Abt

Abt Associates Inc.

Energy Conservation for Housing—A Workbook

Contract #DU100C000018374 Task Order 8

Cambridge, MA
Lexington, MA
Hadley, MA
Bethesda, MD
Washington, DC
Chicago, IL
Cairo, Egypt
Johannesburg, South Africa

January 1998

Prepared for
William Thorson
U.S. Department of Housing
and Urban Development
451 Seventh Street, SW
Room 4214
Washington, DC 20410

Abt Associates Inc.
55 Wheeler Street
Cambridge, MA 02138

Prepared by
Sandra Nolden
Deborah Morse
Scott Hebert

ACKNOWLEDGMENTS

This workbook represents the combined efforts of many individuals. In particular, the authors wish to acknowledge the invaluable contributions made by: Linda Fosburg (technical review) and Jan Nicholson (production) of Abt Associates Inc.; Robert Persons of Persons Engineering (cost-effectiveness worksheets); Jim Zaccaria (illustrations); John Snell of Citizens Conservation Corporation (technical consulting); and Richard Andelman of Citizens Conservation Corporation (contribution to Chapter 5).

The authors also wish to express our thanks for the support and guidance provided by William C. Thorson, who served as HUD's GTR for this effort.

Finally, the authors wish to express our sincere appreciation for the assistance of the Technical Advisory Panel, whose members made valuable suggestions regarding the format and content of the workbook. The following individuals served on the Technical Advisory Panel:

Keith Aldridge
Senior Program Manager
Advanced Energy
Raleigh, NC

Jeannette Brinch
Senior Associate
Energetics
Columbia, MD

Rick Diamond
Staff Scientist
Lawrence Berkeley Laboratory
Berkeley, CA

Jim DiPaolo
Housing Authorities of the City
and County of Denver
Denver, CO

Gary Foster
Housing Authority of the City
of Wilmington
Wilmington, NC

Robert Groberg
U.S. Department of HUD
Washington, DC

Larry Hill
Oak Ridge National Laboratory
Oak Ridge, TN

John Hiscox
Public Housing Authorities
Directors Association
Washington, DC

Fred Kay
Seattle Housing Authority
Seattle, WA

Kenneth King
Housing Authority of the City
of Poplar Bluff
Poplar Bluff, MO

Satinder Munjal
U.S. Department of HUD
Washington, DC

Mark Murfield
U.S. Department of HUD
Kansas City, KS

Jim Parry
Housing Authority of the City and
County of Fresno
Fresno, CA

Denise Ryan
Cincinnati Metropolitan Housing
Authority
Cincinnati, OH

Joseph Sarver
Richmond Redevelopment and
Housing Authority
Richmond, VA

Arthur Sotirion
Springfield Housing Authority
Springfield, MA

Jim Wade
Housing Authority of the City
of Raton
Raton, NM

This workbook updates and builds upon the original *Energy Conservation for Housing: A Workbook,* prepared by Perkins & Will and The Ehrenkrantz Group, and published by the U.S. Department of Housing and Urban Development, Office of Policy Development and Research, in May 1982.

Energy Conservation for Housing: A Workbook

TABLE OF CONTENTS

Chapter 1: Introduction

Additional ECMs to Consider

CHAPTER 1: INTRODUCTION

Public and Indian housing authorities (HAs) spend about $1.1 billion dollars per year on utilities, or about 27 percent of total operating expenses (U.S. Office of the Inspector General 1995). Because energy costs account for such a large portion of a typical HA's operating expenses, cutting energy waste can significantly reduce operating expenses. Even if your HA has made energy-saving capital improvements to your developments over the years, you can still save anywhere from 10 percent to over 60 percent on your energy bills through cost-effective conservation improvements.

1.1 What Is the Purpose of This Workbook?

This workbook is intended to be a guide for HAs that are interested in making energy conservation improvements. It is designed to provide assistance to HA staff of varying degrees of technical proficiency and experience with energy conservation.

In addressing the issue of energy conservation, this workbook has several related objectives:

- To provide you with essential background information about energy conservation;
- To guide you in surveying a development's energy-related systems/equipment and current energy use;
- To offer a checklist for proper operations and maintenance (O&M) to save energy and ensure long life of equipment; and
- To provide step-by-step guidance in assessing the cost-effectiveness of energy conservation options.

1.2 Why HAs Should Make Energy Conservation Improvements

Energy efficiency should be an integral part of every HA's operations and capital improvement planning process. The most compelling reason for your HA to make energy conservation improvements is the potential for significantly reduced energy costs. The extent to which reduced energy costs will affect your HA's operating budget depends on the method of funding the improvements. Generally, an HA can keep 50 percent of the savings based on a three-year rolling base. However, if an HA uses an energy performance contract, it can borrow non-HUD funding and keep 100 percent of the cost savings from energy efficiency improvements, after loan payments, for the life of the loan. (Oak Ridge National Laboratory 1992). *A detailed discussion of funding options is included in Chapter 2.*

In addition to lowering operating costs, energy conservation improvements can help ease capital improvement needs. HAs that replace old, inefficient equipment with new energy-saving equipment address capital improvement needs while reducing energy costs. In many cases, the energy savings from the new equipment are enough to cover the cost of the new equipment within a specified time frame.

Energy conservation improvements can also improve housing from a health, safety, and comfort point of view. For example, adding attic insulation or installing new windows not only saves on energy costs, but can also reduce cold drafts in the winter, resulting in a more comfortable living space. Radiator controls allow residents to eliminate the problem of overheating in their apartments without opening the windows, resulting in energy savings as well as a more healthful environment and improved resident comfort. And sealing and insulating duct work not only save on heating and cooling costs, but can also help to improve indoor air quality.

Finally, energy conservation helps protect the environment. Energy conservation reduces the emission of air pollutants and greenhouse gases from electric power plants and from the direct burning of oil, gas, and propane. It also reduces the need to drill and transport oil, decreases the need to build dams for hydropower, and reduces the need for nuclear power plants.

Energy Conservation: Mini Case Study of Capital Improvements and Cost Savings

In 1990, the Housing Authority of Springfield, Massachusetts, entered into an energy performance contract with an energy services company (ESCO) to make conservation improvements in a 96-unit low-rise development. The ESCO performed an energy audit and recommended the following improvements: new gas boilers and hot water heaters, radiator controls, thermostats, and water-saving toilets and shower heads. The ESCO then arranged the financing through a low-interest loan program of the local gas utility and had the equipment installed.

The energy services company guaranteed that these improvements would produce energy savings of at least 33 percent, and it projected that savings would be 41 percent. The actual savings have been about 45 percent, or over $47,000 per year. In addition, the improvements resulted in water and sewer savings of 17 percent, or about $6,500, for overall energy and water savings of about $54,000 per year. Part of the savings is used to repay the loan that financed the improvements, and another portion is used to pay a management fee to the energy services company. Of the remaining amount, the housing authority keeps about $10,000 per year, half of which is to be spent on programs specifically for the residents, for the life of the 12-year loan.

1.3 How This Workbook Is Organized

The workbook is organized into two primary parts.

Part One provides essential background information and context and presents key concepts related to energy conservation. Chapter 2 focuses on the context for energy conservation, while Chapter 3 helps you understand key energy conservation concepts.

Part Two provides guidance in the process of assessing energy conservation opportunities. Chapter 4 guides you through a survey of a development's building systems and equipment, and Chapter 5 guides you through the process of collecting and organizing energy consumption data. Chapter 6 offers a primer on proper operations and maintenance, along with a comprehensive checklist of operations and maintenance items. Chapter 7 leads you through an analysis of various conservation options, and Chapter 8 allows you to summarize results from this analysis.

This workbook also includes appendices that provide information that should be useful to HAs considering energy conservation improvements:

Appendix A	contains climate data that you will need in completing the survey in Chapter 4.
Appendix B	is a glossary of energy-related terms used throughout this workbook.
Appendix C	is a list of helpful resource organizations that you may want to consult for additional assistance.
Appendix D	is a bibliography of literature cited in this workbook.

1.4 The Process for Making Energy Conservation Improvements, and How This Workbook Can Be Used in This Process

The process for making energy conservation improvements has several steps. This workbook is designed to provide guidance for each step of the process. If your HA has multiple developments, you may wish to obtain and complete one copy of this workbook for each development or type of development.

> **Step 1:** ***Understanding the context of energy conservation.*** Before beginning an energy conservation program, HA staff need to understand the context in which energy conservation improvements are made. Chapter 2 provides background information on such topics as elements of a good energy management program, options for funding improvements, knowing when and how to hire a consultant or contractor, and the importance of involving residents in energy conservation efforts.

Step 2: ***Understanding key energy-related concepts.*** In order to assess energy conservation opportunities, HA staff need to have an understanding of key energy conservation concepts. Chapter 3 explains such concepts as cost-effectiveness, simple payback, interactions between energy conservation measures, and how to determine which developments have the greatest energy-saving potential.

Step 3: ***Surveying energy-related equipment and systems.*** Information about your development's existing equipment and systems is necessary for an assessment of energy-saving opportunities. Chapter 4 guides you through a "walkthrough" survey of a development's physical characteristics, including the condition of buildings and energy-related equipment. Your development's architectural, mechanical, and electrical drawings as well as any previous energy surveys or reports should be useful in completing this step. Information gathered by HA staff in completing the survey will be used in evaluating individual energy conservation measures in Chapter 7.

Step 4: ***Surveying current energy usage.*** A survey of current energy consumption is also necessary for an assessment of energy-saving opportunities. Chapter 5 provides guidance in examining current electricity, gas, oil or other fuel, and water/sewer consumption. To complete this step, you will need to obtain utility records for the past three years for all utilities used in the development. As is the case with the building system/equipment survey, information gathered in completing this survey will be used in evaluating individual energy conservation measures in Chapter 7.

Step 5: ***Checking energy-related operations and maintenance.*** Operations and maintenance (O&M) plays a very important role in energy conservation. Many simple O&M actions can result in significant energy savings at little or no cost. In addition, proper O&M is essential for ensuring that new energy-efficient equipment performs satisfactorily and lasts as long as expected. Chapter 6 highlights the importance of proper O&M and offers a checklist of O&M items for use by HA maintenance staff.

Step 6: ***Assessing energy conservation opportunities.*** After surveying a building's systems and equipment, analyzing current energy use, and recognizing potential savings from improved operations and maintenance, you are ready to assess individual Energy Conservation Measures (ECMs). Chapter 7 provides a catalog of ECMs, grouped into the following categories: Architectural, Heating and Cooling, Domestic Hot Water, Lighting, Miscellaneous, and Additional ECMs to Consider. Each ECM includes a description that helps you decide if the ECM is applicable to one of your developments. If so, you can evaluate whether a particular ECM would be cost-effective for a particular development by completing the cost/benefit worksheet. You will need to obtain cost estimates for ECMs from local contractors to complete the cost/benefit worksheets.

Step 7: ***Summarizing results.*** Once you have completed an assessment of individual ECMs, the results can be summarized and examined. Chapter 8 allows you to summarize results in a summary table.

CHAPTER 2: THE CONTEXT FOR ENERGY CONSERVATION

Before embarking on an energy conservation program, HA staff should understand the context in which energy conservation improvements are made. This chapter provides information on the following topics to help you better understand the context for energy conservation:

- Elements of a good energy management program
- Key "points of entry"
- Financing options
- Getting the lowest cost energy supply
- When to hire a consultant or contractor
- The importance of involving the residents

2.1 Considering the Elements of a Good Energy Management Program

In order to successfully reduce energy costs, HAs should consider the basic elements of a sound energy management program.[1] These elements include: clear objectives and goals for reducing energy use; management commitment to saving energy; a system to monitor energy use and compare it to a goal or standard; and ongoing training/education for management, maintenance, and residents.

> ***Clear objectives and goals.*** Specific, measurable, and achievable goals and objectives for energy conservation are the cornerstone of a successful energy management program. Setting these specific goals and objectives requires familiarity with a development's potential for energy savings. This workbook is designed to aid HA staff in developing these goals and objectives.
>
> ***Management commitment to saving energy.*** The success of an energy management program depends on a strong commitment by management, including the highest level of management. It is a good idea to designate a single HA staff person to have overall responsibility for managing the program. In general, the larger a housing authority is, the more complex energy management will be, and the greater the need for a designated energy manager (U.S. Office of the Inspector General 1995). Management should work to ensure that maintenance staff, which have considerable control over energy usage, are also committed to energy conservation.

---

[1] Adapted from Kennedy et al. (1994).

Energy monitoring system. In order to estimate potential savings and plan energy conservation improvements, an HA (or a hired consultant) needs to analyze current energy use. In addition, the performance of energy conservation improvements can be measured only by tracking energy costs and consumption before and after installation. A system of monitoring energy use, preferably a computer database, is helpful in both cases.

Ongoing training/education. The designated energy manager should receive periodic training about saving energy. In addition, the maintenance staff should be trained in the operation and maintenance of any new equipment or systems installed during an energy conservation program. Finally, residents should be involved in any energy conservation efforts through an energy education program. Resident energy education is discussed in more detail later in this chapter.

2.2 Recognizing Key "Points of Entry"

There are several ways in which your HA can make energy conservation improvements. This section addresses those key "points of entry" which present opportunities for saving energy. These points of entry include: equipment replacement, appliance procurement, and significant renovations to units. And, of course, energy conservation improvements can be made on a stand-alone basis, apart from any particular point of entry.

Equipment replacement. A significant energy-saving opportunity is presented whenever energy-related equipment, such as windows, boilers, furnaces, or hot water heaters, is in need of replacement. By selecting energy-efficient models, your HA can realize significant energy savings. Good timing can help produce additional energy savings. For example, by sealing air leaks, adding insulation and/or installing new windows *before* purchasing a new boiler or furnace, you may be able to purchase a smaller, less expensive heating system because these improvements decrease the amount of heat needed. Also, in many cases, it makes sense to replace old, inefficient equipment before it stops functioning because of the energy savings that can be realized.

Appliance procurement. Every HA purchases appliances such as refrigerators, clothes washers, clothes dryers, and stoves, typically in bulk from a particular distributor. Considerable energy savings can result by taking energy efficiency into consideration when making procurement decisions. For example, the most efficient refrigerators, or "super-efficient" refrigerators, are 13 to 30 percent more efficient than other refrigerators, and their price is competitive with the least expensive models available when purchased in bulk. Efficient front-loading clothes washers, also known as "horizontal axis" clothes washers, currently cost more than top-loading machines but use 25 percent less gas or electricity and 50 percent less water. And because of their easy access, they also make it easy to comply with the American Disabilities Act

(ADA) requirements. For information about volume purchasing of these and other efficient appliances, contact the Consortium for Energy Efficiency, the Federal Energy Management Program (FEMP), or the Energy Star Program (see List of Resource Organizations in Appendix C).

Renovation of units. Some types of renovation present unique opportunities for energy conservation. For example, if the siding on a building is being replaced, this presents a good opportunity to install wall insulation at low cost. And if the roof on a flat-roof building is being replaced, roof insulation can be added relatively inexpensively. (Substantial rehabilitation and new construction, which are not covered in the scope of this workbook, also present significant energy-saving opportunities. Please refer to HUD's Rehabilitation Energy Guidelines, listed in Appendix D.)

2.3 Understanding the Financing Options

There are several ways in which energy conservation improvements can be funded. The most common funding sources include: HUD funding; utility or weatherization program funds; and private financing.

Generally, when an HA makes energy conservation improvements, it can retain for its own use 50 percent of any cost savings from reduced utility consumption (Oak Ridge National Laboratory 1992). The amount of the savings is based on the use of a three-year rolling base of actual consumption. That is, every year the savings are determined by comparing that year's consumption to the rolling base, which is the average of the previous three years' consumption. However, if your HA enters into an energy performance contract, it can "freeze" the rolling base and may retain up to 100 percent of the savings from the improvements, net of loan repayment, for the life of the loan (see "Energy Performance Contracting" later in this section).

HUD Funds

Historically, the most significant source of funding for energy conservation in public housing has been modernization funds. HAs with at least 250 units receive modernization funding through the Comprehensive Grant Program, while smaller HAs compete for funding under the Comprehensive Improvement Assistance Program (CIAP).

In addition to Comprehensive Grant Program and CIAP funds, HAs may use other sources of HUD funding for energy

Using CIAP Funding for Energy Conservation: Mini Case Study

The Housing Authority of Truth-or-Consequences, New Mexico, has made considerable energy conservation improvements using CIAP funding. With three rounds of CIAP funds, the HA has been able to make comprehensive energy conservation improvements to its 100 units. These improvements include storm doors, double-pane windows, caulking and weatherstripping, new gas heating and hot water systems, showerheads and faucet aerators, lighting improvements, and new refrigerators. The HA also converted the master-metered gas to individual meters.

conservation, such as Community Development Block Grant (CDBG) funding through the local government, or HOPE VI funds. In addition, the use of operating funds may be appropriate for some low-cost improvements.

Utility Program Funding

Another potential source of energy conservation funds is the local gas, electric, or water utility company. Local utilities may provide funding for energy conservation because they are required to do so by regulators, because they want to avoid having to build expensive new plants to meet demand, or because they are competing with other utilities.

There are several types of utility conservation programs, sometimes called "demand-side management" or "DSM" programs. Depending on the program, the utility may provide free energy audits, rebates for the purchase of energy-efficient materials or equipment, direct installation of energy conservation measures, and/or financing for the purchase of energy conservation measures. Some utilities offer programs for multifamily buildings, and a few utilities have offered programs especially for public housing. In some cases, utility loan programs can be incorporated into an energy performance contract. Financing for efficiency improvements by utility companies or their non-regulated subsidiaries is well-suited to the add-on method, which allows the HA an additional operating subsidy to cover debt service costs. (See section on private financing later in this chapter.)

The availability and type of utility funding depends on the individual utility company and varies greatly from region to region. In many areas, electric and gas utilities are competing against each other for customers and will provide large incentives to HAs to keep them from switching to the other source of energy or

Utility Program Funding: Mini Case Studies

Water Utility Program Funding. The Housing Authority of the City of Los Angeles obtained, at no cost, about 7,000 water-efficient toilets from the local water utility company. The housing authority had to pay only installation costs, which were about $25 per unit. As a result of this and other water conservation efforts, the housing authority reduced its water consumption by about 19 percent between 1986 and 1991, resulting in savings of about $852,000 (U.S. Office of the Inspector General 1995).

Electric Utility Program Funding. After having an engineering study done, the Housing Authority of Macon, Georgia, decided to make comprehensive energy improvements to McAfee Towers, a 200-unit high-rise building for the elderly. The old through-the-wall heating/cooling units were failing at a rate of about 20 percent per year, resulting in high maintenance and replacement costs. The building's thick masonry walls kept it hot in the summer and cold in the winter, making it necessary to supplement the heat with electric resistance heating. Overall, the building was very expensive to heat and cool, and it was uncomfortable for the residents.

Before making any improvements, the housing authority approached the local electric utility for energy conservation program funding. Georgia Power paid $17,200 toward the installation cost of air-source heat pumps to provide heating and cooling, or about nine percent of the overall cost of the heat pump installation. The HA also installed new windows, exterior thermal insulation, and fluorescent lighting in the dwelling units and common areas. The improvements have reduced energy costs by over 30 percent, the building is more comfortable, and maintenance and replacement costs for dwelling unit heating systems have been dramatically reduced.

to entice them to switch over from the other source. In some states, the electric utility industry is undergoing a process of deregulation, which is likely to affect the type of conservation programs being offered. HAs should check with their local utility to determine what types of programs, if any, are available.

Weatherization Program Funding

Under the U.S. Department of Energy's Weatherization Assistance Program (WAP), local weatherization agencies, called "community action agencies" or "weatherization agencies" provide energy conservation services to low-income housing. The program is limited to low-income households, defined as having incomes below 150 percent of the federal poverty level. In order for an entire apartment building to be weatherized using WAP funding, at least two-thirds of the residents must qualify as low-income households. Typical energy conservation measures include: air sealing, storm windows, replacement windows, attic insulation, water-efficient showerheads and faucet aerators, and tune-up of heating equipment.

Private Financing through an Energy Performance Contract or the "Add-On" Method

HAs can make energy efficiency improvements with no up-front capital through the mechanism of an energy performance contract. An energy performance contract is an agreement with an energy services company, or ESCO. Under an energy performance contract, the ESCO performs an energy audit, recommends specific energy efficiency measures, provides financing or arranges financing from a third party, oversees the installation of the measures, and provides long-term services such as monitoring of energy use, training of maintenance staff, and energy education for residents. Typically, the ESCO guarantees that a certain level of savings will be realized, thus shifting risk from the HA to the ESCO.

Private Financing through an Energy Performance Contractor: Mini Case Study

The Housing Authority of Fall River, Massachusetts, financed a large-scale energy improvement project with private capital through an energy performance contract. The HA hired an energy services company (ESCO) to make comprehensive energy efficiency improvements. After performing an energy audit of seven developments, including both low-rise and high-rise buildings, the ESCO recommended specific energy conservation measures, including new high-efficiency heating and hot water systems, replacement windows, thermostats, and water-efficient toilets, at a cost of $2.1 million. The firm then issued a request for proposals from private financial institutions to provide the financing. Five proposals were received, and one firm was selected to provide financing under an 8-year tax-exempt lease (loan) agreement with the HA at an interest rate of 7.75 percent.

Projected savings from the improvements are 18 percent of gas and 14 percent of water, or about $450,000 per year and $3.8 million over the loan period. About three quarters of this amount will go to repay the loan which paid for the improvements. The remainder will be allocated to the HA, which will pay the ESCO an annual fee for ongoing services such as monitoring of savings and resident energy education. So far, actual cost savings have been in line with projections.

Energy performance contracts are appropriate for comprehensive energy improvements and are generally most feasible for developments that have annual utility consumption in excess of $200,000 and potential energy savings of at least 20 percent. Using an energy performance contract, an HA can retain 100 percent of the savings, net of debt service and payments to the contractor for the life of the loan, which can be up to 12 years.[2] At least 50 percent of the savings must be used for repayment of the loan. The length of the loan period is dependent on the number of years it takes to pay back the loan using at least 50 percent of the savings for debt payments. The savings are determined by monitoring energy consumption and comparing each year's consumption to a "frozen" three-year rolling base. The three-year rolling base is "frozen" before the improvements are made, and each year the savings are determined by comparing that year's consumption to this frozen three-year base.

Another conservation incentive under the performance funding system is the "additional operating subsidy" or "add-on" method. This incentive allows the obligation of an additional operating subsidy as an "add-on" to pay for the amortization cost of energy improvements financed through a loan. With this method, the rolling base is not frozen; instead, the savings are calculated using the difference in energy usage of the old and new equipment or appliances. This method is most appropriate for measures such as refrigerator replacements or lighting upgrades, because the savings are easily calculated. It is particularly well-suited for financing by utility companies, their non-regulated subsidiaries, and other lenders.

If your HA is interested in either type of performance contracting, you should contact your local HUD office and refer to the publication *Energy Performance Contracting Guide for Public and Indian Housing* (Oak Ridge National Laboratory 1992) for more information (see Appendix D, Bibliography). Another good resource is the National Center for Appropriate Technology's (NCAT's) Multifamily Housing Project and Clearinghouse, a HUD-funded project that provides technical assistance to HAs free of charge (see list of resource organizations in Appendix C).

2.4 Getting the Lowest Cost Energy Supply

Energy conservation enables HAs to save on their energy costs by reducing the amount of energy used. Your HA can also save on energy costs by making sure it is getting its energy at the best price possible. There are two basic ways your HA can ensure it is getting the lowest cost energy supply. First, you should ensure that the rates your developments are being charged are as low as possible and that there are no avoidable charges. Second, deregulation in the gas and (in some areas) electricity markets may provide larger HAs leverage to negotiate lower rates with their utility company or seek less expensive alternative supplies.

---

[2] Refer to Performance Funding System (PFS) regulations in 24 CFR 990.

Ensuring rates and charges are as low as possible. HAs can often reduce utility costs simply by ensuring that the rates are as low as possible and that there are no avoidable charges. The first step is to understand how to read the bill. Guidance in reading your utility bills is provided in Chapter 5, and the utility company can also provide assistance. The next step is to review energy and water bills regularly. In reviewing bills, HA staff should check for the following: billing errors; late charges; demand-related charges; large changes in consumption which may be due to incorrect meter readings or leaks; whether your HA is on the lowest rate possible; and unnecessary or avoidable charges. If the bills show high demand charges, you may be able to reduce those charges through load-shedding controls (see ECM No. 41). Your HA should also check with the electric utility to determine if it is being charged for "low power factor," and if so, what steps it recommends to correct the problem and eliminate the charge (see ECM No. 40). Finally, you should ask the electric utility if it offers lower rates for electricity used during certain "off-peak" hours. If so, you may be able to shift some electricity consumption to off-peak hours using controls (see ECM No. 23).

Choosing the least expensive energy supply. HAs are encouraged to explore opportunities for purchasing less expensive electricity or gas supplies. In some cases, it may make sense to switch to a less expensive fuel type for heat and hot water. For example, in many areas, gas is inexpensive compared to electricity. In addition, the deregulation of the gas industry in the early 1990s has made it possible to purchase gas directly from the pipeline, called "transport gas" or "wellhead gas," with the local gas company responsible only for delivery to the customer. Energy conservation incentives described earlier in this chapter in the context of energy performance contracting also apply to the purchase of transport gas.[3]

The electric utility industry is undergoing a similar process of deregulation in some states, creating potential opportunities for HAs to obtain less expensive

Transport Gas, Brokered Power, and Reduced Billing Errors: Mini Case Study

The Chicago Housing Authority (CHA) was able to save millions of dollars in energy costs by obtaining cheaper energy supplies and by finding utility billing errors. The CHA negotiated a transport gas contract to obtain gas supplies at a cheaper price and initiated a process of storing gas when rates are high and purchasing gas when rates are low. This process has resulted in savings of over $30 million since 1993. In addition, through periodic utility bill audits, the energy manager discovered over half a million dollars worth of erroneous utility charges, which the housing authority then recovered. Most recently, the CHA initiated a request-for-proposals for electricity supplies from independent power brokers. A contract was awarded to Wisconsin Electric, which will provide electricity at $0.03 per kilowatt-hour (KWH), a savings of over 50 percent from their current supplier, which had been charging $0.075 per KWH.

---

[3] Refer to PFS regulations in 24 CFR 990.

electricity. As relatively large customers, many HAs already have or will have the option of obtaining cheaper electricity called "brokered power" from new, independent electricity providers. The local electric utility, eager to retain its large customers, may be open to negotiations with your HA to lower its rates or provide additional, value-added services such as energy conservation assistance and/or financing. HAs may even have the opportunity to influence the process of deregulation in their states by participating in public hearings or through direct dialogue with the local utility company.

2.5 Knowing When to Hire a Consultant/Contractor

The level of technical expertise among staff varies from housing authority to housing authority. Many HAs have staff with the technical expertise to install certain energy conservation measures, but even these HAs should consider seeking the expertise of a qualified professional in some cases. An HA should consider hiring a consultant or contractor in the following situations: when complex systems are involved or complicated procedures are required; when the HA is contemplating the installation of more than a few simple measures; and when the HA is considering an energy performance contract. The most appropriate type of consultant or contractor depends on the situation.

Complex systems or complicated procedures are involved. Although this workbook is intended to provide guidance in evaluating energy conservation opportunities, many conservation measures involve complex systems or complicated procedures. The following types of measures should be installed with the assistance of an experienced professional: measures that involve the operation or replacement of the heating or hot water system; complicated procedures such as air leakage reduction and duct sealing; and complicated lighting or electrical improvements. Other measures not listed here may also require the assistance of a qualified contractor. Contractors should have demonstrated expertise in the relevant area, for example, heating systems or lighting systems.

More than a few measures are being contemplated. When more than a few measures are being considered, the HA should be aware that interactions among the measures may increase the level of complexity. In addition, it is important to understand that the savings from more than one related measure will not necessarily be the total of the savings from the measures if they had been installed individually (see Chapter 3). Whenever more than a few measures are being contemplated, you may wish to seek the assistance of a qualified consultant to help assess energy conservation opportunities and set energy conservation goals.

Energy performance contracting is being considered. As described earlier in this chapter, an energy performance contract allows the HA to use private capital to finance energy efficiency improvements and retain 100 percent of savings each year, net of loan payments and fees for the life of the loan (up to 12 years). An energy performance contract is an agreement with an energy services company (ESCO) under which the ESCO typically provides an energy audit, specification of recommended energy improvements, arrangement of financing, installation of improvements, and post-installation services such as monitoring of savings and resident energy education.

To hire an ESCO, the HA prepares a "request for proposals" which it sends to qualified ESCOs. Sometimes a "request for qualifications" is sent out before the request for proposals to narrow the field of candidates. Before soliciting an ESCO, some HAs hire a consultant to provide guidance in setting energy conservation goals, determining whether an energy performance contract would be beneficial for the HA, and, if so, preparing a request for proposals and selecting an ESCO.

2.6 Appreciating the Role of the Residents

The residents play a key role in energy conservation. Resident cooperation in an energy conservation effort can help boost energy savings. By the same token, if residents do not accept certain energy conservation measures or understand their proper operation, energy savings can suffer. For these reasons, any energy conservation effort should involve the residents through a resident energy education program. In addition, HAs with master-metered utilities should consider installing checkmeters or switching to resident-paid utilities to increase resident responsibility for energy use (see ECM No. 37, Install Checkmetering or Individual Meters).

Before starting an energy education program, the HA should understand a few basic principles of comfort and behavior:

Comfort. Comfort is affected by physiological factors, such as temperature, drafts, clothing, and a person’s metabolic rate. For example, a room at 72 degrees F may feel cold in the winter if there is a cold draft coming from the window frame, if the resident is wearing light-weight clothing, or if the resident has a slow metabolism, as many elderly people do. Comfort is also affected by sociological and cultural factors. A person who is accustomed to living in a tropical climate may be less comfortable in that 72-degree F room than someone from Alaska.

Behavior. Human behavior is affected by preferences, habit, lifestyle, values, and knowledge and understanding. Resident behavior that results in high energy or water use may be due to any combination of these. It is important to recognize that one resident may use more energy than another, without being wasteful, simply because he or she has a different but equally legitimate lifestyle. For example, a resident who stays home with children may use more energy than the neighbor who works all day.

The elements of a sound resident energy education program include the following:

Designated resident energy education coordinator. This person should understand the basics of comfort and behavior outlined above and should have good communication skills. The coordinator should strive for effective two-way communication and mutual trust and respect with the residents. Ideally, the coordinator should speak the language(s) spoken by residents if a large portion of the residents do not understand English. If your HA is making improvements using an energy performance contract, the energy services company may provide a coordinator.

Resident meeting before improvements are made. Before any energy conservation measures are installed, the resident energy education coordinator should hold a meeting with the residents to describe planned improvements, explain why the improvements are being made, and focus on the benefits to residents. The residents should be notified of when the improvements will be made and how the installation process may affect them, such as temporary heat, water, or electricity shut-offs, contractors requiring access to the apartments, or noise from construction. In addition, the coordinator should explain how to operate any new equipment that will be installed in the dwelling units, such as thermostats, storm windows, or radiator controls. The coordinator should then help the residents recognize the ways in which they can help save energy and water without sacrificing comfort, such as turning off lights while not in use. If a large portion of residents do not understand English, the coordinator (or a translator) should translate the information.

Periodic workshops with the residents after the improvements. The coordinator should hold periodic workshops, at least annually, to encourage residents to

**Resident Energy Education:
Mini Case Study**

The Housing Authority of Springfield, Massachusetts, hired an energy services company (ESCO) to make conservation improvements under an energy performance contract. Before the improvements were made, ESCO's resident energy education coordinator met with the residents in an interactive workshop. She explained when and why the changes were occurring and how they would affect the residents, and she demonstrated how to operate the new thermostats. The coordinator stressed the direct and indirect benefits to the residents, such as the elimination of overheating, increased resident control over the temperature in their apartments, and reduced energy costs which would allow the HA to improve the development in other ways. She then gave them tips on how they could do their share in saving energy.

After the improvements were installed, the coordinator held energy education workshops twice a year to reinforce energy conservation habits, to report on the level of savings from the improvements, and to get feedback from the residents about their comfort and energy habits. She provided refreshments and a "door prize" to encourage attendance. She also recruited an energetic resident "Site Champion" to increase attendance, to translate the material into Spanish, and to champion energy conservation in the development.

adopt energy-conserving habits. Creative use of written or visual materials may prove helpful. (For example, the Macon Housing Authority of Macon, Georgia, involves residents in its energy conservation efforts through its "Beat the Heat Bingo" and "Wheel of Energy" games.) Because of the turnover of residents and the benefit of repetition, the coordinator should also reiterate what improvements were made and why, and how they benefit the residents. If known, the coordinator should communicate to the residents the level of savings from the energy conservation improvements. Again, if a large portion of residents do not understand English, a translator should be present.

Incentives for the residents. In master-metered buildings, residents have little incentive to save energy or water. Creating such incentives can help encourage energy conserving behavior. For example, the Housing Authority of Danbury, Connecticut, set up a Resident Program Fund when it entered into an energy performance contract with an energy services company. Every year, a certain percentage of the energy savings goes into this fund. The fund has been substantial enough to pay for playground improvements, locked mailboxes, doorbells, permit parking, and new house numbers for the apartments. By highlighting the fact that the improvements are paid for out of energy savings and by involving the residents in the process of deciding what to purchase, the coordinator and the HA have made the most use of this fund as an incentive.

CHAPTER 3: KEY ENERGY CONSERVATION CONCEPTS

In order to be able to assess energy conservation opportunities, or to oversee effectively a hired contractor consultant, HA staff should be familiar with several key energy conservation concepts. This chapter explains these concepts to better equip HA staff in any energy conservation effort:

- **What is an energy conservation measure?**
- **Payback and cost-effectiveness**
- **Principle of "savings follow waste"**
- **Interactivity among energy conservation measures**

In addition to these concepts, there are a number of key terms commonly used in talking about energy conservation. The terms and their definitions, as used in this workbook, are provided in Appendix B.

3.1 What Is an Energy Conservation Measure (ECM)?

An energy conservation measure, or ECM, is a modification to a building or its energy-using systems or equipment that has the potential to save energy in that building. ECMs are sometimes called "energy efficiency measures" or simply "measures."

Chapter 7 presents a catalog of ECMs grouped into six categories: *Architectural*, *Heating and Cooling*, *Domestic Hot Water*, *Lighting*, *Miscellaneous*, and *Additional ECMs to Consider*. For each ECM, information about the measure’s applicability, cost range, typical levels of savings that can be expected, maintenance issues, and other points to consider is provided. For all ECMs except those in the "Additional ECMs to Consider" category, a cost/ benefit worksheet is included to allow the reader to estimate the level of energy savings and to determine whether that ECM is likely to be "cost-effective" for a particular development. (Note: The concept of cost-effectiveness is discussed in the next section.)

These ECMs are considered to be widely applicable to public housing. However, this catalog should not be considered exhaustive, as other energy conservation measures not included in the workbook may be appropriate for some HAs.

3.2 Understanding Payback and Cost-Effectiveness

Payback and cost-effectiveness are the main criteria for judging whether an ECM should be installed, and they are central to the use of this workbook. Therefore, it is important that you understand them.

Payback period. The "payback period" or "payback" of an ECM is the number of years it takes for the energy cost savings generated by the ECM to equal or exceed the cost of purchasing and installing the measure. In other words, the payback is the number of years it takes for the ECM to pay for itself. For example, if it takes five years for the savings from an ECM to cover the cost of installation, then the payback of that ECM is five years. The cost/benefit calculation worksheet provided for each ECM in Chapter 7 will help you estimate the simple payback period for that particular ECM.

In this workbook, a simple payback is used, which does not factor in the costs of financing or the effects of inflation and does not take into account any changes in maintenance costs that may result from the installation of an energy conservation measure. Because the purpose of this workbook is to provide ***preliminary*** estimates of cost-effectiveness, the simple payback method is used. For some ECMs, more thorough analysis of cost-effectiveness should be performed by a trained professional before the measure is installed. Prior to replacing any major utility system, a Life-Cycle Cost Analysis (LCCA) should be performed (refer to *HUD Life-Cycle Cost Analysis for Utility Combinations*, in the bibliography in Appendix D). (See text box on LCCA in Chapter 7.)

Cost-effectiveness. An ECM is considered cost-effective if its payback period is less than a given time frame. Generally, this time frame is fifteen years. Therefore, for the purposes of this workbook, any ECM with a payback of fifteen years or less is considered to be cost-effective, as long as the payback is less than the useful life of the ECM.

The Simple Payback Method

This workbook uses the simple payback method for calculating cost-effectiveness. In addition to the simple payback method, there are other, more sophisticated methods for calculating cost-effectiveness. Some approaches take into account the effects of inflation, interest on borrowed funds, maintenance costs, repair costs, and other costs. Because this workbook is intended to provide a first screening of ECMs for cost-effectiveness, the simple payback method is appropriate for its purposes.

You should note that if a performance contract is used, several measures may be considered together, with a single payback for the whole package of measures. When a performance contract is used, the maximum loan period is twelve years, so the payback for the package of measures must also be twelve years or less (Oak Ridge National Laboratory 1992).

It is important to note that the actual payback and cost-effectiveness of an energy conservation measure will depend on the performance of the measure, which can be affected by interactions with other measures (see discussion later in this chapter), level of maintenance, quality of manufacturing, and, in some cases, resident acceptance of the measure.

3.3 Applying the Principle of "Savings Follow Waste"

Conservation measures produce energy savings by reducing energy waste. The more energy waste that is occurring in a building, the greater potential for energy savings. So developments that waste more energy are likely to be better targets for energy savings. In other words, "savings follow waste."

HAs should keep the "savings follow waste" principle in mind when setting energy conservation priorities. Developments that have the most energy waste should be targeted first for energy conservation efforts. The most energy-wasteful developments are generally those that have the highest per-dwelling unit energy consumption.

3.4 Recognizing Interactivity among Energy Conservation Measures

It is important that HA staff understand that the performance and cost-effectiveness of an energy conservation measure can be affected by the installation of other measures. There are three key points to remember when thinking about interactions among energy conservation measures:

> ***When more than one measure is installed, the total energy savings will not necessarily be the sum of the savings from the measures if they had been installed individually.*** For example, if installing efficient lighting in common areas would save 20 percent on the electricity bill and lighting controls would save 15 percent, the actual electricity savings from the installation of both measures will be somewhat less than 35 percent (the sum of the savings if installed individually). This is because both measures reduce energy waste, and in doing so reduce the amount of potential savings from the other measure (see the discussion of "savings follow waste" above).
>
> ***Some measures can affect the performance of other measures.*** For example, if an HA makes improvements to the building envelope, such as adding attic insulation and new windows, it reduces the building's need for heat in the winter and cooling in the summer. Therefore, if the HA is considering replacing the heating or cooling system, it may be able to install a smaller, less expensive system because of the reduced need for heating or cooling. By the same token, if an HA installs new windows in a building that has a heating system without any controls, the windows may not save any energy because the residents feel compelled to open them to relieve overheating. In such a case, installing appropriate heating system controls would make the windows more effective because they would stay closed.
>
> ***A non-cost-effective measure may be appropriate to install when packaged with other measures.*** In some cases, it can be cost-effective to install measures with paybacks longer than fifteen years when they are part of a larger package of measures.

When several measures are installed at once, they can be financed as a package with a single payback. This is common with energy performance contracts (see Chapter 2). Because the package includes some measures with short payback periods, measures with longer paybacks can also be included, and the overall payback of the package is still acceptable.

CHAPTER 4: BUILDING/SYSTEMS SURVEY: THE "WALKTHROUGH"

Introduction

Before you can determine the applicability and cost effectiveness of any of the ECMs presented in Chapter 7, you will need to collect some basic information about your development. This information is collected in the Building/Systems Survey, or "Walkthrough" Survey, presented in this chapter. Familiarity with the development and its systems is the most important tool that you will need to complete this survey. This familiarity combined with a thorough tour of the development should enable you to complete most of the questions. For some items, you may need to refer to the development's architectural or mechanical drawings. If your HA has a capital improvement plan or recent energy audit, these can be used to help complete the Walkthrough.

The survey was designed specifically to assist you in assessing the applicability and cost effectiveness of each ECM. To this end, most of the questions in the survey are directly related to one or more of the ECMs. (You will note that after many survey questions, a specific ECM is indicated in brackets and italics.)

A separate survey should be completed for each development. For developments that have more than one building type or that have different types of energy systems in different buildings, a separate survey should be completed for each building or system type.

Materials Needed. To thoroughly complete the survey, you will need a calculator, tape measure, and an architectural scale. In addition, you should have access to a complete set of the architectural or mechanical drawings of your development.

Completing the Survey. Begin the survey by answering as many questions as possible using information readily available from site staff and from the architectural or mechanical drawings. Then proceed with the actual walkthrough of your development. Because not all of the questions are applicable to every development, you may want to write in "NA" next to those questions that do not apply to your development. Please refer to Appendix B for a glossary containing the definitions of many of the technical terms that are used in this survey.

It is important to note that all of the questions in the survey refer to the entire development, rather than one specific building. Therefore, for those questions that require quantities or measurements, you should total the figures for one of the buildings and multiply that sum by the number of buildings at the site. However, if your development consists of buildings of several different types (e.g., high-rise buildings and single-family homes, or buildings with central heating systems and buildings with individual heating systems, or very old and very new buildings), you should divide your development by building type and complete a separate survey for each type.

Accuracy of Answers. Without accurate and thorough responses to each of the questions on the survey, it will be difficult to determine which of the ECMs are most relevant for your development. Given this, however, there are still some shortcuts that you can take without jeopardizing the results. For example, if your development consists of five high-rise buildings of a similar construction type, you could calculate or measure the quantities for one of the buildings and then multiply this figure by the number of similar buildings to obtain the total measurement or quantity for the development.

Organization of the Survey Questions. The survey is divided into the following sections:

- General Development Data
- Architectural Data
- Heating and Cooling Systems Data
- Domestic Hot Water System/Water Supply Systems Data
- Lighting Systems Data
- Miscellaneous Data

WALKTHROUGH SURVEY

General Development Data

Development Identification

4-1. Development ID number: ________________

4-2. Development name: ____

4-3. Development address: ____

4-4. Name of person responsible for completing this survey: ____________________________

4-5. Contact person's telephone number: (______) ______ - _____________

Location and Climate

4-6. City: ____

4-7. State: __________

Complete questions 4-8 and 4-9 with information from Appendix A, Climate Data. If your development's specific location is not listed, use data for the closest city listed.

4-8. Heating degree day zone *[ECMs No. 1-8, 13]*: . . . . ______ DDZ

4-9. Heating season hours *[ECM No. 14]*: . . . . ______ Hrs

Building Types and Quantities

4-10. Residential building types (check off applicable building type, then answer all further questions under that type):

☐ Single or twin-family houses
Number of single-family houses: . . . . ______
Number of twin-family houses: . . . . ______

☐ Low-rise multifamily buildings (4 stories or less)
Number of buildings: . . . . ______
Number of stories: . . . . ______

☐ High-rise multifamily buildings (5 stories or more)
Number of buildings: . . . . ______
Number of stories: . . . . ______

4-11. Non-residential building types (i.e., separate structures used as office space, community rooms, laundry facilities, mechanical room, etc.)

☐ Number of buildings: . . . . ______
☐ Number of stories: . . . . ______

4-12. Total number of buildings in your development: . . . . ______

Development Size

4-13. Number of dwelling units in development

Number of 0-1 bedroom units: . . . . ______
Number of 2-3 bedroom units: . . . . ______
Number of 4+ bedroom units: . . . . ______
Total number of dwelling units *[ECMs No. 26, 33]*: . . . ______

4-14. Total number of residents in development *[ECMs No. 21, 22, 23, 25]*:

______

4-15. Average number of residents per dwelling unit (divide total number of residents by total number of dwelling units) *[ECM No. 4]*:

Total Residents ______ / Total Units ______ = ______

Architectural Data

Development Size

4-16. Total floor area of all floors in the development (if more than one building, add all buildings):

______ square feet

4-17 Total development volume (total area in question 4-16 times typical floor-to-ceiling height, usually 8.0 feet) *[ECMs No. 1, 2, 8]*:

______ cubic feet

Windows

4-18 Window area (total for entire development) *[ECMs No. 1, 2]*:

______ square feet

4-19. Window panes (typical or predominant type) *[ECM No. 2]*:

- ☐ Single-pane
- ☐ Double-pane
- ☐ Triple-pane

4-20. Window frame material *[ECM No. 1]*:

- ☐ Wood
- ☐ Metal
- ☐ Vinyl
- ☐ Fiberglass

4-21. Typical window fit (check off predominant condition) *[ECMs No. 1, 2]*:

- ☐ Loose (frame rattles, large air gaps, large drafts)
- ☐ Average (some looseness, no large gaps, no large drafts)
- ☐ Tight (no excessive frame movement or drafts)

4-22. Are the windows equipped with storm windows? *[ECM No. 1]*:

☐ Yes ☐ No

4-23. Are windows and/or storm windows weatherstripped adequately? *[ECMs No. 1, 2]*

☐ Yes ☐ No

4-24. Are office and community spaces in the development air-conditioned? *[ECM No. 3]*

☐ Yes ☐ No

Complete questions 4-25 through 4-27 only for office and community spaces that are air-conditioned. Proceed to question 4-28 if there are no air-conditioned spaces in your development.

4-25. Window area (in air-conditioned office and community spaces only) *[ECM No. 3]*:

South-facing windows only: . . . . ______ square feet
East and west-facing windows only: . . . . ______ square feet

4-26. Are windows in office and community areas well shaded (i.e., 50% of summer daylight hours, 50% of their area) by trees or vegetation? *[ECM No. 3]*:

☐ Yes ☐ No

4-27. Are windows in office and community areas equipped with exterior shades, interior blinds or tinted glass? *[ECM No. 3]*:

☐ Yes ☐ No

Exterior Doors

4-28. Total number of exterior doors in your development *[ECM No. 4]*:

______ doors

4-29. Typical exterior door fit (check off predominant condition) *[ECM No. 4]*:

☐ Loose (large drafts)
☐ Average (no excessive drafts)
☐ Tight (no drafts)

4-30. Are exterior doors adequately weatherstripped? *[ECM No. 4]*:

☐ Yes ☐ No

4-31. Are exterior doors equipped with storm doors? *[ECM No. 4]*:

☐ Yes ☐ No

4-32. Predominant door type (inspect doors, door labels, or construction specifications) *[ECM No. 4]*:

☐ Wood
Specify wood door thickness: ______ inches
☐ Metal (energy conserving type - insulated steel)
☐ Metal (standard type - hollow steel)

Attics and Flat Roofs

4-33. Does the development have attics or flat roofs on the buildings? *[ECMs No. 5, 6]*

☐ Attics (i.e., roofs with crawl space or full attics underneath)
☐ Flat roofs (i.e., flat or nearly flat roofs with no attic or crawl space underneath)

If you checked off "attics" answer questions 4-34 and 4-35. If you checked off "flat roofs" answer questions 4-36 and 4-37.

4-34. Area of attic (assume it is equal to the floor area of the top floor) *[ECM No. 5]*:

______ square feet

4-35. Attic insulation type and level, i.e., depth (measure typical insulation thickness and enter below; round off to nearest inch) *[ECM No. 5]*:

- ☐ Batt fiberglass
- ☐ Dry cellulose
- ☐ Loose fill fiberglass

______ inches

4-36. Area of flat roof (assume that it is equal to the total floor area of the top floor of the building) *[ECM No. 6]*:

______ square feet

4-37. Type of existing flat roof structure (check whether insulated or uninsulated; if uninsulated also check structure type) *[ECM No. 6]*:

- ☐ Insulated
- ☐ Uninsulated
  - ☐ Wood structure
  - ☐ Concrete structure
  - ☐ Steel structure

Walls

4-38. Wall construction, size and insulation (check off whether insulated or uninsulated; for uninsulated construction also check structure and siding type) *[ECM No. 7]*:

- ☐ Insulated construction
- ☐ Uninsulated construction
  - ☐ Wood frame with wood siding
  - ☐ Wood frame with aluminum siding
  - ☐ Wood frame with brick siding
  - ☐ Wood frame with other siding
  - ☐ Concrete block masonry wall
  - ☐ Brick masonry wall
  - ☐ Other masonry wall construction

Total area of all uninsulated exterior (not including windows and doors) *[ECM No. 7]*:

______ square feet

Heating and Cooling Systems Data

Heating System & Fuel Type

4-39. Heating system type (check off applicable type):

☐ Individual heating systems
☐ Central heating system

If you checked off "Central heating system," check off system type:

☐ Boiler
☐ Furnace
☐ Other (e.g., heat pump)

4-40. Heating fuel type (check off applicable type):

☐ Electricity
☐ Natural Gas
☐ Heating Oil
☐ Propane

If you checked off "Individual heating systems" in question 4-39, answer questions 4-41 through 4-43. If you checked off "Central heating system" above, answer questions 4-44 through 4-51.

Individual Heating Systems

4-41. Do the heaters have vent dampers or flue dampers (applies only to oil and gas furnaces and boilers)? *[ECMs No. 9, 10]*:

☐ Yes ☐ No

4-42. Do gas heaters have constant-burning pilot lights? *[ECM No. 10]*:

☐ Yes ☐ No

4-43. Are heaters controlled by thermostats? If yes, indicate type *[ECM No. 13]*:

☐ No
☐ Yes
  ☐ Non-setback
  ☐ Setback

Central Heating System

4-44. Does the system have flue dampers or vent dampers (question applies to oil and gas furnaces and boilers only)? *[ECMs No. 9, 10]*:

☐ Yes ☐ No

4-45. Heat distribution type of your central heating system (check off applicable type) *[ECM No. 16]*:

☐ Steam
☐ Hot water
☐ Forced air

4-46. Check off which of the following are used to control heating:

☐ Outdoor reset and cutout controls (boiler systems only) *[ECM No. 11]*
☐ Non-setback thermostats in the dwelling units *[ECM No. 13]*
☐ Setback thermostats in the dwelling units *[ECM No. 13]*
☐ Radiator controls in the dwelling units (boiler system only) *[ECM No. 14]*
Total number of radiators in your development: ______

4-47. Are all or most hot water or steam distribution pipes insulated (question does not apply to forced air distribution systems)? *[ECM No. 15]*

☐ Yes ☐ No

If NO (i.e., pipes are not insulated), answer question 4-48.

4-48. Measure or estimate from engineering drawings total linear feet lengths of uninsulated pipes. For each diameter of pipe, multiply the average length by the number of pipes. Measure different diameter pipes separately. *[ECM No. 15]*

Linear feet of uninsulated pipes (do not include pipes that are in heated areas such as dwelling units) *[ECM No. 15]*:

3/4" diameter pipe: . . . . ______ linear feet
1" diameter pipe: . . . . ______ linear feet
1-1/2" diameter pipe: . . . . ______ linear feet
2" diameter pipe: . . . . ______ linear feet
3" diameter pipe: . . . . ______ linear feet
4" diameter pipe: . . . . ______ linear feet
6" diameter pipe: . . . . ______ linear feet

Combustion Efficiency Test for Central Boilers and Furnaces

To properly estimate energy savings for replacing a central heating system, a combustion efficiency test must be performed on the existing central boilers or furnaces. (Note: Combustion efficiency is not the same as Annual Fuel Usage Efficiency, or AFUE. Please refer to the Glossary in Appendix B.) A combustion efficiency test determines how completely the fuel is burned in the boiler or furnace by measuring the oxygen or carbon dioxide concentration in the flue gas. Combustion efficiency tests should be performed only on large central boilers or furnaces, not on boilers or furnaces for individual units. A qualified technician, familiar with combustion efficiency test procedures should conduct the test. The test should be conducted during the heating season. If these tests are routinely conducted at your development, use the most recent test data (if not more than two years old) to answer the following question:

4-49. What is the existing combustion efficiency of your central boiler or furnace (enter as decimal fraction, e.g.,: 75% = .75) *[ECM No. 12]*:

______

4-50. Is your central boiler or furnace oversized? (i.e., cycles often—as a rough guideline this means that the boiler or furnace starts up more than two times per hour).

☐ Yes ☐ No

Air-Conditioning (AC) Systems

4-51. Do you have air-conditioning in your development to cool community and office areas? *[ECMs No. 19, 20]*:

☐ Yes ☐ No

4-52. Do you have air-conditioning in your development to cool residential units (do not include individual window or wall AC units if they are owned and installed by the residents)? *[ECMs No. 19, 20]*:

☐ Yes ☐ No

4-53. Does the HA pay for the fuel consumption for residential air conditioning?

☐ Yes ☐ No

If you answered YES to question 4-53, proceed to questions 4-54 through 4-56. If NO, proceed to 4-57.

4-54. Air-conditioning system type and number of units *[ECMs No. 19, 20]*:

☐ Individual window or wall units: ____ units
☐ Central system: ____ units

4-55. Power requirement of typical existing unit or system (read equipment labels, literature, or engineering specification drawings) *[ECMs No. 19, 20]*:

Typical ranges:

Window or wall AC units:	500-5,000 watts
Central AC unit:	2,000-10,000 watts
Chiller:	10,000-1,400,000 watts

______ Watts

4-56. Cooling capacity of typical existing unit or system (read equipment labels, literature or engineering specification drawings) (Note: One ton of cooling capacity = 12,000 Btu) *[ECMs No. 19, 20]*:

Typical ranges:

Window or wall AC units:	5,000-30,000 Btu
Central AC unit:	20,000-60,000 Btu
Chiller:	60,000-12,000,000 Btu

______ Btu

Domestic Hot Water (DHW) System/Water Supply Systems Data

Hot Water Heater Fuel and Type

4-57. Does the development have DHW tanks? *[ECMs No. 22, 23]*:

☐ Yes ☐ No

4-58. Are the DHW tanks insulated? (Note: Most newer hot water heaters have adequate insulation built into the design, but may not look "wrapped.") *[ECMs No. 22, 23]*:

☐ Yes ☐ No

4-59. Water heater type (check off applicable type) *[ECM No. 25]*:

☐ Individual tank water heater
☐ Central DHW heater

4-60. Water heater fuel type:

☐ Heating oil
☐ Natural gas
☐ Electricity
☐ Propane

Water Supply Systems

4-61. Do you have low-flow faucet aerators and shower heads installed on all or most faucets and showers? *[ECM No. 21]*:

☐ Yes ☐ No

4-62. How is proper water pressure maintained in your development? *[ECM No. 36]*:

☐ Roof-mounted storage tank
☐ From street mains (no tanks and no pumps)
☐ Pressurizing pump system (booster pumps)

Total horsepower of existing booster pumps (read pump labels or engineering drawings) *[ECM No. 36]*:

______ horsepower

4-63. Have water-saving toilets been installed in your development? *[ECM No. 35]*:

☐ Yes ☐ No

Central Laundry Facilities

4-64. Do you have central public laundry facilities as part of your development? *[ECM No. 24]*:

☐ Yes ☐ No

4-65. Total number of washing machines *[ECM No. 24]*: ______

4-66. Are washing machines restricted to cold water rinse only? *[ECM No. 24]*:

☐ Yes ☐ No

Lighting Systems Data

Residential Unit Lighting

4-67. Type of lighting in residential units (check off predominant fixture type in each of the following spaces) *[ECM No. 26]*:

Kitchen:
- ☐ Fluorescent
- ☐ Incandescent

Bathroom:
- ☐ Fluorescent
- ☐ Incandescent

Hallway/Foyer:
- ☐ Fluorescent
- ☐ Incandescent

Common Area Lighting

Common areas include offices, community rooms, lobbies, corridors, hallways and stairways in both public and basement floors. All questions refer to "general lighting" only; do not include "task lighting" such as desk lamps, etc.

4-68. Is there incandescent lighting in the common areas? *[ECMs No. 27, 28, 29, 30]*:

☐ Yes ☐ No

If YES, answer questions 4-69 and 4-70. If NO, proceed to question 4-71.

4-69. Total number of incandescent fixtures (common areas only)* *[ECM No. 27]*:

______

* To obtain total number of incandescent fixtures in the common areas select one building that is representative of the buildings on the site, count the number of fixtures in the basement, at the ground floor, and at the typical floor. Multiply the number of fixtures at the typical floor by the number of floors in the building. Add this figure to the number of fixtures located in the basement and the ground floor to obtain the total number of fixtures in the building. Multiply this total building figure by the number of buildings on the site.

4-70. Average watts per incandescent lighting fixture (e.g., 50, 75, or 100 watts) *[ECM No. 27]*:

______ Watts

4-71. Is there fluorescent lighting in the common areas? *[ECMs No. 27, 28, 29, 30]*:

☐ Yes ☐ No

If YES, answer questions 4-72 through 4-75. If NO, proceed to question 4-76.

4-72. Type of fixture (check off predominant type of fixture in common areas) *[ECMs No. 28, 29]*:

☐ 2 tubes/4 feet long
☐ 2 tubes/8 feet long
☐ 4 tubes/4 feet long
☐ 4 tubes/8 feet long
☐ 6 tubes/4 feet long
☐ 8 tubes/4 feet long
☐ Other

4-73. Are the fluorescent lamps "energy-conserving" lamps (e.g., General Electric's Watt-Miser, Osram Sylvania's SuperSaver, Philips Econ-o-Watts, and Duro-Test's Watt-Saver)? *[ECM No. 28]*:

☐ Yes ☐ No

4-74. Are the ballasts electronic? (Note: As a general rule, if the lighting has not been updated, the ballasts are not electronic.) *[ECM No. 29]*:

☐ Yes ☐ No

4-75. Total number of fluorescent fixtures in the development (common areas only) *[ECMs No. 28, 29]*

______

Complete the following questions (4-76 through 4-78) for office areas only. Do not answer the questions if there are no office or management spaces in your development or if the offices are windowless or all "general lighting" is incandescent.

4-76. Are lights located near the windows routinely turned off during the daytime hours? *[ECM No. 30]*:

☐ Yes ☐ No

4-77. Number of fluorescent fixtures within 10 feet of the windows (office areas only) *[ECM No. 30]*:

______

4-78. Type of predominant fluorescent fixture within 10 feet of windows in office areas *[ECM No. 30]*:

- ☐ 2 tubes/4 feet long
- ☐ 2 tubes/8 feet long
- ☐ 4 tubes/4 feet long
- ☐ 4 tubes/8 feet long
- ☐ 6 tubes/4 feet long
- ☐ 8 tubes/4 feet long

Exterior Lighting

4-79. Predominant type of exterior lighting fixture (check off applicable type) *[ECM No. 31]*:

- ☐ None (no exterior lighting)
- ☐ Sodium vapor lamps (high or low-pressure)
- ☐ Mercury vapor lamps
- ☐ Metal halide lamps
- ☐ Incandescent lamps
- ☐ Fluorescent lamps
- ☐ Halogen lamps

4-80. Number of exterior lighting fixtures *[ECMs No. 31, 32]*: ______

4-81. Energy consumption (watts) per predominant exterior lighting fixture type (i.e, per fixture unit) *[ECMs No. 31, 32]*:

______ Watts

4-82. Who pays for exterior lighting electricity? *[ECMs No. 31, 32]*:

- ☐ Housing Authority
- ☐ Local town or city government

4-83. Type of exterior lighting controllers (check off applicable type) *[ECM No. 32]*:

- ☐ Manual switching (no controls)
- ☐ Timers
- ☐ Photo-controls

If you checked Manual Switching or Timers on question 4-83, go to question 4-84. Otherwise, skip to question 4-85.

4-84. Number of hours per year exterior lighting is turned on* *[ECM No. 32]*:

______ Hrs/yr

* Estimate annual hours by multiplying average daily hours of use (hours between turning on and off) by 365 days. Adjust for weekend and seasonal variations, if necessary.

Miscellaneous Data

4-85. Average age and size of existing refrigerators (check off predominant age and size of existing refrigerators in your development) *[ECM No. 33]*:

☐ 1970s
☐ 1980s
☐ 1990s or newer

☐ 13 cubic feet or smaller
☐ 14-15 cubic feet
☐ 16 cubic feet or larger

4-86. Type of motors that could be operating fans or pumps at your development (check off applicable type) *[ECM No. 34]*:

☐ Elevator
☐ Ventilation system
☐ Hydronic heating or cooling system

4-87. Predominant size of motor for each of the above systems *[ECM No. 34]*:

Elevator . . . . ______ horsepower
Ventilation system . . . . ______ horsepower
Hydronic heating or cooling system . . . . ______ horsepower

4-88. Number of motors of each type *[ECM No. 34]*:

______ Elevator
______ Ventilation system
______ Hydronic heating or cooling system

4-89. Average operating hours per year of each motor *[ECM No. 34]*:

Elevator . . . . ______ Hrs/yr
Ventilation system . . . . ______ Hrs/yr
Hydronic heating or cooling system . . . . ______ Hrs/yr

CHAPTER 5: ENERGY CONSUMPTION SURVEY

Introduction

This chapter will guide you through the process of surveying utility consumption data for your development. This data will be used in Chapter 7 to analyze the cost-effectiveness of various energy conservation measures (ECMs) for your development. The local utility company should be a useful resource in providing some of the information needed in this section. To complete this survey, please complete the following steps:

- ***Determine which services or "end uses" are provided by each fuel type***. End uses include heating, lighting, domestic hot water, cooking, etc. This information will be used to complete Table 1.

- ***Determine the metering arrangement for each fuel type***. Utilities can be master-metered, master-metered with checkmeters, or individually metered. This information will be used to complete Table 2.

- ***Collect all the utility bills for your development for the past three years***. This includes bills for gas, electricity, oil, and propane, as well as your development's water and sewer bills. Assistance is provided in this chapter to help guide you through this process.

- ***Read the utility bills***. Guidance is provided in this chapter to help you understand how to read the utility bills.

- ***Determine the average annual cost for each utility***. For each utility, you will determine the average annual cost by multiplying the average annual consumption by its average price.

- ***Determine the energy consumption used for heating***. This information will be used to evaluate the cost-effectiveness of the heating ECMs. This chapter provides a chart to help you determine the amount of energy used for heating, depending on the type of fuel used for heating.

A separate survey should be completed for each development. For developments that have more than one building type or that have different types of energy systems in different buildings, a separate survey should be completed for each building or system type.

ENERGY CONSUMPTION SURVEY

Table 1: End Uses

For each of the following end uses, check off the relevant fuel type:

End Use	Electricity	Natural Gas	Oil	Propane
Heating				
Cooling			▨	▨
Ventilation		▨	▨	▨
Lighting		▨	▨	▨
Site lighting		▨	▨	▨
Domestic hot water				
Cooking (range/oven)			▨	
Electric appliances		▨	▨	▨
Elevators		▨	▨	▨
Water supply pumps		▨	▨	▨
Central laundry (heating of water)				
Miscellaneous (air pumps, fans, vents, etc)		▨	▨	▨

Table 2: Metering Arrangement, or "Who Pays the Bills?"

For each fuel type, check off the metering arrangement/method of payment used:

Fuel Type	Master-metered (HA pays utility directly)	Master-metered with a checkmeter (HA pays utility directly but monitors residents' consumption via checkmeters)	Individually metered (resident pays utility directly)
Electricity			
Natural Gas			
Oil			
Propane			

Collecting the Utility Bills

The bills for each utility need to be collected to complete the energy consumption survey. These bills may include the bills for gas, electricity, oil, propane, as well as your development's water and sewer bills. If the utilities are master-metered, these bills should be used for the survey, even if the HA has checkmeters. If the utilities are individually metered (i.e., residents are billed directly by the utility), you will need to obtain the residents' billing records from the utility company. To do this, you will need to have each resident sign a release form so that the utility can release the resident's records to you. This release form can be obtained from the utility company.

Reading and Understanding the Utility Bills

In order to read the utility bills, you need to be familiar with the terms used on each bill. Below are some terms that may appear on your utility bills:

> ***Total Current Amount***. The total amount being charged for this billing period.
>
> ***Interest Charge***. Interest that is charged to previous outstanding balances.
>
> ***Customer Charge***. An administrative charge from the utility to cover the costs of billing and providing service to the customer.
>
> ***Total Account Balance***. The Total Current Amount plus any outstanding or late charges.
>
> ***Account Number***. The number the utility uses to track the meters and billing information.
>
> ***Meter Number***. A number that helps the utility know which meter is installed in the building.
>
> ***Estimated Read***. Indicates that the utility did not actually read the meter to calculate the amount of energy or water that has been consumed since the last reading. Instead, the utility has estimated the consumption based on previous use and standards set by the utility.
>
> ***Actual Read***. Indicates that the utility examined the meter and calculated the exact amount of energy or water that was used since the last time the meter was read.

Your Electricity Bill

Electricity bills tend to contain a lot of information, but the most important piece of information needed for the purposes of this workbook is the number of kilowatt-hours (kWh) used during that billing period. This is usually listed on your bill as "kWh Usage" or "kilowatt-hours Used."

To obtain the annual consumption for any given year for your development, the kWh consumption from each bill for that year for the development should be added together. On the table on the following page, complete this step for the most current three years, total the annual consumption for each of the three years, and then divide this figure by three to calculate the average annual kWh consumption.

In addition to total kilowatt-hours, the bill contains additional pieces of important and relevant information:

> ***Demand Charge***. The demand charge is the charge found on the bills of multifamily and commercial buildings that is based on the maximum amount of power required by that building at any single time during a billing period. For instance, if everyone in a building turned on all of their electric appliances at the same time, even for just a few minutes, the building would require a certain amount of power from the utility. The amount of power required (demand) is independent of the number of minutes or hours the appliances are on. Demand is shown in terms of kilowatts (kW) rather than in kilowatt-hours (kWh). If your development has high demand charges, you may want to consider the "Install Load Shedding Controls" ECM (ECM No. 41), as described in Chapter 7.
>
> ***Low Power Factor Surcharge***. Power factor is the ratio of the power delivered to a building, as measured by the meter, to the actual power required by electrical equipment. Certain electronic devices such as fluorescent lighting, electric motors, transformers, and other inductive devices have low power factors. Many utilities impose a low power factor surcharge when a customer’s power factor is lower than a certain level. If your development is being charged for low power factor, you may want to consider the "Correct Low Power Factor" ECM (ECM No. 40), as described in Chapter 7.
>
> ***Peak and Off-Peak Rates***. Some utilities charge different rates for electricity consumed at different times of day. Peak rates are charged when the utility has the highest demand on its system, while off-peak rates are charged when the demand is lower. These rates are also called "time-of-use" rates. These different rates will be charged and reflected on the bill only if the development has special time-of-use meters installed. If your utility offers time-of-use rates, you may want to consider the "Install DHW Off-Peak Controls" ECM (ECM No. 23), as described in Chapter 7.

5-1. Electricity Consumption

Year (most recent 3 years)	**Annual Consumption (kWh/yr)**
19___	
19___	
19___	
Total (add all three years) ______kWh	
Average annual consumption (total/ 3 years) _____ kWh/yr	
Average current price of electricity* _____ $/kWh	
Average annual cost of electricity consumption: (____ kWh/yr) x (____ $/kWh) = ____ $/yr	

* For the current price of electricity, refer to the development's current bills or contact the utility company. Also, when referring to the utility bills, remember that the price of electricity often changes seasonally and even hourly. The rates for this table should represent the ***current average annual rates***, including any surcharges.

Rate Structure for Electricity: Charges Beyond kWh Consumption

5-2 Demand charges (shown in terms of kW, not kWh)

☐ No demand charges levied by utility

☐ Charges included in bill

Average annual demand charge amount (above normal kWh charges): $______

Explain demand structure: ____

____

5-3 Time-of-day or time-of-use charges, also known as "peak" and "off-peak" rates charges (i.e., different electricity rates at different times of day):

Are time-of-day meters installed in the development?

☐ Yes ☐ No

If NO, does your utility offer time-of-day charges?

☐ Yes ☐ No

5-4 If the answer to either question in 5-3 is YES, what are the time-of-day charges? *[ECM No. 23]*

Lowest rate charged? _____ $/kWh

Highest rate charged? _____ $/kWh

Describe time-of-day charge structure (i.e., lowest and highest cost time periods, etc.)

____

____

5-5 Low power factor surcharges *[ECM No. 40]*

☐ No low power factor charges levied by utility:

☐ Charges included in bill:

Average annual low power factor charge amount: ____________ $/yr

Describe low power factor charge structure: ______________________________

____

Your Natural Gas Bill

The amount of gas consumed during any billing period is usually listed under the "Gas Used" or "Current Gas Usage" section of the bill. Usage is usually recorded in therms or hundred cubic feet (CCF), which are roughly equivalent. For this survey, usage should be in therms. If the consumption is listed in cubic feet (CF), simply divide the number by 100 to convert it into therms.[1]

To obtain the annual consumption for any given year, the therms from each bill for that year should be added together. On the table on the following page, complete this step for the most recent three years, total the annual consumption for each of the three years, and then divide this figure by three to calculate the average annual gas consumption.

If your bill includes transportation charges (i.e., charges related to the costs of the infrastructure used to transport the gas from the supply source to the HA), include these charges in the total annual cost of gas consumption.

---

[1] Depending on the quality of the gas, one CCF (100 CF) may actually be slightly more than one therm. For the purposes of this guidebook, we assume that one CCF is equivalent to one therm. However, the local gas provider can tell you the factor for converting usage in CCF or CF into therms, if greater precision is desired.

5-6. Natural Gas Consumption

Year (most recent 3 years)	**Annual Consumption (Therms/yr)**
19___	
19___	
19___	
Total (add all three years) ______Therms	
Average annual consumption (total/ 3 years) _____ Therms/yr	
Average current price of natural gas* _____ $/Therm	
Average annual cost of natural gas consumption: (____ Therms/yr) x (____ $/Therm) = ____ $/yr	

* If the current price of natural gas is metered in cubic feet, divide by 100 to change to therms.

Your Oil or Propane Bill

The key piece of information that you need from your oil or propane bills is the number of gallons delivered and the current cost per gallon. Bills are based on the amount of oil or propane delivered, rather than the amount used. Over the course of a year, however, these two amounts are roughly equivalent.

To determine the total consumption for a given year, the gallons listed on each bill should be added together. On the table(s) on the following page, complete this step for the most recent three years, total the annual consumption for each of the three years, and then divide this figure by three to calculate the average annual oil or propane consumption.

For the average current price per gallon of oil or propane, simply determine the average price charged during the most recent year.

5-7. Oil Consumption

Year (most recent 3 years)	**Annual Consumption (Gal/yr)**
19___	
19___	
19___	

Total (add all three years) ______Gal

Average annual consumption (total/ 3 years) _____ Gal/yr

Average current price of heating oil _____ $/Gal

Average annual cost of heating oil consumption:

(____ Gal/yr) x (____ $/Gal) = ____ $/yr

5-8. Propane Consumption

Year (most recent 3 years)	**Annual Consumption (Gal/yr)**
19___	
19___	
19___	

Total (add all three years) ______ Gal

Average annual consumption (total/ 3 years) _____ Gal/yr

Average current price of fuel _____ $/Gal

Average annual cost of fuel consumption:

(____ Gal/yr) x (____ $/Gal) = ____ $/yr

Summary of Fuel Uses and Costs

Use the table below to summarize the results of your entries and calculations made in questions 5-1, 5-6, 5-7, and 5-8. Complete the table only for those fuel types that are used in your development.

5-9. Summary of Fuel Consumption

Fuel Type	**Average Annual Fuel Consumption**	**Current Cost per Fuel or Energy Unit**
Electricity	____ kWh/yr	____ $/kWh
Natural Gas	____ Therms/yr	____ $/Therm
Heating Oil	____ Gal/yr	____ $/Gal
Propane	____ Gal/yr	____ $/Gal

Your Water/Sewer Bill

A water/sewer utility charges its customers based on the amount of water consumed during a billing period and on the amount of water that goes through the sewer system. Because the utility does not have any way of measuring the amount of water that actually goes into the sewer system, it estimates this amount. In some cases, water utilities charge less for sewer in the summer because they assume more of the water is used for irrigation and, therefore, never goes into the sewer system.

Your water bill may show consumption in gallons, cubic feet (CF), or hundred cubic feet (CCF or HCF). However, the most important piece of information on the water/sewer bill is the total amount charged for water, and the total amount charged for sewer. To determine the average amount charged for water, add the water charges for the most recent three years and divide the total by three. Do the same for the sewer charges.

Water and Sewer Charges *[ECM No. 35]*

5-10. Water Charges

Year (most recent 3 years)	**Annual Water Charges ($/yr)**
19___	
19___	
19___	
Total (add all three years): $_________________	
Average annual cost of water consumption (total/3 years): $ ___________	

5-11. Sewer Charges

Year (most recent 3 years)	**Annual Sewer Charges ($/yr)**
19___	
19___	
19___	
Total (add all three years): $_________________	
Average annual cost of sewer charges (total/3 years): $ ___________	

Calculating Annual Heating Use

Calculations for Heating ECMs require that the quantity of fuel used exclusively for heating be determined. For example, in addition to gas being used to heat a development, it may also be used for heating domestic hot water or for cooking. By providing responses to the following items, you will be able to separate heating use from other uses of a particular fuel.

Complete only the items that refer to the type of fuel that is used for heating your development. Please also note that different methods are used for electrically and non-electrically heated developments. Use only the method that applies to your development.

Electrically Heated Developments Only

A. Transfer the following information that you have previously obtained in the Walkthrough and Energy Consumption Surveys:

Heating Degree Day Zone for your development (question 4-8): _____ DDZ

Average annual kWh consumption (question 5-9): _________ kWh/yr

B. Circle the appropriate conversion factor for Heating Degree Day Zone in the table below:

Degree Day Zone (DDZ)	**Conversion Factor**
2 or less	.35
2.1 - 4	.50
4.1 - 6	.65
6.1 - 8	.75

C. Calculate total electricity used for heating in your development by multiplying the average annual kWh consumption by the appropriate conversion factor:

5-12. (Annual kWh Consumption ______) x (Conversion Factor ___) = ______ kWh/yr

Non-Electrically Heated Developments Only

If the fuel used for heating your development is gas, oil, or propane, and is used ***only*** for heating and not for other end-uses (e.g., domestic hot water, cooking, clothes dryers), then skip to the table in question 5-14.

If the fuel used for heating your development is gas, oil, or propane, and is also used for other end uses, complete the items below.

A. Transfer the following information that you have previously obtained in the Walkthrough and Energy Consumption surveys:

Number of dwelling units in your development (question 4-13): __________

Average annual fuel consumption (gas, oil, or propane) (question 5-9):

______ Therms/yr OR

______ Gal/yr

B. Circle the appropriate conversion factor for your heating fuel type in the table below:

Fuel Type	**Conversion Factor**
Natural Gas	100 Therms
Heating Oil	43 Gals
Propane	66 Gals

C. Calculate total fuel used for non-heating uses by multiplying the number of dwelling units by the appropriate conversion factor:

(Number of dwelling units ___) x (Conversion Factor ______) = ______/yr

D. Calculate fuel consumed for heating only by subtracting the non-heating fuel use (step C above) from the average annual fuel consumption (step A above); specify fuel units:

5-13. (Average Annual Consumption ______) - (Non-heating Use = ______) = _______/yr

If the fuel used for heating your development is gas, oil, or propane, and is used only for heating, transfer the Average Annual Fuel Consumption from question 5-9 to the table below. Otherwise, transfer the information that you have previously calculated for question 5-12 or 5-13 (depending on whether your development is electrically or non-electrically heated) to the table. (Check off the fuel type used for heating and fill in the annual quantity.)

5-14. Summary of Heating Fuel Consumption

Heating Fuel Type	**Annual Heating Fuel Consumption**
____ Electricity	_____ kWh/yr
____ Gas	_____ Therms/yr
____ Oil	_____ Gal/yr
____ Propane	_____ Gal/yr

CHAPTER 6: THE ROLE OF PROPER OPERATIONS AND MAINTENANCE

The purpose of this chapter is provide you with a guide to operations and maintenance (O&M) of energy-using systems and equipment. It discusses the importance of proper O&M, highlights elements of a good O&M program, and presents a case study of a housing authority that successfully reduced its energy costs through O&M changes. It includes a checklist to guide maintenance staff in ensuring proper operations and maintenance of energy-using equipment.

6.1 The Importance of Operations and Maintenance

Proper O&M is an essential part of any successful energy management program. Often, HAs can save 10 to 25 percent of the energy used in their developments by improving O&M practices at little or no cost. Good O&M practices can save a significant amount of energy with older systems, and such practices help ensure satisfactory performance of new, efficient equipment.

Proper O&M is also important for ensuring system performance and long equipment life. Without good O&M practices, equipment is more likely to break down. This can cause a temporary lack of services such as heat and hot water, resulting in resident discomfort and possible health and safety problems. Equipment failure can also result in high repair or replacement costs that could have been avoided with better O&M practices.

6.2 Key Elements of a Good O&M Program

A good O&M program includes several elements, as described below.

- ***Equipment information.*** Maintenance staff should have all manufacturer's instructions and manuals available in an accessible location. They should be used when operating equipment or performing maintenance. In addition, maintenance staff should have available a master equipment list that describes the equipment, what its purpose is, how it should be operated, and what its maintenance requirements are.

- ***Routine maintenance and operations checks.*** Maintenance staff should routinely check equipment and systems for proper operation and control settings and perform preventative maintenance on a routine basis. The Checklist in this chapter is intended to provide a guide to this process. Equipment manuals and instructions should also be used when available. It is a good idea for maintenance staff to make and follow a schedule of O&M items to make sure operations checks and maintenance procedures are performed with the recommended frequency.

- ***Record keeping.*** All O&M checks and procedures should be recorded in an O&M log available to all maintenance staff. This practice will help ensure that all necessary O&M items are performed and that they are not duplicated by more than one maintenance staff person. It also provides a record for management.

- ***Training.*** Maintenance staff should be trained to operate and maintain equipment. When new systems are installed, you should make sure the maintenance staff receives training to properly operate and maintain the equipment. This may be provided by the vendor or manufacturer. In some cases, such as when a complicated heating system or energy management system is installed, you may want to consider a maintenance contract for that equipment.

- ***Accountability.*** Maintenance staff should be accountable for ensuring proper O&M. It is generally recommended that a single maintenance staff person or engineer be given overall responsibility for the O&M program. Having a single person in charge helps create an incentive for good O&M and it generally results in a better-run O&M program. In larger HAs, it may be more appropriate to divide responsibility among more than one person.

O&M Improvements: Mini Case Study

The Rochester Housing Authority (RHA) in New York provides a good example of how a comprehensive operations and maintenance program can lower energy costs in public housing. Since the mid-1980s, the RHA has significantly reduced the total energy consumption in some buildings through O&M improvements and by adding inexpensive controls to the boilers.

The O&M improvements that saved the most energy included running only one boiler at a time in the winter, adjusting burners to reduce stack temperature, and setting the outdoor reset controls at a lower temperature. Also, when a resident would complain of being too cold, maintenance staff would go to that apartment, record the temperature, and see what improvements could be made to enhance comfort before turning up the main heat control. Such improvements might include checking the thermostat operation, checking the steam traps, and sealing sources of infiltration.

Maintenance staff read each utility meter on a weekly basis to provide feedback about any changes made to the heating system. The results are posted each week in the maintenance staff room for everyone to review. Keeping score of the buildings' energy use provides direct accountability for energy consumption in each building and sets clear goals for maintenance staff.

The remainder of this chapter is the O&M Checklist. The Checklist is organized into the following categories: *Architectural*, *Heating and Cooling*, *Domestic Hot Water*, *Lighting*, and *Miscellaneous*. O&M items in the Checklist generally require little if any capital expenditure, but may require increased time by the maintenance staff. As is noted in the Checklist, some O&M items apply only to certain system or equipment types.

You will note that some of the O&M items in the Checklist overlap with energy conservation measures. For example, weatherstripping windows and doors is also mentioned in ECM No. 8, Control Air Leakage.

You should also note the importance of knowing the proper, safe way to perform the recommended O&M items before carrying them out. Always follow manufacturers' instructions and, when in doubt, check with an expert before proceeding.

6.3 Operations and Maintenance Checklist

ARCHITECTURAL

☐ ***Caulk frames and openings.*** Air infiltration can occur around the frames of doors, windows and skylights, resulting in heat loss in the winter and heat gain in the summer. Caulking these areas can save on heating/cooling costs and increase resident comfort. Existing caulking that is cracked or deteriorating should be scraped out and replaced with new caulk.

☐ ***Patch holes in the building envelope.*** Holes in the walls, roof, foundations, doors, and vestibules allow air infiltration, resulting in heat loss in the winter and heat gain in the summer. These holes should be patched to save on heating/cooling costs and to increase resident comfort. Holes should be repaired in accordance with building construction type by qualified personnel.

☐ ***Repair cracked window panes.*** Broken window panes allow air infiltration, resulting in heat loss in the winter and heat gain in the summer. Repairing them will save on heating/cooling costs and increase resident comfort. Broken panes should be repaired only as a temporary measure before the window can be replaced (see ECM No. 2).

☐ ***Weatherstrip windows and doors.*** Weatherstripping reduces infiltration around windows and doors, particularly if storm windows and doors are not present. By helping to keep warm air inside during the winter and cool air inside during the summer, weatherstripping saves energy and increases resident comfort. Flexible rubber or plastic strips can be installed to seal any gap between the edge of an operable window and its sash. In general, weatherstripping should not be installed on windows or doors that will be replaced soon.

☐ ***Put in storm windows and doors at the start of the heating season.*** In developments that have storm windows (see ECM No. 1) and storm doors (see ECM No. 4), maintenance staff should make sure that the proper panels are in place at the beginning of the heating season.

☐ ***Remove unit air conditioners in the winter.*** At the start of winter, air conditioners should be removed to reduce infiltration. If removal is not possible or practical, the air conditioners should be covered with special sleeves.

☐ ***Open and close shades in common areas.*** In the winter, blinds or curtains in common areas such as community rooms, lobbies, and offices should be closed at night to keep warm air inside, and open on sunny days to let the sun's rays help heat the room. In the summer, they should be closed during the day to minimize heat gain.

☐ ***Lower awnings in the summer.*** In developments that have awnings (see ECM No. 3), maintenance staff should make sure they are lowered in the summertime to reduce heat gain.

☐ ***Check automatic door closing mechanisms.*** Automatic door closers on exterior doors should be adjusted so that doors close quickly and completely.

HEATING/COOLING

Heating systems in individual dwelling units

☐ ***Turn off pilot light in summer.*** For gas boilers and furnaces without an electronic ignition, the pilot lights should be shut off at the end of the heating season and relit at the start of the next heating season. During non-heating months, a lit pilot light on a gas furnace, boiler, or space heater is a source of energy waste. Installation of electronic ignition, which automatically shuts off and relights the pilot light according to demand, should be considered (see ECM No. 10).

☐ ***Clean and adjust burners.*** Burners on gas or oil furnaces or boilers should be regularly cleaned and adjusted to ensure maximum efficiency. When burners have clogged openings or are in need of adjustment, they are less efficient. A burner is in need of adjustment if any of the following applies: the flame edge touches the combustion chamber, the tip of the flame is orange, fiery droplets are present in the flame, or there is smoke above the chimney. On oil burners, a microscreen filter added at the burner may reduce the chances of clogging.

☐ ***Change/clean filters on forced-air systems.*** Filters on individual forced-air systems should be changed or cleaned bi-monthly by maintenance staff. Disposable filters should be replaced using a type recommended by the equipment manufacturer, and permanent filters should be cleaned according to manufacturer's instructions. Clean air filters improve the performance of heating systems by removing impurities from the supply air. When the filter is dirty, the fan requires more energy to force air through the clogged filter.

☐ ***Inspect equipment for worn or damaged parts.*** Periodic inspection should be made to identify worn or damaged gaskets, casings, linkages, and other parts of stationary and moving equipment. Worn or broken parts should be repaired or replaced with parts specified by the manufacturer.

☐ ***Lubricate equipment.*** Equipment such as blowers, motors, fans, and bearings should be lubricated on a regular basis, according to the manufacturer's manual and using the lubricant specified. Proper lubrication reduces wear and tear on equipment and enhances its performance.

Central boilers and furnaces

☐ ***Turn off pilot light in summer.*** For gas boilers and furnaces without an electronic ignition, the pilot lights should be shut off at the end of the heating season and relit at the start of the heating season. During non-heating months, a lit pilot light on a gas boiler or furnace is a source of energy waste. Installation of electronic ignition, which automatically shuts off and relights the pilot light according to demand, should be considered (see ECM No. 10).

☐ ***Clean and adjust burners.*** Burners on furnaces and boilers should be regularly cleaned and adjusted to ensure maximum efficiency. When burners have clogged openings or are in need of adjustment, they are less efficient. A burner is in need of adjustment if any of the following applies: the flame edge touches the combustion chamber, the tip of the flame is orange, fiery droplets are present in the flame, or there is smoke above the chimney.

☐ ***Check and adjust fuel-to-air ratios.*** In boilers and furnaces, the fuel-to-air ratio is the proportion of fuel provided to the quantity of combustion air. A qualified maintenance staff person or service person should periodically check this ratio by examining stack temperature and levels of carbon dioxide and oxygen in the flue gases. Too little air causes incomplete combustion, while too much results in excess air being heated and exhausted up the stack. The proper ratio is necessary to achieve maximum efficiency. The ratio can be adjusted using the controls that determine the mixture of air to fuel.

☐ ***Calibrate and adjust controls.*** For boilers and furnaces, controls on the burners should be periodically adjusted to ensure that they are operating correctly. Proper settings can be found in manufacturer's equipment manuals. These controls should also be calibrated (adjusted for accuracy) from time to time.

☐ ***Clean fireside of boiler or furnace.*** In boilers and furnaces, the fireside surface (the side on which combustion occurs) should be cleaned monthly during the heating season. Because soot on the fireside surface acts as an insulator and reduces heat transfer, keeping these surfaces clean can significantly increase boiler or furnace efficiency. The manufacturer's manual should be consulted for recommended cleaning method (for example, with a brush, chemical, or detergent).

- ☐ ***Remove scale buildup on heat exchanger and waterside of boiler.*** The heat exchanger and waterside surface of boilers should be cleaned to remove scale buildup. Scale buildup is formed from minerals in the boiler water. It decreases heat transfer, which reduces boiler efficiency. Removal of scale buildup should be done when the boiler is shut down for maintenance. The boiler water can be chemically treated to reduce future scale buildup if scale buildup is a problem.

- ☐ ***Operate only as many boilers as needed at one time.*** In a multi-boiler installation, only those boilers needed to fulfill heating needs at a given time should be operating. Running backup boilers at night can be avoided with the installation of a remote alarm system that alerts maintenance staff of the need to start up a second boiler to meet heating needs.

- ☐ ***Clean oil strainers.*** For oil-fired boilers and furnaces, oil strainers should be cleaned on a regular basis to maintain proper flow rate of oil to the burner. A clogged oil strainer reduces the flow of fuel oil to the burner, resulting in a fuel-to-air ratio that is too low, causing boiler inefficiency. Damaged oil screens should be replaced.

- ☐ ***Clean nozzle or rotary cup on burner.*** For oil-fired boilers and furnaces, fuel oil must be broken up into a fine mist by a rotary cup or nozzle in order to burn efficiently. If cups are dirty or nozzles are clogged, oil cannot burn efficiently and smoke and soot can result. Burner maintenance instructions should be consulted for guidance in cleaning cups and/or nozzles.

- ☐ ***Preheat fuel oil.*** For oil-fired boilers and furnaces, oil should be preheated to the recommended temperature to ensure the proper viscosity (density) at the burner head. The recommended temperatures are 135 degrees for No. 2 oil, 185 degrees for No. 4 oil, and 210 degrees for No. 6 oil.

Central heating distribution systems

- ☐ ***Reduce thermostat settings in unoccupied areas.*** In unoccupied areas such as storage rooms, boilers rooms, and other unoccupied spaces, the thermostat should be kept at 55 degrees to save energy in the winter.

- ☐ ***Check ductwork for leaks.*** If heating or cooling is provided with forced-hot air distribution, maintenance staff should check ducts for any leaks. Gaps or holes in the ductwork waste a large amount of energy and can result in poor indoor air quality. If ducts have any gaps, holes, or other sources of leakage, they should be cleaned, sealed, and insulated (see ECM No. 17).

☐ ***Keep radiators and hot air registers clean and unobstructed.*** Radiators and hot air registers in dwelling units and common areas should be kept clean and at least a foot away from curtains, sofas, and other objects.

☐ ***Operate vents in hot water radiators and baseboard units.*** On hot water radiators and baseboard units, manual vents should be opened at least once a year at the beginning of the heating season to allow trapped air to escape.

☐ ***Check and repair air vents and steam traps.*** On single-pipe steam systems, vents that are stuck in the closed or open position should be repaired to allow proper operation of radiators. On two-pipe steam systems, steam traps should be checked to ensure that they are operating properly and are not stuck open or shut.

☐ ***Balance steam distribution.*** In many steam-heated multifamily buildings, the worst source of inefficiency is in uneven heating. In order to adequately heat some units, other units have to be overheated, forcing residents to open their windows for relief. If there is an automatic balancing system, the system should be checked and adjusted. If there is not an automatic balancing system, the valves on the steam risers and the air vents on the radiators should be adjusted to control balance.

☐ ***Lower steam pressure.*** In boilers with steam distribution systems, the steam pressure should be reduced to the lowest level required for heating needs. When steam pressure is maintained at a level that is higher than necessary, fuel is wasted. Steam pressure can be reduced by adjusting the pressure control. It should be gradually reduced to the lowest level that will satisfy heating needs in all the dwelling units. During hours of low demand and warm weather, steam pressure can be further reduced.

☐ ***Monitor make-up water consumption.*** In steam heating systems, water must be added periodically. Sudden increases in the make-up water consumption indicate that there are leaks in the system that should be repaired.

☐ ***Replace steam traps.*** Steam traps on radiators in steam-heated buildings should be replaced every five years or so.

☐ ***Check heating elements, controls, and fans on electric distribution systems.*** Electric heating elements, controls, and fans should be checked using manufacturer maintenance instructions. All heater elements, contacts, and terminals should be tight.

Heat Pumps

☐ ***Keep air registers open.*** Air registers that provide heating and cooling to conditioned spaces should be kept in the open position with heat pump systems. Closing or blocking off registers can impair the system's performance.

☐ ***Lubricate fan motors and adjust blowers and drive belts.*** Fan motors should be lubricated and the blower unit and drive belts adjusted according to manufacturer's instructions.

☐ ***Clean coils.*** Indoor heat exchanger coils should be cleaned with a vacuum or brush when dirt builds up. Outdoor coils must be free from shrubs or other items that may impede air flow and should be cleaned periodically with a garden hose.

Cooling

☐ ***Turn off cooling systems in unoccupied common areas.*** Air conditioning should be turned off in unoccupied areas and in office areas after hours.

☐ ***Clean or change air filters.*** Air filters should be cleaned or changed monthly during the cooling season, depending on whether they are disposable. Air filters are located in the air handler, behind the grille of return registers, or adjacent to the blower in the main return air duct. Dirty filters block air flow and decrease cooling efficiency.

☐ ***Clean evaporator coils.*** Evaporator coils should be cleaned every three to five years. Dirty evaporator coils result in inefficient cooling and shorten the life of the blower and compressor. Evaporative coils in packaged air conditioners and window units can be reached by removing an access panel. Coils can be cleaned with a bristle brush to loosen and remove dirt.

☐ ***Clean condenser coils.*** The condenser should be cleaned whenever dirt accumulates. If the condenser gets too dirty, the compressor can burn out. Condensing coils can be cleaned with a bristle brush to remove loose dirt. A garden hose can be used to flush the dirt out from the inside out. Caution should be used to avoid damaging the coils.

☐ ***Clean blower.*** Blowers should be cleaned when dirt accumulates on blower blades because dirt reduces their ability to blow air over the condenser coils. Before cleaning the blower, the power should be shut off to the air conditioner at the circuit breaker or main switch. To access the blower, a plate in the blower housing may need to be removed. The blower can be cleaned with a brush and a vacuum cleaner.

☐ ***Maintain chillers.*** On systems with chillers, any leaks in chilled water piping should be repaired. The temperature of the chilled water should be raised to the highest temperature possible without lowering effectiveness of the chiller.

☐ ***Maintain evaporative coolers.*** On evaporative cooling systems, the damper for the air intake duct should be closed before the heating season and opened for the cooling season. The entire cooling water loop should be cleaned and flushed on a monthly basis to avoid fishy or musty odors. Cooler sumps should be completely emptied at the end of the cooling season to remove sediment and microbial growth. Filters should be cleaned and replaced frequently.

DOMESTIC HOT WATER SYSTEM

☐ ***Lower water temperature.*** Domestic hot water should generally be provided at about 120 degrees F. If water in dwelling units is hotter than 120 degrees, the water temperature can be lowered to save energy. Individual hot water heaters should be set at 120 degrees, while in central systems, the temperature should be adjusted so that 120-degree water is provided to the dwelling units.

☐ ***Repair all leaks.*** Maintenance staff should periodically inspect all apartments and repair leaky faucets. One leaking faucet can waste over 1,000 gallons per year as well as 500,000 Btu necessary to heat it. In addition, staff should inspect the entire distribution system, valves, and pumps.

☐ ***Insulate domestic hot water pipes.*** All domestic hot water circulation pipes should be insulated with one-half inch of insulation to reduce heat loss. Older domestic hot water heater tanks should also be insulated (see ECM No. 22).

☐ ***Turn off domestic hot water supply to areas that do not need it.*** Hot water supplies to areas such as utility rooms, boiler rooms, and other rooms should be turned off. Shut off should occur as near to the hot water heater as possible to reduce piping energy losses.

☐ ***Reduce water pressure.*** In buildings where the water pressure is higher than necessary, a pressure regulator should be installed to reduce pressure to the minimum level required by local code. High water pressure results in high flow rates and water waste. It can also increase wear and tear on plumbing equipment and result in leaks.

☐ ***Flush tank-type water heaters.*** Tank-type water heaters (both gas and electric) should be flushed periodically to remove sediment. The accumulation of sediment on the bottom of the tank results in inefficient operation of the water heater. The water should be drained into a bucket until it runs clear.

☐ ***Clean/adjust burners on gas and oil water heaters.*** Burners on gas- and oil-fired domestic hot water heaters should be cleaned and adjusted annually for maximum combustion efficiency. The buildup of soot or other residue decreases combustion efficiency. If necessary, the flame should be adjusted in accordance with the manufacturer’s manual by qualified staff.

☐ ***Check electrodes on electric water heaters.*** Electrodes on electric water heaters should be checked for scale buildup. Removing scale buildup will increase heat transfer.

LIGHTING

☐ ***De-lamp overlit areas.*** In overlit areas, some fluorescent and/or incandescent lamps should be removed to reduce electricity use. In many areas, illumination levels can be reduced by as much as 50 percent while still satisfying minimum lighting requirements. General guidelines for de-lamping fluorescent lamps are: for two-lamp fixtures, remove one lamp in each fixture or both tubes in alternate fixtures; for three-lamp fixtures, remove the lamp in the middle; for four-lamp fixtures, remove the two middle lamps. Ballasts should be removed from fixtures in which all the tubes have been removed. In four-lamp fixtures, the ballast associated with the two inner tubes should be disconnected. Incandescent lamps can be removed wherever minimum lighting levels can still be maintained without them. Any de-lamping should maintain minimum light levels as required by code and security requirements.

☐ ***Keep energy-efficient lamps in stock for replacement.*** Once efficient lighting is installed, maintenance staff need to ensure that these types of lamps are in stock to avoid re-installation of the less efficient lamps. Where cost-effective, energy-saving fluorescent lamps should replace standard incandescent lamps (see ECM Nos. 26, 27).

☐ ***Clean lighting fixtures.*** Lamps, fixtures, reflectors, and diffusers should be regularly cleaned because dirty lighting fixtures transmit less light, decreasing lighting efficacy. Caution should be exercised when cleaning all electrical fixtures. The current should be turned off before cleaning fixtures, and fixtures should be thoroughly dry before turning the current back on. Wiring and connections should not be disturbed.

☐ ***Clean or paint walls.*** Walls should be kept clean to maximize the brightness of a room. When new paint is needed, a non-glossy white paint should be selected.

☐ ***Check timers on exterior lighting.*** Timers on exterior lighting should be checked to ensure they are set properly and that the time is set correctly.

MISCELLANEOUS

☐ ***Calibrate checkmeters.*** Checkmeters should be reviewed every few years to ensure accuracy. The accuracy can be checked by comparing the consumption from the master meter with the consumption from all of the checkmeters. If they are not the same, then the checkmeters should be re-calibrated (adjusted for accuracy).

☐ ***Check for and repair water leaks.*** Staff should check the distribution lines on the street and the service lines on the property. The valve between the distribution line and the sewer line should also be checked. Residents should be encouraged to report water leaks on faucets, showers, tubs, toilets, or garden hoses. Any water leaks inside or outside the buildings should repaired immediately.

☐ ***Reduce ventilation rates.*** Outside air used for ventilation must be heated in the winter, and, in buildings with air conditioning, cooled in the summer. When the amount of outside air taken into a building exceeds the amount required by code, ventilation rates can be reduced to save energy (see ECM No. 42).

☐ ***Reduce the amount of exhausted air.*** In buildings with an air exhaust system, air that is exhausted must be replaced by the air intake system or by air infiltrating into the building. This air must be heated in the winter, and, in buildings with air conditioning, cooled in the summer. Reducing the amount of exhausted air can save energy by reducing the need to heat or cool this air. The exhaust system should be operated only for short periods at a time, when exhaust needs are greatest (for example, when most residents are cooking). Local codes should be checked for minimum exhaust air requirements. Exhaust air volume should be slightly lower than the amount of air being supplied to the building through mechanical ventilation and natural infiltration.

☐ ***Check refrigerators for proper door closure.*** Refrigerators that do not properly close waste electricity and should be repaired. If repair is not possible, the refrigerator should be replaced.

CHAPTER 7: ENERGY CONSERVATION MEASURES

7.1 Introduction

This chapter presents a catalog of energy conservation measures (ECMs). For each ECM, information about the measure's applicability, cost range, maintenance issues, and additional points to consider is provided. A corresponding cost/benefit worksheet is included for each ECM (except for those ECMs in the "Additional ECMs to Consider" category). By completing the worksheets, you will be able to determine which ECMs may be cost-effective for your development. Instructions for evaluating the ECMs and completing the worksheets are also included in this chapter.

The ECMs are grouped into six categories: Architectural, Heating/Cooling, Domestic Hot Water, Lighting, Miscellaneous, and Additional ECMs to Consider. A summary table listing each ECM may be found at the end of this section.

> ***Architectural ECMs.*** Architectural ECMs are measures that affect the exterior or "envelope" of a building. Architectural ECMs save energy used for heating and/or cooling by helping to reduce the amount of heat needed in the winter and/or cooling needed in the summer. Examples of architectural ECMs include storm windows, replacement windows, window sun shades, storm doors, attic insulation, roof insulation, wall insulation, and air leakage control.
>
> ***Heating/Cooling ECMs.*** Heating/Cooling ECMs are measures that save energy by directly affecting heating or cooling equipment. These measures include ECMs that involve changes directly to the equipment, such as vent dampers, electronic ignition, boiler controls, or replacement of inefficient heating or cooling equipment. They also include measures that regulate the temperature in the dwelling units, such as setback thermostats and radiator controls, as well as improvements to the distribution system, such as insulating hot water or steam pipes, converting a steam distribution system to hot water, and sealing and insulating ducts in a forced air distribution system.
>
> ***Domestic Hot Water ECMs.*** Domestic Hot Water ECMs include measures that save energy used for domestic hot water. ECMs such as hot water tank insulation and replacing inefficient hot water heaters save energy because the water is heated more efficiently. Other ECMs in this category, such as water-efficient showerheads, faucet aerators, and converting clothes washers to cold rinse, save energy by reducing the amount of hot water used. Some of these ECMs also save on water and sewer costs.
>
> ***Lighting ECMs.*** Lighting ECMs save electricity through the installation of more efficient lighting and/or by controlling the operation of lights. Examples of Lighting ECMs include replacing incandescent lights with fluorescent lighting in dwelling units and common areas, installing more efficient lamps and ballasts in common areas,

installing lighting controls in common areas, replacing outdoor lighting with high-efficiency lighting, and installing outdoor lighting controls.

Miscellaneous ECMs. Miscellaneous ECMs include installing efficient refrigerators, upgrading or replacing inefficient motors, installing water-saving toilets, converting water supply pumps to a hydro-pneumatic system, and installing checkmetering or individual metering.

Additional ECMs to Consider. The ECMs included in this category are too important to not include in the workbook, but are not as broadly applicable to public housing as the ECMs included in the other categories. Because of their limited applicability, narratives, but not cost benefit worksheets, are provided for these ECMs. Examples of ECMs in this category include installing summertime DHW heaters, installing load-shedding controls, and installing ventilation controls.

Table 1 provides a complete listing of all of the ECMs included in this workbook.

Table 1: Catalog of Energy Conservation Measures

ECM #	Energy Conservation Measure
Architectural ECMs	
1	Install Storm Windows
2	Install Replacement Windows
3	Install Window Sun Shades
4	Install Storm Doors
5	Install/Increase Attic Insulation
6	Install Roof Insulation
7	Install Wall Insulation
8	Control Air Leakage
Heating and Cooling ECMs	
9	Install Vent Dampers
10	Convert to Electronic Ignition
11	Install Boiler Controls
12	Replace Inefficient Heating Plant
13	Install Setback Thermostats

ECM #	Energy Conservation Measure
14	Install Radiator Controls
15	Insulate Hot Water or Steam Pipes
16	Convert Steam Heating to Hot Water Distribution
17	Seal and Insulate Ducts
18	Install Geothermal Heat Pumps
19	Replace Inefficient Air Conditioners
20	Install Swamp Coolers
Domestic Hot Water System ECMs	
21	Install Water Efficient Showerheads and Faucet Aerators
22	Insulate Hot Water Tanks
23	Install DHW Off-Peak Controls
24	Convert Laundry to Cold Rinse
25	Replace Inefficient Hot Water Heater
Lighting System ECMs	
26	Replace Incandescent Lighting with Compact Fluorescent Lamps in Dwelling Units
27	Replace Incandescent Lighting with Fluorescent Lighting in Common Areas
28	Replace Older Fluorescent Lamps with Energy-Saving Lamps in Common Areas
29	Replace Older Fluorescent Lamps and Ballasts in Common Areas
30	Install Lighting Controls In Common Areas
31	Convert Exterior Lighting Fixtures
32	Install Photo-Controls for Exterior Lighting
Miscellaneous ECMs	
33	Replace Older Refrigerators with High-Efficiency Units
34	Upgrade or Replace Inefficient Motors
35	Install Water-Saving Toilets
36	Convert Water Supply Pumps

ECM #	Energy Conservation Measure
37	Install Checkmetering or Individual Metering
Additional ECMs to Consider	
38	Install Summertime DHW Heaters
39	Convert DHW Systems to Solar
40	Correct Low Power Factor
41	Install Load-Shedding Controls
42	Install Ventilation Controls
43	Install Soil Moisture Sensors
44	Install Direct Use Geothermal System for Heating and Hot Water

7.2 Instructions for Evaluating the ECMs and Completing the Worksheets

Before you start filling out the cost/benefit worksheets, you should complete both the Walkthrough Survey in Chapter 4 and the Energy Consumption Survey in Chapter 5. The information that you collect for these two surveys will be necessary to complete the cost/benefit worksheets.

Next, you should go through all of the ECMs and determine which ECMs are applicable to your development. The applicability is indicated at the top of each ECM. If a particular ECM is not applicable to your development, write "N/A" (not applicable) in the margin and go on to the next ECM.

After determining which ECMs are applicable, you should then read through the description of each of the applicable ECMs. Information about the savings that can be expected from the measure, maintenance issues related to the measure, and other items to consider is provided for each ECM. A symbol at the top of each ECM indicates the cost range associated with that ECM for a typical, 100-unit development: "$" indicates a relatively low-cost ECM, $$ indicates moderate cost, and $$$ indicates a high-cost ECM. (Note: Actual costs will vary depending on the size and type of the development and its systems.)

You are now ready to begin to calculate the simple payback for all applicable ECMs using the cost/benefit worksheets. Each worksheet is organized in a series of steps, which follow the same general pattern:

- Obtain total cost of implementing the ECM
- Transfer survey data from Chapters 4 and 5 needed to complete the calculations
- Calculate energy savings
- Calculate cost savings in terms of dollars
- Calculate payback period

Below, guidance is provided for each of the steps.

Obtain Cost Estimate

The first step on every cost/benefit worksheet is to estimate the cost of purchasing and installing the ECM. Cost estimates should made for the entire development rather than for a single piece of equipment (e.g., obtain the cost for installing storm windows for an entire development or building, rather than the cost of one storm window). If you are planning to implement the ECM without the help of an outside contractor, cost estimates can be obtained by calling a vendor or distributor of the product. If, on the other hand, you will be using a contractor to install or implement the ECM, the contractor should provide estimates that include all labor costs and contract margins.

Transfer Survey Data

In this step on the worksheet, you simply transfer specific pieces of information that you collected in Chapter 4, the Walkthrough Survey, and Chapter 5, the Energy Consumption Survey. The left-hand column of each worksheet indicates from which question in each survey the information can be found. For example, "5-9" means question 5-9 in Chapter 5.

In many of the ECM worksheets, the questions on fuel consumption and cost list more than one possible fuel type. You should select and provide data only for the fuel type that applies to your development and to that particular ECM. For example, Step 2 of the Insulate Hot Water Tank ECM (ECM No. 22) asks for the cost of heating fuel, and provides blanks for gas, oil, electric, or propane. Only fill in the blank for the type of heating fuel that is used at your development.

Calculate Energy Savings

This step uses simple formulas to determine the level of savings in terms of therms, gallons, or kilowatt hours per year. Each box in the formula is labeled with a number, such as "2a" or "2b" or "3". To fill in a box labeled "2a", simply enter the amount found in Step 2a. Similarly, to fill in a box labeled "2b", enter the amount found in Step 2b, and fill in the box labeled "3" with the amount found in Step 3, and so on.

Because the formulas will require you to add, subtract, multiply, or divide, it will be helpful to have a calculator on hand to assist you in calculating the energy savings.

Calculate Cost Savings

This step uses formulas to determine the level of savings in terms of dollars per year. As in the previous step, each box in the formula is labeled with a number (for example "2c" or "4a"). Again, simply fill in the box using the amount found in that step number (for example Step 2c or Step 4a). As with the previous step, it will be helpful to have a calculator on hand to assist you in calculating the cost savings.

Calculate Payback Period

The last step on each of the cost/benefit worksheets estimates the simple payback period. As defined in Chapter 3, the simple payback period is the number of years it takes before the energy savings equal or exceed the cost of implementing the ECM. The payback period is found by dividing the cost of the measure by the annual cost savings. As noted in Chapter 3, a simple payback (which does not factor in changes in maintenance costs, the cost of financing, or other costs) is used because this guidebook is intended to provide ***preliminary*** estimates of cost-effectiveness.

The ECMs with the shortest payback periods are the most economically viable ECMs for your development. All ECMs with paybacks of fifteen years or less are considered to be cost-effective, as long as the payback is less than the useful life of the measure. It should be stressed that the paybacks calculated using the worksheets are only approximations. In some cases, a more detailed analysis of cost-effectiveness should be performed by a trained professional. If a new major system is being considered, a life-cycle cost analysis (LCCA) should be performed (refer to *HUD Life-Cycle Cost Analysis for Utility Combinations* in Appendix D).

Life-Cycle Cost Analysis

HUD requires that a life-cycle cost analysis (LCCA) be performed prior to replacing any major energy system (e.g., a new heating system). The LCCA takes into account costs such as labor, maintenance, repairs, and interest. The LCCA Handbook is listed in the bibliography (Appendix D) for your reference.

The next page provides an example of a completed cost/benefit worksheet.

SAMPLE

Cost/Benefit Worksheet
ECM No. 7: Install Wall Insulation

Step 1 Obtain total cost of installing wall insulation:

29,500 $

Step 2 Transfer the following information from the Survey:

4-8 **a** Heating degree-day zone: 3.67 DDZ

4-38 **b** Wall construction and siding type: wood fr./wood

4-38 **c** Wall area to be insulated: 25,300 sq. ft.

5-9 **d** Cost of heating fuel:

Gas: $/Therm

Oil: 1.05 $/gal

Electric: $/kWh

Propane: $/Gal

Step 3 Obtain the following data from Table 1:

Table 1 Savings factor for existing wall type and fuel: 0.035

Step 4 Estimate annual energy savings:

2a		2c		3			
3.67	x	25,300	x	0.035	=	3,250	/yr

Step 5 Calculate annual cost savings:

4		2d			
3,250	x	1.05	=	3,412	$/yr

Step 6 Calculate payback period:

1		5			
29,500	/	3,412	=	8.6	Yrs

Table 1: Savings Factors for Installing Wall Insulation

Instructions:

1) Find your wall construction type (see Step 2b).
2) Proceed across table to column with your heating fuel type.
3) Select the appropriate savings factor and transfer it to Step 3.

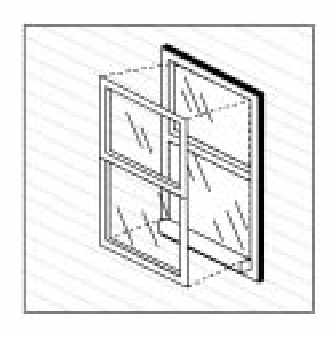
	Heating Fuel Type			
Wall Construction	**Gas**	**Oil**	**Electric**	**Propane**
Wood frame (uninsulated)				
Wood siding	0.049	0.035	1.00	0.053
Aluminum siding	0.052	0.037	1.06	0.057
Brick siding	0.050	0.036	1.02	0.055
Masonry wall (uninsulated)				
Concrete block	0.107	0.076	2.19	0.117
All brick	0.085	0.061	1.75	0.093

Note: This table assumes that R-10 insulation is added to existing walls.

ARCHITECTURAL ECMS

ECM No. 1

INSTALL STORM WINDOWS



Storm windows can save up to 10% on heating costs. The cost-effectiveness of this measure depends on the quality of the existing windows, the cost and type of the storm window, current energy costs, and climate. This ECM is most cost-effective in very cold climates.

APPLICABILITY

- Single-family and multifamily buildings with single-pane windows
- Buildings without storm windows

DESCRIPTION

A large amount of heat can be lost through single-pane windows in the winter, resulting in energy waste. A simple solution is to install storm windows. *Note: if the primary windows are in need of replacement, then energy-efficient replacement windows should be considered as an alternative to storm windows (see ECM No. 2).*

The purpose of storm windows is to save energy and to increase comfort. Storm windows save energy in two ways. First, they reduce air leakage through spaces around the window. Second, they reduce heat conduction through the window by creating an insulating air space between them and the primary window. In addition to saving on heating costs in the winter, storm windows can save on cooling costs in the summer.

Beyond saving energy, storm windows enhance the comfort of the residents, lower maintenance costs on existing windows, and reduce the amount of outside noise and pollutants that enter the dwelling unit.

TYPES

Storm windows can be installed on the exterior or interior of existing windows, depending on the type of storm window. They can be either glass or plastic and can be either fixed or operable. Operable storm windows can be opened and closed, while fixed units are not designed to be opened. Storm windows usually have a single pane, but in extremely cold climates, more expensive double-pane storm windows might be cost-effective. Storm windows with a plain aluminum finish will corrode relatively quickly, reducing the ease of operation and degrading the appearance. Selecting storm windows whose frames have been anodized (treated with a protective oxide coating) or that have a baked enamel finish will prevent this problem.

MAINTENANCE ISSUES

All storm windows. Maintenance staff should make sure storm windows are in place at the start of the heating (or cooling) season. Broken storm windows should be replaced.

Fixed storm windows. This type of storm window is not meant to be opened during the winter, and maintenance staff should make sure that residents do not remove them in the winter. If residents remove storm windows, the HA should try to determine if overheating is a problem.

Operable storm windows. The area around the storm window may need to be recaulked every few years to ensure a good seal, and the tracks should be cleaned occasionally to ensure proper operation. Maintenance staff should make sure that residents keep their storm windows closed when their heat is on.

IMPORTANT POINT TO CONSIDER

- Some windows (e.g., casements) cannot readily be equipped with storm windows.

Cost/Benefit Worksheet
ECM No. 1: Install Storm Windows

Step 1 Obtain total cost of installing the type and quantity of storm windows needed.

$

Step 2 Transfer the following information from the Survey:

4-8 **a** Heating degree-day zone: DDZ
4-18 **b** Total area of windows: sq. ft.
4-17 **c** Total volume of buildings in development: cu. ft.
4-20 **d** Window frame material:
4-21 **e** Average window fit:
5-9 **f** Cost of heating fuel: Gas: $/therm
Oil: $/gal
Electric: $/kWh
Propane: $/gal

Step 3 Obtain the following savings factors from Tables 1 and 2:

Table 1 **a** Conductance savings factor:
Table 2 **b** Infiltration savings factor:

Step 4 Estimate annual energy savings due to conduction losses:

2a x 2b x 3a = /yr

Step 5 Estimate annual energy savings due to infiltration losses:

2a x 2c x 3b = /yr

Step 6 Estimate total annual energy savings:

4 + 5 = /yr

Step 7 Calculate annual cost savings:

6 x 2f = $/yr

Step 8 Calculate payback period:

1 / 7 = yrs

ECM No. 1: Install Storm Windows

Table 1: Conductance Savings Factors

Instructions:

1) Find the frame material of the primary windows (see Step 2d).
2) Find the fuel type.
3) Select the appropriate conductance savings factor and transfer it to Step 3.

Primary Window	Fuel Type			
Frame Material	Gas	Oil	Electric	Propane
Wood	0.11	0.076	2.2	0.12
Metal	0.16	0.11	3.20	0.17

Table 2: Infiltration Savings Factors

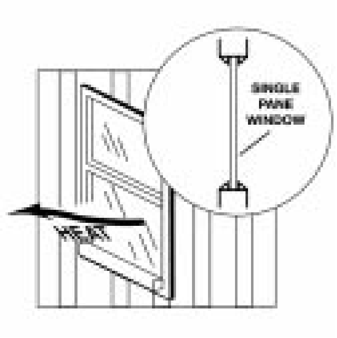
Instructions:

1) Find the fit of the primary windows (see Step 2e).
2) Find the fuel type.
3) Select the appropriate infiltration savings factor and transfer it to Step 3.

Primary Window	Fuel Type			
Fit	Gas	Oil	Electric	Propane
Loose	0.0026	0.0019	0.053	0.0028
Average	0.0017	0.0013	0.036	0.0019
Tight	0.00087	0.00063	0.018	0.00095

ECM No.
2

INSTALL REPLACEMENT WINDOWS



Replacing poor-quality windows can save 10% to 20% on energy consumption for heating. However, if the existing heating system is not adequately controlled, no savings will occur because residents will have to open their windows for relief from overheating.

APPLICABILITY

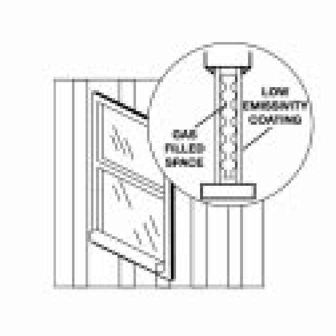
- Single-family and multifamily buildings whose windows need replacement due to deterioration
- Buildings in which the heating is controlled by residents

DESCRIPTION

Windows play a major role in the energy use and comfort of a dwelling unit. In the winter, heat in a room is lost when cold outside air infiltrates into the dwelling unit around the edges of the window. Heat can also be lost by conduction directly through the pane, even if the window fits tightly. The cold drafts and the chilly window pane make the room uncomfortable. But windows can also help to heat a room, by letting the sun's rays enter. Solar radiation is beneficial in the winter but can be a major source of discomfort in hot summer climates.

TYPES

Manufacturers typically represent the energy efficiency of a window in terms of its U-value (the inverse of R-value). A window with a low U-value loses less heat than one with a higher U-value. The U-value of a window depends on the type of glazing, the number of layers of glass, the air space or any special gas between the panes, the thermal resistance of the frame, and the "tightness" of the installation (National Renewable Energy Laboratory 1994).



Layers of glass. Single-pane windows have very little insulating value. Double-or triple-pane windows are more energy-efficient because of the insulating air space between the panes.

Gas-filled spaces between windows. The most advanced windows have inert gases such as argon or krypton in the spaces between panes, increasing the insulating value of the window.

Coatings. A low-emissivity ("low-e") coating, which reduces the amount of heat lost through the window, is appropriate for colder climates. For climates with hot summers and mild winters, a reflective coating or a special "low-e" coating for cooling climates (also called "selective coating") is appropriate.

It is important to choose a window that is right for the particular climate. In most climates, the best energy buy for residential windows is a medium-performance window, such as a gas-filled, double-pane window with low-emissivity glazing and a wood or vinyl frame. This type of window is typically about 5% to 15% more expensive than plain double-pane windows (E Source 1995). Higher-performance windows may be cost-effective in areas with severe winter climates and expensive heating fuel. In climates with mild winters and hot summers, a window with a reflective or selective coating should be specified.

The cost-effectiveness of replacement windows can be boosted by timing their installation with the replacement of the heating system. The reduced heat loss from the new windows may make it possible to install a downsized boiler or furnace.

MAINTENANCE ISSUES

Like most architectural measures, windows are relatively low-maintenance energy conservation measures. Wood-framed windows require some maintenance in the form of occasional painting. Whatever the type of window installed, the main issue for maintenance staff is to make sure that windows remain closed in the winter when the heat is on. The first step in doing this is to ensure that the heating system is adequately controlled to prevent overheating.

IMPORTANT POINTS TO CONSIDER

- Replacement windows should only be installed if overheating is not a problem in the building.
- In climates with moderate to severe winters, replacement windows should be double- or triple-pane. A gas-filled space and low-emissivity coating are also recommended.
- Frames should have a thermal break between the inside and the outside surfaces.
- If existing windows are not in need of replacement, adding storm windows may be a more cost-effective alternative (see ECM No. 1).

Mini Case Study

The New York City Housing Authority installed new thermal-break, double-pane windows in eight high-rise developments in the 1980s. A total of 9,623 dwelling units received replacement windows.

A research team measured the energy consumption before the installation and monitored the consumption for six years after the installation to analyze the level of energy savings achieved. The analysis adjusted for the effects of weather. During the first year, the savings at the eight developments were: 17%, 14%, 21%, 18%, 22%, 17%, 18%, and 9%. The average of all eight developments over the six-year period was 21%.

The savings persisted over the six-year period in all but two developments. The research team speculated that in these developments the windows may not have been properly installed or that other factors such as improper heating system controls might have caused residents to open their windows to relieve overheating (Ritschard & McAllister 1992).

Cost/Benefit Worksheet
ECM No. 2: Install Replacement Windows

This analysis is for replacement of single-pane aluminum frame windows with double-pane low-e coated windows with aluminum frames having thermal breaks, and 1/2" spacing between glazings.

Step 1 Obtain total cost of replacing windows.
$

Step 2 Transfer the following information from the Survey:
4-8 **a** Heating degree-day zone: DDZ
4-18 **b** Area of windows to be replaced: sq. ft.
4-17 **c** Total volume of buildings in development: cu. ft.
4-23 **d** Are existing windows adequately weatherstripped?
5-9 **e** Cost of heating fuel: Gas: $/therm
Oil: $/gal
Electric: $/kWh
Propane: $/gal

Step 3 Obtain the following savings factors from Tables 1 and 2:
Table 1 **a** Conductance savings factor:
Table 2 **b** Infiltration savings factor:

Step 4 Estimate annual energy savings due to conduction losses:
2a x 2b x 3a = /yr

Step 5 Estimate annual energy savings due to infiltration losses:
2a x 2c x 3b = /yr

Step 6 Estimate total annual energy savings:
4 + 5 = /yr

Step 7 Calculate annual cost savings:
6 x 2e = $/yr

Step 8 Calculate payback period:
1 / 7 = yrs

ECM No. 2: Install Replacement Windows

Table 1: Conductance Savings Factors

Instructions:

1) Find the fuel type.
2) Select the appropriate conductance savings factor and transfer it to Step 3.

Fuel	Savings Factor
Gas	0.180
Oil	0.129
Electric	3.692
Propane	0.197

Table 2: Infiltration Savings Factors

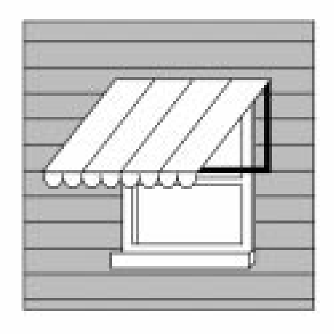
Instructions:

1) Find the existing condition of weatherstripping. (If there is no weatherstripping, select "No".) (See Step 2d.)
2) Find the fuel type
3) Select the appropriate infiltration savings factor and transfer it to Step 3.

Adequate Weatherstripping	Fuel Type			
	Gas	Oil	Electric	Propane
Yes	0.0026	0.0019	0.0533	0.0028
No	0.0009	0.0006	0.0178	0.0010

ECM No. 3

INSTALL WINDOW SUN SHADES



APPLICABILITY

- Air-conditioned office and community spaces
- Air-conditioned spaces without interior shades, blinds, or tinted glass
- Air-conditioned spaces whose windows are not well shaded by exterior trees, vegetation, or other buildings

DESCRIPTION

Solar radiation heat gain through windows often accounts for 50% of air conditioning load in the summertime. If no existing shading exists in air-conditioned spaces such as offices, community rooms, or lobbies, window shading should be considered.

TYPES

Shading of windows can be accomplished in many ways, including exterior shades, tinted film, and interior shades or blinds.

Exterior shading can be of three different types:

> **Architectural elements** include roof overhangs and vertical shading devices that are permanently affixed to the building and require little maintenance after installation.
>
> **Awnings** are fixed to the building and are operated by maintenance staff to control the amount of shading. They can be removed or folded up in the winter.
>
> **Shading screens** are made of metal or fabric and are placed vertically outside the window much like a screen and are specifically designed not to hinder views while shading sunlight.

Tinted film is not as efficient as exterior shading elements and will decrease the benefits of solar heating in winter months. The advantages of film are that it is less costly than other shading devices and maximizes the view while reducing glare.

Interior shades or blinds are not as effective as exterior shading or tinted films because the sunlight enters the space before it is reflected back, thereby trapping much of the heat inside the building. Interior blinds include such devices as roll-down shades, venetian blinds, vertical blinds, and interior sun screens.

MAINTENANCE ISSUES

Awnings and exterior shade screens require more maintenance than other types of sun shades because they need to be removed (or, in the case of some types of awnings, folded up) after the summer. Tinted film may need to be replaced occasionally because it damages easily. Interior sun shades may need occasional maintenance.

IMPORTANT POINTS TO CONSIDER

- Exterior shading should be engineered for correct summer solar angles to ensure effective shading.
- Tinted film is fragile and therefore should not be applied in areas where objects or people come into frequent contact with the windows.
- Exterior shading devices should be designed to withstand snow loads in cold climates.
- Sunshades, particularly on west-facing windows, can be effective in improving comfort and reducing the need for air conditioning in buildings with or without air conditioning.

Cost/Benefit Worksheet
ECM No. 3: Install Window Sun Shades

The following analysis of window shading is only for non-north facing windows (i.e., exclude north-facing windows from this ECM) of office and community spaces that are air-conditioned. Below, south-facing windows and east- and west-facing windows are analyzed separately because the savings are different.

Step 1 Obtain the total cost of installing window shading. Select the type of window shading desired: exterior, tinted film, or interior. If no preference exists, copy this section for as many types of sun shades as you wish to analyze and select the one with the lowest payback.

a South-facing windows: $
b East- and west-facing windows: $

Step 2 Transfer the following information from the Survey:

4-25 **a** Area of south-facing windows in air-conditioned spaces: sq. ft.
4-25 **b** Area of east- and west-facing windows in air-conditioned spaces: sq. ft.
5-9 **c** Cost of electricity: $/kWh

Step 3 Obtain the following savings factors from Tables 1 and 2:

Table 1 **a** Solar load on south windows: kWh
Table 1 **b** Solar load on east and west windows: kWh
Table 2 **c** Savings factor for selected window type:

Step 4 Estimate annual energy savings:

a South-facing windows:

2a		3a		3c			
	x		x		=		kWh/yr

b East and west-facing windows:

2b		3b		3c			
	x		x		=		kWh/yr

Step 5 Calculate annual cost savings:

a South-facing windows:

4a		2c			
	x		=		$/yr

b East- and west-facing windows:

4b		2c			
	x		=		$/yr

Step 6 Calculate payback period:

a South-facing windows:

1a		5a			
	/		=		yrs

b East- and west-facing windows:

1b		5b			
	/		=		yrs

ECM No. 3: Install Window Sun Shades

Table 1: Solar Load in Kilowatt-Hours

Instructions:
1) Locate the closest major city to your location.
2) Select the appropriate solar loads and transfer to Step 3.

Major City	East & West Windows	South Windows
Albuquerque, NM	16	12
Atlantic City, NJ	10	8
Birmingham, AL	24	18
Boston, MA	8	6
Burlington, VT	4	3
Charlotte, NC	14	11
Chicago, IL	10	8
Cleveland, OH	8	6
Cincinnati, OH	20	15
Columbia, SC	24	18
Corpus Christi, TX	40	31
Dallas, TX	24	18
Denver, CO	8	6
Des Moines, IA	12	9
Detroit, MI	14	11
Duluth, MN	6	5
El Paso, TX	20	15
Honolulu, HI	30	24
Indianapolis, IN	12	9
Little Rock, AR	28	22
Minneapolis, MN	8	6
New Orleans, LA	28	22
New York, NY	10	8
Newark, NJ	8	6
Oklahoma City, OK	22	17
Pittsburgh, PA	18	14
Rapid City, SD	16	12
St. Joseph, MO	20	15
St. Petersburg, FL	30	24
San Diego, CA	16	12
Savannah, GA	24	18
Seattle, WA	8	6
Syracuse, NY	4	3
Trenton, NJ	16	12
Tulsa, OK	30	24
Washington, DC	14	11

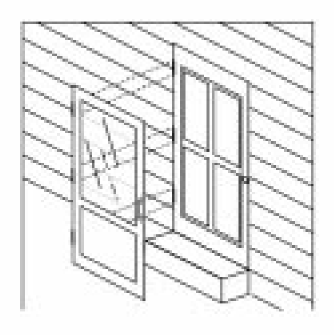
Table 2: Savings Factors for Window Shading

Instructions:
1) Find the type of shade that would be installed.
2) Select the appropriate savings factor and transfer to Step 3.

Type of Shade	Savings Factor
Exterior Shading	0.65
Tinted Film	0.55
Interior Shades	0.45

ECM No.
4

INSTALL STORM DOORS



APPLICABILITY

- Single-family and low-rise multifamily buildings where apartment doors open directly to the outside
- Buildings without storm doors
- Buildings without vestibules

DESCRIPTION

As is the case with storm windows (see ECM No. 1), storm doors save energy in two ways. First, they reduce air leakage through spaces around the existing door. Second, they reduce heat conduction through the door by creating an insulated air space between the door and the storm door. In addition to saving energy, storm doors enhance the comfort of residents, and they protect the primary door, thus reducing maintenance costs.

TYPES

Storm doors come in many types, some of better quality than others. High-quality storm doors should be selected to ensure long-term performance. Inferior storm doors, such as those made from thin gauge metal frames, deteriorate relatively quickly and are usually a poor investment. Storm doors with a plain aluminum finish will corrode relatively quickly, reducing the ease of operation and degrading the appearance. Selecting storm doors that have been anodized (treated with a protective oxide coating) or that have a baked enamel finish will prevent this problem.

MAINTENANCE ISSUES

Some storm doors come with screens for use in the summer. Maintenance staff should make sure the storm doors (and not the screen doors) are in place when the heating season begins.

IMPORTANT POINTS TO CONSIDER

- Minimum door clearance for operation by elderly or disabled residents should be considered.
- Storm doors should have latches or locks for security.
- Storm doors should not be installed over primary doors that have foam cores or plastic trim.

Cost/Benefit Worksheet
ECM No. 4: Install Storm Doors

All exterior doors should be considered in this ECM, not just the main entry doorways.

Step 1 Obtain total cost of installing storm doors on all exterior doors: ☐ $

Step 2 Transfer the following information from the Survey:

4-8	**a**	Heating degree-day zone:	☐	DDZ
4-15	**b**	Average # of residents per dwelling unit:	☐	
4-28	**c**	Total number of doors:	☐	
4-29	**d**	Average fit of existing doors:	☐	
4-30	**e**	Are existing doors weatherstripped?	☐	
4-32	**f**	Type of existing door:	☐	
4-32	**g**	Thickness of doors (if wood):	☐	Inches
5-9	**h**	Cost of heating fuel: Gas:	☐	$/therm
		Oil:	☐	$/gal
		Electric:	☐	$/kWh
		Propane:	☐	$/gal

Step 3 Obtain the following savings factors from Tables 1 and 2:

Table 1	**a**	Conductance savings factor	☐
Table 2	**b**	Infiltration savings factor	☐

Step 4 Estimate annual energy savings due to conduction losses:

2a ☐ x 2c ☐ x 3a ☐ = ☐ /yr

Step 5 Estimate annual energy savings due to infiltration losses:

2a ☐ x 2c ☐ x 3b ☐ = ☐ /yr

Step 6 Estimate total annual energy savings:

4 ☐ + 5 ☐ = ☐ /yr

Step 7 Calculate annual cost savings:

6 ☐ x 2h ☐ = ☐ $/yr

Step 8 Calculate payback period:

1 ☐ / 7 ☐ = ☐ yrs

ECM No. 4: Install Storm Doors

Table 1: Conductance Savings Factors

Instructions:

1) Find existing door type (see Steps 2f and 2g).
2) Find the fuel type
3) Select the appropriate conductance savings factor and transfer it to Step 3.

	Fuel Type			
Existing Door Type	**Gas**	**Oil**	**Electric**	**Propane**
Solid wood 1 3/8"	0.53	0.38	10.9	0.58
Solid wood 1 3/4"	0.38	0.27	7.8	0.41
Hollow steel	1.06	0.76	21.7	1.16
Insulated steel	0.96	0.69	19.7	1.05

Table 2: Infiltration Savings Factors

Instructions:

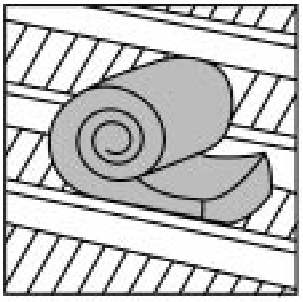
1) Find the fuel type
2) Find average number of residents per dwelling unit (see Step 2b).
3) Find existing door condition (see Steps 2d and 2e).
4) Select the appropriate infiltration savings factor and transfer it to Step 3.

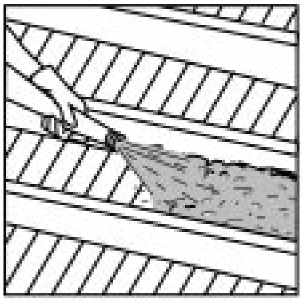
		Existing Door Conditions			
		Non-Weatherstripped			Weather-stripped
Fuel Type	**Residents per Dwelling Unit**	**Loose**	**Average**	**Tight**	**All Fits**
Gas	1-2	6.5	4.3	2.0	0.40
	3	6.7	4.4	2.1	0.50
	4	6.9	4.6	2.3	0.70
	5	7.1	4.9	2.6	0.90
Oil	1-2	4.6	3.0	1.4	0.30
	3	4.8	3.2	1.5	0.40
	4	4.9	3.3	1.7	0.50
	5	5.1	3.5	1.9	0.60
Electric	1-2	133	87	40	7
	3	138	91	44	11
	4	141	94	48	15
	5	145	100	54	19
Propane	1-2	7.1	4.7	2.2	0.44
	3	7.3	4.8	2.3	0.55
	4	7.5	5.0	2.5	0.76
	5	7.8	5.3	2.8	0.98

ECM No. 5

INSTALL/INCREASE ATTIC INSULATION

Because installing attic insulation is relatively easy and inexpensive, it is usually cost-effective. Even in mild climates where some attic insulation was already present, measured fuel savings from attic insulation range from 13% to 21%, according to a compilation of studies by Lawrence Berkeley Laboratory (Cohen et al. 1991).





APPLICABILITY

- Single-family and low-rise multifamily buildings with attics
- Attics that currently have less than 12 inches of insulation

DESCRIPTION

Attic insulation reduces the amount of heat that flows from a dwelling unit through the attic to the cold outside air. By reducing this heat loss, attic insulation reduces the amount of energy needed to heat the dwelling unit in the winter. In the summer, attic insulation saves on cooling costs and keeps buildings more comfortable by reducing the conduction of heat from the hot attic through the ceiling and into the unit (Krigger 1991).

A material's resistance to heat flow is measured in units of "R-value": the higher the R-value, the better the insulating properties. The R-value of insulation depends on the type of insulation and its thickness. The optimal R-value for adding attic insulation depends on the existing insulation, fuel costs, and climate.

TYPES

There are two basic types of insulation used for attics:

Batt insulation (also called rolls or blankets) is made of fiberglass or rock wool. It comes in standard widths to fit between rafters. One advantage of batt insulation is that it does not settle over time, as loose-fill insulation does. Settling can reduce the R-value.

Loose-fill insulation is typically made of fiberglass, rock wool, or cellulose. Cellulose loose-fill insulation is blown into the attic with a machine, while fiberglass and rock wool loose-fill insulation can either be poured or blown into the attic. If properly installed, loose-fill insulation can provide more complete coverage than batts, because the fibers can fill around wires, piping, and other obstacles (E Source 1996). Also, loose-fill insulation is more easily installed than batt insulation where access to the attic is constrained.

The best choice of insulation depends on economic factors, labor, material availability, and environmental concerns.

MAINTENANCE ISSUES

Attic insulation is a relatively maintenance-free energy conservation measure. However, there are several maintenance issues that should be addressed before and after adding insulation.

Before installation. The installation crew should make sure that any exposed wiring is in good condition and will not present a fire hazard. If the HA plans to reduce air leakage (see ECM No. 8), any air sealing in the attic should be performed before attic insulation is installed. Also, any ducts or pipes located in attics should be insulated to prevent freezing or excessive heat loss. Finally, attics with insulation must be ventilated.

After installation. If attic insulation gets soaked due to leakage through the roof, it should be removed, discarded, and replaced. Loose-fill insulation should be checked a year or so after installation for settling; if a significant amount of settling has occurred, it may be necessary to add more insulation.

IMPORTANT POINTS TO CONSIDER

- Insulation must be installed according to manufacturer's directions.
- Unless the attic is used as a habitable space, attic insulation should be installed between the rafters of the attic floor, rather than the attic ceiling.
- A vapor barrier must be present on the warm side of insulation to prevent moisture problems. If existing insulation has a vapor barrier, a second layer should not be added.
- Recessed lights or fans which protrude into the attic space should not be covered by insulation.
- Insulation should not obstruct vents or louvers.
- Installation crews should wear protective gloves and masks.
- Insulation must comply with local fire codes. Loose-fill cellulose insulation must be of fire-treated type.
- Although most insulation materials can have negative health effects when used inappropriately, some companies and organizations have used irresponsible scare tactics to get people to avoid or choose certain products. When possible, seek objective opinions by government research agencies or objective publications (E Source 1996).

Mini Case Study

In 1982, four low-rise developments of the San Francisco Housing Authority received attic insulation, along with a few other low-cost measures, including weatherstripping and caulking. For the most part, the attic insulation was installed where there had been none previously.

A research team measured the energy consumption before the installation and monitored the consumption for six years after the installation to analyze the level of energy savings achieved. The analysis adjusted for the effects of weather.

The savings at the four developments were 10%, 17%, 5%, and 20% the first year after installation. At each development, the level of savings persisted over the six-year period. According to the research team that analyzed the savings, most of the savings resulted from the installation of attic insulation (Ritschard & McAllister 1992).

Cost/Benefit Worksheet
ECM No. 5: Install or Increase Attic Insulation

This analysis is performed for three thicknesses of added insulation in order to assist in determining the maximum economical thickness level.

Step 1 Obtain total cost of installing selected type of insulation.

a R-13 additional insulation (total labor and material costs): $
b R-30 additional insulation (total labor and material costs): $
c R-42 additional insulation (total labor and material costs): $
d Incremental cost of adding R-30 insulation vs. R-13 insulation:
1b - 1a = $
e Incremental cost of adding R-42 insulation vs. R-30 insulation:
1c - 1b = $

Step 2 Transfer the following information from the Survey:

4-8 **a** Heating degree-day zone: DDZ
4-34 **b** Attic area: sq. ft.
4-35 **c** Existing insulation level: inches
4-35 **d** Existing insulation type:
e Existing insulation R-value (use Table 1): R
5-9 **f** Cost of heating fuel: Gas: $/therm
Oil: $/gal
Electric: $/kWh
Propane: $/gal

Step 3 Obtain the following savings factors from Table 2:

Table 2 **a** R-13 additional insulation:
Table 2 **b** R-30 additional insulation:
Table 2 **c** R-42 additional insulation:

Step 4 Estimate annual energy savings:

a R-13 additional insulation:
2a x 2b x 3a = /yr
b R-30 additional insulation:
2a x 2b x 3b = /yr
c R-42 additional insulation:
2a x 2b x 3c = /yr

Step 5 Calculate annual cost savings:

a R-13 additional insulation: 4a x 2f = $/yr
b R-30 additional insulation: 4b x 2f = $/yr
c R-42 additional insulation: 4c x 2f = $/yr

Step 6 Calculate payback period:

a R-13 additional insulation: 1a / 5a = yrs
b R-30 additional insulation: 1d / 5b = yrs
c R-42 additional insulation: 1e / 5c = yrs

ECM No. 5: Install or Increase Attic Insulation

Table 1: R-value vs. Thickness for Typical Attic Insulation Materials

Instructions:

1) Find existing level of insulation in inches (see Step 2c).
2) Find type of existing insulation (see Step 2d).
3) Select the appropriate R-value and transfer it to Step 3.

	R-Value		
Thickness (inches)	**Batt Fiberglass**	**Dry Cellulose**	**Loose Fill Fiberglass**
0	1.6	1.6	1.6
1	3	4	3
2	7	7	5
3	10	11	8
4	13	14	10
5	17	18	13
6	19	21	15
7	23	25	18
8	26	28	20
9	30	32	23
10	33	35	25
11	36	39	28
12	40	42	30

Table 2: Savings Factors for Increasing Attic Insulation

Instructions:

1) Find heating fuel type.
2) Find R-value of existing attic insulation (see Step 2e or Table 1).
3) Select the appropriate savings factor for each level of additional insulation and transfer it to Step 3.

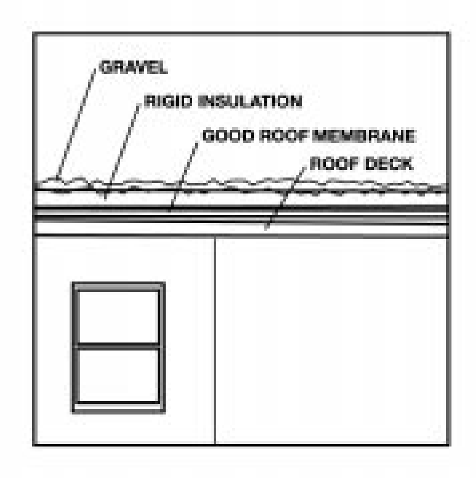
Fuel Type	Existing R-Value [1]	Added R-value			Fuel Type	Existing R-Value [1]	Added R-value		
		13	30	42			13	30	42
Gas	None	0.134	0.009	0.002	Electricity	None	2.74	0.18	0.04
	7	0.022	0.006	0.002		7	0.46	0.11	0.03
	13	0.009	0.004	0.001		13	0.19	0.07	0.02
	19	0.005	0.003	[2]		19	0.11	0.05	0.02
	26	0.003	0.002	[2]		26	0.06	0.04	0.02
	33	0.002	[2]	[2]		33	0.04	0.03	[2]
	40	[2]	[2]	[2]		40	0.03	0.02	[2]
Oil	None	0.095	0.006	0.001	Propane	None	0.146	0.010	0.002
	7	0.016	0.004	0.001		7	0.024	0.007	0.002
	13	0.007	0.003	0.001		13	0.010	0.004	0.001
	19	0.004	0.002	0.001		19	0.005	0.003	[2]
	26	0.002	0.001	0.001		26	0.003	0.002	[2]
	33	0.001	0.001	[2]		33	0.002	[2]	[2]
	40	0.001	[2]	[2]		40	[2]	[2]	[2]

[1] See Table 1.

[2] Additional insulation is not cost-effective; do not complete calculations for these thicknesses.

ECM No. 6

INSTALL ROOF INSULATION



APPLICABILITY

- Single-family and multifamily buildings with flat or nearly flat roofs and no attics
- Buildings with no roof insulation

DESCRIPTION

Roof insulation reduces the amount of heat that flows from a dwelling unit through the roof to the cold outside air. By reducing this heat loss, roof insulation reduces the amount of energy needed to heat the dwelling unit in the winter. In the summer, roof insulation saves on cooling costs and keeps buildings more comfortable by reducing the conduction of heat from the hot roof through the ceiling and into the unit.

A material’s resistance to heat flow is measured in units of "R-value": the higher the R-value, the better the insulating properties. The R-value of insulation depends on the type of insulation and its thickness. Two levels of insulation are analyzed in this ECM: R-10 and R-20. Generally, R-10 is equal to about 1.5-2 inches, and R-20 is equal to 3-4 inches, depending on the type and brand of rigid insulation specified.

Installing Roof Insulation

Roof insulation is usually of a rigid board type installed either under or over the existing roof. The most common way to install roof insulation is to remove any existing gravel, add rigid exterior roof insulation panels directly on top of the existing roofing, then replace the gravel for protection against ultraviolet light. If the roof is in the process of being replaced, insulation panels should be installed under the new roofing.

IMPORTANT POINTS TO CONSIDER

- All insulation must comply with fire codes.
- Adding roof insulation might increase snow build-up in winter because the relatively warm roofs of uninsulated buildings provide for some melting of accumulated snow. The ability of the building structure to accommodate this increased snow load should be analyzed.

Cost/Benefit Worksheet
ECM No. 6: Install Roof Insulation

This analysis is performed for two thicknesses of insulation in order to assist in determining the maximum economical thickness level. It applies to developments with uninsulated or poorly insulated roofs.

Step 1 Obtain total cost of installing insulation:

a R-10 insulation (total labor and material costs): $

b R-20 insulation (total labor and material costs): $

c Incremental cost of adding R-20 vs. R-10:

1b - 1a = $

Step 2 Transfer the following information from the Survey:

4-8 **a** Heating degree-day zone: DDZ

4-36 **b** Roof area: sq. ft.

4-37 **c** Type of existing roof structure:

5-9 **d** Cost of heating fuel:

Gas: $/therm

Oil: $/gal

Electric: $/kWh

Propane: $/gal

Step 3 Obtain the following savings factors from Table 1:

Table 1 **a** R-10 additional insulation:

Table 1 **b** R-20 additional insulation:

Step 4 Estimate annual energy savings:

a R-10 additional insulation:

2a x 2b x 3a = /yr

b R-20 additional insulation:

2a x 2b x 3b = /yr

Step 5 Calculate annual cost savings:

a R-10 additional insulation:

4a x 2d = $/yr

b R-20 additional insulation:

4b x 2d = $/yr

Step 6 Calculate payback period:

a R-10 additional insulation:

1a / 5a = yrs

b R-20 additional insulation:

1c / 5b = yrs

ECM No. 6: Install Roof Insulation

Table 1: Savings Factors for Adding Roof Insulation

Instructions:

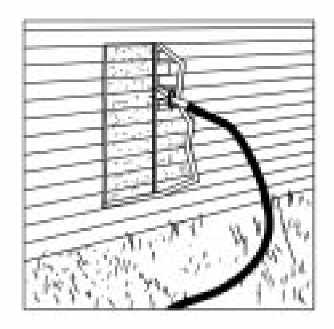
1) Find heating fuel type.
2) Find existing roof structure type (see Step 2c).
3) Select the appropriate conductance savings factors for both insulation levels and transfer to Step 3.

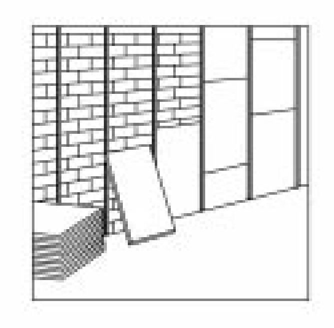
Heating Fuel Type	**Existing Roof Structure**	**Added R-Value**	
		10	**20**
Gas (therms)	Wood	0.120	0.009
	Concrete	0.148	0.010
	Steel	0.239	0.011
Oil (gallons)	Wood	0.086	0.007
	Concrete	0.106	0.007
	Steel	0.171	0.008
Electricity (kWh)	Wood	2.46	0.19
	Concrete	3.04	0.20
	Steel	4.90	0.22
Propane (gallons)	Wood	0.131	0.010
	Concrete	0.162	0.011
	Steel	0.261	0.012

ECM No.
7

INSTALL WALL INSULATION

The installation of wall insulation in single-family and small multifamily buildings has been shown to save an average of 265 therms gas or 2,159 kWh electricity annually, depending on the heating fuel (Brown et al. 1993).





APPLICABILITY

- Single-family and multifamily buildings with uninsulated walls
- Buildings located in heating degree day zones 1.5 and above

DESCRIPTION

The purpose of **wall insulation** is to reduce the amount of heat that flows from a dwelling unit through the walls to the cold outside air. By reducing this heat loss, wall insulation reduces the amount of energy needed to heat the dwelling unit. Wall insulation can also save on cooling costs and reduce overheating in the summer.

A material's resistance to heat flow is measured in units of "R-value": the higher the R-value, the better the insulating properties. The R-value of insulation depends on the type of insulation and its thickness. The savings factors in this ECM assume an R-value of 10 for the insulation.

TYPES

There are two types of insulation used for retrofit applications in walls:

> **Sprayed or blown insulation** can be installed in wood-frame buildings through the top of a wall cavity, if it is accessible. If not, a hole must be cored into each cavity section of the wall and later patched and painted (E Source 1996). The holes can be drilled into the exterior or the interior side of the wall. This type of insulation includes wet-spray cellulose, foams, and blown fiber with binder (known as "Blow-in-Blanket").
>
> **Rigid board** insulation made of foam or fiberglass can be glued or nailed to the exterior or interior of a masonry (brick or concrete block) wall. Exterior insulation is generally preferred because it will not decrease living space and its installation will not disrupt occupancy. Rigid board insulation can also be installed in the walls of wood-frame buildings during re-siding.

IMPORTANT POINTS TO CONSIDER

- This ECM must be implemented by a professional insulation contractor. Care should be taken to ensure than the installer meets all legal and professional standards and has a good history of previous installations.
- Cavity-fill insulation must be compatible with building materials.
- Cavity-fill insulation should be blown in under pressure or expanded within walls to insure even distribution and to avoid future settling.
- All materials must meet local building and fire codes.
- Exterior or interior insulating panels should be protected from impacts, vandalism, and abrasions that could damage them.
- Exterior insulation panels should be protected from weather and ultraviolet radiation.
- Finish and detailing around doors, windows, and other openings should be considered so as not to detract from building appearance and operation of equipment.

Cost/Benefit Worksheet
ECM No. 7: Install Wall Insulation

Step 1	Obtain total cost of installing wall insulation:			$
Step 2	Transfer the following information from the Survey:			
4-8	**a** Heating degree-day zone:			DDZ
4-38	**b** Wall construction and siding type:			
4-38	**c** Wall area to be insulated:			sq. ft.
5-9	**d** Cost of heating fuel:	Gas:		$/therm
		Oil:		$/gal
		Electric:		$/kWh
		Propane:		$/gal
Step 3	Obtain the following data from Table 1:			
Table 1	Savings factor for existing wall type and fuel:			
Step 4	Estimate annual energy savings:			
	2a x 2c x 3	=		/yr
Step 5	Calculate annual cost savings:			
	4 x 2d	=		$/yr
Step 6	Calculate payback period:			
	1 / 5	=		yrs

ECM No. 7: Install Wall Insulation

Table 1: Savings Factors for Installing Wall Insulation

Instructions:

1) Find your wall construction type (see Step 2b).
2) Proceed across table to column with your heating fuel type.
3) Select the appropriate savings factor and transfer it to Step 3.

	Heating Fuel Type			
Wall Construction	**Gas**	**Oil**	**Electric**	**Propane**
Wood frame (uninsulated)				
Wood siding	0.049	0.035	1.00	0.053
Aluminum siding	0.052	0.037	1.06	0.057
Brick siding	0.050	0.036	1.02	0.055
Masonry wall (uninsulated)				
Concrete block	0.107	0.076	2.19	0.117
All brick	0.085	0.061	1.75	0.093

Note: This table assumes that R-10 insulation is added to existing walls.

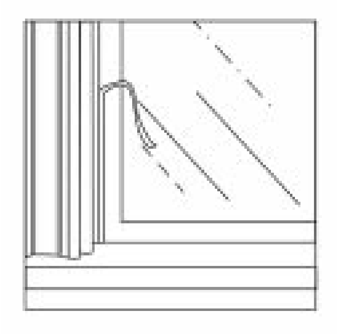
ECM No.
8

CONTROL AIR LEAKAGE

APPLICABILITY

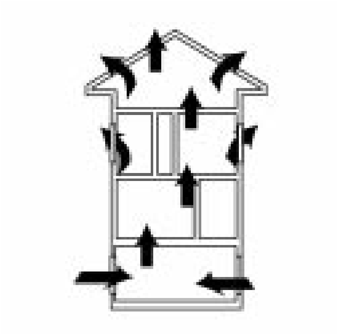
- Single-family and multifamily buildings

DESCRIPTION



Air leakage through holes, gaps, cracks, penetrations, and electrical receptacles is a major source of heat loss from a dwelling unit. Controlling this air leakage through a combination of weatherstripping and strategic sealing of these holes using caulk can significantly reduce the amount of heat lost to the outside, thus reducing the amount of energy needed to heat the dwelling unit. Insulation (see ECMs Nos. 5, 6, and 7) can also help reduce air leakage. In addition to saving energy, controlling air leakage can also reduce moisture problems and reduce the influx of odors and contaminated air from the basement and other units, while increasing the overall comfort of the residents.

Air sealing in single-family and small multifamiliy dwellings has been shown to reduce energy usage by an average of 153 therms or 1,330 kWh per year, depending on the type of heating (Brown et al. 1993).


Stack Effect

But reducing air leakage through air sealing techniques is more complicated than simply weatherstripping and caulking. Two important principles should be understood. First, even if a building is full of holes, air will not move through those holes unless there is a difference in pressure between indoors and outdoors. This pressure differential depends on the difference in temperature between inside and out, wind speed and direction, and mechanical ventilation. If there is no pressure differential, the air stands still and does not leak in or out. This is important because sealing a hole where there is no pressure differential will not save any energy. Pressure tends to be highest on upper and lower floors and in basements. In the heating season, hot air rises and pushes on the ceiling, creating high positive pressure and eventually leaking out. When it does leak out, it is replaced by cold air coming into the lower parts of a building, where the pressure is negative from all the warm air moving upward (E Source 1996). This force is called the "stack effect."

The second important principle is that air sealing can affect air quality. Air leakage is the primary source of ventilation in many buildings. Tightening a building by reducing air leakage can endanger the health of the occupants in buildings with no mechanical If a building does not have mechanical ventilation, it is recommended that a ventilation system be installed before any significant air leakage reduction is performed.

STRATEGIES

ventilation (E Source 1996). This risk is highest in buildings with significant sources of indoor air pollution, such as backdrafting from gas appliances or high occupancy levels.

Weatherstripping. Weatherstripping is a flexible strip that seals a gap between the stationary and movable parts of the door or window. The strip can be made of rubber, plastic, or metal and should be specifically suited to the window or door type. In general, all operable windows and doors leading to the outside should be weatherstripped. New energy-efficient windows may not need weatherstripping, and doors leading to common hallways do not need to be weatherstripped.

An effective air leakage reduction strategy requires an understanding of how air moves in a building. Cold air tends to enter a building from the basement or lower floors and exit from the top floors and through the roof. This is called the "stack effect" and can result in over-heating on top floors and inadequate heating on lower floors.

Air sealing. Air sealing is accomplished by strategically applying caulk to holes, gaps, cracks, penetrations, and electrical receptacles and around windows and door frames. By-pass leakage sites such as channels in stud cavities extending from the basement to the attic also need to be sealed. This process is best performed by an experienced technician equipped with appropriate diagnostic tools and trained to assess sources of indoor air quality problems. A good way to determine where to focus air sealing efforts is to measure how much air leakage is occurring and where it is occurring. The most common diagnostic tool used to measure air leakage is a "blower door", a large fan that the technician temporarily installs in a door or window to measure air tightness and identify sources of leakage. Because of the stack effect, a good strategy in some buildings is to focus air sealing efforts on the bottom and top of a building, where the pressure differential is greatest.

MAINTENANCE ISSUES

Weatherstripping windows and doors may require repairs to the doors and windows before or during the installation to ensure operability. Weatherstripping may need to be replaced occasionally, and sealed areas may need to be occasionally recaulked. In addition, maintenance staff should make sure that window air conditioners are removed during winter months; if they cannot be removed, they should be covered. Maintenance staff should also ensure that windows remain closed in the winter to minimize air leakage. If windows are routinely left open in the winter, maintenance should investigate any potential overheating or air quality problems. Finally, to ensure adequate air quality, the HA needs to make sure that mechanical ventilation systems are functioning.

IMPORTANT POINTS TO CONSIDER

- Air sealing should be performed in conjunction with an assessment of the building’s ventilation system to ensure adequate air quality.
- Air leakage reduction is best performed by an experienced professional.
- Weatherstripping should be selected for quality and durability.
- The technician should check combustion appliances (such as gas-fired heaters and hot water heaters) before and after air sealing to ensure that they are venting properly.

Cost/Benefit Worksheet
ECM No. 8: Control Air Leakage

Step 1 Obtain total cost of air sealing:

______ $

Step 2 Transfer the following information from the Survey:

4-8 **a** Heating degree-day zone: ______ DDZ
4-17 **b** Total volume of buildings in development: ______ cu. ft.
5-9 **c** Cost of heating fuel: Gas: ______ $/therm
Oil: ______ $/gal
Electric: ______ $/kWh
Propane: ______ $/gal

Step 3 Obtain the following savings factor from Table 1:

Table 1 Infiltration savings factor: ______

Step 4 Estimate annual energy savings:

2a 2b 3
______ x ______ x ______ = ______ /yr

Step 5 Calculate annual cost savings:

4 2c
______ x ______ = ______ $/yr

Step 6 Calculate payback period:

1 5
______ / ______ = ______ yrs

Table 1: Infiltration Savings Factors

Instructions:

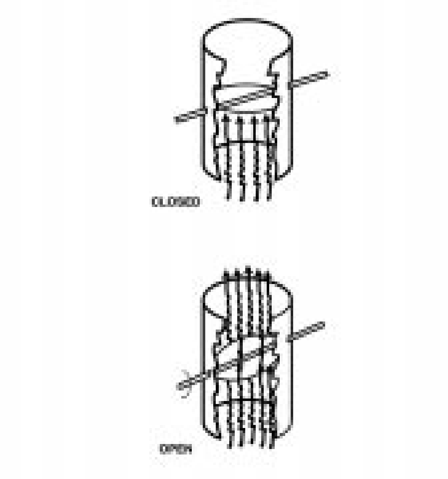
1) Find your fuel type.
2) Select the appropriate savings factor and transfer it to Step 3.

Fuel	Savings Factor
Gas	0.0026
Oil	0.0019
Electric	0.053
Propane	0.0028

HEATING AND COOLING ECMS

ECM No.
9

INSTALL VENT DAMPERS



Savings from a vent damper vary, depending on the size and type of heating system. Savings are likely to be highest with older, larger boilers or furnaces. On average, documented savings on heating energy use in single-family and multifamily buildings fall into the 5-8% range.

APPLICABILITY

- Single-family and multifamily buildings
- Oil- or gas-fired boilers or furnaces with atmospheric burners without vent dampers or flue dampers

DESCRIPTION

All oil and gas furnaces and boilers have a vent (flue or chimney) to discharge unwanted combustion gases to the outside. A **vent damper** is a device installed in the vent of a furnace or boiler that automatically closes the vent when the burner goes off to reduce the loss of warm air up the chimney. By reducing the amount of heat lost through the chimney during this "off cycle," vent dampers save energy. (*Note:* Codes do not allow *flue* dampers, that is, dampers installed upstream of the draft diverter or barometric damper, as a retrofit, although flue dampers can be installed on some appliances at the time of manufacture. Unlike flue dampers, vent dampers are installed *downstream* of the draft diverter [Hewitt 1990].)

The level of savings from a vent damper depends on several factors. In general, savings tend to be higher with larger, older, oversized boilers because their "off-cycle" losses are greater. Savings also depend on the absence of alternate "escape routes" for the hot air, such as out a crevice in the basement or up a neighboring water heater vent. If the hot air finds its way out of the building despite the vent damper, the savings will be lower.

TYPES

There are two basic types of vent dampers: mechanical vent dampers and thermal (bimetallic) vent dampers. Thermal vent dampers are not recommended because they do not allow accurate timing. Timing is important because off-cycle losses are highest just after the boiler shuts off, when the system is still very hot but venting is no longer needed (DeCicco et al. 1995). Mechanical vent dampers can be precisely controlled to open and close at the appropriate times. The most effective mechanical vent damper is a leak-tight vent damper.

MAINTENANCE ISSUES

Maintenance staff should become familiar with the operation of vent dampers that are installed. If possible, maintenance staff should have on hand a copy of the owner's manual for the vent damper.

IMPORTANT POINTS TO CONSIDER

- Before a vent damper is installed on a gas boiler or furnace, the HA should make sure that the burner has an electronic ignition. Installing a vent damper on a system with a standing pilot light may cause safety concerns. If the burner does not have an electronic ignition, one should be installed (see ECM No. 10).
- The vent damper should include a control that prevents the boiler or furnace from operating when the vent damper is in the closed position.
- Contractors must be certified to install vent dampers.

Cost/Benefit Worksheet
ECM No. 9: Install Vent Dampers

Note: For gas boilers and furnaces, this analysis assumes electronic ignition is already installed.

Step 1 Obtain total cost of installing vent dampers:

____ $

Step 2 Transfer the following information from the Survey:

5-14	**a** Annual fuel consumption	Gas:		therms/yr
		Oil:		gal/yr
5-9	**b** Cost of heating fuel:	Gas:		$/therm
		Oil:		$/gal

Step 3 Estimate annual energy savings:

2a

0.077 x ____ = ____ /yr

Step 4 Calculate annual cost savings:

3 2b

____ x ____ = ____ $/yr

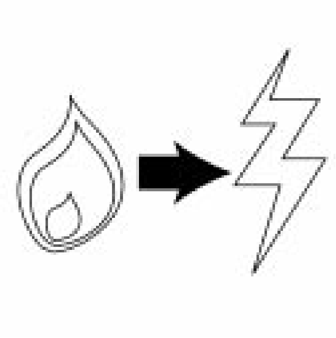
Step 5 Calculate payback period:

1 4

____ / ____ = ____ yrs

ECM No. 10

Convert to Electronic Ignition



Applicability

- Single-family and multifamily buildings
- Gas-fired heating systems with constant-burning pilot lights

Description

When the pilot light of a gas-fired boiler or furnace burns constantly, energy is wasted. This type of pilot light can be replaced with an automatic electric ignition that ignites the pilot only when the thermostat calls for the furnace to be fired. Many companies make pilot ignition retrofit systems that can be easily installed by skilled technicians.

Electronic ignition should be installed before a vent damper is installed on gas heating systems (see ECM No. 9).

Maintenance Issues

Before this measure is installed, maintenance staff should manually shut off the pilot on boilers or furnaces in the summertime. The pilot light should not be shut off on boilers that produce domestic hot water. Safety precautions should be followed when manually turning off the pilot light at the end of the heating season and relighting it at the beginning of the heating season.

Important Points to Consider

- Any new equipment should be properly tested and certified for safety.
- The replacement ignition system should provide for complete summer shutdown.

Cost/Benefit Worksheet
ECM No. 10: Convert to Electronic Ignition

Step 1 Obtain total cost of converting to electronic ignition:

☐ $

Step 2 Transfer the following information from the Survey:

5-14 **a** Annual heating fuel consumption (gas): ☐ therms/yr

5-9 **b** Cost of gas: ☐ $/therm

Step 3 Estimate annual energy savings:

0.056 x ☐ (2a) = ☐ therms/yr

Step 4 Calculate annual cost savings:

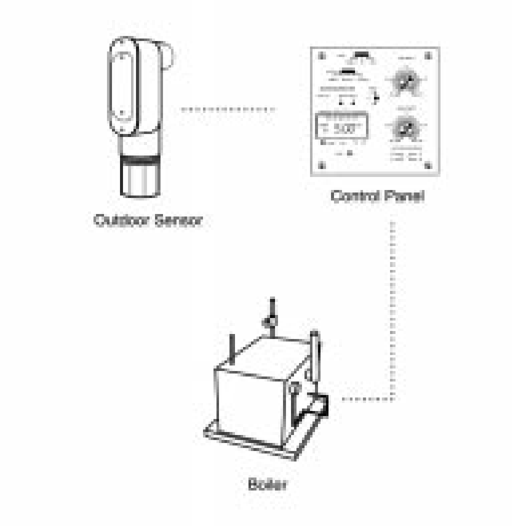
☐ (3) x ☐ (2b) = ☐ $/yr

Step 5 Calculate payback period:

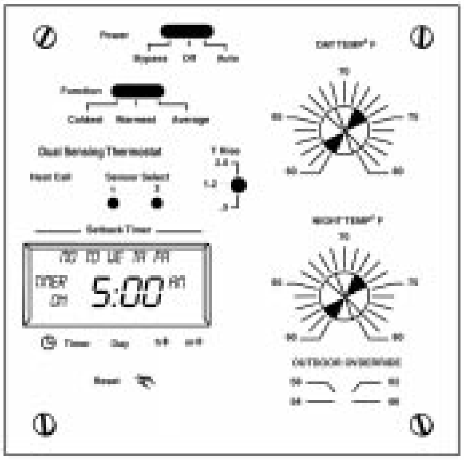
☐ (1) / ☐ (4) = ☐ yrs

ECM No. 11

INSTALL BOILER CONTROLS



Outdoor reset/cutout controls can save 7-9% of heating fuel use, with a payback of 1-2 years (DeCicco et al. 1995).



APPLICABILITY

- Multifamily buildings with central boilers
- Central boilers with no controls linked to outdoor temperature

DESCRIPTION

Boiler controls save energy by regulating the boiler so that it operates only when necessary. Some central boiler systems are totally uncontrolled, providing heat with no regard for how much is needed. In these developments, boilers are started up in the fall and remain on throughout the heating season until they are shut off in the spring. In other cases, the steam or hot water distribution system has apartment-level thermostatic controls, but the boiler runs constantly, even on warmer days when heat is not needed. Controls installed on the boilers can reduce energy waste by shutting off the boiler when the outdoor temperature reaches a specified temperature.

TYPES

The most basic type of boiler control is an outdoor reset/cutout control system, which senses outdoor temperature and cycles the boiler as needed to maintain an appropriate temperature of the water in the boiler. It shuts off or "cuts out" boiler operation when outdoor temperature exceeds a specified temperature. More advanced controls link boiler run time, water temperature, or steam valve openings to outdoor temperature (DeCicco et al. 1995).

MAINTENANCE ISSUES

When controls are installed on boilers, maintenance staff need to be trained in their use and operation. The user's manual should be available to maintenance staff.

IMPORTANT POINT TO CONSIDER

- Other Heating System ECMs should be evaluated in conjunction with this one.

Mini Case Study

The Housing Authority of the City of Trenton, New Jersey, installed boiler controls at three low-rise developments in the mid-1980s. The developments, which consisted of sixteen buildings and 402 apartments, were built in the 1950s and had steam heat.

A research team measured the energy consumption before the installation and monitored the consumption for three years after the installation to analyze the level of energy savings achieved. The analysis adjusted for the effects of weather. During the first year, the savings at the three developments were 31%, 22%, and 5%, with an average of 19%.

In the second year, the savings dropped off at the first two developments to 27% and 12%, respectively, while the savings rose to 14% at the third development. The decrease in savings at the first two developments is attributed to poor maintenance of the heating system and its controls. Proper maintenance is particularly important when mechanical measures such as controls or new systems are installed (Ritschard & McAllister 1992).

Cost/Benefit Worksheet
ECM No. 11: Install Boiler Controls

Step 1 Obtain total cost of installing boiler reset and cutout controls:

$

Step 2 Transfer the following information from the Survey:

5-14	**a** Annual heating fuel consumption:	Gas:		therms/yr
		Oil:		gal/yr
		Propane:		gal/yr
5-9	**b** Cost of heating fuel:	Gas:		$/therm
		Oil:		$/gal
		Propane:		$/gal

Step 3 Estimate annual energy savings:

		2a			
0.08	x		=		/yr

Step 4 Calculate annual cost savings:

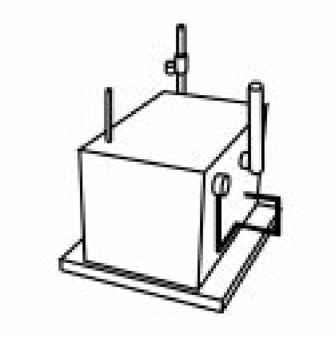
3		2b			
	x		=		$/yr

Step 5 Calculate payback period:

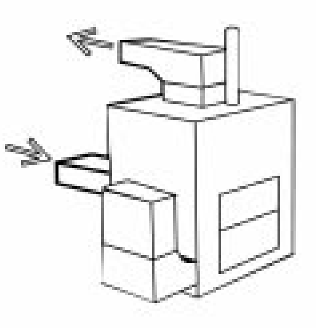
1		4			
	/		=		yrs

ECM No. 12

REPLACE INEFFICIENT HEATING PLANT



Replacing old, inefficient heating plant with high-efficiency condensing boilers or furnaces can save anywhere from 15% to 35% in single-family and multifamily housing.



APPLICABILITY

- Single-family and multifamily buildings
- Central boilers or furnaces with combustion efficiency of less than 60% (*see note, below*), if burner is forced-draft (power burner)
- Central boilers or furnaces with combustion efficiency of less than 75% (*see note, below*), if burner is natural draft (atmospheric burner)
- Electric heating systems in areas where electricity is expensive relative to other fuels

(Note: To determine combustion efficiency, a combustion efficiency test should be conducted in the Walkthrough in Chapter 4.)

DESCRIPTION

Replacing the old heating plant in a building can generate considerable savings if the existing equipment is inefficient and/or the fuel source is expensive compared to other options. A boiler or furnace near the end of its useful life is a particularly good candidate for replacement with high-efficiency equipment.

For this ECM, we discuss several options for replacing the heating plant. However, because it would be impractical to present a cost-effectiveness worksheet for every possible scenario, the cost-effectiveness worksheet for this ECM assumes that an old boiler or furnace is being replaced with a high-efficiency boiler or furnace. To evaluate the cost-effectiveness of other options, an experienced professional should be consulted.

Older furnaces and boilers may not operate as efficiently as they did when they were new, particularly if they have not been properly maintained over the years. In addition, because of advances in technology, new boilers and furnaces are now much more efficient than they used to be, presenting opportunities for savings on heating costs. Replacing the heating plant also provides an opportunity to switch to a less expensive fuel type. For example, where electricity is expensive relative to gas, it may be cost-effective to replace the heating system with a high-efficiency gas system. Heat pump technology has advanced over the past decade, making heat pumps an attractive option in some applications (see text box on next page).

Heat Pumps

A heat pump is a device that takes energy from an outdoor source such as the air, ground, or water and uses it to heat a building. Some heat pump systems can reverse this operation to provide cooling. Heat pumps provide heating and/or cooling most commonly through a forced-air distribution system. Over the years, heat pump technology has improved steadily, making heat pumps an attractive option for energy conservation when properly installed and maintained. About 19% of new single-family and multifamily homes built in the United States from 1991-1993 had heat pumps installed. The majority of heat pumps are in mild climate regions, with the highest concentration of heat pumps in the south.

The two most common types of heat pumps are air-source and ground-source (geothermal) heat pumps (see ECM No. 18). Air-source heat pumps account for 90 percent of all heat pumps bought in the United States. When properly maintained, air-source heat pumps use less than half the electricity of resistance heaters and can have a payback of under five years when replacing electric resistance systems in the coldest climates. Ground-source heat pumps are even more efficient, using about half the energy of air-source heat pumps.

Proper installation and regular maintenance are essential to achieve long-term performance of heat pumps but are often neglected in actual practice. One of the most common problems is duct leakage, which is a concern with any type of forced-air system, whether the heating plant is a furnace or a heat pump. Before installing a heat pump, duct leakage problems should be repaired (see ECM No. 17). Studies show that heat pumps are more complex to maintain than other types of heating equipment, and performance often deteriorates over time. In cold climates, there are additional maintenance concerns, such as snow covering the air intake, and problems with defrost cycle controls.

Source: E Source 1996.

TYPES

The options for the new heating plant depend on the old heating plant. Below, a discussion of options is organized according to the type of old heating plant.

Gas- or oil-fired boilers. Old boilers, which provide heat to a building through steam or hot water distribution systems, can be replaced with new, higher efficiency boilers. The most efficient type of boiler is a condensing boiler, which has become more familiar to the marketplace over the past decade. If the distribution system is steam, a conversion to a hot water distribution system should be considered (see ECM No. 16).

Gas- or oil-fired furnaces. Old fossil-fuel (gas, oil or propane) furnaces, which provide heat to a building as warm air distributed through ducts, can be replaced with new, high efficiency furnaces or with heat pumps (see text box and ECM No. 18).

Electric furnaces. Electric furnaces can be replaced with gas-fired furnaces or heat pumps (see text box and ECM No. 18). Replacing electric furnaces with gas-fired furnaces is recommended in areas where electricity is costly enough relative to gas to render the replacement cost-effective.

Electric resistance heating systems. Electric resistance heating can be replaced with individual gas heaters or heat pumps (see text box and ECM No. 18).

MAINTENANCE ISSUES

Before the installation of new heating plant, maintenance staff should make sure that all applicable architectural operations and maintenance steps have been taken (see the Operations and Maintenance section in this workbook). When an old heating plant is replaced, maintenance staff need to become familiar with the new system's operation. When high-efficiency boilers, furnaces, or heat pumps are installed, the HA needs to make arrangements to ensure proper routine maintenance of the new systems. In some cases, this may be best accomplished by securing a maintenance contract with the installer or another qualified firm.

Mini Case Study

Citizens Conservation Corporation (CCC) replaced existing boilers with high-efficiency condensing boilers in fifteen public and assisted multifamily housing developments in New England over the past decade. In all cases, boiler controls were also installed. In some cases, other measures such as air sealing, attic insulation, setback thermostats, or hot water-saving measures were also installed, and in three developments, steam distribution systems were converted to hot water systems.

For each development, CCC measured the energy consumption before and after the improvements. Total gas savings from the twelve developments that did not receive a steam-to-hot water distribution conversion ranged from 16% to 49% the first year, averaging 31% the first year and 29% in the most recent year consumption was monitored. (Where the distribution system was converted, savings averaged 65%.)

Where savings were lower than expected or decreased over time, problems stemmed from poor maintenance or faulty manufacturing. Condensing boilers are more complex than moderate-efficiency boilers and require proper maintenance by trained staff. And while strides have been made over the past decade in the manufacture of condensing boilers, the HA should be sure to choose a boiler with a proven track record (Nolden 1995).

IMPORTANT POINTS TO CONSIDER

- Prior to replacing major systems, a life-cycle cost analysis (LCCA) should be performed.
- A qualified engineer should be consulted in evaluating whether to replace the heating system and should be involved in the actual installation of a new heating plant.
- Special care should be taken to select a boiler or furnace that is properly sized for the building.
- High-efficiency boilers can be installed in a "modular" configuration with several smaller boilers instead of one large boiler. This approach makes it possible to operate only as many boilers as are needed to satisfy heating needs of a given day. By allowing some of the boilers to remain idle when not needed, energy savings can be realized.
- Other Heating System ECMs should be evaluated as alternatives or complements to this ECM.
- Before the installation of any new heating system, cost-effective architectural measures should be installed. This reduces the amount of heat required, and therefore may result in a smaller-capacity heating system being needed.

Cost/Benefit Worksheet
ECM No. 12: Replace Inefficient Heating Plant

Step 1 Obtain total cost of replacing the heating plant, including equipment, labor, structural alterations, etc.

	$

Step 2 Transfer the following information from the Survey:

5-14	**a** Annual heating fuel consumption:	Gas:		therms/yr
		Oil:		gal/yr
		Propane:		gal/yr
4-49	**b** Combustion efficiency of existing plant:			
5-9	**c** Cost of heating fuel:	Gas:		$/therm
		Oil:		$/gal
		Propane:		$/gal

Step 3 Estimate efficiency improvement (as a decimal fraction):

		2b			
0.93	-		=		

Step 4 Estimate annual energy savings:

3		2a			
	x		=		/yr

Step 5 Calculate annual cost savings:

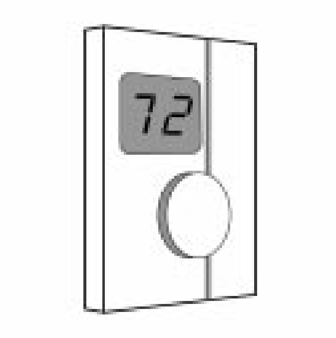
4		2c			
	x		=		$/yr

Step 6 Calculate payback period:

1		5			
	/		=		yrs

ECM No.
13

INSTALL SETBACK THERMOSTATS



Daytime Setting

A 5-degree drop in thermostat setting over the whole winter can significantly lower the heating bill—often by as much as 15%.

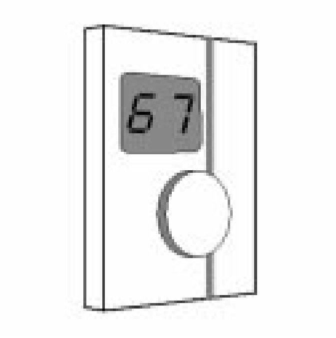
APPLICABILITY

- Single-family and multifamily buildings with non-setback thermostats

DESCRIPTION

Thermostats regulate temperature in a dwelling unit by controlling the heating system. A setback thermostat is a special type of wall-mounted thermostat that automatically lowers the temperature setting by 5-8 degrees at night, raising it back to the daytime setting in the morning. In addition to lowering the temperature at night, temperature-limiting setback thermostats limit daytime temperature to a predetermined setting (generally 72 degrees in family housing and 75 degrees in housing for the elderly). By lowering the temperature at night and limiting the daytime temperatures, setback thermostats save energy.

Resident energy education is crucial when replacing non-setback thermostats with temperature-limiting setback thermostats. At the time of installation, residents should be informed about why the thermostats were selected and how they operate. In buildings where heat had been unlimited, residents may find the lower temperatures uncomfortable at first, particularly if they are in the habit of keeping their windows open in the winter and wearing light clothing. A resident education program should stress the importance of keeping windows closed and should include information about how to dress appropriately at home in the winter.



Nighttime Setting

TYPES

There are two main types of setback thermostats: clock and light-sensitive. Clock-based setback thermostats automatically go into setback mode at a certain time at night and return to the higher setting at a certain time in the morning. Light-sensitive thermostats go into setback mode when the room becomes dark at night, after residents turn out their lights. One disadvantage of clock thermostats is that they need to be programmed to establish the daytime and nighttime settings. They also need to be changed twice a year for Daylight Savings time, and their batteries need to be replaced occasionally. Light-sensitive thermostats do not need to be programmed and do not require batteries. However, one disadvantage of light-sensitive thermostats is that residents may keep lights on to keep temperatures higher.

MAINTENANCE ISSUES

To ensure comfort, HAs should consider installing insulation and other architectural measures such as air sealing before installing temperature-limiting thermostats. After installation, maintenance staff should make sure residents do not tamper with the thermostats in an attempt to raise the temperature limit. If clock thermostats are installed, maintenance will need to access units at least twice a year to adjust for Daylight

Savings time and to change batteries when necessary. Maintenance staff should be trained in programming and setting the thermostats.

IMPORTANT POINTS TO CONSIDER

- Setback thermostats should be of the temperature-limiting type.
- Thermostats in common areas and apartments should be tamper-proof. The electronic temperature-limiting type is more resistant to tampering than the mechanical type.
- Thermostats should be selected for ease of operation. For housing with elderly residents, thermostats with a large digital read-out should be selected (half-inch digits are best for elderly residents).
- Thermostats should be installed in a convenient, accessible location. They should be placed so that elderly residents do not have to bend down or reach up too far and disabled residents can access them readily. The standard location for thermostats is 54 inches from the floor.
- Thermostats in common areas should not be accessible to residents.
- HAs with heat pumps should make sure the thermostats selected are compatible with heat pump systems.

Cost/Benefit Worksheet
ECM No. 13: Install Setback Thermostats

Step 1 Obtain total cost of installing night setback thermostats.

☐ $

Step 2 Transfer the following information from the Survey:

4-8 **a** Heating degree-day zone: ☐ DDZ

5-14 **b** Annual heating fuel consumption:

Gas:	☐	therms/yr
Oil:	☐	gal/yr
Electric:	☐	kWh/yr
Propane:	☐	gal/yr

5-9 **c** Cost of heating fuel:

Gas:	☐	$/therm
Oil:	☐	$/gal
Electric:	☐	$/kWh
Propane:	☐	$/gal

Step 3 Obtain the following savings factor from Table 1:

Table 1 Savings factor: ☐

Step 4 Estimate annual energy savings:

3 ☐ x 2b ☐ = ☐ /yr

Step 5 Calculate annual cost savings:

4 ☐ x 2c ☐ = ☐ $/yr

Step 6 Calculate payback period:

1 ☐ / 5 ☐ = ☐ yrs

ECM No. 13: Install Setback Thermostats

Table 1: Savings Factors for Installing Setback Thermostats Heating Energy Savings from Nightly Setback of 8 Degrees

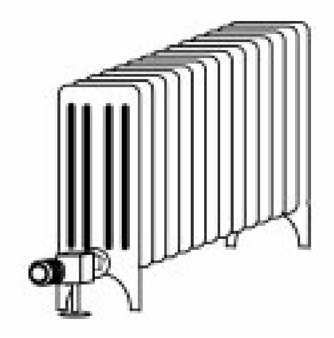
Instructions:

1) Find the appropriate heating degree day zone (DDZ) (see Step 2).
3) Select the appropriate savings factor and transfer it to Step 3.

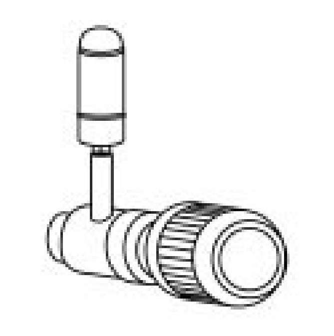
Heating DDZ	**Savings Factor**
2.50 or less	.15
2.51-2.80	.12
2.81-3.40	.10
3.41-4.10	.093
4.11-4.80	.08
4.81-5.50	.075
5.51 or more	.072

ECM No.
14

INSTALL RADIATOR CONTROLS



Thermostatic radiator valves can save up to 15% of heating energy use when installed in buildings where overheating is a problem (NYSERDA 1995).



APPLICABILITY

- Multifamily buildings with hot water or steam heat

DESCRIPTION

A major source of energy waste in hot water- and steam-heated buildings is overheating. In some buildings, maintenance staff have to overheat some apartments to ensure that other apartments get enough heat. The residents in the overheated apartments are forced to open their windows to relieve the overheating. Radiator controls, also known as thermostatic radiator valves, can eliminate a great deal of energy waste by solving the overheating problem. Energy savings from this ECM will be highest in those buildings where some apartments are overheated.

A thermostatic radiator valve is a knob connected to the radiator that regulates the amount of heat that the radiator gives off. Typically, the valve has a range of settings that correspond to different temperatures, enabling the resident to set the control to a specific temperature. By giving the residents control over the temperature in their apartment (up to a maximum level, which the HA can establish), radiator controls increase the comfort of the residents as well as save energy.

MAINTENANCE ISSUES

Before thermostatic radiator valves are installed in steam-heated buildings, maintenance staff should make sure the distribution system is properly balanced (refer to the Operations and Maintenance Checklist in Chapter 6). Once the radiator valves are installed, maintenance staff should be prepared to help answer any questions residents may have about how to operate the controls.

IMPORTANT POINTS TO CONSIDER

- Results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost-effectiveness analysis results in a payback of 15 years or less, a more detailed analysis should be performed.
- Radiator controls are most likely to be cost-effective when installed in buildings with apartments that are overheated.
- Residents should be informed about the benefits of the radiator valves in terms of increased control and comfort, and how to operate them to save energy and stay comfortable.
- An engineer should be involved in the addition of radiator controls to steam systems.

Cost/Benefit Worksheet
ECM No. 14: Install Radiator Controls

Step 1 Obtain total cost of individual radiator controls or zone controls:

☐ $

Step 2 Transfer the following information from the Survey:

4-9 **a** Heating season hours: ☐ Hrs

4-46 **b** Number of radiators in the development: ☐

5-9 **c** Cost of heating fuels:

Gas: ☐ $/therm

Oil: ☐ $/gal

Propane: ☐ $/gal

Step 3 Obtain the following value from Table 1:

Table 1 Savings factor for your heating fuel: ☐

Step 4 Estimate annual energy savings:

2a ☐ x 2b ☐ x 3 ☐ = ☐ /yr

Step 5 Calculate annual cost savings:

4 ☐ x 2c ☐ = ☐ $/yr

Step 6 Calculate payback period:

1 ☐ / 5 ☐ = ☐ yrs

ECM No. 14: Install Radiator Controls

Table 1: Savings Factors per Radiator

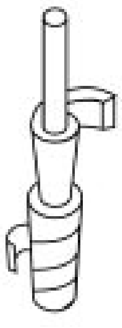
Instructions:

1) Find the fuel type used for heating.
2) Select the savings factor for that fuel type and transfer it to Step 3.

Fuel Type	Savings Factor
Gas	0.0064
Oil	0.0044
Propane	0.0070

ECM No.
15

INSULATE HOT WATER OR STEAM PIPES



APPLICABILITY

- Single-family and multifamily buildings with hot water or steam heating systems
- Hot water or steam pipes that are not insulated

DESCRIPTION

Heat loss from heating system distribution pipes in unheated spaces can be substantial. All hot water or steam pipes running through unheated spaces, such as the basement, crawlspace, or the mechanical room, should be insulated. If piping is already insulated but the insulation is badly worn, it should be replaced.

Pipe insulation can be either rigid fiberglass or flexible foam. Flexible foam insulation is generally less expensive than fiberglass, but it does not last as long and can become brittle and ineffective at very high temperatures.

MAINTENANCE ISSUES

Once installed, pipe insulation requires very little maintenance and should last many years. Maintenance staff should periodically check the insulation for unraveling or deterioration. Unraveling insulation should be reaffixed, and deteriorated insulation should be replaced.

IMPORTANT POINTS TO CONSIDER

- It is important to select pipe insulation with the correct internal diameter. Gaps between the insulation and piping will decrease the insulating value.
- Pipes that are designed to provide heat to a space, such as radiators, should not be insulated.
- Pipe insulation should be heat resistant and should be able to withstand the maximum temperature of the pipe.

Cost/Benefit Worksheet
ECM No. 15: Insulate Hot Water or Steam Pipes

Step 1 Obtain total cost of insulating steam and hot water pipes (total for all pipe sizes)

	$

Step 2 Transfer the following information from the Survey:

4-45		Heat distribution type (steam or hot water)		
4-48	**a**	Linear feet of uninsulated 3/4" diameter pipe:		ft.
4-48	**b**	Linear feet of uninsulated 1" diameter pipe:		ft.
4-48	**c**	Linear feet of uninsulated 1 1/2" diameter pipe:		ft.
4-48	**d**	Linear feet of uninsulated 2" diameter pipe:		ft.
4-48	**e**	Linear feet of uninsulated 3" diameter pipe:		ft.
4-48	**f**	Linear feet of uninsulated 4" diameter pipe:		ft.
4-48	**g**	Linear feet of uninsulated 6" diameter pipe:		ft.
4-9	**h**	Cost of heating fuel: Gas:		$/therm
		Oil:		$/gal
		Propane:		$/gal

Step 3 Obtain the following value from Table 1: Savings factors for heat distribution type (steam or hot water) and pipe diameter:

Table 1	**a**	3/4" diameter pipe:	
Table 1	**b**	1" diameter pipe:	
Table 1	**c**	1 1/2" diameter pipe:	
Table 1	**d**	2" diameter pipe:	
Table 1	**e**	3" diameter pipe:	
Table 1	**f**	4" diameter pipe:	
Table 1	**g**	6" diameter pipe:	

Step 4 Estimate annual energy savings:

a	3/4" diameter pipe:	2a	x	3a	=		/yr
b	1" diameter pipe:	2b	x	3b	=		/yr
c	1 1/2" diameter pipe:	2c	x	3c	=		/yr
d	2" diameter pipe:	2d	x	3d	=		/yr
e	3" diameter pipe:	2e	x	3e	=		/yr
f	4" diameter pipe:	2f	x	3f	=		/yr
g	6" diameter pipe:	2g	x	3g	=		/yr
h	Total (add all results):						/yr

Step 5 Calculate annual cost savings:

4h	x	2h	=	$/yr

Step 6 Calculate payback period:

1	/	5	=	yrs

ECM No. 15: Insulate Hot Water or Steam Pipes

Table 1: Savings Factors for Insulating Pipes

Instructions:

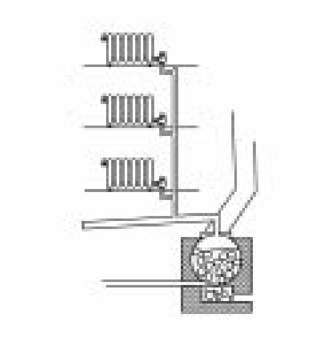
1) Find heating distribution type (steam or hot water) (see Step 2).
2) Find pipe size (diameter) (see Step 2).
3) Find fuel type.
3) Select the appropriate savings factor and transfer it to Step 3.

Heat Distribution Type	**Pipe Size**	**Fuel Type**		
		Gas	**Oil**	**Propane**
Hot water	3/4"	1.02	0.73	1.11
	1"	1.28	0.91	1.40
	1 1/2"	2.10	1.50	2.29
	2"	2.58	1.84	2.82
	3"	3.76	2.69	4.10
	4"	4.74	3.39	5.23
	6"	6.82	4.87	7.45
Steam	3/4"	2.16	1.54	2.36
	1"	2.68	1.91	2.93
	1 1/2"	3.96	2.83	4.32
	2"	4.90	3.50	5.35
	3"	7.08	5.06	7.73
	4"	8.96	6.40	9.78
	6"	13.12	9.37	14.32

Savings factors assume pipes are hot 2,000 hours per year. Actual savings will differ in warmer and cooler climates.

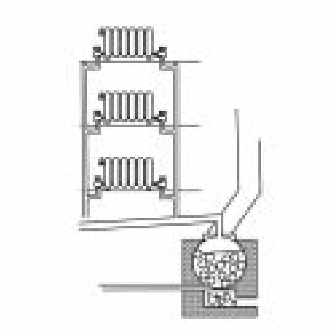
ECM No.
16

CONVERT STEAM HEATING TO HOT WATER DISTRIBUTION



One-Pipe Steam System

Conversions of two-pipe steam systems to hot water systems in cold-climate multifamily buildings have been shown to save 16% to 39%, with an average payback of 12 years. Conversions of single-pipe steam systems have been shown to save 13% to 27%, but cost about twice as much as two-pipe conversions, yielding an average payback of over 30 years (Lobenstein & Hewitt 1995).



Two-Pipe Steam System

APPLICABILITY

- Multifamily buildings with steam heat

DESCRIPTION

Steam-heated buildings use more energy than buildings with hot water distribution systems. This is because with steam heat, the boiler must heat the water to the point at which it becomes steam, which takes much more energy than heating water just enough for a hot water system. In addition, steam-heated buildings often have the problem of uneven heating, which is a big cause of energy waste in multifamily buildings because maintenance staff have to overheat some apartments to provide adequate heat to others. Therefore, converting a steam distribution system to hot water can save energy as well as reduce problems with maintenance and uneven heating of rooms or apartments (Lobenstein 1988).

There are two types of steam heating systems: one-pipe and two-pipe steam systems. With one-pipe systems, steam travels from the boiler to the radiator, fills the radiator, and condenses, and this condensed water (condensate) then goes back out of the radiator through the same pipe, eventually to return to the boiler. In two-pipe steam systems, the steam enters the radiator through one pipe and leaves as condensate through another pipe to return to the boiler. The radiators of two-pipe steam systems are very similar to those of hot water systems and can be kept and used in the new system, with a few minor changes. Single-pipe steam radiators, on the other hand, require the expensive addition of a second pipe, during a conversion. For this reason, it is generally more cost-effective to convert a two-pipe steam distribution system than a single-pipe system.

When converting a system from steam to hot water, the boiler does not necessarily have to be replaced. If the existing boiler is in good condition and able to withstand the maximum water pressure of the proposed system, then it can be converted to be compatible with the new system rather than replaced (Lobenstein 1988). However, if the existing boiler is old, inefficient, and oversized, as is often the case, replacing the boiler may be the best option.

MAINTENANCE ISSUES

Steam-to-hot water conversions generally reduce the amount of maintenance needed because hot water systems require less maintenance than steam systems, and residents have fewer complaints about overheating or underheating. Nevertheless, the maintenance staff will need to become familiar with the operation of the new system and any controls that are installed.

IMPORTANT POINT TO CONSIDER

- Pipes should be pressure tested before conversion to reveal any steam leaks.

Mini Case Study

In 1990, the Housing Authority of Lawrence, Massachusetts, hired an energy services company to make energy conservation improvements at a 292-unit, multi-building low-rise development. The primary energy conservation measure was conversion of the central steam distribution system to high-efficiency condensing boilers with hot water distribution. Other measures included boiler controls, new domestic hot water systems, and thermostatic radiator controls.

The total cost of the improvements was $2.66 million, funded through a $1 million energy performance contract supplemented by a state grant and weatherization funds. Since the installation, savings have averaged about 68%, or $230,000 annually. The payback is estimated at about 11 years.

It is important to note that before these improvements, the housing authority installed high-quality replacement windows, which generated no savings because residents had no control over the heat in their apartments and had to open their windows to keep from overheating. With the new heating system, residents no longer had to keep their windows open, so these windows helped save energy by reducing heat loss (Nolden 1995).

Cost/Benefit Worksheet
ECM No. 16: Convert Steam Heating to Hot Water Distribution

Step 1 Obtain total cost of converting from steam to hot water distribution:

☐ $

Step 2 Transfer the following information from the Survey:

5-14 **a** Annual heating fuel consumption:
Gas: ☐ therms/yr
Oil: ☐ gal/yr
Propane: ☐ gal/yr

5-9 **b** Cost of heating fuel:
Gas: ☐ $/therm
Oil: ☐ $/gal
Propane: ☐ $/gal

Step 3 Estimate annual energy savings:

0.20 x ☐ (2a) = ☐ /yr

Step 4 Calculate annual cost savings:

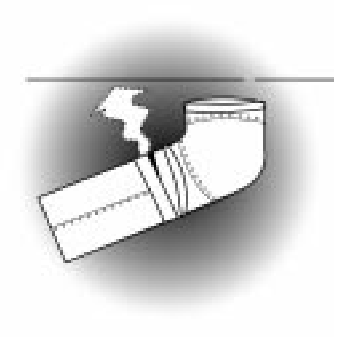
☐ (3) x ☐ (2b) = ☐ $/yr

Step 5 Calculate payback period:

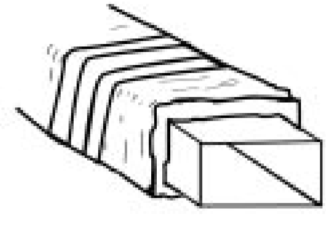
☐ (1) / ☐ (4) = ☐ yrs

ECM No. 17

SEAL AND INSULATE DUCTS



Duct leaks can raise a home's heating and cooling costs by 20-30%.



APPLICABILITY

- Single-family and multifamily buildings with forced-air heating or cooling

DESCRIPTION

In buildings with forced-air heating (or cooling) systems, warm (or cold) air is distributed to each room through flexible or sheet metal ductwork. The air travels from the furnace, heat pump, or air conditioner through a *supply duct* to each room, and it returns to the furnace or heat pump through a *return duct* to be heated (or cooled) again.

Forced-air distribution systems can lose energy in two ways. First, uninsulated ducts running through unconditioned spaces such as basements, crawlspaces, and attics, lose energy through conduction. Second, ducts lose energy through leaks, or convection. Studies show that duct leaks typically raise a home's heating and cooling costs by 20% to 30%. That figure can double in homes where ducts are not insulated ("Discovering Ducts" 1993).

When supply ducts leak to an unconditioned space, less air reaches the room or apartment (the conditioned space). To make matters worse, because not enough air is reaching the conditioned space, the room or apartment may become depressurized, which causes outside air to rush into the space through any path it can find, such as around windows or doors. The furnace (or air conditioner) then has to work harder to heat or cool the space.

When return ducts have leaks, air from unconditioned spaces enters the return duct, reducing the amount of heated (or cooled) air that can enter it through the return grille. Because air cannot leave the room through the grille, the room or apartment becomes pressurized, and the air, seeking another "escape route," squeezes its way to the outside. Not only do leaky return ducts waste energy, but they can cause indoor air quality problems as fumes from combustion appliances, vapors from household cleaners stored in the basement, and soil gases such as methane enter the conditioned space.

To cut energy waste, ducts should be sealed to eliminate any leaks, and then wrapped with insulation. The first step to sealing ducts is to diagnose where the leaks are. This process requires diagnostic tools such as blower doors or pressurization devices and should be done by experienced technicians.

MAINTENANCE ISSUES

Air filters should be changed frequently during the heating (or cooling) season to maintain adequate air flows.

IMPORTANT POINTS TO CONSIDER

- Duct sealing must be done by trained technicians. An untrained person may make a bad situation worse by repairing only the obvious leaks, leaving serious pressure imbalances ("Discovering Ducts" 1993).
- Ducts should be sealed with mastic, never with duct tape. Insulation should then be sealed over the ducts to prevent condensation.

Cost/Benefit Worksheet
ECM No. 17: Seal and Insulate Ducts

This worksheet calculates the heating savings from sealing and insulating ducts. If central air conditioning is also provided, the payback can be expected to be quicker.

Step 1 Obtain total cost of sealing and insulating ducts:

☐ $

Step 2 Transfer the following information from the Survey:

5-14	**a** Annual heating fuel consumption:	Gas:	☐	therms/yr
		Oil:	☐	gal/yr
		Electric:	☐	kWh/yr
		Propane:	☐	gal/yr
5-9	**b** Cost of heating fuel:	Gas:	☐	$/therm
		Oil:	☐	$/gal
		Electric:	☐	$/kWh
		Propane:	☐	$/gal

Step 3 Estimate annual energy savings:

0.16 x ☐ (2a) = ☐ /yr

Step 4 Calculate annual cost savings:

☐ (3) x ☐ (2b) = ☐ $/yr

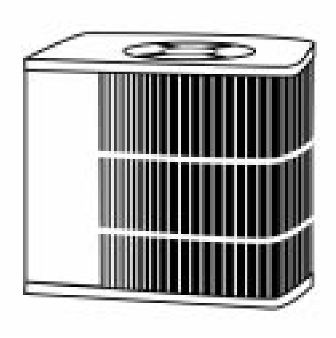
Step 5 Calculate payback period:

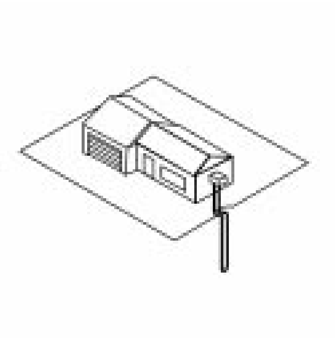
☐ (1) / ☐ (4) = ☐ yrs

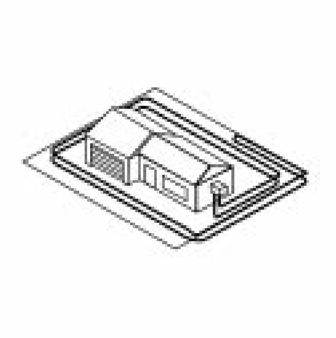
$$$

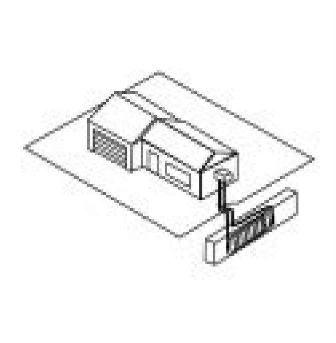
ECM No. 18

INSTALL GEOTHERMAL HEAT PUMPS









APPLICABILITY

- Single-family and low-rise multifamily buildings with old, inefficient heating systems, especially in areas where cooling is also needed

DESCRIPTION

Geothermal heat pumps, also called ground-source heat pumps, are among the most efficient heating and cooling technologies currently available. They can reduce energy consumption by 30% to 60% for heating and 10 to 25 percent for cooling, compared to older, inefficient systems (Rieger 1994). Because they are so efficient, geothermal heat pump systems pay for themselves relatively quickly, typically in three to eight years. Geothermal heat pumps are generally most cost-effective when they replace electric resistance heating systems and inefficient air conditioning systems. The cost-benefit worksheet for this ECM assumes that the existing heating system is electric.

A geothermal heat pump is a device that extracts available heat from the ground, ground water, or surface water and uses it to heat a building. Even on cold days, these sources contain some heat, and the heat pump is able to extract this heat and transfer it indoors. A heat pump can reverse this operation to provide cooling in the summer. Air-source heat pumps, which are more common than geothermal heat pumps but less efficient, work in much the same way, except they extract heat from the outside air rather than the ground or water. Heat pumps provide heating and/or cooling most commonly through a forced-air distribution system.

TYPES

Geothermal heat pumps vary according to the heat source (ground, groundwater, or surface water). Heat pumps that use the ground as the heat source are sometimes called “ground-coupled” heat pumps. Heat pumps that use groundwater are sometimes called “groundwater-source” heat pumps. Groundwater heat pumps and heat pumps that use surface water are both sometimes called “water-to-air” heat pumps.

A geothermal heat pump extracts heat from the soil or water using an underground piping loop. This loop can be closed or open. In a closed-loop system, a loop of plastic piping is buried near the building, and antifreeze is circulated in the loop to gain heat from the ground. In an open-loop system, water from a well or nearby lake or river is pumped through a heat exchanger and then discharged back into the environment. Open-loop systems have several disadvantages, such as build up of algae and minerals inside the heat exchanger and freezing surface water in the winter (E Source 1996). For these reasons, a closed-loop system is generally recommended.

With closed-loop systems, the loop can be vertical, extended 200 to 300 feet below the surface, or horizontal, running as little as four feet below the surface in shallow trenches. A vertical loop is similar to a well, and a fluid in the pipe loop circulates and extracts the heat from the groundwater or soil. Horizontal loops require a larger area of land and function best in moist soil (E Source 1996). The most appropriate type of loop depends on the amount of available land and the type of soil and rock around the development.

Some geothermal heat pumps use a heat exchange device called a "desuperheater" to heat domestic hot water using waste heat. Desuperheaters are particularly effective in regions with high air conditioning loads.

Mini Case Study

At the HUD-owned Park Chase Apartments in Tulsa, Oklahoma, geothermal heat pumps were installed in 1993 to replace the 27-year-old gas boilers and electric chillers. The contractor evaluated the costs and paybacks of several types of heating and cooling systems for the 64-building, 348-unit development: individual gas furnaces and air conditioners; individual electric furnaces and air conditioners; a centralized system with boilers and chillers; air-source heat pumps; and geothermal heat pumps. In the evaluation, the geothermal heat pumps were determined to be the most attractive choice, with higher projected energy savings and a lower first cost than any of the other systems when incentives from the local utility company were taken into account The contractor then sized and installed individually metered heat pumps for each apartment.

The total cost of the improvements, which included new double-pane windows, air sealing, and increased attic insulation, was $396,000 after factoring in $133,000 worth of incentives from the local utility. Since the installation, the heating and cooling costs have been about 45% lower with the new system. Operating cost savings are nearly $50,000 per year, which means a payback of about eight years for the entire package of measures.

The installation was not trouble-free, however. Because local code would not allow the use of plastic pipes inside the buildings, copper pipes were used inside the buildings. The antifreeze used in the system (called GS-4) caused corrosion in the copper pipes, and leaks developed after two years. To remedy the problem, the system was drained and flushed, and a different type of antifreeze (propylene glycol) replaced the corrosive GS-4. Since then, there have been no other problems with the system.

(*Source:* International Ground-Source Heat Pump Association).

MAINTENANCE ISSUES

Proper installation and regular maintenance are essential to achieve long-term performance of heat pumps. Air supply vents should be kept in the open position with heat pump systems because blocking off vents can impair the system's performance. Filters on air vents should be checked on a regular basis for dirt build-up and should be cleaned or replaced as needed. Fan motors should be lubricated and the blower unit and drive belts adjusted according to manufacturer's instructions. Heat exchanger coils should be cleaned with a vacuum or brush when dirt builds up.

IMPORTANT POINTS TO CONSIDER

- Prior to replacing major systems, a life-cycle cost analysis (LCCA) should be performed.
- Geothermal heat pump systems should be selected and designed by an experienced professional. The contractor should be certified to install geothermal heat pumps by a recognized trade association such as the International Ground Source Heat Pump Association.
- The contractor should be certified to handle the refrigerant used in geothermal heat pump systems and should have refrigerant recovery equipment. Uncertified contractors should be avoided.
- Heat pump performance depends on the proper selection and operation of thermostats that are compatible with the heat pump system.
- As with any type of new heating system, heat pump systems should be sized properly. The contractor should perform a room-by-room heat loss calculation rather than using a rough estimate or rule of thumb. In addition, the loop should also be sized properly to ensure cost-effectiveness.
- Some local jurisdictions may not allow antifreeze solutions to be used in closed-loop systems.
- One of the largest sources of inefficiency in any heating or cooling system with forced-air distribution system is duct leakage, whether the heating plant is a furnace or a heat pump. Before installing a heat pump, the duct system should be checked and any duct leakage problems should be repaired (see ECM No. 17).
- Heat pumps require proper maintenance to ensure good performance and long equipment life. Maintenance staff should receive training on the operation and maintenance of these systems, and the HA may want to consider hiring a qualified contractor to provide maintenance service.
- HAs should select heat pumps that are appropriate for their regional climate. Heating efficiency of heat pumps is rated with the Heating Seasonal Performance Factor (HSPF), while heating and cooling efficiency is rated with the Seasonal Energy Efficiency Ratio (SEER). HAs in a particularly hot climate should choose a heat pump that has a high SEER rating. HAs in colder climates should choose a heat pump that has a high HSPF rating.
- Some geothermal heat pumps are available with an option called a "desuperheater" that provides domestic hot water, which can result in lower energy costs for hot water.
- Geothermal heat pumps are not appropriate for high-rise buildings. HAs may want to consider air-source heat pumps for their high-rise buildings, particularly those with electric heat.
- Before the installation of any new heating system, cost-effective architectural measures should be installed. This reduces the amount of heat required, which may result in a smaller-capacity heating system being required.

Cost/Benefit Worksheet
ECM No. 18: Install Geothermal Heat Pumps

This worksheet calculates the heating savings from installing geothermal heat pumps in electrically heated developments. If cooling is also provided, the payback can be expected to be quicker.

Step 1 Obtain total cost of installing geothermal heat pumps:

	$

Step 2 Transfer the following information from the Survey:

5-14	**a** Average annual electricity used for heating		kWh/yr
5-9	**b** Cost of electricity:		$/kWh

Step 3 Estimate annual energy savings:

		2a			
0.45	x		=		kWh/yr

Step 4 Calculate annual cost savings:

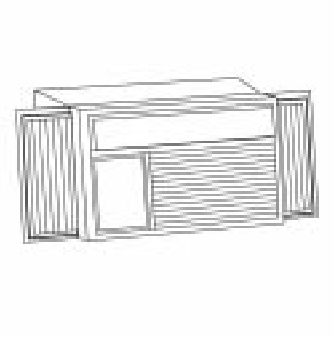
3		2b			
	x		=		$/yr

Step 5 Calculate payback period:

1		4			
	/		=		yrs

ECM No. 19

REPLACE INEFFICIENT AIR CONDITIONERS



APPLICABILITY

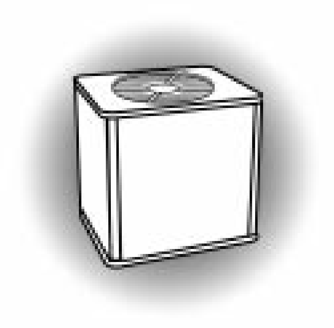
- Single-family and multifamily buildings with older central air conditioners or window AC units

DESCRIPTION

Due to age or lack of proper maintenance, or both, older air conditioners may not operate as efficiently as they did when they were new. In addition, technological developments have produced great advances in air conditioning efficiency, making many older air conditioning systems obsolete. Replacing older air conditioning units can generate substantial electricity and cost savings for the HA. Both central air conditioners and window AC units should be analyzed for replacement.

> In Tulsa, Oklahoma, replacement window air conditioners generated savings of 1,503 kWh, or $107, per year when installed in single-family homes with *high* air conditioning electricity consumption. At an installed cost of $786 per unit, the payback was just over 7 years. However, replacement units installed in homes with *average* air conditioning consumption produced savings of only 535 kWh, or $38, for a payback of 19 years (Ternes 1993).

Residents who own AC units should be encouraged to replace their units with newer, more efficient units. The HA may decide to purchase efficient units in volume and make them available to the residents for purchase.



The level of savings depends on the efficiency of the old unit, the efficiency of the new unit, and the number of hours air conditioning is used during summer days. Savings will be highest if a highly efficient unit replaces a very inefficient unit that is heavily used.

MAINTENANCE ISSUES

Window AC units should be removed in the winter months. If this is not possible or practical, they should be covered with air conditioner covers.

IMPORTANT POINTS TO CONSIDER

- Results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost-effectiveness analysis results in a payback of 15 years or less, a more detailed analysis should be performed.
- Federal regulations require that all air conditioning units be labeled with an efficiency rating (EER). Those units with the highest EER should be selected.
- Care should be taken to select a unit that is appropriately sized. Installing oversized air conditioners will result in energy waste.

Cost/Benefit Worksheet
ECM No. 19: Replace Inefficient Air Conditioners

Step 1 Obtain total cost of replacing existing air conditioners with efficient units:
$

Step 2 Transfer the following information from the Survey:
4-55 **a** Power requirement of existing AC units: Watts
4-56 **b** Cooling capacity of existing AC units: Btu
4-54 **c** Number of existing AC units:
5-9 **d** Cost of electricity: $/kWh

Step 3 Obtain the following value from Table 1:
Table 1 Annual cooling hours (do not multiply by 1000):

Step 4 Calculate existing energy efficiency rating (EER):
2b / 2a =

Step 5 Calculate existing energy use per air conditioner:
3 x 2b / 4 = kWh/yr

Step 6 Calculate new energy use per air conditioner:
3 x 2b / 9.5 = kWh/yr

Step 7 Estimate annual energy savings:
5 - 6 x 2c = kWh/yr

Step 8 Calculate annual cost savings:
7 x 2d = $/yr

Step 9 Calculate payback period:
1 / 8 = yrs

ECM No. 19: Replace Inefficient Air Conditioners

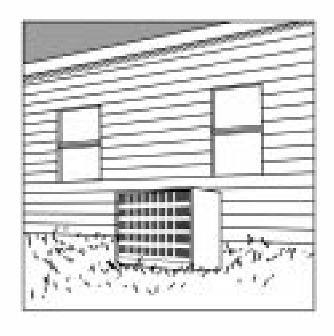
Table 1: Annual Cooling Hours

Instructions:
1) Locate the closest major city to your location.
2) Select the appropriate cooling hours and transfer to Step 3.

Major City	Cooling Hours (in thousands)
Albuquerque, NM	1.4
Atlantic City, NJ	0.7
Birmingham, AL	1.5
Boston, MA	0.8
Burlington, VT	0.4
Charlotte, NC	0.9
Chicago, IL	0.8
Cleveland, OH	0.6
Cincinnati, OH	1.2
Columbia, SC	1.3
Corpus Christi, TX	2.2
Dallas, TX	1.4
Denver, CO	0.6
Des Moines, IA	0.8
Detroit, MI	0.9
Duluth, MN	0.4
El Paso, TX	1.2
Honolulu, HI	2.5
Indianapolis, IN	1.1
Little Rock, AR	2.0
Minneapolis, MN	0.6
New Orleans, LA	2.2
New York, NY	0.8
Newark, NJ	0.7
Oklahoma City, OK	1.6
Pittsburgh, PA	1.1
Rapid City, SD	0.9
St. Joseph, MO	1.4
St. Petersburg, FL	2.0
San Diego, CA	1.4
Savannah, GA	1.3
Seattle, WA	0.8
Syracuse, NY	0.6
Trenton, NJ	0.9
Tulsa, OK	1.8
Washington, DC	1.0

ECM No. 20

INSTALL SWAMP COOLERS



Swamp coolers use 60%-80% less electricity than air conditioners and can pay for themselves in less than 5 years.

APPLICABILITY

- Single-family and multifamily buildings with old, inefficient cooling systems in warm, dry climates

DESCRIPTION

Swamp coolers, also called “direct evaporative coolers,” have long been used to provide cooling in the hot, dry Southwest. Because they use 60% to 80% less electricity than standard air conditioners, the payback for swamp coolers is typically six months to five years compared to conventional air conditioning units, depending on the climate (E Source 1995).

Swamp coolers include a fan, a cellulose pad or filter, and a small water pump. The pump supplies water to the pad, which keeps it wet, and the fan blows hot, relatively dry air through the pad. The air is cooled as is passes through the pad and is then supplied to areas where cooling is desired. Because the process also increases the humidity of the air, swamp coolers are not appropriate for hot, humid climates where extra humidity would be unwelcome.

MAINTENANCE ISSUES

Swamp coolers require routine maintenance to prevent microbial growth in the system, which can cause a fishy or musty odor. The entire cooling water loop should be cleaned and flushed on a monthly basis to avoid unpleasant odors. Cooler sumps should be completely emptied at the end of the cooling season to remove sediment and microbial growth. Evaporative media should be allowed to dry out completely every 24 hours to keep microbial growth in check (E Source 1995). Filters or pads should be cleaned or replaced frequently (depending on whether they are disposable or permanent). Finally, the damper for the air intake duct should be closed before the heating season and opened before the cooling season. If the damper is left open in the winter, it is a major source of air infiltration and heat loss.

IMPORTANT POINTS TO CONSIDER

- Proper maintenance of swamps coolers is essential.
- Swamp coolers are not appropriate for humid climates because they increase the humidity of the air.
- When operating a swamp cooler, a window should be kept open to ensure proper operation and to prevent moisture buildup in the cooled space.
- Swamp coolers and air conditioners should never be used together to cool the same space at the same time. The air conditioner will have to work twice as hard to remove the humidity added by the evaporative cooler, resulting in high energy usage.
- Some utilities offer incentives for the purchase of evaporative coolers. HAs in the Southwest should contact their local electric utility to determine if any incentives are offered.

Cost/Benefit Worksheet
ECM No. 20: Install Swamp Coolers

Step 1 Obtain total cost of installing swamp coolers:

			$

Step 2 Transfer the following information from the Survey:

4-55	**a**	Power requirement of existing AC units:		Watts
4-56	**b**	Cooling capacity of existing AC units:		Btu
4-54	**c**	Number of existing AC units:		
5-9	**d**	Cost of electricity:		$/kWh

Step 3 Obtain the following value from Table 1:

Table 1 Annual cooling hours (do not multiply by 1000):

Step 4 Calculate existing EER:

2b / 2a =

Step 5 Calculate existing energy use per unit:

3 x 2b / 4 = kWh/yr

Step 6 Calculate new energy use per unit:

5 x 0.3 = kWh/yr

Step 7 Estimate annual energy savings:

5 - 6 x 2c = kWh/yr

Step 8 Calculate annual cost savings:

7 x 2d = $/yr

Step 9 Calculate payback period:

1 / 8 = yrs

ECM No. 20: Install Swamp Coolers

Table 1: Annual Cooling Hours

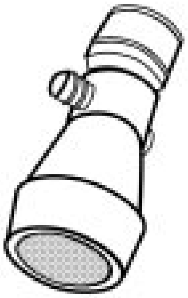
Instructions:
1) Locate the closest major city to your location.
2) Select the appropriate cooling hours and transfer to Step 3.

Major City	**Cooling Hours (in thousands)**	**Major City**	**Cooling Hours (in thousands)**
Albuquerque, NM	1.4	Indianapolis, IN	1.1
Atlantic City, NJ	0.7	Little Rock, AR	2.0
Birmingham, AL	1.5	Minneapolis, MN	0.6
Boston, MA	0.8	New Orleans, LA	2.2
Burlington, VT	0.4	New York, NY	0.8
Charlotte, NC	0.9	Newark, NJ	0.7
Chicago, IL	0.8	Oklahoma City, OK	1.6
Cleveland, OH	0.6	Pittsburgh, PA	1.1
Cincinnati, OH	1.2	Rapid City, SD	0.9
Columbia, SC	1.3	St. Joseph, MO	1.4
Corpus Christi, TX	2.2	St. Petersburg, FL	2.0
Dallas, TX	1.4	San Diego, CA	1.4
Denver, CO	0.6	Savannah, GA	1.3
Des Moines, IA	0.8	Seattle, WA	0.8
Detroit, MI	0.9	Syracuse, NY	0.6
Duluth, MN	0.4	Trenton, NJ	0.9
El Paso, TX	1.2	Tulsa, OK	1.8
Honolulu, HI	2.5	Washington, DC	1.0

DOMESTIC HOT WATER ECMS

ECM No. 21

INSTALL WATER-EFFICIENT SHOWERHEADS AND FAUCET AERATORS



APPLICABILITY

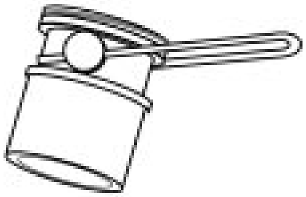
- Single-family and multifamily buildings that do not have water-efficient showerheads and faucet aerators

DESCRIPTION

About half the hot water consumed in a typical household is for bathing, and another 7% to 14% is used in the sink (E Source 1991). By reducing the flow of water coming from the shower and faucets, water-efficient showerheads and faucet aerators can generate significant energy savings at low cost and with easy installation. In addition to saving energy, showerheads and aerators save on water and sewer costs, which are rising in many areas.

Water-efficient shower-heads can reduce hot-water consumption for bathing by 30%, while still providing satisfactory water pressure. A high-quality low-flow showerhead costs $10 to $20 and will pay for itself in energy savings in less than a year (National Renewable Energy Laboratory 1995).

Older showerheads deliver as much as 5 to 10 gallons per minute. New showerheads are required to be water-efficient, delivering 2.5 gallons per minute or less at a standard water pressure. Water-efficient, or low-flow, showerheads are designed to provide an acceptable shower at a greatly reduced flow rate. Most are equipped with a button to switch the water off at the showerhead, to save water while shaving or lathering. Water-efficient showerheads should not be confused with the *flow restrictors* used in the 1970s and early 1980s, which simply reduced the flow rate far below design level, often resulting in an unacceptable shower (E Source 1991).



The average faucet has a flow rate of about 3 to 5 gallons per minute. Adding a screw-in faucet aerator reduces the flow to 0.5 to 1.0 gallons per minute in the bathroom and 1.5 to 2.0 gallons per minute in the kitchen. In addition to saving energy and water, the "foamier" water that comes from faucet aerators wets objects (hands, food, dishes) better than water from a faucet with no aerator, which tends to bounce off the object rather than thoroughly wetting it (E Source 1991).

MAINTENANCE ISSUES

Water-efficient showerheads and faucet aerators can be easily installed by maintenance staff. Once installed, wire mesh screens in faucet aerators may need to be cleaned periodically, depending on the quality of the tap water. Maintenance staff should periodically check for faucet leaks, particularly on the hot water side, and residents should be strongly encouraged to report such leaks. In addition, maintenance staff should make sure residents do not remove showerheads or faucet aerators.

IMPORTANT POINTS TO CONSIDER

- High-quality showerheads should be selected, as lower quality showerheads may simply restrict water flow, resulting in poor performance.
- When water-efficient showerheads are installed, the old showerheads should be removed from the household to discourage re-installation of the old units.
- Where vandalism is a problem, vandal-resistant aerators and showerheads should be selected.
- "Mist" type showerheads provide a poor-quality shower and can increase apartment humidity more than other showerheads, exacerbating any existing moisture problems.
- Residents should be informed about the button on low-flow showerheads that enables them to shut the water off to save water while shaving or lathering.

Cost/Benefit Worksheet
ECM No. 21: Install Water-Efficient Showerheads and Faucet Aerators

Step 1 Obtain total cost of replacing showerheads and aerators (typically one showerhead and two aerators per dwelling unit):

☐ $

Step 2 Transfer the following information from the Survey:

4-14 **a** Total number of residents in development: ☐

5-9 **b** Cost of DHW heating fuel:

Gas: ☐ $/therm
Oil: ☐ $/gal
Electric: ☐ $/kWh
Propane: ☐ $/gal

Step 3 Estimate annual energy savings:

		2a			
Gas:	10.0 x	☐	=	☐	therms/yr
Oil:	7.2 x	☐	=	☐	gals/yr
Electric:	206.5 x	☐	=	☐	kWh/yr
Propane:	10.1 x	☐	=	☐	gal/yr

Step 4 Calculate annual cost savings:

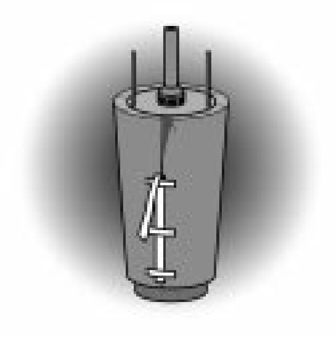
3		2b			
☐	x	☐	=	☐	$/yr

Step 5 Calculate payback period:

1		4			
☐	/	☐	=	☐	yrs

ECM No.
22

INSULATE HOT WATER TANK



Ready-made water heater blankets (or jackets) are easy to install and typically pay for themselves through energy savings in a year or less.

APPLICABILITY

- Single-family and multifamily buildings with older, uninsulated hot water heater tanks.

DESCRIPTION

Although most newer hot water heaters have adequate insulation built into the tank design, older hot water heaters lose a significant amount of heat through the tank walls. This heat loss can account for 25% of the yearly cost of heating domestic hot water. By insulating the tank with a tank insulation blanket, or tank wrap, these losses can be reduced substantially at low cost. Tank wraps come ready-made in a variety of sizes for individual hot water heaters.

TYPES

Tank insulation blankets are typically made of fiberglass or flexible polyurethane foam. Flexible polyurethane foam costs about the same as fiberglass but insulates slightly better (E Source 1991).

MAINTENANCE ISSUES

Maintenance staff can easily install water heater wraps. When installing the tank wrap, maintenance staff should make sure the thermostat on the water heater is set at 120 degrees. Higher temperatures not only waste energy but also can result in scalding.

IMPORTANT POINTS TO CONSIDER

- All seams should be taped along their entire length with a high-quality adhesive tape.
- On gas water heaters, care should be taken to avoid blocking air flow to the burner and to keep insulation safely away from the flame. Insulation should not be installed below the drain valve or near the top vent.

- The insulation should not block access to the valves or thermostat.
- On old electric water heaters, insulation should not cover the electric service connection box (E Source 1991).
- If the water heater is older than ten years old, replacement of the water heater should be considered (see ECM No. 25).
- Most newer models of water heaters are well insulated and do not need an additional layer. However, any water heater that is warm to the touch should be insulated (National Renewable Energy Lab 1995).

Cost/Benefit Worksheet
ECM No. 22: Insulate Hot Water Tank

Step 1 Obtain total cost of insulating all hot water tanks:

$

Step 2 Transfer the following information from the Survey:

4-14 **a** Total number of residents in development:

5-9 **b** Cost of DHW heating fuel:

Gas: $/therm
Oil: $/gal
Electric: $/kWh
Propane: $/gal

Step 3 Estimate annual energy savings for your DHW fuel type:

2a
Gas: 6 x = therms/yr
Oil: 4 x = gals/yr
Electric: 100 x = kWh/yr
Propane: 6 x = gal/yr

Step 4 Calculate annual cost savings:

3 x 2b = $/yr

Step 5 Calculate payback period:

1 / 4 = yrs

ECM No. 23

INSTALL DHW OFF-PEAK CONTROLS

APPLICABILITY

- Single-family and multifamily buildings with electrically heated domestic hot water.

DESCRIPTION

In many regions, electric utilities offer special rates for electricity used at periods during the day when demand is lower on the utility's system. These periods are called "off-peak" periods and vary from utility to utility. The special rates are called "time-of-use" rates. Off-peak controls can be installed on electric water heaters to take advantage of these lower time-of-use rates.

Off-peak controls regulate the water heater so that water is heated during off-peak periods, such as in the early morning hours before the heavy morning use period, when electricity is relatively inexpensive. During peak periods, the water heater is shut off. The main benefit of off-peak controls is cost savings because they enable the HA to take advantage of lower rates. In addition, energy is saved because hot water temperatures are not maintained at 120 degrees the entire day.

To determine if off-peak controls are an option, contact the local utility to find out if time-of-use rates are available, and if so, what the rate schedules are. Off-peak controls should only be installed if hot water needs can still be met. Hot water needs are generally greatest in the morning and early evening hours. Before off-peak controls are installed, the HA should verify with the utility that adequate hot water supplies will be available during these times. In addition, the utility must install special time-of-use meters before the off-peak controls can be installed.

MAINTENANCE ISSUES

After off-peak controls are installed, maintenance staff should become familiar with the schedule of hot water heating.

IMPORTANT POINTS TO CONSIDER

- The local utility must install time-of-use meters before off-peak controls can be installed.
- The hot water heater must have well insulated tanks, because water needs to remain hot for several hours after the water heater shuts off during peak periods.
- Before off-peak controls are installed, the HA should verify with the utility that hot water supplies will be available during heavy use times, such as morning and early evening hours.
- Residents should be encouraged to use hot water wisely through energy education.

Cost/Benefit Worksheet
ECM No. 23: Install DHW Off-Peak Controls

Step 1 Obtain total cost of installing timer controls for domestic hot water heaters to heat the water only during periods of low electricity rates:

$

Step 2 Transfer the following information from the Survey:

4-14 **a** Number of residents in development

5-9 **b** Current cost of electricity: $/kWh

5-4 **c** Lowest rate charged: $/kWh

Step 3 Estimate present annual cost of heating domestic hot water:

2a x 2b x 1400 = $/yr

Step 4 Estimate annual cost of heating domestic hot water with off-peak electricity:

2a x 2c x 1400 = $/yr

Step 5 Calculate annual cost savings:

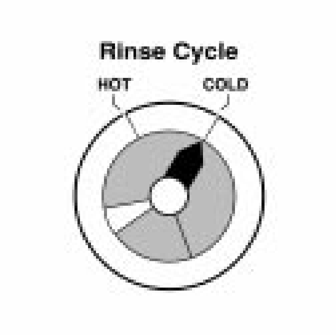
3 - 4 = $/yr

Step 6 Calculate payback period:

1 / 5 = yrs

ECM No.
24

CONVERT LAUNDRY TO COLD RINSE



APPLICABILITY

- Single-family and multifamily buildings with washing machines provided by the HA (either directly or through a vendor)
- Washing machines that have not been converted to cold rinse

DESCRIPTION

Although warm or hot water is necessary to wash many types of clothing, cold water can be used in the rinse cycle for all applications. Converting laundries to cold-rinse cycle can generate significant energy savings by cutting down on hot water use.

If the washing machines are owned by the HA, conversion of the laundry rinse cycles to cold water can be done by maintenance staff or an outside service person. If the washers are owned by a vendor, the HA should ask the vendor to perform the conversion.

IMPORTANT POINT TO CONSIDER

- If residents own their own washing machines, the HA should not convert them to cold rinse cycle unless it can be done without altering the washing machine itself.

Cost/Benefit Worksheet
ECM No. 24: Convert Laundry to Cold Rinse

Step 1 Obtain total cost of converting all washing machines to cold water rinse.

☐ $

Step 2 Transfer the following information from the Survey:

4-65 **a** Total number of washing machines: ☐

5-9 **b** Cost of DHW heating fuel:

Gas: ☐ $/therm

Oil: ☐ $/gal

Electric: ☐ $/kWh

Propane: ☐ $/gal

Step 3 Transfer the following data from Table 1:

Table 1 Savings factor for your fuel type: ☐

Step 4 Estimate total annual energy savings:

2a ☐ x 3 ☐ = ☐ /yr

Step 5 Calculate annual cost savings:

4 ☐ x 2b ☐ = ☐ $/yr

Step 6 Calculate payback period:

1 ☐ / 5 ☐ = ☐ yrs

Table 1: Annual Fuel Savings per Washing Machine

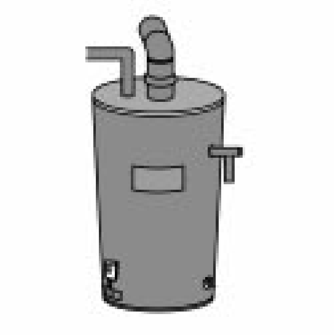
Instructions:

1) Find the fuel used for domestic hot water.
2) Select the savings factor for that fuel type and transfer it to Step 3.

DHW Fuel	**Savings Factor**	
Gas	30	(therms)
Oil	21	(gallons)
Electric	705	(kWh)
Propane	33	(gallons)

ECM No. 25

REPLACE INEFFICIENT HOT WATER HEATER



In each of two small multifamily buildings where the conventional gas-fired central water heater was replaced with a high-efficiency condensing water heater, a research team estimated the annual savings to be 28% (Lobenstein et al. 1992).

APPLICABILITY

- Single-family and multifamily buildings with old, inefficient hot water heating systems

DESCRIPTION

Usually, a water heater is replaced only when it fails. But if the existing water heater is at least ten years old, it is near the end of its useful life, and it may make sense to replace it *before* it fails. By replacing the water heater before it stops working, the HA may enjoy significant energy savings, in addition to avoiding a situation in which residents are without hot water while a new system is being selected. Replacement of old water heaters that are oversized will generally yield higher savings than if the old system is appropriately sized. In any case, if the old water heater is leaking or shows signs of heavy rust or water streaking in the combustion chamber, it should be replaced (Weingarten and Weingarten 1996).

For this ECM, several types of water heating systems are discussed. However, the cost-benefit worksheet is applicable only for replacement of a non-electric hot water heater with a more efficient unit that uses the same fuel type (gas, oil, or propane). To evaluate the cost-effectiveness of other options, an experienced professional should be consulted.

TYPES

The two most common types of water heaters are individual gas or electric **tank-type water heaters** and **central hot water systems**. Individual gas or electric tank-type water heaters are found in single-family homes and apartments in some multifamily buildings. Central hot water heaters are commonly found in older multifamily buildings, where one or two large gas- or oil-fired units supply hot water to all the units in the building. In many cases, central hot water systems are integrated with the boiler system that provides heating. Below is a discussion of options for replacement water heaters.

Individual tank water heaters. If the old water heater is oversized, choosing a smaller water heater will save energy. The HA should also be careful to select a model that has a minimum of R-16 internal insulation (Weingarten and Weingarten 1996). With this built-in insulation, a tank wrap (see ECM No. 22) is not needed. Where electricity is relatively expensive compared to gas, the HA may wish to consider switching to gas water heating during replacement, if gas is in the building or could be brought into the building inexpensively.

Central water heaters. Because central domestic hot water systems are often oversized, replacing the old system with a smaller capacity unit of higher efficiency can yield potentially large savings (DeCicco et al. 1995). Careful analysis by experienced professionals is necessary to size a system appropriately. Regardless of size, a high-efficiency unit should be chosen. The most efficient central water heater is a condensing water heater.

MAINTENANCE ISSUES

To maximize savings, maintenance staff should insulate hot water pipes on distribution systems. On tank-type water heaters, maintenance staff should flush the water out of the bottom of the tank periodically to remove sediment. For gas tank-type water heaters, staff should make sure there is adequate venting and that there are no combustibles near the water heater. If a high efficiency condensing water heater is installed, the HA should either secure a maintenance contract or arrange to have the maintenance staff trained in the operation of the new system. Maintenance of a heat pump water heater is complex and relatively expensive; if a heat pump water heater is installed, the HA should consider getting a maintenance contract.

IMPORTANT POINTS TO CONSIDER

- When selecting a new hot water heater, an experienced professional should be consulted.
- Any water heater should be appropriately sized to ensure both adequate hot water and minimal energy waste. A vendor or contractor should be able to help determine the appropriate size of the new unit.

Cost/Benefit Worksheet
ECM No. 25: Replace Inefficient Hot Water Heater

Step 1	Obtain total cost of replacing hot water heater:							$
Step 2	Transfer the following information from the Survey:							
4-14	**a** Number of residents in development:							
5-9	**b** Cost of DHW heating fuel:					Gas:		$/therm
						Oil:		$/gal
						Propane:		$/gal
Step 3	Transfer the following data from Table 1:							
Table 1	Savings factor for present and proposed system types:							
Step 4	Estimate annual heating energy savings:							
	Gas Systems:		2a		3			
		48 x		x		=		therms/yr
	Oil Systems:		2a		3			
		34 x		x		=		gal/yr
	Propane Systems:		2a		3			
		52 x		x		=		gal/yr
Step 5	Calculate annual cost savings:							
			4		2b			
				x		=		$/yr
Step 6	Calculate payback period:							
			1		5			
				/		=		yrs

ECM No. 25: Replace Inefficient Hot Water Heater

Table 1: Savings Factors for Various Existing and Proposed Systems

Instructions:

1) Find existing type of water heater (central or tank).
2) Find new water heater type.
3) Select the appropriate savings factor and transfer it to Step 3.

	Existing Type	
New Type	**Central**	**Tank**
Central, condensing	0.22	0.39
Central, non-condensing	0.13	0.31
Tank, condensing	0.22	0.39
Tank, non-condensing	NR	0.08

NR = not recommended.

LIGHTING ECMS

ECM No. 26

REPLACE INCANDESCENT LIGHTING WITH COMPACT FLUORESCENT LAMPS IN DWELLING UNITS

Replacing a 75-watt incandescent bulb with a 20-watt CFL that costs $18 will generate enough savings to pay for the CFL in about three years, assuming the lamp is on for 3 hours per day. In addition, because the CFL will last up to ten times longer than the incandescent lamp, the HA will save on maintenance costs for replacing lamps.

APPLICABILITY

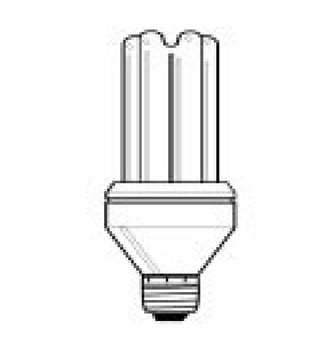
- Single-family homes and apartments in multifamily buildings
- Dwelling units that do not have fluorescent lamps

DESCRIPTION

Standard incandescent light bulbs, typically used in public housing dwelling units, use three to four times more electricity than fluorescent lamps. Replacing incandescent bulbs with fluorescent lamps will save up to 75% of the electricity costs per lamp. In addition, because fluorescent lamps last longer than incandescent bulbs, the HA saves on replacement and maintenance costs. The most appropriate type of fluorescent lighting for dwelling units is a compact fluorescent lamp (CFL). Advances in technology over the past few years have brought great improvements to CFLs in terms of light quality and appearance, and CFLs now come in a variety of shapes and sizes.

Although the initial cost of CFLs is high relative to incandescent lamps, the energy savings and reduced time and expense from lamp replacement make CFLs a cost-effective energy conservation measure for many applications. Because the energy savings from a CFL depend on the number of hours the lamp is on, CFLs should be installed in areas with the heaviest use, such as the kitchen, bathroom, and hallways. To avoid insufficient light levels, the wattage of the CFL should generally be one-third to one-fourth that of the incandescent it is replacing, unless the room was previously overlit.

TYPES



There are two basic types of CFL lamps: screw-in and hard-wired systems.

Screw-in lamps. Screw-in lamps (also called "integral units") fit into existing lamp fixtures, just as incandescent bulbs do. They are available in various shapes and sizes, ranging from 5 to 28 watts (E Source 1994). The best places for screw-in CFLs are in table and standing lamps and ceiling and wall fixtures. Because this type of CFL is removable, special care should be taken to ensure adequate light levels to prevent removal by dissatisfied residents. At $10 to $30 per lamp (E Source 1994), screw-in lamps are less expensive and easier to install than hard-wire fixtures. However, if theft is a concern, hard-wired fixtures may be preferable.

Hard-wired fixtures. Hard-wired fixtures consist of a ballast and a lamp socket that are permanently wired into a fixture. Hard-wired fixtures come in various wattages up to a maximum of 55 watts (E Source 1994). Although hard-wired fixtures are more expensive than screw-in CFLs, they are particularly appropriate where vandalism or theft is a concern because they are not removable. The most appropriate places for hard-wired fixtures are in the kitchen, bathroom, and frequently used incandescent ceiling fixtures.

Another type of CFL lamp is specially designed to replace halogen torchiere lamps. Halogen torchiere lamps are very popular because they are inexpensive, but they are energy hogs, and they pose a serious fire hazard. By contrast, CFL torchieres are six times more efficient than halogen torchieres, and they pose no fire hazard (E Source 1996b).

MAINTENANCE ISSUES

Because compact fluorescent lamps last up to ten times longer than incandescent bulbs, the amount of maintenance staff time required to replace bulbs decreases dramatically. Maintenance staff should watch for removal of screw-in CFLs by residents.

IMPORTANT POINTS TO CONSIDER

- Care should be taken to ensure the light output of a CFL, measured in lumens, is adequate for a particular location. To avoid insufficient light levels, a good rule of thumb is that the wattage of the CFL should generally be one-third to one-fourth that of the incandescent it is replacing.
- CFLs should be selected in appropriate sizes and shapes. For example, some CFLs are too bulky or too long to fit in some fixtures intended for incandescent bulbs.
- Elderly residents often require higher light levels than younger people due to reduced vision capabilities.
- The light output of some CFLs can decrease over time.
- Where theft is a problem, hard-wired CFLs should be selected.
- CFLs are not compatible with dimming switches, unless they come with a special dimming ballast.
- Generally, replacement of fixtures should be done by qualified contractors.
- Because of the high cost of CFLs relative to incandescent bulbs, the HA, not the residents, should consider being responsible for replacing them when they burn out.

Cost/Benefit Worksheet
ECM No. 26: Replace Incandescent Lighting with Compact Fluorescent Lamps in Dwelling Units

This analysis can be done for either one, two, or all of the following dwelling unit light fixtures: kitchen, bathroom, and hallway/foyer. Choose the number of fixtures that applies to your development.

Step 1	Obtain total cost of installing CFLs in dwelling units (one, two, or three per dwelling):		$
Step 2	Transfer the following information from the Survey:		
4-13	**a** Number of dwelling units		
5-9	**b** Cost of electricity:		$/kWh
Step 3	Obtain the following value from Table 1:		
Table 1	kWh saved per year:		kWh/yr

Step 4 Estimate annual energy savings:

2a x 3 = kWh/yr

Step 5 Calculate annual cost savings:

4 x 2b = $/yr

Step 6 Calculate payback period:

1 / 5 = yrs

ECM No. 26: Replace Incandescent Lighting with Compact Fluorescent Lamps in Dwelling Units

Table 1: Annual Electricity Savings from Replacing Incandescent Lamps

Instructions:

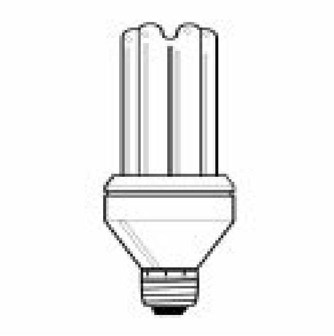
1) Find the average number of bulbs or fixtures that would be replaced per unit. (See question 4-67.)
2) Select the savings for that number of fixtures and transfer to Step 3.

Fixtures per Unit	**Savings (kWh)**
One fixture (kitchen only)	150
Two fixtures (kitchen and bath)	210
Three fixtures (kitchen, bath, hall)	250

This table assumes average usage of lights by residents in the indicated locations; savings may vary substantially between individual dwelling units.

ECM No.
27

REPLACE INCANDESCENT LIGHTING WITH FLUORESCENT LIGHTING IN COMMON AREAS

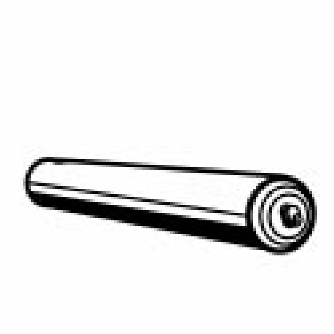


APPLICABILITY

- Multifamily buildings with incandescent lighting in common areas

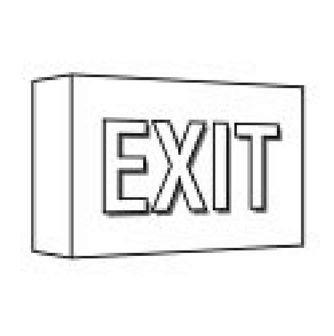
DESCRIPTION

Replacing a 100-watt incandescent bulb in a hallway with a 27-watt CFL that costs $21 will generate enough savings to pay for the CFL in about a year, assuming the lamp is on for 8 hours per day. In addition, because the CFL will last longer than the incandescent lamp, the HA will save on maintenance costs for replacing lamps.



Standard incandescent bulbs (also called lamps) use three to four times more electricity than fluorescent lamps. In many public housing developments, incandescent lamps burn up to 24 hours per day in common areas such as stairwells, hallways, basements, community rooms, lobbies, and exit signs. By replacing these incandescent lamps with fluorescent lamps, the HA can save up to 75% of the electricity used to light those spaces. In addition, because fluorescent lamps last up to ten times longer than incandescent lamps, the HA saves on replacement and maintenance costs.

For replacement of incandescent lamps in common areas, the most appropriate type of fluorescent lighting is usually a compact fluorescent lamp (CFL). Advances in technology over the past few years have brought great improvements to CFLs in terms of light quality and appearance, and CFLs now come in a variety of shapes and sizes.



Although the initial cost of CFLs is high relative to incandescent lamps, the energy savings and reduced time and expense from lamp replacement make CFLs a cost-effective energy conservation measure for many applications. Because the energy savings from a CFL depend on the number of hours the lamp is on, CFLs should be installed in areas with the heaviest use, such as hallways, stairwells, lobbies, and community areas. To avoid insufficient light levels, the wattage of the CFL should generally be one-third to one-fourth that of the incandescent it is replacing, unless the space was previously overlit.

TYPES

There are two basic types of CFL lamps: screw-in and hard-wired systems.

Screw-in lamps. Screw-in lamps (also called "integral units") fit into existing lamp fixtures, just as incandescent bulbs do. They are available in various shapes and sizes, ranging from 5 to 28 watts (E

Source 1994). At $10 to $30 per lamp (E Source 1994), screw-in lamps are less expensive and easier to install than hard-wire fixtures. However, if theft is a concern, hard-wired fixtures may be preferable.

Hard-wired fixtures. Hard-wired fixtures consist of a ballast and a lamp socket that are permanently wired into a fixture. Hard-wired fixtures come in various wattages up to a maximum of 55 watts (E Source 1994). Although hard-wired fixtures are more expensive than screw-in CFLs, they are particularly appropriate where vandalism or theft is a concern because they are not removable. Exit sign lights can be replaced with CFL fixtures or with light-emitting diode (LED) fixtures, which are only 1-2 watts.

MAINTENANCE ISSUES

Because compact fluorescent lamps last up to ten times longer than incandescent lamps, the amount of maintenance staff time required to replace lamps decreases dramatically. Maintenance staff can generate substantial additional savings by turning lights off when they are not needed.

IMPORTANT POINTS TO CONSIDER

- To avoid insufficient light levels, a good rule of thumb is that the wattage of the CFL should generally be at least one-third to one-fourth that of the incandescent it is replacing.
- CFLs should be selected in appropriate sizes and shapes. For example, some CFLs are too bulky or too long to fit in some fixtures intended for incandescent bulbs.
- Elderly residents often require higher light levels than non-elderly due to reduced vision capabilities.
- The light output of some CFLs can decrease over time.
- Where theft is a problem, hard-wired CFLs should be selected.
- CFLs are not compatible with dimming switches, unless they come with a special dimming ballast.
- Generally, replacement of fixtures should be done by qualified contractors.
- If halogen torchiere lamps are used in common areas, they should be replaced with CFL torchieres, which are much more efficient and do not pose a fire hazard.

Mini Case Study

In 1991, the local weatherization agency performed a complete change-out of common area lighting in a 151-unit high-rise of the St. Paul Housing Authority. Incandescent fixtures in stairwells and exit signs were replaced with fluorescent fixtures. In addition, existing common-area fluorescent fixtures were retrofit with new reflectors to increase their lighting output, and old ballasts were replaced with high-frequency ballasts.

The total cost of the measures was $22,400. Analysis showed an electricity savings of 170 megawatt-hours (mWh), or 20% of pre-retrofit consumption. In terms of cost savings, the housing authority saved $7,200 per year, yielding a payback of three years (DeCicco et al. 1995).

Cost/Benefit Worksheet
ECM No. 27: Replace Incandescent Lighting with Fluorescent Lighting in Common Areas

Step 1	Obtain total cost of replacing common area incandescent lights:		$
Step 2	Transfer the following information from the Survey:		
4-69	**a** Number of incandescent fixtures in common areas:		
4-70	**b** Average watts per fixture:		Watts
5-9	**c** Cost of electricity:		$/kWh
Step 3	Obtain the following savings factor from Table 1:		
Table 1	kWh saved per year per fixture:		kWh/yr

Step 4 Estimate annual energy savings:

2a x 3 = kWh/yr

Step 5 Calculate annual cost savings:

4 x 2c = $/yr

Step 6 Calculate payback period:

1 / 5 = yrs

ECM No. 27: Replace Incandescent Lighting with Fluorescent Lighting in Common Areas

Table 1: Annual Electricity Savings per Lamp Replaced

Instructions:

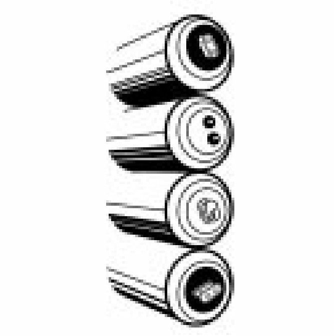
1) Find the average watts per incandescent fixture (see Step 2b).
2) Select the savings for that number of watts and transfer to Step 3.

Average Watts per Incandescent Fixture	Savings (kWh)
50	340
75	510
100	680
150	1020

This table assumes common areas are lit 24 hours a day. Reduce the savings proportionately if lights are on substantially fewer hours per day.

ECM No.
28

REPLACE STANDARD FLUORESCENT LAMPS WITH ENERGY-SAVING LAMPS IN COMMON AREAS



Replacing older fluorescent lamps with "energy-saving" lamps can save on average 15% of the energy used for those fixtures, with a payback of two to three years (E Source 1994).

APPLICABILITY

- Multifamily buildings with older, inefficient fluorescent lighting
- Common areas that are overlit

DESCRIPTION

Developments that have relatively old fluorescent lighting in common areas can realize modest energy savings by simply replacing the existing fluorescent lamps (tubes) with "energy-saving" lamps which use 10% to 20% less electricity. (Note: If there is incandescent lighting in the common areas, see ECM No. 27.) Energy-saving lamps are T12 size (1.5 inches in diameter) and are designed to replace older lamps of the same size. No changes to the fixtures are required. Although energy-saving lamps are slightly more expensive than standard fluorescent lamps, the difference is paid for quickly through energy savings.

Energy-saving fluorescent lamps include General Electric's Watt-Miser, Osram Sylvania's SuperSaver, Philips' Econ-o-Watt, and Duro-Test's Watt-Saver (E Source 1994).

Energy-saving lamps have special gases inside the tube to suppress energy consumption. However, these gases also tend to suppress light output somewhat. For this reason, these lamps should not be used in areas where lower light levels would be undesirable. Also, it should be noted that "energy-saving" lamps are not as efficient as more advanced lighting systems, such as those with electronic ballasts, which can generate savings of 35% to 42% (E Source 1994) (see ECM No. 29).

MAINTENANCE ISSUES

Because fixtures require no modification, replacement can easily be done by maintenance staff. When lamps are replaced, maintenance staff should clean fixtures, reflectors, and diffusers for maximum light output. When disposing of old lamps, federally mandated disposal procedures may apply. The state environmental agency and the regional office of the U.S. Department of Environmental Protection should be contacted before disposing of old lamps.

IMPORTANT POINTS TO CONSIDER

- This ECM is applicable only where existing lamps are T12 size (1.5 inches in diameter).
- Because energy-saving lamps generally have slightly lower light output than the lamps they replace, they should not be used where lower light levels would be undesirable.
- Energy-saving lamps are not as efficient as more advanced lighting systems, such as T-8 lamps with electronic ballasts, which can generate savings of 35% to 42% (see ECM No. 29).

Cost/Benefit Worksheet

ECM No. 28: Replace Older Fluorescent Lamps with Energy-Saving Lamps in Common Areas

Step 1 Obtain total cost of replacing all common area fluorescent lamps:

☐ $

Step 2 Transfer the following information from the Survey:

4-72 **a** Predominant fixture type: ☐

4-75 **b** Total number of this fixture type in common areas: ☐

5-9 **c** Cost of electricity: ☐ $/kWh

Step 3 Obtain the following value from Table 1:

Table 1 kWh saved per year per typical fixture: ☐ kWh/yr

Step 4 Estimate annual energy savings:

2b ☐ x 3 ☐ = ☐ kWh/yr

Step 5 Calculate annual cost savings:

4 ☐ x 2c ☐ = ☐ $/yr

Step 6 Calculate payback period:

1 ☐ / 5 ☐ = ☐ yrs

ECM No. 28: Replace Older Fluorescent Lamps with Energy-Saving Lamps in Common Areas

Table 1: Annual Electricity Savings per Fixture Relamped

Instructions:

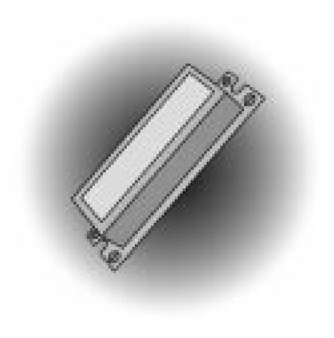
1) Find the predominant type of fixture (number of tubes per fixture and fixture length) (see Step 2a).
2) Select the appropriate level of savings and transfer to Step 3.

Tubes per Fixture	Fixture Length	Savings (kWh)
2	4	100
4	4	200
2	8	200
6	4	300
4	8	400
8	4	400

This table assumes common areas are lit 24 hours a day. Reduce the savings proportionately if lights are on substantially fewer hours per day.

ECM No. 29

INSTALL ELECTRONIC BALLASTS IN COMMON AREAS



Replacing existing magnetic ballasts and older fluorescent lamps with electronic ballasts and new T8 fluorescent lamps saves about 35% to 42% of the electricity used for lighting and has a payback of 3 to 5 years (E Source 1994).

APPLICABILITY

- Multifamily buildings with older fluorescent lighting.

DESCRIPTION

A very common and effective lighting improvement is to replace old fluorescent lamps and ballasts with new T8 (1-inch in diameter) lamps and electronic ballasts. A "ballast" is a device that all fluorescent lights require in order to turn on and give off light. The ballast controls the light output as well as the energy use. Most ballasts in use today are magnetic ballasts. However, electronic ballasts are intrinsically more efficient than magnetic ballasts—lamps operate about 10% more efficiently with electronic ballasts than with magnetic ballasts (Rea 1993). By replacing magnetic ballasts and existing fluorescent lamps with electronic ballasts and new fluorescent lamps, significant savings can be achieved.

In addition, some types of electronic ballasts make it possible to dim fluorescent lights. There are a variety of energy-saving controls associated with dimming, such as "daylight dimming", in which light-level sensors call for just enough fluorescent light to supplement natural light (see ECM No. 30).

MAINTENANCE

When lamps and ballasts are replaced, maintenance staff should clean fixtures, reflectors, and diffusers for maximum light output. Electronic ballasts last up to 10 to 20 years (E Source 1994) and require no maintenance. However, when disposing of old ballasts manufactured prior to 1978 and fluorescent lamps of any age, federally mandated disposal procedures must be followed. If the lighting improvements are being performed by a contractor, the contractor is responsible for disposal of the old materials. If the HA is performing the improvements, it should contact the state environmental agency and the regional office of the U.S. Department of Environmental Protection before disposing of the materials.

IMPORTANT POINTS TO CONSIDER

- This ECM should be considered in conjunction with other lighting options which may be appropriate for a given development, such as controls (see ECM No. 30), better-designed reflectors or diffusers, or other lighting improvements. An experienced lighting professional should be consulted before doing extensive lighting retrofits to help determine the most cost-effective approach to lighting improvements.
- Electronic ballasts are incompatible with some types of occupancy lighting controls.
- Although electronic ballasts had fairly high failure rates when they were new to the market, advances in technology have reduced the failure rate to around that of magnetic ballasts. However, HAs should choose a ballast with a warranty of at least three years; some companies provide five-year warranties.
- If a dimming system is desired, electronic ballasts with dimming capability should be selected.

Cost/Benefit Worksheet
ECM No. 29: Replace Older Fluorescent Lamps and Ballasts in Common Areas

Step 1 Obtain total cost of installing electronic ballasts and new T8 lamps:

$

Step 2 Transfer the following information from the Survey:

4-72 **a** Predominant fixture type:

4-75 **b** Total number of this fixture type in common areas:

5-9 **c** Cost of electricity: $/kWh

Step 3 Obtain the following value from Table 1:

Table 1 kWh saved per year per typical fixture: kWh/yr

Step 4 Estimate annual energy savings:

2b x 3 = kWh/yr

Step 5 Calculate annual cost savings:

4 x 2c = $/yr

Step 6 Calculate payback period:

1 / 5 = yrs

ECM No. 29: Replace Older Fluorescent Lamps and Ballasts in Common Areas

Table 1: Annual Electricity Savings per Fixture Relamped

Instructions:

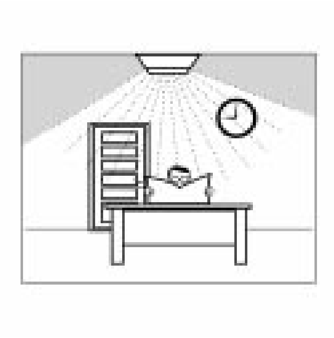
1) Find the predominant type of fixture (number of tubes per fixture and fixture length) (see Step 2a).
2) Select the appropriate level of savings and transfer to Step 3.

Tubes per Fixture	Fixture Length	Savings (kWh)
2	4	123
4	4	246
2	8	246
6	4	369
4	8	492
8	4	492

This table assumes common areas are lit 24 hours a day. Reduce the savings proportionately if lights are on substantially fewer hours per day.

ECM No. 30

INSTALL LIGHTING CONTROLS IN COMMON AREAS



APPLICABILITY

- Multifamily buildings with fluorescent lighting
- Buildings where lights are not routinely turned off when not in use.

DESCRIPTION

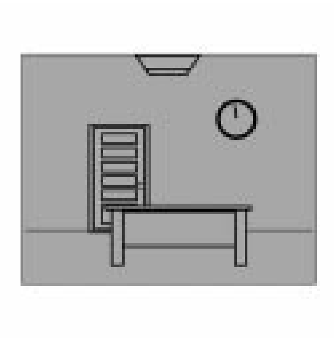
In many developments, lights in common areas are left on regardless of whether they need to be, some staying on 24 hours a day. In some community areas and offices with windows, light from the outside can make full fluorescent lighting unnecessary for much of the day. In both cases, lighting controls can save energy by controlling the operation of fluorescent lights according to how much light is actually needed.

Depending on the type of controls and the particular space, lighting controls can save anywhere from 25% to 75% of the electricity used for lighting.

TYPES

There are two main types of lighting controls that are applicable for public housing: occupancy controls and daylighting controls. The cost/benefit worksheet for this ECM calculates the payback for daylighting controls.

Occupancy controls. With the help of infrared or ultrasonic sensors, occupancy controls turn off or dim all or most of the lights in a space that is unoccupied. This type of control is appropriate for areas that are often unoccupied, such as corridors, stairwells, basements, and restrooms. Energy savings from occupancy-sensor lighting controls range from 25% to 75% of the electricity used to light those spaces, with an average payback of one and a half to three years (Lecker and DeFreese 1996).



Daylighting controls. Using light sensors that detect natural light from windows, daylighting controls dim fluorescent lights accordingly so that the total amount of light in a room stays at a constant, acceptable level. Daylighting controls are appropriate for spaces with a substantial amount of natural light from windows, such as community rooms or office spaces, and work in both clear and cloudy weather. Daylighting controls require dimmable electronic ballasts (see ECM No. 29). The savings from daylighting controls often fall into the range of 40% to 60%. The payback, which depends on a variety of factors including access to daylight and the number of hours the lights are on, is often under five years (E Source 1994).

MAINTENANCE

Maintenance staff should be trained in the operation of any new lighting control system installed. The HA should ask the contractor that installs the new system to provide such training. With daylighting controls, maintenance staff should turn off lights when not in use. If new lamps and/or ballasts are installed with the new controls, federally mandated disposal procedures for the old ballasts and lamps may apply. If the lighting improvements are being performed by a contractor, the contractor is responsible for disposal of the old materials. If the HA is performing the improvements itself, it should contact the state environmental agency and the regional office of the U.S. Department of Environmental Protection before disposing of the materials.

IMPORTANT POINTS TO CONSIDER

- This ECM should be considered in conjunction with other lighting options that may be appropriate, such as electronic ballasts (see ECM No. 29) or other lighting improvements. An experienced lighting professional should be consulted before doing extensive lighting retrofits.
- If daylighting controls are installed, light sensors must be properly placed and precisely calibrated by the installer.
- A poorly designed daylighting system can be worse than none at all (E Source 1994). Design and installation of lighting controls should be performed by an experienced professional.
- Occupancy controls with infrared sensors should not be installed in restrooms with partitions or in large enclosed spaces where the area may exceed sensor capacity (Lecker and DeFreese 1996).
- Occupancy controls with ultrasonic sensors should not be installed closer than 6 to 8 feet from an air vent, more than 14 feet from the floor, or in rooms where the sensor can "see" out doorways or windows (Lecker and DeFreese 1996).

Cost/Benefit Worksheet
ECM No. 30: Install Lighting Controls in Common Areas

This worksheet assumes that the development has dimmable electronic ballasts.

Step 1 Obtain total cost of installing daylight controls on all fluorescent fixtures within 10 feet of exterior windows.

☐ $

Step 2 Transfer the following information from the Survey:

4-77 **a** # fluorescent fixtures within 10 ft. of exterior windows: ☐

4-78 **b** Predominant type of fluorescent fixture: ☐

5-9 **c** Cost of electricity: ☐ $/kWh

Step 3 Obtain the following values from Tables 1 and 2:

Table 1 **a** Watts per fixture: ☐

Table 2 **b** Daylight availability factor: ☐

Step 4 Estimate annual energy savings:

2a		3a		3b			
☐	x	☐	x	☐	=	☐	kWh/yr

Step 5 Calculate annual cost savings:

4		2c			
☐	x	☐	=	☐	$/yr

Step 6 Calculate payback period:

1		5			
☐	/	☐	=	☐	yrs

ECM No. 30: Install Lighting Controls in Common Areas

Table 1: Watts per Typical Fixture

Instructions:

1) Find the predominant type of fixture (number of tubes per fixture and fixture length) (see Step 2b).
2) Select the appropriate number of watts and transfer to Step 3.

Tubes per Fixture	Fixture Length	Watts
2	4	92
4	4	184
2	8	184
6	4	276
4	8	368
8	4	368

Table 2: Daylight Availability Factors

Instructions:

1) Estimate the percentage of exterior wall above desk height that is glass: 25-50%, 50-75%, and 75-100%.
2) Determine whether the building has exterior overhangs projecting at least two feet from the outside face of the glass near the top of the window.
3) Find the appropriate glass type (clear or tinted).
4) Move across to appropriate percentage glass area column.
5) Select the appropriate factor and transfer it to Step 3.

		Percent Glass Area		
Overhangs	**Glass Type**	**25-50%**	**50-75%**	**75-100%**
No overhangs	Clear	1.40	1.48	1.55
Overhangs	Clear	1.25	1.33	1.40
Overhangs	Tinted	1.20	1.28	1.35

ECM No.
31

CONVERT EXTERIOR LIGHTING FIXTURES

APPLICABILITY

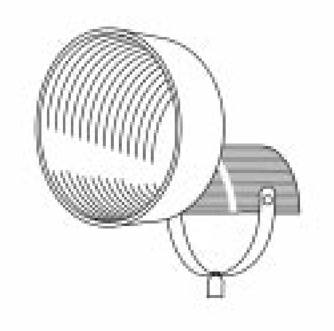
- Developments with mercury vapor, incandescent, or halogen exterior lighting

DESCRIPTION

In developments where mercury vapor, incandescent, or halogen exterior lighting fixtures illuminate exterior areas such as grounds or parking lots, substantial savings can be realized by converting these fixtures to high-pressure sodium (HPS) or metal halide lighting. Both high-pressure sodium and metal halide lighting are twice as efficient as mercury vapor lighting, four times more efficient than halogen, and eight times more efficient than incandescent lighting. In addition, the color quality of both types of lighting is much better than that of mercury vapor lamps. In some cases, such as porch lights, compact fluorescent lamps may be the most appropriate replacement for incandescent lighting. However, the cost benefit worksheet for this ECM assumes that the new lighting is high-pressure sodium or metal halide.

MAINTENANCE

High-pressure sodium lamps and metal halide lamps have long lives, about the same as mercury vapor lamps and about ten times longer than incandescent lamps. However, when HPS lamps or metal halide lamps do need replacement, it is important that maintenance staff use the proper type of replacement lamp. Not all lamps of the same wattage are interchangeable, because the bases may be different and the ballasts may have different power characteristics. The HA should make sure that replacement lamps are compatible with the fixtures.



IMPORTANT POINTS TO CONSIDER

- An experienced lighting professional should convert the fixtures and may be able to provide helpful ideas on lighting design issues, such as where the lighting is needed, how much illumination is necessary, and what should be illuminated.
- The "white" or "indoor" types of HPS lamps have better color quality than the "outdoor" type, but the energy efficiency is much lower.

- Low-pressure sodium lamps are not recommended because all colors appear yellow or gray under these lamps, making identification of cars, license plates, and other colored items very difficult (E Source 1994).
- Recommended light levels should be maintained after conversion.

Cost/Benefit Worksheet
ECM No. 31: Convert Exterior Lighting Fixtures

Step 1 Obtain total cost of converting existing exterior lighting fixtures to high-pressure sodium or metal halide:

$

Step 2 Transfer the following information from the Survey:

5-79 **a** Predominant type of exterior lighting fixture:

4-80 **b** Number of existing fixtures:

4-81 **c** Existing consumption in watts per fixture: Watts

5-9 **d** Cost of electricity: $/kWh

Step 3 Obtain the following value from Table 1:

Table 1 Energy reduction savings factor:

Step 4 Estimate annual energy savings:

2b x 2c x 3 = kWh/yr

Step 5 Calculate annual cost savings:

4 x 2d = $/yr

Step 6 Calculate payback period:

1 / 5 = yrs

ECM No. 31: Convert Exterior Lighting Fixtures

Table 1: Savings Factors for Conversion to High-Pressure Sodium or Metal Halide Lamps

Instructions:

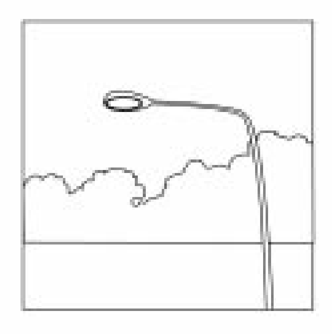
1) Find the predominant type of exterior lighting fixture (see Step 2a).
2) Select the appropriate reduction factor and transfer to Step 3.

Type	Reduction Factor
Mercury Vapor	2.1
Incandescent	3.7
Halogen	3.2

These factors assume existing light output is maintained after conversion.

ECM No. 32

INSTALL PHOTO-CONTROLS FOR EXTERIOR LIGHTING



APPLICABILITY

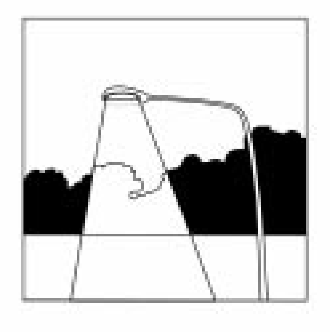
- Developments with exterior lighting controlled manually or by a clock timer

DESCRIPTION

In many developments, outdoor lighting is switched on either manually when maintenance staff leave for the day, or by a clock timer. In either case, lights may be on for several hours before they are needed, particularly in the summertime, resulting in considerable energy waste. Photo-controls are designed to eliminate these unnecessary hours of operation and the resulting energy waste by monitoring natural light levels and switching on lights only when natural light levels fall below a predetermined level. Photo-controls can be installed on individual lamps or grouped together to control multiple lamps.

MAINTENANCE

If maintenance staff are currently switching on exterior lights manually, then this ECM will save maintenance time and effort by eliminating the need to perform this task.



IMPORTANT POINTS TO CONSIDER

- This ECM should be considered in conjunction with the installation of high-pressure sodium or metal halide lighting (see ECM No. 31).
- An experienced lighting professional should be consulted for assistance in system design.

Cost/Benefit Worksheet
ECM No. 32: Install Photo-Controls for Exterior Lighting

Step 1 Obtain total cost of installing photo-controls for all general site and parking area lighting.

$

Step 2 Transfer the following information from the Survey:

4-84	**a**	Annual hours exterior lighting is on:	
4-80	**b**	Number of fixtures:	
4-81	**c**	Watts per fixture:	Watts
5-9	**d**	Cost of electricity:	$/kWh

Step 3 Calculate existing energy consumption per fixture:

2a x 2b x 2c / 1000 = kWh/yr

Step 4 Calculate energy consumption per fixture with photo-controls:

4,200 x 2b x 2c / 1000 = kWh/yr

Step 5 Calculate annual energy savings per fixture:

3 - 4 = kWh/yr

Step 6 Calculate annual cost savings per fixture:

5 x 2d = $/yr

Step 7 Calculate payback period:

1 / 6 = yrs

MISCELLANEOUS ECMS

ECM No. 33

REPLACE OLDER REFRIGERATORS WITH HIGH-EFFICIENCY UNITS

The most efficient new refrigerators are two to four times more efficient than old refrigerators, with a payback of three to ten years, depending on the efficiency of the unit being replaced (see Table 1 on the ECM worksheet).

APPLICABILITY

- Single-family and multifamily buildings with refrigerators over eight years old.

DESCRIPTION

After lighting, refrigerators are the second largest single user of electricity in most households (not including households with electric heat or hot water). Because refrigerators are such a significant user of energy, they should be a focus of conservation efforts. Older refrigerators use up to four times more electricity than the most efficient new refrigerators available in the same size. By replacing these old, inefficient units with new more efficient refrigerators, the HA can realize substantial energy and cost savings. In many cases, it is cost-effective to replace older refrigerators *before* scheduled replacement because of the electricity cost savings.

Although other appliances, such as clothes washers, dryers, and stoves, use less energy, it makes sense to take efficiency into account when purchasing these as well. For example, efficient front-loading clothes washers use 25% less gas or electricity and 50% less water than standard top-loading models.

The most common size of refrigerators in public housing is the 14-15 cubic-foot size range. In that size range, the most efficient refrigerator available today uses 437 kWh per year. This automatic defrost model has been called a "super-efficient" refrigerator by energy experts because it is 30% more efficient than federal standards require and 12% more efficient than the next most efficient model available. (This model is manufactured by Maytag under the Magic Chef label. For more information, contact the Consortium for Energy Efficiency, listed in Appendix C.) Even more efficient models are expected to be developed in the next few years. By contrast, the average refrigerator in that size purchased before 1991 uses around 1,100 kWh, with older units using more than 1,500 kWh per year.

The savings from refrigerator replacement depend on the efficiency of the old refrigerators. In general, the older and bigger a refrigerator, the more electricity it uses. The table on the next page presents sample paybacks for replacing old refrigerators in the 14- to 15-cubic-foot size range with the most efficient model available in that size. If the payback is shorter than the number of years before scheduled replacement, it is cost-effective to replace the refrigerators before scheduled replacement.

MAINTENANCE ISSUES

Maintenance staff should check to make sure temperature settings are on a medium setting rather than the coldest setting. If manual defrost models are purchased, maintenance staff should be available to assist residents with defrosting their refrigerators. Residents who defrost their refrigerators with sharp objects can do irreparable harm to the appliance.

IMPORTANT POINTS TO CONSIDER

- At time of publication, "super-efficient" refrigerators were available only through a special bulk purchasing program. For information about purchasing super-efficient refrigerators, contact the Consortium for Energy Efficiency, listed in Appendix C.
- The HA or a qualified contractor must properly dispose of old refrigerators.
- Generally, automatic defrost models are less efficient than manual defrost models. However, the most efficient model available in the 14-cubic-foot size range has automatic defrost.

Sample Paybacks for Replacing Older 14-cubic-foot Refrigerators with "Super-Efficient" Refrigerators

Old Model Annual Energy Use (Approx. Age)	New Model Annual Energy Use	Annual Energy Savings	Annual Cost Savings ($0.08/kWh)	Payback
~800 kWh (late 1980s)	437 kWh	363 kWh	$29	12 years
~1100 kWh (early 1980s)	437 kWh	663 kWh	$53	6.6 years
~1400 kWh (1970s)	437 kWh	963 kWh	$77	4.5 years

Note: Assumes a price of $350 for the new refrigerator. Assumes price of electricity is $0.08/kWh—savings will be higher where electricity is more expensive and lower where it is less expensive.

Mini Case Study

In 1997, the New York City Housing Authority installed 20,000 new "super-efficient" refrigerators under a program with the local utility, the New York Power Authority (NYPA). The new refrigerators use 437 kWh per year, compared to the old refrigerators, which used on average 1,100 kWh per year. The average savings are projected to be 663 kWh per year, or $53 per year, assuming $0.08/kWh. The price of the refrigerators is $308, yielding a payback of 5.8 years.

NYPA financed the purchase of the new refrigerators and the removal and recycling of the old units as part of an overall energy conservation program tailored to the housing authority. Under the program, NYCHA receives 20,000 new refrigerators every year for four years. NYCHA makes monthly payments to NYPA on the loan, which has an interest rate of 6% and a period not to exceed ten years.

Under the Performance Funding System (PFS), NYCHA receives an "add-on" subsidy from HUD to pay the debt service costs associated with the new refrigerators. (For more information on the "add-on" subsidy, refer to the section on Energy Performance Contracting in Chapter 2.)

Cost/Benefit Worksheet
ECM No. 33: Replace Older Refrigerators with High-Efficiency Units

Step 1 Obtain total cost of replacing older refrigerators with high-efficiency units:

$

Step 2 Transfer the following information from the Survey:

4-13 **a** Total number of dwelling units in development:*

4-85 **b** Average age of existing refrigerators:

5-9 **c** Cost of electricity: $/kWh

Step 3 Obtain the following value from Table 1:

Table 1 Approximate annual energy use of each old refrigerator: kWh/yr

Step 4 Calculate annual energy savings per refrigerator:

3

\- 437 = kWh/yr

Step 5 Estimate annual energy savings:

2a 4

x = kWh/yr

Step 6 Calculate annual cost savings:

5 2c

x = $/yr

Step 7 Calculate payback period:

1 6

/ = yrs

* Worksheet assumes one 14- to 15-cubic-foot refrigerator per dwelling unit, and that all refrigerators are to be replaced with refrigerators of similar size that use 437 kWh per year.

ECM No. 33: Replace Older Refrigerators with High-Efficiency Units

Table 1: Energy Use of Existing Refrigerators

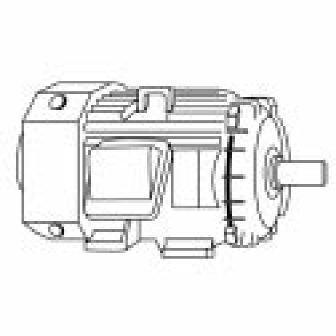
Instructions:

1) Find the approximate average age of the old refrigerators (see Step 2b).
2) Select the appropriate energy use and transfer it to Step 3.

Age	Energy Use
1970s	1400 kWh/yr
Early 1980s	1100 kWh/yr
Late 1980s	800 kWh/yr

ECM No. 34

UPGRADE/REPLACE MOTORS



APPLICABILITY

- Multifamily buildings with inefficient motors

DESCRIPTION

In many large multifamily buildings, upgrading or replacing inefficient motors can generate substantial electricity and cost savings for an HA.

The major opportunities for upgrading or replacing motors are generally found in elevators, ventilation systems, and hydronic heating or cooling systems. The potential savings depend on the size (typically measured in horsepower) and efficiency (measured at full load) of the old motor and the number of hours the motor is in operation. In general, motors that are larger, more inefficient, and in use a large percentage of the time are the best candidates for upgrading or replacement.

Elevators. Elevator drive motors can range in size from a fraction of a horsepower to over 20 horsepower. The hours of operation depend on how much the elevator is used. A fair estimate for elevator motors is that they are in operation 25% to 50% of the time. In general, motors that are 2 horsepower or larger, with efficiencies at least four percentage points lower than those shown in the Table below, are good candidates for replacement with high-efficiency motors.

Ventilation Systems. Ventilation fan motors also come in a wide range of sizes. They tend to be in operation more hours per day than elevator motors. In general, ventilation fan motors larger than 1 horsepower, with efficiencies at least four percentage points lower than those shown in the Table below, are good candidates for replacement with high-efficiency motors.

Hydronic heating or cooling systems. Pump motors larger than 5 horsepower on hydronic heating or cooling systems are potential candidates for upgrading through the addition of adjustable speed drives, also called variable speed drives or variable frequency drives. With an adjustable speed drive, the pump motor can run at a lower speed when the load is below maximum, resulting in energy and cost savings.

Recommended Efficiencies for Replacement Motors

Size of Motor (horsepower)	Recommended Efficiency
1-2	86.5
3-5	89.5
7.5-10	91.7
15	92.4
20	93.0

Source: E Source 1996a.

MAINTENANCE ISSUES

Because all motors reach the end of their useful lives at some point, maintenance staff should have high-efficiency replacement motors on hand in anticipation of future motor failure.

IMPORTANT POINTS TO CONSIDER

- Results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost-effectiveness analysis results in a payback of 15 years or less, a more detailed analysis should be performed.
- An experienced professional should analyze the performance of existing motors to assess potential savings and to determine the proper size and type of replacement motor. If the existing motors are oversized, installing smaller replacement motors can yield additional savings.

Cost/Benefit Worksheet
ECM No. 34: Upgrade/Replace Motors

This worksheet is arranged for one or more motors of a single size and type. Make additional copies of the worksheet to evaluate motors of various sizes.

Step 1 Obtain total cost of upgrading/replacing motors of one size: ☐ $

Step 2 Transfer the following information from the Survey:

4-87 **a** Size of motor(s) to be evaluated in this worksheet: ☐ HP

4-88 **b** Number of motors of this size and type: ☐

4-89 **c** Average operating hours of this size motor: ☐ Hrs/yr

5-9 **d** Cost of electricity: ☐ $/kWh

Step 3 Obtain the following value from Table 1:

Table 1 Savings factor for this size motor: ☐ kWh/hr

Step 4 Calculate annual energy savings for this size motor:

2b ☐ x 2c ☐ x 3 ☐ = ☐ kWh/yr

Step 5 Calculate annual cost savings:

4 ☐ x 2d ☐ = ☐ $/yr

Step 6 Calculate payback period:

1 ☐ / 5 ☐ = ☐ yrs

ECM No. 34: Upgrade/Replace Motors

Table 1: Savings Factors for Upgrading/Replacing Motors

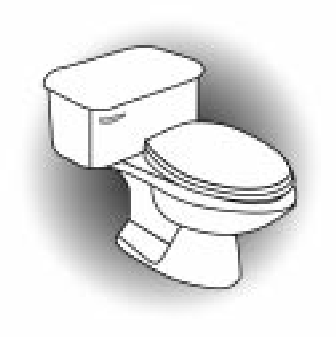
Instructions:

1) Find motor size (horsepower) (see Step 2a).
2) Select the appropriate savings factor and transfer it to Step 3.

Motor Size (horsepower)	Savings Factor
1	0.07
2	0.10
3	0.19
5	0.22
10	0.41

ECM No. 35

INSTALL WATER-SAVING TOILETS



Replacing old toilets with new, water-efficient toilets can save anywhere from 10% to 35% of total water use, depending on how much water the old toilets were using, the number of people in the household, and various other factors.

APPLICABILITY

- Single-family and multifamily buildings that do not have water-saving toilets

DESCRIPTION

In many areas, water and sewer rates have increased dramatically over the past few years and are rivaling or exceeding the cost of energy. Reducing water use through conservation strategies can generate significant cost savings.

One of the biggest water uses in a household is the toilet, accounting for 25% to 50% of total household water consumption. Significant advances in technology over the past decade have resulted in the availability of reliable, high-quality water-saving toilets on the market. While older toilets use anywhere from 4 to 10 gallons per flush, all new models use 1.6 gallons or less per flush, cutting the water use by 60% to 80%. Replacing old toilets that leak or run generates even more savings.

Detecting Water Leaks

A major source of water consumption at many public housing developments is leakage. HA staff should check the distribution lines on the street and the service lines on the property for leaks. The valve between the distribution line and the service line should also be checked. The HA may also want to distribute a notice to tenants asking them to notify the HA of any leaks from faucets, showers, tubs, toilets, or garden hoses.

MAINTENANCE ISSUES

Although the quality of water-saving toilets has improved greatly over the past few years, maintenance staff should be aware that water-saving toilets may clog if residents place objects other than toilet paper in them. Maintenance staff should repair any water leaks from faucets or toilets to cut water waste, and residents should report such leaks.

IMPORTANT POINTS TO CONSIDER

- High-quality toilets should be selected.
- Because water-saving toilets will clog if misused, this measure should be accompanied by resident education to prevent unacceptable items from being placed in the toilet.
- Water-saving toilets may not operate properly in buildings with very old sewer lines.

Mini Case Study

The City of Colorado Springs Housing Authority installed water-saving toilets in a four-unit building in 1992. The 1.6-gallon toilets were installed as part of an overall package of measures that included several energy-saving measures but no other water-saving measures. The cost of the toilets was $158 per unit, totalling $632 for the building.

An independent evaluator analyzed the water savings from the new toilets. The annual water savings for the building were estimated to be 13,160 gallons, or about a 35% drop in total water usage. The cost savings on the building’s water and sewer bills were $182 per year, yielding a 3.5-year payback (U.S. Department of Energy 1995).

Cost/Benefit Worksheet
ECM No. 35: Install Water-Saving Toilets

Step 1 Obtain total cost of replacing toilets:

☐ $

Step 2 Transfer the following information from the Survey:

5-10 **a** Annual water bill: ☐ $/yr

5-11 **b** Annual sewer bill: ☐ $/yr

Step 3 Calculate total "water" cost:

2a ☐ + 2b ☐ = ☐ $

Step 4 Calculate annual cost savings:

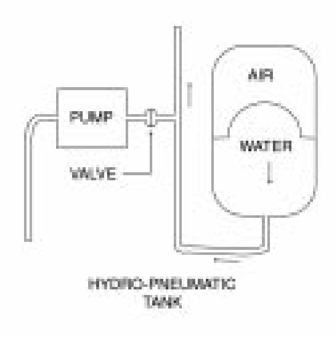
3 ☐ x 0.2 = ☐ $/yr

Step 5 Calculate payback period:

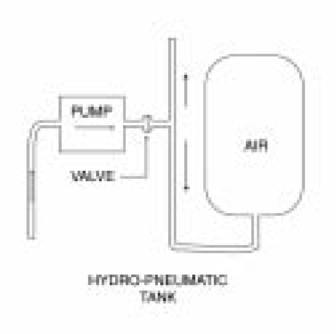
1 ☐ / 5 ☐ = ☐ yrs

ECM No.
36

CONVERT WATER SUPPLY PUMPS



No demand:
- pump off
- valve closed
- hydro-pneumatic tank maintains water pressure



Demand:
- tank empties
- valve opens
- pump starts supplying water to building and refilling tank

APPLICABILITY

- High-rise multifamily buildings without roof-mounted water tanks

DESCRIPTION

In high-rise buildings that do not have water tanks on the roof, pumps are used to maintain adequate water pressure in the domestic water system. These pumps must operate continuously to provide adequate water pressure, even when there is no water demand. Converting water supply pumps to a system called a "hydro-pneumatic" system will keep adequate pressure levels without continuous pump operation, resulting in electricity savings.

During those periods when domestic water is not required, pressure is maintained by a hydro-pneumatic tank that contains air and water separated by a flexible membrane. When demand occurs for water, the imbalance of pressure causes the water stored in the tank to be provided to the building. When the tank is emptied, the pumps are activated and the water is supplied directly to the building. When demand ceases, water is pumped into the tank until adequate pressure can be maintained by the system and the pumps shut down.

The savings assumed for this ECM are 33% of the total pumping energy used for water supply. This level of savings is based on the assumption that water demand is minimal between 11 pm and 7 am.

MAINTENANCE ISSUES

Maintenance staff should be aware of a planned course of action in case the system ceases to function properly.

IMPORTANT POINTS TO CONSIDER

- System pumps and tank must be properly sized to provide adequate amounts of water for the entire building or project.
- The entire system must be located in a readily accessible space for maintenance purposes.
- The tank must be located in an area that can support its weight structurally. If such a space is not readily available, structural modifications may be required.

Cost/Benefit Worksheet
ECM No. 36: Convert Water Supply Pumps

Step 1 Obtain total cost of installing hydro-pneumatic water pressure systems:
$

Step 2 Transfer the following information from the Survey:
4-62 **a** Total horsepower of existing booster pumps: HP
5-9 **b** Cost of electricity: $/kWh

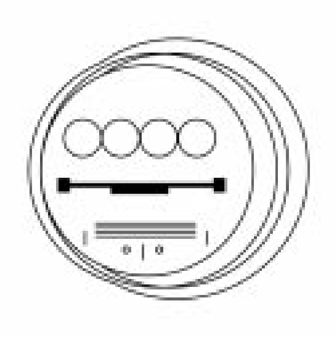
Step 3 Estimate annual energy savings:
2a
x 2190 = kWh/yr

Step 4 Calculate annual cost savings:
3 2b
x = $/yr

Step 5 Calculate payback period:
1 4
/ = yrs

ECM No.
37

INSTALL CHECKMETERING OR INDIVIDUAL METERING



APPLICABILITY

- Multifamily buildings with HA-paid electricity or gas

DESCRIPTION

In developments where the HA pays for electricity or gas consumption, residents have little incentive to conserve energy because they are not accountable for the amount of energy they use. Establishing accountability and responsibility for energy usage can reduce consumption by 10% to 25%. There are two different ways to establish resident accountability: checkmetering or individual metering.

Checkmetering. Checkmeters measure the electricity or gas consumed by a dwelling unit. The checkmeters are installed in addition to the master meter. The master meter, which is owned by the utility, measures total building consumption, and the HA is responsible for paying the bill to the utility. The checkmeters, on the other hand, are owned by the HA. The HA provides each household a utility allowance in the form of a maximum level of consumption that it may consume without a surcharge. When a household exceeds this level, the resident must pay a surcharge. The HA should make sure any charges are clearly explained to the residents.

Individual metering. Where utilities are individually metered, each household has a separate account with the utility company and pays the bill directly to that company. The meters are installed by the utility company. Individually metered utilities are sometimes called "retail service" or "tenant-paid" utilities. The HA provides a utility allowance to the household in the form of a reduction in monthly amount for rent that the household pays to the HA. When a household’s consumption exceeds the utility allowance, the household is still responsible for paying the bill. Therefore, the household has an incentive to keep consumption within the reasonable limits of the utility allowance.

MAINTENANCE ISSUES

If checkmeters are installed, staff (or a hired contractor) will need to read the checkmeters monthly, bi-monthly, or quarterly to determine each dwelling unit's consumption. In the case that the total consumption read from the checkmeters does not equal the total consumption measured by the master meter (shown on the HA's bill from the utility), maintenance staff should check the calibration of the checkmeters.

IMPORTANT POINTS TO CONSIDER

- Results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost-effectiveness analysis results in a payback of 15 years or less, a more detailed analysis should be performed.
- State and local laws should be reviewed to determine if checkmetering or individual metering is permissible.
- Prior to modifications to utility service arrangements with residents, the necessary changes should be made in resident leases in accordance with HUD regulations.
- During and after the transition to individual metering or checkmetering, the HA should work with residents with high consumption to help them find ways to reduce energy usage. The HA should investigate and, where possible, eliminate any sources of high consumption that may be beyond the control of the resident, such as inefficient equipment and appliances. If the high consumption is beyond the control of the resident and cannot be reduced, the utility allowance may need to be adjusted.
- HAs should work closely with resident organizations in making plans for conversion of utility service to individual metering and billing. Residents should be informed of any changes in charges and rent structure that will result, including the financial rewards for conserving energy.
- Private, performance-based financing for energy conservation improvements can be difficult to obtain for developments with individual metering because monitoring the performance of conservation improvements requires keeping track of a large number of individual utility consumption records, which energy services companies are generally reluctant to do.
- Because utilities typically charge a higher rate for energy sold to individuals than to a larger user, such as a whole building or development, switching to individual metering may result in higher per-apartment utility costs than installing checkmeters. In addition, switching from a single master meter to several individual meters may result in significantly higher monthly customer service charges.
- Some utilities require a deposit to set up an account if the customer has a poor credit record. Some residents may be unable to pay such a deposit and therefore may be unable to obtain utility service. The HA should consider this possibility and its potential effects before switching to individual metering.
- If checkmeters are installed, the HA should consider the additional maintenance staff time needed to read the checkmeters on a regular basis.

Cost/Benefit Worksheet
ECM No. 37: Install Checkmetering or Individual Metering

Step 1	Obtain total cost of installing checkmeters or individual retail service:			$
Step 2	Transfer the following information from the Survey:			
5-9	**a** Average annual fuel consumption:	Gas:		therms
		Electric:		kWh
5-9	**b** Cost of energy:	Gas:		$/therm
		Electric:		$/kWh
Step 3	Obtain the following value from Table 1:			
Table 1	Reduction factor of utility consumption:			
Step 4	Estimate annual energy savings for applicable fuel:			
	2a x 3 =			/yr
Step 5	Calculate annual cost savings:			
	4 x 2b =			$/yr
Step 6	Calculate payback period:			
	1 / 5 =			yrs

Note: If installing checkmetering or individual metering for both gas and electricity, make a copy of this worksheet and complete a separate worksheet for each fuel source.

ECM No. 37: Install Checkmetering or Individual Metering

Table 1: Reduction Factor for Various Utility Functions

Instructions:

1) Find the appropriate fuel (gas or electricity).
2) Find the appropriate end uses (refer to Chapter 5, Table 1).
3) Select "individual metering" or "checkmetering."
4) Select the appropriate reduction factor and transfer it to Step 3.

Fuel	End Uses	Individual Metering	Checkmetering
Gas	Heating only	0.35	0.25
Gas	Heating, cooking, DHW	0.25	0.15
Electricity	Lights and appliances only	0.25	0.15
Electricity	Lights, appliances and DHW	0.30	0.20
Electricity	Lights, appliances, DHW, heating	0.35	0.25

ADDITIONAL ECMS TO CONSIDER

ECM No. 38

INSTALL SUMMERTIME DHW HEATERS

APPLICABILITY

- Multifamily buildings with central combination boilers for heat and hot water

DESCRIPTION

Combination heat and hot water boilers are designed to provide both heat and hot water in a single system. During the winter, the boiler provides both heat and hot water, but during the summer, the boiler provides only hot water because no heat is needed. These systems can be fairly efficient in the wintertime, when the boiler is running at full capacity. However, during the summer, they tend to be very inefficient because the boiler is running at very low capacity. Installing a separate water heater to provide hot water during the summer months can provide efficiency gains of 25% or more.

There are a few different types of combination heat/hot water boiler systems. This ECM applies to the following two types: (1) systems where there is a tank on the boiler (sometimes called a "side-arm" water heater) that has an internal coil that boiler water runs through to heat the water in the tank; (2) systems where water is heated in a coil inside the boiler. Other types of combination systems—in particular, systems where several smaller boilers provide heat, and only a few are used for hot water in the summer—are generally not inefficient enough to merit installation of a separate hot water heater for summer use.

MAINTENANCE ISSUES

Installing a summertime DHW heater can reduce maintenance because the large central boiler system is turned off during the summer.

IMPORTANT POINTS TO CONSIDER

- In most cases, the separate DHW heater should operate only during the summer months because in the winter hot water is generally more efficiently generated by the central boiler.
- Installing a separate DHW heater presents an opportunity to change to a less costly fuel type and should be considered. In this analysis, however, the same fuel type is assumed.
- Performance of this ECM in several HAs has shown mixed results, with savings ranging from zero to over 25%.

ECM No. 39

CONVERT DHW SYSTEMS TO SOLAR

APPLICABILITY

- Single-family and multifamily buildings, particularly in sunnier climates.

DESCRIPTION

Solar domestic hot water (DHW) systems save energy by utilizing the sun's energy instead of electricity, gas, oil, or other fuels. Solar panels located on the roof or on the ground collect energy from the sun. In “active” solar water heating systems, the energy is then transferred to the hot water storage tank using heat transfer fluid and a device called a heat exchanger. The system includes an auxiliary fuel source, such as gas or electricity, to heat the water when the sun's rays are not sufficient to meet water heating needs.

Solar DHW systems can save up to half of a development's water heating costs. However, the savings will vary based on the availability of sunlight. Potential savings are highest in the sunniest climates, but significant savings can also be realized in areas with average sun exposure.

Savings also depend on the mechanical performance of the system. In some cases where systems have failed due to poor manufacturing or lack of proper maintenance, the systems have saved no energy at all.

For example, the San Francisco Housing Authority installed solar DHW systems in five developments in the 1980s. Savings ranged from 1% to 23% during the first year, but by the third year, three of the developments were using more energy for hot water than before the solar systems were installed. The drop in savings was attributed to a deterioration of the systems. However, although solar water heaters have often been non-cost-effective in the past, refinements in solar technology are making solar DHW systems more attractive.

MAINTENANCE ISSUES

Active solar hot water heaters are complex systems that require considerable maintenance. This maintenance has costs in terms of staff time and training or hiring a contractor to provide maintenance of the system. Historically, maintenance costs have been a significant part of the life cycle cost of solar water heaters (Wong and Leber 1996). Failure to properly maintain solar DHW systems can result in deterioration of the equipment, resulting in non-cost-effectiveness.

IMPORTANT POINTS TO CONSIDER

- A qualified professional should be consulted to assess the likely cost-effectiveness of a solar DHW system for a particular development.
- Because maintenance costs of solar DHW systems can be significant, they should be taken into account before making a decision to install this ECM.
- The installation of solar DHW systems in high-rise buildings requires extensive new hot water distribution plumbing and therefore is less cost-effective than systems installed in low-rise buildings or single-family homes.
- Pipes connecting solar panels to the storage tank should be insulated.

ECM No. 40

CORRECT LOW POWER FACTOR

APPLICABILITY

- Buildings being charged by the local utility for low power factor

DESCRIPTION

Some HAs are charged extra on their electric bills for a low power factor. Although correcting low power factor does not actually save energy, it can save some HAs thousands of dollars every year in reduced charges and can be accomplished relatively inexpensively.

Power factor is the ratio of the power delivered to a building, as measured by a meter, to the actual power being used by electrical equipment. It is always a number between zero and one. Certain electronic devices, such as fluorescent lighting, electric motors (including those in fans, air conditioners, refrigerators, and elevators), transformers, and all other inductive devices have inherently low power factors. Low power factors are costly to utility companies because their systems run less efficiently. Most utility companies assume an average level for power factor (typically 0.85 to 0.9). When a customer's power factor is lower than this assumed average, the utility company may impose a surcharge.

A customer's power factor and any charges for low power factor can be found by examining an electricity bill. If charges are reflected on the bill, the HA should consult a utility representative to verify the nature of the charges and to inquire how to raise the power factor to an acceptable level to avoid these charges. Low power factor can usually be corrected with devices called capacitors, which are relatively easy to install.

MAINTENANCE ISSUES

The maintenance staff should be made aware of any low power factor problems and should be informed of the process of correcting low power factor.

IMPORTANT POINTS TO CONSIDER

- The HA should consult an electrical consultant or engineer to develop a power correction plan that outlines what corrections have to be made to avoid low power factor charges.

ECM No. 41

INSTALL LOAD-SHEDDING CONTROLS

APPLICABILITY

- Multifamily buildings with demand charges

DESCRIPTION

Electric utility companies typically charge their multifamily and commercial customers both an “energy rate”, which is based on the total electricity usage, and a “demand charge”, which is the price for the maximum level of power the utility has to supply to that customer during a billing period. This maximum load, which is measured by meters owned by the utility company, is highest when all or most of a building's electrical systems are in operation. Load-shedding controls reduce the maximum electrical load of a building, therefore reducing the demand charge and the overall price of electricity. Load-shedding controls do not necessarily save a significant amount of electricity, but because they can save on electricity *costs*, they are included in this workbook.

Load shedding can be achieved by limiting or eliminating electrical equipment operation during maximum use periods and shifting operation to other times. As such, it applies only to buildings that have electrical equipment that can be controlled at certain times. Typical loads that may be shifted include: domestic hot water; make-up air handlers; heating and cooling of office and public spaces such as corridors and stairways; use of auxiliary equipment such as office machines; extra elevators and service elevators; and large pumps, including water and storage tank pumps.

Load shedding can be accomplished by manual procedures or by automatic controls. Automatic controls range from simple sensors that shut off low-priority equipment when a certain building load is reached to time clocks to sophisticated computer-driven energy management systems (EMS) (see text box on next page).

The first step in implementing this ECM is to review current electric bills and contact the local electric utility to determine the demand charge structure and maximum load times. The utility should help maintenance staff or the staff engineer in determining how electrical loads can be reduced and in evaluating appropriate controls.

Energy Management Systems

Energy Management Systems (EMS) are computer-driven control systems that monitor and control energy-using equipment in a building or group of buildings. An EMS is typically applied to the largest electrical loads, such as pumps, water heaters, lighting, and heating and cooling, to shift electrical load as well as to reduce energy consumption. An EMS can also track energy use. Typically, a single computer controls equipment in one or more buildings.

If an EMS is being considered, a proven system with a good track record should be selected. Most energy management systems are proprietary systems of a particular manufacturer, and appropriate replacement parts can only be obtained by that manufacturer. In addition, because these systems are changing rapidly due to technological developments, in some cases replacement parts are no longer available from the manufacturer after a few years. Also, it should be noted that a new EMS system may not interface properly with existing controls and other components. Finally, maintenance staff should be trained to operate any new EMS system that is installed. Service contracts can be very expensive.

For more information on EMS, contact the Electric Power Research Institute, listed in Appendix C.

MAINTENANCE ISSUES

The maintenance issues associated with load-shedding controls vary depending on the type of controls. Less complex controls such as time clocks generally require moderate maintenance, for example, resetting time clocks after power outages. Complex systems, such as energy management systems, require a more sophisticated, ongoing maintenance program. If an EMS is installed, maintenance staff will need to understand the operation and maintenance of the system and appropriate procedures for mechanical problems. Some HAs may wish to hire a contractor to maintain and oversee the EMS.

IMPORTANT POINTS TO CONSIDER

- In general, load-shedding is not appropriate for heating and cooling of dwelling units (except for very short periods of time), or for cooking.
- The cost-effectiveness of this ECM depends on the demand rate structure of the electric utility company. This ECM may become more or less cost-effective if the rate structure changes.

ECM No.
42

INSTALL VENTILATION CONTROLS

APPLICABILITY

- Mid- and high-rise multifamily buildings with central ventilation systems

DESCRIPTION

In all housing, ventilation is necessary to maintain adequate indoor air quality. It does this by providing outdoor air to dilute and remove indoor air pollutants such carbon dioxide, odors, and moisture. Ventilation can be provided by natural infiltration of air into the building through leaks in the building envelope, by tenant-controlled fans in the bathroom and/or kitchen, or by a central ventilation system. In buildings with central ventilation, the fans are typically in the kitchen and bathroom. While adequate ventilation is important for health and safety, too much ventilation or uncontrolled ventilation can result in energy waste. This is because outside air that comes into a building through ventilation must be heated during the heating season and, in buildings with air conditioning, cooled during the cooling season.

In many mid- and high-rise developments, central ventilation fans run 24 hours per day, accounting for 15% or more of the total energy use. Often, however, adequate ventilation can be provided with these fans running less than 24 hours per day. Mechanical timer controls can be installed to provide ventilation during scheduled periods each day. By reducing the number of hours of operation while still ensuring adequate ventilation, timer controls save energy. Timers are a simple and low-cost energy conservation measure with an average payback of less than one year (Hayes and Shapiro-Baruch 1994).

MAINTENANCE ISSUES

In many buildings, a large percentage of ventilation fans are inoperable, and even when the operable fans run 24 hours per day, ventilation can be inadequate. In such buildings, the ventilation system components should be repaired or replaced before considering this ECM. Also, before installing ventilation timer controls, maintenance staff should ensure that apartment ventilation grilles and exhaust vents allow adequate air flow.

IMPORTANT POINTS TO CONSIDER

- Mechanical ventilation should occur a *minimum* of 8 hours per day to provide adequate ventilation. Some buildings may require more mechanical ventilation because of less natural air infiltration or because there are more indoor air pollutants which must be diluted or removed. In some areas, local code requires that mechanical ventilation be on significantly more than 8 hours per day. In some cases, code requires mechanical ventilation 24 hours a day.
- Timer controls should not be installed on ventilation fans that are required by local building code to provide constant ventilation. For example, in some localities, bathroom fans are required to provide constant ventilation.
- This ECM should not be installed in buildings where a significant number of ventilation fans are inoperable.
- Replacing ventilation motors with energy-efficient units can also yield energy savings (see ECM No. 34).
- ASHRAE (the American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.) has developed ventilation standards for buildings. These standards should be referenced when making ventilation improvements. The standards listed in the bibliography were being updated at the time of publication of this workbook.

ECM No.
43

INSTALL SOIL MOISTURE SENSORS

APPLICABILITY

- Developments with irrigation (sprinkler) systems

DESCRIPTION

In some developments, particularly in the Southwest, irrigation is a major water end use. The amount of water used for irrigation can be reduced substantially using soil moisture sensors. Soil moisture sensors are devices that measure the moisture of the soil in the root zone and are connected to the controls of the sprinkler system. When the soil moisture sensors detect that the soil is dry, the sprinkler system is turned on. Then, when there is enough moisture in the root zone, the sprinkler system is turned off again. By ensuring that watering occurs only when necessary, soil moisture sensors can save water. Some moisture sensors are adjustable for different moisture levels.

Many soil moisture sensors are appropriate only for sprinkler systems that have time clocks or controls. If the system is manually controlled, maintenance staff can use a soil moisture sensor or moisture meter to determine when the soil is in need of watering and can water accordingly.

MAINTENANCE ISSUES

Sprinkler heads should be maintained to ensure properly directed irrigation and to avoid watering areas such as sidewalks and pavement. Adjustable sprinkler heads should not be set at a fine mist because much of the water evaporates into the air before it reaches the plants.

IMPORTANT POINTS TO CONSIDER

- Soil moisture sensors should be installed in the root zone of the soil.
- One soil moisture sensor should be installed per irrigation zone.
- When adding plants or creating a lawn, drought-resistant varieties should be selected.

$$$

ECM No. 44

INSTALL DIRECT USE GEOTHERMAL SYSTEM FOR HEATING AND HOT WATER

APPLICABILITY

- Multifamily buildings near a geothermal resource

DESCRIPTION

In certain geographical areas in the Western United States, the water below the ground is hot. This hot ground water is a "geothermal resource." HAs near a geothermal resource that is at least 120 degrees Fahrenheit may be able to use the energy in this geothermal resource for space heating and hot water. Geothermal energy is a clean, renewable source of energy that is virtually "free" once the system is installed. The basic components of a direct use geothermal system are a well, a pump to bring the hot water up from the ground, a heat exchanger that extracts the energy from the hot water, and a second well to return the geothermal water back into the ground.

Typical savings from direct use geothermal systems are 30% to 50% of the cost of using natural gas. However, the extent to which direct use geothermal systems have been used in housing is limited, and the track record for this technology is mixed. A study evaluating the performance of direct-use geothermal for heating in eight schools, hospitals, and other institutions found that four of the projects had unsatisfactory results. Problems included drilling failure, inadequate geothermal resource, and pump failure (Lienau and Lunis 1991).

It is important to note that there are significant capital costs involved in installing a direct use geothermal system for heat and hot water. Costs include exploring the resource and verifying adequate temperature, drilling the wells, and installing pumps, valves, heat exchangers, and distribution equipment. A qualified engineer must be involved in the design of the system. In addition to capital costs, there are some ongoing operational costs, such as maintenance costs and the cost of the power required to pump the water.

The cost-effectiveness of a geothermal system depends on the cost of installing the system, the temperature of the resource, and the cost of other available fuels such as gas and electricity. Generally, the higher the temperature of the resource and the more costly other sources of fuel, the more likely it is that a geothermal system will be cost-effective.

A total of 271 cities and communities in ten states have been identified as having geothermal resources that could potentially utilize geothermal energy (Lienau and Ross 1996). These states include: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, and Washington. If your HA is in one of these states and is interested in finding out if there is a geothermal resource nearby, contact the Geo-Heat Center (see Appendix C). The Geo-Heat Center also provides technical assistance for feasibility analysis and equipment and materials selection.

MAINTENANCE ISSUES

Maintenance issues associated with a geothermal system depend on whether a relatively simple system or a more complicated system is installed. Simpler systems do not require highly trained personnel, while more complicated systems with components that are different from those normally operated by HA staff will require that staff are trained in the maintenance and operation of the system (Lienau and Lunis 1991).

IMPORTANT POINTS TO CONSIDER

- Installing a direct use geothermal system for heat and hot water requires large up-front capital expenditure.
- HAs interested in a geothermal system should contact the Geo-Heat Center to determine if a potential geothermal resource is in the area. If so, the Geo-Heat Center can provide technical assistance in determining project feasibility.
- Once feasibility is determined, a qualified engineer should be involved in system design.
- Some states may provide grants for the development of direct use geothermal systems.

CHAPTER 8: SUMMARY OF RESULTS

It may be helpful for you to compile the relevant information for each ECM for which you have completed the cost/benefit worksheet. The table below will assist you in this task. If you have determined that a particular ECM is not relevant or applicable for your development, simply check the "N/A" box next to this ECM. For those ECMs that are applicable to your development, enter the total cost of installing or implementing the ECM, the annual savings in dollars and units (e.g., kWh, therms), and the payback period.

When completing this table, please remember that when more than one measure is installed, the total energy or dollar savings will not necessarily be the sum of the savings from the measures if they had been installed individually. In other words, do not add up the dollar or energy values in the savings column and assume that, by implementing several ECMs, your development will achieve the cumulative savings generated by each ECM. Please refer to Chapter 3, Key Energy Conservation Concepts, for more information regarding the interactivity among energy conservation measures.

> Remember, if you are considering more than one measure, the results may not be cumulative.

ECM #	**ECM**	**N/A**	**Total Cost ($)**	**Annual Savings**		**Payback Period**
				$	**Units**	
Architectural ECMs						
1	Install Storm Windows					
2	Install Replacement Windows					
3	Install Window Sun Shades: South-Facing Windows					
3	Install Window Sun Shades: East- and West-Facing Windows					
4	Install Storm Doors					
5	Install/Increase Attic Insulation - R13					
5	Install/Increase Attic Insulation - R30					
5	Install/Increase Attic Insulation - R42					
6	Install Roof Insulation - R10					
6	Install Roof Insulation - R20					
7	Install Wall Insulation					

ECM #	ECM	N/A	Total Cost ($)	Annual Savings		Payback Period
				$	Units	
8	Control Air Leakage					
Heating and Cooling ECMs						
9	Install Vent Dampers					
10	Convert to Electronic Ignition					
11	Install Boiler Controls					
12	Replace Inefficient Heating Plant					
13	Install Setback Thermostats					
14	Install Radiator Controls					
15	Insulate Hot Water or Steam Pipes					
16	Convert Steam Heating to Hot Water Distribution					
17	Seal and Insulate Ducts					
18	Install Geothermal Heat Pump					
19	Replace Inefficient Air Conditioners					
20	Install Swamp Coolers					
Domestic Hot Water System ECMs						
21	Install Water-Efficient Showerheads and Faucet Aerators					
22	Insulate Hot Water Tank					
23	Install DHW Off-Peak Controls					
24	Convert Laundry to Cold Rinse					
25	Replace Inefficient Hot Water Heater					
Lighting System ECMs						
26	Replace Incandescent Lighting with Compact Fluorescent Lamps in Dwelling Units					
27	Replace Incandescent Lighting with Fluorescent Lighting in Common Areas					
28	Replace Older Fluorescent Lamps with Energy-Saving Lamps in Common Areas					
29	Replace Older Fluorescent Lamps and Ballasts in Common Areas					

ECM #	ECM	N/A	Total Cost ($)	Annual Savings $	Units	Payback Period
30	Install Lighting Controls in Common Areas					
31	Convert Exterior Lighting Fixtures					
32	Install Photo-Controls for Exterior Lighting					
Miscellaneous ECMs						
33	Replace Older Refrigerators with High-Efficiency Units					
34	Upgrade or Replace Inefficient Motors					
35	Install Water-Saving Toilets					
36	Convert Water Supply Pumps					
37	Install Checkmetering or Individual Metering					

APPENDIX A: CLIMATE DATA

Location	Heating Degree Day Zone	Heating Season Hours
Alabama		
Birmingham	2.02	2316
Mobile	1.28	1908
Montgomery	1.66	2112
Arizona		
Phoenix	1.20	1860
Tuscon	1.35	1980
Arkansas		
Fort Smith	2.27	2244
Little Rock	2.28	2244
California		
Bakersfield	1.60	2172
Fresno	1.91	2304
Long Beach	1.25	2880
Los Angeles	1.00	2952
Oakland	2.07	4380
Sacramento	2.02	2532
San Diego	1.16	2688
San Francisco	2.13	4380
Colorado		
Colorado Springs	4.01	3312
Denver	3.67	3252
Grand Junction	3.42	2892
Pueblo	3.24	3300
Connecticut		
Hartford	3.94	3168
Delaware		
Wilmington	3.01	2820
DC		
Washington	2.70	2700

Location	Heating Degree Day Zone	Heating Season Hours
Florida		
Jacksonville	1.04	1692
Miami	.17	1200
Orlando	.60	1980
Tallahassee	1.20	1884
Tampa	.59	1116
West Palm Beach	.25	1200
Georgia		
Atlanta	2.17	2316
Augusta	1.83	2064
Macon	1.66	2028
Savannah	1.46	1968
Idaho		
Boise	3.56	3324
Lewiston	3.28	3228
Pocatello	4.45	3480
Illinois		
Chicago	4.03	3012
Springfield	3.39	2892
Indiana		
Evansville	2.97	3060
Fort Wayne	3.85	3060
Indianapolis	3.35	2904
South Bend	4.01	3084
Iowa		
Burlington	3.75	2916
Des Moines	4.16	2964
Sioux City	4.38	3036
Kansas		
Dodge City	3.03	2772
Topeka	3.15	2772
Wichita	2.91	2640
Kentucky		
Lexington	2.88	2796
Louisville	2.88	2604
Louisiana		
Baton Rouge	1.29	1884
Lake Charles	1.15	1812
New Orleans	1.13	1740
Shreveport	1.60	1956

Location	Heating Degree Day Zone	Heating Season Hours
Maine		
Portland	4.87	3636
Maryland		
Baltimore	2.88	2808
Massachusetts		
Boston	3.43	3144
Michigan		
Detroit	4.11	3108
Flint	4.44	3432
Grand Rapids	4.28	3252
Minnesota		
Duluth	6.73	3780
Minneapolis-	5.38	3156
St. Paul	5.43	3288
Rochester		
Mississippi		
Jackson	1.68	2100
Meridian	1.74	2160
Missouri		
Columbia	3.05	2820
Kansas City	3.21	2640
St. Louis	2.90	2664
Springfield	2.83	2722
Montana		
Billings	4.65	3432
Great Falls	4.97	3684
Helena	5.41	3816
Miles City	5.21	3360
Missoula	5.23	3744
Nebraska		
North Platte	4.25	3480
Nevada		
Elko	4.86	3636
Ely	5.16	3648
Las Vegas	1.87	2472
Reno	3.67	3552
New Hampshire		
Concord	4.78	3492

Location	Heating Degree Day Zone	Heating Season Hours
New Jersey		
Newark	3.02	2904
New Mexico		
Albuquerque	2.75	2664
Roswell	2.48	2496
New York		
Albany	4.34	3216
Binghampton	4.66	3492
Buffalo	4.36	3276
New York	2.96	2892
Rochester	4.17	3252
Syracuse	4.14	3156
North Carolina		
Asheville	2.71	2796
Charlotte	2.22	2448
Greensboro	2.52	2616
Raleigh	2.35	2424
North Dakota		
Bismark	6.15	3480
Fargo	6.30	3444
Ohio		
Akron	3.86	3048
Cincinnati	2.95	2844
Cleveland	3.75	3012
Columbus	3.48	2940
Dayton	3.44	2916
Toledo	3.96	3096
Youngstown	3.98	3084
Oklahoma		
Oklahoma City	2.44	2388
Tulsa	2.43	2340
Oregon		
Medford	2.96	3240
Pendleton	3.14	3120
Portland	2.92	3516
Salem	2.91	3504

Location	Heating Degree Day Zone	Heating Season Hours
Pennsylvania		
Allentown	3.55	3012
Erie	4.32	3096
Harrisburg	3.13	2892
Philadelphia	2.97	2808
Pittsburgh	3.17	3036
Rhode Island		
Providence	3.64	3252
South Carolina		
Charleston	1.59	2412
Columbia	1.87	2184
Greenville-Spartanburg	2.18	2412
South Dakota		
Rapid City	4.61	3432
Sioux Falls	5.17	3216
Tennessee		
Chattanooga	2.35	2508
Knoxville	2.37	2508
Memphis	2.23	2292
Nashville	2.44	2448
Texas		
Abilene	1.88	2100
Amarillo	2.68	2736
Austin	1.32	1812
Corpus Christi	.75	1452
Dallas-Fort Worth	1.74	1968
El Paso	1.93	2196
Houston	1.12	1740
Lubbock	2.38	2484
Midland-Odessa	1.89	2100
San Angelo	1.66	1860
San Antonio	1.21	1740
Waco	1.54	1896
Wichita Falls	1.54	2208
Utah		
Salt Lake City	3.65	3168
Vermont		
Burlington	5.20	3372

Location	Heating Degree Day Zone	Heating Season Hours
Virginia		
Norfolk	2.34	2592
Richmond	2.56	2652
Roanoke	2.71	2712
Washington		
Olympia	3.37	4380
Seattle	2.88	3708
Spokane	4.31	3612
Yakima	3.67	3324
West Virginia		
Charleston	2.85	2748
Huntington	2.87	2640
Wisconsin		
Green Bay	5.34	3408
La Crosse	4.82	3168
Madison	5.10	3216
Milwaukee	4.84	3312
Wyoming		
Casper	4.91	3552
Cheyenne	4.64	3684
Sheridan	5.01	3552

APPENDIX B: GLOSSARY[1]

Air leakage. Air moving into (infiltration) or out of (exfiltration) a dwelling unit through holes, gaps, and cracks in the *building envelope* and around windows and door frames.

Air-source heat pump. A *heat pump* that extracts energy from the outside air and uses it to heat and cool a building.

Air sealing. The process of strategically applying *caulk* or other material to holes, gaps, cracks in the building envelope and around window and door frames to reduce air leakage.

Anodized. Metal that has been treated with a protective oxide coating that reduces corrosion. Storm windows and door frames often have an anodized surface.

Atmospheric burner. A burner that relies on natural drafts to supply air for combustion. Also called a "*natural-draft burner*."

Ballast. A device necessary to turn on a fluorescent lamp.

Blower door. A device used to temporarily pressurize or depressurize buildings to detect the location of sources of air leakage.

Boiler. A device that produces hot water or steam for heating purposes.

Btu. British thermal unit, or the amount of heat required to raise one pound of water one degree Fahrenheit.

Building envelope. All external surfaces of a building subject to climate impact, such as walls, windows, doors, roof, and floor.

Calibration. The process of checking or adjusting a measuring instrument, such as a checkmeter. Checkmeters need to be calibrated periodically to ensure accurate measurement.

Caulk. Material used to seal cracks or spaces in a structure.

CCF. One hundred cubic feet (for example, of water or natural gas).

CFL. *Compact fluorescent lamp*.

Combustion chamber. The part of a boiler or non-electric furnace where the fuel is burned.

Combustion efficiency. A measure of how completely the fuel is burned in a boiler or non-electric furnace once it is up and running in a steady state. The combustion efficiency of a boiler or furnace can be determined by measuring the oxygen or carbon dioxide concentration in the flue gas. Combustion efficiency should not be confused with Annual Fuel Usage Efficiency (AFUE), which is a measure of efficiency that takes into account the effects of the boiler or furnace cycling on and off.

---

[1] Words that appear in italics are defined elsewhere in this Glossary.

Compact fluorescent lamp. A fluorescent lamp that is much smaller than a long fluorescent tube and which is appropriate for replacing standard incandescent bulbs. There are two primary types of compact fluorescent lamps (CFLs): "screw-in," which can replace incandescent bulbs with no wiring, or "hard-wired," which require wiring and fixture modifications.

Conduction. The type of heat transfer that occurs when heat moves through a solid.

Control. Any device used to regulate a system or equipment, such as lighting or boiler controls.

Convection. Heat transfer that occurs when heat moves by motion of a fluid or gas, usually air.

Cost-effective. Any energy conservation measure whose energy saving benefits within a given time frame (for example, fifteen years) exceed the cost of installing the measure.

Degree day. The difference between the daily median temperature and 65 degrees F. when the median temperature is less than 65 degrees F, degree days are *heating degree days* and are a measure of the severity of the winter. When the median temperature is greater than 65 degrees F, degree days are cooling degree days and are a measure of the severity of the summer.

Demand charge. A charge found on the bills of multifamily and commercial buildings that is based on the maximum amount of power required by the building at any time during a billing period. For instance, if everyone if the building turned on all their electric appliances at the same time, even if for just a few minutes, the building would require a certain amount of power from the utility. The amount of power required (demand) is independent of the length of time the appliances are on. The demand is shown in terms of kilowatts (kW).

Double-pane windows. Windows that have two panes of glass to reduce heat loss in the winter and/or heat gain in the summer.

Ducts. Conduits or pipes through which warm or cool air is transported from the heater or air conditioner to dwelling units in a forced-air system.

Electronic ignition. A device in a gas-fired heating system that saves energy by turning on the pilot light when gas is needed and turning it off when gas is not needed.

Energy audit. A process of examining energy consumption and building systems that identifies and specifies the energy and cost savings likely to be realized through the purchase and installation of particular energy conservation measures.

Energy conservation. The act or process of saving energy through increases in the efficiency of systems or equipment or through changes in energy-using practices.

Energy conservation measure (ECM). A modification to energy-using systems or equipment that has the potential to save energy in a building. ECMs are sometimes called "energy efficiency measures" or simply "measures."

Energy efficiency. The amount of output or activity per unit of energy consumed.

Energy efficiency rating (EER). A measure of the energy efficiency of an appliance or piece of equipment.

"Energy-saving" lamp. A particular type of efficient fluorescent lamp that replaces a standard fluorescent tube and is easily installed because it requires no changes to wiring or fixtures. Most "energy-saving" lamps are available only in one size (T-12).

Energy-rate. The rate electric utilities charge for the amount of energy, or *kilowatt-hours*, used.

Flue damper. A device in the vent of a furnace or boiler that shuts off the vent when the burner goes off to reduce the loss of warm air up the chimney. A flue damper is installed upstream of the draft diverter, while a *vent damper* is installed downstream of the draft diverter.

Forced-draft burner. A burner that has a fan to supply air for combustion. Also called a "*power burner*."

Furnace. A device that produces hot air for heating purposes.

Geothermal heat pump. A *heat pump* that extracts energy from the ground or water using underground loop systems and uses it to heat and/or cool a building and in some cases provide domestic hot water. Also called a ground-source heat pump.

Heat pump. A device that takes energy from an outdoor source such as the air, ground, or water and uses it to heat and cool a building and in some cases provide domestic hot water. Heat pumps provide heating and/or cooling most commonly through a forced-air distribution system.

Heating degree day. A measure of the heating requirement for a given location. The annual heating degree days for a particular location is the sum of the difference between outdoor temperature and 65 degrees, when outdoor temperature is below 65 degrees, for all the days in a year.

Heating degree day zone. A number that reflects the number of *heating degree days* in a particular geographical area. Appendix A includes a table that provides the heating degree day zone for various geographical areas.

Hydro-pneumatic system. A water supply pump system that has a special "hydro-pneumatic" tank that uses an air chamber to maintain water pressure without continuous operation of the supply pump, thus saving electricity.

Insulation. Material that reduces the conduction of heat.

Kilowatt-hour (kWh). A common unit for electricity. One kilowatt-hour (kWh) is 1,000 watt-hours or the amount of electricity consumed by a 100-watt lamp in ten hours.

Lamp. In the energy industry, "lamp" is used to describe both incandescent light bulbs as well as fluorescent tubes and bulbs.

Low-e windows. Windows that have a *low-emissivity coating* which reduces heat lost to the outside (or, in cooling climates, gained from the outside).

Low-emissivity coating. A coating on some windows that reduces the amount of heat that can be transferred through the window.

MBtu. One thousand *Btu*.

Natural-draft burner. A burner that relies on natural drafts to supply air for combustion. Also called an "*atmospheric burner*."

Off-peak rate. A rate charged by some utilities for electricity used during times when the utility experiences lower demand, called "off-peak periods." This rate is lower than the rate charged for electricity used during "peak periods." Peak and off-peak rates are also called "*time-of-use*" rates. A building must have time-of-use meters to take advantage of time-of-use rates.

Outdoor reset/cutout control. A control on a boiler that senses outdoor temperature and cycles the boiler as needed to maintain an appropriate water temperature and shut (cut out) boiler operation when the outdoor temperature reaches a specified temperature.

Payback. The number of years it takes for the energy cost savings generated by an energy conservation measure to equal the cost of installing that measure.

Peak rate. A rate charged by some utilities for electricity used during times when the utility experiences high demand, called "peak periods." This rate is higher than the rate charged for electricity used during "off-peak periods." Peak and off-peak rates are also called "*time-of-use*" rates. A building must have time-of-use meters to take advantage of time-of-use rates.

Photo-controls. Controls that regulate the operation of exterior lights so that they come on when it starts to get dark in the evening and turn off when it gets light in the morning.

Power burner. A burner that has a fan that supplies air for combustion. Also called a "*forced-draft burner*."

Power factor. The ratio of the power delivered to a building, as measured by the meter, to the actual power being used by electrical equipment. Certain electronic devices such as fluorescent lighting, electric motors, transformers, and other inductive devices have low power factors. Many utilities impose a low power factor surcharge when a customer’s power factor is lower than a certain level.

R-value. A measure of a material’s resistance to heat *conduction* through it. The higher the R-value, the better the insulating value. R-value is the inverse of *U-value*.

Reflective coating. A coating on windows that reduces the amount of heat gained through the window. Appropriate for warm climates.

Setback thermostat. A *thermostat* that automatically sets the temperature back by a few degrees at night or during any other preset time period in order to conserve energy.

Solar radiation heat gain. The amount of heat gained in a room directly from the sun's rays.

Stack effect. When warm air rises in a building, it leaks out of a building through gaps, holes or windows on the upper floors. This air is then replaced by cold air coming into the lower parts of the building. This "stack effect" results in residents on the bottom floors being too cold, and residents on the top floors being too warm. The residents on the top floors then open their windows to cool off, thus increasing the stack effect.

Storm windows. Secondary windows typically installed outside the primary window to reduce the amount of heat lost during the winter or heat gained during the summer.

Sun shades. Devices such as awnings, shading screens, and tinted window film designed to save energy used for cooling by reducing solar radiation through windows.

T12 lamps. A size of fluorescent lamp often used in common areas. Fluorescent lamp diameters are measured in eighths of inches. A T12 lamp is twelve eighths of an inch, or one and one half inches, in diameter. Similarly, a T8 lamp is eight eighths of an inch, or one inch in diameter.

Therm. A common unit of measurement of natural gas equal to 100,000 *Btu* of energy. Depending on its quality, natural gas typically contains approximately 1,000 Btu per cubic foot. Therefore, a therm of natural gas is usually equal to about 100 cubic feet.

Thermal break. A discontinuation between the outer and inner surfaces of a window frame to reduce the frame's ability to conduct heat.

Thermal resistance. A measure of a material's resistance to heat *conduction* through it, also called R-value.

Thermostat. A device that establishes and automatically maintains a desired temperature.

Thermostatic radiator valve. A device installed on a radiator to control the amount of heat given off by the radiator.

Time-of-use rates. Different rates charged by a utility depending on whether the electricity is used during peak periods or off-peak periods. A building must have time-of-use meters to take advantage of time-of-use rates.

U-value. A measure of a material's ability to conduct heat. The lower the U-value, the better the insulating value. U-value is the inverse of *R-value*.

Vent damper. A device installed in the vent of a furnace or boiler that automatically shuts off the vent when the burner goes off to reduce the loss of warm air up the chimney.

Wattage. A measure of the electric power required by a device such as a light bulb or appliance.

Weatherstripping. A flexible strip that seals the gap between the stationary and movable parts of a door or window.

APPENDIX C: LIST OF RESOURCE ORGANIZATIONS

Advanced Energy (formerly North Carolina Alternative Energy Corp.)
909 Capability Road
Suite 2100
Raleigh, NC 27606
919-857-9000
www.aec.ncsu.edu

Alliance to Save Energy
1725 K Street NW, #914
Washington, DC 20006-1401
202-857-0666
www.ase.org

American Council for an Energy-Efficient Economy (ACEEE)
1001 Connecticut Avenue, NW, Suite 801
Washington, DC 20036
202-429-8873
www.crest.org/aceee

American Gas Association
1515 Wilson Blvd.
Arlington, VA 22209
703-841-8660
www.aga.com

American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE)
1791 Tullie Circle NE
Atlanta, GA 30329
404-636-8400
www.ashrace.org

California Energy Commission
www.energy.ca.gov

Center for Energy and the Urban Environment
510 1st Avenue North, Suite 400
Minneapolis, MN 55403-1609
612-335-5858

Consortium for Energy Efficiency
1 State Street, Suite 1400
Boston, MA 02109
617-589-3949

Edison Electric Institute
701 Pennsylvania Avenue NW
Washington, DC 20004-2696
202-508-5000
www.eei.org

Electric Power Research Institute (EPRI)
P.O. Box 10412
Palo Alto, CA 94303
415-855-2000
www.epri.com

Energy Efficiency and Renewable Energy Clearinghouse
P.O. Box 3048
Merrifield, VA 22116
800-363-3732
www.eren.doe.gov

Energy Star Program (Equipment and Applicances)
(collaboration between U.S. Dept. of Energy and U.S. Environmental Protection Agency)
888-STAR-YES
www.energystar.gov

Federal Energy Management Program (FEMP)
Appliance Procurement Guide
800-363-3732
www.eren.doe.gov/femp

Florida Solar Energy Center
1679 Clear Lake Road
Cocoa, FL 32922-5703
407-638-1000
www.fsec.ucf.edu

Gas Research Institute
8600 West Bryn Mawr Avenue
Chicago, IL 60631
773-399-8100
www.gri.org

Geo-Heat Center
Oregon Institute of Technology
3201 Campus Drive
Klamath Falls, Oregon 97601
541-885-1750
www.oit.osshe.edu/admin/geoheat

International Ground-Source Heat Pump Association
490 Cordell South
Stillwater, OK 74078
405-744-5175
www.igshpa.okstate.edu

Lawrence Berkeley National Laboratory
Center for Building Science
Mailstop 90-3058
1 Cyclotron Road
Berkeley, CA 94720
510-486-4835
eande.lbl.gov/cbs/cbs/html

National Center for Appropriate Technology (NCAT)
Multifamily Housing Project and Energy Efficiency Clearinghouse
P.O. Box 3838
Butte, MT 59702
406-494-4572

National Renewable Energy Laboratory (NREL)
1617 Cole Blvd.
Golden, CO 80403
303-275-3000
www.nrel.gov

New York State Energy Research and Development Authority
Corporate Plaza West
286 Washington Avenue Extension
Albany, NY 12203-6399
518-862-1090
www.nyserda.org

North Carolina Alternative Energy Corporation
(*see* Advanced Energy)

Oak Ridge National Laboratory
P.O. Box 2008
Building 4500 N., MS 6205
Oak Ridge, TN 37831-6205
423-576-5454
www.ornl.gov

Oregon Energy Line
Oregon State University Extension Energy Program
800 NE Oregon Street, #10
Portland, OR 97232
800-457-9394

Pacific Gas and Electric's Smarter Energy Line
P.O. Box 15005
111 Almaden Boulevard, Room 602
San Jose, CA 95115-0005
800-933-9555

U.S. Department of Energy
Office of Building Technology
1000 Independence Avenue SW
Washington, DC 20585
202-586-9445
www.eren.doe.gov/buildings

Vermont Energy Investment Corporation
127 Pine Street
Burlington, VT 05401-8410
802-658-6060

Additional Resource Organizations

local utility
local weatherization provider
HUD field office

APPENDIX D: BIBLIOGRAPHY

American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE). 1989. *Standard 62-89, Ventilation for Acceptable Indoor Air Quality*.

Brown, M., L. Berry, and L. Kinney. 1993. *Weatherization Works: An Interim Report of the National Weatherization Evaluation*. ORNL/CON-373. Oak Ridge, TN: Oak Ridge National Laboratory.

Cohen, S.D., C.A. Goldman, and J.P. Harris. 1991. *Measured Savings and Economics of Retrofitting Existing Single-Family Homes: An Update of the BECA-B Database*. Report LBL-28147, vol. 1. Berkeley, CA: Lawrence Berkeley Laboratory, Applied Science Division.

DeCicco, John, Rick Diamond, Sandra Nolden, Janice DeBarros, and Tom Wilson. 1995. *Improving Energy Efficiency in Apartment Buildings.* Washington D.C.: American Council for an Energy-Efficient Economy.

"Discovering Ducts: An Introduction." 1993. *Home Energy,* September/October.

E Source, Inc. 1991. *Water Heating*. E Source Technology Atlas Series. Boulder, CO.

E Source, Inc. 1994. *Lighting*. E Source Technology Atlas Series. Boulder, CO.

E Source, Inc. 1995. *Space Cooling*. E Source Technology Atlas Series. Boulder, CO.

E Source, Inc. 1996. *Space Heating*. E Source Technology Atlas Series, vol. 3. Boulder, CO.

E Source, Inc. 1996a. *Drive Power*. E Source Technology Atlas Series, vol. 4. Boulder, CO.

E Source, Inc. 1996b. *Halogen Torchieres: Cold Facts and Hot Ceilings.* E Source Tech Update, September. Boulder, CO.

Hayes, V., and I. Shapiro-Baruch. 1994. "Evaluating Ventilation in Multifamily Buildings." *Home Energy*, July/August.

Hewitt, M. 1990. "Do Vent Dampers Work in Multifamily Buildings?" *Home Energy* March/April.

Kennedy, William, Wayne Turner, and Barney Capehart. 1994. *Guide To Energy Management*. Lilburn, GA: Fairmount Press.

Krigger, John. 1991. *Your Home Cooling Energy Guide*. Helena, MT: Saturn Resource Management.

Lecker, G., and K. DeFreese. 1996. "Shedding Light on Lighting Control Design." *Consulting-Specifying Engineer*, vol. 20, no. 5, November.

Lienau, Paul, and Ben Lunis. 1991. *Geothermal Direct Use Engineering and Design Guidebook.* Geo-Heat Center. Klamath Falls, OR: Oregon Institute of Technology.

Lienau, Paul, and Howard Ross. 1996. *Final Report: Low Temperature Assessment Program.* Geo-Heat Center. Klamath Falls, OR: Oregon Institute of Technology.

Lobenstein, M.S. 1988. "Converting Steam-Heated Apartment Buildings." *Home Energy*, May/June.

Lobenstein, M.S., and M. Hewitt. 1995. "The Best Boiler and Water Heating Retrofits." *Home Energy*, September/October.

National Renewable Energy Laboratory. 1994. *Energy-Efficient Windows.* Publication DOE/CH10093-290 FS 216. Washington, DC: U.S. Department of Energy, October.

National Renewable Energy Laboratory. 1995. *Energy-Efficient Water Heating*. Publication DOE/GO-10095-063 FS 204. Washington, DC: U.S. Department of Energy, January.

New York State Energy Research and Development Authority (NYSERDA). 1995. *Thermostatic Radiator Valve (TRV) Demonstration Project*. Report 95-14.

Nolden, S. 1995. "The Key to Persistence." *Home Energy*, September/October.

Oak Ridge National Laboratory. 1992. *Energy Performance Contracting for Public and Indian Housing*. Washington, DC: U.S. Department of Energy and U.S. Department of Housing and Urban Development, February.

Rea, Mark, ed. 1993. *Lighting Handbook: Reference & Application.* 8th ed. New York: United Illuminating Engineering Society of North America.

Rieger, T. 1994. "Ground-Source Heat Pumps Gaining Ground." *Home Energy*, July/August.

Ritschard, R., and J.A. McAllister. 1992. "Persistence of Savings in Multifamily Public Housing." *Proceedings of the 1992 Summer Study on Energy Efficiency in Buildings*. Vol. 4, pp. 201-215. Washington, D.C.: American Council for an Energy-Efficient Economy.

Steven Winters Associates, Inc. 1996. *HUD Rehabilitation Energy Guidelines for One-to-Four Family Dwellings*. Washington, DC: U.S. Department of Housing and Urban Development, Office of Policy Development and Research.

Steven Winters Associates, Inc. 1996. *HUD Energy Guidelines for Multi-Family Rehabilitation Projects*. Washington, DC: U.S. Department of Housing and Urban Development, Office of Policy Development and Research.

Ternes, M. 1993. "Affordable Cooling with Window Air Conditioners." *Home Energy*, July/August.

U.S. Department of Energy (DOE). 1995. *Improving Energy Efficiency in Public Housing: A Colorado Field Experiment.* Prepared by Financial Energy Management. Denver, CO: U.S. Department of Energy, Denver Support Office.

U.S. Department of Housing and Urban Development (HUD). 1995. *HUD Life-Cycle Cost Analysis for Utility Combinations.* Handbook 7418.1, CHG-1. Washington, DC: May.

U.S. Office of the Inspector General (OIG). 1995. *Report on Review of Opportunities to Reduce Utility Costs at Public Housing Authorities*. No. 95-SE-101-0001. Washington, DC: May 31.

Walker, L. 1994. *Service In Action: Installing Storm Windows and Doors.* Publication No. 4.656. Colorado State University Cooperative Extension.

Weingarten, L., and Weingarten, S. 1996. "Water Heaters and Energy Conservation Choices, Choices!" *Home Energy*, May/June.

Wong, T., and J. Leber. 1996. "Analysis of Various Water Heating Systems." *Proceedings of the 1996 Summer Study on Energy Efficiency in Buildings.* Vol. 1, pp. 255-263. Washington, D.C.: American Council for an Energy-Efficient Economy.