.)

Parking lots and garages are another area where careful O&M can save energy and minimize the above effects. Parking lots and garages are challenging environments to light. The lighting must accommodate both vehicular and pedestrian traffic, endure harsh operating environments, and take into account public safety considerations and light trespass issues (especially for parking lots, but also for garages). At the same time, these objectives must be met in the most economical way possible. Specific issues that O&M for parking lot and garage lighting must address include the following:

- Vibration from vehicle traffic can create a harsh operating environment for light sources.
- Most parking garage lights operate 24 hours a day.
- Public safety concerns may favor whiter light and a high color rendering index (CRI) despite higher cost (as compared to sodium lamps).
- Failed lamps can create safety hazards and generate complaints if not promptly replaced.
- Lamps not protected with shatter (or bullet) resistant lenses can be frequently damaged and increase routine maintenance needs.

As in the case for indoor lighting, the Illuminating Engineer Society of North America has arrived at the levels of illumination for outdoor applications (see Table 3).

TABLE 3. IESNA RECOMMENDED OUTDOOR LIGHTING LEVELS

Location	Light level in foot-candle (fc)[1]	Uniformity ratio[2]
(a) Streets, local commercial	0.9 Avg.	6:1
Residential	0.4 Avg.	6:1
(b) Parking, multi-family residential:		
• Low vehicular/pedestrian activity	0.2 Min.	4:1
• Medium vehicular/pedestrian activity	0.6 Min.	4:1
(c) Parking, industrial/commercial/institutional/municipal:		
• High activity, e.g., regional shopping centers/fast food facilities, major athletic/civic/cultural events.	0.9 Min.	4:1
• Medium activity, e.g. community shopping centers, office parks, hospitals, commuter lots, cultural/civic/recreational events	0.6 Min.	4:1
• Low activity, e.g., neighborhood shopping, industrial employee parking, schools.	0.2 Min.	4:1
(d) Sidewalks	0.5 Avg.	5:1
(e) Building entrances, commercial, industrial, institutional	5.0 Avg.	—

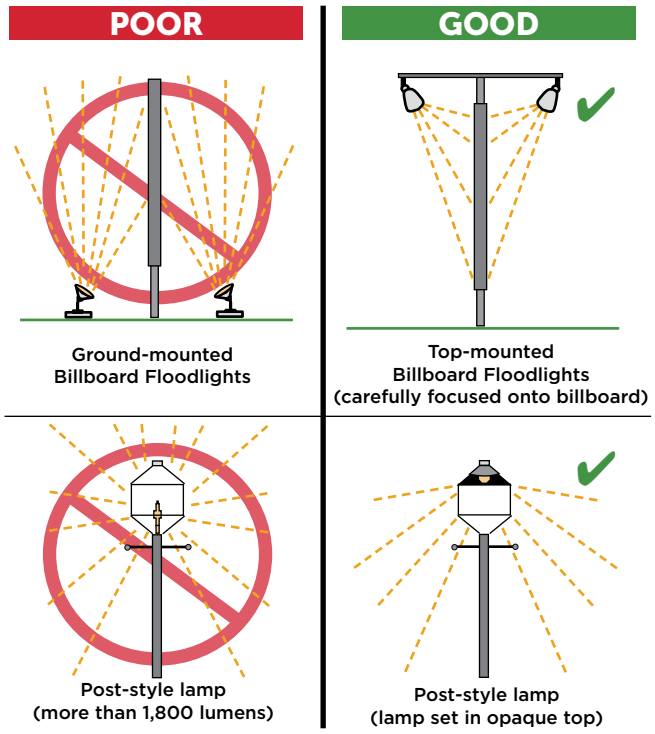
Notes:
1. Illumination levels are maintained horizontal footcandles on the task, e.g., pavement or area surface. Light levels need to be measured with a calibrated light meter capable of reading low light levels for outdoor use.
2. Uniformity ratios dictate that average illuminance values shall not exceed minimum values by more than the product of the minimum value and the specified ratio. E.g., for commercial parking high activity, the average footcandles shall not be in excess of 3.6 (0.9 x 4).

The following measures can maintain outdoor and exterior illumination levels necessary for the safety of the public, employees, and property, while reducing total electrical usage:

- Evaluate existing exterior lighting systems and identify non-critical lighting (which can be done as part of an overall lighting audit, as described earlier).

- Clearly label all switching devices to save time and help employees identify which lights should be shut off at specific times.
- Replace inefficient light sources (mercury vapor, incandescent, halogen) with energy-efficient lamp technologies wherever possible (metal halide, high-pressure sodium, and linear and compact fluorescent sources, as well as LEDs where it is cost-effective). Avoid fluorescent sources that are not suited for low-temperature operation. Eliminate incandescent sources or significantly limit the time that they operate.
- Use IESNA-recommended light level ranges. Use the lower recommended values to lower energy usage. Abnormally bright lights can create glare and deep shadows, which hampers sight. Illumination ratios between areas should be minimal (e.g., less than 10:1).
- Locate outdoor lighting where it is needed, and with minimum interference to the light path.
- In parking lots, use efficient cutoff lighting fixtures that emit no light above the horizontal or into the sky, and use fixtures that emit no more than 2.5% of the lamp lumens upward.
- Use cutoff lighting fixtures for all lamps greater than 2800 lumens to minimize wasted light going up into the atmosphere.

FIGURE 4. EXAMPLES OF COMMON LIGHTING FIXTURES AND THEIR DISTRIBUTION



Source: BC Hydro (2005)

Outdoor and Exterior Lighting Controls

As with indoor lighting, excellent automatic lighting controls are available to turn off exterior lights when not needed:

- Daylight controls or photo sensors turn off lights whenever adequate daylight is available.
- Energy management systems (EMS) and time clocks limit operating hours.
- Timer switches turn on lights for only short duration.

Evaluate and set specific outdoor lighting, as appropriate, to automatically lower or turn off after the close of business and/or after all employees have left the premises, or in non-critical, specific areas with no residential functions. After business hours, lower light levels to minimal levels, just enough to detect movement and provide sufficient security. Use timers, motion sensors, or an EMS to turn off or reduce lighting.

Security lighting activated with motion sensors, so that lights come on only when someone is in the immediate area (consult with local law enforcement or local codes), is an effective way to reduce operating time. Energy-efficient lamp sources ideal for these applications include fluorescent and induction lamps.

When using "on-off" motion sensors for security lighting, avoid the use of sources that require a period of time to achieve full brightness (HID sources such as Metal Halide [MH] or High Pressure Sodium [HPS]). Incandescent sources can also be an effective source for this type of application since they are not sensitive to temperature effects, especially if they only operate for short periods.

Parking Lot and Garage Lighting Options

Many outdoor areas, garages, and parking lots use area luminaires for general illumination (generally, lighting specifiers and designers refer to a complete lighting fixture—lamp, ballasts, lens, housing, etc, as a "luminare"). These luminaires tend to be HPS, MH, or linear fluorescent lamps. HPS lamps are used because of their low cost, high efficacy, and long life. MH or fluorescent sources typically have shorter lives but produce a whiter light.

A number of solid-state lighting-based (SSL-based) luminaires (products using a LED light source) are currently being introduced into the market as replacements for HID-based luminaires. Generally, the adoption of LEDs will require the replacement of the whole fixture, not just the light source, and can represent a significant investment beyond routine O&M measures. However, well-designed SSL-based fixtures have the potential to provide greater control of light distribu-

tion, better lighting color quality, longer life, and energy savings when compared to some traditional light sources.

Parking lot and garage lighting can be excellent applications for LED lighting for several reasons:

- LEDs can provide longer life, better color rendition, and lower energy use than HPS.
- LEDs can be directed to achieve better light distribution.
- LEDs can be easily adapted for controls such as motion sensors and photoelectric cells.
- LEDs can function well in cold temperature environments.
- LEDs can also withstand significantly more abuse.

Unlike conventional light sources, LEDs typically do not "burn out" and fail suddenly, but rather produce diminished light output over time. Some LED luminaires on the market claim to have a life expectancy of 50,000 hours or more, meaning they will still be producing 70% of their initial light output at 50,000 hours of use. High operating temperatures can reduce LED light output and shorten the operating life; conversely, cooler operating conditions may extend the life of the diodes.[6] The same selection rule for other lighting products should be applied here: At a minimum, these product must meet the requirements of the ENERGY STAR program for SSL products, and demonstrate their lighting and lifetime performance qualities with test results rather than marketing claims.

From an economic perspective, the initial purchase price may limit acceptance of LED replacement fixtures. Despite the significant reduction in annual energy consumption and maintenance costs that they can offer, LED products' high upfront cost can be a significant barrier to their adoption for retrofit projects. However, one additional advantage that LEDs may have is that they can withstand a fair amount of abuse (when properly constructed) because they use multiple point sources of light rather than a large bulb that can easily be damaged.

[6] Note, however, that the long-term performance of LED luminaires is still largely untested. For example, a claimed product life of 50,000 hours translates to nearly six years of continuous operation. IESNA has only recently published an official test method for lumen depreciation testing (LM-80, released in September 2008). Consequently, no independent data is available to corroborate manufacturers' lifetime estimates.

LAMP DISPOSAL

ACTION ITEMS

1. Handle spent lamps with care.
2. Avoid crushing or breaking lamps during transport.
3. Set aside a location to collect spent lamp.
4. Educate everyone on the need for careful handling and disposal options.
5. Follow recommended guidelines on how to handle broken lamps.
6. Do not discard broken lamps—they should also be put aside for recycling.
7. Arrange for regular recycling pickup.

Overview of Regulations

Fluorescent and other high-intensity-discharge (HID) light sources generally require care in their handling and disposal. Fluorescent light sources, HID, and mercury vapor lamps all require various amounts of mercury to operate (ranging from 3 mg to over 100 mg, or about the tip of a ballpoint pen to a small bearing). Care is needed during the unpacking, installing, or replacing process for these light sources, as they can break if dropped or mishandled.

Mercury, especially in larger quantities, is considered a hazardous material, and the EPA and states regulate its disposal and handling. In general, state waste disposal regulations take precedence over federal regulations. Additionally, some county disposal regulations are even more stringent than a state's regulations.

On July 6, 1999, EPA added hazardous waste lamps to the federal list of "universal wastes." Hazardous waste lamps are any lamps that are characteristically hazardous, as determined by the TCLP (Toxicity Characteristic Leaching Procedure). This includes fluorescent, high intensity discharge, neon, mercury vapor, high-pressure sodium, and metal halide lamps, *if they are characteristically hazardous (that is, as confirmed by the TCLP test results).*

The new rule became effective on January 6, 2000. Options for managing lamps include managing them as hazardous waste, managing them under the universal waste rule, or using a type of lamp that is not hazardous. "Universal wastes" are also hazardous wastes; however, they have less stringent requirements for storage, transport, and collection. Universal wastes are regulated under 40 CFR 273 and other state codes.

Federal regulations currently allow a conditionally exempt, small-quantity generator (someone generating less than 220 pounds of hazardous waste/month) to dispose of its waste in a municipal waste landfill. Newer lamps on the market have lower levels of mercury and thus are not considered hazardous waste. If the lamps pass the TCLP, they are not hazardous waste and may be disposed in a municipal waste landfill. Manufacturers are required to disclose whether or not their lamps pass the TCLP tests, and indicate the amount of mercury present in a lamp in product catalogues and consumer packaging.

If a collection and recycling system already exists in the building for linear fluorescent lamps, it can be easily expanded to include CFLs. If, however, a collection and recycling program does not exist for either linear or compact lamps, then it should be considered and included as part of a comprehensive user and occupant outreach and education on energy efficiency (especially to help address user-supplied devices and programs to provide CFLs to occupants). A list of fluorescent lamp recyclers is generally available from the state departments of environmental protection, or from the resources listed below. Generally, a collection area or areas will be needed and designated for spent (and broken) lamps, and a location will be needed to set aside for collection and storage in between recycling pick-ups. (See also the chapters on Recycling and Special Waste Programs and Resident Education.) Information from the EPA on CFL cleanup can be found at: http://www.epa.gov/cfl/cflcleanup.html.

User Education, Lamp Collection, and Recycling

If CFLs are being provided to occupants and workers and installed in housing units as a part of the building's comprehensive energy efficiency measure, the measure should also include:

- Educating users on the care, handling, and application of CFLs
- Providing users with clear information on recycling and disposal of spent and broken lamps
- Providing users with options for recycling and disposal of spent and broken lamps on site.

The EPA, through the ENERGY STAR program, has created comprehensive user guides and guidelines that can help in communicating with occupants about CFLs and mercury. They can be found at: www.energystar.gov. Some relevant points on handling CFLs are summarized below.

CFL USE IN LIVING AREAS: CFLs are mostly made of glass, and can break if dropped or roughly handled. Everyone needs to use care when removing from packaging, installing, or replacing CFLs. Screw and unscrew these lamps by their base, and never forcefully twist them into or out of light sockets.

HANDLING OF BURNED-OUT CFLS: EPA recommends that CFLs be recycled where possible. Recycling options or drop-off points need to be provided to users and residents. Users should not send fluorescent light bulbs or any other mercury-containing product to an incinerator.

BROKEN CFLS CLEAN-UP STEPS: EPA recommends the following clean-up and disposal steps for broken lamps:

1. Air out the room before clean up: Open a window and leave the room for 15 minutes or more.
2. Hard surfaces: Scoop up glass fragments and powder using stiff paper or cardboard and place in a sealable container or bag, then use sticky tape to pick up any remaining small glass pieces and powder. Wipe the area clean with damp paper towels or disposable wet wipes. Place towels in a container or plastic bag and seal shut.
3. Carpeting or rugs: Pick up glass fragments and place them in a sealable container or plastic bag, then use sticky tape to pick up any remaining small glass fragments and powder. Vacuum the area if needed. Put the vacuum bag or vacuumed debris in a container or bag and seal shut.
4. Clothing, bedding, etc.: Wrap up and throw away clothing or bedding with embedded broken lamp fragments to avoid spreading broken fragments. Do not wash such clothing or bedding.
5. Disposal of clean-up materials: Place all clean-up materials outdoors in a trash container or protected area for the next normal trash pickup, and wash your hands after disposal and clean up.

Resources

Four of the best and most accurate resources on lamp recycling and consumer mercury information can be found on the Internet, listed below.

- The U.S. Environmental Protection Agency (EPA) maintains a website that lists contact information for state agencies charged with hazardous waste regulations: http://www.epa.gov/epaoswer/hazwaste/state/links.htm
- The ENERGY STAR program (DOE and EPA) website provides information about CFLs and mercury, along with links to recycling and other information sources and factsheets: http://www.energystar.gov
- Envirobiz International Environmental Information Network's website (click on government regulatory agencies) at: http://www.envirobiz.com/waste-disposal.html
- Earth's 911, a nonprofit educational organization, provides recycling resources by zip code at its website: http://www.1800cleanup.org

REFURBISHING AND UPGRADING OF RESIDENTIAL UNITS

For residential and office units, one of the main opportunities to reduce future energy consumption is the unoccupied period between occupants, when extensive and thorough upgrading work can be carried out without interruption, and in integration with other energy-efficient measures. As discussed earlier, an energy audit should be conducted for the area to be refurbished to identify the major efficiency opportunities, including HVAC, windows, and lighting.

This section focuses on a few main points to improve lighting energy efficiency during the refurbishment process. Consider these suggestions in addition to the points regarding light levels, fixtures and lamps selection, bulk purchasing, proper applications, and sensor selection covered elsewhere in this chapter. (Other environmentally beneficial practices to accomplish between occupancies are discussed in the Unit Turnaround chapter.)

ACTION ITEMS

1. Upgrade fixtures and lamps to the most energy-efficient options.
2. Upgrade bath and other infrequently used areas with sensors or sensor-nightlight combinations, and integrate with control systems.
3. Choose light colors for upgraded walls and floor areas.
4. Thoroughly clean walls and floors not upgraded of dust and dirt.
5. Thoroughly clean fixtures and lenses not upgraded.
6. Educate everyone on the need for careful handling and disposal options.
7. Follow recommended guidelines on handling broken lamps.

REPLACEMENT OF LAMPS AND FIXTURES: During the refurbishment process, it is essential that existing indoor linear fluorescent systems be replaced, delamped, or upgraded with the most energy-efficient lamp-ballast combination possible. Check that the upgraded areas meet IESNA recommended levels and state building codes. Similarly, evaluate and upgrade as needed the outdoor and public area fixtures and systems.

Next, incandescent and other fixtures (both indoor and outdoor) should be upgraded or replaced with CFL-based fixtures. For residential units, we recommend that CFLs in all high-use sockets such as kitchens, living rooms, and bathrooms. Where possible, we also recommend replacing incandescent fixtures with dedicated CFL fixtures. If you install dedicated CFL fixtures, stock replacement lamps and make them available to occupants, or include these fixtures on a regular inspection schedule. Finally, because of the decreasing costs of CFLs, you may want to conduct a cost-benefit analysis of the tradeoff between dedicated CFL fixtures (as they tend to cost more) compared to making CFLs available to occupants on an as-needed basis.

The selection of linear systems and CFLs should follow the guidelines provided in the sections on CFL and linear lamp replacement earlier in this chapter. It may be important to consider using the most efficient fixtures, lamps, and ballast

systems throughout the building, as this can reduce inventory size and the need to stock specialized replacement parts.

CODE COMPLIANCE: Depending on how extensive the refurbishment process, you will need to check with local authorities on compliance with building and energy codes. Many states have adopted ASHRAE 90.1 for energy management requirements, controls, and power density. Similarly, California's Title 20 (commercial buildings) and Title 24 (residential buildings) also have very specific requirements for power densities, controls, and specific fixture (luminaire) types used in various building areas.

SENSORS AND OTHER CONTROL SYSTEMS: During the refurbishment process, consider including or upgrading sensors and other control systems to further reduce energy use. These systems include occupancy sensors in bathrooms, storage, hallways, meeting rooms, and other low-use areas, as well as integration of public areas, parking, etc. into an existing or new EMS if available. Consider the LED-nightlight systems, discussed in the earlier section on occupancy sensors, for sensors for bathrooms and other low-use areas. Again, the selection process should follow the discussions and recommendations above to ensure proper installation and use. Consider the same sensor systems throughout the building, as this can reduce sensor inventory size and the need to stock specialized replacement parts.

HANDLING AND DISPOSAL OF MERCURY-CONTAINING LAMPS: Set aside used and replaced fluorescent and HID lamps from the refurbishment process for collection and recycling. If a collection system already exists in the building for linear fluorescent lamps, then it should be utilized. If, however, a collection and recycling program does not exist for either linear or compact lamps, consider starting one as part of a comprehensive refurbishment process. A list of fluorescent lamp recyclers is available at the websites listed in the previous section. If lamps are broken during the refurbishment process, follow the guidelines above for handling of broken lamps to maintain safety and to avoid contamination of other materials discarded from the refurbishment process.

WALLS AND WINDOWS: If new paint, wall covers, and/or flooring are called for, consider light, cheery colors and semi-gloss paints for the walls, as well as flooring (to the extent possible). These colors reduce the light loss from darker wall colors and flat, dull surfaces. In addition, during the refurbishment process, take note of large window areas; south-facing windows, if not replaced, should be covered with reflective film to manage glare and solar heat gain. Other window coverings should also be considered for both daylight harvesting and thermal control.

CLEAN FIXTURES, WALLS, AND FLOORS: Finally, during the refurbishment process, thoroughly clean areas not slated for new paint or fixtures. At the conclusion of the refurbishment process, make sure that the cleaning crew responsible for the final cleanup not only cleans vertical and horizontal surfaces, but also cleans fixtures and lenses that are upgraded, as well as those that are not. These actions are especially needed in dusty, dirty areas such as kitchens, laundry rooms, and printer rooms in offices. This will help to maintain the light level for the new occupants, and reduce the accumulation of dirt and dust to an acceptable level.

ACRONYMS IN THIS CHAPTER

ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
CFL	Compact fluorescent lamp
CRI	Color rendering index
EMS	Energy management systems
HID	High intensity discharge
HPS	High-pressure sodium
HVAC	Heating, air conditioning, and ventilation
IESNA	Illuminating Engineering Society of North America
IR	Infrared
LED	Light emitting diode
LEED	Leadership in Energy and Environmental Design (U.S. Green Building Council)
LLD	Lamp lumen depreciation
lpw	Lumens per watt
MH	Metal halide
O&M	Operations and maintenance
PHA	Public housing authority
PIR	Passive infrared
PL	Photoluminescent
SSL	Solid-state lighting
TCLP	Toxicity characteristic leaching procedure
US	Ultrasonic

Chapter 5 | Parking Garage and Surface Lot Maintenance

INTRODUCTION

A regular maintenance program will prolong the useful life of a parking structure or surface lot and reduce the cost of operation if problems are found and addressed early on. Aside from major structural repairs and scheduled replacements or upgrades, most parking area maintenance is not complicated and simply needs to be performed routinely.

PARKING MAINTENANCE AT-A-GLANCE

Introduction

Clean the Parking Garage

Inspect Floor Drains and Lighting Fixtures

Clean Surface Parking Lots

This chapter covers activities that would fit in a green operations and maintenance plan. It describes what the building staff should do on a regular basis to keep parking areas clean and safe, and also suggests how to lessen environmental impacts when resurfacing or replacement is required.

CLEAN THE PARKING GARAGE

In addition to presenting a well-kept public image, regular cleaning of a parking garage can help identify and address potential problems. Place trash receptacles in convenient locations to reduce the likelihood that trash will be discarded next to vehicles or as litter. Empty the receptacles regularly, since overflowing trash can become litter, block floor drains and lead to water buildup, attract pests, and present a pedestrian hazard on walkways and in stairwells. Removing trash from parking surfaces also eliminates debris that can hold moisture and de-icing salts in contact with concrete.

ACTION ITEMS

1. Collect and remove trash daily.
2. Sweep parking surfaces and stairwells weekly.
3. Wash the parking deck surface at least twice a year (spring and fall). Dust, oil, grease, dirt, and de-icing chemicals from parking structures can be tracked inside the building.
4. Inspect floor drains and lighting fixtures for proper function.

Sweep and wash parking surfaces periodically (wash at least twice yearly) to remove dust, oil, grease, dirt, and de-icing chemicals that can be tracked inside the building. Fluids from vehicles, such as grease, oil, and antifreeze, can build up in parking spaces and at the garage entrances and exits, and may become a slip hazard for pedestrians. If it is not possible to collect the dirty water after a washdown, consider using a mechanical scrubber that collects the dirty cleaning fluid as it cleans.

Maintain waterproofing systems (e.g., deck sealers, joint sealants, membranes) according to manufacturers' instructions to ensure performance and check monthly for leaks or deterioration.

INSPECT FLOOR DRAINS AND LIGHTING FIXTURES

Water penetration into concrete presents a potential structural hazard to the reinforcing steel. It is important to keep water from ponding and penetrating for long-term structural stability. Make sure that floor drains, basins, and traps are kept free of trash and debris to prevent clogging and standing water. Use temporary filters (e.g., burlap) when possible during washdowns to prevent sediment and trash from entering the drains.

Pedestrian safety requires adequate lighting in all areas of the garage at all times. Inspect lighting fixtures for burned-out bulbs, dirty lenses, dirty photocells or sensors, and battery pack status on emergency lighting (see also the chapter on Lighting).

HVAC equipment for control rooms or operator booths should have filters cleaned or replaced regularly (see also the chapter on HVAC).

CLEAN SURFACE PARKING LOTS

As with parking garages, regular cleaning of a surface parking lot can help identify and address potential problems. Activities to perform include the following:

- **REMOVE TRASH REGULARLY** to prevent overflowing receptacles, litter problems, blocked drains, pests, and vehicle or pedestrian hazards. Trash generally should be removed daily, but may be removed less often based on actual receptacle usage or by adding additional capacity (i.e., more or larger receptacles).
- **SWEEP THE PARKING LOT SURFACES WEEKLY** to remove dirt and smaller trash not collected in receptacles. Clean up spills of vehicle fluids, such as grease, oil, or antifreeze, with the appropriate media (e.g., towels, wipers, absorbents) and dispose of them properly. Avoid pressure-washing surface lots because vehicle fluids will contaminate the water runoff. If washing the surface lot is required, use a mechanical scrubber that collects the dirty cleaning fluid as it cleans.
- **KEEP DRAINS OR OIL/WATER SEPARATORS FREE OF TRASH AND DEBRIS** to prevent clogging and standing water.
- **REMOVE WEEDS AND OTHER UNWANTED VEGETATION**. Staff or contractors responsible for grounds-keeping should address vegetation that grows in the seams and cracks of paved areas. Environmentally preferred herbicides or hand removal should be used whenever possible and before the size of the vegetation causes damage to the parking lot surfaces (see also the chapter on Landscaping).
- **INSPECT LIGHTING FIXTURES** for burned-out bulbs, dirty lenses, dirty photocells or sensors, and battery pack status on emergency lighting. Pedestrian safety requires adequate lighting of surface parking lots. When replacing outdoor parking lot fixtures, consider fixtures that meet the International Dark-Sky Association program requirements to reduce light pollution (see also section on Lighting).
- **EVALUATE THE POTENTIAL TO USE LIGHTER COLOR OR SOLAR-REFLECTIVE SURFACE MATERIALS** if resurfacing or replacing the parking lots is required. A lighter color or reflective material will absorb less heat and reduce the temperature of the parking lot and surrounding residential area. Surface parking lots with cooler surfaces may also extend the life of the lot. Pervious concrete is another option for concrete parking areas where stormwater runoff or drainage is an issue. Pervious, or permeable, concrete uses larger aggregate and very little sand to create concrete with large internal voids that allow water to quickly drain through. Pervious concrete installations

can reduce or eliminate the curbs, drains, piping, catch basins, and other stormwater management features typically used to address stormwater runoff over large paved areas. The National Ready Mixed Concrete Association provides background materials on the use of pervious concrete at http://www.perviouspavement.org.

Chapter 6 | **Purchasing**

INTRODUCTION

A public housing authority (PHA) can improve the health of its staff and residents, save money, and reduce its environmental impact through its purchasing decisions. Light bulbs, cleaning products, appliances, and other commonly used items are now available with such features as higher energy efficiency, less solid waste, and less toxic chemical ingredients.

This chapter suggests ways for the PHA to evaluate its need and potential use for environmentally preferable products (EPP) and outlines how to purchase EPPs through a four-step process:

- Gathering data about current product use
- Creating a Green Purchasing Action Plan
- Monitoring purchases against the plan on a regular basis
- Identifying environmentally preferable products for purchase.

PURCHASING AT-A-GLANCE

Introduction

Step 1: Gathering Data

Step 2: Creating an Action Plan

Step 3: Monitoring on a Regular Basis

Step 4: Identifying Products
Appliances and Electronics
Carpeting and Floor Care Products
Lighting
Paints
Paper Products
Water Fixtures

STEP 1: GATHERING DATA

A PHA's first step to implement a green purchasing program is to gather information about current purchasing practices. The PHA should identify who will be its green purchasing coordinator to gather information on:

- **CURRENT PROCUREMENT DATA BY PRODUCT CATEGORIES:** A designated green purchasing coordinator should work with the building managers to determine the annual dollar amount spent in the past year on products for which environmentally preferable alternatives are available. (More information on these products is provided later in this chapter and in the other chapters of the manual.) Common product categories include cleaning supplies, floor care products, paints and stains, light bulbs, paper products, and water-efficient fixtures.
- **CURRENT PROCUREMENT PRACTICES:** After calculating the total dollar amount and the quantity (number of products) of each type of product purchased within each category, the PHA should assess how items are procured: for example, through a blanket contract that includes product specifications or on an as-needed basis. Many times, a blanket contract or other long-term procurement contract is established to provide a consistent supply of products that meet certain specifications, a reduction in pricing due to a long-term agreement, and the convenience of identifying a reliable supplier.
- **CURRENT CONTRACTS:** If the products are purchased through a blanket contract, then the PHA should find out the timeline of current contracts, including the end date and the schedule of upcoming bidding opportunities for each contract. The best time to change the product specifications to require or specify EPPs is usually when existing contracts are up for bid.

To implement a fully functional green purchasing program, all information about products purchased needs to be routinely recorded in some kind of readily accessible data system.

STEP 2: CREATING AN ACTION PLAN

The PHA's second step is to develop a Green Purchasing Action Plan that outlines specific goals over a period of time. For example, in a five-year Green Purchasing Action Plan, the first-year goal might be to establish the specific categories targeted for green purchasing and the amount of each product category that will meet the new EPP specification. The second-year goal might identify additional

products that will be purchased using EPP specifications and might increase the amount of all purchases (perhaps from 10% in the first year to 25% in the second year) that meet the specifications in the Green Purchasing Plan. In the third year the goal might be to increase the amount of EPP to 50%, with increases over time. Instead of an overall goal for all purchases, the goals could be customized for each product category. For example, a second-year goal may be 5% of all light bulb purchases and 5% of all paper products meet the requirements of the Green Purchasing Action Plan.

First-year goals are typically to create the plan itself, set specific and quantifiable goals for the percentage of each product category for the following years, clarify responsibilities, and provide training and/or orientation to staff. When creating the plan, it is important to design a simple tracking system, so that the actual purchases can be compared with the goals. Also, a review should be conducted at least annually to review and adjust as needed the goals set in the first year. The PHA should track and report the quantity of products in each category included in the Green Purchasing Plan that were purchased for that year and track the percentage that met the EPP specifications.

The PHA should monitor progress of the Green Purchasing Action Plan at least on a quarterly basis. An example of a simplified tracking worksheet is below:

Name of vendor	Name of product	Product category	Number of product(s) purchased 2010	Date contract expires	Amount of purchase	Meets product specifications? (energy efficiency, recycled content, etc.)
Lights R Us	"Green" CFLs	Light bulbs	12 cases	12/31/11	$120	Yes
Paper R Us	Non-green printing paper	Printing paper	1 case of 50 reams	1/5/11	$50	No

The PHA should compare the percentage of each product category that meets the environmentally preferable specifications to the previously set goal. If the Green Purchasing Plan is successful, the PHA should be able to increase the percentage of products in each product category that meet the EPP specifications each year. The PHA should consider collecting feedback from the building staff to learn of any concerns about replacing existing products with environmentally preferable alternatives. Obstacles and issues in terms of the purchasing process should also be identified. The PHA should review the feedback to determine how to overcome challenges in implementing the program. The Green Purchasing Action Plan may need to be adjusted to reflect any issues encountered with replacing current products with environmentally preferable alternatives.

For the initial phase of the Green Purchasing Action Plan, the PHA may want to consider focusing on a few specific product categories where EPP choices are readily available and increase the number of product categories over time. The

initial phase may include categories with an easy way to identify environmentally preferable products, such as third-party certification programs, as discussed later in this chapter and in the Cleaning and Lighting chapters.

In order to determine which product categories to include in the Green Purchasing Action Plan, the PHA should prioritize based on such factors as dollar amount spent on product categories and environmental impact. There may be product categories that are easily identified, but do not account for a large amount of expenditures (such as cordless phones for office areas). Instead, the PHA should focus on categories that represent the higher expenditures and more significant environmental impact (such as floor care products and paper products). Periodic training will likely be required not only for the purchasing staff, but also for the building staff for using, installing, and maintaining environmentally preferable products.

The Green Purchasing Action Plan should include:

- Prioritization of product categories by dollar volume, environmental significance or environmental impact, and availability of environmentally preferable products at a reasonable cost;
- Implementation schedule for green purchasing based on prioritization, timing of upcoming bidding opportunities, and ease of implementation for each category (or steps to develop this implementation schedule as needed). The PHA should adjust or revise the implementation schedule during each review period to reflect current progress and challenges;
- Designation of a Green Purchasing Program coordinator. It is critical that, as part of the green purchasing program, a designated person on the PHA building staff has the responsibility for implementing green purchasing. This person will be responsible for ensuring that the Action Plan is implemented, identify which products should be given priority for EPP purchases, develop the specifications, make sure staff are trained as necessary, and collect feedback from staff on how the new products are working;
- Monitoring and reporting protocols to document progress on green purchasing.

The PHA should consider including a process in the Green Purchasing Plan to test and/or evaluate new products to make sure they meet the PHA's requirements prior to specification for purchase. Conducting product testing beforehand helps prevent a situation where large quantities of an environmentally preferable product are purchased, but do not meet the performance needs, resulting in wasted funds. Creating a successful feedback system for the building managers will also help address any issues in replacing traditional products with EPP alternatives. In reviewing prices, the PHA should use lifecycle costing, that is, determining the cost of a product over the duration of its life, not just the

initial purchase price. For example, purchasing a low-quality appliance may have a lower initial cost, but if it requires constant maintenance or repairs, the lifecycle cost would be the time and labor by the building maintenance staff to constantly repair it, as well as the expense to replace the item. A reliable appliance may be less prone to needing repairs and may not need to be replaced for a longer period of time, so, despite the higher initial cost, would end up costing less. Many EPP products have a higher initial cost, but last much longer than a lower quality product, and may result in savings in terms of energy and other costs. All these aspects should be taken into account when comparing the cost of a traditional vs. EPP products. For some products, staff will need training in how to use, install, or maintain the new product effectively.

STEP 3: MONITORING ON A REGULAR BASIS

Once the Green Purchasing Action Plan is in place, it is critical that the coordinator monitors progress quarterly and conducts at least an annual review. Management should also review progress, identify any obstacles to increasing the number of products that meet the EPP specifications, and make any needed adjustments to the plan. Each annual review should also involve updating the plan, including specifying additional product categories.

In addition, it is important for the agency to educate purchasing staff and the staff that use the products about why green purchasing is important, and to adopt agency-wide policies that clearly state the organization's commitment to green purchasing. A robust green purchasing program would include the following:

- An explicit statement of commitment to green procurement from top management;
- An explicit policy statement on green procurement explaining broad goals for the institution;
- Evidence that green procurement has been incorporated in standard and routine procurement procedures such as in relevant manuals or documents or in purchasing procedures and instructions to purchasing agents, as well as evaluation methods that address adherence to procedures and expectations;
- Evidence that the agency has explicitly engaged its staff (including purchase request originators as well as administrative procurement staff) in the greening process through education, and rewards and incentives;

- Evidence of communication and education about green procurement throughout the organization, to all building staff, and to residents (see the Resident Education and Special Programs chapter).

STEP 4: IDENTIFYING PRODUCTS

A number of specific product categories, mentioned in the other chapters of this manual, are common PHA purchases that have environmentally preferable alternatives. These categories include appliances and electronics, cleaning and floor care products, lighting, paints and stains, paper products, and water fixtures. Appliances and electronics are a major source of energy use in residential units, and purchasing energy-efficient options would save energy and reduce costs. Cleaning and floor care products, as well as paints, contribute significantly to poor indoor air quality. Water-efficient fixtures reduce water costs, and purchasing responsibly harvested wood products can benefit surrounding ecosystems. Below are examples of environmentally preferable options for each of these product categories, including certifications to look for, if available, and websites for additional information.

Appliances and Electronics

Purchasing appliances that consume less energy can cut costs and help improve the environment. Two programs identify environmentally preferable options for appliances and electronics: ENERGY STAR-qualified appliance and electronics products and EPEAT registered computers.

- **ENERGY STAR.** A joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy, ENERGY STAR helps save money and protects the environment through energy efficient products and practices. Appliances and electronic that have earned the ENERGY STAR meet strict energy efficiency guidelines set by the EPA and US Department of Energy. Information on ENERGY STAR and a list of products can be found at http://www.energystar.gov.

- **ELECTRONIC PRODUCT ENVIRONMENTAL ASSEMENT TOOL (EPEAT).** Registered electronics products must meet requirements for energy efficiency as well as other lifecycle-based criteria such as recyclability design, reduced use of hazardous materials, and consumer information about take-back programs. The EPEAT program has three tiers, Bronze, Silver and Gold. Information on EPEAT and a list of registered products can be found at http://www.epeat.net.

Cleaning and Floor Care Products

Traditional cleaning products can contain hazardous chemicals where exposure may cause a number of health concerns, including certain types of cancer, reproductive disorders, major organ damage, and permanent eye damage. Indoor air pollution from volatile organic compounds from cleaning chemicals can cause other common health problems, including asthma and other respiratory ailments, headaches, dizziness, and fatigue. These health problems can affect anyone exposed to these chemicals, including PHA staff and residents. See the chapter on Cleaning Procedures and Products for more information about environmentally preferable cleaning products.

The PHA should look for cleaning products identified by the following organizations:

- **ECOLOGO.** Certified cleaning products must meet certain lifecycle-based standards that include performance, chemical restrictions, and packaging requirements in either Environmental Choice CCD-146 for Hard Surface Cleaners, CCD-147 Floor-care products, or CCD-148 Carpet and Upholstery Cleaners. Information on EcoLogo and certified product listings can be found at http://www.ecologo.org/.

- **DESIGN FOR THE ENVIRONMENT (DFE).** A program of the U.S. Environmental Protection Agency, the DfE label identifies safer chemical-based products. The program uses EPA's chemical expertise and resources to carefully evaluate products and to label only those that have met the program's highly protective Standard for Safer Cleaning Products and stringent safer ingredient criteria. DfE labels a wide variety of chemical-based products, such as all-purpose and specialty cleaners, laundry detergents, carpet and floor care products, and paints and surface treatments. For more information, visit www.epa.gov/dfe.

- **GREEN SEAL.** Certified products must meet lifecycle-based standards that include performance, chemical restrictions, and packaging requirements in the Green Seal GS-37 Standard for Industrial and Institutional Cleaning Products, the Green Seal GS-53 Standard for Specialty Cleaning Products, the Green Seal GS-40 Standard for Industrial and Institutional Floor-Care Products or the Green Seal GS-41 Standard for Industrial and Institutional Hand Cleaners. Information on Green Seal and certified product listings can be found at http://www.greenseal.org.

Lighting

Energy used for lighting accounts for up to 22% of all U.S. electricity use. Purchasing energy-efficient lighting, as with energy-efficient appliances and electronics, can result in significant energy and operating cost savings as well as decrease the PHA's overall environmental impacts. Energy-efficient lighting also lasts longer, again resulting in savings in long-term replacement costs.

In order to reduce energy consumption for lighting, PHAs should purchase T8 and T5 linear lamps and compact fluorescent lamps (CFLs). Switching to CFLs can save more than $40 in energy costs over the lifetime of the bulb and last 10 times longer than traditional incandescent bulbs.[1] Qualified light bulbs and fixtures must meet the ENERGY STAR requirements for minimum energy usage in order to qualify to use the ENERGY STAR label. Information on ENERGY STAR and a list of qualified products can be found at http://www.energystar.gov. See the chapter on Lighting for more information on lighting and light bulb products and purchasing.

Paints

Paint is one of the largest contributors to indoor air pollution due to volatile organic compounds (VOCs) and other chemical components that can have short and long-term health effects. The EPA reports that indoor concentrations of many VOCs can be up to 10 times higher than outdoors.[2] The PHA should purchase low-VOC paints and products without hazardous chemicals. VOC levels and hazardous chemicals are listed on product labels or on material data safety sheets (MSDS). If the information is not readily available, the PHA should request this information from the supplier or manufacturer.

- **GREEN SEAL.** Certified products must meet performance, Volatile Organic Compound (VOC) limits, and chemical restrictions for either the Green Seal GS-11 Standard for Paints and Coatings, the Green Seal GS-47 Standard for Stains and Finishes, or the Green Seal GS-43 Standard for Recycled-Content Latex Paint. Information on Green Seal and certified product listings can be found at http://www.greenseal.org.
- **GREENGUARD.** Certified paints must meet the VOC emission limits of the GREENGUARD Children & Schools Standard. Information on GREENGUARD and certified product listings can be found at http://www.greenguard.org.

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1 EnergyStar Products - Lightbulbs (CFLs) for Consumers. Accessed 12/27/10. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LB

2 http://www.epa.gov/iaq/voc.html

Paper Products

Purchasing paper products made from responsibly managed forests helps address the problem of illegally harvested timber that can severely damage ecosystems and surrounding communities. Purchasing products with recycled content reduces waste.

- **ECOLOGO.** Certified products must meet the resource and energy consumption, sub-lethal toxicity, chemical oxygen demand, and net solid waste requirements as specified in EcoLogo CCD-082 for Toilet Tissue, CCD-083 for Facial Tissue or CCD-086 for Hand Towels. Information on EcoLogo and certified product listings can be found at http://www.ecologo.org.
- **FOREST STEWARDSGIP COUNCIL (FSC).** The chain-of-custody verification ensures products meet FSC standards for responsibly harvest forest products and may have an additional verification of recycled content. Information on FSC can be found at http://www.fscus.org.
- **GREEN SEAL.** Certified products must meet recycled content limits, manufacturing process, and performance requirements as specified in the Green Seal GS-1 Standard for Sanitary Paper Products (toilet tissue, facial tissue, paper towels and napkins) or the Green Seal GS-7 Standard for Printing and Writing Paper. Information on Green Seal and certified product listings can be found at http://www.greenseal.org.

Water Fixtures

Replacing water fixtures with more efficient fixtures can help reduce the amount of water consumed, which can result in cost savings, reduce the load to wastewater treatment plants, and conserve a natural resource.

- **WATERSENSE.** Qualified fixtures must meet requirements for water efficiency and performance in order to qualify to use the WaterSense label, a program of the U.S. Environmental Protection Agency. Information on the WaterSense program and a list of qualified water fixtures can be found at http://www.epa.gov/watersense.

Chapter 7 | Recycling and Special Waste Programs

INTRODUCTION

This chapter provides an overview of the environmental, social, and financial benefits of waste reduction through recycling for multifamily housing complexes and communities.

In 2008, 250 million tons of solid waste, or trash, was generated in the United States; nearly 54% of this was buried in landfills and 13% was incinerated. Landfills are the second largest source of methane production, one of the greenhouse gases that contribute to climate change. Reducing waste addresses climate change at a local level. An estimated 55–65% of the solid waste in the United States is from homes and apartments.

WASTE PROGRAMS AT-A-GLANCE

Introduction

Recycling

Special Waste Management Programs
Household Hazardous Waste and E-Waste
Programs to Reduce Litter and Illegal Dumping

Construction, Demolition, and Tenant Move-In/Move-Out

Appendices
Waste and Recycling Assessment Checklist
Recycling Strategies

Recycling and waste prevention not only conserve natural resources, but also reduce litter and costs related to trash disposal. Waste prevention and management programs, such as computer reuse, battery recycling, and household hazardous waste collection programs, can help to reduce illegal dumping activities and keep toxic materials out of the environment. Recycling and waste prevention activities benefit the community and help to create a sense of connection and the feeling that people are "doing the right thing" in terms of protecting the environment.

This chapter has three sections:

- Steps to setting up a recycling program: Recycling programs are becoming easier to implement and may simply require a call to your trash hauler.

- Additional strategies and resources for setting up special waste programs: These programs include ways to properly dispose of hazardous materials and maintain the building and common ground free of litter and illegal dumping.
- Information on construction, demolition, and tenant turnover: During these periods, a lot of waste can be generated. Some of the programs mentioned here are also discussed in the Residential Education and the Unit Turnaround chapters of the manual.

The appendices include a Waste & Recycling Assessment checklist and information on disposal and recycling of common household items.

RECYCLING

Recycling is the collection, remanufacturing, and redistribution of an item that requires energy and additional resources to turn the old materials into new products. Recycling programs are designed to prevent solid waste from going to landfills. It is easier to recycle certain materials in some geographic areas than in others, mainly due to market demand and proximity to a recycling facility. Recycling requires not only placing recyclables in the correct bin, but also, to the extent possible, purchasing products made from recycled materials.

It is best to start with a simple program that collects items easily recycled in your area. This will ensure program success, increase resident participation, and provide an opportunity to identify future volunteers and supporters. Many programs begin with recycling a few major items such as paper, corrugated cardboard, beverage containers, and/or scrap metals, following a process such as this one:

1. **IDENTIFY A PROGRAM CHAMPION**
   Identify a staff person to be the main contact person. Post his or her contact name, phone/cellular phone number, and days and hours available for assistance on a central bulletin board, in flyers, and in educational pamphlets.

2. **CONDUCT A WASTE SURVEY**
   Conduct a waste survey to record a baseline of current waste generation practices and costs, and identify potential program options. (See the Waste & Recycling Assessment Checklist at the end of this chapter.) The survey should involve a housing authority walk-through to look at waste containers in common areas, parking areas, laundry rooms, dumpster locations, and community gardens to see what types of materials are being disposed. Interview maintenance staff and residents to assess activities that require special attention, such as scavengers that regularly go through the trash,

landscaping and vegetable gardens that produce more green waste, frequent move-ins and move-outs that generate useable items discarded in a hurry, or broken appliances that can possibly be recycled.

3. IDENTIFY RESOURCES, SERVICES, AND PROGRAM OPTIONS

Check with your local trash hauler, city and state agencies, independent recyclers, or nonprofits for information about local recycling and partnership opportunities. Check with your local jurisdiction and city and state agencies for regulatory requirements and fees or penalties for noncompliance. A list of links to State Agency Waste Management Programs can be found at http://www.astswmo.org/resources_stateagencylinks.htm. A list of recyclers, drop-off centers, thrift stores, and household hazardous waste collection programs can be found online at http://earth911.com/, by calling toll-free at 1-800-CLEANUP, or through a free iPhone app at iRecycle.

4. IDENTIFY WHICH MATERIALS TO COLLECT OR WHICH PROGRAM TO IMPLEMENT

Use the information collected through your checklist, walk-through, and interviews to determine which materials are currently being disposed that can be reused or recycled. With this information, work with program providers to determine which materials to recycle and the services they provide. Make sure any agreement is in writing. Many recyclers only accept newspapers, cans, glass and plastic bottles, and/or cardboard. Program options could include "co-mingled" (put all recyclables in one container) or "source-separated" recycling (separate materials in individual containers). If separate containers are necessary, start with only a few materials and be sure containers are well labeled, adjacent to a trash container, and convenient.

5. IDENTIFY KEY PARTNERS

Internal partners (informed and educated residents and maintenance staff) are critical to the success of the recycling program. Recruit residents to promote the program or to help keep the collection site clean and materials sorted properly. External partners (such as your hauler, recyclers, salvage companies, or community and nonprofit organizations) can also help implement and maintain the recycling program, provide monthly feedback on recycling results, and provide educational materials and containers.

6. DETERMINE RECYCLING COSTS, SUBSIDIES, AND REBATES

Work with program providers to determine the true costs of setting up the recycling program; for example, add fees and equipment costs to the disposal costs or subtract subsidies from a beverage container redemption program from overall program cost. Consider disposal avoidance costs as hauling and disposal costs continue to rise.

7. DECIDE ON COLLECTION METHOD, CONTAINER TYPES, CONTAINER LOCATION, AND SIGNAGE

Determine container types such as boxes for individual units, or centralize containers for the entire building. Locate smaller containers in common areas such as the mail and laundry rooms. Always place trash bins next to the collections bins. Recycling signs should be simple (include images), list items accepted as well as items NOT accepted, and be multi-lingual where appropriate. Clearly communicate instructions on what materials to recycle, the location of bins, and the collection schedule to residents and maintenance staff. If scavenging is an issue, lock containers.

8. MONITOR AND EVALUATE THE PROGRAM

Review monthly trash and recycling statements to monitor the amount of material that is being recycled. Tracking could include total recycling weight per household, net disposal costs per household, or the recycling contamination rate. Request comments from the program provider on condition of materials, such as contaminants in the recycling containers. The amount of material recycled is a good indication of resident and staff involvement with the program. Declining volume might indicate the need for more outreach. With this information, provide feedback and share success and results with residents and maintenance staff.

9. RESIDENT EDUCATION AND OUTREACH

Promote the program before its rollout, and continue to provide information to residents and maintenance staff by using flyers, central bulletin boards, and educational pamphlets. Signs and other educational and promotional materials should be multi-lingual, where appropriate. Instill "ownership" by getting residents and maintenance staff involved in surveying, designing, implementing, and monitoring the program. Include educational materials in the move-in and move-out packages. Remind residents to "Buy Recycled" to maintain the demand for your recyclables. Due to resident turnover, it is important to promote the program frequently to ensure the program is sustained on an ongoing basis. (See the Residential Education chapter for more information about resident recycling.)

SAMPLE POSTERS, SIGNS AND GRAPHICS

Several websites provide sample templates, signs, and graphics that can be downloaded:

- Marian County Recycling Posters:
  http://www.co.marion.or.us/PW/ES/recyclingposters.htm
- CalRecycle: http://www.calrecycle.ca.gov/Gallery/
- Environmental Defense Fund:
  http://www.edf.org/article.cfm?ContentID=3542

Other waste reduction strategies include:

- Use a "waste exchange" to locate or get rid of materials and equipment.
- Use hand dryers or limit paper towel dispensers for common areas.
- Make double-sided copies whenever possible for educational materials.
- Shredded paper is useful as packing material, but make sure that the paper being shredded does not contain confidential information.
- Purchase non-toxic alternatives for cleaning supplies, in bulk or concentrated form (see the Cleaning Procedures and Products chapter).
- Purchase reusable or refillable products instead of single-use, disposable items.
- Use washable rags and mops. Old towels, sheets, and t-shirts work well.
- Buy only in bulk for non-perishable items.

SPECIAL WASTE MANAGEMENT PROGRAMS

In addition to waste reduction and recycling, housing authorities can implement other waste programs that play an important role in decreasing environmental impacts. These programs keep hazardous and electronic waste out of landfills and help to curb illegal dumping.

Household Hazardous Waste and E-Waste Programs

Many products considered hazardous require special care when disposed. Criteria to determine if products are considered hazardous include if they contain corrosive, toxic, ignitable or reactive ingredients. They usually have the word "Caution" on their labels.

Examples of hazardous waste include paints, cleaners, motor oil, pesticides, batteries, fluorescent lamps, mercury thermostats, and other mercury-containing equipment, among others. (See the list at the end of this chapter.)

Electronic waste, also known as E-Waste, is anything with a plug or an electronic chip. These items should not be thrown in the trash due to their hazardous content. Electronic waste includes batteries, computers, televisions, and personal electronic products such as mobile phones and digital music players. Lighting products, such as CFLs, linear fluorescents, halogen lamps and other non-incandescent bulbs, should also not be disposed of in the trash. The proper disposal of these products is with other hazardous waste.

The steps to create a program for properly these types of waste are similar to those to recycle other products. They are repeated here with information on resources and other special considerations for hazardous and electronic waste.

1. **IDENTIFY A PROGRAM CHAMPION**
   Identify a staff person to be the main contact person. Post his or her contact name, phone/cellular phone numbers, and days and hours available for assistance on central bulletin boards, in flyers, and in educational pamphlets.

2. **CONDUCT A HAZARDOUS WASTE SURVEY**
   Conduct a waste survey to record hazardous products that are currently in use by the PHA, where they are stored, and how they are currently disposed. The survey should also involve interviews with maintenance staff and residents to assess daily activities of the residents and the housing authority.

3. **IDENTIFY RESOURCES, SERVICES, AND PROGRAM OPTIONS**
   Contact local environmental, health, or solid waste agencies for options in your area for proper handling and disposal of these materials, collection schedules, and drop-off locations. Check with your local jurisdiction, and city and state agencies for regulatory requirements, and fees or penalties for noncompliance. A list of links to State Agency Waste Management Programs can be found online at http://www.astswmo.org/resources_stateagencylinks.htm or http://www.epa.gov/osw/wyl/stateprograms.htm. Other useful information can be found at http://earth911.com or toll-free at 1-800-CLEANUP.

4. **DECIDE ON A PROGRAM METHOD AND IMPLEMENTATION**
   Use the information gathered from the waste survey and the options available in your area to determine the type of hazardous waste program to create. If there is hazardous waste pick-up in your area, determine container types and locations for hazardous waste. Label the locations and bins properly. If your area has a drop-off location for hazardous waste, select a secure area for waste to be stored until it can be taken to the drop-off location, as well as a schedule (weekly, bi-weekly, monthly, or quarterly) and logistics to transport the waste to these locations. Notify residents of bins for household hazardous waste collection, or information on when the next hazardous waste drive is scheduled so that they can properly store and hold onto hazardous waste until the next drive. (See the Residential Education chapter for more information.)

5. **MONITOR AND EVALUATE THE PROGRAM**
   Review hazardous waste statements, if pick-up programs are available. Track program success and opportunities for program improvement and expansion. For drop-off programs, monitor the frequency and volume of drop-offs and identify changes or improvements that could be made. Provide feedback and share success results with residents and maintenance staff.

6. RESIDENT EDUCATION AND OUTREACH

Promote the program before rollout, and continue to provide information to residents and maintenance staff by using flyers, central bulletin boards, and educational pamphlets. Signs and educational and promotional materials should be multi-lingual, where appropriate. Instill "ownership" by getting residents and maintenance staff involved in surveying, designing, implementing, and monitoring the program. Include educational materials in the move-in and move-out packages. Due to frequent turnover of residents, it is important to promote the program frequently to ensure the program is sustained on an ongoing basis. (See the Residential Education chapter for more information.)

Additional resources:

- EPA household hazardous waste collection programs: http://www.epa.gov/wastes/conserve/materials/hhw.htm
- Rechargeable Battery Recycling Corporation list of collection sites by zip codes: http://www.call2recycle.org
- Environmental Protection Agency website with links to local program locators: http://www.epa.gov/wastes/conserve/materials/ecycling/donate.htm#local

Programs to Reduce Litter and Illegal Dumping

Litter is any kind of trash not thrown away properly, including abandoned items and illegal dumping. It poses a health danger and attracts rodents that may carry diseases to homes and the communities. One of the top reasons people litter is because they see the area is already littered.

Illegal dumping activities include any type of material placed in a public or private location that is not designated as a waste disposal site.

Check with state and local agencies for requirements, penalties, and hotlines to report litter and illegal dumping activities. Post signs and otherwise let residents and maintenance staff know this information.

Strategies to prevent litter and illegal dumping include the following:

- Educate residents on prevention and compliance requirements, and penalties for non-compliance.
- Provide sufficient trash containers in heavy-use locations, exits, parking lots, recreation, and picnic/eating areas.
- Make sure trash bags are tied and cans have lids that can be securely attached.
- If scavengers are a problem, use locking bins or chains tightened just enough to get trash in but prevent someone from crawling in.

- Plant or decorate areas along sidewalks or curbs. People litter less where areas have been beautified.
- Distribute portable or pocket ashtrays and litter bags.
- Check with the local public works division for assistance with graffiti removal. Many collect and recycle latex paints for this purpose. Removal within the first 24–48 hours is most effective.
- Work with local civic groups to identify and eliminate problem areas and eyesores.
- Coordinate a "free dump day" with local agencies or your trash hauler. Be prepared for a large turnout!
- Post signs with ordinance and fine warnings, multi-lingual where appropriate.

Additional resources:

- Keep America Beautiful: 203-659-3000 or http://www.kab.org
- EPA Illegal Dumping Prevention Guidebook: http://www.epa.gov/reg5rcra/wptdiv/illegal_dumping/downloads/il-dmpng.pdf
- EPA Region 9 Illegal Dumping Prevention Project: http://www.epa.gov/reg5rcra/wptdiv/illegal_dumping/index.html

CONSTRUCTION, DEMOLITION, AND TENANT MOVE-IN/MOVE-OUT

Construction and demolition, whether large or small projects, offers additional reduce, reuse, and recycling opportunities:

- Regulations and recycling requirements vary from city to city, so check with your local agencies for instructions for proper recycling and disposal guidelines. HUD guidelines and grants are available for asbestos and lead paint issues.
- Check with local haulers and recyclers to set up a proper on-site collection and storage area, container types, recycling, and pickup procedures. Some companies provide off-site construction debris management.
- Provide instructions to residents on health and safety issues during construction stages, construction locations and activity schedule, and contact information for questions and additional information.

Tenant move-in and move-out generates a lot of waste. If managed well, it can offer additional reduce, reuse, and recycling opportunities. See the Unit Turnaround section for more information.

APPENDIX A: WASTE & RECYCLING ASSESSMENT CHECKLIST

WASTE & RECYCLING ASSESSMENT CHECKLIST

CONDUCTED BY: DATE:

PROPERTY SITE / LOCATION: **CONTACT & PHONE:**

Bin(s) Location	Number	Size	Pick-up Frequency/ when	Fees / Hauler

Where do the residents take their trash?
- ☐ Chute
- ☐ Trash Room
- ☐ Outside Dumpster
- ☐ Other: _____

Where is the trash bin located?
- ☐ Chutes lead to centralized location
- ☐ Outside building - where: _____
- ☐ Inside building - where: _____

What types of trash bins are there?
- ☐ Carts
- ☐ Large Bin
- ☐ Roll-off (usually 20+ cubic yards)
- ☐ Compactor
- ☐ Other: _____

Who picks up the trash?
- ☐ Private Waste Hauler
- ☐ City
- ☐ Self-Haul

How is the trash service payment billed?
- ☐ Flat fee per pick-up
- ☐ Flat fee per month
- ☐ By weight
- ☐ By volume

How are the residents billed for trash?
- ☐ Included in rent / maintenance fee
- ☐ Billed separately

For each trash bin location or chute, is there room for a recycling bin?
- ☐ Yes
- ☐ No
- ☐ Other: _____

What other areas would be ideal for a recycling bin?
- ☐ Laundry room(s)
- ☐ Mail area
- ☐ Community room / shared space
- ☐ Parking area(s)
- ☐ Other: _____

Other issues / comments / suggestions:

_____

_____

_____

_____

List Key Players & Contact Info:

_____

_____

_____

Use multiple forms if multiple buildings or locations

APPENDIX B: RECYCLING STRATEGIES (INCLUDE REDUCE/REUSE OPTIONS WHERE APPROPRIATE)

Easy recycling locater: use http://earth911.com/

WHAT IS COMMONLY RECYCLED & WAYS TO REDUCE/REUSE

	Find recycler	Drop-off	Notes & other ways to reduce or reuse
Paper			
Newspaper	√	√	Animal shelters often use
Mixed paper, magazines, phone books	√		Donate books & magazines
Chipboard (like cereal boxes)	√		
Containers			
Aluminum cans	√	√	Non-profits & schools recycle to raise $
Steel cans	√	√	Non-profits & schools recycle to raise $
Glass bottles & glass food containers*	√	√	Non-profits & schools recycle to raise $; mason jars are made for reuse
Plastic bottles #1 #2	√	√	Non-profits & schools recycle to raise $; worth more in states with deposit take back incentives
Other plastic containers #3–#6	√	√	Limited programs recycle these #s
Metals			
Scrap metals	√	√	Can salvage if item has any metal
Non-ferrous	√	√	Copper wiring, brass keys, etc.
Appliances	√	√	Donate working units; recycle broken units
Plastic			
Bags (shopping, dry cleaners, etc.)	√		Reuse old bags; many grocery stores recycle; many dry cleaners recycle dry cleaner bags and hangers
Polystyrene peanuts & packaging		√	Take to local postal & shipping store if they will take back
Yard Trimmings			
Grass & trimmings	√	√	Compost.
Tree trunks & branches		√	Some landscapers will accept & grind for reuse
Food Waste			
Cooking oil		√	Bio-fuel collection becoming popular (bio-fuels are made from organic matters such as corn, vegetable oil to power a vehicle and for other energy uses)

	Find recycler	Drop-off	Notes & other ways to reduce or reuse
Other Items			
Clothing & shoes	√	√	Some thrift stores now have collection boxes they can leave at your site
Carpet		√	Limited locations, also try: www.carpetrecovery.org/
Eyeglasses		√	Try eyecare centers or mail-in to Lions Club International
Sharps & needles		√	Drop-off collection sites, mail-back services, or put in the trash in a bottle labeled "DO NOT RECYCLE = NEEDLES"; Disposal Centers http://www.safeneedledisposal.org/dispcenters for proper disposal by location; State Waste Links for regulation/information http://www.safeneedledisposal.org/resswl.html
Propane & helium tanks	√	√	Scrap metal recycler (helium gas is used to make balloons; propane fuel and gas are used to power gas grills or propane-powered appliances such as stove, washers and dryers.)
Wood & pallets	√	√	Depending upon quantity, pick up may be available
Tires		√	Fuel & road use demands increases recyclability; check with tire stores for take-back program and drop-off locations

* Never mix window glass, Pyrex®, ceramic, or other glass with food & beverage container glass.

HOUSEHOLD HAZARDOUS WASTES COLLECTION AND HANDLING

	Special collection	Recycle	Notes & other ways to reduce or reuse
Household Hazardous Waste (HHW)			
Paint (oil-based)*	√		Do NOT mix paint, leave in original container with labels; often used as fuel blending
Paint (water-based latex)	√	√	Can donate or be recycled into new paint
Solvents & cleaners	√		Should not be thrown away in regular trash. Find alternative, less toxic products; check for certification logos such as Green Seal or EcoLogo
Motor oil	√	√	Many auto supply stores accept this; check with oil change stations such as Quick Lube for drop-off locations
Antifreeze	√	√	Many auto supply stores accept this
Absorbents such as kitty litter if used to clean up leaked automotive fluids	√		Take for safe disposal
Batteries (all types - even single use)	√		Consider rechargeable batteries instead; new D.O.T. regulations for larger than 9V: ends must be taped.
Pesticides	√		Find non-toxic alternatives http://www.epa.gov/pesticides/controlling/index.htm
Mercury-containing equipment		√	Safe handling important; long fluorescent lamp tubes and thermostats should not be broken. (See Lighting chapter for more information on disposal of broken pieces.)
Bulbs (lamps, especially CFLs)	√	√	Dispose of your compact fluorescent light bulbs as HHW; mail-in services will charge; Home Depots recycle
Laptops & computers	√	√	Reuse with groups that refurbish before choosing a "recycler"
Televisions & monitors	√	√	Check with local agencies regarding disposal fees; some recyclers take for free
Cell-phones, iPods, etc.	√	√	Many mail-in programs provide free shipping labels for groups & schools; many shelters and schools reuse them
Other electronics, stereos, radios	√	√	Anything with a circuit board or digital clock display should not be landfilled or incinerated

* Paint made before 1978 might contain lead, and paint made before 1991 might contain mercury.

Chapter 8 | Roofing Maintenance

INTRODUCTION

The life expectancy of commercial roofs using single-ply membranes or asphalt shingles in North America is about 20 years, with metal roofs and tile roofs (slate, clay, or concrete) averaging a longer duration. All roofing types require similar maintenance activities. Proper roof maintenance can identify and correct minor defects and problems that, if left unattended, can eventually lead to damage or roof failure. In addition to describing routine maintenance, this chapter covers two larger improvements: the use of more reflective roofing materials and "green roofs" that are planted with vegetation.

ROOFING MAINTENANCE AT-A-GLANCE

Introduction

Perform Regular Inspections and Remove Debris

Restrict Roof Access

Consider a More Reflective Roof

Install and Maintain Vegetative Roofs

PERFORM REGULAR INSPECTIONS AND REMOVE DEBRIS

Qualified staff should perform routine roof inspections monthly. Remove all debris, leaves, paper, vegetation, and other items that can clog drains and gutters, and clean out roof drains.

Additional inspections should be performed after severe weather (e.g., high winds, heavy snow or ice loads, and hail), installation or servicing of rooftop equipment, or building construction. Avoid chopping ice and digging snow off the roof, which can damage roofs. After removing vegetation with large roots, patch the holes left in the roofing material.

ACTION ITEMS

1. Perform routine roof inspections monthly.
2. Keep roofs clean and free of debris.
3. Keep drainage systems clear.
4. Keep roof access limited to authorized personnel to minimize foot traffic.
5. Consider adding, in the Southeastern United States or California, a reflective roof coating or replacing existing roofs with a roof material with a higher solar reflectance (also known as a "cool roof").
6. Treat green roof areas like other landscaped areas, with regular monitoring and maintenance.

Qualified staff should thoroughly inspect the roof at least twice a year—once in the spring and once in the fall—to identify problems such as split seams, separated layers, damaged coatings, failed gaskets or flashings, split seams or panels (metal roofing), clogged drains and gutters, and surface punctures. The inspections should include an examination of the building interior areas directly below the roof.

Pay particular attention to rooftop equipment and other roof penetrations, such as skylights, exhaust fans, air handlers, and vent stacks. Grease and particulates from exhaust fans, oil leaking from HVAC units, and air pollutants can damage roof materials. Any damaged areas should be noted and reported to the appropriate maintenance personnel for repair.

Specialized or extensive roof repairs that are identified during routine inspections may need to be performed by a roofing professional if building staff have not been trained in the proper procedures. In addition to repairs identified during inspections, some roof types, such as metal roofing, may require scheduled maintenance to replace gaskets or sealants at specific intervals, as these parts may wear out before the longer-lived metal roof material. Metal roof repairs must also be performed using the correct fasteners (to avoid reactions between dissimilar metals) and sealants (due to the thermal expansion of the metal panels). Improper repairs can exacerbate the original damage noted during a routine inspection for any type of roof.

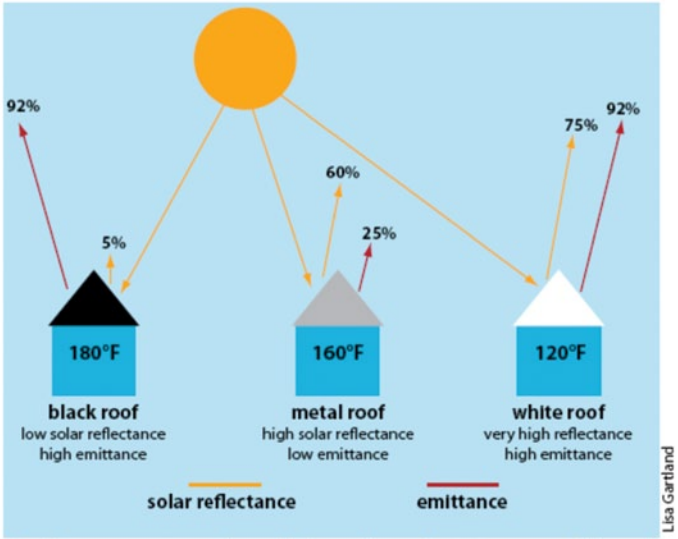
RESTRICT ROOF ACCESS

The more people walk on the roof, the more potential for damage. Limit roof access to authorized personnel. Keep foot traffic to a minimum and limit walking for routine inspections to designated areas. Uninformed walking can be detrimental to many types of roofing. For example, metal roof seams can be damaged when stepped on, dents from walking can create low areas where moisture can collect or leak around penetrations, and grit on shoe bottoms can scratch protective coatings and expose raw metal surfaces. Similarly, walking directly on flat roofs can create tears or cracks in films and membranes, expose surfaces by shifting ballast, or compress small areas that allow water to pond.

CONSIDER A MORE REFLECTIVE ROOF

In the Southeastern United States and California, consider adding a light-colored reflective coating to reduce the building energy use (by reducing the solar heat gain in the building) and to extend the life of the roof (by reflecting the ultraviolet rays in sunlight that break down many roofing materials). Reflective, or "cool roofs," can provide a building with up to 50% energy savings and reduce peak cooling demand by 10–15%. Dark-colored roofs can absorb more than 70% of the solar energy that falls on them, making the rooftop temperature as much as 90°F above the ambient air temperature. The heat is absorbed by the roof, radiated upward into the atmosphere, and radiated downward into the building. In urban areas, darker and more heat-absorbing materials (such as roofing, road surfaces, and surface parking lots) can contribute to an increased ambient temperature relative to less developed areas in what is often called the urban heat island effect.

SAMPLE ROOF SURFACE TEMPERATURES OF DIFFERENT SOLAR REFLECTANCE MATERIALS



On a hot, sunny, summer day, a black roof that reflects 5 percent of the sun's energy and emits more than 90 percent of the heat it absorbs can reach 180°F (82°C). A metal roof will reflect the majority of the sun's energy while releasing about a fourth of the heat that it absorbs and can warm to 160°F (71°C). A cool roof will reflect and emit the majority of the sun's energy and reach a peak temperature of 120°F (49°C).

Source: *Reducing Urban Heat Islands: Compendium of Strategies—Cool Roofs*, U.S. Environmental Protection Agency, October 2008.

More details on qualified roofing products can be found through the ENERGY STAR program (www.energystar.gov). Two roofing savings calculators to estimate the cooling energy savings, along with any potential increase in heating costs, are:

- Department of Energy Cool Roof Calculator:
  http://www.ornl.gov/sci/roofs%2Bwalls/facts/CoolCalcEnergy.htm
- Environmental Protection Agency Cool Roof Calculator:
  http://www.roofcalc.com

According to the 2009 U.S. Department of Energy's *Buildings Energy Data Book* (http://buildingsdatabook.eren.doe.gov), heating accounts for 46% of a residential building's total energy use, while cooling accounts for 6%. For commercial buildings, 20% of total energy use is for heating and 6% for cooling. As a result, a dark-colored roof is usually more appropriate for buildings in climate areas that have more heating days than cooling days (see the chapter on HVAC

for more information). The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) recommends exploring cool roofs in climate zones 1–3 (for a map of climate zones, see http://resourcecenter.pnl.gov/cocoon/morf/ResourceCenter/dbimages/full/973.jpg), where buildings are cooled the majority of the time. It may turn out that the energy savings do not justify the expense, but the potential savings should be investigated.

For all buildings, consider specifying equipment-appropriate white or light color finishes (e.g., tan or gray) on rooftop equipment, which may help prolong the life of the equipment. Paint existing equipment with a light-colored paint the next time the equipment requires painting.

INSTALL AND MAINTAIN VEGETATIVE ROOFS

Roofs that are covered, in part or in whole, with vegetation are often referred to as "green roofs" or "living roofs." This type of roofing is usually comprised of several parts: the growing medium in which the vegetation is planted, a drainage system, a waterproofing layer, and an irrigation system. Green roofs have been successfully installed in many climate zones in the United States, although arid parts of the West are not good candidates due to the challenges of irrigation.

Properly installed and maintained green roofs offer a number of benefits, such as reduction of urban heat island effects, absorption and reduction of rainwater runoff, protection for underlying roof materials, and contact with garden/landscaped space for urban residents (if designed for resident/tenant access). See the Landscaping chapter for more information.

Green roofs are classified primarily by the depth and weight of the growing medium, which affects the structure of the roof needed to support the weight and the types of vegetation that can be planted. Shallow-growing, medium-depth, lighter-weight green roofs are considered "intensive," while heavier, deeper, medium-weight roofs are considered "extensive." Roofs in between the two extremes are sometimes called "semi-intensive" or "semi-extensive," depending on which form they more closely resemble. When considering the installation of a green roof on an existing roof, consult a professional (e.g., architect or structural engineer) to determine if the roof can support the added weight.

Roofs with public access to decks or recreation areas may also feature more limited "garden" areas, such as plants in a raised bed or containers. As with any landscaped area, green roofs and roof gardens require periodic maintenance to prune or remove unwanted plants and weeds; replace dead plants with new specimens; water; apply fertilizers, herbicides, or pesticides, if needed; and examine the drainage and irrigation systems for proper operation. Watering may be needed frequently during the establishment of the green roof; once established,

the normal rainfall may be sufficient for location-appropriate plantings. Once established, excessive temperatures or long periods without rain may require irrigation, so care must be taken to treat the green roof as a landscaped area that requires monitoring and maintenance. If ongoing watering is necessary for roof plantings, a rainwater collection system can provide some of the irrigation water, where roof structure and layout permit. Again, see the Landscaping chapter for additional information.

Since the growing medium is shallower than ground plantings and the drainage usually ends up in the roof downspouts, care should also be taken in the selection and use of any maintenance chemicals, such as fertilizers, herbicides, and pesticides. (See the Cleaning Procedures and Products and the Landscaping chapters for more information on pest management.)

If the building includes a green roof, the ideal scenario is to set up a maintenance contract to periodically examine the roof and provide service and support.

Chapter 9 | Snow Removal and De-Icing

INTRODUCTION

Removing snow and ice from sidewalks and roadways is an important health and safety issue that can have significant environmental impacts depending on the ice-melting chemicals used. This chapter describes ways to minimize the use of these chemicals and, when they are needed, to select the least environmentally damaging options.

SNOW REMOVAL AND DE-ICING AT-A-GLANCE

Introduction

Reducing the Need for Ice-Melting Chemicals

Mechanical Removal

Product Selection

REDUCING THE NEED FOR ICE-MELTING CHEMICALS

Because almost all ice-melting formulations contain potentially harmful chemicals, one of the most important activities is to reduce the need for these products. Where occupant and visitor movement and building codes permit, building staff should close unneeded stairways, sidewalks, and roads during the winter season, which will reduce the area that must be cleared of snow and ice. Before selecting which areas to close, check with local building codes to ensure that required entry or egress points are maintained as part of snow removal procedures.

Keep the weather in mind. A light, powdery snow may not require an ice-melting chemical, just shoveling or sweeping. If freezing rain, wet, heavy snow, or sleet is expected, applying ice-melting products (see Product Selection below) before precipitation begins (also known as pretreating), along with during and

ACTION ITEMS

1. Reduce the need for ice-melting chemicals through selective closing of stairs, sidewalks, and roads where permitted by building codes.
2. Improve mechanical removal strategies by increasing the frequency of shoveling, brushing, or plowing and increasing the amount of equipment in use.
3. Use ice-melting products based on potassium chloride or magnesium chloride instead of those based on sodium chloride or calcium chloride when possible.

after the storm event, will maximize the products' effectiveness. Pretreating surfaces will help prevent snow and ice from bonding to surfaces so they can be more easily removed.

Pay attention to expected temperatures during snow and ice events to guide ice-melting product application. Since these products generally are intended to melt ice, they should be used when ice is going to form. In warmer climates such as the Southeastern region (or early/late in the winter season in colder climates), snow may fall, melt, and later turn to ice when temperatures fall below freezing. If the snow is removed before freezing, the use of an ice-melting product may not be needed. In colder climates, such as the Northern and some parts of the Southwestern regions, snow may fall and turn to ice quickly due to below-freezing temperatures, so applying ice melters before, during, and after the storm will provide the most benefit.

Procedures for handling snow and ice should be documented, particularly for locations that experience few snow events, such as the Southeast. Having a snow and ice plan, with the necessary equipment and ice-melting chemicals on hand, will allow workers to react in a timely and appropriate manner.

MECHANICAL REMOVAL

The use of ice-melting chemicals can also be reduced by preventing the formation of ice after snow falls. Removing snow in a timely fashion using shovels, snow blowers, or plows before it is compacted by traffic can reduce the need for ice-melting chemicals. When manually shoveling, ensure that workers are adequately protected from the cold and use correct techniques to eliminate back and other potential injuries. When mechanical equipment is used, make sure it is well maintained to minimize environmental impacts such as leaking gas, oil, or lubricant. Workers operating mechanical equipment should use safety goggles and ear protection.

PRODUCT SELECTION

When temperatures and product availability permit, use ice-melting products that contain potassium or magnesium chloride, rather than products that contain sodium or calcium chloride. While all chlorides may be toxic to vegetation if used in large quantities, potassium and magnesium chloride products are less damaging to plants, concrete, carpeting, and hard surface flooring. These products are often safer to use around pets, which may be a concern for some residential buildings. Products based on acetates, because they do not contain any chlorides, share these safer attributes and are also good options. Other considerations include the following:

- **USE GRANULAR/SOLID ICE MELTERS** in pellet or crystal form to break the bond between ice and the road surface, so that the ice and snow can be physically removed by shoveling or plowing.
- **CONSIDER A LIQUID ICE MELTER** where it is especially important to prevent ice from forming or where the use of a granular/solid ice-melting chemical is not possible (e.g., due to physical layout such as steep slopes).

The table below lists common ice-melting products, *with the more preferable choices in italics.* They are listed in order of effective temperature, with products that work in the coldest temperatures listed first. The U.S. Environmental Protection Agency's Design for the Environment (DfE) program has recognized some ice-melting products for safer chemistry (see http://www.epa.gov/dfe for a list of these products).

When using blended products containing two or more ice-melting materials, read labels carefully for effective temperature ranges. Apply granular or crystal ice melter compounds with a spreader (or sprayer for liquids) to minimize the amount of product used and ensure a uniform application. The use of granular/solid products with colored granules promotes uniform distribution by visually confirming application. Workers applying chemical ice-melting products compounds should also be provided appropriate personal protective equipment (e.g., gloves, goggles) to prevent exposure.

Ice Melt Material	Effective Temperature	Typical Physical Form	Notes
Calcium chloride	-25°F	Solid	Expensive. Can leave an oily/slippery residue after use.
Potassium acetate	***-15°F***	***Liquid***	***Expensive. Safer for concrete and vegetation. Good for extreme cold. No powdery residue when dry.***
Calcium magnesium acetate	***5°F***	***Solid or liquid***	***Expensive. Safer for concrete and vegetation. No powdery residue when dry.***
Magnesium chloride	***5°F***	***Solid***	***Safer for concrete and vegetation. Needs a high application rate. No powdery residue when dry.***
Sodium acetate	***5°F***	***Solid***	***Expensive. Safer for concrete. Less suitable for walkways. No powdery residue when dry.***
Sodium chloride (rock salt)	20°F	Solid	Inexpensive. Harmful to concrete, metals, and vegetation. Does not work at low temperatures.
Potassium chloride	***25°F***	***Solid***	***Expensive. Does not work at low temperatures.***
Urea (nitrogen fertilizer)	25°F	Solid	Safer for concrete. Does not work at low temperatures.

Note: Preferred items in ***italics.***

Follow the product label instructions for storage carefully to ensure products are viable when needed, especially in areas where use is infrequent. Ice-melting products usually need to be stored in tightly sealed containers to prevent moisture absorption, and sunlight can cause packaging materials (especially bags) to become brittle from exposure. At a minimum, products should be stored under cover in a dry location, ideally in tightly sealed packaging or containers.

Chapter 10 | Water Fixtures and Conservation

INTRODUCTION

Responsible use of fresh water means ensuring that all water-consuming fixtures in public areas are operating properly, with no leaks or drips, constantly running toilet tanks, or "ghost" flushes from automatic sensor-based fixtures. A faucet leak of one drop per second can waste 3–7 gallons of water per day. From an economic standpoint, water is often paid for twice: once for the initial consumption and a second time in the form of wastewater (e.g., "sewer") fees. Therefore, reducing water consumption can result in significant cost savings.

WATER AT-A-GLANCE

Introduction

Restrooms
Faucets
Toilets
Urinals
Public Showers/Locker Rooms

Kitchens

Drinking Water Fountains and Coolers

Washing Machines

Acronyms in this Chapter

Water consumption is also related to energy use, as less water in the wastewater system reduces the energy required by treatment plants to treat and supply the water. In addition to inspecting regularly for water leaks and responding immediately when receiving reports from residents, the public housing authority (PHA) can achieve water savings by ensuring water fixtures are installed with the appropriate flow-control devices.

RESTROOMS

Faucets

Current green building plumbing codes[1] require most public restroom faucets to have a flow rate of no more than 0.5 gallons per minute (gpm). Older restroom faucets may have flow rates of 2.2 gpm or higher, so significant water savings results from simply installing new faucet flow-control devices (aerators) with a 0.5 gpm flow rate. Replacement flow-control devices are available in two flow types: aerated stream or laminar flow. Aerators add air to the water and tend to feel "lighter" in flow. Laminar flow devices produce a stream comprised only of water; they feel "heavier" and may be perceived as a higher flow rate by users. Laminar flow controls also tend to deliver a constant flow rate of water regardless of any variance in the incoming water line pressure. Replacement flow-control devices can be an acceptable fix until faucets are replaced with water-efficient models.

If faucets are due for replacement, select faucets with a flow rate of 0.5 gpm. When faucet replacement is not possible, ensure that the pre-installed flow-control device (typically 1.5 gpm–2.2 gpm for retail faucets) is replaced with the correct replacement 0.5 gpm model.

The PHA should also consider faucets with electronic sensors that turn faucets on and off when hands are detected or mechanical metering devices that dispense a pre-set amount of water. Electronic sensor faucet models are available that may be hardwired, controlled with a battery pack (that must be periodically replaced), or even use a built-in solar panel or internal hydroelectric turbine to recharge the battery during use.

ACTION ITEMS

1. Ensure public faucets use faucet flow-control devices, such as aerators, that have a flow rate of no more than 0.5 gallons per minute.
2. Ensure public toilets use no more than 1.6 gallons per flush (gpf). High-efficiency 1.28 gpf toilets and dual-flush (0.8–1.1 gpf/1.28–1.6 gpf) toilets are available and may be acceptable replacements.
3. Ensure public urinals have a flushometer with a maximum flow rate of 0.5 gpf. Lower flow rates of 0.25 gpf (one-quarter gallon) or 0.125 gpf (one pint) flushometers are also available and may be acceptable replacements.
4. Inspect public drinking fountains regularly for leaks and proper function. Fountains that chill water should have insulated piping. Install a timer to turn off refrigeration during periods of low use, and adjust the dispensed water temperature to 70° Fahrenheit (versus the typical 50–65°F).
5. Check washing machines weekly for water leaks, and investigate resident comments about malfunctioning equipment.

Toilets

Toilets in public restrooms may be either flushometer or tank style. Flushometer toilets use water directly from the building water supply to flush automatically

[1] International Green Construction Code, March 2010.

after each use and may be manually (via lever or button) or sensor-operated. Tank-style toilets store the water needed for flushing in a tank that must be refilled after each use. Tank-style toilets may be gravity fed or contain a pressure-assistive device in the tank to increase the force of the water during flushing. If a toilet has a pressure-assist device, it is important that the pressure is set correctly. If the pressure is too low, it will not flush correctly, but if the pressure is too high, the pressure valve may rupture. Pressure-assist tank-style toilets can be somewhat noisier due to the "whoosh" from the air pressure when flushed or air compression when refilling, but in public areas, the slight additional noise may not be an issue.

Pre-1992 toilets may have a flow rate of up to 7 gallons per flush (gpf). Given the longevity of vitreous china and availability of replacement parts for the tank mechanisms, many of these older toilets are still in use. While retrofit devices and techniques exist to reduce the flow rate of older tank-style toilets, often design issues impair the function with a reduced flow of water and do not result in water savings (e.g., from double flushing). Achieving both performance and water savings usually requires replacing older tank-style toilets with new ones. Replacement flushometers are available to retrofit older flush valves to meet or exceed current water conservation flow rates.

Current plumbing codes require a maximum flow rate of 1.6 gpf, and some high-efficiency models that are part of the EPA's WaterSense program use only 1.28 gpf. Dual-flush tank-style toilets are also available that use a half flush (typically 0.8 gpf) for liquid waste and full flush (1.6 gpf) for solid waste. Dual-flush flushometers are also available with a 1.6 gpf full flush or 1.1 gpf reduced water flush. There is a minor educational component to using dual-flush toilets, as users must select the proper button or lever direction, and thus may be more suited to public restrooms used by a consistent group of users (e.g., staff or residents) versus those used by the general public.

Urinals

As with toilets, pre-1992 urinals can use up to 5 gallons per flush. Due to their fairly durable and wall-mounted design, some are still in use. Current plumbing codes require a maximum flow rate of 0.5 gpf and WaterSense compliance, but replacement flushometers are available that use 0.25 gpf (one-quarter gallon) or 0.125 gpf (one pint). It is important to consult the manufacturer of the replacement flushometer to ensure compatibility with the actual vitreous china urinal fixture.

Another option is a waterless urinal, designed to function without the need for a water flush after use. Most models require a sealing liquid or cartridge to maintain the trap seal that must be periodically replaced, although some newer models use only mechanical action. These fixtures require somewhat different

cleaning and maintenance procedures, so the cost of the new fixture and any additional maintenance items (e.g., trap seal cartridges) or procedures should be considered along with the water savings.

Public Showers/Locker Rooms

If there are public showers for staff or locker room areas, the PHA should check to see if the showerhead is functioning properly and if there are leaks or drips from fixtures, particularly if the facilities are used infrequently. If possible, replace older fixtures with water-efficient fixtures, typically 1.7-2.5 gpm. There are 1.5 gpm showerheads available, but as the gpm decreases, the pressure increases and the combination of hot water and pressure may risk scalding. All fixtures should be checked (such as a dripping faucet), as a small leak can result in a large amount of water consumed.

KITCHENS

If there is a common kitchen area, check faucets to ensure the fixtures are functioning properly and there are no drips or leaks. If aerators are installed, check that they are functioning properly and at the appropriate gallons per minute. (Typical residential aerator values are 1.5–2.0 gpm for kitchen.) If not installed, consider purchasing aerators as they can be effective ways to manage water use when installed properly. Residents may remove aerators if the flow rate is too low, which would result in additional water use. The PHA may also consider a gooseneck-type faucet, which helps prolong the life of the fixture as there are less instances of residents pulling on the faucet neck while trying to wash large objects or fill large pots. If there are dishwashers in the common areas, refer to the WaterSense or ENERGY STARÒ requirements for current specifications since there are different specifications for commercial and residential dishwashers. (The current ENERGY STAR specification for residential dishwashers is no more than 0.88 cycles per kilowatt hour for a compact model and water consumption in the range of 0.54–1.0 gallon per rack of dishes for a commercial dishwasher.) The PHA should also check inlet water hoses and shut-off valves and ensure no water puddles around the equipment. Any loud noises or external water flow from dishwashers may be a sign that the equipment is malfunctioning.

DRINKING WATER FOUNTAINS AND ELECTRIC WATER COOLERS

If the PHA has water fountains in public areas, check them regularly. Water fountains tend to have fairly low flow rates (often 0.5–0.7 gpm) and operate only when a button or push bar is depressed. Regular inspection, such as with daily cleaning, will ensure that the bubbler head is not leaking water or that the buttons or push bars are not stuck in the "on" position.

Electric water coolers that chill water prior to dispensing (via internal or remote refrigeration) have an additional opportunity to save energy. Any accessible piping can be insulated, a timer can be installed to shut off the refrigeration during periods of low use (e.g., late evening), and the dispensed water temperature can be adjusted to 70° Fahrenheit (versus the typical 50–65°F).

WASHING MACHINES

Whether the PHA uses a commercial size washing machine or a "residential" model, regular inspections help avoid problems, especially water leaks that can be substantial (due to the flow rate of water in the inlet hoses and the low traffic of laundry rooms) or dangerous (due to the presence of electricity for washers and dryers). Investigate residents' comments about machines "not working" or "washing strangely" promptly.

Check washing machines for leaks at least bi-weekly, with attention paid to the inlet water hoses and shutoff valves. The owner's manual for the particular model of washing machine (check online if the hard copy is missing) should provide any recommended maintenance activities, such as cleaning the inlet water filters and lint filter, to allow the washing machine to operate at maximum efficiency.

When replacing equipment, purchase washing machines labeled as part of the ENERGY STAR program, or that exceed the program's guidelines based on the yellow EnergyGuide label found on most appliances. Clothes washers that have earned this designation are 30% more efficient than non-qualified models.

ACRONYMS IN THIS CHAPTER

gpf	Gallons per flush
gpm	Gallons per minute

SECTION TWO

Unit Maintenance and Turnaround

Chapter 11 | Unit Maintenance

INTRODUCTION

Regular maintenance of individual residential units is a critical aspect of establishing the safety and comfort of the residents living in public housing units. Regular unit maintenance also saves money for the public housing authority (PHA). Weatherization or use of energy-efficient lights saves on energy costs, and regular cleaning of filters can prolong the life of equipment, which will reduce capital expenditures for repairs or replacement. In addition, issues like pest management and identification of water leaks can usually be corrected with small repairs early, but if left unaddressed can develop into serious problems that can affect health and safety, and require large capital investments to correct.

UNIT MAINTENANCE AT-A-GLANCE

Introduction
Pest Management
HVAC Maintenance
Weatherization
Lighting
Water Fixtures
Air Quality
Appliances
Structural Defects
Acronyms in this Chapter

Another benefit of regular unit maintenance is the opportunity to provide information to residents about how to save energy and water and to reduce environmental impacts. The PHA can incorporate resident education (see the tips below, as well as the Resident Education chapter of this manual) if the building staff, as part of the maintenance visit, speaks directly to residents regarding any maintenance issues. This communication also provides a chance to talk about greening tips and advice for proper upkeep of the unit, which can help the residents understand environmental consequences of certain behaviors (for example, pouring paint down the drain). Residents may be willing to make small behavioral changes once they understand and recognize the environmental impacts, all of which can add up to significant changes.

If resources and budget considerations allow, more regular inspections, such as quarterly, are recommended, as frequent inspections can simplify equipment maintenance. Whatever the frequency, the PHA should conduct unit maintenance on a regular basis. Intermittent or irregular maintenance may not adequately address all equipment and structural issues and may affect the safety and living conditions of the residents.

Building maintenance staff that conducts the unit maintenance inspections should have a comprehensive understanding and working knowledge of the equipment and should always be courteous and considerate of the safety and well-being of the residents.

As summarized in this chapter, regular unit maintenance should address:

- Pest management
- Heating, ventilation and air conditioning (HVAC) maintenance
- Weatherization
- Lighting
- Water fixtures
- Air quality
- Appliances
- Structural defects.

PEST MANAGEMENT

Pests are any living organisms that are detrimental to the living conditions of households. Common pests include insects, such as ants, termites, fleas, ticks, spiders, bedbugs and cockroaches, and animals, such as mice, lizards, and snakes. Pests may include stray animals (cats or dogs) or wild animals (deer, skunks, voles, squirrels), but do not include domesticated animals that are kept as household pets. If building management allows pet ownership, residents are expected to provide adequate care and supervision of their own pets.

During regular unit maintenance, the maintenance staff should look for evidence of pests, checking for commonly infested areas such as corners of the rooms, kitchen areas, doorframes, wood structures (for termites), and behind appliances. If pests have been reported in the past, the staff should pay special attention for any evidence: For example, if a mouse was reported, the inspector should look for mice droppings. If a pest is identified, pest eradication should begin as soon as possible, following Integrated Pest Management (IPM) guidelines as explained in the Cleaning Procedures and Products chapter of this manual.

The best way to address pests is to remove their food supply with effective cleaning and to seal up places where they can enter into the units or between buildings. During subsequent visits, the maintenance staff should continue to check for recurrence of pests.

RESIDENT EDUCATION: Ask residents to report any incidents of pests to the building maintenance staff. Building maintenance staff can advise residents of certain behaviors that may reduce the occurrence of pests, such as:

- not leaving food out
- using airtight food containers
- cleaning up spills or food crumbs
- washing dishes after use
- keeping floors, tables, and counters free of clutter
- keeping trash covered
- using screens for open windows or doors.[1]

ACTION ITEMS

1. Check for evidence of pests (room corners, kitchen areas, doorframes, etc).
2. If a pest is identified, address as soon as possible using IPM policy.
3. Check for recurrence of pests.

HEATING, VENTILATION, AND AIR CONDITIONING MAINTENANCE

A major area for regular maintenance is the heating, ventilation and air conditioning (HVAC) system. The HVAC system consumes a significant amount of energy, and regular filter cleaning can prolong the efficiency of the equipment and, ultimately, the life of the equipment. During the unit maintenance visit, the staff should make sure air registers, radiators, return air grilles, and other heating and cooling system components are not blocked, and advise residents to keep these areas clear. The building maintenance staff should perform adequate cleaning and proper maintenance of air filters, exhaust fans, and ductwork to ensure these elements are in working order. They should also check ductwork for leaks and that thermostat and water heater are in proper operation (e.g., water heater set to 120°F). The building maintenance staff should also check for any gas leak, or smell of gas.

The staff should check if residents have brought in additional heating or cooling devices. Individuals have different comfort levels, but their use of these devices may indicate that the current heating and cooling system is not operat-

[1] U.S. Environmental Protection Agency. Asthma. *Cockroaches and Pests.* Last updated Oct. 5, 2010. http://www.epa.gov/asthma/pests.html

ACTION ITEMS

1. Check that air registers, radiators, return air grilles, and other heating and cooling system components are clear and not blocked.
2. Conduct adequate cleaning and proper maintenance of air filters, exhaust fans, and ductwork.
3. Check ductwork for leaks.
4. Check with residents for any additional heating or cooling needs.
5. Check for any gas leaks (or smell of gas).

ing properly. The PHA should also advise residents that some of these devices consume energy even if not turned on or in use. By minimizing the number of additional devices used, the PHA can reduce overall energy use.

RESIDENT EDUCATION: Advise residents to keep registers, radiators, return air grilles, or other heating and cooling system components clear and unblocked. Residents should be advised that during certain seasons, particularly fall or spring, opening windows and doors may help with air circulation and therefore help improve air quality as well as reduce energy consumption. *However, if windows/doors are open, HVAC systems should always be turned off.* Advise residents to report any HVAC problems to the building maintenance staff, such as heating or cooling issues or noisy exhaust fans, which may be a sign of malfunctioning equipment.

WEATHERIZATION

Weatherization is an important part of regular unit maintenance. Proper insulation with no infiltration leaks ensures that the system is running in its optimal state and can have a significant effect on the amount of energy used. Commonly used areas, such as exterior doors and windows, can develop cracks that reduce the efficiency of the system. Interior air can leak to the exterior areas, or exterior air can leak to the interior areas, and, thus, increase the system load to achieve the desired temperature. The maintenance staff should check all exterior doors and windows to ensure the weather-stripping seal is intact. If weather-stripping seal is broken or not intact, they should fix or replace it. They should also check that all doors and windows, both interior and exterior, are in working order. Broken door hinges, windows, or window screens should be repaired. It is also important to check all detectors (fire or smoke, carbon monoxide, radon) on a regular basis to ensure that they are in working order. The maintenance staff should replace detector batteries at least annually or as needed, as detectors should always be operable. On an annual basis, maintenance staff should check attic space and walls to ensure there are adequate levels of insulation, referring to ENERGY STAR guidelines, if necessary.[2]

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[2] U.S. Environmental Protection Agency and U.S. Department of Energy, *Air Seal and Insulate with EnergyStar.* http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_sealing

RESIDENT EDUCATION: Advise residents to tell the building maintenance staff about any visible or noticeable evidence of air leaks (hot or cold air coming from door frames or wall cracks, i.e., not from vents) or if windows or doors are not functioning properly (such as windows coming loose from their frames). Residents should also report if they are aware that any detectors (carbon monoxide/smoke/radon) are low on battery.

ACTION ITEMS

1. Look for any air infiltration leaks; caulk as necessary.
2. Inspect exterior doors and window weather-stripping seals; fix or replace as necessary.
3. Check that all doors and windows are in working order.
4. Check that all detectors (fire/smoke, carbon monoxide, radon) are operable.
5. Annually, check attic space and insulation levels within walls.

LIGHTING

The PHA should conduct routine maintenance of unit lighting systems. The building maintenance staff should check that there is good, high-quality lighting for each area based on the lighting needs. They should replace, delamp, or upgrade lamps or indoor lighting systems with the most energy-efficient lamp-ballast combination possible. They should check that all light fixtures are in working order and that CFLs or energy-efficient lights are installed in high-use areas such as kitchens, living rooms, and bathrooms. The building staff should also clean existing or replacement light fixtures to ensure the maximum amount of light is properly dispersed. Many kitchens can be upgraded from existing T12 lamps to T8 and T5 lamps and/or magnetic to electric ballasts. Bathrooms may have 18" florescent lamps, which can also be replaced with more energy-efficient options (see Lighting chapter). If the PHA installs dedicated CFL fixtures, replacement lamps should be stocked and made available to occupants, or the fixtures should be checked on a regular basis. The PHA should consider including or upgrading sensors and other control systems, such as timers, for bathrooms, storage, hallways, meeting rooms, and other low-use areas, as appropriate.

The maintenance staff should follow the proper protocol for hazardous clean-up of any cracked or broken CFLs (see Lighting chapter) and collect any used or spent CFLs for proper disposal (i.e., through a take-back system). The building staff should look for other electrical issues, such as exposed or distressed electrical wires, broken light covers, or broken or cracked electrical wall plate covers, as they can pose fire hazards. Building staff should replace or repair any electrical problems.

ACTION ITEMS

1. Check all light fixtures are in working order; install energy-efficient replacements where possible.
2. Collect spent CFLs for proper disposal. The PHA should use available take-back systems for spent CFLs.
3. Clean all light fixtures to allow for maximum light dispersal.
4. Check for exposed or distressed electrical wires; fix as needed.
5. Replace or repair broken light covers or wall plate covers.

RESIDENT EDUCATION: Suggest to residents that they replace incandescent bulbs with CFLs as this can result in energy savings. Residents should be advised how to properly dispose of CFLs and to report broken CFLs to the building maintenance staff for hazardous clean-up. Residents should also be advised to report exposed or distressed electrical wires, broken or cracked light covers, or electrical wall plate covers for repair.

WATER FIXTURES

The maintenance staff should verify all unit water fixtures function properly and are water-efficient, using WaterSense[3] as a guide where possible. Water fixtures should be checked for leaks, such as dripping faucets, as a small leak can result in a large amount of water consumed (see Water Conservation chapter).

- **FAUCETS AND AERATORS:** The staff should check that faucets and aerators, if installed, are functioning properly and operating at the appropriate gallons per minute. (Typical residential faucet aerator values are 1.0 gallons per minute (gpm) for a bathroom and 1.5–2.0 gpm for a kitchen). The staff should make sure that aerators are installed properly; if the flow rate is too low, residents may remove the aerator, which would increase water use.
- **SHOWERHEADS:** Residential showerheads should be checked to make sure they are at the appropriate gallons per minute, typically 1.75–2.0 gpm.
- **TOILETS:** The toilet should be checked for its flush capacity, typically no more than 1.6 gallons per flush (gpf) to meet EPA WaterSense requirements, and that no foreign substances are in the toilet tank. The staff should check that the toilet does not continuously run or has "phantom flushing" (i.e., flushes without anyone touching it), as this may be a sign of a leaky valve.

ACTION ITEMS

1. Check that thermostats and water heaters are in proper operation (e.g., water heater set to 120°F).
2. Check to make sure that water fixtures (faucets, aerators, showerheads) are in working order and operating at their appropriate gpm flow rates.
3. Check that toilets are operating at appropriate flush capacity and there are no foreign substances in toilet tanks.
4. Check for leaks from water fixtures or running toilets.
5. If fixture replacement is required, use WaterSense requirements.

[3] U.S. Environmental Protection Agency WaterSense Program (www.epa.gov/WaterSense)

- **BEHIND FIXTURES:** The staff should also check behind toilets for water puddles and that appliances, such as washing machines, have no leaks from inlet water hoses or shutoff valves. They can ask residents if they have noticed any water leaks or other maintenance issues. If a replacement fixture is required, the PHA should follow WaterSense requirements.

AIR QUALITY

Indoor air quality affects residents' comfort, so the building maintenance staff should check for contributors to poor indoor air quality.

Mold and mildew are common problems that can develop from a water leak or moisture collection. Mold and mildew can grow on surfaces such as wood, paper, carpet, foods, and insulation. Issues with mold need to be addressed immediately, as they can cause serious problems, including permanent respiratory problems and possible structural damage if left unattended.[4] Mold and mildew growth may not be visible, so the maintenance staff should examine the unit, including the ceilings, for visual signs of condensation or water damage. They should ask the residents if they have noticed any moldy smells. Mold and mildew can be difficult to identify (e.g., mold growth on the back of wallpaper) and only noticeable through increased respiratory problems, so it is important that the PHA record any complaints.

If mold or mildew is discovered, the affected area should be cleaned thoroughly with a general purpose cleaner in conjunction with an Environmental Protection Agency-registered disinfectant, if necessary, to minimize further growth (see the Cleaning Procedures and Products chapter). Any water source, such as a water leak, should be addressed immediately and any excess water or moisture mopped up. If there is a suspected case of hidden mold, the building maintenance staff should consider working with a contractor trained in mold remediation.

RESIDENT EDUCATION: Ask residents to report water leaks from fixtures, as well as any visible water damage, condensation or evidence of mold and mildew, such as moldy smells, so issues can be addressed early. Residents should report any noticeable increase in respiratory problems.

ACTION ITEMS

1. Check the unit for visual signs of condensation or water damage.
2. Ask residents if they have noticed any moldy smells or have experienced any increased respiratory problems.
3. If mold or mildew is discovered, clean the affected area thoroughly using an EPA-registered disinfectant or work with a professional trained in mold remediation.

[4] U.S. Environmental Protection Agency. *Mold Remediation in Schools and Commercial Buildings,* March 2001. http://www.epa.gov/mold/mold_remediation.html

APPLIANCES

Regular unit maintenance can ensure that appliances continue to function properly. The maintenance staff should check that kitchen appliances are functioning properly. For example, they should make sure that the refrigerator door seal is intact, as this affects energy consumption and freshness of food. The staff should also check the condition of the range/oven and any evidence of dust collection, mold, or residual food items, and conduct any cleaning or maintenance as necessary. They should check that residents are using the appliances properly (e.g., not using the stove as heating). In addition, the unit maintenance visit is a good time to check the condition of any PHA-owned meters (such as water, electric, and natural gas) and to record the current meter reading. Meters should be operating properly and can provide valuable tracking data for the energy usage of the household.

RESIDENT EDUCATION: Advise residents to use appliances properly. Residents can be provided tips on proper cleaning and maintenance of appliances and advised to report any appliances that are not functioning properly.

ACTION ITEMS

1. Check that appliances are working and are being used properly.
2. Check condition of appliances; clean/perform maintenance as necessary.
3. Check that PHA-owned meters are working and record meter readings.

STRUCTURAL DEFECTS

The construction and physical attributes of the building may deteriorate over time with the wear of residential living. Therefore, the maintenance staff should check for structural failures of the physical building during regular unit maintenance. Small cracks or failures may be easily repaired, but unattended problems may develop into serious structural failures that can affect the safety and comfort of residents and be costly to address. The building maintenance staff should check interior walls, floors, ceilings, doors, windows, paint, screens, and radiators, as well as exterior porches, steps, and walkways for structural faults, such as cracks or any other damage to structural components.

If repairs are required, the PHA should refer to the Purchasing chapter for purchasing and installing environmentally preferable products. If an extensive repair is required, the PHA may elect to conduct renovations

ACTION ITEMS

1. Check interior walls, floors, ceilings, doors, windows, paint, screens and radiators for cracks or other damage to structural components; make repairs as necessary.
2. Check exterior porch, steps, and walkways for structure faults, such as cracks or any other damage to structural components: make repairs as necessary.

when the unit is vacant. However, regular maintenance can usually catch the need for small structural repairs so large-scale renovations are not needed as often. Regular unit maintenance can reduce unit turnaround time, which means that vacant units have new tenants in a shorter amount of time.

RESIDENT EDUCATION: Advise residents to report any visible damage or structural damage to the building manager, so repairs can be made immediately.

ACRONYMS IN THIS CHAPTER

CFL	Compact fluorescent lamp
EPA	Environmental Protection Agency
gpf	Gallons per flush
gpm	Gallons per minute
HVAC	Heating, ventilation, and air conditioning
IPM	Integrated pest management
PHA	Public housing authority

Chapter 12 | Unit Turnaround

INTRODUCTION

As with any residential property, there will be a percentage of units that become vacant. The reasons vary from shifts in the economy, changes in job or job status, life changes such as birth, death, marriage, or divorce, or changes in circumstances to qualify to live in public housing. Regardless of the reason, one of the challenges for PHAs is to make the vacated unit ready, so new tenants can move in as quickly as possible. Ensuring that units not sit vacant is an important consideration for PHAs as HUD has specific requirements for how long units may remain vacant.

A number of issues can increase the amount of time for unit turnaround. Addressing proper disposal of hazardous products, using green cleaning practices, and conducting comprehensive equipment maintenance may take time, but are necessary for unit maintenance and satisfaction of new tenants. In addition, many large-scale repairs (such as mechanical issues) are best addressed when the unit is unoccupied.

UNIT TURNAROUND AT-A-GLANCE

Introduction

Pest Management

Initial Unit Inspection
HVAC
Weatherization
Lighting
Water Fixtures
Structural Defects

Unit Cleaning

Unit Renovation

Painting

Waste Management
Residential Waste
Construction and Demolition Waste

Final Unit Check

Acronyms in this Chapter

As described in this chapter, unit turnaround should address:

- Pest management
- Initial unit inspection

- Unit cleaning
- Unit renovation
- Waste management
- Final unit check

PEST MANAGEMENT

The first step in the initial unit inspection process is to check for pest infestation. Common pests include insects, such as ants, termites, fleas, ticks, spiders, and cockroaches, or animals, such as mice, snakes, deer, skunks, squirrels, and stray cats and dogs.

Canvas strap of mattress box spring showing evidence of bed bugs

http://www.epa.gov/bedbugs/

When inspecting a newly vacated unit, the building staff should look for evidence of pests, checking for commonly infested areas such as corners of the rooms, kitchen areas, doorframes, wood structures (for termites), behind and inside appliances, and in other small crevices. Bedbugs have increasingly become a common problem; they present additional challenges as they spread easily and are difficult to identify. The building staff should look for dark spots on bedding, bedbug eggs and eggshells, skins of nymphs, live bedbugs, or rusty or reddish stains on bed sheets or mattresses as evidence of bedbugs (see photo).[1]

If a pest is identified, pest eradication should begin as soon as possible, following the Integrated Pest Management (IPM) guidelines in the Cleaning Procedures and Products chapter in this manual. The best way to address pests is to remove their food supply with effective cleaning and to seal up places where they can enter the units or go between buildings. If a unit is suspected to have a bedbug infestation, the staff should remove potentially contaminated furniture, bedding, clothing, boxes, or baggage and properly dispose of it to minimize the risk of future infestation.

ACTION ITEMS

1. Check for infestation of pests, particularly bedbugs.
2. If a pest is identified, address as soon as possible using an IPM policy.
3. If there is a bedbug infestation, dispose of any potentially contaminated items (furniture, bedding, clothing, boxes, or baggage)

INITIAL UNIT INSPECTION

Once pests have been addressed, the unit should be inspected as outlined in the Unit Maintenance chapter, including HVAC, weatherization, lighting, water

[1] U.S. Environmental Protection Agency. Pesticides: Controlling Pests. Bed Bug Information http://www.epa.gov/pesticides/bedbugs/

fixtures, and structural defects. The PHA should consider an energy audit, which will identify major efficiency opportunities such as HVAC, windows, and lighting. The unit should be maintained on a regular basis to ensure optimal functioning, but the PHA can take advantage of a vacant unit to conduct extensive upgrades or renovations without interruption. The staff should inspect the condition of all aspects of the unit including appliances, walls, windows, floors, cabinets and carpets, tiles, etc. to determine which products will need to be repaired or replaced. Items that are no longer usable or cannot be repaired or touched-up should be replaced. The PHA should check that each item truly needs to be replaced as simple repairs or touch-ups may be sufficient.

The initial unit inspection should cover the following areas:

- Heating, ventilation, and air conditioning (HVAC)
- Weatherization
- Lighting
- Water fixtures
- Structural defects.

Heating, Ventilation, and Air Conditioning (HVAC)

The building staff should make sure air registers, radiators, return air grilles, and other heating and cooling system components are not blocked. They should perform adequate cleaning and proper maintenance of air filters, exhaust fans, and ductwork and ensure that these pieces are in working order. They should also check ductwork for leaks and that thermostat and water heater are in proper operation. The PHA should check if any HVAC equipment, filters, or ductwork needs to be replaced. If so, energy-efficient options should be used when possible (see HVAC chapter). The building maintenance staff should also check for any gas leak (or smell of gas) from natural gas sources for safety concerns.

ACTION ITEMS

1. Check that air registers, radiators, return air grilles, or other heating and cooling system components are clear and not blocked.
2. Conduct adequate cleaning and proper maintenance of air filters, exhaust fans, and ductwork.
3. Check ductwork for leaks.
4. Check for any gas leak (or smell of gas).

Weatherization

The building staff should check all exterior doors and windows to ensure the weather-stripping seal is intact; if it is broken or not intact, they can fix or replace

it as needed. They should also check all doors and windows, both interior and exterior, repairing any broken door hinges, broken windows, or broken window screens. If windows need to be replaced, the PHA should use energy-efficient options. The PHA should make note of large window areas and consider installing window coverings for south-facing windows, such as reflective film, which will help manage glare and solar heat gain. Other window treatments to consider include insulating blinds or exterior shading of walls or windows to address thermal control. The building staff should check all detectors (fire or smoke, carbon monoxide, radon) and replace batteries at least annually or as needed, as detectors should always be operable. Annually, the staff should check attic space and walls to ensure adequate levels of insulation, referring to ENERGY STAR guidelines, if necessary.[2]

ACTION ITEMS

1. Check for air infiltration leaks; caulk as necessary.
2. Check weather-stripping seal on exterior doors and windows.
3. Check all doors and windows are in functional order and installed properly.
4. Check all detectors (fire/smoke, carbon monoxide, radon) are in working order.
5. Check attic space and insulation within walls.

Lighting

The PHA should replace, delamp, or upgrade existing lamps or lamp systems with the most energy efficient lamp-ballast combination (see Lighting chapter). Light fixtures that are not replaced should be in working order, and CFLs or energy-efficient lights should be installed as a replacement in high-use areas such as kitchens, living rooms, and bathrooms. Depending on the extent of the lighting refurbishment, the PHA may need to consult the local authority on compliance with building and energy codes. The PHA should consider installing or upgrading sensors and other control systems, such as timers, for infrequently used areas such as bathrooms, storage, hallways, and meeting rooms. If sensors are used, the PHA should consider the same sensor systems throughout the building to simplify repairs and the need for sensor inventory. The building staff should also clean all existing or replacement light fixtures to ensure the maximum amount of light is properly dispersed, particularly in dirty areas such as laundry rooms or exterior areas that may be more prone to collecting dust and dirt.

If repainting, the PHA should consider light-colored semi-gloss paint, which will reduce light loss. If dedicated CFL fixtures are installed, the PHA should stock replacement lamps to make available to occupants or to monitor on a regular basis. The maintenance staff should follow the proper protocol for hazardous clean-up for cracked or broken CFLs (see Lighting chapter). The maintenance

[2] U.S. Environmental Protection Agency and U.S. Department of Energy, *Air Seal and Insulate with EnergyStar*. http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_sealing

staff should collect any used or spent CFLs for proper disposal (i.e., through take-back systems). The building staff should also look for other electrical issues, such as exposed or distressed electrical wires, broken light covers, and broken or cracked electrical wall plate covers, as all can pose fire hazards. Building staff should replace or repair any electrical issues, as necessary.

ACTION ITEMS

1. Check all light fixtures are in working order; replace with CFLs where possible.
2. Collect spent CFLs for proper disposal. The PHA should use available take-back systems.
3. Clean light fixtures to allow for maximum light dispersal.
4. Check for any exposed or distressed electrical wires; fix as needed.
5. Replace or repair broken light covers or wall plate covers.

Water Fixtures

The building staff should verify all water fixtures in the unit function properly and identify water fixtures that need to be replaced using WaterSense[3] as a guide. Faucets should be checked that they are functioning properly with no leaks or dripping water. The PHA may consider installing aerators, which reduce water consumption, provided residents are amenable to the change. The building staff should check that new or previously installed aerators have the proper flow rate. If the flow rate is too low, residents may remove the aerators, which increases water usage. Typical residential faucet aerator values are 1.0 gallons per minute (gpm) for the bathroom and 1.5–2.0 gpm for the kitchen. Residential showerheads should be checked for the appropriate gallons per minute, typically 1.75–2.0 gpm or replaced according to WaterSense requirements, as needed (see also Water Conservation chapter).

All water fixtures should be checked for leaks, such as dripping faucets, and the toilet checked for its flush capacity, which typically should be no more than 1.6 gallons per flush (gpf) to meet EPA WaterSense requirements. The building staff should check that no foreign substances are in the toilet tank, and that toilets do not continuously run or "phantom flush" (i.e., flush without anyone touching it), as these are signs of a leaky valve. The building staff should also check for water puddles behind toilets and for water leaks from inlet water hoses and shutoff valves on water-using appliances such as washing machines. The PHA should identify if any water fixtures need to be installed and, if so, select

ACTION ITEMS

1. Check that the thermostat and water heater operate properly (e.g., water heater set to 120°F).
2. Check to make sure that water fixtures (faucets, aerators, showerheads) are in working order and operating at appropriate gallons per minute flow rate.
3. Check that toilets are operating at appropriate flush capacity and contain no foreign substances in the toilet tank.
4. Check for leaks from water fixtures or running toilets.
5. Check for evidence of water damage or mold and mildew (moldy smells).
6. If fixture replacement is required, use WaterSense requirements.

[3] U.S. Environmental Protection Agency. WaterSense Program. www.epa.gov/WaterSense.

the appropriate water-conserving fixture. For example, a new toilet should meet WaterSense requirements.

A variety of water-conserving toilets are available, including gravity flush, pressure assist, and dual flush. Each type has different considerations, and residents may not report leaks from gravity flushing. The pressure-assist toilet is less prone to leaks, but the pressure needs to be set correctly. If the pressure is too low, it will not flush correctly; if the pressure is too high, it may rupture the pressure valve (1.28 gpm is the typical pressure setting). Dual-flush systems offer two types of flush (0.8/1.60 gpm or 0.8/1.28 gpm), but may offer a wide trap, which results in fewer clogs and is less prone to maintenance calls. Regardless of the type installed, the building staff should make sure the fixture meets the WaterSense requirements and is regularly checked for leaks.

Structural Defects

The construction and physical attributes of the building may deteriorate over time with the wear of residential living. Therefore, the maintenance staff should check for structural failures of the physical building during regular unit maintenance. Small cracks or failures may be easily repaired, but unattended problems may develop into serious structural failures that can affect the safety and comfort of residents and be costly to address. The building maintenance staff should check interior walls, floors, ceilings, doors, windows, paint, screens, and radiators, as well as exterior porch, steps and walkways for structure faults, such as cracks or any other damage to structural components. Other goods, such as appliances, also wear over time. The inspection should cover the condition of the appliances to see if they need to be repaired or replaced. The PHA should identify if any items required for replacement (see Purchasing for specific requirements). Any PHA-owned meters should be checked for proper functioning.

ACTION ITEMS

1. Check for any structural failures, including interior walls, floors, ceilings, and windows; make repairs as necessary.
2. Check condition of appliances; clean/perform maintenance as necessary.
3. Check that PHA-owned meters are working and record meter reading.

UNIT CLEANING

A vacant unit provides an opportunity to conduct more comprehensive cleaning than when the unit is occupied. Even if using environmentally preferable products, an important consideration for any cleaning program is to ensure good

cleaning procedures, such as using proper protective equipment; following instructions on product labels; and adequately ventilating the unit by opening windows/doors, using motorized fans, and opening vents, where possible. The PHA should communicate clearly to workers that products should be used ONLY for their intended use (e.g., NOT using bathroom cleaner for glass windows or using oven cleaners for walls). Using a cleaning product for purposes other than its intended use may expose workers to potential health and environmental hazards and may reduce the effectiveness of the cleaner.

Prior to cleaning, the building staff should examine the unit, including the ceilings, for visual signs of condensation or water damage (using indicators such as moldy smells), noting that not all mold and mildew may be visible. If mold or mildew is discovered, the affected area should be cleaned thoroughly with a general purpose cleaner in conjunction with an EPA-registered disinfectant to minimize further growth. Any water source, such as a water leak, should be addressed immediately and excess water or moisture mopped up. If there is a suspected case of hidden mold (such as behind wallpaper), the building maintenance staff should consider working with a contractor trained in mold remediation.

The PHA should thoroughly clean all areas of the unit (kitchen, bedroom, living areas, bathrooms, closets). Areas not identified for new paint or replacement should be thoroughly cleaned, including both vertical and horizontal surfaces (i.e., walls and floors), as well as existing light fixtures and lenses to maximize lighting conditions. Certain areas, such as laundry rooms and outdoor areas, are more prone to accumulating dust and dirt and should be cleaned to maintain acceptable light levels. If disinfection is required due to pest infestation or identified mold or mildew, the PHA should use EPA-registered disinfectants in conjunction with a general cleaning program (see the Cleaning Procedures and Products chapter).

UNIT RENOVATION

Prior to starting renovation work, the PHA should identify any environmental considerations that may require a certified practitioner to minimize contamination. Refer to the Environmental Protection Agency for requirements for renovations and additional environmental considerations. HUD Guidelines and grants are available for lead paint and asbestos issues.

The PHA should identify which items will need to be purchased for unit renovation, including paint, stains, caulks, sealants, adhesives, floor finishes, floor strippers, and cleaning products using environmentally preferable products where possible. To minimize the unit turnaround time, the PHA should have a variety of products on hand. Based on the unit inspection or energy audit, the PHA should identify any equipment or appliances that need to be replaced. During renovation, the PHA may replace drywall, carpets and flooring, ceiling tiles,

doors, windows, screens, appliances, tiles, cabinets and other durable goods, in addition to systems such as heating and cooling systems, lamp and lamp systems, and water fixtures. When looking to purchase a replacement, the PHA should be familiar with the suggestions provided in the Purchasing chapter for product categories where environmentally preferable products are available. The PHA should look to see if a green product directory is available for assistance in selecting materials; if not, the PHA can gather the necessary information directly from the manufacturer or supplier.

PAINTING

During unit turnaround, the unit may require renovation such as repainting walls or refinishing cabinetry. When selecting new paint colors, the PHA should select light colors and semi-gloss paint for wall covers and/or flooring, which reduces the light loss. The PHA should use environmentally preferable products, according to the Purchasing Guides, such as low-VOC paints and stains and zinc-free floor finishes.

The PHA should protect workers from exposure to dust and fumes, using precautions such as facemasks. As with cleaning, even if using low-VOC products, the PHA should maintain adequate ventilation by opening windows/doors, using motorized fans, and opening vents, where possible. If applying floor strippers or finishes, the PHA should conduct this task last (after the other cleaning tasks) and ensure proper signage and notification during application and drying time. Once renovation work is complete, the PHA should conduct a clean air flush by running the HVAC system on full capacity and opening all the doors and windows for 24–48 hours to exhaust any hazardous fumes or odors.

WASTE MANAGEMENT

Residential Waste

Prior to move-out day, the PHA should provide tenants with move-out instructions about safe removal and disposal of items, including drop-off centers, contact information for electronic waste, universal waste items, and centers for large items, such as furniture. The PHA should also provide additional information for residents to identify and properly dispose of household hazardous waste. The PHA should consider creating a "set-aside" area and coordinate with a local non-profit group to take usable items such as small appliances, clothing, and

household products. The PHA should also consider contacting local agencies and community and non-profit organizations for reuse and take-back programs for items such as batteries or CFLs. Some groups coordinate or identify nearby "drop-off donation" boxes, which will make it more convenient during move-out day. Salvage yards or scrap metal recyclers may be willing to take large metal items. For mattresses, bedding, and upholstery furniture, the PHA should work with an organization that specializes in these items as reusing potentially contaminated items with bedbugs, dust mites, or mold may lead to health hazards and risk further contamination.

The PHA should recycle materials that are left behind or abandoned that can be recycled and properly dispose of the remaining items (see Table 1).

TABLE 1. COMMON ITEMS DISCARDED DURING MOVE-INS/MOVE-OUTS OR LEFT IN ABANDONED UNITS

	Recycle	Donate	Notes & other ways to reduce or reuse
Recyclable materials			
Paper, cardboard boxes	√	√	Set aside good boxes for reuse
Household products & cleaning supplies		√	Check with local shelter or animal rescue; usually accepts unopened product but some will take it opened
Household goods, cookware, lamps, picture frames, garden tools		√	Thrift stores, shelters, Internet listings
Small appliances		√	Thrift stores, shelters, Internet listings
Larger appliances, water heaters	√	√	Thrift stores, shelters, Internet listings; remind residents to request pick-up service when purchasing new one
Furniture, bicycles, exercise equipment		√	Thrift stores, shelters, Internet listings
Clothing and shoes	√	√	Thrift stores, shelters, Internet listings; blue jeans recycled for insulation and cotton shirts as rags

Construction and Demolition Waste

Construction or demolition projects, whatever their size, also generate waste. The PHA should look into local regulations and recycling requirements, as some communities have regulations for these waste management activities. A growing number of organizations, including haulers and recyclers, specialize in construction debris recycling. The PHA should consider setting up an on-site collection and storage area, container types, and recycling procedures during construction or demolition. The PHA should advise residents on any health or safety concerns and minimize dust and debris from workers and residents. The PHA should create and implement an air quality management program during construction or

demolition. See the chapter on Recycling and Special Waste Programs for additional details about construction materials, such as concrete, wood, metal, glass, and other materials, with recovery potential.

FINAL UNIT CHECK

The last step in the unit turnaround process is to conduct a final unit check to ensure the unit is move-in ready for new tenants and nothing has been overlooked during the unit turnaround process. The building staff should verify that work has been satisfactorily completed and existing or newly installed items are in working condition, including:

- Mechanical equipment is functional and thermostats are set correctly
- Doors and windows can open and close properly without excessive force
- Detectors (smoke, carbon monoxide, radon) are operable
- Lamps and lamp systems have been replaced and are in working order
- Light fixtures are clean with adequate light dispersal
- Water fixtures are working and/or have been installed correctly, checking the flow rate of any aerators
- There are no noticeable structural defects in walls or ceilings
- Appliances are in working order and/or have been installed correctly (including refrigerator and stove)
- Unit has been appropriately cleaned, including all horizontal and vertical surfaces
- All dirt and waste from repairs have been cleaned up.

ACRONYMS IN THIS CHAPTER

CFL	Compact fluorescent lamp
EPA	Environmental Protection Agency
gpf	Gallons per flush
gpm	Gallons per minute
HVAC	Heating, ventilation, and air conditioning
IPM	Integrated pest management
PHA	Public housing authority
VOC	Volatile organic compound

SECTION THREE

Residential Initiatives for a Greener PHA

Chapter 13 | Resident Education and Special Programs

INTRODUCTION

Residential behavior is an important contributor to the environmental impact of a public housing authority (PHA). On an individual level, residents might not feel that they play a significant role in the PHA's environmental performance, but their behavior is a major determinant of the amount of energy and water used overall. Energy costs will be higher if residents leave their lights on while not occupying their unit. In addition, resident behavior can affect the efficiency of key systems; for example, it does not matter how efficient an HVAC system is if residents turn up thermostats to run heat while windows are open. Residential behavior not only affects the living conditions of an individual unit, but also it affects neighboring residents; for example, the attraction of pests or leaks in one apartment may affect another.

RESIDENT EDUCATION AT-A-GLANCE

Introduction

Resident Education

Special Programs to Reduce Environmental Impacts
Recycling
Household Hazardous Waste and Electronic Waste
Purchasing Assistance
Landscaping, Community Gardening, and Composting

The best time to educate residents on steps they can take to decrease their environmental impact is when they first sign their leasing agreement. Residents should also be reminded of positive actions they can take during unit maintenance visits, the yearly unit inspection, and resident association meetings.

This chapter consists of two sections. The first section, on residential education, suggests items to review with residents when they first move in and then again during unit maintenance visits and yearly unit inspections. It identifies five main areas where simple actions by residents can improve the environment:

- Asking for assistance from the maintenance staff
- Reducing energy use

- Reducing water use
- Reducing solid waste
- Purchasing environmentally preferable products.

The second section describes special programs to reduce environmental impacts: programs and initiatives the PHA can implement to encourage residents to act more easily on the information provided to them during the resident education meetings. These programs include:

- Recycling
- Household hazardous waste and electronic waste recycling and safe disposal
- Purchasing assistance
- Landscaping stewardship, community gardening, and composting.

To facilitate these programs, the building manager will need to reach out to residents by hosting periodic meetings and handing out or posting flyers. If there is a residents' association, the manager can also work with this group.

RESIDENT EDUCATION

There are five main areas to discuss with each resident about steps they can take to improve the environment, reduce the costs of utilities, and, in many cases, improve their living conditions.

1. **ASK FOR ASSISTANCE.** One of the most important messages is to encourage residents to ask for assistance from the maintenance staff. They should seek help if something in their unit is not working properly—for example, a leaking faucet, or refrigerator or window not closing properly. Encourage them to ask for assistance if they are having any pest or mold issues, or if they need help removing an air conditioning unit from a window when the weather gets cold. Getting the residents to ask for assistance will allow for more preventative maintenance of units, a better living environment for the resident, and energy and water savings.

2. **REDUCE ENERGY USE.** Educate residents on three easy ways they can reduce their energy use.

- **THERMOSTATS.** Show residents how to use the thermostat in their unit to turn the heat down and air conditioning up. Advise residents to keep the thermostat at 78°F or above in the summer and at 68°F or below in the winter and to keep windows and doors closed when the heat or air conditioning is on, as leaving them open wastes energy. In units where residents are responsible for paying for their own utilities, keeping windows and doors closed saves them money; in units where residents do not pay for utilities, urge them to keep windows and doors closed because it helps save energy and is good for the environment.
- **TURN THINGS OFF.** Ask residents to turn off lights and appliances when they are not in use. If residents are responsible for utilities, show how this will save them money.
- **SEASONAL TURNOVER.** Prior to major seasonal changes, hold resident education meetings on how to change over units between seasons. Suggest to residents that they open their windows in the spring and autumn to reduce heating and cooling needs. Ask them to take air conditioning units out from the windows when it gets cold and offer assistance from building staff to remove the units. Provide information about the importance of proper, safe use of space heaters, and the dangers of improper usage.

3. **REDUCE WATER USE.** Educate residents about ways to reduce their water usage.
   - **TURN FIXTURES OFF.** Ask residents to turn off running water when it is not being used. If residents are responsible for utilities, show how this will save them money.
   - **MAINTENANCE.** Urge residents to notify maintenance staff about leaking or running faucets, toilets, or other water fixtures that need to be repaired or replaced.
   - **LAUNDRY.** Show residents the load size settings on the washing machines and ask them to consolidate loads of laundry as much as possible, which will save time, energy, and money.
   - **REPLACEMENTS.** Advise residents that if they are going to purchase their own replacement showerheads or other water fixtures, to get a low-flow water fixture (see Water Fixtures and Conservation chapter for information).

4. **REDUCE SOLID WASTE.** Educate residents on how to increase the amount of goods they recycle and to properly dispose of products that contain hazardous materials.

- **RECYCLING.** Urge residents to recycle as much material as possible, as this diverts material from landfills and can be used to create other goods. Explain what items can be recycled, typically glass, aluminum, and plastic. (See section below for information on how to create a recycling program and a full list of items that are recyclable.) Show residents examples of different plastics and what their resin code symbols look like to educate them on which items they can recycle, and explain the need to rinse food containers before recycling. Post flyers near recycling bins identifying which items can be recycled, including which types of plastics.

- **HOUSEHOLD HAZARDOUS WASTES AND ELECTRONIC WASTE.** Explain what hazardous materials are and how to properly dispose of them. Hazardous materials include batteries, paint, compact fluorescent lights, mercury thermometers, and electronics. Urge residents not to put these items in the regular trash. (See section below and Recycling chapter for information on how to create a household hazardous and electronic waste program and a list of items that are considered hazardous.)

5. **PURCHASE ENVIRONMENTALLY PREFERABLE PRODUCTS.** Educate residents about the benefits of buying environmentally preferable products and how to identify them.

- **SMALL APLLIANCES AND ELECTRONICS.** Advise residents to buy ENERGY STAR and EPEAT labeled small appliances and electronics. These labels can be found on thousands of small appliances and electronics, including televisions and computers. The ENERGY STAR label signifies that the product is a leader in energy efficiency in its product category and the EPEAT label signifies that they have met requirements for energy efficiency, reduced hazardous materials, and have "take-back" programs.

- **LIGHT BULBS.** Advise residents to contact PHA staff to replace spent or broken light bulbs. Request that if they buy light bulbs on their own to select compact fluorescent lamps (CFLs). These lamps may have higher up-front costs, but use less energy and will last longer. More information from the EPA on the benefits of CFLs can be found here: http://www.epa.gov/cfl/. Beginning January 1, 2012 the sale of incandescent bulbs will begin to be phased out in the United States.

- **PAPER PRODUCTS.** Advise residents to purchase paper products with the highest recycled content they can find. Numerous labels on paper products tell the recycled content of a product. These labels include Ecologo, Forest Stewardship Council (FSC), Green Seal, and Sustainable Forestry Initiative® (SFI).

- **PERSONAL CARE, CLEANING, AND LAUNDRY CARE PRODUCTS.** Advise residents to buy products that have one of three ecolabels: Design for the Environment (DfE), Ecologo, or Green Seal. Products that have these labels have been formulated to be safer for human and environmental health and can be found on hundreds of products.
- **GENERAL TERMS AND STATEMENTS TO LOOK FOR.** Many products are marketed as environmentally friendly. If residents cannot find products with labels that indicate any of the programs described above, they can look for specific terms and statements that include "made with recycled content," "reduced toxicity and/or hazardous material," and "manufactured with renewable energy."

SPECIAL PROGRAMS TO REDUCE ENVIRONMENTAL IMPACTS

The PHA can implement programs and initiatives to encourage residents to act on the information provided to them during the resident education meetings. These programs include recycling, household hazardous waste and electronic waste recycling and safe disposal, purchasing assistance, and landscaping programs. To facilitate the programs, the building manager will need to reach out to residents directly by hosting periodic resident meetings and handing out or posting flyers. If there is a residents' association, the manager can also work with this group.

Recycling Programs

Recycling is one of the easiest and most effective actions residents can take to decrease their environmental impacts. This program is described here and in the Recycling and Special Waste Programs chapter of this manual. Creating a successful recycling program is simple and includes six key steps:

1. Check with local waste haulers and recyclers to determine what materials can be picked up for recycling, and if aluminum, paper, and other materials can be collected together (co-mingled) or need to be sorted.
2. Create clearly marked recycling stations that are accessible to residents.
3. Place flyers or signs near recycling stations that state which items can be recycled and, if sorting is needed, which items go in each bin.

4. Hand out flyers to inform residents of the program, which items can be recycled, and how to sort items, if required. Invite them to an informational meeting and provide an incentive to residents to attend (such as a micro-fiber towel, reusable bag, or stainless steel water bottle).
5. Track recycling results and effectiveness of the program, as well as any problems regarding separation or collection of potential recyclable content.
6. Offer incentives for volunteers to sign up as captains to assist the elderly with recycling, aid other residents who have questions, and help monitor the program.

Items that can be readily recycled in most jurisdictions include:

- Clear, green, and brown glass bottles and jars
- Aluminum cans
- White office paper (e.g., copier, bond, computer)
- Mixed office paper (e.g., ledger paper, folders, pamphlets, brochures, envelopes)
- Mail (e.g. advertisements/direct mailings, catalogues)
- Newspaper
- Cardboard
- Telephone books, magazines, and other books
- Plastics (typically only those with PETE and HDPE symbols).

Recycling plastic can be tricky and confusing, as not all plastic can be recycled. It is important to sort plastics because the waste stream can be ruined if plastics that are not recyclable are mixed in with those that are. Plastic is identified by the resin code symbol found on the bottom of each item. These symbols show a triangle with a number of 1 through 7 inside, and are the best way to determine if an item can by recycled and which bin to place it in. Find out from your local waste and recycling hauler which plastics items they accept and then educate residents to look for the resin code symbols. Place pictures of the symbols above the appropriate bins. The resin code symbols are as follows:

Resin Code Symbol	1 PETE	2 HDPE	3 V	4 LDPE	5 PP	6 PS	7 OTHER
Types of products made from this material	Soda and water bottles, medicine containers	Milk and water bottles, laundry detergent bottles, toys	Pipe, meat wrap, cooking oil bottles	Wrapping films, grocery bags	Syrup bottles, yogurt tubs, diapers	Coffee cups, clamshell food packaging	PLA, mixed source

It is important to enlist residents to sort recyclables. Make clear which items can be recycled and where they should be placed. Recyclables that contain foods such as soda or soup should be rinsed out prior to being placed in collection bins to minimize the potential for attracting pests (e.g., ants and cockroaches). It is important that facility management and staff support the recycling efforts and address residents who frequently contaminate the recycling bins with non-recyclable items.

Additional resources:

- Marian County (Oregon) Recycling Posters: http://www.co.marion.or.us/PW/ES/wastereduction/education/resourcelibrary/
- CalRecycle: http://www.calrecycle.ca.gov/Gallery/

Household Hazardous Waste and Electronic Waste Program

The amount of household hazardous waste (HHW) and unwanted electronic equipment (e-waste) items is growing in the United States. Throwing these items into the trash, pouring them down the drain, or getting rid of them in other improper ways pollutes the environment and poses a threat to human and pet health, as well as PHA staff and public works employees who might accidentally handle improperly disposed items. This program is described here and in the Recycling and Special Waste Programs chapter. The following steps can be taken to implement an effective HHW and e-waste program:

1. Check with local waste haulers and the municipality to determine if there is hazardous waste pick-up or where hazardous items can be taken.
2. Create a monthly or quarterly hazardous and e-waste collection day for the PHA by either having a local waste hauler come and collect items or by bringing items from the PHA to a local hazardous and e-waste collection area.
3. Inform residents which items are hazardous and how to properly dispose of them (i.e., do not pour down drain or throw away with regular trash) by handing out flyers. Invite residents to an informational meeting and provide an incentive to encourage residents to attend.
4. Notify residents when household hazardous and e-waste collections days are scheduled, so that they can hold onto items until that time.
5. Offer incentives for volunteers to sign up as captains to assist the elderly with hazardous waste, aid other residents who have questions, and help monitor that hazardous waste is disposed of correctly.

Household Hazardous Waste items include:

- Acids
- Aerosols
- Antifreeze
- Asbestos tile
- Batteries
- Cleaning chemicals
- Drain openers
- Fluorescent light bulbs
- Furniture stripper
- Stains
- Varnish
- Fertilizer
- Lighter fluid
- Mercury thermometers and mercury-containing devices
- Moth balls
- Motor oil
- Paint
- Pesticides and poisons
- Roofing tar
- Solvents/thinners
- Transmission fluids
- Windshield wiper and brake fluids
- Wood preservatives

E-waste items include:

- Audio/visual equipment
- Audio cassettes
- Camcorders
- CD Rom drives and CDs/DVDs
- Cell phones
- Computers and monitors
- Connectors, cords, and wires
- Copy machines
- Fax machines
- Floppy drives
- Hard drives
- Memory chips
- Network/video/sound cards
- Pagers
- Power supplies
- Printers
- Scrap computer plastic

- Scrap computer metal
- Tape drives
- TVs
- VCRs
- VCR tapes
- Video games and software

Purchasing Assistance Program

Purchasing environmentally preferable products is another way that residents can decrease their environmental impact. The PHA should consider creating a purchasing assistance program to buy items in bulk and sell them to residents. A purchasing assistance program would allow residents to purchase items at lower cost than if they were to buy individual items at a store, and it would make it easier for the residents to purchase environmentally preferable products, as these products are not always readily available. (See the chapter on Purchasing for more information.)

Compact fluorescent lamps (CFLs) are a great example of products to buy under this kind of program. The initial higher cost of CFLs is one of the main reasons consumers do not buy them. Purchasing CFLs in bulk, at a lower per unit cost, and passing these savings on to residents, would make them more attractive to residents. Encouraging residents to use CFLs would also bring cost savings to the housing authority through reduced energy costs. When residents buy CFLs from the PHA, staff can use the opportunity to remind residents about proper disposal and what to do if there is breakage. (See the Lighting chapter for more information on CFLs and their safe disposal. Information from the EPA can also be found at http://www.epa.gov/cflcleanup.)

The following steps can be taken to implement a purchasing assistance program:

1. Identify products to include in the program, such as CFLs, cleaning products, personal care products, and laundry products. The products offered should be environmentally preferable options. However, make sure the products are effective and meet resident needs. Start the program with one or two items residents are most likely to purchase. It may make sense to host a meeting or information session to provide information on the products that could be provided under this new program and what the costs of the environmentally preferable products would be.

2. The program can be offered on a continuous basis, allowing residents to purchase products any time from the PHA, or monthly in which residents would place orders for products.

3. Notify residents of the purchasing program, what is available, and its benefits (i.e., cost savings, health and environmental benefits) through flyers, posting notices, and/or meetings.

4. Educate residents on the proper use and disposal of the products. If possible, create a take-back system for products purchased through the program. For example, collect spent/broken CFLs to ensure proper disposal.

5. Track the number of products of each type that are purchased through the program. Request feedback from residents on the quality and cost of the products offered and suggestions for additional products to be available.

Landscaping Stewardship, Community Gardening, and Composting Programs

Education and stewardship are the keys to success and acceptance of native plantings (see Landscaping chapter). Education, both formal and informal, helps people understand the changes actively taking place around them and how they can help care for, as well as become ingrained in, the process of bettering the environment.

EDUCATION: Native landscapes require maintenance and project management, especially in the initial installation. Formal education by attending native-plant seminars and workshops should be a requirement for maintenance workers and allows them to participate in the greening of America.

STEWARDSHIP: Through stewardship, an individual or group cares about and safeguards the environment to create a healthier place. Stewardship actively engages citizens by providing opportunities to allow them to participate in bettering the environment. One option would be to offer reduced rent to a tenant from every building who would be assigned to maintain the new plantings to supplement the watering and weeding as necessary.

Stewardship also involves the community. Involve a local church group, college sorority or fraternity, or other organization in projects and let them adopt a garden plot or an area of the landscape, such as a rain garden, to plant and maintain. Post information about the project to strengthen community pride. Allow volunteers to get the landscape certified by environmental groups such as the National Wildlife Federation.

INDOOR PLANTS act as air filters and are effective in removing carbon dioxide and harmful pollutants from the home. In the past 25 years, asthma rates have risen to epidemic levels. While research is determining the many factors involved, such as herbicides used in landscapes, second-hand smoke, building

materials, and molds, indoor plants help provide better air quality in the home. Easy-growing plants, such as the peace lily, spider plant, and pathos, are inexpensive and useful in filtering out unsafe gases from cleaning products, drywall, and paints.

Community Gardens

Community gardens are an allotment of space or a plot of land divided into gardens to be shared by the inhabitants of the development. Community gardens greatly improve the quality of life for residents by supplying a sense of community through social interaction with other residents, exercise for gardening participants, and healthy produce. Gardens also provide a refuge from the hectic pace and noisy deluge of urban life.

Steps to begin a community garden include the following:

- **ORGANIZE A COMMITTEE OF VOLUNTEERS** to plan and manage the garden. The committee must come to a consensus regarding decisions about the use of chemicals, use of tools, weeding tasks, plot rotation, and what is to be planted for an exchange of produce, if desired. The committee members can also be drawn from outside the building, which invests the community in the garden.
- **INVITE HORTICULTURAL SPEAKERS** from local colleges, garden clubs, master gardeners (for a list, visit http://www.ahs.org/master_gardeners/), or native plant societies (see Landscaping chapter) to visit the community garden to provide information and discuss concerns with residents.
- **LOCATE THE GARDEN NEAR A WATER SOURCE OR RAIN BARREL;** most vegetables need a great deal of water to produce during the growing season. Have an initial soil test performed, including a test for unsafe levels of lead or other heavy metals, before selecting a site for any vegetable garden. The ideal pH for growing vegetables is between 6.5 and 6.8. Vegetable plants deplete the soil of nutrients to produce more vegetables. Soil tests are helpful to ensure proper nutrients are available. A soil test should be repeated every two years in a community garden.

Community Composting

Backyard composting is a technique that residents can use to turn their food scraps and yard trimmings into valuable soil amendment and organic matter to add to the community garden. Composting is ideal for food scraps from fruits and vegetables, coffee grounds, tea bags, leaves, grass clippings, and even shredded newspaper. Composting options, such as vermicomposting in which worms eat the food scraps, take up very little space, can be done year-round, and could be an ideal program for multi-family housing complexes.

Follow these steps to implement backyard composting:

1. Check on local and state regulations for composting in urban areas, as some communities require rodent-proof bins.
2. Identify a well-drained area in the building complex, preferably near the community garden, away from the residential areas in case of fruit flies or ants, and easy to clean and maintain. Compost bins or piles are usually a cubic yard (3' x 3' x 3') and additional room for turning works best. Larger piles require careful maintenance and can ignite if they become too dry or too tall.
3. A number of sources can provide detailed information, including your local solid waste agency, gardening clubs, or the Internet. Specially designed bins are not required but are convenient and provide containment, especially in an urban environment. Each program provider can describe how best to monitor and maintain the compost pile, what materials can and cannot be composted, and how to resolve problems such as odor management and control of insects and rodents.
4. Provide residents and maintenance staff instructions on what materials can and cannot be recycled, composting locations, and how to properly maintain the composting area. For example: Do not compost meat scraps, fatty foods, dead animals, pet manure, diseased plant material, or noxious weeds.

Additional resources:

- EPA composting guide: http://www.epa.gov/osw/conserve/rrr/greenscapes/pubs/compost-guide.pdf
- USDA Alternative Faming Systems Information Center composting: http://afsic.nal.usda.gov/nal_display/index.php?info_center=2&tax_level=2&tax_subject=293&topic_id=1403