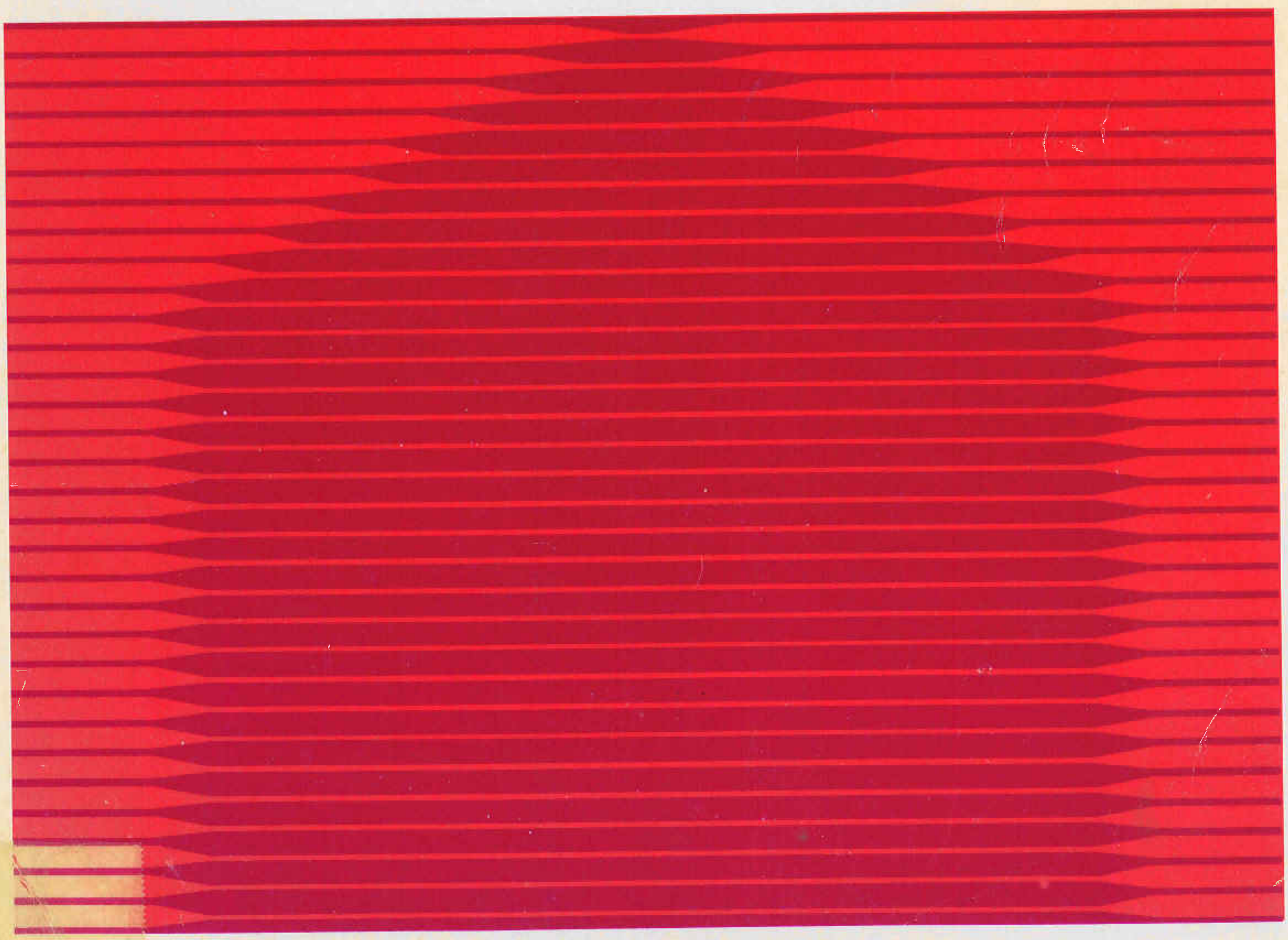
U.S. Department of Housing and Urban Development
Office of Policy Development and Research

Energy Conservation for Housing

A Workbook



Energy Conservation for Housing: A Workbook

Prepared by the
joint venture

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Physical Condition of Public Housing Stock.

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FOREWORD

In recent years, attention has focused increasingly on the nation's energy problems and efforts to reduce energy consumption and costs. Given the magnitude of energy costs, many actions that could reduce energy consumption by only a small percentage would yield significant energy cost savings.

Studies of residential energy conservation retrofit programs indicate that it is technically and economically feasible to save more than 50 percent of the energy that is now consumed. However, these results are dependent on accurate assessments and knowledgeable actions for specific buildings. This workbook was designed to address the special needs of multifamily housing property managers in formulating these assessments and determining the appropriate retrofit actions for the buildings they manage.

I am confident its use will assist multifamily property managers in their efforts to reduce energy consumption, and thereby conserve limited natural resources. I am pleased to make it available.

E. S. Savas

E. S. Savas
Assistant Secretary for
Policy Development and
Research

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CHAPTER 1. INTRODUCTION

SECTION 1. GENERAL CONSIDERATIONS

1-1. Purpose. The Energy Conservation Workbook for Housing grew out of research conducted for the study "An Evaluation of the Physical Condition of Public Housing Stock." It was prepared specifically to assess the existing energy consumption and energy conservation potential in this country's public housing. However, this workbook should be applicable in conventional multifamily housing, given the similarities between it and the public housing stock, in terms of construction types and other physical characteristics.

Section 14 of the United States Housing Act of 1937, as amended by the Housing and Community Development Act of 1980, restructured the Public Housing Modernization Program into the Comprehensive Improvement Assistance Program (CIAP). Under this program, the U.S. Department of Housing and Urban Development (HUD) is authorized to provide financial assistance to Public Housing Authorities (PHAs) to improve the physical condition and upgrade the management and operation of existing public housing projects. An important aspect of these improvements is energy conservation in the buildings, equipment, operation and maintenance of a project.

1-2. Applicability.

a. The material contained in this workbook can assist PHAs and other owners or managers of multifamily housing in identifying cost-effective Energy Conservation Opportunities (ECOs) and for establishing priorities for funding.

b. The workbook materials can also be used to conduct energy audits* to make multifamily properties more energy efficient.

c. Benefits realized with a completed energy conservation program include:

(1) Reduced energy operating costs (estimated at 30-60 percent depending on project characteristics)

(2) Reduced energy use to the nation thereby decreasing dependence on foreign supplies and decreasing pressures to build new power generating plants.

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* HUD 24 CFR 865, Subpart C - Energy Audit and Energy Conservation Measures requires that PHAs conduct energy audits for all of their projects.

(3) Reduced replacement costs due to extended life of building components and equipment.

(4) Reduced airborne pollution due to combustion of fossil fuels.

(5) Improved interior environment for tenants or project personnel, due to decreased drafts, cold spots, heat gain and glare.

1-3. Definitions. The following terms are used throughout this workbook. Understanding their meaning will greatly aid in comprehending the workbook.

a. Energy Audit. A process when carried out identifies and specifies the energy and cost savings which are estimated to result from installing or accomplishing an energy conservation opportunity.

b. Operation and Maintenance Opportunities (O&Ms). Measures that improve energy efficiency of buildings and equipment that require no capital cost to implement.

c. Energy Conservation Opportunities (ECOs). Physical or O&M improvements or modifications that, if undertaken for a building or facility, or its equipment, are likely to reduce the energy cost in an amount sufficient to recover the installation costs within an acceptable time period. Energy conservation opportunities are listed in Chapter 4.

d. Payback period means the number of years required to accumulate net savings to equal the cost of an energy conservation opportunity.

e. Cost Effective. As used in this handbook, an Energy Conservation Opportunity with a pay back period of fifteen (15) years or less and the payback period is not longer than the useful life of the product shall be considered cost effective.

f. Cost/Benefit Analysis. When capital cost and the cost savings realized (benefit) from implementing an ECO, are known then a ratio of these numbers, capital cost divided by cost savings (benefit), results which equals payback years. This ratio can be used to determine whether the ECO is cost effective. This procedure is referred to herein as a cost/benefit analysis and the calculations required for each ECO are labeled as Cost/Benefit Worksheets.

g. Physical Needs Assessment - The Energy Conservation Survey. The Energy Conservation Survey was designed to serve as a part of the Comprehensive Assessment of Physical and Management Improvement Needs which is required for public housing under the Comprehensive Improvement Assistance Program (CIAP). The Energy Survey, also referred to as the Survey, consists of information to be collected about architectural details; heating, electrical and secondary systems; and, historical utility consumption schedules.

SECTION 2. - SCOPE

1-4. Scope. This workbook helps identify and analyze opportunities which exist to reduce energy consumption in a housing project. These opportunities exist in improved operation and maintenance practices and through investments in energy conserving devices or modifications to the buildings and equipment. This workbook is divided into five chapters and eight appendices, the contents of which are summarized below:

a. Chapter 1 is the introduction describing the purpose, applicability and background information which led to the development of this workbook.

b. Chapter 2 describes the organization and use of the Workbook.

c. Chapter 3 describes the Physical Needs Assessment for the purpose of ascertaining energy conservation opportunities in public housing.

d. Chapter 4 describes Energy Conservation Opportunities (ECOs) applicability decision criteria, general descriptions, and special concerns for 50 ECOs. These ECOs all require initial capital investment of material and/or labor.

e. Chapter 5 describes how the results of the ECO analyses can be summarized into a format suitable for a modernization program, tabulating the requirements for funding.

f. Appendix A includes all necessary forms for completing the Physical Needs Assessment (the Survey).

g. Appendix B includes detailed descriptions, illustrations and worksheets necessary to conduct cost/benefit analyses of the 50 ECOs suggested in this workbook.

h. Appendix C contains forms summarizing results of ECO calculations and forms suitable as exhibits for requests for funding.

i. Appendix D contains all pertinent climate data for selected U.S. cities necessary to complete cost/benefit worksheet calculations.

j. Appendix E contains a list of maintenance items that tenants should use to improve the operation and reduce the energy consumption of tenant owned and operated equipment.

k. Appendix F contains a glossary of terms and phrases used in this workbook.

l. Appendix G contains a list of abbreviations used in this workbook.

m. Appendix H contains a bibliography of books and reports used in the preparation of this workbook.

1-5. Energy Conservation Opportunities. Since Energy Conservation Opportunities (ECOs) require a cost/benefit analysis to determine cost-effectiveness this section forms the bulk of the workbook. Each of the 50 ECOs included in this workbook is described in Chapter 4 and further defined in Appendix B along with methods to estimate savings and payback.

The 50 ECOs included in this workbook are not meant to represent the only ECOs possible. In fact, many additional ECOs exist. The ECOs included herein are only a representative sample of the total and are included because they apply to the greatest number of public housing types. Any other ECO that will cost-effectively save energy in a particluar building according to the general procedures contained herein should be considered equal to those included in this workbook.

The estimates of savings for the ECOs included here are only approximations. If more accurate engineering results are available from a professional source then they should be substituted. For example, heating savings only are estimated for the insulation ECOs. If a dwelling unit is air-conditioned additional savings will also be realized with insulation and credit can be taken for it if documented by a professional.

1-6. Mixed Building Types. In projects with multiple buildings of different types, such as a high rise and low rise; or heating systems such as central systems and individual dwelling unit heaters, it might be advantageous to obtain two copies of this workbook and

use a separate one for each type of building or system. The application for funds would then include summaries of each workbook completed.

1-7. Relevant Codes, Regulations and References. This workbook includes guidelines and procedures for evaluating existing public housing to assess energy conservation needs. The guidelines and procedures are designed to complement all federal, state and local code and ordinances that apply to project sites and buildings. When this handbook conflict with any of the said codes, the more stringent requirement shall apply.

a. Field Office Requirements. All applicable standards developed by the governing Field Office shall be met. When the Field Office deems necessary, additional or more stringent requirements shall be met.

b. Rehabilitation Work. All modernization, alteration, repair and replacement in public housing shall comply with the following documents:

(1) Modernization Standards, HUD Handbook 7485.2 REV.
(2) Minimum Property Standards for Multifamily Housing, HUD 4910.1.
(3) A Guide for the Preparation of a Life-Cycle Cost Analysis for Heating and Cooling Systems and Energy Conservation Measures in Residential Buildings, HUD 4075.17.
(4) Manual of Acceptable Practices, HUD 4930.1
(5) ASHRAE Standard 90-75 "Energy Conservation in New Building Design" and any revision thereof.
(6) Current ANSI standards, specifications for Making Buildings and Facilities Accessible to and Usable for Physically Handicapped People.

SECTION 3. BACKGROUND (For Public Housing)

1-8. Energy cost escalation has been one of the major contributors to the serious growth in subsidy requirements in public housing. Fuel costs are expected to continue to rise significantly faster than both rents and inflation, thus aggravating an already sever problem. However, potential for savings is substantial because so little has been done so far to up-grade the energy performance of the public housing stock. A recent study conducted by the Department found the following conditions to exist:

a. Public housing uses an estimated 146 million BTUs of energy per dwelling unit or 162 trillion BTUs per year for the public housing stock as a whole. This is equivalent to 28,100,000 barrels of oil. In 1980 costs this translates into $673 per dwelling unit or $749 million for the entire stock. This amount is expected to increase substantially during the next several years.

b. The range in usage between high energy-use projects (ones in severe climates and with high-usage building and system characteristics) and low energy-use projects is over five to one.

c. The major categories of energy use as a percent of total energy dollars are as follows:

End Use	Range	Average
Heating	27-80%	52%
Domestic Hot Water	8-38%	18%
Lights and Appliances	8-42%	26%
Miscellaneous	2-10%	4%

d. Energy usage in public housing is higher on a per dwelling unit basis than private sector housing. This can be accounted for in part by the older housing stock; the lack of energy conservation measures to date; and the fact that project office space, site lighting and other public space energy use has been pro-rated to the dwelling unit averages.

1-9. The energy conservation potential of public housing was addressed in the HUD study which found:

a. Because of the relatively high energy usage by public housing, there is significant potential for savings. These potential savings are summarized below and illustrated in Figure 1-1.

Energy Conservation Category	Potential Cost Savings
Operation and Maintenance	11%
Windows and Door Improvements	13%
Wall/Ceiling/Roof Insulation	6%
Mechanical Equipment Improvements	13%
Electrical	2%
Other	4%
National Average	48%

Note: The above averages were based on an analysis of 58 Energy Conservation Opportunities in a randomly selected representative sample of public housing projects.

b. This potential level of savings can be accomplished with an investment in material and labor of between $800 and $2500 per dwelling unit (1980 dollars) depending on building type, systems types and location. Expected return on this investment was esti-

mated to be over 15% with a combined payback of about 6 years for all actions having a payback within 15 years.

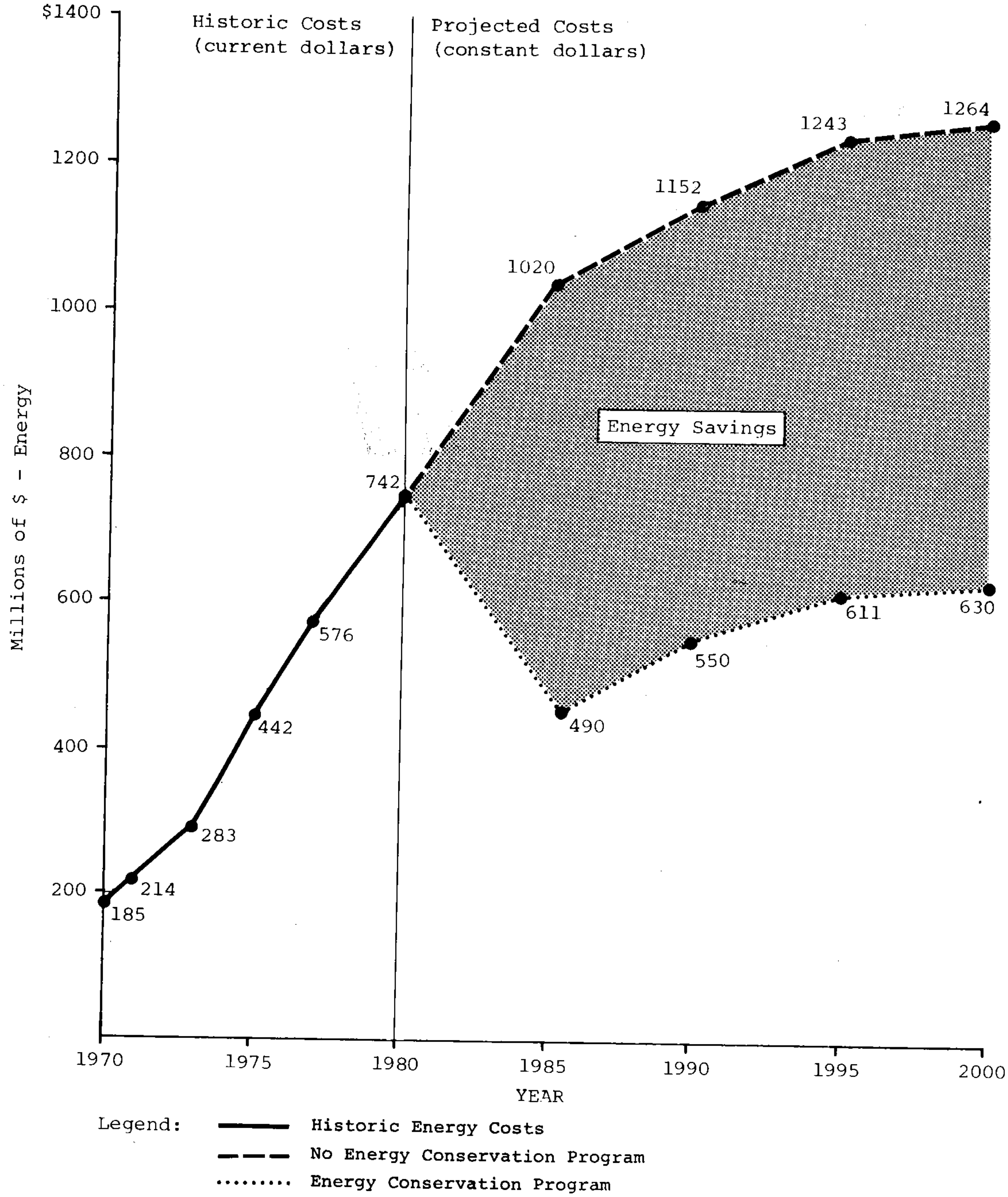
c. In addition to the recommended investment level for energy conservation retrofit, selective solar energy retrofit systems are cost effective and are recommended for funding. These systems are primarily for domestic hot water since active solar space heating retrofit systems were found to be only marginally economical. It was found:

   (1) Five percent (5.0%) of the public housing stock would have solar domestic hot water systems that pay back in less than 15 years;

   (2) 17 percent would pay back in 30 years, and

   (3) Energy cost savings to the total public housing stock would be 1.4% and 4.2% respectively.

Figure 1-1 **Energy Cost Savings of a Comprehensive Energy Conservation Program for Public Housing**



CHAPTER 2. ORGANIZATION AND USE

2-1. Purpose. The general purpose of an energy audit is to collect information which upon analysis will assist in the identification of ways to reduce individual project dependence on energy and thereby reduce operating costs. This is accomplished by first identifying applicable ECOs and then determining the cost effectiveness of ECOs requiring capital cost. The payback periods of ECOs with less than 15 years will then be used to determine the order of implementation.

2-2. Responsibility. This workbook assumes that it is the responsibility of the project management personnel to complete this energy conservation workbook. In so doing, the appropriate personnel must review and become familiar with the scope and procedures of this workbook and must analyze all ECOs for applicability and cost effectiveness. It is suggested that the operations or maintenance supervisor assist in obtaining the required data needed to complete the ECO analyses and assist in obtaining cost estimates for applicable ECOs.

2-3. Organization of Procedure. The energy audit process in this Handbook consists of three phases and is outlined in Figure 2-1.

a. Review Phase. The first task is to review the procedures and scope of this workbook. This includes understanding the information in the introductory sections and reviewing the organization and content of the rest of the workbook. Energy Conservation Opportunities (ECOs) are presented in a separate section of this workbook (Appendix B). The description of each ECO should be read before deciding on its applicability. After the description and general information on the ECOs is understood, the appropriate personnel should select those ECOs which are applicable to the project under review.

In order to obtain accurate project data and cost estimates, the following actions should first be carried out:

(1) Obtain utility records for the last three years for all fuel types used in the project: electricity, gas, oil, etc.

(2) Obtain a complete record set of architectural, mechanical and electrical drawings of the project including specifications, if available.

(3) Obtain any other project records that will assist in providing quantitative data on the project such as previous

surveys or reports.

(4) Obtain the names of local contractors who can provide cost estimates for the implementation of ECOs selected.

(5) Proceed with the review and information gathering phase with other personnel such as operations and/or maintenance supervisors.

b. Data Collection - Survey Phase. Using the Energy Survey forms provided in Appendix A, the project survey can be completed. This survey can be undertaken by the operation and/or maintenance personnel, it is of critical importance to the ECO economic analysis that information be as accurate as possible. The type of survey information required will be of two types; quantitative data obtained from reviewing project construction drawings, specifications or other information sources, and qualitative information obtained from an actual walk-through inspection of buildings, equipment rooms and dwelling units. Additional tasks to complete the survey are:

(1) Complete utility forms. When all utility data are available (preferably for the past three years) the utility forms in Appendix A should be completed. The objective of these forms is to provide accurate fuel cost data and total yearly energy consumption data.

(2) Choose specifications. After description and related concerns for an applicable ECO are understood, it is very often necessary to choose a specific design or type of a product or building component that will work best with project buildings or equipment. This might require consultation with operation and/or maintenance personnel, contractors or outside professionals. It is essential that the appropriate design or type of equipment or material is chosen to obtain accurate cost data.

(3) Obtain Manufacturer Cost Estimates. After project data information is obtained, and the appropriate design or type of ECO is selected, then a contractor/manufacturer should be contacted to obtain an estimate of the installed cost. This is done for each applicable ECO. Accurate records of this estimate must be kept.

If an ECO is expected to be installed by in-house staff then only material cost need be obtained. Whenever possible, however, prices should be obtained from a local contractor

to reflect total cost of installation and quantity discounts when applicable.

c. Cost/Benefit Analysis Phase. The Cost/Benefit Worksheet is organized as a step-by-step worksheet procedure which can be completed on worksheets as provided in Appendix B. After all information is obtained in Phase 2 (project data, utility data and cost data), each ECO that applies to the project can be analyzed individually. The first step is to transfer the required information, which is asked for in the first two or three steps of the Cost/Benefit Worksheet, from the survey and utility forms and cost estimates. Only the information required to estimate savings and payback are needed.

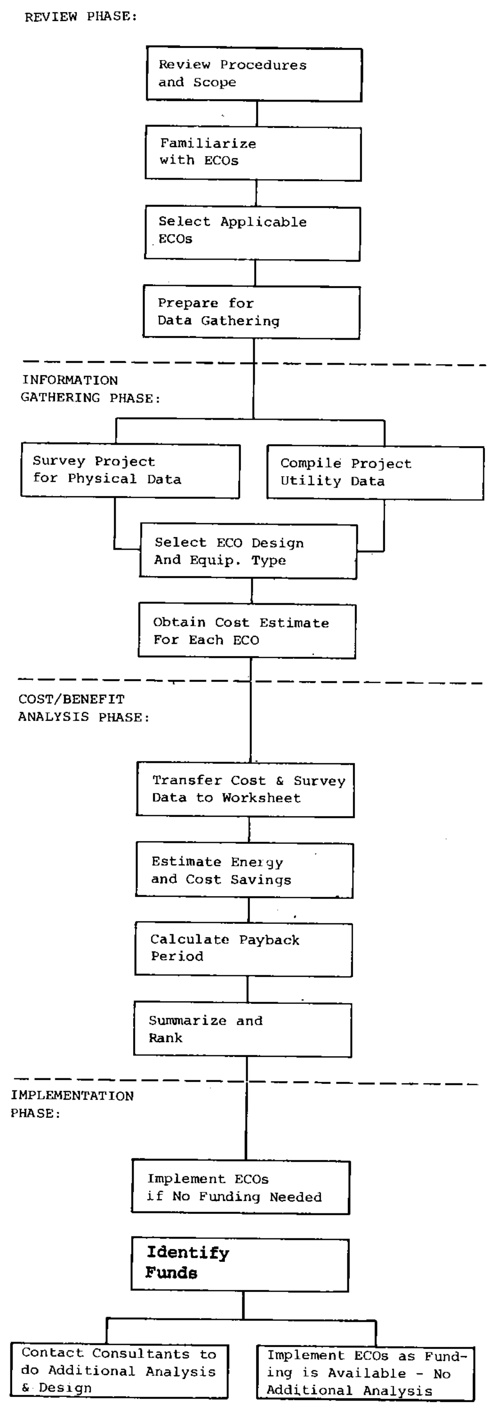
(1) Energy and cost savings for each ECO can be estimated by following a simple calculation procedure that leads to an approximation of what the individual ECO will save on a project basis.

(2) Simple payback is calculated by dividing the cost of implementing the ECO by the cost savings. This will estimate the approximate number of years it will take to recover an investment.

(3) The cost effectiveness of an ECO can be determined based on the payback period. If it is fifteen years or less, and is less than the useful life of the product implementation is recommended. ECOs should be implemented in the order of least-to-greatest payback as funds are made available. It is permissible to change implementation order if other considerations exist. The results of all cost/benefit analyses will be summarized in Appendix C, Summary of the Results.

d. Application for Funds. All ECOs with less than fifteen year payback will be listed in order of least-to-greatest payback in the forms provided in Appendix C.

Figure 2-1 The Energy Audit Process



CHAPTER 3. PHYSICAL NEEDS ASSESSMENT - THE ENERGY CONSERVATION SURVEY

3-1. Introduction. To complete the analysis of each ECO, the project must be surveyed for qualitative and quantitative information. Qualitative or judgement information can be obtained by a "walk-through" inspection of the project. Quantitative or numerical information can be obtained from architectural and mechanical drawings of the project.

All questions in the Survey (Appendix A) have been designed to collect only that data which is specifically required for completion of ECOs suggested in this handbook. The Survey forms are designed to give a broad, but not an all inclusive view of the project.

3-2. Responsibility. It is assumed that completion of the survey, as of the workbook, is the responsibility of the project management. Many of the questions, however, can be more easily answered by the project maintenance engineer. It is, therefore, suggested that all work be done by a team composed of these or comparable staff members.

3-3. Materials needed. A calculator, tape measure, and architectural and engineering scales are necessary. A complete set of project drawings (and sometimes specifications), as well as utility records, will be needed and should be assembled before work on the workbook begins. If drawings can not be obtained, a considerable amount of on-site measurements and counting will have to be done.

3-4. Implementation. The following instructions are recommended to complete the survey.

a. Begin by answering as many questions as possible with information contained on the drawings and general familiarity with the project.

b. Proceed with a walk through the project to answer remaining questions. Since not all questions will apply to all projects, and hence not all questions will have answers marked in the right-side column, it is suggested that the number preceding each question be circled as a record of completely answering the question. The letters "NA" (for: Not Applicable) can be written in spaces reserved for answers, if they do not apply. Questions with boxes in the right-hand column require only check marks. Questions with long lines require quantities (in units specified) to be entered there.

c. Most questions are self-explanatory. Those that are more

complicated, or require qualitative judgements, include short explanations. A glossary of mechanical, architectural, and energy terms is included in Appendix F.

d. All questions refer to the entire project, not any one specific building. All building quantities must therefore be combined to obtain project quantities before entering them in the answer columns. The exceptions are projects composed of radically different structures, such as high and low-rise buildings, high-rise and single or twin buildings, centrally and individually-heated dwelling units, very old and very new buildings, etc. In these cases, as explained at the beginning of this handbook, it might be easier to divide the project into smaller components and complete a separate workbook for each.

e. Many questions refer to "predominant" or "typical" conditions. The answers must be based on familiarity with the entire project to accurately represent the average project conditions.

3-5. Accuracy of answers. Providing accurate answers is essential. Many shorthand methods, however, are useful for obtaining quantities. If the project is composed of many similar buildings, for example, calculate or measure quantities for one, then multiply by the number of buildings to obtain project totals (adjust to reflect differences between buildings). To obtain total window or door area, measure typical types and multiply by their quantities. Some quantitative answers might also have been collected in past surveys or can be found in project records. In general, strive for accuracy, but use the simplest method possible to achieve it.

3-6. Organization. The survey is divided into the following sections:

a. 1.0 General Project Data,
b. 2.0 Architectural Data,
c. 3.0 Heating Systems Data,
d. 4.0 Secondary Systems Data,
e. 5.0 Electrical Systems Data,
f. 6.0 Utility Data: Electricity,
g. 7.0 Utility Data: Natural Gas,
h. 8.0 Utility Data: Heating Oil,
i. 9.0 Utility Data: Other Fuels,
j. 10.0 Summary of Fuel Uses and Costs,
k. 11.0 Summary of Heating Use.

Sections 1 through 5 deal with basic physical data gathering, sections 6 through 9 deal with fuel consumption data, and sections 10 and 11 summarize fuel consumption.

CHAPTER 4. ENERGY CONSERVATION OPPORTUNITIES

4-1. Organization. Fifty ECOs have been included in this workbook. Although many other ECOs are possible, those selected here represent the ECOs most widely applicable to public housing project types. They have been grouped in four categories:

a. Architectural ECOs,
b. Heating System ECOs,
c. Secondary System ECOs, and
d. Electrical System ECOs.

Below are short descriptions of each ECO. Appendix B contains full descriptions, illustrations and complete cost/benefit worksheets.

4-2. Architectural ECOs. Architectural opportunities are designed primarily to improve the energy design of the building envelope, i.e., wall and roof construction and window and door condition. The following ECOs are included:

a. ECO #1: Improve Architectural O&M. Maintaining the building shell in good condition has a direct effect on energy consumption. By caulking around window and door frames, at the sill plate, at corners and where penetrations in the wall occur infiltration can be reduced substantially. In addition to caulking, any holes or cracks in the building shell should be filled, windows and doors should be aligned properly to insure a tight fit, and broken glass should be repaired.

b. ECO #2: Install Replacement Windows. When existing windows need replacement for modernization reasons, new energy efficient windows should be used. These windows should be at least double glazed, well weatherstripped and with a thermal break frame.

c. ECO #3: Install Storm Windows. The installation of energy conserving storm windows (tight fitting with integral weatherstripping) will improve the insulating value of the window and reduce infiltration thereby reducing heat losses.

d. ECO #4: Weatherstrip Windows and Doors. The addition of new or improving of old weatherstripping at all operable windows and doors decreases infiltration thereby reducing heating energy required to bring the infiltrated air to room temperature.

e. ECO #5: Install Insulating Window Shades. At night when the majority of heat is lost through a window, thermal shades or

shutters can be used to increase the insulating value of the window. These would be used like regular shades and could also keep sun out during the summer.

f. ECO #6: Install Window Sun Shades. In spaces that are air conditioned in summer such as management offices, community rooms, etc., the direct sunlight entering through the windows can contribute up to 50% of the air conditioning load. By shading the sun either by external shading elements, tinted glass or interior blinds, air conditioning energy can be substantially reduced.

g. ECO #7: Install Storm Doors. On all doors to dwelling units or low volume doors to hallway and stairs, storm doors can be installed to reduce air infiltration and increase the insulating value of the door. Storm doors should be well weather-stripped or have automatic door closers.

h. ECO #8: Construct Vestibules. On heavily trafficked doors such as lobby doors on high rise projects the installation of a vestibule will reduce infiltration through door opening and increase the insulating value of the doors.

i. ECO #9: Install or Increase Attic Insulation. Installing or increasing insulation in the attic increases the thermal resistance of the attic space reducing heat loss during the winter and heat gain during the summer. Attic insulation can be either batt or loose fill type insulation and require a vapor barrier on the warm side.

j. ECO #10: Install Roof Insulation. Addition of insulation to the roof would increase the thermal resistance of the building and reduce heat loss during the winter. Roof insulation is suggested only for flat roofs without attics. If attics exist then the recommended action is to install attic insulation. Roof insulation can be added to a roof without reroofing if the roof is in good condition and does not need reroofing.

k. ECO #11: Install Wall Insulation. Addition of wall insulation would increase the thermal resistance of the exterior walls and reduce winter heat loss through wall surfaces. Wall insulation can be either blown-in type in cavity walls or applied rigid insulation on masonry walls.

l. ECO #12: Install Passive Solar Collectors. Passive solar collectors save fuel by trapping solar energy that normally falls on the south wall. This can be done either by providing south-facing windows to allow the sun to directly heat a space,

or by providing a "solar wall" collector which will collect the solar heat and allow it to circulate naturally into the space.

4-3. Heating System ECOs. Heating systems energy conservation opportunities are designed to increase the efficiency of the heating plant, reduce distribution losses and ensure fuel conservation by project tenants and office staff. The following ECOs are included:

a. ECO #13: Install Setback Thermostats. During night time or periods of non-occupancy in specific building sections setback thermostats can be used to reduce interior temperatures. This results in lower heat losses due to the smaller difference between conditioned space temperature and the outside environment. An average installation will result in savings of 10 to 15 percent of the heating fuel at a cost of as little as $30.00 for the control device.

b. ECO #14: Improve Space Heating O&M. The efficiency of space heating equipment must be improved to save energy. Action must be taken to bring the existing equipment to peak efficiency and to maintain that efficiency. Distribution losses must be eliminated and building loads reduced.

c. ECO #15: Install Flue Dampers. The installation of an automatic flue damper saves energy by preventing heat from escaping from the boiler while it is in the off cycle. When the boiler is fired, the flue damper opens automatically for normal operation resulting in energy and energy cost savings. The magnitude of the savings is a function of the frequency and length of the off cycle.

d. ECO #16: Convert to Electric Ignition. If a gas pilot light is maintained continuously for the purpose of firing the furnace, fuel is wasted during the times when ignition is unnecessary. Electric ignition apparatus acts to ignite the furnace fuel by going on only when the furnace is fired. Therefore, the fuel required to maintain a pilot 24 hrs/day would be saved.

e. ECO #17: Reduce Burner Nozzle Size. After performing energy conservation measures, the heating load of the building may have been decreased to the point where the existing nozzle of the furnace can be reduced in size. It is also possible that the original nozzel was oversized. In both cases, the size should be reduced. By decreasing the size less oil and gas is burned and the boiler operates with greater efficiency.

f. ECO #18: Install Tenant Fuel Metering. HUD regulations for public housing may require that, to the extent practicable, all gas and oil consumed by the tenants shall be individually metered either through checkmeters or by the establishment of retail service. Installing tenant meters may give the tenants an incentive to keep oil and gas use below the allowable limit and could save 10 to 20 percent of the total consumption.

g. ECO #19: Improve Central Heating O&M. A boiler efficiency improvement program must include two aspects: (1) action to bring the boiler to peak efficiency and (2) action to maintain the efficiency at the maximum level. Many operations must be performed to maintain a boiler at or near its peak efficiency. Additional actions must be taken to reduce distribution losses.

h. ECO #20: Install Modulating Burners. A modulating burner continuously varies the air and fuel valve settings as a function of the load. The linkage can be adjusted at one firing position for peak combustion efficiency. Savings are achieved as most of the boiler ventilation losses are eliminated as well as "cold" start efficiency losses. Implementation costs usually include a new burner and controls.

i. ECO #21: Install Flue Heat Recovery. Energy conservation is realized through the recovery of heat from the exhaust gases from the boiler. By installing a heat exchanger in the exhaust flue, otherwise wasted heat can be utilized for heating domestic hot water, or boiler feed water. The higher the exhaust stack temperature the more heat available for useful recovery uses. Utilizing this heat that would otherwise be vented to the atmosphere increases the overall efficiency thus saving fuel and fuel costs. Care must be taken not to drop the flue temperature too low so as to cause condensation of possibly corrosive mositure from the flue gases.

j. ECO #22: Install Turbulators. In a typical boiler, (fire tube), hot boiler tube gases cool, contract and assume the shape of the tube. This forms a hot core which slides down the center of the flue tube without effectively transferring heat to the walls. Only the water along the hot combustion chamber and the upper rear flue tubes effectively absorbs the heat. This increases energy losses out the stack. A gas turbulence device consists of metal strips which are formed into opposing 30°, 45°, and 60° bends. Inserted into the boiler return tubes, the device creates a turbulence of gases breaking up the hot core and forcing more heat transfer into the water thus reducing stack losses and increasing the efficiency of the boiler.

k. ECO #23: Install Summer-time Domestic Hot Water (DHW) Heaters. Often DHW is produced by steam/hot water converters located in the existing boiler plant. During non-heating months, a boiler is fired to maintain hot water in the tank. This practice lowers the overall efficiency substantially. It is very costly to produce hot water in this manner and substantial savings are possible by installing a separate hot water heater running at about 80 percent efficiency.

l. ECO #24: Replace Obsolete Heating Plant. Often an old plant becomes obsolete due to its relative operating inefficiencies, or scarcity of spare parts or fuel used. Replacing a plant is feasible when the savings of fuel, labor or maintenance outweigh the cost of a new plant. Often efficiency can be gained by specifying multiple boilers and or air atomizing burners.

m. ECO #25: Improve Central Distribution O&M. Even when a central heating plant is very efficient, large losses can occur during the distribution. All attempts at minimizing these losses should be made.

n. ECO #26: Insulate Hot Water or Steam Pipes. The insulating of hot, bare pipes can reduce heat losses. If the bare pipes are in areas that are to be heated, then the heat is not actually wasted, (unless the area overheats). If this is the case, the heat can be distributed and used more efficiently by insulating the bare pipes. When the uninsulated pipes pass through areas that are not to be heated, then insulation is a necessity in order to conserve energy.

o. ECO #27: Install Radiator or Zone Controls. Individual radiator controls allow accurate matching of heat supplied to a space with the actual load conditions of the space. This will result in greater comfort levels and lower heat losses due to elimination of any space overheating. These devices are usually applied to steam or hot water systems which have only manual hand valve control. Zone controls work in similar fashion but supply an entire zone of a building.

4-4. Secondary Systems ECOs. Secondary systems include domestic hot water (DHW), water supply, central laundry equipment, and ventilation and air conditioning (AC) systems. The following Secondary Systems ECOs are included:

a. ECO #28: Improve Domestic Hot Water O&M. Inefficient DHW heaters and distribution systems waste energy. All equipment should be upgraded to peak efficiency, distribution losses eliminated and maintenance programs instituted.

b. ECO #29: Install Flow Restrictors. Flow restriction devices replace conventional shower heads and faucets and reduce domestic hot water flow by more than 50 percent, while maintaining adequate spray by atomizing the remaining water. These devices can be installed with minimal effort by maintenance personnel. Tamper-proof installations are also possible.

c. ECO #30 Insulate DHW Tanks. All domestic hot water tanks should be insulated. Hot water tank insulation is usually a high density fiberglass jacket that surrounds the domestic hot water tank on all sides and top. This insulation will help reduce the heat loss through the tank walls which typically amounts to 25% of the total yearly cost of heating domestic hot water.

d. ECO #31: Convert DHW Systems to Solar. Domestic hot water (DHW) accounts for about 18 percent of the energy costs in public housing. It is here that solar energy retrofit systems have their greatest potential. Solar DHW systems usually consist of solar panels located on the roof or on the ground along the building they serve. These panels are heated by the sun and transfer the heat to a storage tank which is drawn upon as needed.

e. ECO #32: Install DWH Off-Peak Controls. In regions where utility companies have time-of-day electric rates in effect, it is often cost effective to heat domestic hot water (DHW) during periods of the day when electric rates are lowest. These might be in early morning hours when domestic hot water could be heated prior to the heavy morning use period. Although cost savings are the main objective for the housing authority, energy is also saved because DHW temperatures are not maintained at 120° or 140° all day, thereby eliminating some stand-by losses. In addition, using non-peak electricity helps reduce the demand on utilities to build new power plants.

f. ECO #33: Install Cold Water Saving Devices. To reduce the amount of water delivered to a project and collected from a project (as sewage) install water saving devices in your toilet tanks. A conventional toilet tank uses 5 to 7 gallons of water every time it is flushed. As a result flushing uses up to 45% of all water consumed by an average family. Water saving devices can reduce this use to 2.5 to 3 gallons per flush.

g. ECO #34: Convert Water Supply Pumps. Pumps are used to maintain adequate water pressure in the domestic water system of high-rise buildings that do not have roof mounted water tanks.

These pumps must operate continuously to provide adequate water pressure, even when there is no water demand. By installing a hydro-pneumatic system to maintain water pressure without using the pumps, electrical energy can be saved because pumping time is substantially reduced.

h. ECO #35: Convert Laundry to Cold Rinse. During the rinse cycle cold water rather than hot or warm water can be used on all public laundry machines. Depending on the controls, conversion of laundry rinse cycles to cold water can be done by PHA maintenance staff or outside servicemen.

i. ECO #36 Improve Ventilation/AC O&M. Significant cooling energy savings can be achieved simply by modifying the manner in which cooling and ventilating systems are operated. Examples of minimal expense modifications are: 1) belt maintenance, 2) bearing lubrication, 3) cleaning of fans and heat exchangers, 4) proper sealing of plenum access doors, 5) maintenance of insulation on pipe and ducts, and 6) central plant preventive maintenance program. Proper modification and maintenance of ventilation and air conditioning systems serves to keep the systems running at peak efficiency. This not only conserves energy and energy costs but helps insure long life and low maintenance of the equipment.

j. ECO #37: Install Ventilation Warm-Up Cycles. Warm-up cycle can be installed on central air systems that do not operate 24 hours per day. Normally, when the supply fan is operating, the outside air dampers open. With a warm-up cycle installed the outside dampers remain closed until space temperature has been established. This saves energy by reducing the amount of cold air to be treated.

k. ECO #38: Replace Obsolete AC Equipment. Often a chiller or air conditioning plant becomes obsolete as alternative sources of energy used to drive centrifugal or reciprocating compressors become economically attractive. Replacing a plant becomes feasible when the savings outweigh the present costs of energy, labor, or maintenance on the existing plant. A careful evaluation is required which should also consider possible future changes.

4-5. Electrical Systems ECOs. Electrical energy conservation opportunities are designed primarily to reduce electricity usage for interior and site lighting by increasing the efficiency of light bulbs and fixtures, reducing their use times, and reducing or eliminating uitlity billing surcharges. The following ECOs are included:

a. ECO #39: Improve Electrical/Lighting O&M. Proper operation and maintenance of project lighting and electrical systems serves to keep the system running efficiently and keeps operating cost to a minimum. Some of the areas which should receive particular attention are: (1) delamping, (2) relamping (3) cleaning of bulb and fixtures, etc.

b. ECO #40: Convert Incandescent Lamps (Dwellings). Present low-efficiency incandescent lamps in kitchens, bathrooms and foyers should be converted to higher-efficiency "electronic" or fluorescent lamps. As these fixtures are turned on for long periods of time, considerable energy savings can be realized through conversion.

c. ECO #41: Convert Incandescent Lamps (Circulation). Low-efficiency incandescent lamps in corridors, lobbies, stairways, etc. should be converted to higher-efficiency "electronic" or fluorescent lamps to reduce electrical consumption.

d. ECO #42: Convert Incandescent Lamps (Public Areas). Low-efficiency incandescent lamps in community and activity spaces should be converted to higher-efficiency "electronic" or fluorescent lamps to reduce electrical comsumption.

e. ECO #43: Replace Fluorescent Bulbs. Low-efficiency fluorescent bulbs should be replaced with newer high-efficiency types. These bulbs require no changes in present fixtures but are capable of producing the same amount of light while consuming less electricity. Replacement can be done during regular maintenance procedures.

f. ECO #44: Install High-Efficiency Ballasts. Low-efficiency ballasts on exisiting fluorescent fixtures should be converted to high-efficiency types. High-efficiency (also known as energy saving) ballasts reduce electrical consumption without affecting the light output of fluorescent bulbs. They also have longer lives, reducing replacement frequency.

g. ECO #45: Install Daylighting Controls. Fluorescent fixtures within 10 feet of exterior windows in public and community areas should be equipped with photo-electric sensors. These sensors will turn the lights off wherever adequate natural daylighting is available. This reduces the hours artificial lighting is on, reducing electrical consumption.

h. ECO #46: Convert Site Lighting Lamps. Considerable electrical energy can be saved by replacing existing mercury vapor and other low-efficiency exterior lighting with either the lower

pressure sodium (LPS) lamps or the high pressure sodium (HPS) lamps. Low pressure sodium lamps are even more efficient as compared to the high pressure sodium lamps. However, the color of light obtained from LPS lamps is of yellow monochromatic nature as opposed to white color light form HPS lamps. For comparison purposes, mean lumens emitted per watt for LPS, HPS and Mercury Vapor (MV) lamps are approximately 100, 80 and 30 respectively, although efficiencies of these lamps tend to increase further with the increase in their capacities due to decrease in ballast losses.

i. <u>ECO #47: Install Site Lighting Photo-Controls.</u> Photocells are devices used to sense light. Based upon the available daylight, the photocell will open or close a relay or automatically adjust a dimmer setting. Photocells can be used to control site lighting systems based upon quantity of available light. In this application, the photocell senses sunset and turns the lights on, and then senses sunrise to turn the lights off, reducing the total hours site lighting is on to a minimum.

j. <u>ECO #48: Install Tenant Metering</u>. HUD regulations for public housing may require that, to the extent practicable, all electricity consumed by tenants should be individually metered. This can be accomplished either through provision of "retail service" or through the use of checkmeters. Installing tenant meters may give the tenants incentive to keep electric use below allowable limits and could save 15 to 25 percent of the total electricity consumed.

k. <u>ECO #49: Correct Low Power Factor</u>. The power which must be supplied to any induction load such as induction motor, transformer, fluorescent lamp, etc., is made up of real and reactive power. Power factor is a ratio of real power (kW) to apparent power (kVA). Many utilities make up for the expense of producing reactive power by including power factor provisions in their rates. A power factor improvement or at least a review of power factor economics is indicated for any building that purchases at primary level or on a large commercial power rate, or which maintains one or more of its own electric substations. More specifically, (some power factor improvement will prove worthwhile if electric use meets one or more of the following conditions): (1) Power demand is recorded on bill (in kVA); (2) electric rate has a kVAR or power factor penalty clause; (3) there are problems with voltage regulation or chronic low voltage, or (4) load growth limits spare capacity and you need more capacity.

1. ECO #50: Install Load-Shedding Controls. Utility companies base their electrical charges on both, total usage of electricity and maximum, or "peak", load demand. The major purpose of load shedding or limiting controllers, is to reduce the peak electrical loads of a project, thus reducing the overall price of electricity to the project.

CHAPTER 5. PRESENTATION OF RESULTS

5-1. PURPOSE. Upon completion of the ECO analyses the final results for each ECO evaluated should be recorded on the summary sheets located in Appendix C, Summary of Results. The summary forms achieve several purposes which include:

a. Serving as a means of insuring against double counting funds by eliminating mutually exclusive ECO's;

b. Enabling the identification of the most desirable ECO when ECOs are inter-related;

c. Serving as a listing of findings such that they can be recorded on project cost estimate worksheets for fund application to the Comprehensive Improvement and Assistance Program (see Modernization Standards Handbook - Appendix A);

d. As a checklist to insure completeness of survey and cost/ benefit analyses; and with

e. The form entitled Summary of Funds Required allows for a further listing of applicable ECOs from the most to the least cost-effective and;

f. Allows for the distinction between ECOs which are ready for implementation, i.e. require capital funds; or ECOs which require further analysis, i.e. require planning funds.

5-2. FURTHER ANALYSIS may be necessary because some of the ECOs included in this workbook require very detailed analyses to determine whether they are cost-effective or even compatible with existing buildings or systems. For these ECOs this workbook has provided a simplified method of determining preliminary feasibility. If this preliminary cost benefit analysis proves cost-effective then it is worthwhile to contact an architect/engineer or other qualified person for further analysis.

If an analysis shows that several Energy Conservation Measures (ECOs) are cost-effective, the results should be reviewed to determine if the amount of the estimated total savings in energy is realistic, and that the ECOs have been correctly analyzed.

Energy savings can be overstated because the energy saved by one ECO can reduce the savings attributable to another ECO. For example energy saved by Improved Central Heating O&M (ECO #19) will reduce the amount of energy that can be saved by adding Roof Insulation (ECO #10).

Appendix A
Physical Needs Assessment
The Survey

The Energy Conservation Survey

Introduction

To complete the analysis of each ECO, the project has to be surveyed for qualitative and quantitative information. Qualitative, or judgement, information can be obtained by a "walkthrough" inspection of the project. Quantitative or numerical information can be obtained from architectural and mechanical drawings of the project.

All questions in the survey have been designed to collect only that data which is specifically required for completion of ECOs suggested in this handbook. The survey is designed to give a broad, but not an all inclusive view of the project.

Responsibility. Completion of the survey, as of the workbook is the responsibility of the project management. Many of the questions, however, can be answered easily by the project maintenance engineer. It is, therefore, suggested that all work be done by a team composed of these comparable staff members.

Materials needed. A calculator, tape measure, and architectural and engineering scales are necessary. A complete set of project drawings, specifications and utility records should be assembled before work on the workbook begins. If drawings are available considerable on-site measuring and counting will be required.

Filling out the survey. Begin by answering as many questions as possible using information available from the drawings and those familiar with the project. Then proceed with a walk through the project to answer remaining questions. Since not all questions will apply to all projects, and hence not all questions will have answers marked in the right-side column, it is suggested that the letters "NA" (for: Not Applicable") be written in spaces reserved for answers, if they do not apply.

Questions with boxes in the right-hand column require only check marks. Questions with long lines require quantities (in units specificed) to be entered there.

Most questions are self-explanatory. Those that are more complicated, or require qualitative judgements, include

short explanations. A glossary of mechanical, architectural, and energy terms is included in Appendix F.

Two other points need emphasis. Firstly, all questions refer to the entire project, not any one specific building. All building quantities must therefore be combined to obtain project quantities before entering them in the answer columns. The exceptions are projects composed of radically different structures, such as high and low-rise buildings, high-rise and single or twin buildings, centrally and individually-heated dwelling units, very old and very new buildings, etc. In these cases, as explained at the beginning of this workbook, it might be easier to divide the project into smaller components and complete a separate workbook for each.

Secondly, many questions refer to "predominant" or "typical" conditions. The answers must be based on familiarity with the entire project if they are to accurately represent the average project conditions.

Accuracy of answers. Providing accurate answers is essential. Many shorthand methods, however, are useful for obtaining quantities. If the project is composed of many similar buildings, for example, calculate or measure quantities for one, then multiply by the number of buildings to obtain project totals (adjust to reflect differences between buildings). To obtain total window or door area, measure typical types and multiply by their quantities. Some quantitative answers might also have been collected in past surveys or can be found in project records. In general, strive for accuracy, but use the simplest method possible to achieve it.

Organization of survey questions. Each question in the survey is preceded in the left hand margin by a question number. The first digit of each number is the survey section; the second a consecutive question number within that section.

The survey is divided into the following sections:

1. General Project Data,
2. Architectural Data,
3. Heating Systems Data,
4. Secondary Systems Data,
5. Electrical Systems Data,
6. Utility Data: Electricity,

7. Utility Data: Natural Gas,
8. Utility Data: Heating Oil,
9. Utility Data: Other fuels,
10. Summary of Fuel Uses and Costs,
11. Summary of Heating Use.

Sections 1 through 5 deal with basic physical data gathering, Sections 6 through 9 deal with fuel consumption data, and Sections 10 and 11 summarize fuel consumption.

1. General Project Data

Project Identification

1-1. Project ID number: .... __ __ /__ __ __ /__ __ __

1-2. Project name: ______________________________

1-3. Project address: ______________________________

1-4. Project telephone number: .. __ __ __ /__ __ __ /__ __ __ __

1-5. Name of person responsible for completing this workbook: ______________________

Location and climate

1-6. City: .... ______________

1-7. State: .... ______________

Complete questions 1-8 through 1-11 with information from Appendix D. If the specific project location is not listed, use data for closest city listed.

1-8. Heating degree day zone: .... ______________

1-9. Solar factor: .... ______________

1-10. Winter solar factor: .... ______________

1-11. Heating season hours: .... ______________

Building Types and Quantities

1-12. 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: ...... ______________

(Question 1-12 continued on next page.)

Low-rise multi-family buildings
(4 stories or less): .... ☐

Number of buildings: .... ________________

Number of above grade stories
(height): .... ________________

High-rise multi-family buildings
(5 stories or more): .... ☐

Number of buildings: .... ________________

Number of above grade stories
(height): .... ________________

1-13. Non-residential building types (i.e., separate structures used for project offices, community rooms, activity rooms, central laundries, central mechanical spaces, etc.):

Number of buildings: .... ________________

Number of stories: .... ________________

1-14. Total number of buildings in project: ... ________________

Project Size

1-15. Number of dwelling units (DUs) in project:

Small-sized DUs (0-1 bedroom): .... ________________

Medium-sized DUs (2-3 bedrooms): ...... ________________

Large-sized DUs (4 or more bedrooms): . ________________

Total: .... ________________

1-16. Number of dwelling units with south or nearly south-facing windows: .... ________________

1-17. Total number of tenants in project: ..... ________________

1-18. Average number of tenants per dwelling unit (divide total number of tenants by total number of dwelling units):

(Total Tenants) ____________ ÷ (Total DUs) ____________ = ________________

2. Architectural Data

Project Size

2-1. Total floor area of all floors for the project (if more than one building add all buildings): .... ______________ SF

2-2. Total project volume (total project area times typical floor-to-floor height; usually 8.5 feet): .... ______________ CF

Flat Roofs & Attics

2-3. Do you have flat roofs or attics on your buildings:

Flat roofs (i.e. flat or nearly flat roofs with no attic or crawl space underneath): .... ☐

Attics (i.e. roofs with crawl space or full attics underneath): .... ☐

If you checked off "Flat roofs" also answer questions 2-4 and 2-5. If you checked off "Attics" answer questions 2-6 and 2-7.

2-4. Area of flat roof (assume it is equal to total floor area of top floors): .... ______________ SF

2-5. Construction of flat roof (check whether insulated or uninsulated; if uninsulated also check structure type):

Insulated: .... ☐

Uninsulated: .... ☐

Wood structure: .... ☐

Concrete structure: .... ☐

Steel structure: .... ☐

2-6. Area of attic (assume it is equal to total floor area of top floors): .... ______________ SF

2-7. Attic insulation depth (measure typical insulation thickness and enter here; round off to nearest 1/2 inch): .... ________ INCHES

Walls

2-8. Wall construction, size and insulation (check off whether insulated or uninsulated; for uninsulated construction answer or check off all further questions):

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 walls (not including windows and doors): .... ________ SF

2-9. Are south-facing walls of low-rise buildings (i.e., 4 stories or less) totally shaded (by vegetation, adjoining buildings, etc.) during winter months? .... Yes ☐ No ☐

Windows

2-10. Window area (total for entire project): ________ SF

2-11. Window area of south-facing windows in a typical south-facing dwelling unit (estimate only for low-rise buildings): ________ SF

2-12. Window glazing (typical or predominant type):

Single-glazed:.................................... ☐

Double-glazed:.................................... ☐

Triple-glazed:.................................... ☐

2-13. Window frame material:

Wood: .... ☐

Metal: .... ☐

2-14. Typical window fit (check off predominant condition):

Loose (frame rattles, large air gaps, large drafts): .... ☐

Average (some looseness, no large gaps no large drafts): .... ☐

Tight (no excessive frame movement or drafts): .... ☐

2-15. Are window openings equipped with storm windows? .... Yes ☐ No ☐

2-16. Are windows and/or storm windows well weatherstripped? .... Yes ☐ No ☐

2-17. Are windows equipped with thermal (energy saving) shades (i.e. shades used for nightime insulation)? .... Yes ☐ No ☐

2-18. Are office and community spaces in your project air-conditioned? .... Yes ☐ No ☐

Complete questions 2-19 through 2-21 only for office and community spaces which are air-conditioned (proceed to question 2-23 if there are no air-conditioned spaces in your project).

2-19. Window area (in air-conditioned office and community spaces only):

South-facing windows only: .... ________ SF

East and West-facing window only: ..... ________ SF

2-20. Window glazing type (typical condition in office and community areas):

Clear glass: .... ☐

Tinted glass: .... ☐

2-21. Are windows in office and community areas well shaded (i.e. 50% of summer daylight hours, 50% of their area) by trees or vegetation? .... Yes ☐ No ☐

2-22. Are windows in office and community areas equipped with exterior shades, interior blinds or tinted glass? .... Yes ☐ No ☐

Exterior Doors

2-23. Total number of exterior doors in your project: .... ________

2-24. Typical exterior door fit (check off predominant condition):

Loose (large drafts): .... ☐

Average (no excessive drafts): .... ☐

Tight (no drafts): .... ☐

2-25. Are exterior doors well weatherstripped? .... Yes ☐ No ☐

2-26. Are exterior doors equipped with storm doors? .... Yes ☐ No ☐

2-27. Predominant door type (inspect doors, door labels, or construction specifications; check off the appropriate type; if wood also measure thickness):

Wood: .... ☐

Specify door thickness: .... ________ Inches

Metal (energy conserving type): .... ☐

Metal (standard type): .... ☐

2-28. In low-rise buildings (4 stories or less) are exterior doors built with vestibules? .... Yes ☐ No ☐

2-29. In multi-family buildings, are <u>all</u> main entry exterior doors built with vestibules or revolving doors ("main entry" is defined as all doors used by more than 25% of the tenants): .... Yes ☐ No ☐

If you checked off "No" to question 2-29 also answer question 2-30; if "Yes" proceed to question 3-1.

2-30. Estimate the percent of tenants using each main entry door to enter or leave the building (write percent as decimal fraction, i.e. 25% - .25; side entries might include doors to parking areas, outdoor activity areas, etc.). If your project consists of more than one building, average the percentages for the type listed as if they represented only one door (example: if you have two buildings where one side entry is sued by 60%, the other by 40%, assume 50%):

Main lobby door: .... ________ (%)

Side entry #1: .... ________ (%)

Side entry #2: .... ________ (%)

3. Heating Systems Data

Heating System & Fuel Type

3-1. Heating system type (check off applicable type):

Individual (D.U.) space heaters: .... ☐

Central boiler plant: .... ☐

3-2. Heating fuel type (check off applicable type):

Electricity: .... ☐

Natural Gas: .... ☐

Heating Oil: .... ☐

Other: .... ☐

Specify: .... ______________

Heating system ECOs apply to either Central or Space systems, but never to both. You need, therefore, only answer the questions below which apply to your heating system type. If you checked of "Individual Space Heaters" in Question 3-1 above, answer only Questions 3-3 through 3-7. If you checked off "Central Boiler Plant" above, answer only questions 3-8 through 3-13. Consult your maintenance engineers if you need help.

Individual Space Heaters

3-3. Do you have flue dampers installed on your gas and oil space heaters (question does not apply to other fuel types)? .... Yes ☐ No ☐

3-4. Are your space heaters fired with constant-burning gas or oil pilot lights? .... Yes ☐ No ☐

3-5. Number of individual space heaters in your project (usually number of dwelling units plus office and community area units): .... ________

3-6. Are space heaters in your project presently oversized? .... Yes ☐ No ☐

3-7. Are space heaters manually controlled or equipped with night-time setback thermostats (check off applicable type)?

Manually controlled: .... ☐

Setback thermostat controlled: .... ☐

Central Boiler Plant

3-8. Do you have turbulators or baffles installed in your central boiler? .... Yes ☐ No ☐

3-9. Do you have modulating or non-modulating burners (question applies to gas and oil burners only)?

Modulating: .... ☐

Non-Modulating: .... ☐

3-10. **Do you have more than one** non-modulating boiler in your central heating plant? ... Yes ☐ No ☐

3-11. Do you have flue dampers installed (question applies to oil and gass boilers only)? .... Yes ☐ No ☐

3-12. Do your have flue recovery devices installed on your central boiler plant flue (does not apply to electrically heated boilers)? .... Yes ☐ No ☐

3-13. Is your plant a high-pressure or low-pressure system (check off applicable type):

High-pressure (125 psi or more): .... ☐

Low-pressure (less than 125 psi): .... ☐

3-14. Heat distribution medium of your central heating system (check off applicable type; if "air" answer all further questions):

Steam: .... ☐

Hot water: .... ☐

Air: .... ☐

Are community and office areas on a separate air distribution system from other building areas? .... Yes ☐ No ☐

Total CFM capacity of air system supplying community and office areas: .... ________ CFM

Percent (as decimal fraction) of minimum outdoor air supplied to community and office areas (if not known to maintenance engineers, assume .05): .... ________ (%)

3-15. Is your furnace/boiler output larger than 350 lbs of steam per hour (question applies only to steam systems)? .... Yes ☐ No ☐

3-16. What are the controls of your central boiler plant?

Manual temperature controls: .... ☐

Central night-time setback thermostat: .... ☐

Zone controls: .... ☐

Individual (D.U.) radiator or convector controls:..... ☐

Total number of rooms with radiators or convector heaters*: .... ________

* If total number of radiators or convector heaters is not known, take the total number of rooms in project and subtract the total number of rooms that do not have radiators or convectors (usually: bathrooms, and hallways; sometimes: dining rooms and kitchens).

3-17. Are all hot water or steam distribution pipes insulated (question does not apply to hot air distribution systems)? .... Yes ☐ No ☐

If NO, (i.e. pipes are not insulated) measure or estimate from engineering drawings total linear feet lengths of uninsulated pipes. Measure different diameter pipes separately.

3-18. Linear feet of uninsulated pipes (do not include pipes which are designed to provide heat to spaces; do not include the first six feet of each condensate discharge pipe):

3/4" diameter pipe .... ________ LF

1" diameter pipe .... ________ LF

1-1/2" diameter pipe .... ________ LF

2" diameter pipe .... ________ LF

3" diameter pipe .... ________ LF

4" diameter pipe .... ________ LF

6" diameter pipe .... ________ LF

Combustion Efficiency Test

To properly estimate energy savings for heating equipment ECOs, a combustion efficiency test must be performed on the existing equipment.

Combustion efficiencies should only be performed on large central boilers not on boilers for individual dwelling units (i.e. space heaters). A qualified technician familiar with combustion efficiency test procedures should do the work. The test should be performed during the heating season. If such tests are routinely performed at your project, use most recent test data (if not more than 2 years old) to answer the following questions.

3-19. What is the existing <u>combustion efficiency</u> of your central heating plant (enter as decimal fraction, example: 75% = .75): .... ________ (%)

3-20. Is your central system plant oversized (cycles often): .... Yes ☐ No ☐

3-21. Estimate total overall seasonal efficiency by subtracting the value in Table A3-1 below from combustion efficiency above and enter here. Example: .75 (combustion efficiency) - .20 (seasonal losses) = .55 .... ________

Table A3-1

Seasonal Efficiency Losses:

Heating Plant Type:	Overall Seasonal Efficiency Losses Oversized Plant	Overall Seasonal Efficiency Losses Well Sized Plant
Steam boiler, gas fuel:	.20	.10
Hot-water boiler, gas fuel:	.20	.10
Steam boiler, oil fuel:	.20	.10
Hot-water boiler, oil fuel:	.20	.10

4. Secondary Systems Data

Domestic Hot Water (DHW) Systems

4-1. Water heater type (check off applicable type):

Individual (D.U.) heaters: .... ☐

Central DHW heater, separate from main heating boiler: .... ☐

Central DHW heater, side-arm type: combined with main boiler: .... ☐

Central DHW heater, water-type combined with main boiler: .... ☐

4-2. Water heater fuel type:

Heating Oil: .... ☐

Natural Gas: .... ☐

Electricity: .... ☐

Other: .... ☐

Specify: .... ____________

4-3. Do you have DHW tanks? .... Yes ☐ No ☐

4-4. Are your DHW tanks insulated? .... Yes ☐ No ☐

4-5. Do you have restrictors, regulators, or low-flow faucets and shower heads installed on all faucets and showers? ... Yes ☐ No ☐

Water Supply Systems

4-6. Annual water supply charge (cost of water supply to project): ...... ____________ $/yr

If charge is not based on quantity check here: .... ☐

4-7. Annual sewage charge (cost of sewage discharge): .... ____________ $/yr

If charge is not based on quantity check here: .... ☐

4-8. How is proper water pressure maintained in your project?

Roof-mounted storage tank: .... ☐

From street mains (no tanks and no pumps): .... ☐

Pressurizing pump system: .... ☐

Total horsepower of water-pressurizing pumps (read pump labels or engineering drawings): ... ______________ HP

4-9. Do you have water-saving toilet tanks, flash valves or other water-saving toilet devices installed in your project? ...... Yes ☐ No ☐

Air-Conditioning (AC) Systems

4-10. Do you have air-conditioning units or system(s) in your project to cool community and office areas: .... Yes ☐ No ☐

4-11. Do you have air-conditioning units or system(s) in your project to cool dwelling units (do not include individual window or wall AC units if they are owned and installed by tenants)? .... Yes ☐ No ☐

Does building owner pay for their fuel consumption? .... Yes ☐ No ☐

If you answered YES to questions 4-10 or 4-11 proceed to also answer questions 4-12 through 4-14 below; If NO proceed to question 4-15.

4-12. Air-conditioning system type:

Individual window or wall units: .... ☐

Central system: .... ☐

4-13. Total power rating requirement of existing units or system (read equipment labels, literature or engineering specification drawings): .... ________ Watts

4-14. Total cooling capacity of existing units or system (read equipment labels, literature or engineering specification drawings): .... ________ BTU

Public Laundry Systems

4-15. Do you have central public laundry facilities as part of your project? ..... Yes ☐ No ☐

4-16. Total number of washing machines: .... ________

4-17. Do you use cold water (rather than warm or hot water) for rinse cycle in your washing machines? .... Yes ☐ No ☐

5. Electrical Systems Data

Site Lighting

5-1. Predominant type of site lamps (check off applicable type):

None (no site lighting): .... ☐

Sodium vapor lamps (high or low-pressure): .... ☐

Mercury vapor lamps with
self ballast: .... ☐

Mercury vapor lamps without
self ballast: .... ☐

Metal halide lamps: .... ☐

Incandescent lamps: .... ☐

Tungsten halogen lamps: .... ☐

Fluorescent lamps: .... ☐

5-2. Number of site fixtures: .... ____________

5-3. Energy consumption (Watts) per predominant
site fixture type (each unit): .... ____________ Watts

5-4. Who pays for site lighting electricity?
Building owner: .... ☐

Local town or city government: .... ☐

5-5. Type of site lighting controllers (check off applicable types):

Manual switching: .... ☐

Photo-cells: .... ☐

Clock timers: .... ☐

Astronomical timers (i.e.
timers which adjust for seasonal
sun-set and sun-rise times): .... ☐

5-6. Annual hours site lighting is turned on*: ________ Hrs/yr

* If fixtures are controlled by photocells or astronomical timers assume 4500 hours. If they are manually turned on and off or controlled by timers, estimate annual use by multiplying average daily hours of use (hours between turning on and off) by 365 days. Adjust for weekend and seasonal variations, if necessary.

Dwelling Unit Lighting

5-7. Type of fixture in DUs (check off predominant fixture type in each of the following spaces):

Bathroom:

Fluorescent: .... ☐

Incandescent: .... ☐

Kitchen:

Fluorescent: .... ☐

Incandescent: .... ☐

Hallway/foyer:

Fluorescent: .... ☐

Incandescent: .... ☐

Circulation Area Lighting

Circulation areas include all lobbies, corridors, hallways and stairways in both public and basement floors. Do not include circulation areas within dwelling units.

5-8. Type of predominant fixture in circulation areas (indicate whether fluorescent or incandescent, then check off and complete all other questions under the selected type):

Fluorescent: .... ☐

2 tubes/4 feet long .... ☐

(Question 5-8 continued on next page.)

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 .... ☐

Are fixtures of high-efficiency (energy-conserving) type? .... Yes ☐ No ☐

Are ballasts of high-efficiency (energy-conserving) type? .... Yes ☐ No ☐

Total number of fluorescent fixtures in project (circulation areas only)*: .... ________

Incandescent: .... ☐

Average watts per fixture: .... ________ Watts

Are fixtures of high-efficiency (energy-conserving) type? .... Yes ☐ No ☐

Total number of incandescent fixtures (circulation areas only)*: .... ________

* To obtain total number of fixtures in circulation areas count in each building fixtures in basement, at ground floor, and at typical floor (use "ceiling plan" drawings if they exist and are accurate). Multiply typical floor quantity by number of floors. Add all floors together, then add all buildings together.

Office and Community Areas Lighting

Includes all PHA management offices, community rooms, recreational rooms, etc. All questions refer to "general lighting" only; do not include "task lighting" such as desk lamps, etc.

5-9. Type of predominant fixture in office and community areas (indicate whether fluorescent or incandescent, then check off and complete all other questions under the selected type):

Fluorescent: .... ☐

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 .... ☐

Are fixtures of high-efficiency (energy-conserving) type? .... Yes ☐ No ☐

Are ballasts of high-efficiency (energy-conserving) type? .... Yes ☐ No ☐

Total number of fluorescent fixtures in project (office and circulation areas only): .... ____________

Incandescent: .... ☐

Average watts per fixture: .... ____________ Watts

Are fixtures of high-efficiency (energy-conserving) type? .... Yes ☐ No ☐

Total number of incandescent fixtures in project (office and community areas only): .... ____________

5-10. Total number of fluorescent fixtures in the project (add all totals in questions 5-7, 5-8 and 5-9): .... ____________

Complete the following questions (5-11 through 5-14) for office areas alone. Omit if there are no offices or management spaces in your project. Omit if offices are windowless or all "general lighting" is incandescent.

5-11. Are offices located in windowless spaces? .... Yes ☐ No ☐

5-12. Are lights near windows routinely turned off during daytime hours? .... Yes ☐ No ☐

5-13. Number of fluorescent fixtures within 10 feet of exterior windows (office areas alone): .. ________________

5-14. Type of predominant fluorescent fixture within 10 ft. of exterior windows in office areas:

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 .... ☐

6. Utility Data: Electricity

Electicity Uses

6-1. End uses of electricity in your project (check off items for which electricity is used):

- Heating .... ☐
- Cooling .... ☐
- Ventilation .... ☐
- Lighting .... ☐
- Site Lighting .... ☐
- Domestic Hot Water .... ☐
- Cooking (range/oven) .... ☐
- Appliances .... ☐
- Elevators .... ☐
- Water Supply Pumps .... ☐
- Miscellaneous (Air Pumps, Fans, Vents, etc.) .... ☐
- Central Laundry (heating of water) .... ☐

Pay Structure

6-2. Payment method (check off method of payment used):

- Building owner pays directly to utility (tenants not billed) .... ☐
- Tenants billed directly and pay own bills .... ☐
- Tenants billed directly but reimbursed for all costs .... ☐

(Question 6-2 continued on next page.)

Tenants billed directly but reimbursed up to a limit .... ☐

What is the limit? .... ________ KWH/yr

________ $/yr

Charge Structure

Obtain data from your bills or ask utility company for assistance.

6-3. Peak load demand charges (charges above normal electricity costs):

No peak load demand levied by utility .... ☐

Charges included in bill: .... ☐

Average annual peak load demand charge amount (above normal KWH charges): .... ________ $

Explain peak load demand charge structure: ________________________________

____

____

6-4. Time-of-day charges also known as "peak" and "off-peak" rates charges (different electrical rates at different times of day):

Are time-of-day meters installed in the project? .... Yes ☐ No ☐

If NO, does your utility offer time-of-day charges? .... Yes ☐ No ☐

If the answer to either question above is Yes, what are the time-of-day charges?

Lowest rate charged: .... ________ $/KWH

Highest rate charged: .... ________ $/KWH

(Question 6-4 continued on next page.)

Explain time-of-day charge structure (explain lowest and highest cost time periods, etc.): ____________________

____

____

6-5. Low Power factor surcharges (charges above normal electricity costs):

No power factor charges levied by utility: .... ☐

Charges included in bill: .... ☐

Average annual power factor charge amount (above normal KWH charges): .... ____________ $/yr

Explain power factor charge structure: ____________________

____

____

Average Annual Electricity Consumption

6-6. Estimate average annual consumption by completing the following worksheet (enter data in table for most recent three years):

Year:	Annual Consumption:
19____:	____________ KWH/yr
19____:	____________ KWH/yr
19____:	____________ KWH/yr
Total (add all three years):	____________ KWH

(Question 6-6 continued on next page.)

Calculate average annual consumption:

(Total)
KWH) ____________ ÷ 3 (years) = ____________ KWH/yr

Current Electricity Price

6-7. Enter current price of electricity including any surcharge (use your current bills or contact your utility company; when using your bills, remember that price of electricity often changes seasonally and even hourly - the rates here should represent current annual average rates):

Average price of electricity: .... ____________ $/KWH

Annual Electricity Cost

6-8. Calculate annual cost of electrical consumption (multiply average annual consumption, final calculation in question 6-6, by average annual price of electricity, question 6-7):

(KWH/yr) ____________ X ($/KWH) ____________ = ____________ $/yr

7. Utility Data: Natural Gas

Natural Gas Uses

7-1. End uses of natural gas (check off items for which natural gas is used):

- Heating .... ☐
- Cooling .... ☐
- Domestic hot water .... ☐
- Cooking (range/oven) .... ☐

Pay Structure

7-2. Payment method (check off method of payment used):

- Building owner pays directly to utility (tenants not billed) .... ☐
- Tenants billed directly and pay own bills .... ☐
- Tenants billed directly but reimbursed for all costs .... ☐
- Tenants billed directly but reimbursed up to a limit .... ☐

What is the limit (If metered in cubic feet, divide by 100) .... ________ Therms/yr

________ $/yr

(Questions continued on next page.)

Average Natural Gas Consumption

7-3. Estimate average annual consumption by completing the following worksheet (enter data in table for most recent three years):

Year:	Annual Therms
19____:	________ Therms/yr
19____:	________ Therms/yr
19____:	________ Therms/yr
Total (add all three years):	________ Therms

Calculate average annual consumption:

(Total Therms) ________ ÷ 3 (years) = ________ Therms/yr

Current Natural Gas Price

7-4. Enter current price of natural gas (if metered in cubic feet divide by 100 to change to therms):

Average price of natural gas: .... ________ $/therm

Annual Natural Gas Cost

7-5. Calculate annual price of natural gas consumption (multiply average annual consumption, question 7-3, by average price, question 7-4):

(Therm/yr) ________ X ($/therm) ________ = ________ $/yr

8. Utility Data: Heating Oil

Heating Oil Uses

8-1. End uses of heating oil in your project (check off items for which oil is used):

- Heating .... ☐
- Cooling .... ☐
- Domestic Hot Water .... ☐

Types of Heating Oil Used

8-2. Oil type:

- Fuel oil #2 .... ☐
- Fuel oil #4 .... ☐
- Fuel oil #6 .... ☐

Pay Structure

8-3. Payment method (check off method of payment used):

- Owner pays directly to utility (tenants not billed) .... ☐
- Tenants billed directly and pay own bills .... ☐
- Tenants billed directly but reimbursed for all costs .... ☐
- Tenants billed directly but reimbursed up to a limit .... ☐

What is the limit? .... ________ Gallons

________ $

(Questions continued on next page.)

Average Annual Heating Oil Consumption

8-4. Estimate average annual consumption by completing the following worksheet (enter data in table for most recent three years):

Year:	Annual Gallons
19____:	________ Gal/yr
19____:	________ Gal/yr
19____:	________ Gal/yr
Total (add all three years):	________ Gal

Calculate average annual consumption:

(Gal/yr) __________ ÷ 3 (years) = __________ Gal/yr

Current Heating Oil Price

8-5. Enter current price of heating oil: ..... __________ $/gal.

Annual Cost of Heating Oil

8-6. Calculate annual price of heating oil consumption (multiply average annual consumption, question 8-4, by average price, question 8-5):

(Gal/yr) __________ X ($/gal) __________ = __________ $/yr

9. Utility Data: Other Fuels

Fuel Consumption & Costs

If your project is using any other fuel types in addition to or in place of electricity, gas or oil identify them and provide the following information for each (follow guidelines set forth in other utility data sections). All information should be provided in units of MBTUs.

Fuel Type #1:

9-1. Fuel type (specify): .... ________

9-2. End uses (list uses of that fuel): ...... ________

____

____

____

9-3. Payment method (specify who pays): ...... ________

9-4. Average annual consumption: .... ________ MBTU/yr

9-5. Average unit cost: .... ________ $/MBTU

9-6. Annual cost of fuel (average consumption multiplied by unit cost): .... ________ $/yr

Fuel Type #2:

9-7. Fuel type (specify): .... ________

9-8. End uses (list uses of that fuel): ...... ________

____

____

____

9-9. Payment method (specify who pays): ...... ________

(Questions continued on next page.)

9 - UTILITY DATA: OTHER FUELS

9-10. Average annual consumption: .... ________ MBTU/yr

9-11. Average unit cost: .... ________ $/MBTU

9-12. Annual cost of fuel (average consumption multiplied by unit cost): .... ________ $/yr

10. Summary of Fuel Uses / Costs

Summary of Utility Data

10-1. Summarize here the results of your entries and calculations in Appendix sections 6 through 9. Complete only as many rows as there are fuel types used in your project.

Fuel Type:	Average Annual Fuel Consumption:	Current Cost per Fuel or Energy Unit:
Electricity:	KWH/yr	$/KWH
Natural Gas:	Therms/yr	$/Therm
Heating Oil #2:	Gal/yr	$/Gal
Heating Oil #4:	Gal/yr	$/Gal
Heating Oil #6:	Gal/yr	$/Gal
Other (Fuel #1):	MBTU/yr	$/MBTU
Other (Fuel #2):	MBTU/yr	$/MBTU

11. Summary of Heating Use

Heating Use Calculations

11-1. Calculate quantity of fuel consumed for heating only:

Calculations for Heating Systems ECOs require that the quantity of fuel used exclusively for heating be known. For example, if a project is heated with gas then total gas consumption might include the use of gas for heating domestic hot water, cooling, etc. in addition to heating. Completion of the following worksheets will separate heating use from other uses of that fuel.

Complete only the calculations which refer to the type of fuel which is used for heating in your project. Note that different procedures are used for electrically and non-electrically heated projects. Use only the procedure which applies to your type.

Electrically Heated Projects Only

A. Transfer here the following information previously obtained in the survey:

Heating Degree day zone for your project (question 1-8): .... ______________ DDZ

Average annual KWH consumption (Question 10-1): .... ______________ KWH/yr

B. Circle the appropriate conversion factor for your building type and heating degree day zone in table below:

Degree Day Zone:	Low-Rise Buildings:	High-Rise Buildings:
2 or less	.30	.25
2.1 - 4	.45	.30
4.1 - 6	.60	.40
6.1 - 8	.75	.50
8.1 or more	.80	.60

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

(Annual KWH) ____________ X (Conversion Factor) ____________ = ____________ KWH/yr

Non-Electrically Heated Projects Only

If the fuel used for heating in your project is not used for any other purpose, there is no need to complete the calculations below. Simply enter the appropriate data (question 10-1) in the summary section below. If your heating fuel is, however, also used for other purposes, complete the calculations below.

A. Transfer here the following information previously obtained in the survey:

Number of dwelling units in your project (question 1-15): ...... ____________

Average annual heating fuel consumption (question 10-1): .... ____________ /yr

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

Fuel Type:	Conversion Factor:
Natural Gas:	100 Therms
Heating Oil:	43 Gals
Other:	60 MBTU

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

(Number of DUs) ____________ X (Conversion Factor) ____________ = ____________ /yr

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

(Average Use) ____________ - (Non-heating Use) ____________ = ____________/yr

Summary of Heating Consumption

11-2. Transfer here the results of above calculations (mark off the fuel type used for heating and fill in the annual quantity).

Heating Fuel Type:	Annual Heating Fuel Use:
____Gas	________ Therms/yr
____Oil	________ Gals/yr
____Electricity	________ KWH/yr
____Other	________ MBTU/yr

NOTES AND CALCULATIONS

Appendix B
Energy Conservation Opportunities (ECOs)

APPENDIX B

Energy Conservation Opportunities

Introduction

Energy Conservation Opportunities (ECOs) require capital cost investments. To determine whether it is wise to invest money in any given ECO, savings and payback periods must be calculated. Each ECO in this chapter is, therefore, divided into two parts: description and calculations.

All ECOs suggested in this workbook have been grouped in four categories:

1)	Architectural ECOs	general project and building operation, envelope construction, etc.
2)	Heating System ECOs	central and individual space heating, piping, distribution and controls, etc.
3)	Secondary System ECOs	domestic hot water, cooling, central laundry facilities, ventilation, etc.
4)	Electrical System ECOs	lighting, site lighting, electrical equipment, etc.

Part one of each ECO is a verbal and graphic description of the ECO, its energy saving rationale (how energy is saved), guidelines for equipment selection and concerns or "things to look for" in selecting and implementing the ECO. Its relationship to the HUD Modernization Standards Handbook requirements and other ECOs is also explained.

Part two of each ECO consists of a worksheet with calculation procedures for estimating the cost, savings and payback period. Applicability guidelines are given at the beginning of this part. Tables with savings factors, if necessary, are given at the end of each ECO worksheet.

Instructions

After completing the Survey and Utility Data forms, systematically analyze each ECO suggested in this workbook. Read its description and decide on its applicability. If applicable, estimate its cost and calculate its payback period.

Applicability. Not all ECOs apply to all projects. If the project does not fall into the category described under "Applicability" simply mark "NA" on the margin and in Appendix C, "Summary of Results", and proceed to the next ECO.

If it does apply, check the box on the right hand side and complete the cost/benefit worksheet to see if this ECO is cost-effective.

Calculations. Cost/benefit calculations are organized in steps depending upon their complexity, different ECOs have a different number of steps. Generally, however, they are organized in the same order:

a) obtain total cost of implementing this ECO,
b) transfer survey data needed to complete the calculations,
c) calculate energy savings,
d) calculate cost (dollar) savings,
e) calculate payback period.

Obtain Total Cost of Implementing this ECO

a) Cost estimates are for the entire project, not for each piece of equipment or each building. **If implementation will be done by outside contractors, include all labor** costs and profit margins. **Include all applicable delivery** charges and equipment **rental charges (scaffolds, cherry**-pickers, etc.). **Ask about discounts for quantity purchases.**

Obtaining reliable and competitive prices may require extra lead time. It should be the first task after deciding on the applicability. Records of all estimates and quantities should be retained.

b) Transfer survey data. Data to be transferred from the survey follows the cost estimate step. Numbers in the left-hand column, next to each question, refer to the survey question where the answers are located.

Questions on fuel consumption and costs may list more than one possible fuel type. Select and provide data only for the type which applies to your project. Do the same in selecting proper savings factors.

c) Calculate energy and cost savings. Savings and payback calculations are organized in numbered steps. Complete each step as instructed. Numbers in parenthesis on each line in the formula refer to final answers in previous steps. For example, calculation formula labeled "Step 5" might read:

(2) __________ X (3a) __________ = __________ Units

This means, take the number or quantity from the right-hand column in Step 2 and multiply it by the number or quantity from Step 3a. Write all numbers on the lines provided; final calculation answers are always in the extreme right-hand colummn.

Calculations may sometimes require the use of Savings Factors provided in the equation or accompanying tables. Savings factors allow the conversion of known quantities to savings estimates. They might represent percent estimates, conversion factors, constants or results of combinations of constants and do not necessarily represent any real energy units.

d) Calculate payback period. The last step in each calculation estimates the payback period. Payback period is the time necessary to recover through savings, the investment cost required to implement any given ECO. As such it is used as a measure of the economic "desirability" of an ECO: those with the shortest payable period should be implemented first. All ECOs with a payback period of 15 years or less are considered to be economically viable and should be implemented as long as the payback period is less than the useful life of the product.

As each ECO is analyzed, applicability decided, and calculations completed, enter the results in Appendix C - Summary of Results. "Successful" ECOs will then be ranked for priority inclusion in funding decisions.

Example: On the following pages completed worksheets for a typical ECO have been reproduced. They illustrate how the forms should be filled in. If, based on the "Applicability" description it was decided that this ECO does not apply to this project, the letters "NA" would have been marked on the margin and in the summary section and all calculations omitted.

ECO #11: INSTALL WALL INSULATION

Applicability

This ECO applies only to:
2-8 a) buildings with uninsulated walls,
1-8 b) buildings located in climate zones 1.5 and above.

Check here if this ECO applies: ☑

Cost/Benefit Worksheet

Step 1 Obtain total cost of installing wall insulation: 62,912 $

Step 2 Transfer the following information from the Survey:

1-8 **a** Heating degree day zone: 4.3 DDZ

2-8 **b** Wall construction and siding type: Wood Fr./Wd.

2-8 **c** Wall area (if total wall area is not being considered for insulation, enter here only the area under consideration): 35,760 SF

10-1 **d** Cost of heating fuel: Gas: ______ $/therm
Oil: 1.50 $/gal
Electricity: ______ $/KWH
Other: ______ $/MBTU

Step 3 Obtain the following data from Table 11-1:

Table 11-1 Savings factor for existing wall type and fuel type: .054

Step 4 Estimate annual energy savings:

(2a) 4.3 x (2c) 35,760 x (3) .054 = 8,303 Gals /yr

Step 5 Calculate annual cost savings:

(2d) 1.50 x (4) 8,303 = 12,455 $/yr

Step 6 Calculate payback period:

(1) 62,912 ÷ (5) 12,455 = 5.1 Yrs

Table 11-1 Savings Factors for Installing Wall Insulation

Existing Wall Conditions:	Heating Fuel Type: Gas	Oil	Elec.	Other
Wood frame (uninsulated):				
Wood siding:	.075	.054	1.55	.0528
Aluminum Siding:	.075	.054	1.55	.0528
Brick Siding:	.072	.051	1.48	.0504
Other:	.058	.042	1.20	.0408
Masonry Wall (uninsulated):				
Concrete block:	.058	.042	1.20	.0408
All brick:	.075	.054	1.55	.0528
Other:	.075	.054	1.55	.0528

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

Instructions:
1 - Find your wall construction type;
2 - Proceed across table to column with your heating fuel type;
3 - Circle and transfer the appropriate savings factor to Step 3.

1. Architectural ECOs

Architectural energy conservation opportunities are designed primarily to improve the energy design of the building envelope, i.e., wall and roof construction and window and door condition. All are designed to reduce heat losses in winter, and unwanted heat gains in summer.

The following ECOs are included:

ECO #1: Improve Architectural O&M

ECO #2: Weatherstrip Windows and Doors

ECO #3: Install Storm Windows

ECO #4: Install Replacement Windows

ECO #5: Install Insulating Window Shades

ECO #6: Install Window Sun Shades

ECO #7: Install Storm Doors

ECO #8: Construct Vestibules

ECO #9: Install or Increase Attic Insulation

ECO #10: Install Roof Insulation

ECO #11: Install Wall Insulation

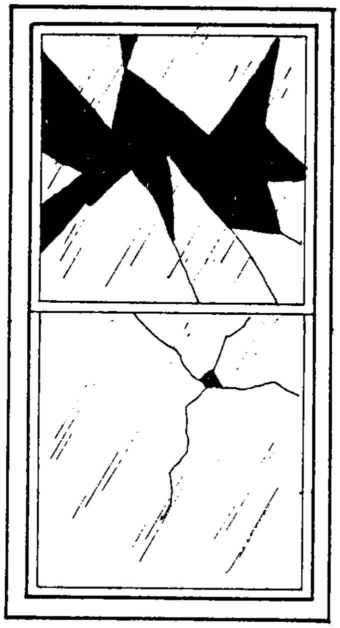
ECO #12: Install Passive Solar Collectors

If results of ECO #8 Construct Vestibules, and ECO #12, Install Passive Solar Collectors, prove cost effective, further analysis and design by professional consultants will be necessary before they can be implemented.

The consideration of all ECOs must meet the required provisions set forth in the Modernization Standards Handbook for each relevant building service, system or space type.

ECO No. 1

Improve architectural O&M



Description

Proper operation and maintenance (O&M) of the building envelope and architectural elements must be assured before other, generally more costly ECOs are implemented. Operation and maintenance items listed here require little, if any, capital cost expenditures, but might require increased maintenance staffs.

Because O&M items require little capital cost investment they must be implemented first, and in fact, savings estimates for other ECOs assume that all of the following items have been implemented. The specific O&M items included in this ECO are:

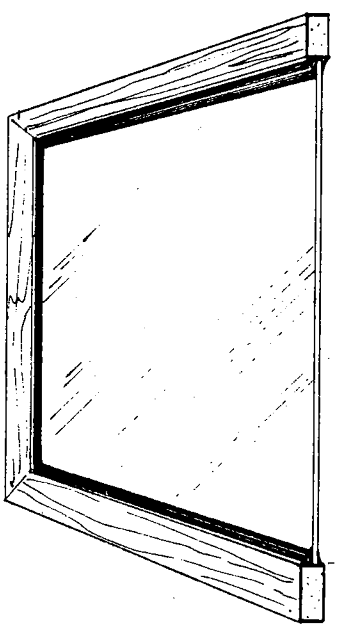
a) replacing of broken glass,

b) repairing/replacing of window putty and gaskets,

c) caulking all window and door frames and wall and roof penetrations,

d) patching of all wall and roof holes,

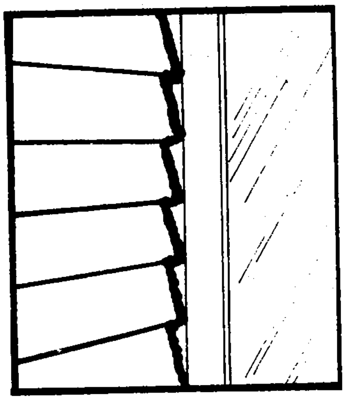
e) ensuring of summer attic ventilation.



O&M Items

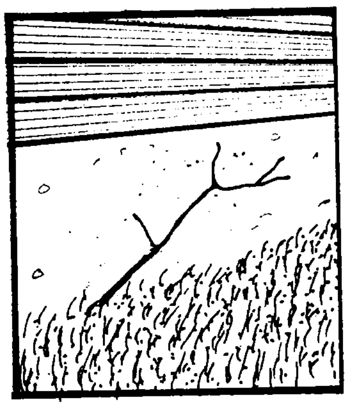
Broken Glass. Repair or replace all broken glazing on windows, storm windows, skylights, vestibules, doors, transoms, etc. to prevent infiltration. Cracked, broken or missing glass allows outside air to infiltrate a building thereby increasing the heating and cooling load. Because this air must be either heated or cooled the total energy consumption is increased.

Putty. To prevent infiltration through windows make sure putty is in good condition. Putty which is cracked or dried should be replaced. Gaskets on pivot windows should be flexible and provide a complete seal. Inspect windows to determine condition of gaskets.



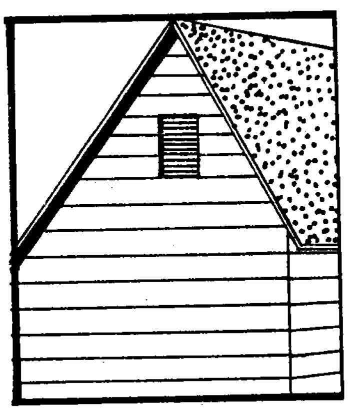
Caulk Frames and Openings. Frames and openings should be caulked where they meet the wall. Existing caulking which is cracked, dried or missing should be scraped out and replaced with a new sealant. Caulking should be done at all window and door frames, corners of buildings, sill plates, penetrations through walls, around vents, louvers, etc. Do not caulk windows and doors which need replacement.

Patch holes. Patch and repair any holes in the building envelope (walls, roof, foundations, entrance structures). Repair holes according to building construction type. Repairs should be done by qualified personnel.



Attic ventilation. Attic vents and louvers should be in good condition to insure proper ventilation of the attic space in the summer.

Inspect attic spaces and roof exteriors for conditions of vents. Repair or replace those which are missing or damaged and remove all accumulated paint. If accessible, attic insulation should be inspected to determine if it is obstructing vents.



Properly ventilated attics reduce the heat loan in the summer. Ventilation panels and louvers accelerate cooling by allowing warm air, which rises, to escape through gable or ridge vents and be replaced by cooler air entering at eave vents. This reduces heat build-up in the summer. Attic ventilation is also necessary to prevent condensation problems.

Modernization Standards Handbook reference: 9-7, 10-2.

Applicability

This ECO applies to all projects requiring work on any of the following items (see full descriptions on previous pages):

a) broken glass,
b) window putty and gaskets,
c) caulking,
d) patching holes,
e) attic ventilation.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1

Obtain cost of performing any of the applicable O&M items:

a	broken glass:	_______ $
b	window putty and gaskets:	_______ $
c	caulking:	_______ $
d	patching holes:	_______ $
e	attic ventilation:	_______ $
f	Total (add all costs of applicable items):	_______ $

Step 2

Transfer the following information from the survey:

2-2	a	Total volume of project:		_______ CF
10-1	b	Cost of heating fuel:	Gas:	_______ $/therms
			Oil:	_______ $/gal
			Electric:	_______ $/KWH
			Other:	_______ $/MBTU

Step 3

Obtain savings factors for all applicable items from Table 1-1:

Table 1-1 **a** broken glass: ____________

Table 1-1 **b** window putty and gaskets: ____________

Table 1-1 **c** caulking: ____________

Table 1-1 **d** patching holes: ____________

Table 1-1 **e** attic ventilation: ____________

f Total (add savings factors of all applicable items): ____________

Step 4

Estimate annual energy savings:

(2a) ____________ X (3f) ____________ = ____________ /yr

Step 5

Calculate annual cost savings:

(2b) ____________ X (4) ____________ = ____________ $/yr

Step 6

Calculate payback period:

(1f) ____________ ÷ (5) ____________ = ____________ Yrs

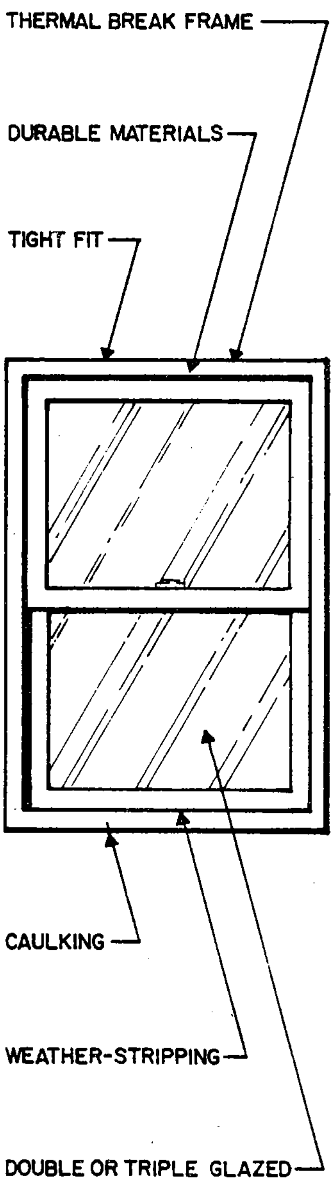
Table 1-1

Savings Factors for Architectural O&M

Items to be Implemented:	Heating Fuel: Gas	Oil	Elec	Other
a) broken glass:	.012	.009	.26	.009
b) window putty/gaskets:	.003	.002	.06	.002
c) caulking:	.003	.002	.06	.002
d) patching holes:	.006	.005	.012	.005
e) attic ventilation:	.004	.003	.08	.003

ECO No. 2

Install replacement windows



Description

Heat loss through inadequately glazed and weather stripped windows is one of the largest causes of energy loss in housing. When existing windows are in poor condition and replacement windows are needed, the installation of double or even triple glazed replacement windows should be considered. Existing single glazed windows which, although in good condition, cannot readily accept the installation of storm windows (ECO #3) because they would interfere with their operation, should also be considered for replacement with double or triple glazed windows in this ECO.

Multi-glazed energy conserving windows are available in all ranges of style, size and quality with either wood or metal thermal-break frames. Select the type most compatible with existing conditions.

Energy savings from such replacements result from reduced heat loss through the glass (double glazing has half the heat loss of single pane) and by reducing infiltration losses. Additional benefits include greater comfort in dwelling units, and the upgrading of building stock.

Modernization Standards Handbook reference: 9-7.

Concerns

- If wood window frames are selected they should be properly treated with wood preservatives.
- Each frame of the selected window unit should incorporate a thermal break between the inside and outside surfaces (the manufacturers should be able to provide information on this design aspect).
- All applicable codes should be checked for window regulations (some codes specify tempered glass, most specify area of units which have to be operable, etc.)

Applicability

This ECO applies only to:

a) projects with windows needing replacement due to deterioration (See Modernization Standards Handbook),

b) projects with windows that cannot be fitted with storm windows (ECO #3).

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

This analysis must be performed for both double and triple glazed replacement windows.

Step 1

Double Glazed Replacement Window:

a Total cost of replacement windows if existing windows are in good condition but storm windows are not compatible.
Total cost: ________ $

or

a Only cost of double glazed replacement window over the cost of a single glazed replacement window when existing window has to be replaced for moderization reasons.
Incremental Cost increase ________ $

Triple Glazed Replacement Window:

b Only cost of triple glazed replacement over the cost of double glazed replacement window.
Incremental Cost Increase: ________ $

Step 2

Transfer the following information from the survey:

1-8 **a** Heating degree day zone: ________ DDZ

2-10 **b** Total area of all windows (if all windows do not need replacement enter here only the area of those needing replacement): ________ SF

2-2 **c** Total project volume: ________ CF

10-1 **d** Cost of heating fuel:
Gas: ________ $/Therm
Oil: ________ $/Gal
Electric: ________ $/KWH
Other: ________ $/MBTU

2-14 **e** Average condition of window fit: ______

2-16 **f** Are existing windows weather-stripped? ______

Step 3

Obtain the following savings factors from Tables 2-1 and 2-2:

Table 2-1 **a** Conductance savings factor - double glazed: ______

Table 2-1 **b** Conductance savings factor - triple glazed: ______

Table 2-2 **c** Infiltration savings factor: ______

Step 4

Estimate annual energy savings due to conduction losses:

a Double glazed replacement windows:

(2a) ______ X (2b) ______ X (3a) ______ = ______ /yr

b Triple glazed replacement windows:

(2a) ______ X (2b) ______ X (3b) ______ = ______ /yr

Step 5

Calculate annual energy savings due to infiltration losses:

(2c) ______ X (2a) ______ X (3c) ______ = ______ /yr

Step 6

Calculate total annual energy savings:

a Double glazed replacement windows:

(4a) ______ + (5) ______ = ______ /yr

b Triple glazed replacement windows:

(4b) ______ + (5) ______ = ______ /yr

Step 7

Calculate annual cost savings:

a Double glazed replacement windows:

(6a) ______ X (2d) ______ = ______ $/yr

b Triple glazed replacement windows:

(6b) __________ X (2d) __________ = __________ $/yr

Step 8 Calculate payback period:

a Double glazed replacement windows:

(1a) __________ ÷ (7a) __________ = __________ Yrs

b Triple glazed replacement windows:

(1b) __________ ÷ (7b) __________ = __________ Yrs

Results of both parts A & B should be entered in Summary of Results if these parts were separate.

Table 2-1

Conductance Savings Factors

Replacement Window Type:	Fuel Type: Gas	Oil	Electric	Other
Double glazed:	.200	.143	4.1	.14
Triple glazed:	.057	.041	1.18	.04

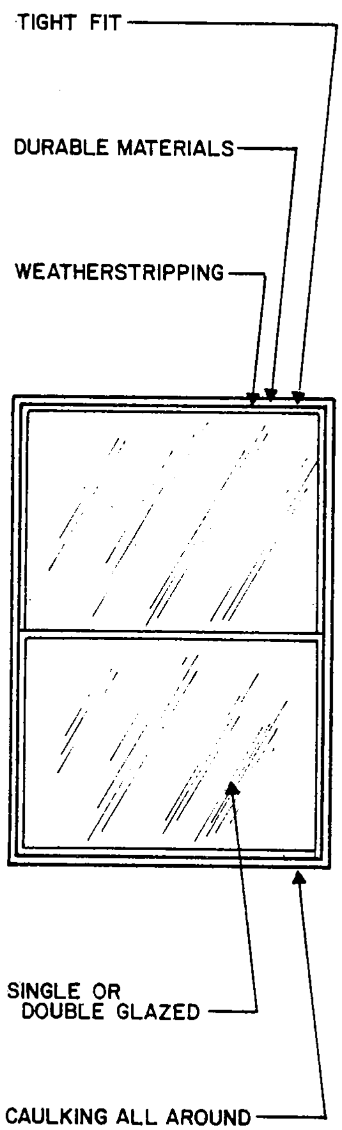
Table 2-2

Infiltration Savings Factors

Existing Window Condition:	Fuel Type: Gas	Oil	Electric	Other
No or poor weatherstripping:	.0030	.0021	.062	.0021
Well weatherstripped:	0	0	0	0

ECO No. 3

Install storm windows



Description

When the existing windows are poorly sealed or single glazed, there is probably a large amount of energy loss through them. One of the easiest possible corrective measures is to install storm windows.

Storm windows can be installed on either the interior or exterior of an existing window. They can be either glass or plastic and can be either fixed glass or operable. Storm windows usually have a single pane of glass, but in extremely cold climates double-glazed storm windows might be cost effective.

Storm windows save energy in two ways. First, they reduce air leakage through the window and secondly, they reduce heat conduction by creating an insulating air space. They are equally effective in reducing heating season loads, by reducing heat losses, and cooling season loads, by reducing heat gains.

Storm windows are usually a good investment for most projects. Their energy savings are maximized in both, extremely cold and extremely hot climates where heating and cooling expenses are great, however they can be cost effective in all climates.

In addition to saving energy, storm windows also help in maintaining more uniform and therefore, more comfortable interior temperatures, lower maintainance costs on existing windows, and reduce outside noise, dust, pollen and pollutants which enter living spaces.

Modernization Standards Handbook reference: 9-7.

Concerns

- Some windows, because of their operation, will not accept storm windows unless the primary windows can be left inoperable.

Those usually include awning and pivot type windows. Make certain you do not include these windows in your calculations. Consider replacing windows (ECO #2) in these situations.

- Storm windows must be carefully matched to existing windows to insure that operable windows can be opened and storm windows can be properly sealed to existing window frames.

- Many old-fashioned storm windows are not as energy efficient as new designs. Only storm windows that are "energy conserving" should be considered. These designs include provisions for proper sealing to frame to minimize air leakage, weatherstripping of all operable sash and thermal-break type frame. Storm windows without these features will not save as much energy as calculated here.

Applicability

This ECO applies only to:

2-12 a) single glazed windows,

2-15 b) windows without storm windows.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of installing the type and quantity of storm windows needed: ________ $

Step 2 Transfer the following information from the survey:

1-8	**a**	Heating degree day zone:	________ DDZ
2-10	**b**	Total area of windows:	________ SF
2-2	**c**	Total project volume:	________ CF
2-16	**d**	Are your windows weatherstripped?	________
2-14	**e**	Average window fit:	________
2-13	**f**	Window frame material:	________
10-1	**g**	Cost of heating fuel: Gas:	________ $/therm
		Oil:	________ $/gal
		Electric:	________ $/KWH
		Other:	________ $/MBTU

Step 3 Obtain the following values from Tables 3-1 and 3-2:

Table 3-1	**a**	Conductance savings factor for your heating fuel and window type:	________
Table 3-2	**b**	Infiltration savings factor for your heating fuel type and window fit:	________

Step 4 Estimate annual conductance energy savings:

(2a) ________ X (2b) ________ X (3a) ________ = ________ /yr

Step 5 Estimate annual infiltration energy savings:

(2a) ________ X (2c) ________ X (3b) ________ = ________ /yr

Step 6 Calculate total annual energy savings:

(4) ________ + (5) ________ = ________ /yr

Step 7 Calculate annual cost savings:

(6) ________ X (2g) ________ = ________ $/yr

Step 8 Calculate payback period:

(1) ________ ÷ (7) ________ = ________ Yrs

Table 3-1

Conductance Savings Factors

Existing Window Frame Material:	Fuel Type: Gas	Oil	Elec	Other
Wood	.171	.122	3.5	.12
Metal	.200	.143	4.1	.14

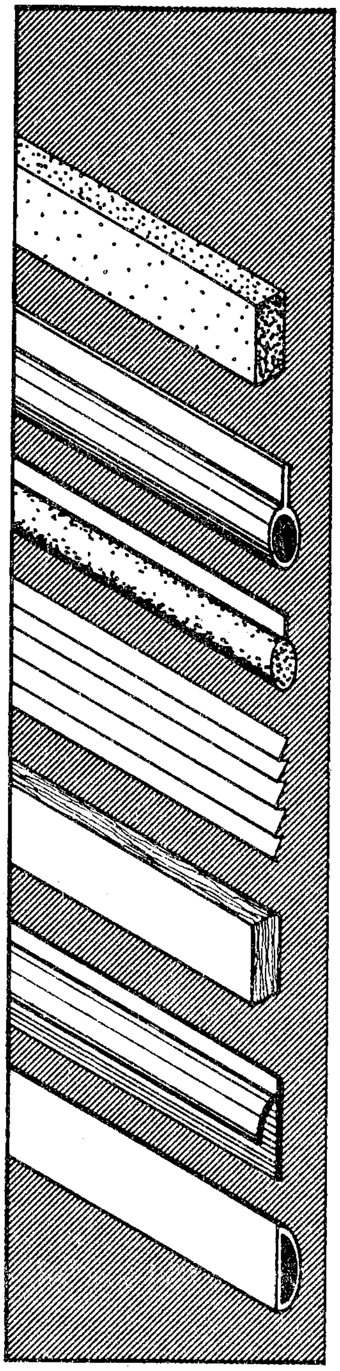
Table 3-2

Infiltration Savings Factors

Existing Window Fit:	Fuel Type: Gas	Oil	Elec	Other
Non-weather-stripped windows:				
Loose fit	.0041	.0030	.085	.0029
Average fit	.0030	.0020	.062	.0021
Tight fit	.0020	.0014	.041	.0014
Weatherstripped windows:	0	0	0	0

ECO No. 4

Weatherstrip windows and doors



Description

All operable windows and doors should be weather-stripped to prevent unwanted air infiltration in winter and summer.

Weatherstripping is usually a flexible strip that seals any gap between the edge of an operable window or door and its sash. The strip can be made of rubber, plastic or metal and should be specifically suited to the window or door type.

Weatherstripping reduces infiltration rates on windows and doors especially when storm windows and doors are not present. With proper weather-stripping heating loads are reduced in winter because less warm air leaks out of spaces and cooling loads are reduced in summer because less warm outside air leaks into spaces. With proper weatherstripping comfort is also increased because drafts, dust, pollen, and pollutants are eliminated.

Modernization Standards Handbook reference: **9-7.**

Concerns

- High product quality, provisions for future adjustments and minimum maintenance require-ments should be considered when selecting and installing weatherstripping.
- Although weatherstripping can be easily done by maintenance staff, the use of experienced contractors should be considered, especially if they will be involved in other work on the building.
- After installation, proper maintenance and inspection programs should be developed and implemented.
- Make certain not to weatherstrip at this time windows and doors that will need replacement or installation of storm windows or doors in other ECOs.

ECO #4: WEATHERSTRIP WINDOWS AND DOORS

Applicability

2-16, 25 This ECO applies only to projects with: a) windows and doors without existing weatherstripping, and b) when new storm windows or new replacement windows are not needed.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of weatherstripping windows and/or doors:

______ $

Step 2 Transfer the following information from the survey:

1-8	**a**	Heating degree day zone:		______ DDZ
2-14, 24	**b**	Average fit of windows and doors:		______
2-2	**c**	Total Project volume:		______ CF
10-1	**d**	Cost of heating fuel:	Gas:	______ $/therms
			Oil:	______ $/gal
			Electric:	______ $/KWH
			Other:	______ $/MBTU

Step 3 Obtain the following data from Table 4-1:

Table 4-1 Infiltration savings factor: ______

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

Table 4-1

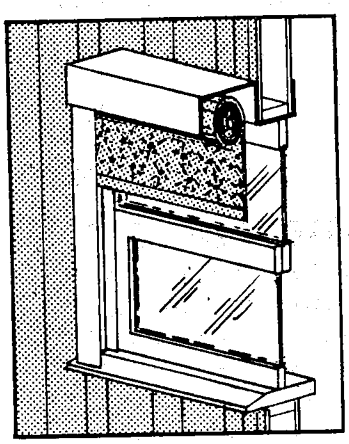
Infiltration Savings Factors

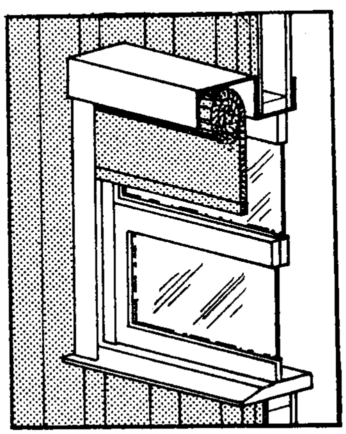
Existing Window and Door Fit:	Gas	Fuel Type: Oil	Elec	Other
Loose fit:	.0041	.0030	.085	.0029
Average fit:	.0030	.0021	.062	.0021
Tight fit:	.0020	.0014	.041	.0014

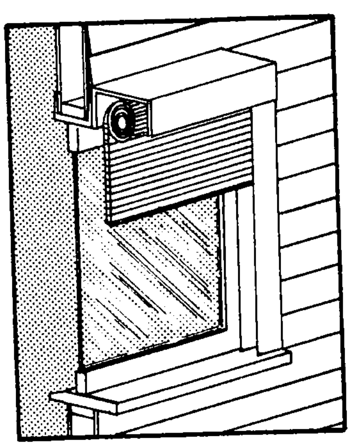
Note: This table assumes that 100% of windows and doors need weatherstripping. If substantially less than 100% actually need weatherstripping then multiply the appropriate savings factor above by the percent of windows and doors that need weatherstripping. Example: If only 50% need weatherstripping multiply the factor by .50 and enter the result in Step 3. Cost estimate (Step 1) should also reflect this reduction.

ECO No. 5

Install insulating window shades







Description

Thermal shutters or shades are designed to provide window insulation at night. They usually are stored in a valance above the window and are pulled down on tracks along the side of the window locking on the bottom. The tracks and bottom lock prevent cold air from infiltrating around the shade at night.

Thermal shades and shutters range in insulation value, material, come in many decorative fabrics and can be installed in most windows. Shutters are installed outside the windows and shades are installed inside.

It will always be more cost effective to install storm windows or double glazing before thermal shades are installed. The savings estimate given herein, therefore, assumes the building already has storm windows or double glazing. Insulating value of R-5 to R-7 and shutters closed 10 hours per day were also assumed.

Only projects located in climates with more than 4000 degree days i.e. heating degree day zones of 4.0 and more should be analyzed. Savings in warmer climates will not pay for the cost of installation within the required time period.

Cost Guidelines

Thermal shades vary in costs depending on type, R-value, installation hardware and local labor charges. They can be expected to cost between $4.50 - $8.00 (1980 prices) per square foot of window, installed. These numbers should be used as guidelines only, actual costs should be obtained from a local contractor.

Modernization Standards Handbook reference: 9-7.

Concerns

- Thermal shutters and shades must be compatible with existing window types and must not interfere with the window's operation.

ECO #5: INSTALL INSULATING WINDOW SHADES

- Thermal shutters and shades must be easy and convenient to use to insure their daily operation by occupants and in emergency egress cases.
- Durability and ease of maintenance are important criteria in selection.
- Tenants should be instructed to pull them down at night during the heating season. They can also be used in summer to lower air conditioning costs.

Applicability

This ECO applies only to:

1-8 a) projects located in heating degree day zones 3.0 or more,

2-17 b) projects without insulating shades or shutters.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of installing thermal shutters or shades: ________ $

Step 2 Transfer the following information from the survey:

1-8 **a** Heating degree day zone: ________ DDZ

2-10 **b** Total window area: ________ SF

10-1 **c** Cost of heating fuel: Gas: ________ $/therm

Oil: ________ $/gal

Electric: ________ $/KWH

Other: ________ $/MBTU

Step 3 Obtain the following value from Table 5-1:

Table 5-1 Thermal shade savings factor: ________

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

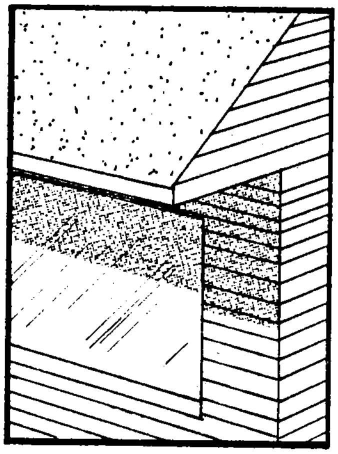
Table 5-1

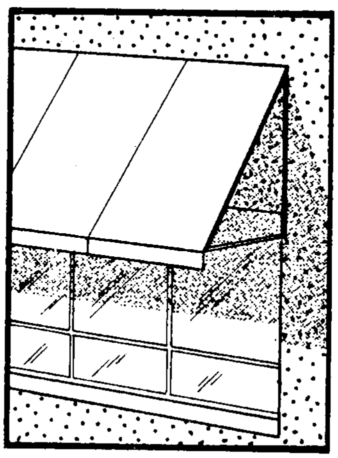
Thermal Shade Savings Factors

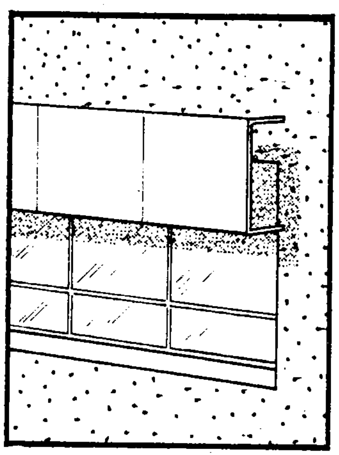
Fuel Type:	Gas	Oil	Elec	Other
Savings Factor:	.075	.053	1.54	.053

ECO No. 6

Install window sun shades







Description

Summer window shading reduces the solar radiation heat gain through windows which often accounts for 50% of the air conditioning load.

If interior blinds or shades exist their proper use will insure a sizeable reduction in solar gain in summer and additional shading will not be necessary. However, if no existing shading exists and interior spaces such as offices, public spaces, lobbies, etc. are air conditioned then window shading should be analyzed.

Types of Window Shading

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

Exterior shading can be one of the following three types:

(1) Architectural elements such as roof overhangs or vertical shading devices which are permanently affixed to the building and require little maintenance after installation.

(2) Awnings which are fixed to the building and are operated by the staff to regulate the amount of shading. They can be removed or folded up in the winter; and

(3) Shading screens which 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.

In addition to exterior shading elements, tinted films and interior blinds can also be used. Tinted film can be applied to the inside of any window and is available in many colors and tones. 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 they are less costly than other shading devices and maximize view as well as eliminate glare.

Interior shades or blinds are not as efficient as exterior shading or tinted film because the sunlight has entered the space before it is reflected back, thereby trapping much of the heat inside the building.

Interior blinds or shades include such devices as roll-down shades, roll-down transparent tinted shades, venetian blinds, vertical blinds and interior sun screens.

Modernization Standards Handbook reference: 9-7.

Concerns

- Exterior shading must be engineered for correct summer solar angles to insure proper shading.

- Tinted film is fragile, therefore it should not be used in areas where objects or people come in frequent contact with windows.

- Interior shading must reflect sunlight out the window, not just up to the ceiling, to achieve air conditioning savings.

- All exterior shading devices should be designed to withstand snow loads in cold-climate projects.

Applicability

The ECO applies only to:

2-18 a) projects with air conditioned office and community spaces,

2-22 b) air conditioned spaces without interior shades, blinds or tinted glass,

2-21 c) air conditioned spaces without windows well shaded by exterior trees, vegetation or other buildings.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

The following analysis of window shading is only for non-north-facing windows (i.e. exclude north-facing windows from this ECO) of office and community spaces that are air-conditioned. South facing windows and east and west-facing windows have different savings and are analyzed separately if they apply.

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:

2-19 **a** Area of south-facing windows in air-conditioned spaces: ________ SF

2-19 **b** Area of east and west-facing windows in air-conditioned spaces: ________ SF

10-1 **c** Cost of electricity: ________ $/KWH

Step 3

Obtain the following data from Tables 6-1 and 6-2:

Table 6-2 **a** Solar loads on south windows: ________ KWH

Table 6-2 **b** Solar loads on east and west facing windows: ________ KWH

Table 6-1 **c** Savings factor for selected window shade type: ________

Step 4

Estimate annual energy savings:

a South-facing windows:

(2a) ______ X (3a) ______ X (3c) ______ = ______ KWH/yr

b East and west-facing windows:

(2b) ______ X (3b) ______ X (3c) ______ = ______ KWH/yr

Step 5

Calculate annual cost savings:

a For south-facing windows:

(2c) ______ X (4a) ______ = ______ $/yr

b For east and west-facing windows:

(2c) ______ X (4b) ______ = ______ $/yr

Step 6

Calculate payback period:

a South-facing windows:

(1a) ______ ÷ (5a) ______ = ______ Yrs

b East and west-facing windows:

(1b) ______ ÷ (5b) ______ = ______ Yrs

Results of both, parts (a) and (b), should be entered in Summary of Results as if these parts were separate ECOs.

Table 6-1

Savings Factors for Window Shading

Type of Shade:	Savings Factor:
Exterior Shutters	.65
Tinted Film	.55
Interior Shades	.45

Table 6-2

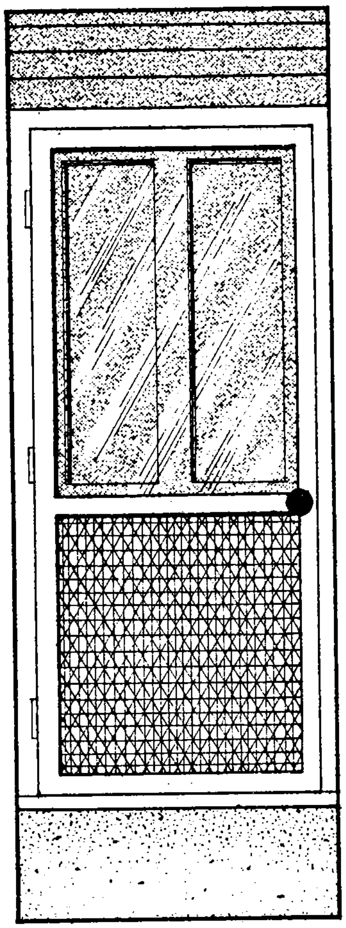
Solar Load in KWHs

Major City:	East and 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

Instructions: Use the closest city to actual project location and enter the values in Step 3.

ECO No. 7

Install storm doors



Description

Although doors do not lose as much energy as windows, installing storm doors is still very cost effective. Storm doors are, however, more costly than storm windows, and since energy losses through doors are lower, it will usually take longer to recover the investment.

Just like storm windows, storm doors save energy in two ways, they reduce heat conduction by creating an insulated air space and they reduce air leakage through the existing door. Additional advantages are increased security, reduced outside noise, dust, etc., and reduced maintenance requirements for the main door.

Implementation Guidelines

Storm doors come in many types and of different qualities. The type that best fits your existing door frames and a high quality type should be selected to ensure proper fit and longevity. Although storm doors are usually installed by a contractor, installation by maintenance staff might be considered.

Buying inferior storm doors, such as those made from thin gauge metal frames with untempered glass panels, is usually a poor investment as they will probably need replacement within a short time.

Modernization Standards Handbook reference: 10-8.

Concerns

- Minimum door clearances for the operation by handicapped or elderly tenants should be considered.
- Consideration of safety and vandalism must be made when selecting any glass storm doors.
- Adequate closers and latches must be provided.

Applicability

This ECO applies only to:

1-12 a) low-rise buildings,
2-26 b) buildings without storm doors,
2-28 c) buildings without vestibules.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Note: All exterior doors should be considered in this ECO, 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:

1-8	a	Heating degree day zone:	________ DDZ
2-25	b	Are existing doors weatherstripped?	________
2-24	c	Average fit of existing doors:	________
2-23	d	Total number of doors:	________
2-2	e	Total building volume:	________ CF
2-27	f	Type of existing door:	________
2-27	g	Thickness of door (if wood):	________ Inches
1-18	h	Average number of tenants per dwelling unit:	________
10-1	i	Cost of heating fuel: Gas:	________ $/therm
		Oil:	________ $/gal
		Electric:	________ $/KWH
		Other:	________ $/MBTU

Step 3 Obtain the following values from Tables 7-1 and 7-2:

Table 7-1 **a** Conductance savings factor for your heating fuel and door type: ________

Table 7-2 **b** Infiltration savings factor for your weatherstripping condition, number of people per D.U. and heating fuel type: ________

Step 4 Estimate annual conductance energy savings:

(2a) ______ X (2d) ______ X (3a) ______ = ______ /yr

Step 5 Estimate annual infiltration energy savings:

(2a) ______ X (2d) ______ X (3b) ______ = ______ /yr

Step 6 Calculate total annual energy savings:

(4) ______ + (5) ______ = ______ /yr

Step 7 Calculate total annual cost savings:

(2i) ______ X (6) ______ = ______ $/yr

Step 8 Calculate payback period:

(1) ______ ÷ (7) ______ = ______ Yrs

ECO #7: INSTALL STORM DOORS

Table 7-1

Conductance Savings Factors

Existing Door Type:		Fuel Type: Gas	Oil	Elec	Other
Solid Wood:	1"	1.8	1.3	36.9	1.26
	1 1/4"	1.4	1.0	29.6	1.01
	1 1/2"	1.1	.8	23.4	0.80
	2"	.9	.7	19.1	0.65
Steel door:	Standard metal door:	1.6	1.1	32.5	1.11
	Energy conserving metal door:	.9	.7	18.4	.63

Table 7-2

Infiltration Savings Factors

		Existing Door Conditions:		
		Non-weatherstripped		Weatherstripped
Fuel Type	Tenants per Dwelling Unit	Loose	Average tight	All fits
Gas (therms)	2 or less	6.5	2.0	.4
	3	6.7	2.1	.5
	4	6.9	2.3	.7
	5	7.1	2.6	.9
Oil (gals)	2 or less	4.6	1.4	.3
	3	4.8	1.5	.4
	4	4.9	1.7	.5
	5	5.1	1.9	.6
Electric (KWH)	2 or less	133.3	40.2	7.3
	3	137.7	44.0	11.1
	4	140.7	47.5	14.7
	5	145.1	54.2	18.5
Other (MBTU)	2 or less	4.55	1.37	.25
	3	4.70	1.50	.38
	4	4.80	1.62	.50
	5	4.95	1.85	.63

ECO No. 8

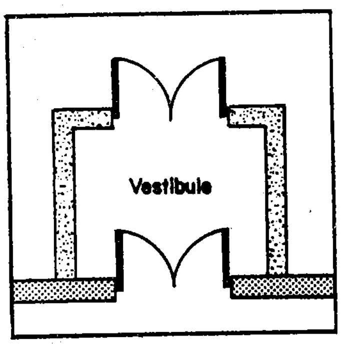
Construct vestibules

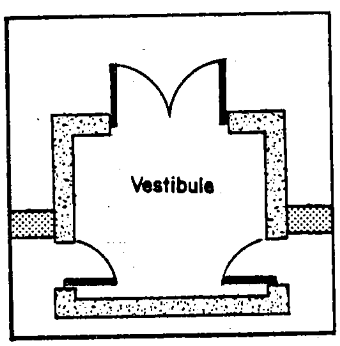
Description

In multi-family buildings main entry doors experience heavy and continuous traffic. Each time such doors are opened cold air is allowed to enter the building. Once inside this air has to be heated, thereby increasing the building's energy requirements. In high-rise buildings adding storm doors is both impractical and inadequate; constructing vestibules to form "air locks" should be considered instead.

Cold air enters a building through cracks around doors and windows and through the opening action of doors. In multi-family buildings where the main entry doors are heavily used, the cold air entering through opening doors contributes significantly to the heating load. Vestibules decrease this infiltration substantially, saving significant amounts of energy. In addition drafts are reduced, making the lobby and surrounding spaces more comfortable.

Vestibule Types





Although the main building entry is the most obvious location for a new vestibule, consider all entries with heavy traffic flows. These might include side entries, entries from parking lots, outdoor activity areas, etc.

Vestibules may be added on either the inside or the outside of the existing doorway, or by eliminating the existing doors and constructing a new vestibule that extends partially outside. The choice can only be made by carefully analyzing the available space conditions. Constructing the vestibule inside the building is usually less expensive since no roof has to be constructed and interior construction materials may be used.

Vestibule doors may be either manually operated and self-closing or, if traffic is particularly heavy, they can be automatically opened and closed by either pressure pads or photo-electric cell controllers. In either case only well

insulated, well-constructed and well-weather-stripped doors should be specified.

Modernization Standards Handbook reference: 4-3.

Concerns

- Vestibules and doors must be constructed with adequate levels of insulation, properly sized doors and good weatherstripping.
- In housing for the elderly and handicapped, doors and vestibules must meet all appropriate requirements for manuverability.
- If project buildings are already equipped with revolving doors which, although substantially more costly, are very energy efficient, ensure that the revolving doors and not the side doors are used to gain entry into the building.
- Check applicable fire codes to insure that installation of a vestibule does not conflict with fire exit requirements.
- Vestibules should be designed by qualified professionals to assure compliance with all applicable codes and regulations.

Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

This ECO applies only to:

1-12 a) multi-family buildings,

2-29 b) buildings without revolving doors or vestibules.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

The following worksheet is designed to allow cost/benefit analysis of up to three vestibules. Complete as many entries as are appropriate to your project, i.e. all entrances used by more than 25% of the tenants. If only the main lobby is heavily used (i.e. other doors are used by less than 25% of the tenants) complete only lobby calculations.

Step 1

After deciding on the appropriate design of each vestibule under consideration obtain the total cost of construction for each:

a Main lobby: ____________ $

b Side entry #1: ____________ $

c Side entry #2: ____________ $

Step 2

Transfer the following information from the Survey:

1-8 **a** Heating degree day zone: ____________ DDZ

2-30 **b** Percent of tenants using Main Lobby: ____________ (%)

2-30 **c** Percent of tenants using Side entry #1: ____________ (%)

2-30 **d** Percent of tenants using Side entry #2: ____________ (%)

1-15 **e** Total number of dwelling units: ____________

10-1 **f** Cost of heating fuel: Gas: ____________ $/therm

Oil: ____________ $/gal

Electric: ____________ $/KWH

Other: ____________ $/MBTU

Step 3

Obtain the following values from Table 8-1:

Table 8-1 **a** Infiltration savings for your fuel type: ____________

Table 8-1 **b** Conductance savings for your fuel type: ____________

Step 4

Calculate annual infiltration energy savings for each vestibule:

a Main lobby:

(2a) ______ X (2b) ______ X (2e) ______ X (3a) ______ = ____________/yr

b Side entry #1:

(2a) ______ X (2c) ______ X (2e) ______ X (3a) ______ = ____________/yr

c Side entry #2:

(2a) ______ X (2d) ______ X (2e) ______ X (3a) ______ = ____________/yr

Step 5

Calculate annual conduction energy savings (assumed the same for all vestibules):

(2a) ____________ + (3b) ____________ = ____________/yr

Step 6

Calculate total annual energy savings for each vestibule:

a Main lobby:

(4a) ____________ + (5) ____________ = ____________/yr

b Side entry #1:

(4b) ____________ + (5) ____________ = ____________/yr

c Side entry #2:

(4c) ____________ + (5) ____________ = ____________/yr

Step 7 Calculate total annual cost savings for each vestibule:

a Main lobby:

(6a) ________ x (2f) ________ = ________ $/yr

b Side entry #1:

(6b) ________ x (2f) ________ = ________ $/yr

c Side entry #2:

(6c) ________ x (2f) ________ = ________ $/yr

Step 8 Calculate payback period for each vestibule:

a Main lobby:

(1a) ________ ÷ (7a) ________ = ________ Yrs

b Side entry #1:

(1b) ________ ÷ (7b) ________ = ________ Yrs

c Side entry #2:

(1c) ________ ÷ (7c) ________ = ________ Yrs

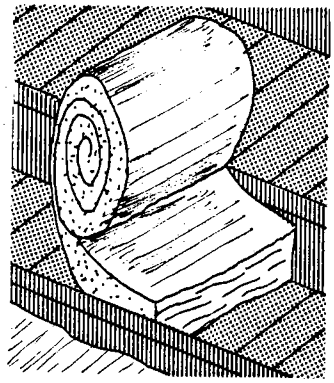
Enter in summary chapter (Appendix C) all three vestibules under consideration as if they were separate ECOs.

Table 8-1 Savings from Installing Vestibules

Savings:	Fuel Type: Gas	Oil	Elec	Other
Infiltration Savings:	1.4	1.0	3.0	1.01
Conductance Savings:	8.7	6.2	177.6	6.06

ECO No. 9

Install/increase attic insulation

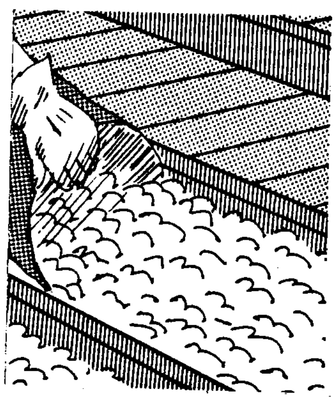


Description

Note: This ECO applies only to buildings with attics. ECO #10 applies to all buildings with flat roofs and no attics.

In many projects attics are rarely insulated to adequate levels. Installing or increasing present levels of insulation should therefore be analyzed.

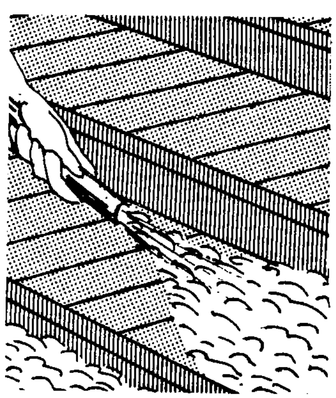
Insulation is a non-conducting material. It's resistance to heat transfer is measured by its R-value -- the higher the R-value, the greater its insulating properties. Insulating value of attic insulation is also determined by its thickness -- the thicker the insulation, the greater its resistance to heat. Optimal thickness for any building depends on the value of existing insulation, fuel costs and climate.



Adding insulation to attics is recommended in almost all climates. To determine the highest economical level, three different thicknesses are tested in this ECO.

Types of Insulation

The type of insulation to be selected depends on existing conditions, local availability, ease of installation, price and contractor preference. There are two basic types to choose from: "batt" insulation and blown-in or poured "loose-fill" insulation.



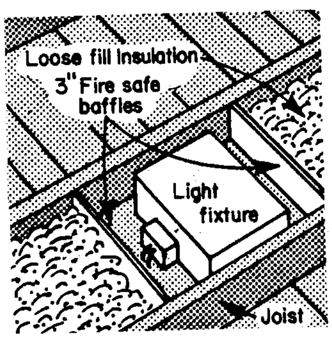
Loose fill insulation is pellets or fibers composed of glass fiber, rock wool, cellulose, vermiculite or perlite. It can be blown or poured into attic spaces.

Batt insulation (sometimes also called "blankets") is made of flexible materials composed of glass fiber or rock wool. It is commonly produced in standard widths in order to fit between studs and structural members. Both can be purchased with vapor barrier sheets already attached.

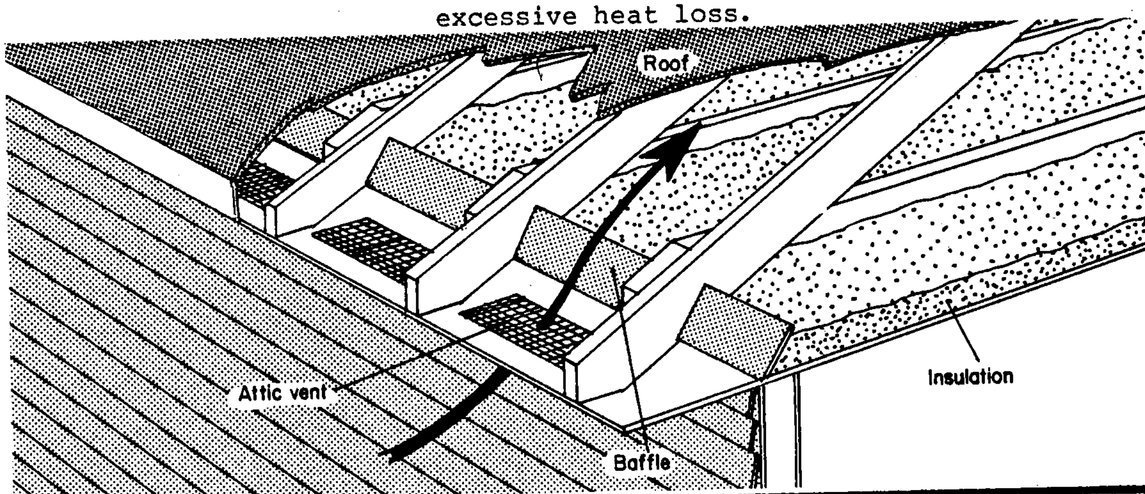
Unless the attic is used as a habitable space, insulation should be located inbetween the joists or structural members of the attic floor rather than its ceiling. This ensures that the unused attic space is not being heated unnecessarily.

Modernization Standards Handbook reference: 9-4.

Concerns



- Vapor barriers must be present on the warm side of insulation. If existing insulation has a vapor barrier a second layer should not be added.
- All attics with insulation must be ventilated. Insulation should not obstruct vents or louvers.
- Recessed lights or fans which protrude into attic space should not be covered.
- **If installed by management staff, protective gloves and masks should be worn.**
- Insulation must be installed according to manufacturer's directions.
- All insulation must comply with local fire codes. Loose fill cellulose must be of fire treated type.
- Any ducts or pipes located in attics must also be insulated to prevent freezing or excessive heat loss.



Applicability

This ECO applies only to:

2-3 a) buildings with attics,

2-7 b) attics with less than 12" of existing insulation

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

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

Step 1

Obtain total cost of installing selected type of insulation.

a 4" additional insulation (total labor and material costs): ________ $

b next 4" additional insulation (this is the incremental cost increase of installing 8" of insulation over the cost of installing 4" of insulation): ________ $

c next 4" addition insulation (this is the incremental cost increase of installing 12" of insulation over the cost of installing 8" of insulation): ________ $

Step 2

Transfer the following information from the Survey:

1-8 **a** Heating degree day zone: ________ DDZ

2-6 **b** Attic area: ________ SF

2-7 **c** Existing insulation depth: ________ Inches

10-1 **d** Cost of heating fuel: Gas: ________ $/therms

Oil: ________ $/gal

Electric: ________ $/KWH

Other: ________ $/MBTU

Step 3

Obtain the following savings factors from Table 9-1:

Table 9-1 **a** 4" additional insulation: ________

Table 9-1 **b** 8" additional insulation: ______

Table 9-1 **c** 12" additional insulation: ______

Step 4

Estimate annual energy savings:

a 4" additional insulation:

(2a) ______ X (2b) ______ X (3a) ______ = ______ /yr

b 8" additional insulation:

(2a) ______ X (2b) ______ X (3b) ______ = ______ /yr

c 12" additional insulation:

(2a) ______ X (2b) ______ X (3c) ______ = ______ /yr

Step 5

Calculate annual cost savings:

a 4" additional insulation:

(4a) ______ X (2d) ______ = ______ $/yr

b 8" additional insulation:

(4b) ______ X (2d) ______ = ______ $/yr

c 12" additional insulation:

(4c) ______ X (2d) ______ = ______ $/yr

Step 6

Calculate payback period:

a 4" additional insulation:

(1a) ______ ÷ (5a) ______ = ______ Yrs

b 8" additional insulation:

(1b) ______ ÷ (5b) ______ = ______ Yrs

c 12" additional insulation:

(1c) ______ ÷ (5c) ______ = ______ Yrs

ECO #9: INSTALL OR INCREASE ATTIC INSULATION

Table 9-1

Savings Factors for Increasing Attic Insulation

Fuel Type	Existing Depth in inches	4" Added Insulation	8" Added Insulation	12" Added Insulation
GAS (therms)	None	.063	.008	.003
	1"- 2"	.023	.005	.003
	2½"- 4"	.009	.004	.002
	4½"- 6"	.005	.003	-
	6½"- 8"	.003	.002	-
	8½"- 10"	.002	-	-
	10½"- 12"	.002	-	-
	Over 12"	-	-	-
OIL (gallon)	None	.045	.006	.002
	1"- 2"	.016	.003	.002
	2½"- 4"	.007	.002	.002
	4½"- 6"	.004	.002	-
	6½"- 8"	.002	.00	-
	8½"- 10"	.001	-	-
	10½"- 12"	.001	-	-
	Over 12"	-	-	-
ELECTRICITY (KWH)	None	1.29	.18	.06
	1"- 2"	.47	.09	.05
	2½"- 4"	.19	.08	.03
	4½"- 6"	.11	.05	-
	6½"- 8"	.07	.04	-
	8½"- 10"	.04	-	-
	10½"- 12"	.03	-	-
	Over 12"	-	-	-
OTHER (MBTU)	None	.044	.006	.003
	1"- 2"	.016	.004	.002
	2½"- 4"	.0064	.0033	.0011
	4½"- 6"	.0038	.0017	-
	6½"- 8"	.0024	.0012	-
	8½"- 10"	.0014	-	-
	10½"- 12"	.0012	-	-
	Over 12"	-	-	-

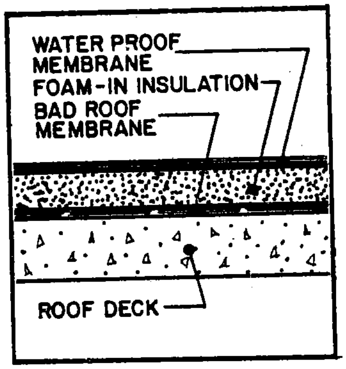
- : indicates additional insulation is not cost effective, do not complete calculations for these thicknesses.

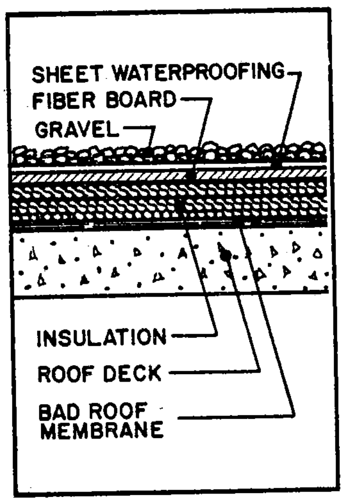
Instructions:

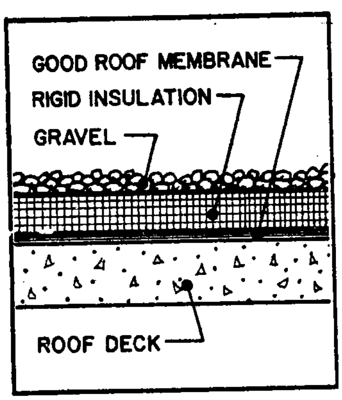
1 - Find heating fuel type.
2 - Find the depth of existing attic insulation.
3 - Circle the appropriate savings factors for each level of additional insulation and transfer to Step 3.

ECO No. 10

Install roof insulation







Description

Note: This ECO applies only to buildings with flat or nearly flat roofs and no attics. ECO #9 applies to all buildings with attic spaces.

This ECO assumes that insulation will be added only to buildings without any existing insulation. It is probably not cost effective to add more insulation to insulated roofs because of the relatively high cost of installation. The next time the building is re-roofed, however, the addition of more insulation should be considered.

Insulation is a non-conducting material. It's resistance to heat transfer is measured by its R-value -- the higher the R-value, the greater its insulating properties. Insulating value of roof insulation is also determined by its thickness -- the thicker the insulation, the greater its resistance to heat. Optimal thickness for any building depends on the value of existing insulation, fuel costs and climate.

Two levels of insulation are analyzed in this ECO: R-10 and R-20. Depending on the exact type and brand of rigid insulation specified the thickness will vary, but generally R-10 is equal to 1-1/2 to 2 inches and R-20 is equal to 3 to 4 inches.

Installing Roof Insulation

Roof insulation is usually of a rigid board type installed either under or over the existing roof. The most common way of retrofitting roof insulation is to remove existing gravel (if any), add rigid exterior roof insulation panels directly on top of the existing built-up roofing, then put gravel back for ultraviolet protection. On roofs that need reroofing because of deterioration, insulation should be installed under the new roofing.

Modernization Standards Handbook reference: 9-4.

Concerns

- All insulation must comply with local fire codes.

- Adding roof insulation might increase snow buildup in winter because the "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.

Applicability

This ECO applies only to:

2-3 a) projects with flat roofs (no attics),

2-5 b) projects with poorly or totally uninsulated roofs.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

This analysis must be performed for two thicknesses of insulation in order to assist in determining the maximum economical thickness level.

Step 1

Obtain total cost of installing insulation:

a	R-10 additional insulation:	______ $
b	R-20 additional insulation:	______ $

Step 2

Transfer the following information from the Survey:

1-8	**a**	Heating degree day zone:		______ DDZ
2-4	**b**	Roof area:		______ SF
2-5	**c**	Type of existing roof structure:		______
10-1	**d**	Cost of heating fuel:	Gas:	______ $/therms
			Oil:	______ $/Gal
			Electric:	______ $/KWH
			Other:	______ $/MBTU

Step 3

Obtain the following saving factors from Table 10-1:

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

(1b) ______ ÷ (5b) ______ = ______ Yrs

Choose and circle here the level of insulation that has the greatest payback 15 years or less. Enter results in summary chapter (Appendix C) only for that level.

Table 10-1

Savings Factors for Adding Roof Insulation

Heating Fuel Type	Existing Roof Structure	Adding R-10 insulation (1½"-2", rigid)	Adding R-20 insulation (3"-4", rigid)
GAS (Therms)	Wood	.0514	.0614
	Concrete	.0771	.0887
	Steel	.0871	.0986
OIL (Gallons)	Wood	.0367	.0439
	Concrete	.0551	.0633
	Steel	.0622	.0704
Electric (KWH)	Wood	1.06	1.26
	Concrete	1.58	1.82
	Steel	1.78	2.02
Other (MBTU)	Wood	.036	.043
	Concrete	.054	.062
	Steel	.061	.069

Instructions:
1 - Find heating fuel type;
2 - Find existing roof structure type;
3 - Circle the appropriate savings factors for both insulation levels and transfer to Step 3.

ECO No. 11

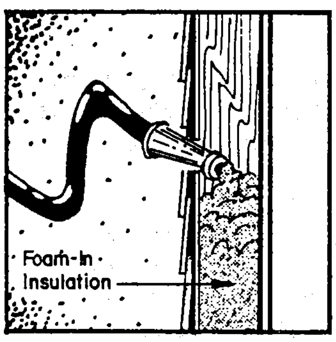
Install wall insulation

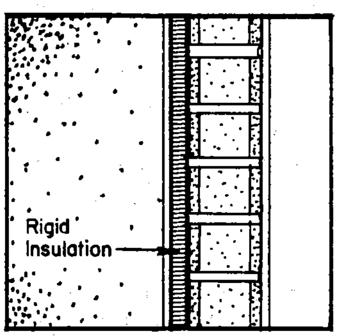
Description

Adding insulation to the exterior walls of a building involves either filling the cavity between the wood studs with blown-in insulation or applying rigid insulation to the exterior of a solid masonry wall.

Insulation is a non-conducting material which reduces the transfer of heat. The material's resistance to heat transfer is measured by its R-value. The higher the R-value, the greater its insulating properties. The exact value depends on the type of insulation and its thickness. Savings factors in this ECO assumed an R-10 insulation.

Insulation added to walls increases the thermal resistance thereby reducing heat transfer, saving energy in the winter and reducing overheating in the summer.





Types of Wall Insulation

Wood frame buildings with an air space between the studs can be filled with insulation by drilling holes in the exterior or interior walls and spraying in plastic foam or granular insulation.

Solid masonry walls (concrete block or brick) can be insulated by adding insulation panels to the exterior or interior of the wall. Exterior insulation is preferred in one and two-story buildings because it will not decrease living space and its construction will not disrupt occupancy.

Because of the relatively high cost of installing retrofit wall insulation it should only be considered in this ECO if project buildings have no existing wall insulation and are located in cold climates. Installation of wall insulation is not economical in very warm climates.

Special Considerations

This ECO must be implemented by a professional insulation contractor. Special care should be taken to insure that installer meets all legal and professional standards and has a good history of previous installations.

Modernization Standards Handbook reference: 9-3.

Concerns

- Cavity fill insulation must be compatible with building materials.

- Cavity fill insulation must be blown in under pressure or expanded within walls to insure even distribution and to avoid future settling.

- Contractor should add vapor protection to inside wall surfaces if insulation is not vapor-proof.

- All fastenings and materials must meet local building and fire codes.

- Spray-in foam insulation might emit poisonous fumes during installation. Check to see if occupants must be evacuated during installation.

- Sprayed-in formaldahyde foam insulations have been linked to illness and have been known to emit fumes even after installation. Health effects of all insulation types should be considered before implementation.

- Exterior or interior insulating panels must be protected from impacts, vandalism and abrasions that could damage them. Exterior insulation must be protected from weather and ultraviolet radiation.

- Finish and detailing around doors, windows and other openings must be considered so as not to detract from building appearance and operation of equipment.

Applicability

This ECO applies only to:

2-8 a) buildings with uninsulated walls,

1-8 b) buildings located in climate zones 1.5 and above.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of installing wall insulation: ________ $

Step 2 Transfer the following information from the Survey:

1-8 **a** Heating degree day zone: ________ DDZ

2-8 **b** Wall construction and siding type: ________

2-8 **c** Wall area (if total wall area is not being considered for insulation, enter here only the area under consideration):

________ SF

10-1 **d** Cost of heating fuel: Gas: ________ $/therm

Oil: ________ $/gal

Electricity: ________ $/KWH

Other: ________ $/MBTU

Step 3 Obtain the following data from Table 11-1:

Table 11-1 Savings factor for existing wall type and fuel type: ________

Step 4 Estimate annual energy savings:

(2a) ________ X (2c) ________ X (3) ________ = ________ /yr

Step 5 Calculate annual cost savings:

(2d) ________ X (4) ________ = ________ $/yr

Step 6 Calculate payback period:

(1) ________ ÷ (5) ________ = ________ Yrs

Table 11-1

Savings Factors for Installing Wall Insulation

Existing Wall Conditions:	Heating Fuel Type: Gas	Oil	Elec.	Other
Wood frame (uninsulated):				
Wood siding:	.075	.054	1.55	.0528
Aluminum Siding:	.075	.054	1.55	.0528
Brick Siding:	.072	.051	1.48	.0504
Other:	.058	.042	1.20	.0408
Masonry Wall (uninsulated):				
Concrete block:	.058	.042	1.20	.0408
All brick:	.075	.054	1.55	.0528
Other:	.075	.054	1.55	.0528

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

Instructions:
1 - Find your wall construction type;
2 - Proceed across table to column with your heating fuel type;
3 - Circle and transfer the appropriate savings factor to Step 3.

ECO No. 12

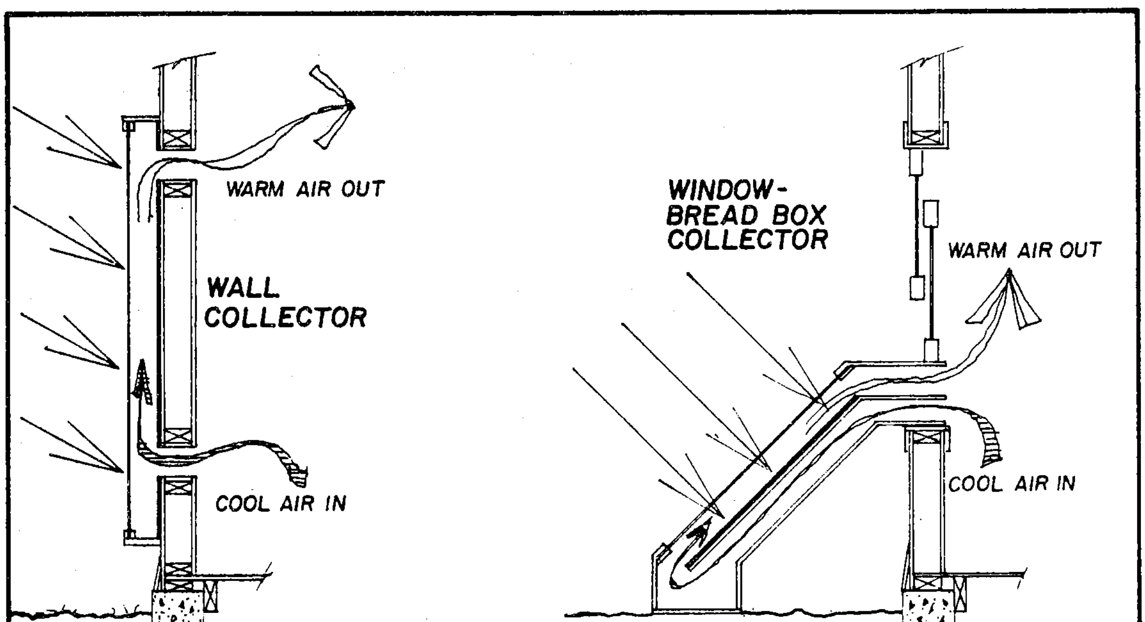
Install passive solar collectors

Description

Passive solar energy can be defined as the direct use of the sun's energy in a building without the aid of pumps, fans and other mechanical equipment to store or distribute it. This can be done either by providing south facing windows to allow the sun to directly heat a space, or by providing a "solar wall" collector which will collect the solar heat and allow it to circulate naturally into the space.

Retrofitting passive solar windows or wall collectors on existing housing has been successful throughout the country. When properly sized and installed passive solar collectors require little maintenance, are reliable, and are durable.

Passive solar collectors save fuel by trapping the solar energy that normally falls on the south wall. This heat is then allowed to enter the house through vents in the wall. On sunny days the amount of solar heat thus generated will be substantial.



When passive solar collectors are incorporated in new housing they can reduce heating requirements up to 70 percent. When existing housing is retrofitted for passive solar collectors, the savings are usually lower because of improper orientation, higher installation costs and low-mass construction. While passive solar installations in existing housing may make a smaller contribution to the reduction of heating needs, it can be cost effective while providing from 10-25% energy savings.

Types of Passive Solar Collectors

Collectors include direct gain windows, glazing over existing masonry walls and installation of thermosyphon air panels. All collectors have in common the requirement that they face south and be unshaded in winter.

Direct gain windows allow the sun's heat to enter the dwelling unit directly. This type of system can be efficient and can add light and views to a space. Disadvantages are problems with overheating on very sunny days, deterioration of fabrics in direct sunlight and conflicts of privacy and security.

Glazing over of existing masonry walls and adding thermosyphon air panels are both alternatives to adding new windows.

If existing walls are south-facing, uninsulated, and masonry, glazing them is the preferred method to create a solar collector. If the south-facing wall is of conventional non-masonry construction a thermosyphon air panel can be installed. Both these systems trap the solar energy inside the glass where it is converted to heat. This heat rises and enters the space through vents at the top of the collector.

Modernization Standards Handbook reference: 9-3.

Concerns

- Passive solar collectors must be shaded from summer sun.

- Issues of security and vandalism must be considered in adding additional glazing.

Note: Installation of passive solar collectors requires a detailed analysis by an architect/engineer. This preliminary analysis shows that it has economic potential in the project. Further analysis is required because the cost benefit analysis performed here is based on many assumptions which may not be true for your projects. Existing conditions are also critical to the design and sizing of any passive solar systems. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

This ECO applies to:

1-12 a) low rise buildings,

2-9 b) buildings with south-facing walls that are not totally shaded in winter,

c) if table 12-1 (see Step 3 below) indicates that 0 (no) panels are needed.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1

Obtain the unit cost of installing a solar collector onto your south facing wall (either glazing over existing masonry wall or adding a thermosyphon panel). Use 20 square feet per panel as your unit size:

Unit price per panel: ________ $/ea

Step 2

Transfer the following information from the Survey:

1-9 **a** Solar factor: ________

1-10 **b** Winter solar factor: ________

1-12 **c** Building type (low-rise multi-family or single/twin): ________

1-16 **d** Number of dwelling units with south-facing walls: ________

2-11 **e** Area of south-facing windows per typical south-facing dwelling unit: ________ SF

f Cost of heating fuel: Gas: ________ $/therm

Oil: ________ $/gal

Electric: ________ $/KWH

Other: ________ $/MBTU

Step 3 Obtain the following values from Tables 12-1 and 12-2:

Table 12-2 **a** Number of panels needed (if Table 12-2 indicates 0 (no) panels needed, do not proceed - this ECO does not apply): ____________

Table 12-1 **b** Savings factor for your fuel type: ____________

Step 4 Estimate annual energy savings:

(2b) ______ X (2d) ______ X (3a) ______ X (3b) ______ = ____________ /yr

Step 5 Calculate annual cost savings:

(4) ____________ X (2f) ____________ = ____________ $/yr

Step 6 Calculate total cost of installing passive solar collectors:

(1) ________ X (2d) ________ X (3a) ________ = ____________ $

Step 7 Calculate payback period:

(6) ____________ ÷ (5) ____________ = ____________ Yrs

Table 12-1

Savings Factors for Installing Passive Solar Collectors

Fuel Type:	Savings Factors:
Gas:	35.7 therm
Oil:	25.5 gallon
Electric:	73.3 KWH
Other:	25.0 MBTU

Note: Savings are based on: 20 sf per panel, 12.5% efficiency of solar system divided by conversion factor for MBTUs to fuel type.

Table 12-2

Number of 20sf Passive Solar Collector Panels Required

Building Type	Existing South Glazing	Solar Factor 0-.1	.1-.28	.285-.38	.385-.47	.475-.54	.54+
Low-rise single/ twin family	No south glass (0)	2	3	4	5	6	7
	Small amt. (20sf)	1	2	3	4	5	6
	Average Low (40sf)	0	1	2	3	4	5
	Average (60sf)	0	0	1	2	3	4
	Average Large (80sf)	0	0	0	1	2	3
	Large amt. (100sf)	0	0	0	0	1	2
Low-rise Multi-family	No south glass (0)	1	2	3	4	5	6
	Small amt. (20sf)	0	1	2	3	4	5
	Average Low (40sf)	0	0	1	2	3	4
	Average (60sf)	0	0	0	1	2	3
	Average Large (80sf)	0	0	0	0	1	2
	Large (100sf)	0	0	0	0	0	1

Instructions: 1) Locate the type of building that applies to your project. 2) Identify the average south-facing glass per dwelling unit (use "average" if amount cannot be accurately estimated). 3) Find the number of panels for your Solar Factor, circle and enter in Step 3.

NOTES AND CALCULATIONS

2. Heating Systems ECOs

Heating Systems energy conservation opportunities are designed to increase the efficiency of the heating plant, reduce distribution losses and ensure fuel conservation by project tenants and office staff.

The following ECOs are included:

ECO #13: Install Setback Thermostats

ECO #14: Improve Space Heating O&M

ECO #15: Install Flue Dampers

ECO #16: Convert to Electric Ignition

ECO #17: Reduce Burner Nozzle Size

ECO #18: Install Tenant Fuel Metering

ECO #19: Improve Central Heating O&M

ECO #20: Install Modulating Burners

ECO #21: Install Flue Heat Recovery

ECO #22: Install Turbulators

ECO #23: Install Summer-time DHW Heaters

ECO #24: Replace Obsolete Heating Plant

ECO #25: Improve Central Distribution O&M

ECO #26: Insulate Hot Water or Steam Pipes

ECO #27: Install Radiator or Zone Controls

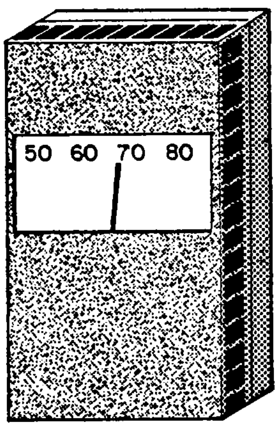
ECOs 17, 20, 21, 23 and 24 need further analysis by mechanical engineers if their analyses here prove them cost-effective.

Although some of the remaining ECOs are very simple to implement, all require professional assistance or at least full understanding of mechanical systems.

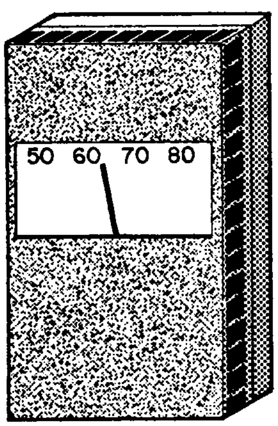
Conservation opportunities related to the main heating boiler require that its efficiency be known. It is, therefore, essential that the boiler efficiency test described in Section 3 of Appendix A be completed before their analyses are started.

ECO No. 13

Install setback thermostats



DAYTIME SETTING



NIGHTTIME SETTING

Description

High-limit setback thermostats have two separate temperature settings; one for daytime hours and one for normal sleeping hours when daytime settings are unnecessary or even uncomfortable. They also limit the maximum daytime temperatures to those recommended for energy conservation (typically 68^{o} - 70^{o}F.). The hours between 10 p.m. and 6 a.m. are usually considered nighttime. Night temperatures are set at 60-62^{o}F, 8^{o}F less than daytime temperatures of 68-70^{o}F.

Thermostats must be tamper-proof and not adjustable by tenants. Presently, many manufacturers produce high-limit setback thermostats. A reliable two-setpoint thermostat, properly matched to project heating system should be adequate.

The number of thermostats needed is contingent on the type of project heating system. For a centrally heated building only one master thermostat is needed to control the heating plant. For buildings with individual dwelling unit space heaters as many thermostats as there are heating units is required.

Modernization Standards Handbook reference: 6-3.

Concerns

- Central thermostats should be located in areas inaccessible to the public to prevent tampering.
- Individual thermostats located in dwelling units should be tamperproof, to prevent the tenant from re-setting them to higher temperatures.
- Additional savings will be realized if temperatures can be set back during the mid-day hours when dwelling units are unoccupied.

Applicability

The ECO applies only to:

3-7 a) projects without night-time setback thermostats,
3-7 b) projects without manually controlled space heaters.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain the total cost of installing night setback thermostats: ________ $

Step 2 Transfer the following information from the survey:

1-8	**a**	Heating degree day zone:		________ DDZ
11-2	**b**	Annual heating fuel consumption:	Gas:	________ Therms/yr
			Oil:	________ Gals/yr
			Electric:	________ KWH/yr
			Other:	________ MBTU/yr
10-1	**c**	Cost of heating fuel:	Gas:	________ $/therm
			Oil:	________ $/gal
			Electric:	________ $/KWH
			Other:	________ $/MBTU

Step 3 Obtain the following value from Table 13-1:

Table 13-1 Percent heating savings: ________ (%)

Step 4 Estimate annual energy savings:

(2b) ________ X (3) ________ = ________ /yr

Step 5 Calculate annual cost savings:

(4) ________ X (2c) ________ = ________ $/yr

Step 6 Calculate payback period:

(1) ________ ÷ (5) ________ = ________ Yrs

ECO #13: INSTALL NIGHT-TIME SETBACK THERMOSTAT

Table 13-1

Heating Energy Savings

Heating Degree Days Zone:	Percent Savings from 8°F Night Setback:
2.5 or less	.15
2.51 - 2.8	.12
2.81 - 3.4	.10
3.41 - 4.1	.093
4.11 - 4.8	.08
4.81 - 5.5	.075
5.5 or more	.072

ECO No. 14

Improve space heating O&M

Description

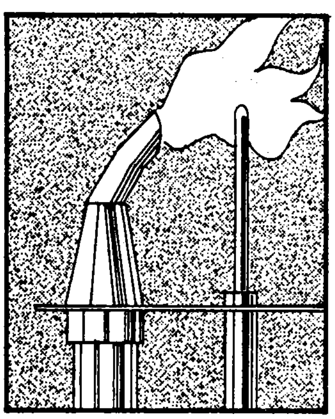
Note: This ECO applies only to projects with individual dwelling unit space heating equipment. ECO #19 applies to projects with central heating plants.

Proper operation and maintenance (O&M) of the building space heating equipment must be assured before other, generally more costly ECO's are implemented. Operation and maintenance items listed require little, if any, capital cost expenditures but may require increased maintenance staffs.

Because O&M items require little capital cost investment they must be implemented first, and in fact, savings estimates for other ECO's assume that all of the following items have been implemented. The specific items included in this ECO include:

a) turning off pilot in summer
b) lowering heating temperatures to 68°F.
c) clean and adjust burners
d) change/clean filters
e) inspection and lubrication

O&M Items

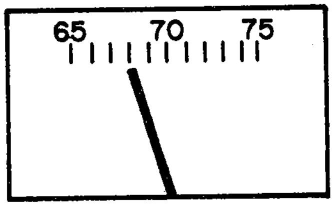


Pilot. Turn off gas pilots in furnaces, and other space heaters during non-heating months and tenant vacancies. Keeping the pilot light on for extended periods without accompanying heating demands wastes a significant amount of fuel.

A notice should be prominently posted on each piece of equipment affected. This should state that the pilot must be relit before unit is reactiviated.

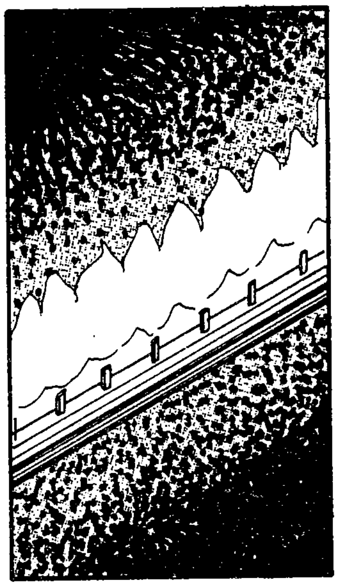
Pilot lights must be shut-off in accordance with manufacturer's guideline by qualified personnel.

Lower temperatures. Lower the interior space temperature to 68°F to conserve energy. Set



manual and locking thermostat controls so that space is heated only to 68°F. Thermostats may have to be changed to prevent tenant adjustment.

Consult local codes for minimum space temperature for elderly or handicapped residents.



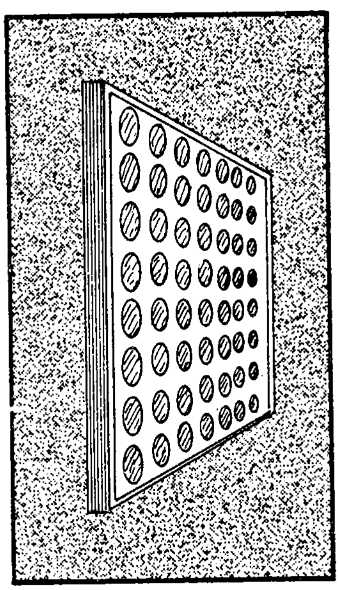
Clean/adjust burners. Burners on gas or oil fired furnaces should be regularly cleaned and adjusted to achieve proper firing rate.

On gas furnaces burners should be regularly cleaned of rust and scale which clog burner openings.

Clogged openings and poorly adjusted burners reduce burner efficiency and firing rates, wasting energy.

Burners should also be inspected for tightness, linkage operation, etc.

The following conditions indicate a need for burner adjustment: flame edge touches combustion chamber, tip of flame is orange, presence of fiery droplets, smoke above chimney.



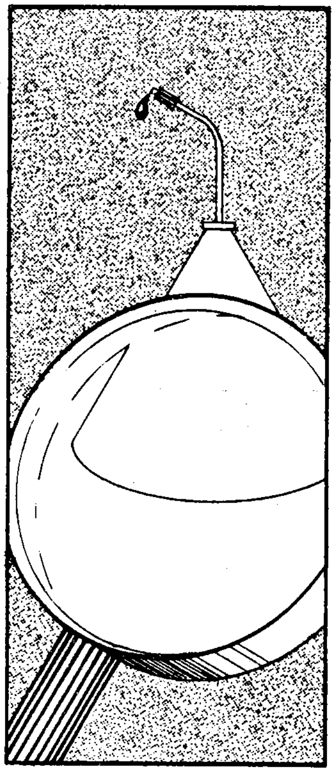
Change filter. Combustion air filters and those in forced air and gravity systems should be regularly changed using a type recommended by the equipment manufacturer.

Filters on individual forced air systems should be changed bi-monthly by the maintenance staff.

Air filters improve heating performance by removing impurities from the supply air so that it can burn more completely. A clean filter removes as much foreign matter as possible and reduces the operating time of the furnace and the energy used by the fan to force air through a clogged filter.

Air filters are frequently of a disposable type and can be discarded when dirty. Permanent types should be cleaned according to the manufacturer's directions.

When re-inserting the filter heated air should strike the oiled side first.



Inspect/lubricate equipment. Periodic inspection should be made for broken housings, gaskets, casings, packing leakage, condition of linkages, and worn or damaged parts on all stationary and moving equipment. Remedial action should immediately be taken to eliminate any problems.

All equipment should be lubricated on a regular schedule . This should be done as directed in the manufacturer's manual, using the lubricant specified. Parts may include blowers, motors, fans, bearings, etc.

Equipment which is operating at less than peak efficiency wastes energy. Damaged equipment allows dirt, air, or water to infiltrate the equipment and affect its performance. Proper lubrication reduces wear and tear on equipment, enhancing its performance.

If directed by equipment manual, turn off power before lubricating equipment.

Always use replacement parts of the type specified by the manufacturer.

Modernization Standards Handbook reference: 6-2,3.

Applicability

This ECO applies to all projects heated with individual dwelling unit heaters needing work on any of the following O&M items (see full descriptions on previous pages):

a) turn pilots off,
b) lower temperatures to 68°F.,
c) clean/adjust burners,
d) change/clean filters,
e) inspect/lubricate equipment.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain cost of performing any of the applicable O&M items:

a	turn pilots off:	______ $
b	lower temperatures to 68°F.:	______ $
c	clean/adjust burners:	______ $
d	change/clean filters:	______ $
e	inspect/lubricate equipment:	______ $
f	Total (add cost of all applicable items):	______ $

Step 2 Transfer the following data from the survey:

10-1	**a**	Cost of heating fuel:	Gas:	______ $/therm
			Oil:	______ $/gal
			Electric:	______ $/KWH
			Other:	______ $/MBTU
11-2	**b**	Annual heating fuel consumption:	Gas:	______ Therms/yr
			Oil:	______ Gal/yr
			Electric:	______ KWH/yr
			Other:	______ MBTU/yr

Step 3 Obtain the following value from Table 14-1:

Table 14-1 Savings factor for implementing O&M items: ____________

Step 4 Estimate annual energy savings:

(2b) ____________ X (3) ____________ = ____________ /yr

Step 5 Calculate annual cost savings:

(2a) ____________ X (4) ____________ = ____________ $/yr

Step 6 Calculate payback period:

(1f) ____________ ÷ (5) ____________ = ____________ Yrs

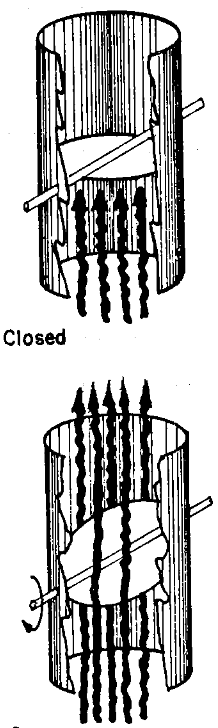
Table 14-1

Savings Factors for Space Heating O&M

Category of Work Needed:	Savings Factors
Minor work needed: (1 or 2 items needed)	.01
Medium work needed: (3 items needed)	.03
Major work needed: (4 or more needed)	.05

ECO No. 15

Install flue dampers



Description

All oil and gas furnaces and boilers have a flue or chimney to discharge unwanted combustion gases to the outside. Flues will also discharge heated room air and heat stored in the boiler and boiler water. To prevent these losses, automatic dampers can be installed.

Flue Damper Operations

A flue damper automatically closes when the boiler or space heater is not firing and re-opens when firing begins. A motor with a thermal sensor will open and close the damper or the damper can be bimetallic and open and close automatically in response to a change in temperature.

Bimetallic dampers are usually easier to install since they require no external power source. Mechanically operated dampers, however, are more efficient since they close immediately after the burner shuts off.

Each flue or heating stack will require a separate flue damper. Installation and damper selection can be done only by a skilled technician. Local utility companies should be checked for approved units and required installer qualifications required.

Modernization Standards Handbook reference: 6-3.

Concerns

- Flue dampers should carry certification of safety approval and must meet all ANSI "Fail-safe" and other standards.

- Individual gas units can be installed with a modulating gas valve to adjust firing rate, or an automatic flue damper, but not both. Deciding which to install must be done by skilled technicians and depends on system configuration and local material costs, etc.

- Check local codes to see if installation is legal.

Applicability

This ECO applies only to:

3-2 a) gas and oil heated projects,

3-3 b) projects without flue dampers.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of installing flue dampers: ________ $

Step 2 Transfer the following information from the survey:

1-8	**a** Heating degree day zone:			________ DDZ
11-2	**b** Annual heating fuel consumption:	Gas:		________ Therms/yr
		Oil:		________ Gals/yr
		Electric:		________ KWH/yr
		Other:		________ MBTU/yr
10-1	**c** Cost of heating fuel:	Gas:		________ $/therm
		Oil:		________ $/gal
		Electric:		________ $/KWH
		Other:		________ $/MBTU

Step 3 Obtain the following value from Table 15-1:

Table 15-1 Percent savings for flue damper installation (expressed as decimal): ________ (%)

Step 4 Estimate annual energy savings:

(2b) ________ X (3) ________ = ________ /yr

Step 5 Calculate annual cost savings:

(4) ________ X (2c) ________ = ________ $/yr

Step 6

Calculate payback period:

(1)	÷	(5)	=	Yrs

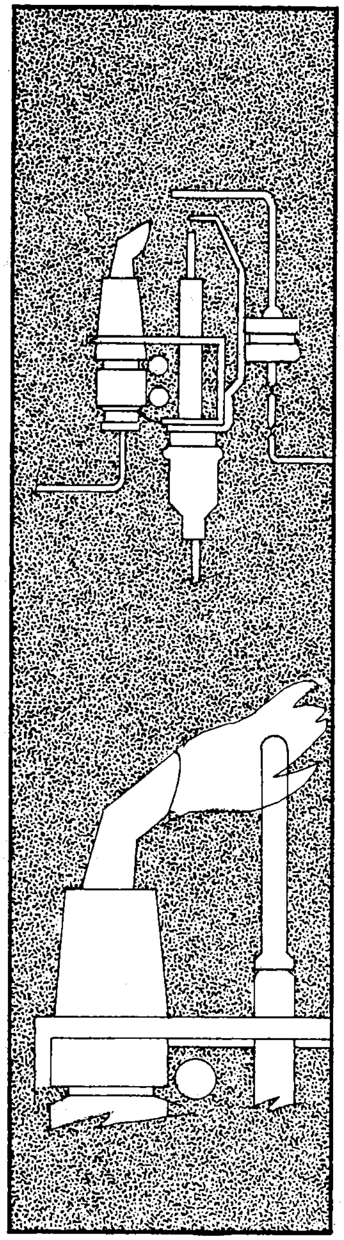
Table 15-1

Percent Savings When Using Flue Dampers

Degree Days Zones	Percent Savings (as decimal fraction)
2.5 or less	.02
2.51 - 2.8	.035
2.81 - 3.4	.06
3.41 - 4.1	.065
4.11 - 4.8	.07
4.81 - 5.6	.075
5.61 - 6.4	.08
6.41 or more	.085

ECO No. 16

Convert to electric ignition



Description

Gas and oil-burning furnaces are usually ignited by gas-burning pilot lights which burn constantly whether the furnace is fired or not, wasting energy. This type of pilot light can be replaced with an automatic electric ignition which ignites the pilot only when the thermostat calls for the furnace to be fired.

Many companies make pilot ignition retrofit systems which can be easily installed by skilled technicians. Most manufacturers also provide a matching flue damper (see ECO #15) which can be interlocked with the ignition system for best operation.

All-electric ignition devices which generate a high-voltage spark are also available for furnaces which can be fired directly by electronic sparks. In all cases, project engineering staff, furnace service company and local utility company should be consulted for selection guidance.

Modernization Standards Handbook reference: 6-3.

Concerns

- Select only equipment which has been properly tested and certified for safety.
- Consult local utility company for approved equipment and installers.
- Replacement ignition system should have provisions for complete summer shut down.
- Check fire code regulations.
- As a temporary measure, shut the pilot light off during the summer season when furnace is shut down. Follow all safety procedures when doing so.

Applicability

This ECO applies only to:

3-4 a) projects fired with constant-burning gas or oil pilot lights,

3-1 b) projects heated with individual space heaters.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain the total cost of converting to electric ignition: ________ $

Step 2 Transfer the following information from the survey:

3-5 **a** Number of individual space heaters: ________

1-8 **b** Heating degree day zone: ________ DDZ

10-1 **c** Cost of heating fuel: Gas: ________ $/therm

Oil: ________ $/gal

Step 3 Obtain the following value from Table 16-1:

Table 16-1 Savings for each pilot light installed: ________

Step 4 Estimate annual energy savings:

(2a) ________ X (3) ________ = ________ /yr

Step 5 Calculate annual cost savings:

(4) ________ X (2c) ________ = ________ $/yr

Step 6 Calculate payback period:

(1) ________ ÷ (5) ________ = ________ Yrs

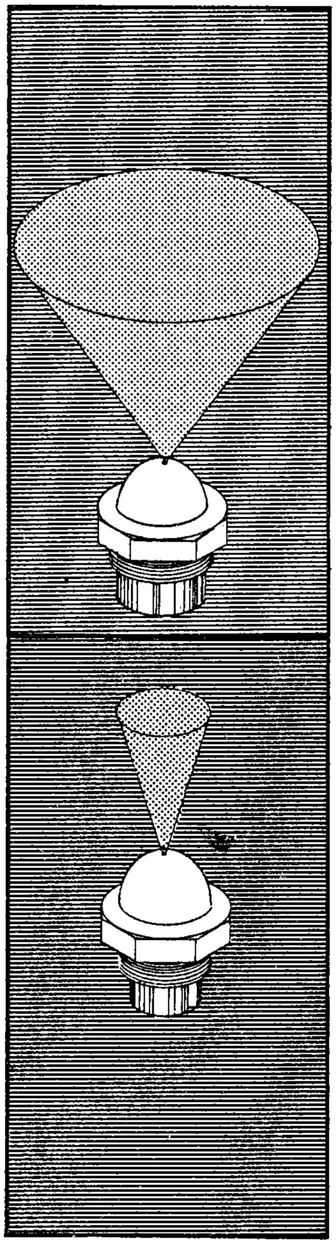
Table 16-1

Savings per Pilot Light

Degree Day Zone	Gas Pilot (Therms)
Warm climate (less than 2.5):	13
Temperate climate (2.6 to 3.7):	18
Cold climate (3.8 or more)	20

ECO No. 17

Reduce burner nozzle size



Description

Note: Reducing nozzle size of gas and oil heating equipment can be done for both individual dwelling unit space heating systems and central systems. This ECO is, however, only for individual dwelling unit heaters. See ECO #20 for central-system projects.

After performing energy conservation measures, the heating load of the building may have been decreased to the point where the existing nozzle of the furnace can be reduced in size. It is also possible that the original nozzle was oversized. In both cases, the size should be reduced. By decreasing the size less oil and gas is burned and the boiler operates with greater efficiency.

Modernization Standards Handbook reference: 6-3.

Concerns

- If this preliminary analysis proves cost effective, a full analysis should be done by a licensed engineer. Choosing the proper nozzle size is dependent on the heater efficiency, unit size and heating load. Only an engineer can perform the proper energy calculations.

- Consult heater manufacturer literature or representative for acceptable nozzle and installation procedures.

Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

This ECO applies only to:

3-1 a) gas and oil space heaters,
b) heaters which are expected to be oversized after implementing other ECOs,
3-6 c) heaters which are currently oversized.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain the total cost of reducing nozzle sizes on all oversized space heater: ________ $

Step 2 Transfer the following information from the survey:

11-2 **a** Annual heating fuel consumption:
- Oil: ________ Gal/yr
- Gas: ________ Therm/yr

10-1 **b** Cost of heating fuel:
- Oil: ________ $/gal
- Gas: ________ $/therm

Step 3 Estimate new heating fuel consumption:

(2a) ________ X .56 = ________ /yr

Step 4 Estimate annual energy savings:

((3) ________ ÷ .6) - ((3) ________ ÷.65) = ________ /yr

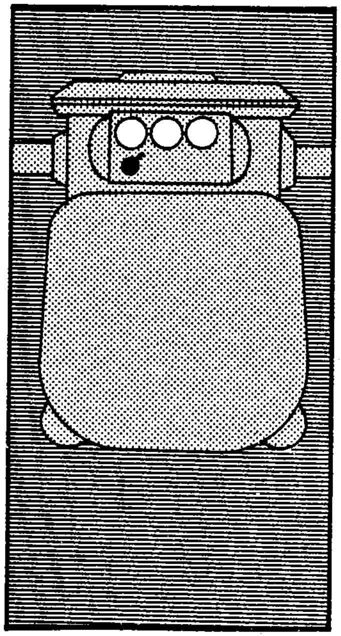
Step 5 Estimate annual cost savings:

(4) ________ X (2b) ________ = ________ $/yr

Step 6 Calculate payback period:

(1) ________ ÷ (5) ________ = ________ Yrs

ECO No. 18
Install tenant fuel metering



Description

This ECO discusses only gas and oil, a separate ECO deals with metering of electricity.

HUD regulations for public housing may require that, to the extent practicable, all gas and oil consumed by tenants should be individually metered. This can be accomplished by either provision of "retail service" (dwelling units individually billed by the utility or service company),or when checkmeters exist for guaging consumption. In either case the tenants receive a reasonable allowance from the public housing authority (PHA) for average usage and only the excess usage, above the allowance, is paid by the tenant.

Installing tenant meters will give the tenants incentive to keep oil and gas use below the allowable limit and could save 10 to 25 percent of the total consumption. In either case PHA responsibility will be limited only to the allowance established and will save the PHA 10-25 percent of the total cost.

HUD regulations may also specify how PHAs with existing retail service or checkmeters should establish allowances. This ECO should be analyzed for PHAs only if installing tenant metering is mutually beneficial to both tenants and the PHA.

Types of Tenant Metering

Retail service metering requires that the utility provide individual metering or bills to every dwelling unit, and tenants purchase gas or oil directly from the utility.

"Checkmetering" (sometimes called submetering) requires a device for measuring gas consumption in individual dwelling units where service is supplied by the PHA through a "master" meter. The PHA then determines from reading its checkmeter, the amount of tenant usage. The PHA then surcharges the tenants for excess usage.

Modernization Standards Handbook reference: 6-3.

Concerns

- State and local laws should be analyzed to determine if checkmetering or individual billing is permissible.

- The utility supplier may have regulations against checkmetering.

- Prior to modifications to utility service arrangements with the tenants or charges with respect thereto, the requisite changes should be made in tenant dwelling leases in accordance with the requirements of HUD regulations.

- To the extent practicable, PHAs should work closely with tenant organizations in making plans for conversion of utility service to individual metering and billing, explaining the national policy objectives of energy conservation, the changes in charges and rent structure which will result, and the goals of achieving an equitable structure which will be advantageous to tenants who conserve energy.

- During and after the transition period PHA's shall advise and assist tenants with high fuel consumption on methods for reducing their usage. This advice and assistance may include counseling, installation of new energy conserving equipment or appliances and corrective maintenance.

Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less a more detailed analysis should be performed.

Applicability

This ECO applies only to:

8-3 a) project without individual or check meters or where tenants are not individually billed for oil and gas consumption,

b) project where installing tenant metering is mutually beneficial to both tenants and PHA (see text).

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of installing individual or checkmeters (for oil-heated buildings, conversion cost might be zero or equal to annual processing charges only): ________ $

Step 2 Transfer the following information from survey:

11-2 **a** Total annual tenant heating fuel consumption: Gas: ________ Therms

Oil: ________ Gal

10-1 **b** Cost of heating fuel: Gas: ________ $/therms

Oil: ________ $/gal

Step 3 Obtain the following value from Table 18-1:

Reduction factor of utility consumption (as decimal fraction): ________ (%)

Step 4 Estimate energy savings:

(2a) ________ x (3) ________ = ________ /yr

Step 5 Calculate cost savings:

(4) ________ * (2b) ________ = ________ $/yr

Step 6 Calculate payback period:

(1) ________ ÷ (5) ________ = ________ Yrs

Table 18-1

Reduction Factor For Various Utility Functions

Utility Function:	Tenant Retail Services:	Checkmeters:
Cooking	.25	.15
Domestic Hot Water	.25	.15
Heating	.35	.25

ECO No. 19

Improve central heating O&M

Description

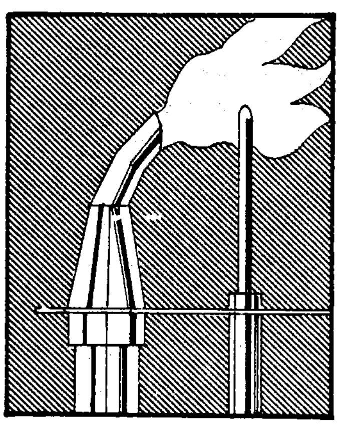
Note: This ECO applies only to projects with central heating plants. ECO #14 applies to projects with individual dwelling unit space heating equipment.

Central boiler and furnaces should be operated and maintained (O&M) to insure maximum efficiency.

Proper operation and maintenance (O&M) of the building space heating equipment must be assured before other, generally more costly ECO's are implemented. Operation and maintenance items listed here require little, if any, capital cost expenditures but might require increased maintenance staffs.

Because O&M items require little capital investment they must be implemented first, and in fact, savings estimates for other ECO's assume that all of the following items have been implemented. The specific items included in this ECO include:

a) turning off pilot lights in summer,
b) cleaning and adjusting burners,
c) adjusting fuel-to-air ratios,
d) maintenance of boiler water and fireside,
e) cleaning oil strainers,
f) calibrating and adjusting controls,
g) maintaining recommended fuel temperatures,
h) lowering steam pressure.

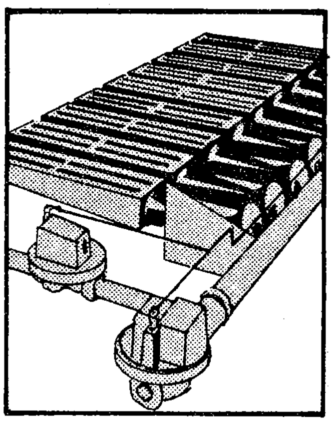


O&M Items

Pilot. Turn off gas pilots in boilers, furnaces, and space heaters during non-heating months and tenant vacancies. Keeping the pilot light on for extended periods without accompanying heating demands wastes a significant amount of fuel.

A notice should be prominently diplayed on each piece of equipment affected. This should state that the pilot must be relit before unit is reactivated.

Pilot lights must be shut-off in accordance with manufacturer's guidelines by qualified personnel.



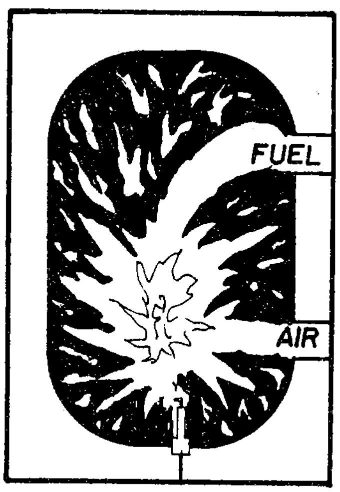
Clean/adjust burners. Burners on gas or oil fired furnaces should be regularly cleaned and adjusted to achieve proper firing rate.

On gas furnaces burners should be regularly cleaned of rust and scale which clog burner openings.

Clogged openings and poorly adjusted burners reduce burner efficiency and firing rates, wasting energy.

Burners should also be inspected for tightness, linkage operations, etc.

The following conditions indicate a need for burner adjustment: flame edge touches combustion chamber, tip of flame is orange, presence of fiery droplets, smoke above chimney.



Fuel/air ratio. The fuel-to-air ratio should be adjusted to achieve maximum combustion efficiency, indicated by stack temperature, percent of CO_2, and excess O_2 present in flue gases.

This relationship can be regulated by adjusting the automatic control device or adjusting manual controls which determine the mixture of air to fuel. Any modifications should be made by a qualified service person.

The fuel-to-air ratio is the proportion of fuel provided to the quantity of combustion air. Proper adjustment of this ratio is necessary to achieve maximum combustion efficiency. It should be frequently adjusted to achieve the most beneficial rate for fuel type, heat load, etc. Too little air causes incomplete combustion; too much results in excess air being heated and exhausted up the stack.

Fuel-to-air ratio adjustments must be preceded by first performing a stack analysis. This tests the current combustion efficiency by measuring the level of stack temperature, CO_2, and O_2

in the flue gases. This test can be done by qualified maintenance personnel or fuel service representative. It should be a regular procedure during the heating season.

Fuel-to-air ratio can also be affected by air leakage through cracks, damaged gaskets, or casing on the furnace. These must be repaired before adjusting the ratio.

Water/fireside maintenance. The fireside (side on which combustion occurs) of the furnace or boiler should be cleaned monthly during the heating season. Deposits of soot, fly ash, and slag should be removed.

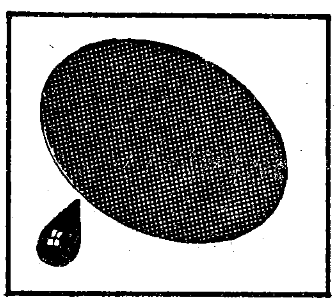
The waterside of the boiler should be regularly cleaned during shutdown to remove all scale or other sediment.

The presence of soot or other deposits on the fireside of the furnace acts as an insulator and retard heat transfer. Likewise, scale buildup on the waterside of a boiler reduces heat transfer rate, causes overheating, and can result in cracked boiler tubes. Keeping these surfaces clean can improve the heating efficiency of the heating plant by as much as 7 percent.

During waterside cleaning be sure that the rear portion is thoroughly cleaned.

Consult manufacturer's manual for recommended cleaning method: brush, chemical, detergent, etc.

Feed water should be treated to minimize future buildup.



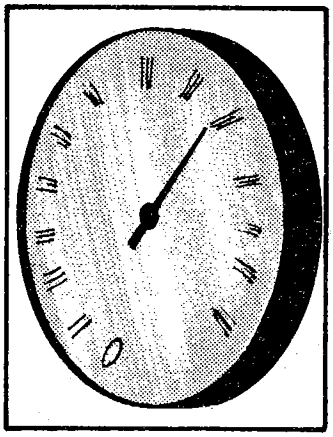
Clean oil strainer. Clean on a regular basis to maintain proper flow rate of oil to burner and fuel-to-air ratio.

Screen should be replaced if damaged and cleaned if dirty.

Clean strainers maintain the flow of oil and prevent pressure losses due to a clogged strainer. Optimum flow rate and fuel-to-air ratio

improve boiler performance and minimize heating and pumping losses.

Fine mesh baskets may possibly be replaced with a larger mesh model without damaging the system. This will further reduce pressure and pumping losses. This modification must first be approved by the furnace serviceman.



Calibrate/adjust controls. Instruments which measure heat generation and distribution should be periodically calibrated (tested for accuracy) to insure that they are reliable monitors of the equipment performance.

Similarly, all automatic and manual controls must be regularly adjusted for the system to operate properly.

Proper settings can be found in manufacturer's equipment manuals. All work on gauges, meters, thermometers, valves, etc., should be done by a qualified operator or serviceman.

Instruments and controls continuously measure, analyse and regulate a system so it can be employed to greatest advantage. Only if these instruments and controls are accurate can they be used as reliable indicators of performance and as aids in adjusting equipment for maximum efficiency.

Fuel oil temperature. Oil should be preheated to the recommended temperature to insure the proper viscosity at the burner head.

Regular inspection of the heater should be made to determine if proper temperature is being maintained.

The proper fuel temperature improves the viscosity of the oil. Oil of the proper viscosity is more readily burned as a result of "atomization", a process which breaks the oil into tiny particles exposing the greatest possible amount of surface area for combustion and increases burning efficiency by as much as 3 percent.

Recommended fuel temperature for the particular grade of oil is usually available in the furnace manufacturer's manual or from the fuel service.

Generally the range is 135°F for #2 oil; 185°F for #4 oil; 210°F for #6 oil.

Lower steam pressure. Lower to minimum required for heating needs. During hours of low demand and warm weather, steam pressure can be further reduced.

Steam which is maintained at low pressure levels requires less heat and also releases its heat more easily than high pressure steam. For these reasons use of low pressure steam increases space heating efficiency and reduces maintenance problems associated with high pressure steam.

Steam pressure should be reduced gradually until determination is made of lowest level which will satisfy distribution needs.

Pressure should be recorded in a maintenance log book.

Modernization Standards Handbook reference: 6-3.

Applicability

3-1 This ECO applies to all projects with central heating systems that need work on any of the following O&M items (see full descriptions on previous pages):

a) turn off pilot lights in summer,
b) clean/adjust burners,
c) adjust fuel-to-air ratios,
d) boiler water/fireside,
e) clean oil strainers,
f) calibrate/adjust controls,
g) fuel temperatures,
h) lower steam pressure.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1

Obtain cost of cleaning, adjusting inspecting, and lubricating individual dwelling unit heaters:

a	turn off pilot lights in summer:	________ $
b	clean/adjust burners:	________ $
c	adjust fuel-to-air ratios:	________ $
d	boiler water/fireside:	________ $
e	clean oil strainers:	________ $
f	calibrate/adjust controls:	________ $
g	fuel temperatures:	________ $
h	lower steam pressure:	________ $
i	Total (add all costs of applicable items)	________ $

Step 2

Transfer the following data from the survey:

10-1	Cost of heating fuel:	Gas:	________ $/therm
		Oil:	________ $/gal
		Electric:	________ $/KWH
		Other:	________ $/MBTU

b Annual heating fuel consumption:

Gas:	______	Therm/yr
Oil:	______	Gal/yr
Electric:	______	KWH/yr
Other:	______	MBTU/yr

Step 3

Obtain the following value from Table 19-1:

Table 19-1 Savings factor for implementing O&M items: ______

Step 4

Estimate annual energy savings:

(2b) ______ X (3) ______ = ______ /yr

Step 5

Calculate annual cost savings:

(2a) ______ X (4) ______ = ______ /yr

Step 6

Calculate payback period:

(1i) ______ ÷ (5) ______ = ______ Yrs

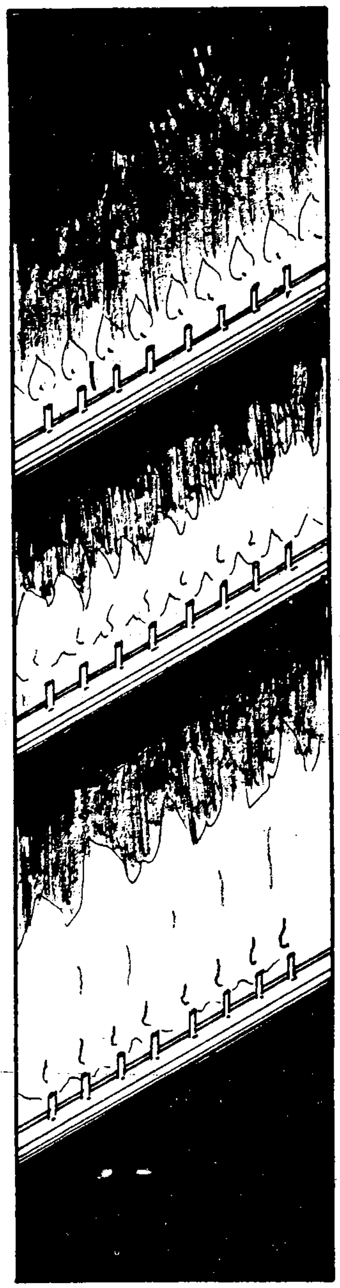
Table 19-1

Savings Factors for Central Heating O&M

Category of Work Needed:	Savings Factors:
Minor work needed:	.01
Medium work needed:	.03
Major work needed:	.05

ECO No. 20

Install modulating burners



Description

Boilers are sized to heat a building or project during the coldest days of the winter. At these extreme temperatures the boiler operates at its highest efficiency. When the temperature increases and the boiler is operating at part load, its efficiency decreases. Installation of a modulating burner allows the boiler to continue to operate efficiently even at low load.

After implementing Energy Conservation Opportunities listed in this handbook the heating load will be substantially reduced. It might be reduced to a point where the existing burner is greatly oversized for the new, lower heating load. This might be corrected by installing a smaller burner or smaller nozzle size. Installation of a properly sized modulating burner which would provide the most efficient operation is assumed in this ECO.

When efficiency increases, energy will be saved because the boiler will be able to produce more heat for the same quantity of fuel. How much energy can be saved by installation of a modulating burner is dependent upon how oversized the boiler is and how inefficient it is at part load, both factors which cannot be easily identified and are outside the scope of this handbook.

Types of Burners

Modulating burners are available in two basic types: a true modulating burner and a high-low burner. Modulating burners are more efficient and have been used here for this analysis. Project engineers, however, might decide that a high-low burner is a better investment. If more than one boiler exists they can be cycled to match the load in which case modulating or high-low burners are not needed.

Modernization Standards Handbook reference: 6-3.

Concerns

- The attached energy savings calculations are intended only as a preliminary estimate. If this appears favorable, an engineer should be contacted to make a further analysis.

- Select the appropriate burner type for your size boiler and fuel type.

- Develop maintenance programs to maintain boiler heating efficiencies. Follow manufacturer's specifications.

- Select electric ignition instead of continuous burning pilot lights for added savings.

Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

This ECO applies only to:

3-1 a) projects with central heating systems,

3-2 b) projects with oil and gas burning heating systems.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Estimate total cost of installing modulating burners: ________ $

Step 2 Transfer the following data from the survey:

11-2	a	Annual heating fuel use:	Gas:	________ Therms/yr
			Oil:	________ Gal/yr
10-1	b	Cost of heating fuel:	Gas:	________ $/therm
			Oil:	________ $/gal

Step 3 Calculate annual energy savings:

(2a) ________ X 0.083 = ________ /yr

Step 4 Calculate annual cost savings:

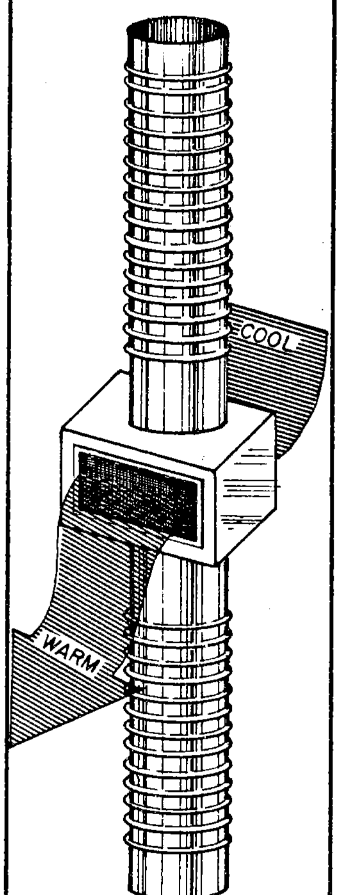
(2b) ________ X (3) ________ = ________ $/yr

Step 5 Calculate payback period:

(1) ________ ÷ (4) ________ = ________ Yrs

ECO No. 21

Install flue heat recovery



Description

A portion of the heat from boiler combustion gases that is normally lost to the atmosphere, can be recovered and used to preheat combustion air, preheat boiler water, or used directly or indirectly for space heating if flue temperatures are hot enough (above 500°F).

Flue heat exchangers can be external or internal. External exchangers are generally used in small systems and are simpler but less efficient. Internal exchangers require installation by trained personnel, are more costly, and are used only in high pressure systems.

Using recovered heat reduces total energy consumption. Internal flue heat recovery devices on large equipment can save up to 33% of the flue losses. Smaller external devices will save less.

Types of Recovery Devices

External flue heat recovery devices are recommended mostly on small oil and gas furnaces. The simplest devices, such as metal fins, attach to the flue pipe, thereby increasing the radiating area of the flue. More complicated external heat exchangers have built-in fan units to increase their efficiency. Although these flue heat devices can save energy estimates for them are not included in this ECO.

Internal flue heat recovery devices are more costly, but more efficient, and require removal and replacement of a segment of the flue duct. The devices are usually installed on large high pressure central oil and gas systems (125 psi min.). This type of flue recovery is analyzed in this ECO.

Internal flue heat recovery units usually consist of an array of finned tubes installed within the flue and directly exposed to the hot combustion gases. Heat is transferred to air or water circulated through the tubes and reused for pre-

heating. A fan or pump is required to maintain adequate movement of the heat transfer medium to prevent overheating.

Heat recovered through these systems can be used to preheat air for combustion or to preheat boiler water. The equipment used for preheating is an integral part of this ECO and its cost should be included with the heat recovery unit.

Although some units can be installed by in-house maintenance staff, professionals should be consulted for large furnace equipment, particularly when the recovered heat is used for preheating water or air.

Modernization Standards Handbook reference: 6-3.

Concerns

- Consult local municipalities or utility companies for a list of tested and approved devices.
- Compare maintenance requirements for all internal units.
- Ascertain the need of some units for special adapter pieces to fit project flue size.
- Make sure that fan power cables do not touch the flue pipe.
- If a flue damper is also being installed, work for this ECO should be done at the same time.

Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

This ECO applies only to:

3-2 a) non-electrically heated projects,

3-12 b) projects without flue heat recovery devices,

3-13 c) projects with central, high pressure (125 psi min.) systems.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain the total cost of installing flue heat recovery devices: ________ $

Step 2 Transfer the following information from the survey:

3-19 **a** Boiler plant combustion efficiency: ________ (%)

11-2 **b** Total annual heating fuel: Gas: ________ therm/yr

Oil: ________ gal/yr

Other: ________ MBTU/yr

10-1 **c** Cost of heating fuel: Gas: ________ $/therm

Oil: ________ $/gal

Other: ________ $/MBTU

Step 3 Obtain the following values from Table 21-1:

Table 21-1 Savings factor for your central boiler efficiency: ________

Step 4 Estimate annual energy savings:

(2b) ________ X (3) ________ = ________ /yr

Step 5 Calculate annual cost savings:

(2c) ________ X (4) ________ = ________ $/yr

Step 6 Calculate payback period:

(1) ________ ÷ (5) ________ = ________ Yrs

Table 21-1

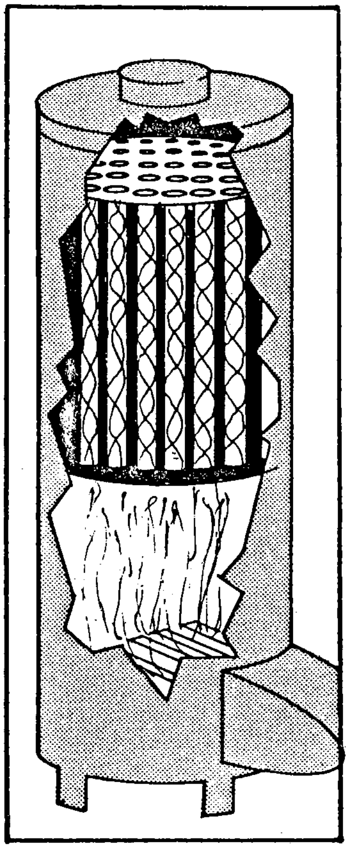
Savings Factors for Installing Flue Heat Recovery Devices

Central Boiler Efficiency:	Savings Factors:
.70	.083
.68	.090
.66	.097
.64	.103
.62	.110
.60	.117
.58	.123
.56	.130
.54	.137
.52	.143
.50	.150
.48	.157

Interpolate as neccessary for efficiency values not listed here.

ECO No. 22

Install turbulators



Description

To reduce boiler heat lost through the flue, turbulators or baffles can be installed. Even after the boiler has been cleaned and adjusted to achieve the best efficiency possible, flue gas temperatures may exceed 400°F. Turbulators or baffles keep the hot gases in contact with the waterside of the boiler longer thereby allowing more heat to be transferred to the water before the gases are discharged through the flue. If properly sized for each top-to-bottom row of firetubes, turbulators will also regularize heat transfer, further increasing boiler efficiency.

Types of Turbulators

The simplest turbulators consist of snakelike metal strips that fit easily inside the fire tubes in the boiler. Normally, heated air passes through these tubes transmitting heat to the boiler water circulated around the firetubes.

Turbulators can be installed in most boilers without long shut-down periods, changes, or modifications to the existing boiler. They can be used in vertical and horizontal boilers as well as cast iron sectional boilers. Most turbulators will last the lifetime of the boiler and require little maintenance.

Modernization Standards Handbook reference: 6-3.

Concerns

- Some boilers are designed to operate at higher stack temperatures than are advisable for turbulators. Check with equipment manufacturers.

- Some turbulators must be cleaned regularly according to manufacturer's guidelines.

Applicability

This ECO applies to:

3-8 a) central system gas and oil boilers,
b) projects with furnaces larger than 350 lbs. of steam per hour,
c) boilers without turbulators or baffles.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost for installing turbulators or baffles: ________ $

Step 2 Transfer the following information from the Survey:

11-2 **a** Annual heating fuel use: Gas: ________ Therms/yr

Oil: ________ Gals/yr

10-1 **b** Cost of heating fuel: Gas: ________ $/therms

Oil: ________ $/gals

Step 3 Estimate annual energy savings:

(2a) ________ X 0.02 = ________ /yr

Step 4 Calculate annual cost savings:

(2b) ________ X (3) ________ = ________ $/yr

Step 5 Calculate payback period:

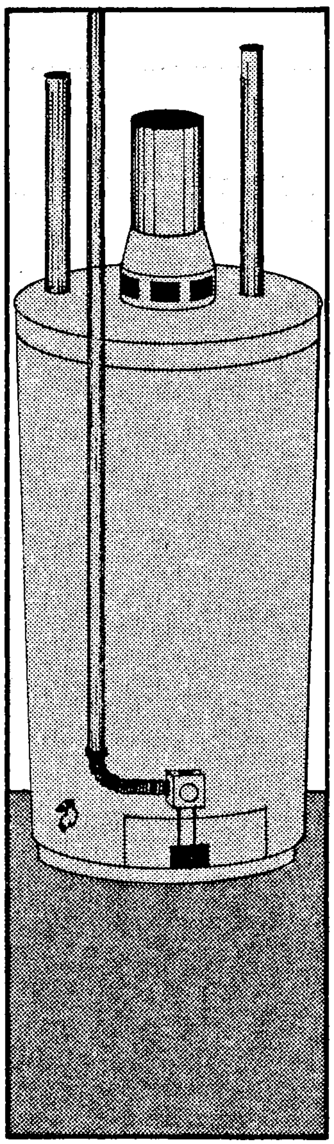
(1) ________ ÷ (4) ________ = ________ Yrs

ECO No. 23

Install summer-time DHW heaters

Description

In systems where water is heated in a side-arm heater on the boiler, the boiler must generate steam in the summer just to satisfy the hot water loads. At this low load the boiler is very inefficient and installation of a separate hot water heater should be considered.



In systems where water is heated in a coil submerged below the water line of the boiler, the boiler has to maintain heated water at about 150°F. While this system is less efficient than a separate hot water heater, the difference in efficiency is not significant in most cases. When the integral water heater is inefficient, however, installation of a separate DHW heater should be considered.

Since a side-arm domestic hot water heater and sometimes water-type DHW heater are very inefficient in the summer, by using a separate self-contained unit solely for the summer months, efficiency will be increased 25 percent or more in some cases. Maintenance savings will also occur because the large central boiler system will not be operational during the summer.

Concerns

- A separate DHW heater should operate only during the summer months. During the heating months it is more efficient to obtain domestic hot water from a central boiler.

- Separating DHW presents the opportunity to change to a less costly fuel type and should be considered. In this analysis, however, the same fuel type is assumed.

<u>Note</u>: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

This ECO applies only to:

3-1 a) central system boilers,

4-1 b) projects without separate heating and DHW system,

4-1 c) project with a side-arm type combined DHW and heating system or inefficient water-type combined DHW and heating systems,

3-2 d) non-electric boilers only.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1

Obtain total cost of installing a separate summer domestic hot water heater: ________ $

Step 2

Transfer the following information from the survey:

3-20 **a** Boiler plant seasonal efficiency: ________

1-17 **b** Number of tenants in project: ________

10-1 **c** Cost of heating fuel: Gas: ________ $/therm

Oil: ________ $/gal

Other: ________ $/MBTU

Step 3

Estimate the following efficiency savings:

.7 - ((2a) ________ - .1) = ________

Step 4

Estimate annual energy savings:

a Gas systems:

(2b) ________ X (3) ________ X 18 = ________ Therm/yr

b Oil systems:

(2b) ________ X (3) ________ X 13 = ________ Gal/yr

c Other fuel systems:

(2b) ________ X (3) ________ X 18 = ________ MBTU/yr

Step 5 Calculate annual cost savings:

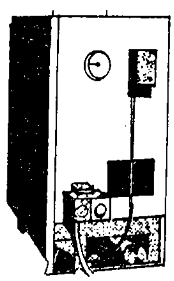
(2c) ________ X (4) ________ = ________ $/yr

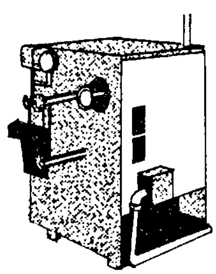
Step 6 Calculate payback period:

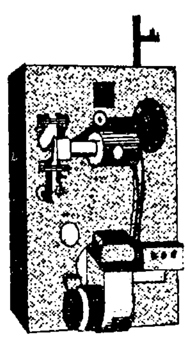
(1) ________ ÷ (5) ________ = ________ Yrs

ECO No. 24

Replace obsolete heating plant







Description

Existing equipment, due to age or lack of proper maintenance, may not operate as efficiently as it did when new. In addition, advances in technology have made many existing heating plants obsolete. Replacement of the heating plant should therefore be considered.

Replacing existing central boilers is very complicated and expensive. It is suggested here only as an extreme-case solution when all other ECOs concerning heating equipment have proven not applicable or do not raise the existing efficiency to desired standards.

Replacement of old heating plants with new and more efficient equipment will generate savings due to more efficient operation, reduced losses and reduced maintenance costs.

It also allows change of the heating fuel to a less expensive fuel type. In this ECO, however, the same fuel type was assumed and therefore all savings credited are due to increased efficiency only.

Modernization Standards Handbook reference: 6-3.

Concerns

- Existing equipment must be evaluated to determine the economic benefits of replacement as opposed to repair or upgrading of existing units.

- Selection of size and type of replacement equipment is critical if any energy savings are to be realized. Oversized equipment, even if new and efficient, will not generate any substantial savings.

- Assistance of qualified engineers will be needed and is legally required for the actual installation of a new plant.

Applicability

This ECO applies only to:

3-1 a) central oil and gas heating plants,

3-19 b) heating plants with combustion efficiency of less than 60% (.6).

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of replacing the heating plant. Include all equipment, labor, transportation costs, cost of structural alterations, etc.: ____________ $

Step 2 Transfer the following data from the survey:

3-19 **a** Combustion efficiency of existing boiler (as a decimal fraction): ____________ (%)

11-2 **b** Annual heating fuel use: Gas: ____________ Therms/yr

Oil ____________ Gals/yr

c Cost of heating fuel: Gas: ____________ $/therm

Oil: ____________ $/gal

Step 3 Calculate assumed efficiency increase:

0.8 - (2a) ____________ = ____________ (%)

Step 4 Calculate annual energy savings:

(2b) ____________ X (3) ____________ = ____________ /yr

Step 5 Calculate annual cost savings:

(2c) ____________ X (4) ____________ = ____________ $/yr

Step 6 Calculate payback period:

(1) ____________ ÷ (5) ____________ = ____________ Yrs

Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

ECO No. 25

Improve central distribution O&M

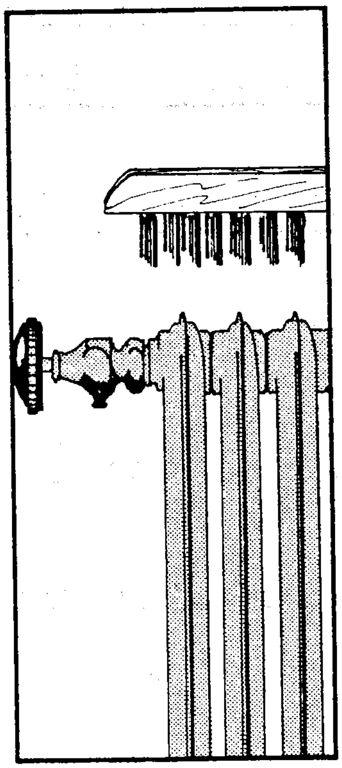
Description

Proper operation and maintenance (O&M) of the building central distribution system must be assured before other, generally more costly ECO's are implemented. Operation and maintenance items listed here require little, if any, capital cost expenditure but may require increased maintenance staffs.

Because O&M items require little capital cost investment they should be implemented first, and in fact, savings estimates for other ECO's assume that all of the following items have been implemented. The specific items included in this ECO include:

a) cleaning of heating surfaces,
b) venting of radiators,
c) cleaning and refurbishing of steam traps,
d) checking of condensate return system.

O&M Items



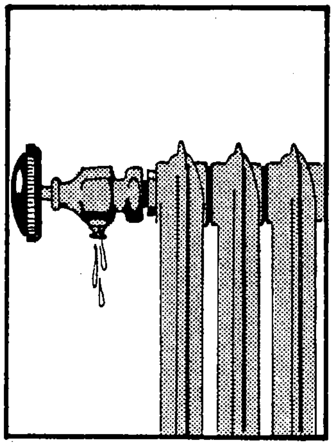
Clean heating surfaces. Heat transfer surfaces of radiators, convector units, and baseboard finned tube units should be kept clean and free of obstruction. This enables air to circulate freely around the unit.

Periodic cleaning with a vacuum should include all surfaces of the unit. A stiff brush may be needed for radiator surfaces.

Maximum heat transfer from surface to air promotes heating efficiency. A layer of dust or other obstruction acts as an insulator and prevents efficient heat transfer.

Care should be taken not to damage the aluminum fins on finned tube units.

Vent radiators. Air should be vented ("bleed air") from radiators at the beginning of each heating season to insure that steam completely fills the interior of the unit in a steam system or hot water in a central hot water system.



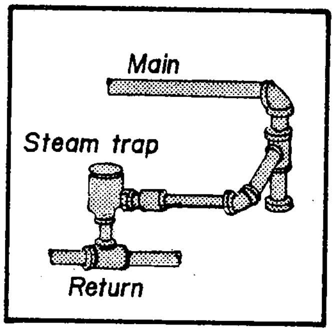
At this time all vents should be checked for proper operation; those which are damaged or painted shut should be repaired.

On steam systems open valve until steam begins to escape. On hot water systems purge air until hot water begins to escape.

Water or steam which escapes during the venting procedure is very hot. Care should be taken.

The presence of "hammering" noises indicates water trapped in a steam system caused by air or inadequate piping slope.

Steam traps. Clean and refurbish steam traps to insure that steam is conserved and condensate is removed.



Inspect all traps at commencement of each heating season to determine if they are operating properly: shut tightly, have an acceptable frequency of discharge, and remove condensate completely.

The downstream side of the trap should be tested (using a pyrometer) for temperature drop. If the return pipe is cold the trap is not functioning; if it is very hot it is passing steam.

Traps should be installed in all large central systems.

Check condensate return. Periodically check the entire condensate return system for cracked or missing insulation on lines, valves, and tanks. Heat loss through cracked or missing insulation lowers the temperature of the condensate, which increases distributive heat loss. This increases the boiler load by forcing the furnace to work harder to return the condensate to steam.

When replacing insulation, it is best to use a type identical to that originally specified.

No asbestos insulation should be used.

Modernization Standards Handbook reference: 6-2,3.

Applicability

This ECO applies to all central heating system projects which require work on any of the following items (see full descriptions on previous pages):

a) cleaning heating surfaces,
b) venting radiators,
c) cleaning and refurbishing steam traps,
d) check condensate return system.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain cost of performing any of the applicable O&M items:

	a	cleaning heating surfaces:	________ $
	b	venting radiators:	________ $
	c	cleaning and refurbishing steam traps:	________ $
	d	check condensate return system:	________ $
	e	Total (add all costs of applicable items):	________ $

Step 2 Transfer the following information from the survey:

10-1	**a**	Cost of heating fuel:	Gas:	________ $/therm
			Oil:	________ $/gal
			Electric:	________ $/KWH
			Other:	________ $/MBTU
11-2	**b**	Annual heating fuel use:	Gas:	________ Therm/yr
			Oil:	________ Gal/yr
			Electric:	________ KWH/yr
			Other:	________ MBTU/yr

Step 3 Obtain the following data from Table 25-1

Table 25-1 Savings factor for amount of work needed: ________

Step 4 Estimate annual energy savings:

(2b) ________ X (3) ________ = ________ /yr

Step 5 Calculate annual cost savings:

(2a) ________ X (4) ________ = ________ $/yr

Step 6 Calculate payback period:

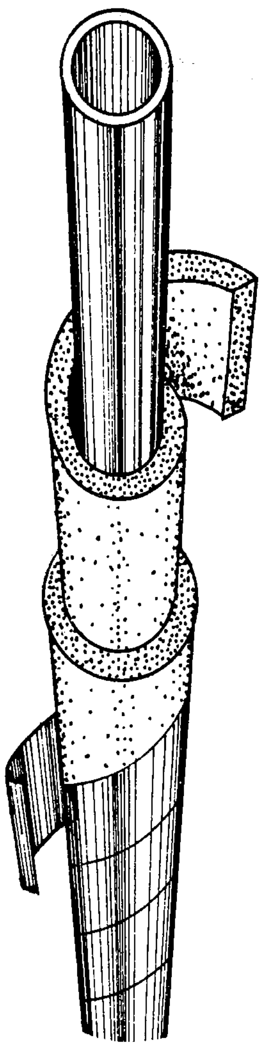
(1e) ________ ÷ (5) ________ = ________ Yrs

Table 25-1 Savings Factors for Implementing Central Distribution O&M Items

Category of Work Needed:	Savings Factors:
Minor work needed:	.01
Medium work needed:	.03
Major work needed:	.05

ECO No. 26

Insulate hot water or steam pipes



Description

All hot water or steam pipes running through unheated or overheated spaces should be insulated such as in unheated basements. Pipe insulation can be either rigid or flexible foam or fiberglass. Recommended thickness of insulation depends on pipe diameter and temperature. If piping is already insulated it should be replaced if all of it is badly worn, or repaired if the damage is only in small sections.

Heat loss from pipes in unheated spaces, such as mechanical rooms, storage rooms, etc. can be substantial. Insulating the pipes will cut heat loss to less than 20% of losses through uninsulated pipes.

Recommended insulation thicknesses vary with pipe size and are different for hot water and steam carrying pipes. The following table lists recommended insulation thicknesses and should be used for cost-estimating guidelines.

Pipe Diameter Size:	Recommended Insulation Thickness: Hot Water Pipes:	Steam Pipes:
3/4"	3/4"	1"
1"	3/4"	1"
1-1/2"	1"	1-1/2"
2"	1"	1-1/2"
3"	1"	1-1/2"
4"	1"	1-1/2"
6"	1"	2"

Modernization Standards Handbook reference: 6-3.

Concerns

- Do not insulate pipes that were designed to provide heat to a space.
- Insure that pipe insulation is capable of withstanding the maximum temperature of the pipe.

ECO #26: INSULATE HOT WATER OR STEAM PIPES

- Insulate all valves, pipe fittings and flanges.
- Do not insulate steam traps or the first six feet of the condensate discharge.
- Insure that pipe insulation meets local fire and health codes.

Applicability

This ECO applies only to:

3-14 a) projects with hot water or steam distribution,

3-17 b) projects whose hot water and steam pipes are not insulated.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Cost and savings for pipe insulation are different for different pipe diameters. The following worksheet allows calculations for different sizes.

Step 1

Obtain total cost of insulating all steam and hot water pipes (total all pipe sizes): ______________

Step 2

Transfer the following information from the survey:

10-1 **a** Cost of heating fuel:

Gas:	______________	$/therm
Oil:	______________	$/gal
Electric:	______________	$/KWH
Other:	______________	$/MBTU

3-14 **b** Heat distribution medium (steam or hot water): ______________

3-18 **c** Linear feet of uninsulated pipe (for each pipe diameter size):

3/4" Diameter pipe:	______________	LF
1"	______________	LF
1 1/2"	______________	LF
2"	______________	LF
3"	______________	LF
4"	______________	LF
6"	______________	LF

Step 3

Obtain the following values from Table 26-1:
Savings factors for system type (steam or hot water) and pipe diameter size:

Table 26-1	a	3/4" Diameter pipe:	______
Table 26-1	b	1"	______
Table 26-1	c	1-1/2"	______
Table 26-1	d	2"	______
Table 26-1	e	3"	______
Table 26-1	f	4"	______
Table 26-1	g	6"	______

Step 4

Estimate annual energy savings:

a Complete calculations for each uninsulated pipe size:

(2c, 3/4")	X	(3a)	=	______
(2c, 1")	X	(3b)	=	______
(2c, 1-1/2")	X	(3c)	=	______
(2c, 2")	X	(3d)	=	______
(2c, 3")	X	(3e)	=	______
(2c, 4")	X	(3f)	=	______
(2c, 6")	X	(3g)	=	______

b Total (add all results): ______ /yr

Step 5

Calculate annual cost savings:

(2a) ______ X (4b) ______ = ______ $/yr

Step 6

Calculate payback period:

(1) ______ ÷ (5) ______ = ______ Yrs

Table 26-1

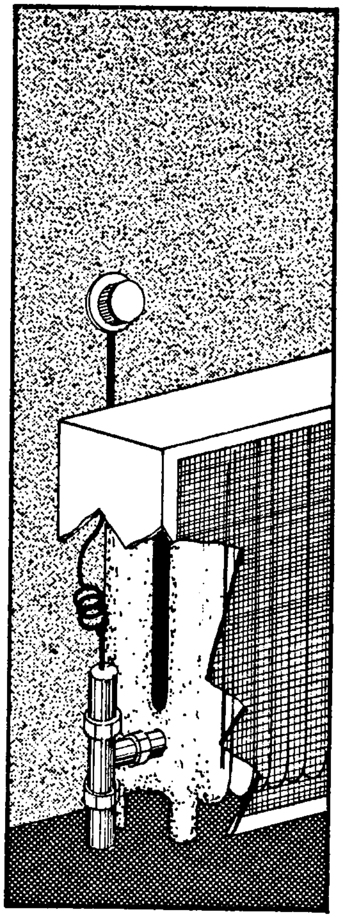
Savings Factors For Insulating Pipes

System Type/ Pipe Size	Fuel Type: Gas	Oil	Other
Hot Water:			
3/4"	1.02	.73	1.02
1"	1.28	.91	1.28
1-1/2"	2.1	1.50	2.10
2"	2.58	1.84	2.58
3"	3.76	2.69	3.76
4"	4.74	3.36	4.74
6"	6.82	4.87	6.82
Steam:			
3/4"	2.16	1.54	2.16
1"	2.68	1.91	2.68
1-1/2"	3.96	2.83	3.96
2"	4.90	3.50	4.90
3"	7.08	5.06	7.08
4"	8.96	6.40	8.96
6"	13.12	9.37	13.12

Savings factors above assume pipes are hot 2000 hours per year. Actual savings will differ in warmer and colder climates.

ECO No. 27

Install radiator or zone controls

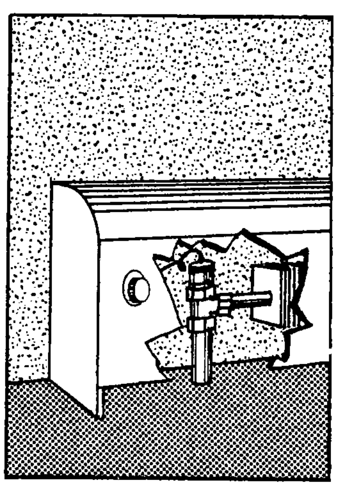


Description

In buildings with central radiation systems without radiator or zone controls the heating needs of the coldest apartments are met while other apartments, such as those on the sunny side of the building, are overheated and windows are opened to regulate temperatures. Energy is wasted because without such controls the system cannot be adjusted to heating needs efficiently.

This problem can be solved in one of two ways, either by installing zone controls or individual radiator controls. Zone controls separate each facade of the building and supplying only the amount of heat necessary for that part of the building. Individual controls are a finer-tuned version of zone controls because each radiator is allowed to respond to its own thermostat setting, providing only the amount of heat needed for that unit.

Through the use of radiator or zone controls heating energy is saved by supplying steam or hot water in proportion to the need for heat. Both types of controls will maintain comfortable indoor temperatures without overheating any other spaces.



Types of Controls

Individual radiator controls come in two types depending on the system in your building. One-pipe steam systems use thermostatically controlled air vent regulators. These can be installed quickly at the air vents.

Two-pipe hot water or steam systems require a thermostatic control valve to be installed in the supply pipe and require the pipe to be cut before the valve is installed.

Zone controls can only be installed in projects with pipe distribution systems which can be sectioned off according to the different building thermal zones. Professional contractors will have to analyze the system to determine whether

zone controls are possible. If zone controls are possible it is likely that they will be less costly then individual radiator controls.

Modernization Standards Handbook reference: 6-3.

Concerns

- One-pipe steam systems can be retrofitted with individual controls by PHA maintenance staff. Two-pipe and zone control systems require trained personnel for installation.

- All controls must be installed in accordance with manufacturer's instructions and meet professional and legal standards.

Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

This ECO applies only to

3-1 a) projects with central heating systems,
3-2 b) projects with non-electric heating fuels,
3-16 c) projects without individual radiator controls or with no zone controllers.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of installing individual radiator controls or zone controllers: ________ $

Step 2 Transfer the following information from the survey:

10-2 **a** Cost of heating fuel:

- Gas: ________ Therm/yr
- Oil: ________ Gal/yr
- Other: ________ MBTU/yr

3-16 **b** Number of rooms in project with radiators or convector heaters: ________

1-11 **c** Heating season hours: ________

Step 3 Obtain the following value from Table 27-1:

Table 27-1 Savings factor for your heating fuel: ________

Step 4 Estimate annual energy savings:

(2b) ________ X (2c) ________ X (3) ________ = ________ /yr

Step 5 Calculate annual cost savings:

(2a) ________ X (4) ________ = ________ $/yr

Step 6 Calculate payback period:

(1) ________ ÷ (5) ________ = ________ Yrs

Table 27-1

Savings Factors Per Radiator

Fuel Type:	Savings Factor:
Gas:	.0032 Therm
Oil:	.0022 Gal
Other:	.0032 MBTU

NOTES AND CALCULATIONS

3. Secondary Systems ECOs

Secondary Systems in housing building types include domestic hot water systems (DHW), water supply, central laundry equipment, and ventilation and air conditioning (AC) systems. Air conditioning is considered in only one ECO and is listed as a secondary system because relatively few public housing project include AC systems.

The following ECOs are included:

ECO #28: Improve Domestic Hot Water O&M

ECO #29: Install Flow Restrictors

ECO #30: Insulate DHW Tanks

ECO #31: Convert DHW Systems to Solar

ECO #32: Install DHW Off-Peak Controls

ECO #33: Install Cold Water Saving Devices

ECO #34: Convert Water Supply Pumps

ECO #35: Convert Laundry to Cold Rinse

ECO #36: Improve Ventilation/AC O&M

ECO #37: Install Ventilation Warm-up Cycle

ECO #38: Replace Obsolete AC Equipment

Analysis for ECO 31, Convert DHW Systems to Solar, gives only rough estimates of possible system cost and savings. If it proves cost-effective in this simplified analysis, further design, system selection and sizing should be done by an experienced solar designer.

Generally, however, secondary systems include many of the most cost-effective and simple-to-install ECOs possible.

ECO No. 28

Improve domestic hot water O&M

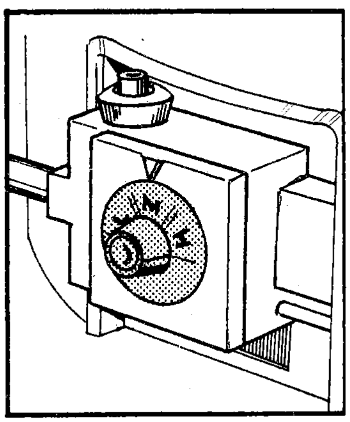
Description

Proper operation and maintenance (O&M) of Domestic Hot Water (DHW) systems must be assured before other, generally more costly ECOs are implemented. Operation and maintenance items listed here require little, if any, capital cost expenditure, but might require increased maintenance staffs

Because O&M items require little capital cost investment they must be implemented first, and in fact, savings estimates for other ECO's assume that all of the following items have been implemented. Specific items in this ECO include:

a) lowering DHW temperatures
b) cleaning and adjusting DHW burners
c) draining bottom of DHW tanks
d) fixing leaks

O&M Items



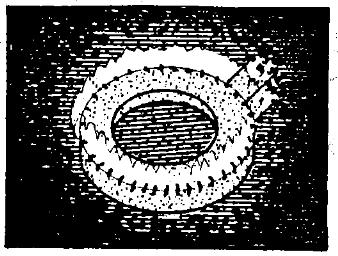
Lower temperature. Domestic hot water supply of 120°F is usually sufficient. In central systems the temperature should be lowered incrementally until it reaches 120°F at the location of use, not at the heater.

Individual domestic hot water heaters should also be set at 120°F. In the absence of calibrated controls, the dial should be set at "Medium" or "M" on dials.

Lowering the temperature for domestic hot water heaters saves fuel because less fuel is consumed maintaining a lower temperature than a higher one. In central systems heat loss to the distribution load (by conduction and radiation from pipes) will also be reduced.

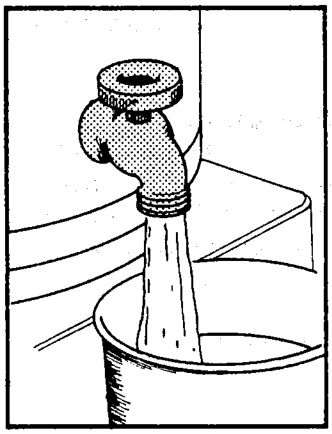
If a higher temperature such as 140° F., is required in laundry rooms a booster heater should be used.

Clean/adjust burners. Annually clean and adjust burners on DHW heaters for maximum combustion



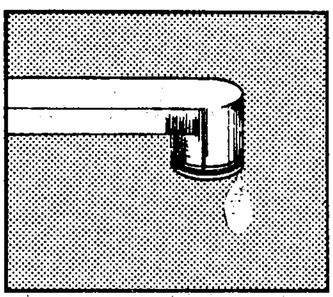
efficiency. Flame should be adjusted and controls and electrodes checked. This operation should be done in accordance with manufacturers' manuals by qualified personnel.

Cleaning and adjusting burners on domestic hot water heaters increases combustion efficiency and improves heat transfer. The buildup of soot or other residue decreases combustion efficiency in burners and the presence of scale on electrodes of electric heater reduces heat transfer.



Drain tank. On an annual basis flush the domestic hot water tank to remove sediment. Allow water to run into a bucket or drain until it runs clear.

The accumulation of sediment on the bottom of the tank insulates the burner flame or electrode and prevents effective heat transfer. This wastes energy and can cause rumbling noises in the system.



Fix leaks. Perodically inspect plumbing and faucets in all dwelling units for leaks in kitchen and bath fixtures. Determine cause of leak and repair promptly.

Fixing leaky faucets reduces distributive heating losses and monthly water consumption. One leaky faucet can waste up to 5,000 gallons of water annually.

Modernization Standards Handbook reference: 6-4.

Applicability

This ECO applies to all projects requiring work on any of the following items (see full descriptions on previous pages):

a) lower DHW temperatures,
b) clean/adjust DHW burner,
c) drain bottom of DHW tank,
d) fix leaks.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1		Obtain cost of performing any of the applicable O&M items:		______ $
	a	lower DHW temperatures:		______ $
	b	clean/adjust DHW burner:		______ $
	c	drain bottom of DHW tank:		______ $
	d	fix leaks:		______ $
	e	Total (add all costs of applicable items):		______ $
Step 2		Transfer the following information from the survey:		
1-17	**a**	Total number of tenants:		______
10-1	**b**	Cost of DHW fuel:	Gas:	______ $/therm
			Oil:	______ $/gal
			Electric:	______ $/KWH
			Other:	______ $/MBTU
Step 3		Obtain savings factors for all applicable items - Table 28-1		
Table 28-1	**a**	lower DHW temperatures:		______
	b	clean/adjust DHW burner:		______
	c	drain bottom of DHW tank:		______
	d	fix leaks:		______

e Total (add all savings factors for applicable items): ____________

Step 4 Estimate annual energy savings:

(2a) ____________ X (3e) ____________ = ____________ /yr

Step 5 Calculate annual cost savings:

(2b) ____________ X (4e) ____________ = ____________ $/yr

Step 6 Calculate payback period:

(1e) ____________ ÷ (5) ____________ = ____________ Yrs

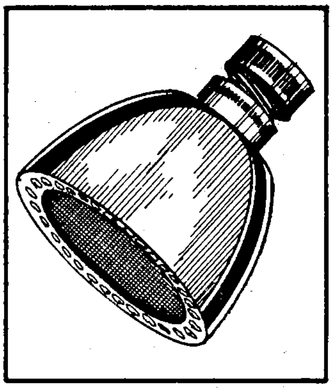
Table 28-1

Savings Factors for Architectural O&M

Action Taken:	Heating Fuel: Gas	Oil	Electric	Other
a) lower temperature	.5	.4	10	.4
b) clean/adjust burners	.1	.08	2	.08
c) drain tanks	.025	.02	.05	.02
d) fix leaks	1.2	1	24	1

ECO No. 29

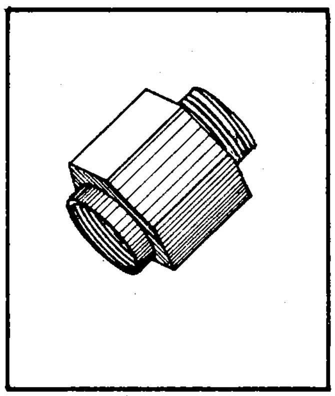
Install flow restrictors



Description

Conventional shower heads release 5-12 gallons of water per minute. Kitchen and bathroom sink faucets supply 5-8 gallons per minute when fully open. By installing flow restrictors these quantities can be reduced to 3 gallons per minute or even less.

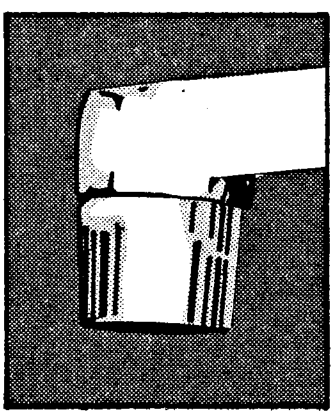
Since about two-thirds of that water has to be heated (the rest is cold water), substantial energy savings can be realized if water use is reduced by installing flow restrictors.



In areas where the building owner is billed for water consumption and/or sewer discharge, additional savings will also result from lower quantities of water used. Projects employing pumps for water pressurizing and/or distribution will have even greater savings. These are, however, too small to have a significant impact on the payback period and have been omitted from the savings estimates below.

Types of Restrictors

Hot water consumption can be lowered by use of either restrictors or regulator valves. Restrictors, as the name implies, merely restrict, or limit the amount of water that passes through them. Most restrictors also aerate the water to increase the apparent intensity of the water spray.



Regulator valves, on the other hand, are constructed to act as pressure compensating flow controllers allowing about the same volume of water to pass through the shower head at high water pressures as at low pressures.

Where existing faucets and shower heads are of a type that will not accept flow restrictors or regulators, existing heads and faucets might be replaced with low-flow units, or with faucet flow restrictors which install within the pipe or screw into the lead-in pipe. These options should be considered when existing plumbing or

fixtures need to be replaced to satisfy other HUD Modernization Program requirements.

Modernization Standards Handbook reference: 5-3, 4.

Concerns

- In localities, especially rural areas, where existing water pressures are low (less than 50 psi), flow restrictors might be either unacceptable or ineffective in reducing water consumption. In low pressure areas properly designed low-flow shower heads and faucets are preferred to restrictors.

- Most restrictors come with female and male threads and some are produced in either type. Many restrictors, although fitting both standard pipe sizes (1/2" and 3/8") are designed to work more efficiently with only one pipe size. Different types produce different savings. Read manufacturer's specifications carefully to determine which is most appropriate.

- Many building codes specify minimum flow rates. Make certain that selected restrictors meet these standards.

- In hard water areas, consider how easily the restrictor can be cleaned of sediment.

- Some manufacturers sell conventional shower heads with added restrictors labeled "conservation shower heads". In most cases it will be cheaper to buy the restrictor separately and install it yourself. Many shower heads come with "on-off" valves which will save additional amounts of energy if tenants use them (i.e. turn them off between wetting and rinsing).

- Many restrictors come in vandal-proof versions which require a special key to install and remove.

Applicability

4-5 This ECO applies only to projects without restrictors, regulators or low-flow faucets and shower heads.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of installing flow restrictors (typically, one shower and two faucets per dwelling unit): ________ $

Step 2 Transfer the following information from the survey:

1-17 **a** Total number of tenants in project: ________

4-2, 10-1 **b** Cost of DHW heating fuel: Gas: ________ $/Therm

Oil: ________ $/gal

Electric: ________ $/KWH

Other: ________ $/MBTU

Step 3 Estimate annual energy savings (use only line matching your DHW fuel type):

If gas:
(2a) ________ X 22.1 (Therms) = ________ Therm/yr

If oil:
(2a) ________ X 15.8 (Gallons) = ________ Gal/yr

If electric:
(2a) ________ X 454.2 (KWHs) = ________ KWH/yr

If other:
(2a) ________ X 15.8 (MBTUs) = ________ MBTU/yr

Step 4 Calculate annual cost savings:

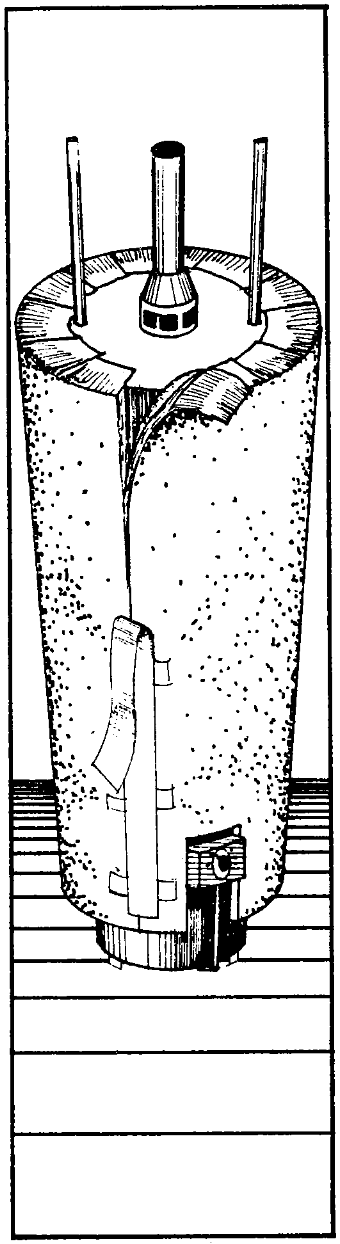
(2b) ________ X (3) ________ = ________ $/yr

Step 5 Calculate payback period:

(1) ________ ÷ (4) ________ = ________ Yrs

ECO No. 30

Insulate DHW tank



Description

All domestic hot water tanks should be insulated. Hot water tank insulation is usually a high density fiberglass jacket that surrounds the domestic hot water tank on all sides and top.

This insulation will help reduce the heat loss through the tank walls which typically amounts to 25% of the total yearly cost of heating domestic hot water.

Modernization Standards Handbook reference: 6-4.

Concerns

- On gas domestic water heaters care should be taken not to block air flow to the burner and to keep insulation safely away from the flame.

- Access to all valves and thermostats should be provided.

- Type of insulation selected should be able to withstand temperatures of tank.

- Select only code approved insulation types and install following manufacturers recommendations and safety regulations.

Applicability

4-4 This ECO applies only to projects with uninsulated individual dwelling unit DHW tanks.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

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

Step 2 Transfer the following information from the survey:

1-17 **a** Number of tenants in project: ________

4-2, 10-1 **b** Cost of DHW heating fuel:

Gas:	________	$/therms
Oil:	________	$/gal
Electric:	________	$/KWH
Other:	________	$/MBTU

Step 3 Calculate annual energy savings (Use line matching your DHW fuel type):

If gas:
(2a) ________ X 6 (therms) = ________ Therm/yr

If oil:
(2a) ________ X 4 (gallons) = ________ Gal/yr

If electric:
(2a) ________ X 100 (KWH) = ________ KWH/yr

If other:
(2a) ________ X 4 (MBTU) = ________ MBTU/yr

Step 4 Calculate annual cost savings:

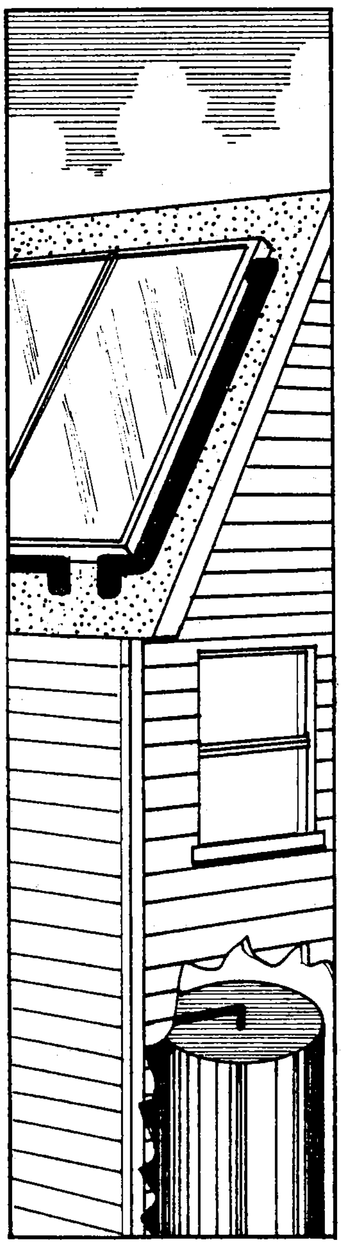
(2b) ________ X (3) ________ = ________ $/yr

Step 5 Calculate payback period:

(1) ________ ÷ (4) ________ = ________ yrs

ECO No. 31

Convert DHW systems to solar



Description

Domestic hot water (DHW) accounts for about 18 percent of the energy costs in public housing. It is here that solar energy retrofit systems have their greatest potential. Solar DHW systems usually consist of solar panels located on the roof or on the ground along the building they serve. These panels are heated by the sun and transfer the heat to a storage tank which is drawn upon as needed.

Solar DHW retrofit systems save energy by utilizing the sun rather than fossil fuels to heat the water. Solar DHW heating can usually save from 30 to 70 percent of the project's water heating costs. The exact amount depends upon the size of the system which proves most effective for a project and the availability of sunlight. For this analysis a typical system that provides about 40-60 percent of the hot water needed is assumed.

In high-rise buildings which use electricity to heat DHW solar retrofits are usually not economical because extensive new water distribution plumbing is required.

Typical Solar Systems

Solar domestic hot water systems typically include solar collectors, circulating pumps, heat exchanger(s), storage tank(s), controls and an auxiliary heat source. Operation of the system begins at the collectors, where the sun's energy is collected and absorbed by a heat transfer fluid which is usually non-freezing and sometimes toxic. This heat transfer fluid is then piped to a heat exchanger where it gives off the acquired heat to domestic water which is piped to and from the hot water storage tank. Separate piping loops preserve the purity of the water.

For typical uses, approximately 1.5 to 2.0 gallons of storage capacity are required per each square foot of collector. When solar energy is not available or is inadequate to meet demand,

water is heated by an auxilliary heater using conventional fuels, such as oil, gas or electricity.

Flat plate collectors are usually used for solar hot water systems and have been assumed for the purpose of this handbook because of their efficient and cost-effective operation in the required temperature range of 110 to 140 degrees F.

If the calculations below show that a solar DHW system is economical and is approved for implementations, an experienced solar designer should properly size the system. The assumptions made in this analysis are useful only as a general indication of economic feasibility and should not be used for final system sizing.

Cost Considerations

The exact cost of installing a solar domestic hot water system depends on system size, location of installation, ease of retrofitting, specifications of equipment, construction details and local labor expertise. For this preliminary analysis it is assumed that all low-rise projects use packaged solar retrofit systems available as complete kits exclusive of installation. These systems are assumed to have 50 square feet of collector area. Actually, warm, sunny climates need less collector area and cold, less sunny areas need more. These package systems typically range in cost between $2,300 to $3,000 installed but local contractors should be consulted to obtain accurate quotes.

For high-rise projects it was assumed that a custom system would be designed by an architect or engineer. This analysis assumes 30 square feet of collector per dwelling unit but this again would vary with climate. Costs of these types of systems range between $60-$100 (1980) per square foot.

Modernization Standards Handbook reference: 6-4.

Concerns

- Solar collector panels must be located in an unshaded area facing within 20 degrees of

south and tilted from the horizontal at an angle equal to the latitude.

- All piping to collector panels from storage tank must be insulated.

- To reduce costs standardized package systems for low-rise dwelling units should be used wherever feasible.

- To reduce distribution losses for all low-rise single or twin building projects with a central heating system, consider installing individual solar DHW heaters as opposed to a central system.

- All solar systems components must meet industry and code standards for performance and safety.

Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

This ECO applies to all projects except electrically heated high-rise buildings.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of retrofitting DHW system with a solar heated system. Include all system components (including any additional plumbing) and labor costs: ________ $

Step 2 Transfer the following information from the survey:

1-15 **a** Number of dwelling units in project: ________

10-1 **b** DHW heating fuel cost: Gas: ________ $/therm

Oil: ________ $/gal

Other: ________ $/MBTU

Step 3 Transfer the appropriate savings factor from Table 31-1 for your location, building type and DHW fuel:

Table 31-1

Oil: ________ Gal/yr

Gas: ________ Therm/yr

Other: ________ MBTU/yr

Step 4 Estimate annual energy savings:

(2a) ________ X (3) ________ = ________ yr

Step 5 Calculate annual cost savings:

(2b) ________ X (4) ________ = ________ $/yr

Step 6 Calculate payback period:

(1) ________ ÷ (5) ________ = ________ Yrs

Table 31-1

Savings Factors for Converting DHW to Solar:

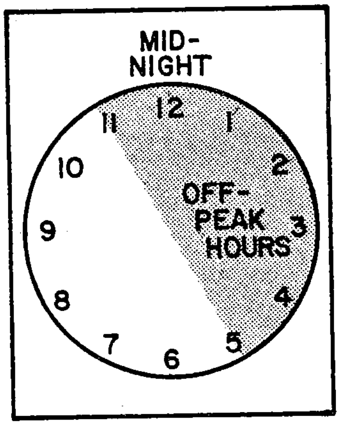
Building Type:	Low Rise:			High Rise:	
State	Gas	Oil	Electric	Gas	Oil
Alabama	161.7	115.5	3658.6	96.6	69.0
Arkansas	169.3	120.9	3830.2	101.2	72.3
Arizona	225.1	160.8	5094.2	134.6	96.1
California	195.4	139.6	4419.3	116.8	83.4
Colorado	211.6	151.1	4786.3	126.5	90.4
Connecticut	118.1	84.4	2672.9	70.6	50.4
Delaware	142.7	101.9	3229.4	85.3	60.9
D.C.	142.7	101.9	3229.4	85.3	60.9
Florida	184.6	131.9	4176.6	110.3	78.8
Georgia	161.2	115.1	3646.7	96.3	68.8
Idaho	162.9	116.4	3685.2	97.4	69.6
Illinois	141.5	101.1	3202.7	84.6	60.4
Indiana	132.2	94.4	2989.6	79.0	56.4
Iowa	156.3	111.6	3534.2	93.4	66.7
Kansas	168.3	120.2	3806.6	100.6	71.9
Kentucky	140.5	100.4	3179.0	84.0	60.0
Louisiana	176.7	126.2	3996.0	105.6	75.4
Maine	116.4	83.1	2634.4	69.6	49.7
Maryland	144.2	103.0	3261.9	86.2	61.6
Massachusetts	127.5	91.1	2883.0	76.2	54.4
Michigan	141.3	100.9	3196.8	84.4	60.3
Minnesota	160.7	114.8	3634.9	96.0	68.6
Mississippi	170.3	121.6	3853.9	101.8	72.7
Missouri	157.0	112.1	3552.0	93.8	67.0
Montana	153.6	109.7	3475.0	91.8	65.6
Nebraska	171.0	122.1	3868.7	102.2	73.0
Nevada	201.0	143.6	4549.5	120.1	85.8
New Hampshire	116.4	83.1	2634.4	69.6	49.7
New Jersey	160.4	114.6	3629.0	95.9	68.5
New Mexico	220.0	157.1	4975.8	131.5	93.9
New York	126.7	90.5	2868.2	75.8	54.1
N. Carolina	156.8	112.0	3546.1	93.7	66.9
North Dakota	150.4	107.4	3401.0	89.9	64.2
Ohio	124.5	88.9	2817.9	74.4	53.1
Oklahoma	178.4	127.4	4037.4	106.6	76.1
Oregon	152.6	109.0	3451.4	91.2	65.1
Pennsylvania	137.3	98.1	3108.0	82.1	58.6
Rhode Island	127.5	91.1	2883.0	76.2	54.4
S. Carolina	164.6	117.6	3723.7	98.4	70.3
South Dakota	153.6	109.7	3475.0	91.8	65.6
Tennessee	157.5	112.5	3563.8	94.1	67.2
Texas	182.1	130.1	4120.3	108.8	77.7
Utah	165.4	118.1	3741.4	98.8	70.6

Table 31-1 Savings Factors for Converting DHW to Solar:

Building Type:	Low Rise:			High Rise:	
State	Gas	Oil	Electric	Gas	Oil
Vermont	127.7	91.2	2883.0	76.3	54.5
Virginia	150.4	107.4	3401.0	89.9	64.2
Washington	124.5	88.9	2817.9	74.4	53.1
West Virginia	127.5	91.1	2883.0	76.2	54.4
Wisconsin	136.8	97.7	3096.2	81.8	58.4
Wyoming	211.6	151.1	4786.3	126.5	90.4

ECO No. 32

Install DHW off-peak controls



Description

In regions where utility companies have time-of-day electric rates in effect, it is often cost effective to heat domestic hot water (DHW) during periods of the day when electric rates are lowest. These might be in early morning hours when domestic hot water could be heated prior to the heavy morning use period.

Although cost savings are the main objective for the building owner, energy is also saved because DHW temperatures are not maintained at 120° or 140° all day, thereby eliminating some stand-by losses. In addition, using non-peak electricity helps reduce the demand on utilities to build new power plants.

Concerns

- Time-of-day meters must be installed prior to use of off-peak controllers. DHW tanks should be well insulated to take full advantage of lower time-of-day rates since water has to remain hot for many hours after it is heated up to the required 120-140°F.

- There are normally two times during the day when domestic hot water needs are the greatest. These are the morning hours (6 to 9 o'clock) and early evening hours. Hot water should be available during these two periods even if it is restricted during other times. Unique circumstances for each project, however, should be taken into account.

- Since the ECO requires that tenants modify their hot water use somewhat, it is important to consider tenants needs when implementing.

Applicability

The ECO applies to:

6-1 a) projects that use electricity to heat domestic hot water,

6-4 b) projects that have time-of-day electric service charges.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1

Obtain total cost of installing timer controls for domestic hot water heaters to heat the water during periods of low electrical rates: ________ $

Step 2

Transfer the following information from the survey:

6-7 **a** Average cost of electricity: ________ $/KWH

6-4 **b** Lowest cost of electricity: ________ $/KWH

1-17 **c** Number of tenants in project: ________

Step 3

Estimate present annual cost of heating Domestic Hot Water:

(2c) ________ X (2a) ________ X 500 = ________ $/yr

Step 4

Estimate annual cost of heating Domestic Hot Water with off-peak electric use:

(2c ________ X (2b) ________ X 500 = ________ $/yr

Step 5

Estimate annual cost savings:

(3) ________ - (4) ________ = ________ $/yr

Step 6

Calculate payback period:

(1) ________ ÷ (5) ________ = ________ Yrs

ECO No. 33

Install cold water saving devices

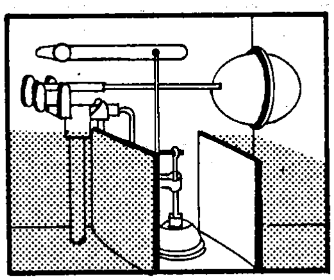
Description

To reduce the amount of water delivered to a project and collected from a project (as sewage) install water saving devices in your toilet tanks (Note: ECO #29: Install Flow Restrictors, deals with reducing hot water consumption; this ECO is designed to reduce cold water use).

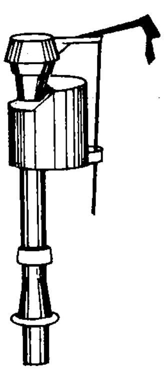
A conventional toilet tank uses 5 to 7 gallons of water every time it is flushed. As a result flushing uses up to 45% of all water consumed by an average family. Water saving devices can reduce this use to 2.5 to 3 gallons per flush.

Although water saving devices are designed primarily to save water and costs rather than energy, they have been included in this workbook because water is becoming a limited resource in many parts of the country and because water distribution systems use energy to power pumps and purification equipment.

Types of Devices



Two types of devices are available. The simpler one consists of a plastic dam which fits around the drain in your tank and prevents up to half of the water in the tank from being flushed away.



The second option is to replace the existing ballcocks with water saving ballcocks and drain assemblies. They can be adjusted for most effective water quantity and are usually made of non-degradable non-corrosive materials.

If the entire tank needs replacing to satisfy modernization requirements, specify water-saving design and include only the additional cost of such a tank (above normal price) as the cost of this ECO.

Modernization Standards Handbook reference: 6-4.

Concerns

- Select devices which properly fit your tanks. More than one type might be needed.
- Choose materials which do not rust or degrade over time.
- After installation, maintain devices properly by checking periodically for leaking valves, proper adjustment, and to ensure that tenants have not removed them.
- For systems with flushing valves rather than tanks, install water flow restrictors.

Applicability

4-9 This ECO applies only to projects without water-saving toilet tanks or devices.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of installing all water saving tank and/or valve devices (typically one device per D.U. plus devices in public toilets): ________ $

Step 2 Transfer the following information from the survey:

4-6 **a** Annual water tax amount (cost of water used at project): ________ $

4-7 **b** Annual sewer tax amount (cost of sewage discharge): ________ $

Step 3 Calculate total "water" cost:

(2a) ________ + (2b) ________ = ________ $

Step 4 Estimate annual energy savings: 0.0

Step 5 Calculate annual cost savings:

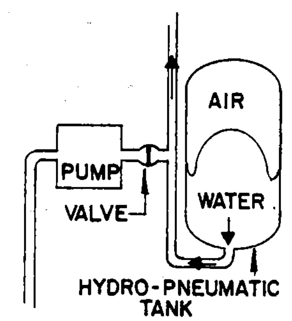
(3) ________ X 0.15 = ________ $/yr

Step 6 Calculate payback period:

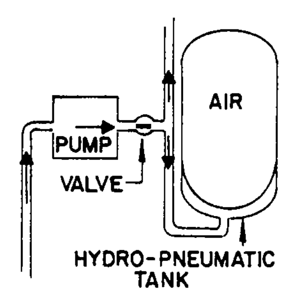
(1) ________ ÷ (5) ________ = ________ Yrs

ECO No. 34

Convert water supply pumps



NO DEMAND:
- PUMP OFF,
- VALVE CLOSED,
- HYDRO-PNEUMATIC TANK SUPPLIES PRESSURE



DEMAND
- TANK EMPTIES,
- VALVE OPENS,
- PUMP STARTS, SUPPLYING WATER TO BUILDING AND REFILLING TANK

Description

Pumps are used to maintain adequate water pressure in the domestic water system of high rise buildings that do not have roof mounted water tanks. These pumps must operate continuously to provide adequate water pressure, even when there is no water demand. Hydro-pneumatic systems can be used instead to keep adequate pressure levels without continuous pump operation.

System Operation

During those periods when domestic water is not required, pressure is maintained by a hydropneumatic tank which contains air and water separated by a flexible membrane. When a demand occurs, 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 water is supplied to the building directly. 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 option are 33% of the total pumping energy used for domestic water supply. This is based on minimum water demand between 11 p.m. and 7 a.m.

Modernization Standards Handbook reference: 6-3.

Concerns

- System pumps and tank must be properly sized to provide adequate amounts of water for the entire building or project.
- Entire system must be located in readily accessible space for maintenance purposes.
- Tank must be located in an area which can support its weight structurally or structural modifications may be required.

Applicability

This ECO applies only to:

1-12 a) high rise projects,

4-8 b) projects without roof-mounted water tanks.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of installing hydro-pneumatic water system: ________ $

Step 2 Transfer the following information from the survey:

4-8 **a** Total horsepower of present water pressurizing pumps: ________ HP

10-1 **b** Cost of electricity: ________ $/KWH

Step 3 Estimate annual energy savings:

(2a) ________ X 2190 = ________ KWH/yr

Step 4 Calculate annual cost savings:

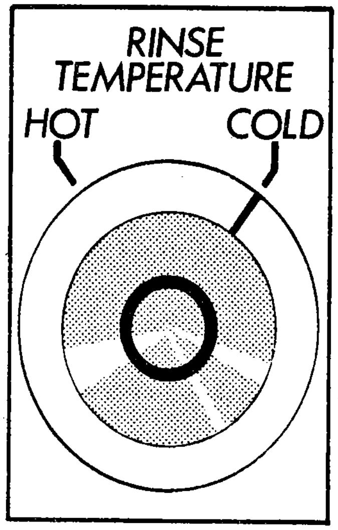
(3) ________ X (2b) ________ = ________ $/yr

Step 5 Calculate payback period:

(1) ________ ÷ (4) ________ = ________ Yrs

ECO No. 35

Convert laundry to cold rinse



Description

Although cold-water detergents are readily available, most people prefer and some conditions require that hot water be used during the washing cycle. During the rinse cycle, however, cold water can be successfully used under all conditions.

Depending on the controls, conversion of laundry rinse cycles to cold water can be done by project maintenance staff or outside servicemen. Contact the manufacturer or read their literature for more information.

Modernization Standards Handbook reference: 6-4.

Applicability

4-17 This ECO applies only to laundries which use hot water for rinsing cycle.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1

Obtain total cost of converting all washing machines to cold water rinse: ______ $

Step 2

Transfer the following data from the survey:

4-16 **a** Total number of washing machines: ______ $/therm

10-1 **b** Cost of DHW heating fuel: Gas: ______ $/therm

Oil: ______ $/gal

Electric: ______ $/KWH

Step 3

Transfer the following data from Table 35-1:

Table 35-1 Savings factor for your fuel type: ______

Step 4

Estimate annual energy savings:

(2a) ______ X (3) ______ = ______ /yr

Step 5

Calculate annual cost savings:

(4) ______ X (2b) ______ = ______ $/yr

Step 6

Estimate payback period:

(1) ______ ÷ (5) ______ = ______ Yrs

Table 35-1

Annual Fuel Savings Per Each Washing Machine

DHW Fuel Type:	Savings Factors:	
Gas:	30	(Therms)
Oil:	21	(Gallons)
Electricity:	705	(KWH)

ECO No. 36

Improve ventilation/AC O&M

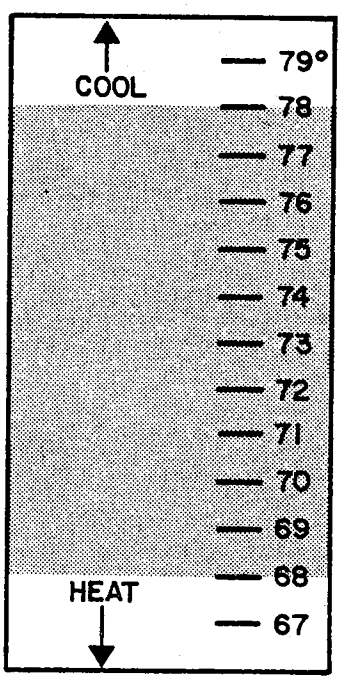
Description

Proper operation and maintenance (O&M) of the building ventilation and air conditioning systems must be assured before other, generally more costly ECOs are implemented. Operation and maintenance items listed here require little, if any, capital cost expenditure, but may require increased maintenance staff.

Because O&M items require little capital cost investment they must be implemented first, and in fact, savings estimates for other ECOs assume that all of the following items have been implemented. The specific items in this ECO include:

a) Set dead band for 68° - 78°F,
b) reduce outdoor air intake,
c) replace filters with low resistance filters,
d) shade outside A/C units,
e) check condition of duct system,
f) adjust chiller controls,
g) develop new A/C efficiency standards.

O&M Items



Set dead band for 68° - 78°F. By neither heating nor cooling air between 68° and 78°F. energy is saved.

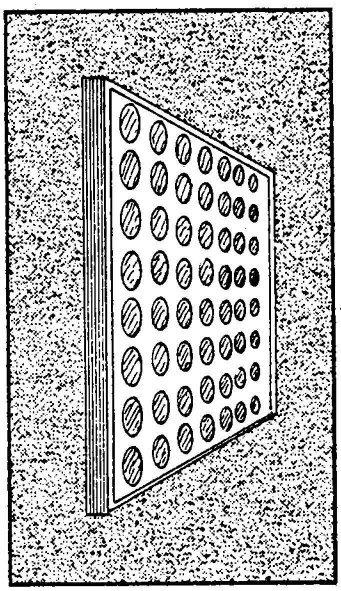
In hot and cold deck systems, the cold deck should be raised to the highest acceptable level and the hot deck lowered. This operation should be performed by a qualified technician.

Reduce outdoor air intake. Significant amounts of energy can be saved by reducing the amount of outside air which is heated and/or cooled. Energy is often wasted in the following ways: the ventilation rate grossly exceeds that required to meet comfort or code requirements or ventilation is not adjusted for the type or level of use. As much as 10% of the space conditioning energy can be wasted in this manner.

Accidental entry of outside air can be prevented by regularly checking dampers for seals and operating condition.

Unoccupied spaces should not be ventilated.

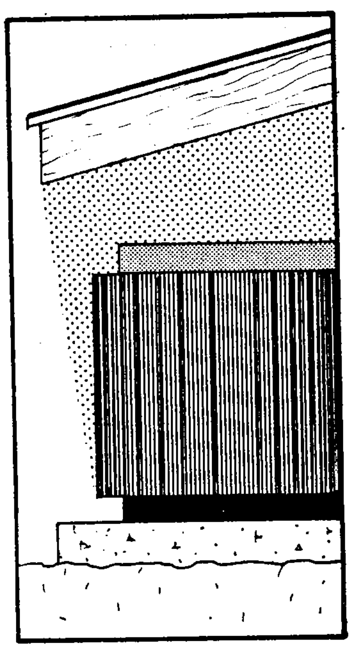
Reduce fresh air intake to limits set by local codes. Minimum legal ventilation rates are published as part of the local building code, or, in their absence, they must meet HUD MPS requirements.



Reduce level of fresh air available to boiler taking care not to create choking problems.

If permitted by code, close fresh air dampers during first and last hour of occupancy period.

Replace Filters. Replace high-efficiency high-resistance filters with high-efficiency low-airflow-resistance types. Determine minimum filtration requirements (50% filteration rate is usually sufficient) and select an appropriate replacement. Lowering the filter resistance saves energy by reducing the load on the fans which circulate the air.



Shade Outside A/C Unit. Shading outside airconditioning units conserves energy by helping to lower the air temperature surrounding the condensor coils. This allows heat to be removed at a faster rate and increases operating efficiency.

During operation in direct sun the air which surrounds the condenser coils becomes warm and cannot remove as much latent heat as possible.

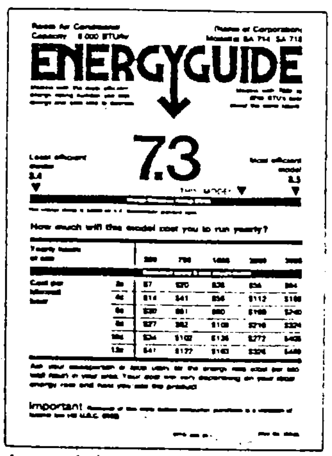
Whenever possible shade outside air-conditioning units. Do not prune trees which overhang airconditioning units. Use awnings or fencing to shade existing units.

Do not allow shading devices or shrubbery to interfere with condenser air flow. Shading devices must allow for easy escape of hot air from the unit (i.e., hot air should not be trapped under the shading device).

Check Condition of Duct System.
Sealing all leaks in ductwork will reduce distributive heat loss and resistance in the system. At the beginning of each heating and cooling season check ductwork for leaks. Use access panels, panels in hung ceilings and areas at registers to locate any leaks. Tape or caulk such leaks.

Adjust Chiller Control. Adjust chiller control according to outdoor temperature and occupancy load. Set demand at lowest setting that will maintain building temperature at acceptable cooling levels. Adjust chiller control as air conditioning load diminishes "following the load". This should be done by qualified maintenance staff or service personnel.

As the temperature of the supply air is raised, the temperature of chilled water and evaporation also increases. Since chilled water can be supplied at a higher temperature the cooling load is reduced.



A sample energy cost label

Develop New A/C Efficiency Standards. Develop standards for selection and performance for all project-owned appliances so the most energy efficient and/or cost-effective type available is selected.

To this end the Federal Trade Commission has developed an information labeling system to guide potential purchasers in their choice of the most energy-efficient model. Label information describes annual cost of operating appliance, range of efficiency, EER on air conditioners, and capacity of appliance.

All energy using equipment in public housing must meet Department of Energy standards.

For public housing, all authorities are required to purchase the most energy-efficient equipment offered by a manufacturer.

Modernization Standards Handbook reference: 6-5.

Applicability

This ECO applies to all projects requiring work on any of the following items (see full descriptions on previous pages):

a) set dead band for 68° - 78°F,
b) reducing outdoor air intake,
c) replacing filters with low resistance filters,
d) shading outside A/C units,
e) checking condition of duct system,
f) adjusting chiller controls,
g) developing new A/C efficiency standards.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain cost of performing any of the applicable O&M items:

a	68° - 78°F. dead band:	______ $
b	outdoor air intake reduction:	______ $
c	filter replacement:	______ $
d	shading outside A/C units:	______ $
e	checking condition of duct system:	______ $
f	adjusting chiller controls:	______ $
g	developing new A/C efficiency standards:	______ $
h	Total (add costs of all applicable items):	______ $

Step 2 Transfer the following information from the survey:

11-2 Total heating fuel consumption: ______ $/yr

Step 3 Obtain the following data from Table 36-1:

Table 36-1 Savings Factor for improved ventilation/AC: ______

Step 4 Estimate annual cost savings:

(3) ________ X (2) ________ = ________ $/yr

Step 5 Calculate payback period:

(1) ________ ÷ (4) ________ = ________ Yrs

Table 36-1

Savings Factors for Ventilation/AC O&M

Amount of Work Required:	Savings Factor:
Minimum work required:	.01
Average work required:	.025
Major work required	.05

ECO No. 37

Install ventilation warm-up cycle

Description

Warm-up cycle can be installed on central air systems that do not operate 24 hours per day. Normally, when the supply fan is operating, the outside air dampers open. With a warm-up cycle installed the outside dampers remain closed until space temperaure has been established (usually about one hour). This saves energy by reducing amount of cold air to be treated.

This ECO is economical only for projects where air systems for community areas and management offices are, or can be, controlled separately from other building locations. In buildings where air systems are not separated, installation or conversion of air ducts would make warm-up cycle costs prohibitive.

Modernization Standards Handbook reference: 6-5.

Concerns

- Warm-up cycle should only be activated during unoccupied periods when fresh air ventilation is not required.

Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

4-10 This ECO applies only to projects with air systems in community and/or office spaces which are separate from other areas.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of installing warm-up cycle controls: ________ $

Step 2 Transfer the following information from the Survey:

a Total CFM of air system for community and office areas: ________ CFM

b Percent (as decimal fraction) of minimum outdoor air flow for community and office areas: ________ (%)

1-8 **c** Heating degree day zone: ________ DDZ

10-1 **d** Cost of heating fuel: Oil: ________ $/gal

Gas: ________ $/therm

Electric: ________ $/KWH

Step 3 Estimate annual energy savings (complete line matching your fuel type):

If oil:
(2a) ______ X (2b) ______ X (2c) ______ X .26 = ________ Gal/yr

If gas:
(2a) ______ X (2b) ______ X (2c) ______ X .37 = ________ Therm/yr

If electric:
(2a) ______ X (2b) ______ X (2c) ______ X 7.6 = ________ KWH/yr

Step 4 Calculate annual cost savings:

(3) ________ X (2d) ________ = ________ $/yr

Step 5 Calculate payback period:

(1) ________ ÷ (4) ________ = ________ Yrs

ECO No. 38

Replace obsolete AC equipment

Description

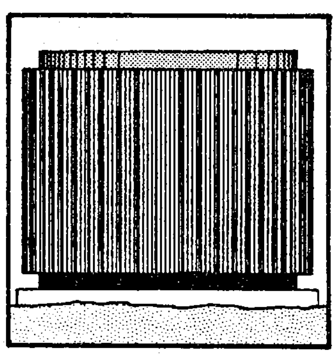
Existing equipment, due to age or lack of proper maintenance, may not operate as efficiently as it did when new. In addition, advances in technology have made many existing air conditioning systems obsolete.

Both central air conditioners and window AC units should be analysed for replacement. Tenant owned units should not, however, be included. In these cases the tenants should be instructed to consider replacing their own air conditioners with newer, more efficient units.

Modernization Standards Handbook reference: 6-6.

Concerns

- An assessment of the existing equipment condition must be performed to determine the economic benefits of replacement as opposed to repair or upgrading of existing units.
- New federal regulations require that all air conditioning units be labeled with an efficiency rating (EER); select those units with the highest EER rating.
- Do not select oversized units; select the smallest unit size that will do the job properly.
- If more than one unit is used to cool a single space, consider replacement with a bigger unit; larger units are usually more efficient, because they produce more cooling output for a given amount of energy used.



Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

4-11 This ECO applies only to projects with project-owned window or wall air conditioners or air conditioning systems.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain the total cost of replacing existing AC units with new energy efficient units: ________ $

Step 2 Transfer the following information from the survey:

4-13 **a** Total power requirement of existing A/C units: ________ Watts

4-14 **b** Total cooling capacity of existing A/C units: ________ BTUs

10-1 **c** Cost of electricity: ________ $/KWH

Step 3 Transfer the following data from Table 38-1:

Table 38-1 Annual cooling hours ________ Hrs/yr

Step 4 Calculate existing EER:

(2b) ________ ÷ (2a) ________ = ________

Step 5 Calculate existing energy use:

((3) ________ X (2b) ________) ÷ (4) ________ = ________ KWH/yr

Step 6 Calculate new energy use:

((3) ________ X (2b) ________) ÷ 9 = ________ KWH/yr

Step 7 Calculate annual energy savings:

(5) ________ - (6) ________ = ________ KWH/yr

Step 8 Calculate annual cost savings:

(7) ________ X (2c) ________ = ________ $/yr

Step 9

Calculate payback period:

(1)	÷	(8)	=	Yrs

Table 38-1

Annual Cooling Hours

Major City:	Cooling Hours (In thousands):
Albuquerque, NM	1.4
Atlantic City, NJ	.7
Birmingham, AL	1.5
Boston, MA	.8
Burlington, VT	.4
Charlotte, NC	.9
Chicago, IL	.8
Cleveland, OH	.6
Cincinnati, OH	1.2
Columbia, SC	1.3
Corpus Christi, TX	2.2
Dallas, TX	1.4
Denver, CO	.6
Des Moines, IA	.8
Detroit, MI	.9
Duluth, MN	.4
El Paso, TX	1.2
Honolulu, HI	2.5
Indianapolis, IN	1.1
Little Rock, AR	2.0
Minneapolis, MN	.6
New Orleans, LA	2.2
New York, NY	.8
Newark, NJ	.7
Oklahoma City, OK	1.6
Pittsburgh, PA	1.1
Rapid City, SD	.9
St. Joseph, MO	1.4
St. Petersburg, FL	2.0
San Diego, CA	1.4
Savannah, GA	1.3
Seattle, WA	.8
Syracuse, NY	.6
Trenton, NJ	.9
Tulsa, OK	1.8
Washington, DC	1.0

Locate closest city to your location, circle and enter cooling hours in Step 3.

NOTES AND CALCULATIONS

4. Electrical Systems ECOs

Electrical Systems energy conservation opportunities are designed primarily to reduce electricity usage for interior and site lighting. Electrical consumption for heating and domestic hot water has been addressed in the Heating and Secondary Systems sections of this workbook. This particular section addresses tasks which increase the efficiency of lighting bulbs and fixtures, reduce their use times, and eliminate or reduce utility billing surcharges.

The following ECOs are included:

ECO #39: Improve Electrical/Lighting O&M

ECO #40: Convert Incandescent Lamps (Dwellings)

ECO #41: Convert Incandescent Lamps (Circulation)

ECO #42: Convert Incandescent Lamps (Public Areas)

ECO #43: Replace Fluorescent Bulbs

ECO #44: Install High-Efficiency Ballasts

ECO #45: Install Daylighting Controls

ECO #46: Convert Site Lighting Lamps

ECO #47: Install Site Lighting Photo-Controls

ECO #48: Install Tenant Metering

ECO #49: Correct Low Power Factor

ECO #50: Install Load-Shedding Controls

"Lamp" ECOs suggest conversion of existing fixtures or lamp sockets to more energy-efficient types. "Bulb" ECO suggests the replacement of existing bulbs with more energy-efficient types without fixture or socket modifications.

Only ECO #48, Install Tenant Metering, and ECO #49, Correct Low Power Factor, will require further design and analysis if they proved cost-effective in this workbook.

All other ECOs, although they may require the assistance of professional staff, can be very easily implemented by project's own maintenance staff, if so desired.

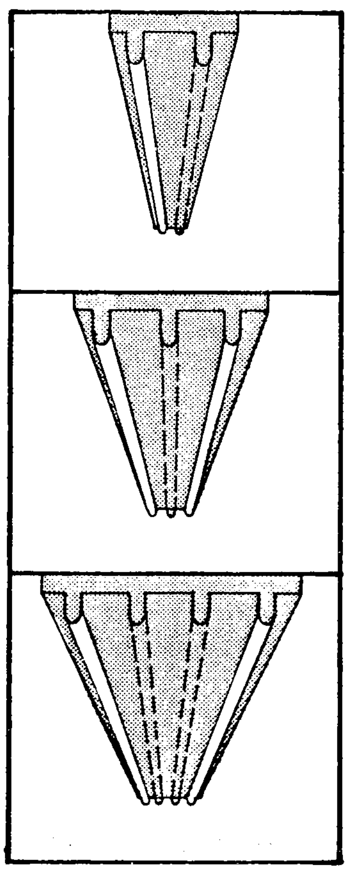
ECO No. 39

Improve electrical/lighting O&M

Description

Proper operation and maintenance (O&M) of electrical and lighting systems must be assured before other, generally more costly ECOs are implemented. Operation and maintenance items listed here require little, if any, capital cost expenditures, but might require increased maintenance staffs. They must be implemented first, and in fact, savings estimates for other ECOs assume that all O&M items have been implemented. The specific items in this ECO include:

a) removing bulbs and lamps ("delamping"),
b) cleaning light fixtures,
c) initiating tenant appliance review,
d) establishing lamp replacement standards,
e) reviewing elevator service.



O&M Items

Delamping. Remove fluorescent and/or incandescent lamps in overlit areas to reduce electrical use.

In many areas illumination levels can be reduced by as much as 50% while still satisfying minimum lighting requirements.

General guidelines for fluorescent fixture delamping are:

For 2 lamp fixtures, remove one bulb in each fixture if they are not wired in series; for 2 lamp fixtures installed in rows, remove both bulbs in alternate fixtures.

For 3 lamp fixtures, remove the middle lamp

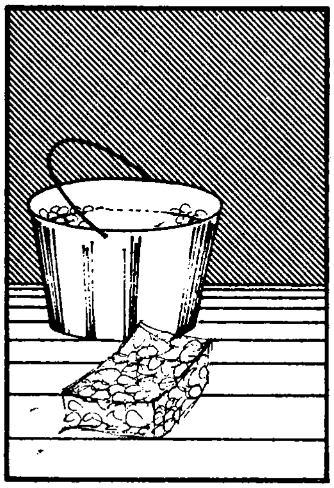
For 4 lamp fixtures, remove both inside lamps.

Incandescent illumination can be reduced by simply removing the appropriate number of bulbs.

Ballasts which consume energy should be removed from fixtures in which all the tubes have been removed. In a 4 lamp fixture, disconnect wiring

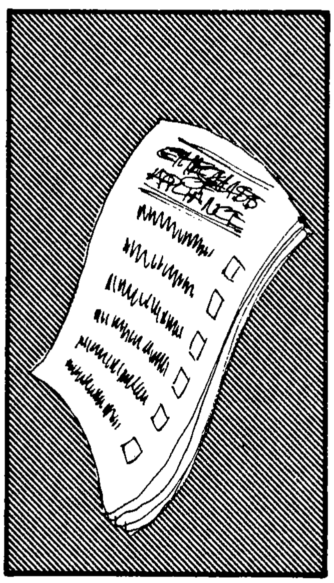
to the ballast associated with the 2 inner tubes.

Building codes usually specify minimum lighting levels - make sure to comply with all code requirements and ensure tenant safety.



Cleaning Fixtures. Surfaces which are dirty transmit less light. This decreases lighting efficiency and causes occupants to activate more fixtures to maintain the required level of illumination. Lamps, fixtures, reflecting surfaces and diffusing surfaces should, therefore, be regularly cleaned to assure maximum illumination. Lenses which have become yellowed should be replaced.

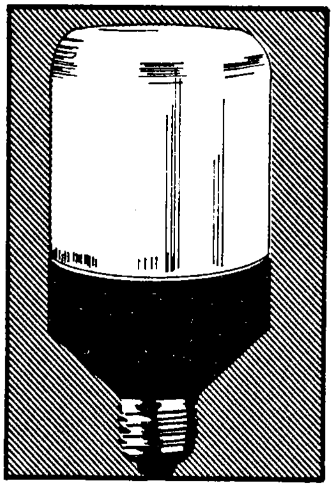
Caution should be exercised when cleaning all electrical fixtures; wiring and connections should not be disturbed. The current should be OFF! Make sure fixture is thoroughly dry before reactivating it.



Tenant Appliance Review: Educate tenants to operate and maintain appliances for maximum efficiency by distributing a tenant checklist. This document describes general guidelines for proper operation, maintenance, and energy saving measures tenants can employ when using appliances. A sample tenant checklist is provided in Appendix E.

Typical appliances which whould be reviewed for use include: ranges, refrigerators, washers, dryers, irons, toasters, air-conditioners, etc. Minimizing their use will not only conserve fuel resources but will also save the tenants money.

Lamp Replacement. Develop guidelines for bulb replacement types. First, attempt to consolidate the number of low-wattage incandescent bulbs and substitute a single higher wattage bulb wherever possible. In general the level of lumens (lighting output) remains approximately the same.



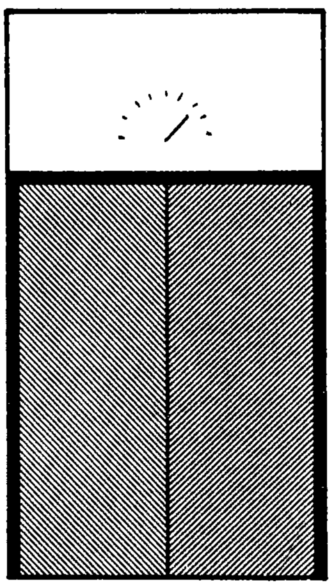
Second, reduce the level of lumens; this enables you to reduce the wattage consumed by lighting.

Whenever possible substitute a high-efficiency type bulb when replacement becomes necessary.

Consult manufacturer's literature for most efficient bulb which is appropriate for the task. Review data for watts (power required), lumens (light emitted), and bulb life (life expectancy).

Elevator Review. Review elevator use to determine if building is over-elevatored during non-critical hours of service. If over-elevatored, remove one or more from operation during periods of light use.

If possible, connect elevators to load shedding or demand-limiting equipment to limit peak demand.



Adjust demand-type controls so fewest elevators travel least distance to satisfy service demand.

Lengthen floor dwell time (waiting period) to increase passenger load if no elevators are deactivated.

Balance idling time with motor start-up time to equalize power consumption.

Particular concern must be paid to the Modernization Standards Handbook 7485.2 Rev. for elevators and security implications of their operation.

Any changes to elevator equipment should be done by qualified servicemen and should follow manufacturer's recommendations.

Modernization Standards Handbook reference: 7-1-6.

Applicability

This ECO applies to all projects needing work on the following O&M items (see full description on previous page)

a) delamping,
b) cleaning fixtures.,
c) tenant appliance review,
d) lamp replacement,
e) elevator review.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain cost of performing any of the applicable O&M items:

a	delamping:	______ $
b	cleaning fixtures:	______ $
c	tenant appliance review:	______ $
d	lamp replacement:	______ $
e	elevator review:	______ $
f	Total (add all costs of applicable items):	______ $

Step 2 Transfer the following data from the survey:

1-15	**a**	Total number of dwelling units:	______
10-1	**b**	Cost of electricity:	______ $/KWH

Step 3 Transfer here the following data from Table 39-1:

Table 39-1 KWH savings (select applicable category): ______ KWH/yr

Step 4 Estimate annual energy savings:

(2a) ______ X (3) ______ = ______ KWH/yr

Step 5 Calculate annual cost savings:

(2b) ______ X (4) ______ = ______ $/yr

Step 6

Calculate payback period:

(1f)	÷	(5)	=	Yrs

Table 39-1

KWH Savings per Dwelling Unit

Category of Work Needed	KWH Savings:
Minor Work Needed:	100
Average Work Needed:	200
Major Work Needed:	350

ECO No. 40

Convert incandescent lamps in dwellings

Description

Incandescent light bulbs in dwelling units consume up to 3 or 4 times the energy of more efficient lamps such as fluorescent or new "electronic" lamp types. Converting these incandescent lamps to high-efficiency lamps can be done by either replacing the existing fixtures with new fixture housings or by installing fluorescent or other efficient bulb types directly into the existing sockets.

High-efficiency bulbs combine lower electricity use with good light color quality, longer life and savings of up to 3 or 4 times the energy needed by an incandescent bulb of the same light output. These savings could amount to 100 KWH or $5/year (at 5 cents per KWH) for a single 100 watt bulb assuming average usage.

Types of High Efficiency Lamps

Fluorescent lamps are the most common type of high efficiency lamps available for indoor use. They can be obtained in a variety of sizes, wattages and color renditions.

Incandescent-to-fluorescent conversion kits might be used in some locations, especially in dwelling units. The kits can be either screwed into the existing socket or rewired in its place if a more permanent solution (which is less vulnerable to pilfirage) is desired. To further increase savings in selecting new fluorescent fixtures consider only energy-efficient designs. Fluorescent lights have a life of 7 to 12 times longer than incandescent.

Recent developments in lighting research have resulted in the production of "electronic" replacement lamps for standard incandescent sockets which have wattage savings and life expectancies comparable to the highly efficient fluorescent

lamps. The new lamps are usually larger than conventional bulbs but fit the same sockets without any physical conversion. These lamps provide the same lighting output at up to 70% energy savings and have a life of 5 to 10 times longer than incandescent lamps.

Modernization Standards Handbook reference: 7-2-4.

Concerns

- Generally, replacement of fixtures can be done only by qualified and licensed electrical contractors. To accept fluorescent fixtures which are larger in size, modifications to existing suspended ceilings might also be required. Replacement of bulbs, of course, can be done by maintenance staff.

- Because of their larger size, "electronic" bulbs might not fit all incandescent fixtures; they should only be considered for those fixtures where they fit.

- Electronic lamps are a new development in the industry; they may not be available in all areas.

- Ensure that minimum code-required lighting levels are maintained after replacement.

- Energy-saving fluorescent lamps and ballasts should be installed wherever possible.

Applicability

This ECO applies only to

5-7 a) projects where bathroom, kitchen or foyer lighting is incandescent,

6-2 b) projects where PHA pays all electricity bills.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

This analysis can be done for either one, two, or all of the following dwelling unit fixtures: bathroom light, kitchen light and foyer/hallway light. Choose the number of lights that are applicable to your project.

Step 1 Obtain total cost of replacing dwelling unit light bulbs (one, two or three lights per dwelling): ________ $

Step 2 Transfer the following information from the survey:

1-15 **a** Number of dwelling units: ________

10-1 **b** Cost of electricity: ________ $/KWH

Step 3 Obtain the following value from Table 40-1:

Table 40-1 KW hours saved per year: ________ KWH/yr

Step 4 Estimate annual energy savings:

(2a) ________ X (3) ________ = ________ KWH/yr

Step 5 Calculate annual cost savings:

(4a) ________ X (2b) ________ = ________ $/yr

Step 6 Divide total cost of replacing lamps by 5 to account for longer life of new bulbs:

(1) ________ ÷ 5 = ________ $

Step 7 Calculate payback period:

(6) ________ ÷ (5) ________ = ________ Yrs

Table 40-1

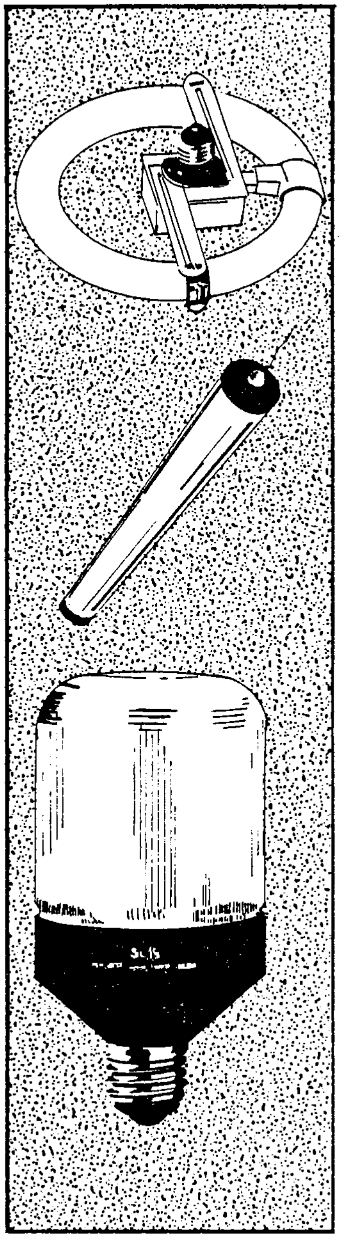
Electricity Savings From Replacing Incandescent Lamps

Fixture Choice:	Savings (KWH):
One fixture/D.U. (kitchen only):	150
Two fixtures/D.U. (kitchen and bathroom):	210
Three fixtures/D.U. (kitchen, bathroom, hallway):	250

This table assumes average usage of lights by tenants; savings could vary substantially between individual dwelling units.

ECO No. 41

Convert incandescent lamps in circulation areas



Description

Note: This ECO is nearly identical to ECO #40 but applies to circulation areas.

Incandescent light bulbs in circulation areas such as hallways, lobbies, and stairs use up to 3 to 4 times the energy of other, more efficient lamp types, such as fluorescent or new "electronic" lamp types. Converting these incandescent lamps to high-efficiency lamps can be done by either replacing the existing fixtures with new fixture housings or by installing fluorescent or other bulb types directly into the existing sockets.

High-efficiency bulbs combine lower electricity use with good light color quality, longer life, and savings of up to 3 or 4 times the energy needed by an incandescent bulb of the same light output. These savings could amount up to 400 KWH per year for a single 100 watt bulb or $20/year at 5 cents per KWH.

Types of High Efficiency Lamps

Fluorescent lamps are the most common type of high efficiency lamps available for indoor use. They can be obtained in a vareity of sizes, wattages and color renditions.

Incandescent-to-fluorescent conversion kits might be used in some locations, especially in hallways and stairways. The kits can be either screwed into the existing socket or rewired in its place if a more permanent solution, less vulnerable to pilferage, is desired. To further increase savings in selecting new fluorescent fixtures consider only energy-efficient designs. Fluorescent lights have a life of 7 to 12 years longer than incandescent.

Recent developments in lighting research have resulted in the production of "electronic" replacement lamps for standard incandescent sockets which have wattage savings and life expectancy comparable to the highly efficient flourescent lamps. The new lamps are usually larger than conventional bulbs but fit the same sockets without any physical conversion. These lamps usually have a life five times longer than incandescent lamps and can produce savings of up to 70 percent.

Modernization Standards Handbook reference: 7-2, 3,4.

Concerns

- General replacement of fixtures can be done only by qualified and licensed electrical contractors. In some cases modifications to existing suspended ceilings will also be required to accept the larger fluorescent fixtures. Replacement of bulbs, of course, can be done by maintenance staff.

- Because of their larger size, the new "electronic" bulbs might not fit all existing incandescent fixtures; they should only be considered for those fixtures where they fit.

- Electronic lamps are a new development in the industry and may not be available in all areas.

- Ensure that minimum code-required lighting levels are maintained after replacement.

- Energy saving fluorescent lamps and ballasts should be installed wherever possible.

Applicability

5-8 This ECO applies only to projects where circulation areas are lighted with incandescent bulbs.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of replacing circulation area light bulbs: ________ $

Step 2 Transfer the following information from the survey:

5-8 **a** Number of incandescent fixtures in hallways, stairs and lobbies: ________

5-8 **b** Average watts per fixture: ________ W

10-1 **c** Cost of electricity: ________ $/KWH

Step 3 Obtain the following value from Table 41-1:

Table 41-1 KW hours saved per year: ________ KWH/yr

Step 4 Estimate annual energy savings:

(2a) ________ X (3a) ________ = ________ KWH/yr

Step 5 Calculate annual cost savings:

(4) ________ X (2c) ________ = ________ $/yr

Step 6 Divide total cost of replacing lamps by 5 to account for longer life of new bulbs:

(1) ________ ÷ 5 = ________ $

Step 7 Calculate payback period:

(6) ________ ÷ (5) ________ = ________ Yrs

ECO #41: CONVERT INCANDESCENT LAMPS (CIRCULATION)

Table 41-1

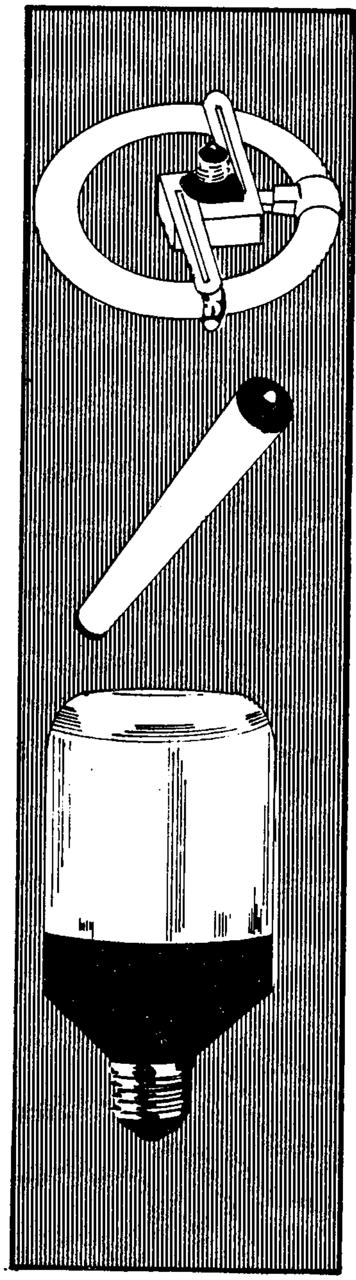
Annual KWH Savings Per Fixture

Existing Average watts per fixture:	KWH saved:
50 - watt fixture:	300
75 - watt fixture:	450
100 - watt fixture:	600
150 - watt fixture:	900

This table assumes circulation areas are lit 24 hours a day. Reduce this number proportionately if lights are on substantially fewer hours per day.

ECO No. 42

Convert incandescent lamps in public areas



Description

Note: This ECO is nearly identical to ECO # 40 and # 41 but applies to public spaces.

Incandescent light bulbs in management/community spaces use up to 3 to 4 times the energy of other, more efficient lamps, such as fluorescent or "electronic" lamp types. Converting these incandescent lamps to high efficiency lamps can be done by either replacing the existing fixtures with new fixture housings or by installing fluorescent or other bulb types directly into the existing sockets.

High-efficiency bulbs combine lower electricity use with good light color quality, longer life and savings of up to 3 or 4 times the energy needed by an incandescent bulb of the same light output. These savings could amount up to 400 KWH per year for a single 100 watt bulb or $20/year at 5 cents per KWH.

Types of High Efficiency Lamps

Fluorescent lamps are the most common type of high efficiency lamps available for indoor use. They can be obtained in a vareity of sizes, wattages and color renditions.

Incandescent-to-fluorescent conversion kits might be used in some locations. These kits can be either screwed into the existing socket or rewired in its place if a more permanent solution, less vulnerable to pilferage, is desired. To further increase savings in selecting new fluorescent fixtures consider only energy-efficient designs. Fluorescent lights have a life of 7 to 12 years longer than incandescent.

Recent developments in lighting research have resulted in the production of "electronic"

replacement lamps for standard incandescent sockets which have wattage savings and life expectancies comparable to the highly efficient flourescent lamps. The new lamps are usually larger than conventional bulbs but fit the same sockets without any physical conversions. These lamps have a life five times longer than incandescent lamps and can produce savings of up to 70 percent.

Modernization Standards Handbook reference: 7-2-5.

Concerns

- Generally, replacement of fixtures can be done only by qualified and licensed electrical contractors. To accept the larger fluorescent fixtures modifications to existing suspended ceilings might also be required. Replacement of bulbs, of course, can be done by maintenance staff.

- Because of their larger size "electronic" bulbs might not fit all existing incandescent fixtures; they should only be considered for those fixtures where they fit.

- Electronic lamps are a new development in the industry; they may not be available in all areas.

- Ensure that minimum code-required lighting levels are maintained after replacement.

- Energy-saving flourescent lamps and ballasts should be installed wherever possible.

Applicability

5-9 This ECO applies only to projects where office and community areas are lighted with incandescent lamps.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of replacing office and community areas light bulbs: ________ $

Step 2 Transfer the following information from the survey:

5-9 **a** Number of incandescent fixtures in office/community areas: ________

5-9 **b** Average watts per fixture: ________ W

10-1 **c** Cost of electricity: ________ $/KWH

Step 3 Obtain the following value from Table 42-1:

Table 42-1 KW hours saved per year: ________ 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 Divide total cost of replacing lamps by 5 to account for longer life of new bulbs:

(1) ________ ÷ 5 = ________ $

Step 7 Calculate payback period:

(6) ________ ÷ (5) ________ = ________ Yrs

ECO #42: CONVERT INCANDESCENT LAMPS (PUBLIC AREAS)

Table 42-1

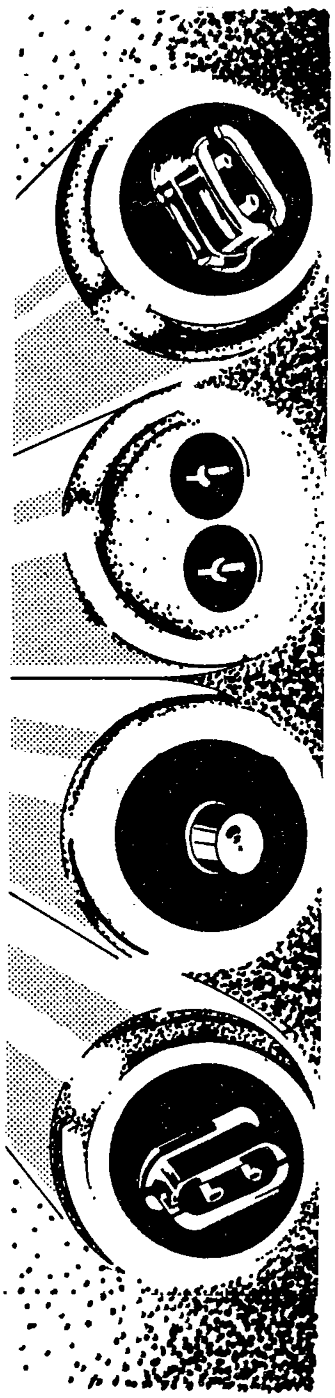
KWH Saved Per Fixture Type (watts)

Existing Average Watts per fixture:	KWH saved:
50 - watt fixture:	100
75 - watt fixture:	150
100 - watt fixture:	200
150 - watt fixture:	300

These savings assume an average use of 8 hours per day.

ECO No. 43

Replace fluorescent bulbs



Description

Note: Since greater savings can be achieved by converting incandescent lights to fluorescent see ECOs 40, 41 and 42 for incandescent conversions. This ECO will analyze only conversion of fluorescent bulbs and it applies to fixtures and areas where previous ECOs did not apply.

Replacement bulbs for less-efficient fluorescent lamps are available which can provide the same or slightly lower light output at 10 to 20% lower wattage consumption. Unlike other bulb conversions, these require no changes to the fixtures, housings, power supplies or controls; old bulbs need to be replaced with new, energy-saving lamps.

Energy-efficient lamps are slightly higher priced, but since the original cost of the bulb usually amounts to only 5% of the life-span operating costs, they are very cost-effective, generally providing net savings during the first year of operation.

Installation Guidelines

Since fixtures need no modification in this ECO, replacement can be easily done by PHA maintenance staff.

Although this ECO assumes that all lamps will be replaced at one time, these same lamps might be used as replacement fixtures during regularly scheduled bulb replacement programs.

Modernization Standards Handbook reference: 7-2-5.

Concerns

- Consult manufacturers' representatives and literature for proper replacement models; More than one type of replacement lamp might be needed to fit all existing fixtures.

- Replacement lamps selected should have an equivalent or longer life than conventional lamps. Consult manufacturers' literature for data.

- Combine bulb replacement with general lighting maintenance programs, such as cleaning of fixtures, de-lamping, etc.

- If tenants are individually metered (and pay their own electricity bills) do not include dwelling unit lamps in the total number of lamps to be replaced but advise them to do it on their own. If the building owner pays all electricity bills, include dwelling unit lamps in this ECO.

- Inform all tenants not to replace the new energy efficient lamps with conventional units when they burn out.

- Higher-efficiency lamps might have a lower lighting output than the lamps they replace. Make sure minimum code-required light levels are met.

Applicability

5-9 This ECO applies only to projects without energy-efficient incandescent or fluorescent lamps in all fixtures in public or office spaces.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of replacing all existing fluorescent lamps with "high-efficiency" lamps: ________ $

Step 2 Transfer the following information from the survey:

5-9 **a** Predominant fixture type: ________

5-9, 10-1 **b** Total number of fluorescent fixtures in project (office and circulation areas only): .... ________

10-1 **c** Cost of electricity: ________ $/KWH

Step 3 Obtain the following value from Table 43-1:

Table 43-1 KWHs saved per typical fixture type: ________ KWH/yr

Step 4 Estimate total 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

Table 43-1

KWH Savings per Fixture Type per Year

Fixture Type:		KWH Savings:
2 tubes	4 feet	30 KWH
4 tubes	4 feet	60 KWH
2 tubes	8 feet	60 KWH
6 tubes	4 feet	100 KWH
4 tubes	8 feet	120 KWH
8 tubes	4 feet	120 KWH

Savings estimates based on 430 milliamp lamps and ballast.

ECO No. 44

Install high-efficiency ballasts

Description

New energy efficient ballasts are now available that replace standard fluorescent ballasts with units that will save lighting energy costs without reducing the lighting level. They save electricity by providing electric energy to the fluorescent lamps more efficiently.

High-efficiency ballasts are made by many manufacturers and replace existing standard ballasts without any special wiring. Additional advantages of these new ballasts include extended life (at least twice that of standard ballasts) and lower operating temperatures (reducing air conditioning loads).

Replacement Guidelines

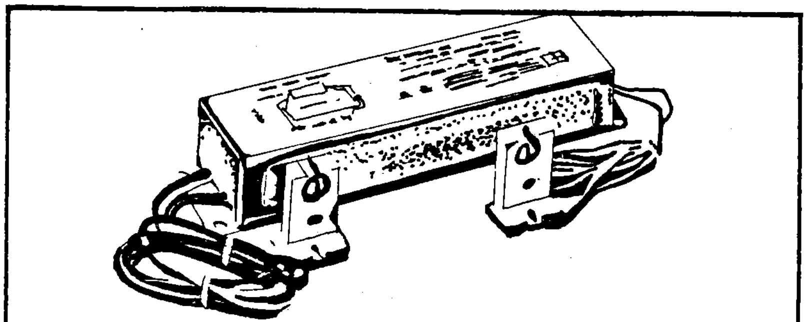
These ballasts are more expensive and might only be cost effective at a time when standard ballasts need replacing. At that time the cost of this ECO would be equal to the difference in price between high-efficiency ballast and standard ballasts, rather than the full cost of new units.

Modernization Standards Handbook reference: 7-2, 4,5.

Concerns

- High efficiency ballasts must meet industry standards for fire safety and must be UL approved.

- Ballasts must be installed by qualified electricians.



Applicability

5-8,9 This ECO applies only to projects without high-efficiency fluorescent light ballasts.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of installing new high-efficiency ballasts: ________ $

Step 2 Transfer the following information from the survey:

5-8,9 **a** Predominant type of fluorescent fixture: ________

5-8,9 **b** Number of fluorescent fixtures: ________

10-1 **c** Cost of electricity: ________ $/KWH

Step 3 Obtain the following value from Table 44-1:

Table 44-1 KWH savings per year with new ballast: ________ 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 Divide total cost by 2 to account for longer life of new ballasts:

(1) ________ ÷ 2 = ________ $

Step 7 Calculate payback period:

(6) ________ ÷ (5) ________ = ________ Yrs

ECO #44: INSTALL HIGH EFFICIENCY BALLASTS

Table 44-1

KWH Savings per Fixture Type per Year

Fixture Type:		KWH Savings:
2 tubes	4 feet	33.6 KWH
4 tubes	4 feet	67.2 KWH
2 tubes	8 feet	67.2 KWH
6 tubes	4 feet	100.7 KWH
4 tubes	8 feet	134.3 KWH
8 tubes	4 feet	134.3 KWH

Savings assume average time fixtures are tuned on is 10 hours per day. Adjust above numbers as proportionately if actual time on is substantially different.

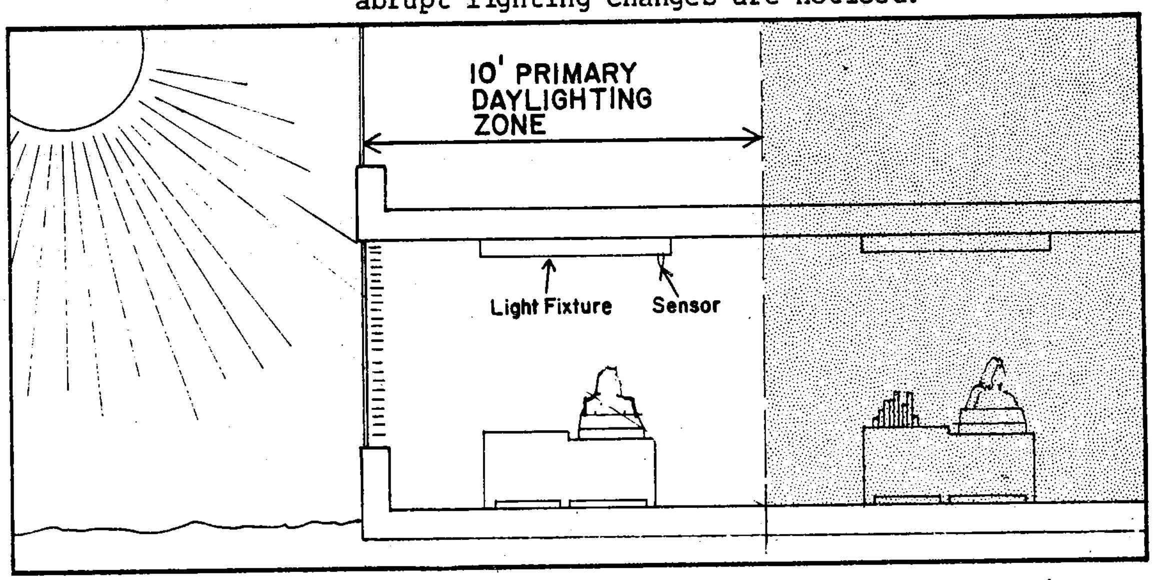
ECO No. 45

Install daylighting controls

Description

If the project has fluorescent lighting fixtures near window areas (within about 10 feet), daylighting can frequently be used to provide a portion of the lighting needs.

By dimming these fixtures available daylight can be utilized to provide general lighting. This is accomplished by a system consisting of a photoelectric sensor mounted below the fixture, a dimmer with controls and appropriate dimming ballast. The sensor measures available daylight and dims the output (and energy use) of fluorescent tubes as much as possible while maintaining the same lighting levels as in adjacent space where fluorescent tubes are operating at full capacity. This dimming is done gradually so no abrupt lighting changes are noticed.



Savings due to decreased electric consumption vary depending on amount and type of windows and existing lighting levels. Where typical fluorescent lights near windows are on all day, however, energy consumption can usually be decreased by 40 percent to 60 percent.

Installation of the required dimming equipment is relatively inexpensive since it can usually be

accomplished on an individual fixture and requires no rewiring of existing circuits.

The amount of available daylight depends on several factors. These include window area above desk height, type of glass, whether or not there are exterior overhangs, and the spacing of windows. It should be noted, however, that orientation (direction in which windows faces, such as north or east) has little effect on the amount of available diffuse light.

Price Guidelines

The following table represents approximate costs of daylighting controllers per fixture, based on averages obtained from manufacturers' literature and typical installation labor costs. These costs (in 1980 dollars) are guidelines only to assist in verifying cost estimates from contractors who might not be familiar with these products.

Table 45-1

Cost Per Installed Fixture

Fixture type:		Average cost:
2 tubes	4 feet	$75
4 tubes	4 feet	$125
2 tubes	8 feet	$125
6 tubes	4 feet	$190
8 tubes	4 feet	$255
4 tubes	8 feet	$255

Modernization Standards Handbook reference: 7-2-4.

Concerns

- Local codes usually require that installation of dimming controls be done by qualified electricians only.

- The use of daylight is only possible if the working surfaces are not shaded from light coming from windows by obstacles or partitions. Work surfaces should be rearranged to have the light from the windows come from the opposite side of the worker's writing arm. This insures that their arm will not cast a shadow on their work surface.

Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

This ECO applies only to:

5-11 a) projects where offices and community areas are located in areas with windows,

5-12 b) projects where lights are not routinely turned off during daylight hours.

Check here is this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Table 45-1 — 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:

5-13 **a** Number of fluorescent fixtures within 10 feet of exterior windows: ________

5-14 **b** Predominant type of fluorescent fixture: ________

10-1 **c** Cost of electricity: ________ $/KWH

Step 3 Obtain the following values from Tables 45-2 and 45-3:

Table 45-3 **a** Watts per fixture: ________ W

Table 45-2 **b** Daylight availability factor: ________

Step 4 Estimate energy savings:

(2a) ________ X (3a) ________ X (3b) ________ = ________ KWH/yr

Step 5 Calculate annual cost savings:

(4) ________ X (2c) ________ = ________ $/yr

Step 6 Calculate payback period:

(1) ________ ÷ (5) ________ = ________ Yrs

Table 45-2

Daylight Availability Factors

Existing Overhang and Glazing Condition:	Percent Glass Area: 75-100%	50-75%	25-50%
No overhang:			
Clear Glass:	1.55	1.48	1.40
With Overhang:			
Clear glass:	1.40	1.33	1.25
Tinted Glass:	1.35	1.28	1.20

Instructions: 1) Estimate the percentage of your exterior wall above the desk height which is glass; the catagories are 25-50%, 50-75%, 75-100%. 2) Determine whether you have exterior overhangs projecting at least 2 feet from the outside face of the glass at the top of the window. 3) Find your glass type (clear or tinted). 4) Move across in until you reach the appropriate percentage of glass area above desk height. Circle and transfer the appropriate factor to Step 3.

Table 45-3

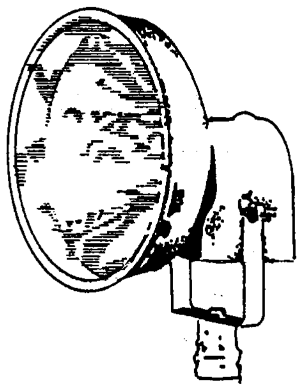
Watts per Typical Fixture Type

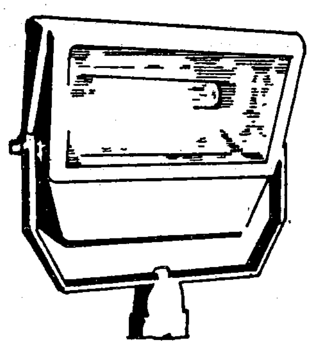
Fixture Type:		Watts
2 tubes	4 feet	92 Watts
4 tubes	4 feet	184 Watts
2 tubes	8 feet	184 Watts
6 tubes	4 feet	276 Watts
4 tubes	8 feet	368 Watts
8 tubes	4 feet	368 Watts

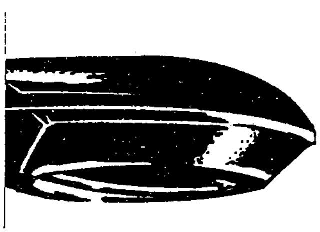
Table based on 430 milliamp lamps and ballast.

ECO No. 46

Convert site lighting lamps







Description

Existing site lighting fixtures, including those for general ground and parking areas, can be converted to energy-efficient sodium vapor fixtures.

Sodium vapor fixtures provide approximately twice as much light per watt of energy as mercury vapor lighting and as much as five times the light per watt as incandescent lighting. Both high and low-pressure sodium vapor lamps are applicable in this ECO.

Modernization Standards Handbook reference: 7-2,5.

Concerns

- Recommended lighting levels must be maintained after conversion (see codes and regulations).

- In some cases existing site lighting levels may be excessive; reducing site lighting levels to only those necessary will save additional energy.

Applicability

This ECO applies only to

5-1 a) projects without sodium-vapor site lamps, and

5-4 b) projects where owner pays for cost of site lighting.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost for converting present site lighting fixtures to sodium vapor lamps: ________ $

Step 2 Transfer the following information from the survey:

5-1 **a** Predominant type of present site lighting lamps: ________

5-3 **b** Consumption in watts per fixture for present lamps: ________ W/unit

5-2 **c** Number of present fixtures: ________

10-1 **d** Cost of electricity: ________ $/KWH

Step 3 Obtain the following value from Table 46-1:

Table 46-1 Energy reduction savings factor: ________

Step 4 Estimate energy savings:

(2b) ________ X (2c) ________ x (3) ________ = ________ KWH/yr

Step 5 Calculate cost savings:

(4) ________ X (2d) ________ = ________ $/yr

Step 6 Calculate payback period:

(1) ________ ÷ (5) ________ = ________ Yrs

Table 46-1

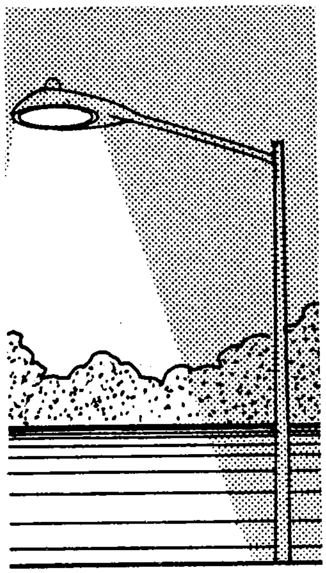
Savings Factors for Conversion to Sodium Vapor Lamps

Present Lamp Type:	Reduction Factor:
Mercury Vapor Lamps (self ballasted)	2250 3690
Metal Halide Lamps	900
Incandescent and Tungsten Halogen Lamps	3600
Fluorescent	1350

The above calculations assume that present light output will be maintained after conversion.

ECO No. 47

Install site lighting photo-controls



Description

Site lighting can be switched on and off by an automatic photo-cell controller. The controller monitors the natural light levels (daylight) and switches artificial site lighting only when available daylighting falls below a predetermined level.

Unless site lighting is operated by a timer clock, site lights are usually switched on when the maintenance staff leaves at the end of the working day, regardless of the available daylight. Photo-cell controllers can save energy by reducing the hours of lamp operation.

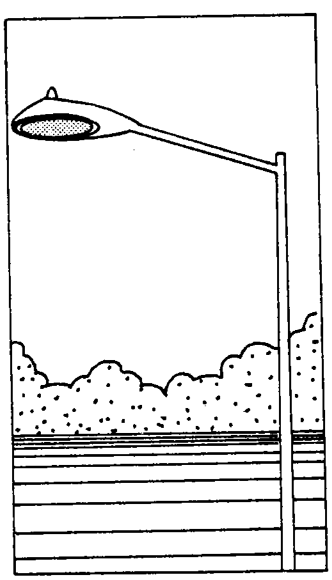
Installation Guidelines

The number of necessary photo-cell controllers depends on the wiring design of your existing lighting. Although photo-cells are usually mounted on each fixture or group of fixtures to monitor lighting levels at the specific site location, they can also be centrally mounted, in closer proximity to switching and wiring gear.

Modernization Standards Handbook reference: 7-2-5.

Concerns

- Consult manufacturers' representatives or literature for lamp-to-photo-cell compatibility, requirements and assistance in system design.



Applicability

This ECO applies only to:

5-5 a) projects where site lighting is controlled manually or by clock timer,

5-4 b) projects where owner pays for site lighting electricity.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of installing photo-cell controllers for all general site and parking lights: ________ $

Step 2 Transfer the following information from the survey:

5-6 **a** Annual hours site lighting is on: ________ Hrs/yr

5-2 **b** Number of site fixtures: ________

5-3 **c** Watt consumption per site fixture: ________ Watt

10-1 **d** Cost of electricity: ________ $/KWH

Step 3 Calculate present site lighting energy consumption:

(2a) ______ X (2c) ______ X (2d) ______ = ________ KWH/yr

Step 4 Calculate photo-cell controlled site lighting energy consumption:

4,500 hrs X (2c) ______ X (2d) ______ = ________ KWH/yr

Step 5 Estimate annual energy savings:

(3) ______ - (4) ______ = ________ KWH/yr

Step 6 Calculate annual cost savings:

(5) ______ X (2b) ______ = ________ $/yr

Step 7 Calculate payback period:

(1) ______ ÷ (5) ______ = ________ Yrs

ECO No. 48

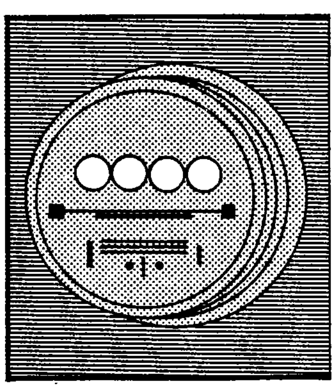
Install tenant metering

Description

HUD regulations may require that, to the extent practicable, all electricity consumed by the tenants in public housing should be individually metered. This can be accomplished either through provision of "retail service" (dwelling units individually billed by the utility) or through the use of check meters. In either case the tenants receive a reasonable allowance from the PHA for average usage and only the excess usage, above this allowance, will be paid by the tenant.

This ECO discusses only electricity metering ECO #18 deals with metering of remaining fuel types.

If no individual tenant metering exists and tenants and management agree that installing tenant meters will give the tenants incentive to keep electricty use below the allowable limit, the average saving could be 15 to 25 percent of the total electricity consumption. Incentives to tenants include saving money if bills are less than allowances and reducing pressure to increase rents.



Types of Tenant Metering

Retail service metering requires that the utility provide individual metering to every dwelling unit and tenants would purchase electricity directly from the utility.

Checkmetering (also called submetering) requires a device for measuring electric consumption within each individual dwelling unit where the utility service is supplied by the owner through a "master" meter. The owner then ascertains from its

reading of the checkmeter it has installed the amount of tenant usage.

<u>Establishing allowable usage</u>. Allowable tenant electric usage, beyond which public housing tenants are responsible, must be established; HUD regulation provides for two methods.

Modernization Standards Handbook reference: 7-2.

Concerns

- State and local laws should be analysed to determine if checkmetering is permissible.
- The utility supplier might have regulations against checkmetering.
- Prior to making any conversion to Retail Service the project management should adopt revised rent schedules providing appropriate allowances for the tenant-supplied Utilities resulting from the conversion.
- Prior to implementing any modifications to Utility Services arrangements with the tenants or charges with respect thereto, the requisite changes should be made in tenant dwelling leases.
- To the extent practicable in public housing, PHAs should work closely with tenant organizations in making plans for conversion of Utility Service to individual metering, explaining the national policy objectives of energy conservation, the changes in charges and rent structure which will result, and the goals of achieving an equitable structure which will be advantageous to tenants who conserve energy.
- A transition period of at least six months should be provided in the case of initiation of Checkmeters during which tenants will be advised of the charges but during which no Surcharge will be made, based on such readings. This trial period will afford tenants

ample notice of the effects the Checkmetering System will have on their individual Utility charges and also afford a test period for the adequacy of the Utility allowances established.

- During and after the transition period the project manager should advise and assist those tenants with high utility comsumption on methods for reducing their usage. This advice and assistance may include counseling, installation of new energy conserving equipment or appliances and corrective maintenance.

Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

This ECO applies only to projects without individual or checkmeters and where such meters are practical and mutually beneficial to both tenant and PHA.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain the total cost of installing checkmeters or individual retail service: ______ $

Step 2 Transfer the following information from the survey:

10-1 **a** Total annual tenant electrical consumption: ______ KWH/yr

10-1 **b** Cost of electricity: ______ $/KWH

Step 3 Obtain the following values from Tables 48-1:

Table 48-1 Reduction factor of utility consumption: ______ (%)

Step 4 Estimate annual energy savings:

(2a) ______ X (3) ______ = ______ KWH/yr

Step 5: Calculate annual cost savings:

(4) ______ X (2b) ______ = ______ $/yr

Step 5 Calculate present worth of savings:

(5) ______ X (3c) ______ = ______ $

Step 6 Calculate payback period:

(1) ______ ÷ (5) ______ = ______ Yrs

Table 48-1

Reduction Factors For Various Utility Functions

Utility Functions:	Tenant Retail Services:	Checkmeters:
Lights and appliances only	.25	.15
Lights, appliances and Domestic Hot Water	.35	.25

ECO No. 49

Correct low power factor

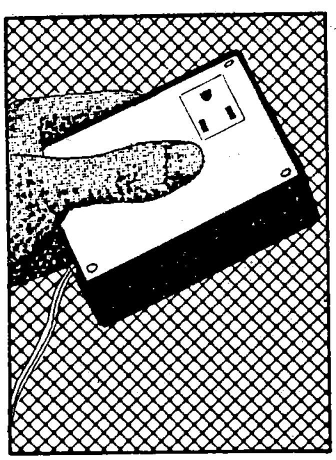
Description

Power factor is the ratio of the power charged, as measured by a meter, to the actual power used by electric equipment. Since this extra power is not measured by an electric meter, many utility companies impose an additional penalty charge if the power factor falls below a certain level.

Every inductive device, such as electric motors (including those in all fans, air conditioners, refrigerators and elevators), transformers, etc., have an inherently low power factor.

Most utility companies assume an average level for power factors (typically .85 to .9), and base their normal charges on this level. However, if a user has a lower-than-average power factor, a surcharge is imposed to reflect the actual energy supplied by the utility. If the project is charged extra because of a low power factor (it can be checked by looking at electrical bills), installing devices to correct it will reduce electricity bills because energy is being saved at the utility plant and they will lower the rate in return.

Types of Power Factor Correctors



In the past, power factor correction could be achieved only by use of synchronous motors and condensers and static capacitors. Recently, however, electronic correctors have been introduced at relatively modest prices as another option.

Synchronous motors are generally impractical except for industrial applications. Synchronous condensers are very expensive. Both capacitors and the new correctors are, however, a viable alternative. They are relatively simple to install and have reasonable payback periods.

Both can be installed anywhere in the electrical system. Electronic controllers are probably the easiest to install and, in fact, requires no electrician. They are based on a NASA developed patent. Industrial versions are still quite

expensive. Recently, however, simpler consumer market modules, tailored to specific applications (such as refrigerators) became available at a very low cost ($25-30 each).

Definiton of Power Factor

The following description of power factor is excerpted from "Total Energy Management", NEMA:

> Power factor is a ratio of real power (KW) to apparent power (KVA) or,
>
> $$\text{Power Factor} = \frac{\text{Real Power (KW)}}{\text{Apparent Power (KVA)}}$$
>
> Electric utilities must provide both real and reactive power for their customers. Reactive power does not register on a kilowatt hour meter, but producing it still requires the utility to put additional investment into capacitors and generating, transmission and distribution facilities.
>
> Many utilities make up for the expense of producing reactive power by including power factor provisions in their rates. As it so happens, many utilities are defining low power as anything less than .9. Thus if a building consumes 10 million KWH per year at 3.5 cents per KWH and has a power factor of .87, its penalty would be:
>
> $$\frac{\text{KWH/Yr}}{\text{Power Factor}} - \frac{\text{KWH/Yr}}{.9} \times \text{KWH rate}$$
>
> $$\frac{10{,}000{,}000}{.87} - \frac{10{,}000{,}000}{.9} \times \$.035 = \$13{,}409.03$$

Modernization Standards Handbook reference: 7-2.

Concerns

- The help and advice of an electrical consultant or an engineer, and representative of the local utility company will be needed to develop a proper power factor correction plan.

Determine whether or not the project is paying a penalty charge for a low power factor. Determine what corrections have to be made to avoid these penalties and specify the measures accordingly.

- Most utility companies have a surcharge for customers with a power factor of 0.85 to 0.90 or less. If this is the case instruct the engineer or contractor to design a correction plan that will raise the factor to that level. If surcharge structure is different, however, seek advice from your utility company as to the most effective and cost-beneficial target level. Ask them to estimate expected annual cost savings.

- Consult the local electrical codes and national standards for requirements and/or specified locations for installation.

Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

6-5 This ECO applies only to projects charged extra for low power factor.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Note: Lowering power factor will not result in energy savings as shown on your electrical meter reading; it will, however, result in lower electrical cost. Most utility companies charge extra for all customers with a power factor of 0.85 to 0.90 or less. If you can raise your power factor to 0.85 to 0.90 or more, you will not be charged extra, and those are your effective cost savings.

Step 1

Obtain total cost of installing power factor correction devices to eliminate low power factor surcharges: ________ $

Step 2

Transfer the following information from the survey:

6-5 Present annual power factor surcharge: ________ $/yr

Step 3

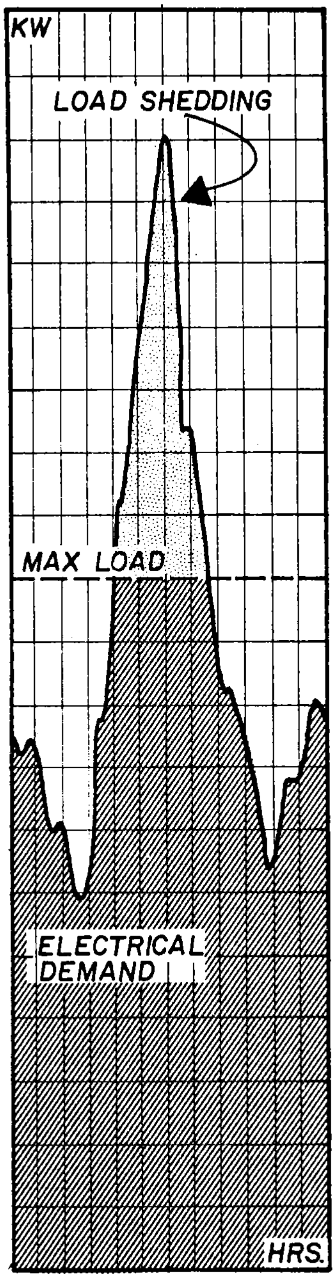
Calculate payback period: Note: The following equation assumes that low power-factor surcharges will be eliminated through this ECO and, as a result, savings are assumed to be equal to present surcharges. If the project surcharge structure is different, ask the utility company to estimate annual savings and use that amount in the equation (i.e., as Step 2 amount):

(1) ________ ÷ (2) ________ = ________ Yrs

Note: There are no energy savings associated with this ECO.

ECO No. 50

Install load-shedding controls



Description

Utility companies base their charges on both, total usage of electricity and maximum, or "peak", load demand. The major purpose of load shedding, or limiting, controllers is to reduce the peak electrical loads of a building, therefore reducing the overall price of electricity.

The peak load demand surcharge is made by utility companies for installing and maintaining a service capacity larger than would be necessary for the average power demand. This extra capacity required is very expensive to the utilities, because it is rarely used -- usually less than 5% of the year.

Peak demand is usually established by measuring the maximum average load over a specified time period (usually 15 or 30 minutes) for each given month. It is this load that is then used to establish the overall price schedule for that month's billing.

Peak loads can be reduced by limiting or eliminating electrical equipment operation during maximum use periods. As such, it applies only to buildings which have enough electrical equipment that can be controlled at certain times. Typical loads that are difficult to defer include:

1. Lights;
2. D.U. heating (except for very short periods of time);
3. D.U. cooling;
4. Cooking;
5. One-cab elevators.

Typical controlled loads which are easier to defer include:

1. Domestic Hot Water;
2. Heating & cooling of office and public spaces, corridors and stairways;

3. Use of auxilliary equipment (snow melters, office machines, vending machines, etc.);
4. Extra elevators & service elevators;
5. Large pumps (including water & storage tank pumps, etc.).

Load shedding can be accomplished by manual procedures and automatic controllers. Although manual methods may be very effective if properly and reliably instituted, for this ECO, installation of automatic equipment is assumed.

Available automatic load limiting devices (range in complexity from manual switches, simple thermal sensors (which work like circuit breakers to switch off low-priority equipment when a pre-set building load is reached) time clocks, and sophisticated electronic units (that read current loads and control many pieces of equipment through timers and priority-programmed switches).

One such system, called the Permissive Load Controller (PLC) reduces peak kilowatt demand by disconnecting equipment that is not vital for running a building or whose use can be deferred to a different time.

To institute this ECO, consult with the local utility to analyze the peak load rate structure and to determine maximum load times. The utility and your maintenance or mechanical engineers should help in determining how peak loads can be reduced (types of controllers necessary) and selection of deferrable equipment.

Modernization Standards Handbook reference: 7-2.

Concerns

- This ECO should be designed and installed by a qualified outside consultant if it proves cost-effective in this workbook.

- Unlike other ECOs, which are specifically designed to save energy, load shedding primarily saves cost, not energy, although some energy is saved by switching equipment off, rather than just deferring its use to other times. This ECO is included here because

of its importance in reducing energy costs to the housing authority, or owner and its overall desirability in terms of putting lower demands on utility companies. Energy savings are not included in the cost/benefit analysis because of the difficulty of estimating actual load reductions.

Note: The results of this analysis are only preliminary because many additional factors, too detailed to include here, must be considered. If this cost/benefit analysis results in a payback period of 15 years or less, a more detailed analysis should be performed.

Applicability

6-3 This ECO applies to projects where utility bills include peak load demand surcharges.

Check here if this ECO applies: ☐

Cost/Benefit Worksheet

Step 1 Obtain total cost of buying and installing load shedding controllers: ________ $

Step 2 Transfer the following information from the survey:

There are two ways of calculating peak load costs and expected savings. If your pay structure is based on average load pricing plus peak load pricing, fill in items 2b and 2e. If your pay structure is based on a KWH pricing that includes a peak load demand charge, fill in items 2f and 2g.

6-8 **a** Annual peak load demand charge ________ $/yr

Step 3 Obtain from your local utility company or contractor that will provide controller an estimate of the percent savings of your annual peak load demand charge (express as decimal): ________

Step 4 Calculate annual cost savings:

(2a) ________ X (3) ________ = ________ $/yr

Step 5 Calculate payback period:

(1) ________ ÷ (4) ________ = ________ Yrs

Note: There are not energy savings associated with this ECO.

Appendix C
Summary of Results

APPENDIX C

Summary Of Results

As you complete each ECO analysis transfer to the tables on the following 5 pages the final results. If an ECO was judged not applicable mark V in "N/A" column. For all applicable ECO's transfer results of Cost/Benefit analysis as they appear on the last line of each ECO worksheet.

If you are requesting funds for ECOs not listed in this workbook, summarize their results in the last table provided.

When all results have been obtained proceed to complete the second half of this appendix.

Note that gray tone areas indicate that additional analysis is required for these ECOs.

Annual Savings should be stated in $ (dollars) and in Units (kilowatt hours, therms, gallons, etc.)

APPENDIX C: SUMMARY OF RESULTS

Architectural ECOs:

ECO Number	ECO Name	N/A	Total Cost ($)	Annual Savings $	Annual Savings Units	Payback Period
ECO #1:	Improve Architectural O&M					
* ECO #2:	Install Replacement Windows Double Glazed					
	Triple Glazed					
* ECO #3:	Install Storm Windows					
* ECO #4:	Weatherstrip Windows & Doors					
ECO #5:	Install Insulaing Window Shades					
ECO #6:	Install Window Sun Shades South					
	East & West					
ECO #7:	Install Storm Doors					
ECO #8:	Construct Vestibules Lobby					
	Side Entry #1					
	Side Entry #2					
ECO #9:	Install or Increase Attic Insulation 4"					
	8"					
	12"					
ECO #10:	Install Roof Insulation					
ECO #11:	Install Wall Insulation					
ECO #12:	Install Passive Solar Collectors					

* NOTE: ECOs 2, 3, and 4 are mutually exclusive; funds are required for only one of them.

APPENDIX C: SUMMARY OF RESULTS

Heating System ECOs:

ECO Number	ECO Name	N/A	Total Cost ($)	Annual Savings $	Annual Savings Units	Payback Period
ECO #13:	Install Setback Thermostats					
ECO #14:	Improve Space Heating O&M					
ECO #15:	Install Flue Dampers					
ECO #16:	Convert to Electric Ignition					
ECO #17:	Reduce Burner Nozzle Size					
ECO #18:	Install Tenant Fuel Metering					
ECO #19:	Improve Central Heating O&M					
* ECO #20:	Install Modulating Burners					
* ECO #21:	Install Flue Heat Recovery					
* ECO #22:	Install Turbulators					
* ECO #23:	Install Summer-Time DHW Heaters					
ECO #24:	Replace Obsolete Heating Plant					
ECO #25:	Improve Central Distribution O&M					
ECO #26:	Insulate Hot Water or Steam Pipes					
ECO #27:	Install Radiator or Zone Controls					

* NOTE: ECO #24 is mutually exclusive of ECOs 20 through 23. Fund ECO #24 only if all the others have a payback period greater than 15 years or are not applicable. If any of ECOs 20-23 apply or pay back in 15 years or less, do not fund ECO #24. However, a further analysis of these ECOs might suggest that replacing an obsolete heating plant (ECO #24) is a better investment.

Secondary System ECOs:

ECO Number	ECO Name	N/A	Total Cost ($)	Annual Savings $	Annual Savings Units	Payback Period
ECO #28:	Improve Domestic Hot Water O&M					
ECO #29:	Install Flow Restrictors					
ECO #30:	Insulate DHW Tanks					
ECO #31:	Convert DHW Systems to Solar					
ECO #32:	Install DHW Off-Peak Controls					
ECO #33:	Install Cold Water Saving Devices					
ECO #34:	Convert Water Supply Pumps					
ECO #35:	Convert Laundry to Cold Rinse					
ECO #36:	Improve Ventilation/AC O&M					
ECO #37:	Install Ventilation Warm-Up Cycle					
ECO #38:	Replace Obsolete AC Equipment					

APPENDIX C: SUMMARY OF RESULTS

Electrical System ECOs:

ECO Number	ECO Name	N/A	Total Cost ($)	Annual Savings $	Annual Savings Units	Payback Period
ECO #39:	Improve Electrical/ Lighting O&M					
ECO #40:	Convert Incandescent Lamps (Dwellings)					
ECO #41:	Convert Incandescent Lamps (Circulation)					
ECO #42:	Convert Incandescent Lamps (Public Areas)					
ECO #43:	Replace Flourescent Bulbs					
ECO #44:	Install High-Efficiency Ballasts					
ECO #45:	Install Daylighting Controls					
ECO #46:	Convert Site Lighting Lamps					
ECO #47:	Install Site Lighting Photo-Controls					
ECO #48:	Install Tenant Metering					
ECO #49:	Correct Low Power Factor					
ECO #50:	Install Load-Shedding Controls					

Additional ECOs not listed in this handbook:

ECO Number	ECO Name	N/A	Total Cost ($)	Annual Savings $	Annual Savings Units	Payback Period
ECO #X1:						
ECO #X2:						
ECO #X3:						
ECO #X4:						
ECO #X5:						
ECO #X6:						
ECO #X7:						
ECO #X8:						
ECO #X9:						
ECO #X10:						

APPENDIX C

Funds Required

The following three pages summarize the ECO selection process and constitute basis for HUD funds application. Complete these forms based on information in Appendix C: Summary of Results, and as clarified in footnotes.

Complete the forms by listing all applicable ECOs with a payback period of 15 years or less. For ease of evaluation, list them in order of shortest-to-longest payback period. Do not list ECOs with a payback period of more than 15 years.

Note that cost data on these forms is divided into two columns. Cost numbers marked with gray tone in Appendix C: Summary of Results forms should be entered in the second column (Analysis Required). All costs without the gray tone should be entered in the first cost column (Ready to Proceed).

This is necessary to distinguish which ECOs are ready to implement (those requiring no further analysis) and those that require additional analysis by Architect/Engineer or other qualified person to substantiate the preliminary results of this workbook. If, however, additional and more detailed analysis has been made for these ECOs supporting data can be attached.

If you are utilizing ECOs not included in this workbook include them here, mark them with an asterisk and attach all supporting data.

If you have completed more than one workbook for your project, prepare separate summaries for each workbook.

APPENDIX C: SUMMARY OF REQUIRED FUNDS EXHIBIT

Project ID number: .... __ __ /__ __ __ /__ __ __

Project Name: ______________________________

Project Address: ______________________________

This application summarizes Energy Handbook # ______of_____completed.

ECO Number and Name (in order of shortest-to-longest payback period)	Payback Period (Yrs)	Annual Savings $	Annual Savings Units	Cost of ECO ($): Ready to Proceed	Cost of ECO ($): Analysis Required
Sub-totals (this page):					

APPENDIX C: SUMMARY OF REQUIRED FUNDS EXHIBIT

Project ID number: .... __ __ /__ __ __ /__ __ __

Project Name: ______________________________

Project Address: ______________________________

This application summarizes Energy Handbook # ______of_____completed.

ECO Number and Name (in order of shortest-to-longest payback period)	Payback Period (Yrs)	Annual Savings		Cost of ECO ($):	
		$	Units	Ready to Proceed	Analysis Required
Sub-totals (this page):					

APPENDIX C: SUMMARY OF REQUIRED FUNDS EXHIBIT

Project ID number: .... __ __ /__ __ __ /__ __ __

Project Name: ______________________________

Project Address: ______________________________

This application summarizes Energy Handbook # ______of_____completed.

ECO Number and Name (in order of shortest-to-longest payback period)	Payback Period (Yrs)	Annual Savings $	Annual Savings Units	Cost of ECO ($): Ready to Proceed	Cost of ECO ($): Analysis Required
Sub-totals (this page):					

Totals (add pages 1, 2, and 3):

Appendix D
Climate Data

APPENDIX D
Climate Data

Location	Heating Degree Day Zone	Solar Factor	Winter Solar Factor	Heating Season Hours
Alabama				
Birmingham	2.02	.166	.248	2316
Mobile	1.28	.107	.243	1908
Montgomery	1.66	.136	.249	2112
Arizona				
Phoenix	1.20	.071	.343	1860
Tuscon	1.35	.082	.336	1980
Arkansas				
Fort Smith	2.27	.173	.269	2244
Little Rock	2.28	.177	.264	2244
California				
Bakersfield	1.60	.101	.324	2172
Fresno	1.91	.120	.324	2304
Long Beach	1.25	.085	.299	2880
Los Angeles - City	1.00	.068	.300	2952
Oakland	2.07	.138	.305	4380
Sacramento	2.02	.128	.322	2532
San Diego	1.16	.080	.295	2688
San Francisco - City	2.13	.142	.307	4380
Colorado				
Colorado Springs	4.01	.242	.339	3312
Denver	3.67	.222	.338	3252
Grand Junction	3.42	.203	.345	2892
Pueblo	3.24	.196	.339	3300
Connecticut				
Hartford	3.94	.346	.233	3168
Delaware				
Wilmington	3.01	.242	.254	2820
DC				
Washington - Nat'l AP	2.70	.222	.249	2700

APPENDIX D: CLIMATE DATA

Location	Heating Degree Day Zone	Solar Factor	Winter Solar Factor	Heating Season Hours
Florida				
Jacksonville	1.04	.084	.252	1692
Miami	.17	.014	.238	1200
Orlando	.60	.048	.252	1980
Tallahassee	1.20	.098	.251	1884
Tampa	.59	.048	.251	1116
West Palm Beach	.25	.021	.235	1200
Georgia				
Atlanta	2.17	.178	.249	2316
Augusta	1.83	.148	.253	2064
Macon	1.66	.134	.252	2028
Savannah	1.46	.121	.247	1968
Idaho				
Boise	3.56	.219	.332	3324
Lewiston	3.28	.238	.282	3228
Pocatello	4.45	.270	.337	3480
Illinois				
Chicago - O'Hare AP	4.03	.313	.264	3012
Springfield	3.39	.256	.271	2892
Indiana				
Evansville	2.97	.233	.252	3060
Fort Wayne	3.85	.332	.238	3060
Indianapolis	3.35	.284	.241	2904
South Bend	4.01	.340	.242	3084
Iowa				
Burlington	3.75	.275	.279	2916
Des Moines	4.16	.298	.286	2964
Sioux City	4.38	.308	.291	3036
Kansas				
Dodge City	3.03	.195	.319	2772
Topeka	3.15	.223	.288	2772
Wichita	2.91	.196	.304	2640
Kentucky				
Lexington	2.88	.243	.243	2796
Louisville	2.88	.241	.244	2604

APPENDIX D: CLIMATE DATA

Location	Heating Degree Day Zone	Solar Factor	Winter Solar Factor	Heating Season Hours
Louisiana				
Baton Rouge	1.29	.110	.239	1884
Lake Charles	1.15	.101	.233	1812
New Orleans	1.13	.093	.246	1740
Shreveport	1.60	.128	.256	1956
Maine				
Portland	4.87	.415	.240	3636
Maryland				
Baltimore	2.88	.233	.253	2808
Massachusetts				
Boston	3.43	.286	.246	3144
Michigan				
Detroit - City AP	4.11	.346	.243	3108
Flint	4.44	.386	.235	3432
Grand Rapids	4.28	.357	.246	3252
Minnesota				
Duluth	6.73	.534	.259	3780
Minneapolis-St. Paul	5.38	.403	.274	3156
Rochester	5.43	.420	.265	3288
Mississippi				
Jackson	1.68	.136	.252	2100
Meridian	1.74	.145	.246	2160
Missouri				
Columbia	3.05	.231	.270	2820
Kansas City	3.21	.236	.279	2640
St. Louis	2.90	.219	.271	2664
Springfield	2.83	.215	.270	2722
Montana				
Billings	4.65	.302	.316	3432
Great Falls	4.97	.327	.312	3684
Helena	5.41	.363	.305	3816
Miles City	5.21	.339	.315	3360
Missoula	5.23	.390	.275	3744
Nebraska				
North Platte	4.25	.275	.316	3480

APPENDIX D: CLIMATE DATA

Location	Heating Degree Day Zone	Solar Factor	Winter Solar Factor	Heating Season Hours
Nevada				
Elko	4.86	.287	.348	3636
Ely	5.16	.300	.353	3648
Las Vegas	1.87	.105	.364	2472
Reno	3.67	.205	.367	3552
New Hampshire				
Concord	4.78	.411	.238	3492
New Jersey				
Newark	3.02	.246	.252	2904
New Mexico				
Albuquerque	2.75	.160	.351	2664
Roswell	2.48	.163	.311	2496
New York				
Albany	4.34	.375	.237	3216
Binghampton	4.66	.446	.214	3492
Buffalo	4.36	.401	.223	3276
New York - Central Park	2.96	.257	.236	2892
Rochester	4.17	.377	.226	3252
Syracuse	4.14	.376	.226	3156
North Carolina				
Asheville	2.71	.217	.256	2796
Charlotte	2.22	.175	.259	2448
Greensboro	2.52	.195	.264	2616
Raleigh	2.35	.190	.254	2424
North Dakota				
Bismark	6.15	.411	.307	3480
Fargo	6.30	.441	.293	3444
Ohio				
Akron	3.86	.340	.233	3048
Cincinnatti	2.95	.256	.236	2844
Cleveland	3.75	.337	.228	3012
Columbus	3.48	.307	.232	2940
Dayton	3.44	.293	.240	2916
Toledo	3.96	.335	.242	3096
Youngstown	3.98	.372	.219	3084

APPENDIX D: CLIMATE DATA

Location	Heating Degree Day Zone	Solar Factor	Winter Solar Factor	Heating Season Hours
Oklahoma				
Oklahoma City	2.44	.177	.282	2388
Tulsa	2.43	.184	.269	2340
Oregon				
Medford	2.96	.213	.285	3240
Pendleton	3.14	.224	.287	3120
Portland	2.92	.245	.244	3516
Salem	2.91	.235	.253	3504
Pennsylvania				
Allentown	3.55	.299	.244	3012
Erie	4.32	.396	.223	3096
Harrisburg	3.13	.263	.244	2892
Philadelphia	2.97	.245	.248	2808
Pittsburgh - City	3.17	.291	.223	3036
Rhode Island				
Providence	3.64	.305	.245	3252
South Carolina				
Charleston	1.59	.131	.247	2412
Columbia	1.87	.148	.259	2184
Greenville - Spartanburg	2.18	.173	.258	2412
South Dakota				
Rapid City	4.61	.304	.311	3432
Sioux Falls	5.17	.360	.294	3216
Tennessee				
Chattanooga	2.35	.204	.236	2508
Knoxville	2.37	.198	.245	2508
Memphis	2.23	.177	.258	2292
Nashville	2.44	.206	.242	2448
Texas				
Abilene	1.88	.136	.282	2100
Amarillo	2.68	.170	.322	2736
Austin	1.32	.106	.254	1812
Corpus Christi	.75	.062	.246	1452
Dallas-Fort Worth	1.74	.133	.267	1968
El Paso	1.93	.116	.340	2196
Houston	1.12	.099	.231	1740

Location	Heating Degree Day Zone	Solar Factor	Winter Solar Factor	Heating Season Hours
Texas (Continued)				
Lubbock	2.38	.148	.329	2484
Midland-Odessa	1.89	.119	.323	2100
San Angelo	1.66	.121	.279	1860
San Antonio	1.21	.097	.254	1740
Waco	1.54	.121	.260	1896
Wichita Falls	1.54	.111	.285	2208
Utah				
Salt Lake City	3.65	.220	.340	3168
Vermont				
Burlington	5.20	.458	.232	3372
Virginia				
Norfolk	2.34	.181	.264	2592
Richmond	2.56	.208	.252	2652
Roanoke	2.71	.217	.256	2712
Washington				
Olympia	3.37	.294	.235	4380
Seattle - Urban Site	2.88	.240	.246	3708
Spokane	4.31	.301	.293	3612
Yakima	3.67	.249	.301	3324
West Virginia				
Charleston	2.85	.257	.227	2748
Huntington	2.87	.247	.238	2640
Wisconsin				
Green Bay	5.34	.415	.264	3408
La Crosse	4.82	.372	.266	3168
Madison	5.10	.390	.268	3216
Milwaukee	4.84	.375	.264	3312
Wyoming				
Casper	4.91	.284	.355	3552
Cheyenne	4.64	.286	.333	3684
Sheridan	5.01	.330	.311	3552

Appendix E
Tenant Checklist

APPENDIX E

Tenant Checklist

The following is a list of operations and maintenance items that will improve the energy-efficiency of equipment and household items owned and controlled by the tenants. The list should be made readily available to all tenants and they should be encouraged to follow all hints and suggestions listed here.

Range.

- Never use the range (oven and burner top) to heat a room.
- Use top of range whenever possible instead of oven.
- Use small cooking appliances (toasters, electric frypans, etc.) instead of the range whenever practical.
- Do not open oven doors while baking.
- Do not preheat oven or broiler.
- Try to cook many things at once in the oven.
- On electric ranges turn off burners 5 minutes before end of cooking time; heat remaining in coils will finish the job.
- On electric ranges keep reflector pans under burners clean for faster cooking.
- Pans for stove top should fit burner size, have flat bottoms and tight lids.
- Use minimum amount of water needed; use a covered pan for boiled water; start with hot water from the faucet.
- Plan foods before cooking to eliminate warm-ups.
- Flame on gas range should be bluish, if not request repair.
- If you suspect the thermostat is not working (oven is too hot or cold) request repair.

Refrigerator.

- Clean condenser coils four times a year. First unplug unit. The coils are located in the back of the unit or behind the bottom grill panel. Use a vacuum brush attachment or soft dust brush.
- At least four times a year check condensate pan underneath to remove water and food particles.
- Defrost freezer when frost level reaches 1/4", otherwise freezer effectiveness is reduced by the layer of ice.
- Set temperature of refrigerator at 34-37°F (milk will be cold). Set temperature of freezer at 0-5°F (ice cream will be hard).
- Check gaskets for tightness, loose gaskets let cold air escape.
- Keep freezer full because frozen foods help to retain the cold.
- Leave space in refrigerator for air to circulate.
- Do not leave liquids uncovered in the refrigerator, they increase ice formation.
- Do not obstruct unit, allow sufficient air circulation around it.
- Keep surfaces of refrigerator and freezer clean.
- Avoid opening refrigerator and freezer doors unnecessarily allowing cold to escape.
- Let hot dishes cool before putting them in refrigerator.

Washer.

- Wash only full loads but do not overload washer; clothes should fill tub loosely.
- Always use cold water rinse and when practical a cold or warm wash cycle.

- Add only amount of detergent recommended. Too many suds will not clean clothes better but will leave a residue on them and also overwork the machine.

- Clean lint filter after each load of wash (on tenant owned washers).

Air Conditioners.

- EER: Energy Efficiency Ratio is by law listed for every appliance; when purchasing an air conditioner select a higher EER number along similar models. In a range of 6 to 10 the higher number is desirable.

- Try to place unit in window which is shaded during the day.

- Do not block flow of air with drapes or furniture.

- Clean outside coils or grill monthly to remove dust, grass clippings, etc.

- Keep filter clean.

Heating and Cooling.

- Open windows in evening in summer and close at mid-day.

- Increase temperature to 78°F in summer in air conditioned rooms.

- In winter open shades and drapes during sunny days and close them at night.

- Lower thermostat to 68°F during day, 62°F at night in wintertime.

- Wear suitable clothing. In the winter wear warmer clothes including sweaters and pants, in the summer wear light-weight clothes.

- Keep windows clean for greater heat gain in wintertime.

General Hints.

- Turn off unnecessary lights.

- Keep light fixtures clean (bulbs, shades, covers) to obtain all available light.
- Unplug instant turn-on TV if you are away for more than 3 hours.
- Turn off TV, radio, and stereo when no one is using them.
- Turn off all appliances when you finish using them, including coffee pots.
- Keep cooking appliances out of drafts, they lose heat.
- Empty vacuum bags before they are overloaded.
- Iron large amounts of clothes at one time.
- Iron first those fabrics which require lower heat.
- Keep all information about your appliance in one place (a large envelope or bag)!
- READ the manual which comes with all appliances you purchase!

Appendix F
Glossary

APPENDIX F
Glossary

Active solar system - a solar system which uses pumps or other mechanical means to transfer the heated or cooled fluids from the collectors to the storage medium and back again to the collectors.

Air infiltration - outdoor air leaking into a structure uncontrollably. Due mainly to cracks in the structure, around door and window frames. Air infiltration will increase greatly as the air pressure, due to increased wind velocity, increases. In a well-built house, the air infiltration may be less than 1/2 air change per hour. In a poorly built home, air infiltration could be as high as 2 or more air changes an hour.

Ballast - a device used in starting circuit for fluorescent and high intensity discharge lamps.

Blowdown - the discharge of water from a boiler or cooling tower pump that contains a high proportion of total dissolved solids.

Boiler - a unit which heats water or produces steam. It includes a burner, heat exchanger, flue and container.

Boiler Capacity - the rate of heat output in BTU/hr measured at the boiler outlet for the design rated input.

Boiler Horsepower - some older boilers are rated in horsepower rather than directly in terms of an energy rating. One operating boiler horsepower is defined as 33,500 BTU per hour.

British Thermal Unit (BTU) - a heat unit equal to the amount of heat required to raise one pound of water one degree Farenheit.

Building Envelope - all external surfaces which are subject to climatic impact which enclose conditioned spaces; for example, walls, windows, roof, floor, etc.

Building Load - heating load is the rate of heat loss from the building at steady state conditions when the indoor and outdoor temperatures are at their selected design levels (design criteria). The heating load always includes infiltration and may include ventilation loss and heat gain credits for lights and people. Cooling load is the rate of

heat gain to the building at steady state condition when indoor and outdoor temperatures are at their selected design levels, solar gain is at its maximum for the building configuration and orientation, and heat gains due to infiltration, ventilation, lights, and people are present.

Caulking - a flexible material used to seal up cracks or spaces in a structure.

Coil - the area of an evaporator where heat transfer occurs.

Cold Deck - a cold air chamber forming part of a ventilating unit.

Condensation - droplets of water and sometimes frost (in extremely cold climates) which accumulate on the inside of the exterior covering of a building.

Condenser - a heat exchanger which removes heat from vapor changing it to its liquid state (in refrigeration systems the component which rejects heat).

Conduction - method of heat transfer where heat moves through a solid.

Control - any device for regulation of a system or component, manual or automatic.

Convection - method of heat transfer where heat moves by motion of a fluid or gas, usually air.

Damper - a device used to vary the volume of air passing through an air outlet, inlet or duct.

Degree Day - the difference between the median temperature of any day and 65°F when the median temperature is less than 65°F.

Demand Rate - the price for the maximum connected load of power a utility company is prepared to supply a commercial customer. The demand rate reflects the premium the company charges to cover the peak load draw, as well as the investment in the equipment it must make to do so. Demand billing schedules are usually adjustable if the customer does not use this peak load over a specified period, which varies from one month to one year.

Duct Work - the conduit or piping system through which ventilated warm or cool air is conveyed from the source of supply to the premises or outlet. Ducts are usually made of galvanized metal or fiberglass; they may be lined or covered with insulating materials.

Eaves - a roof overhang which projects over the walls.

Efficiency of Fixtures - ratio of usable light to energy input for a lighting fixture or system (lumen/watt).

Energy - the capacity for doing work; taking a number of forms which may be transformed from one into another, such as thermal (heat), mechanical (work), electrical and chemical; in customary units, measured in kilowatt hours (kWh) or British thermal units (BTU); in SI units, measured in joules (J), where 1 joule = 1 watt-second.

Energy Audit - this means any process which identifies and specifies the energy and cost savings which are likely to be realized through the purchase and installation of particular energy conservation measures or renewable resource energy measures.

ECO - Energy Conservation Opportunity. Any action which results in the saving of energy. ECO's are considered modifications and include maintenance and operational changes which involve essentially no cost and also energy measures which involve cost.

Energy Efficiency - the amount of output or activity per unit of energy consumed. When applied to air conditioners it is the cooling output (BTU) divided by kilowatt input.

Evaporator - a heat exchanger which adds latent heat to a liquid changing it to a gaseous state (in a refrigeration system it is the component which absorbs heat).

Flue - the space in a chimney through which fumes (smoke, gases) travel to the outdoors.

Foot-candle - energy of light at a distance of one foot from standard (sperm oil) candle.

Furnace - a unit, similar to a boiler, used to heat air.

Gable End Louvers - a fixed attic vent. Gable end louvers are the triangular shaped louvers mounted in the top point

of the gable. Because they are inexpensive and somewhat inconspicuous they have been a popular type of attic vent and are manufactured in a wide range of sizes.

Glazing, Single - a single sheet of glass.

Heat Transfer - the exchange of heat through building materials.

Heat Transfer, Conduction - heat transfer through a solid. A typical example is when a metal spoon is placed in a hot cup of liquid. The portion of the metal spoon not submerged quickly heats up by conduction. In homes, a typical example of heat loss by conduction is through window panes. To slow this heat transfer, use double-pane glass.

Heat Transfer, Convection - the transfer of heat from one object to another by the movement of air, water or another fluid.

Heat Transfer, Radiation - whenever one object is warmer than another, heat energy will be transmitted across space by radiation.

Hot Deck - a hot air changer forming part of a ventilating unit.

Humidity, Relative - a measurement indicating moisture content of air.

Infiltration - the process by which outdoor air leaks into a building by natural forces through cracks around doors and windows, etc. (usually undesirable).

Insulating Value or "R" Value - all insulation materials commercially available have an "R" value printed on the package. This "R" value is the resistance to heat transfer that the material possesses. Every material has at least some "R" value.

Insulators - all materials conduct heat to one degree or another, but materials which conduct heat slowly are called heat insulators. Materials commonly used as insulators included particleboard, perlite or vermiculite, cellulose fibers, mineral wool and fiberglass.

Insulating or Double-Pane Glass - two or more panes of glass separated by an airtight space.

Ventilation is controlled by louvers, fans and opening windows, among other methods.

Viscosity - the internal friction due to molecular cohesion in fluids. The correct viscosity is important for the proper atomization of fuel oils and a suitable atomizing temperature should be determined from the viscosity/temperature characteristics of the specifications of the oil being used and the atomizing viscosity recommended by the burner manufacturer.

Watt - unit of measurement for electric power. One volt x one ampere = one watt. 1000 watts - 3412 BTU.

Zone - a space or group of spaces within a building with heating and/or cooling requirements controlled by a single thermostat.

NOTES AND CALCULATIONS

Life Cycle Cost - the cost of the equipment over its entire life, including operating and maintenance costs.

Load Factor - this is a ratio expressing a customer's average actual use of the utility's capacity proved or built to meet his maximum demandon an as needed basis. A customer whose maximum demand is 450 kW and who consumes that amount every hour of each day of the month as a perfect or 100% load factor for that month. A customer who consumes or places that demand for a few hours on each day of the month will have an exceedingly low load factor.

Load Profile - time distribution of building heating, cooling, and electrical load.

Lumen - unit of light output from a source.

Luminaire - a lighting fixture.

Payback - the time required for the cost of energy saved to equal the total cost of modification.

Passive Solar System - a solar system which uses natural and architectural components to transfer the heated or cooled fluids from the collectors to the storage medium and back again to the collectors. There is no use of pumps, etc.

Peak Loading Pricing - a pricing principle that charges more for purchases that contribute to the peak demand and, thereby, cause the expansion of productive capacity when the peak demand exceeds the peak capacity (less minimum excess capacity). In the electric power industry, this means charging more for electricity bought on or near the seasonal peak of the utility or on or near the daily peak. The latter requires special meters; the former does not.

Power - in connection with machines, power in the time rate of doing work. In connection with the transmission of energy of all types, power refers to the rate at which energy is transmitted; in customary units, it is measured in watts (W) or British thermal units per hour (BTU/hr), and in SI units is measured in watts (W).

Power Factor - relationship between kVA and kW. When the power factor is unity, kVA equals kW.

Power Factor Charge - in basic terms, power factor is lost

energy due to the characteristics of the electric equipment. The utility may charge the customer whatever it costs the utility to remove this loss.

R-Value - the resistance to heat flow expressed in units of square feet x hour x degree F/BTU.

Refrigerant - the fluid used for heat transfer in a refrigerating system, which absorbs heat at a low temperature and a low pressure of the fluid and a low pressure of the fluid and rejects heat at a higher temperature and a higher pressure of the fluid, usually involving changes of state of the fluid.

Relative Humidity - this is a measurement, expressed as a percentage, indicating the amount of water vapor in the air compared to the amount that the air could contain if it were completely saturated with moisture.

Reset - adjustment of the set point of a control instrument to a higher or lower value automatically or manually to conserve energy.

Terminal Element - the means by which the transformed energy from a system is finally delivered; i.e., registers, diffusers, lighting fixtures, faucets, etc.

Thermosiphoning - heat transfer through a fluid (such as air or liquid) by currents resulting from the natural fall or heavier, cooler fluid and rise of lighter, warmer fluid.

Thermostat - a device that functions to establish and maintain a desired temperature automatically.

Trombe Wall - masonry, typically to 16 inches thick, blackened and exposed to the sun behind glazing; a passive solar heating system in which a masonry wall collects, stores and distributes heat.

U-Value - a coefficient expressing the thermal conductance of a composite structure in BTU per suqare feet x hour x Degree F temperature difference (reciprocal of R-Value).

Vapor Barrier - a moisture-impervious layer designed to prevent moisture migration.

Ventilation - the introduction of air into a space, such as a house, by some controlled mechanical system or unit.

Appendix G
Abbreviations

APPENDIX G

Abbreviations

°F	=	Degrees Fahrenheit
#	=	Number
$	=	Dollars
%	=	Percent
(%)	=	Percent as decimal
AC	=	Air Conditioning
ANSI	=	American National Standards Institute
ASHRAE	=	American Society of Heating, Refrigerating and Air Conditioning Engineers
BTU	=	British Thermal Unit
CF	=	Cubic Feet
CFM	=	Cubic Feet per Minute
CFR	=	Code of Federal Regulations
CIAP	=	Comprehensive Improvement Assistance Program
DDZ	=	(Heating) Degree Day Zone
DHW	=	Domestic Hot Water
DU _or_ D.U.	=	Dwelling Unit
ECO	=	Energy Conservation Opportunity
Elec	=	Electric(ity)
FR	=	Federal Register
Gal	=	Gallons
HUD	=	U. S. Department of Housing and Urban Development
Hrs	=	Hours
I	=	Inches
IN	=	Inches
KWH	=	Kilowatt Hour
LF	=	Linear Feet
Lbs _or_ Lb	=	Pounds
MMBTU	=	Million of BTUs
N/A _or_ NA	=	Not applicable
NEMA	=	National Electrical Manufacturers Association
O&M	=	Operation and Maintenance
P-B _or_ PB	=	Payback Period
PHA	=	Public Housing Authority
PSI _or_ psi	=	Pounds per Square Inch (pressure)
R	=	Resistance (value)
SF	=	Square Feet
W _or_ Watt	=	Watts
Yr _or_ Yrs	=	Year(s)

Additional Abbreviations

Appendix H
Bibliography

APPENDIX H
Bibliography

American Society of Heating, Refrigerating and Air-Conditioning Engineers. Handbook of Applications. New York: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1978.

American Society of Heating, Refrigerating and Air-Conditioning Engineers. Handbook on Equipment. New York: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1975.

American Society of Heating, Refrigerating and Air-Conditioning Engineers. Handbook of Fundamentals. New York: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1977.

American Society of Heating, Refrigerating and Air-Conditioning Engineers. Handbook and Product Directory on Systems. New York: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1980.

Balcomb, Douglas J. (U.S. Department of Energy). Passive Solar Design Handbook. Springfield, Virginia: National Technical Information Service, U.S. Department of Commerce, 1980.

Burt, Hill, Kasar, Rittleman Associates (Department of Energy). Minimum Energy Dwelling (MED) Workbook. Springfield, Virginia: National Technical Information Service, 1978.

Derven, Ronald and Carol Nichols. Successful How to Cut Your Energy Bills. Farmington, Michigan: Structure Publishing Co., 1980.

Do-It-Yourself Insulation and Weatherstripping (Sunset Books and Sunset Magazine, editors). Menlo Park, California: Lane Publishing, 1978.

Dubin, Mindell, Bloome Associates (Federal Energy Administration). Guidelines for Saving Energy in Existing Buildings. Washington, D.C.: National Technical Information Service, June, 1975.

Energy-Saving Projects You Can Build (Better Homes and Gardens, editors). New York: Meredith Corp., 1979.

Energy Savers Catalog (Consumer Guide, editors). New York: Beekman House, 1979.

Federal Energy Administration. How to Save Money by Insulating Your Home. Washington, D.C.: Government Printing Office, 1977.

Gatts, Robert R., Robert G. Massey and John C. Robertson (U.S. Department of Commerce, National Bureau of Standards). Energy Conservation Program Guide for Industry and Commerce. Washington, D.C.: Government Printing Office, 1974.

IES Lighting Handbook (John Kaufman and Jack Christen, editors). New York: Illuminating Engineering Society, 1972.

Kokette, Stephen. Money Saving Conservation Products and Projects for the Homeowner. Madison, Wisconsin: Aylmer Press, 1978.

McGuinness, William J. and Benjamin Stern. Mechanical and Electrical Equipment for Buildings. New York: John Wiley and Sons, 1971.

National Bureau of Standards Building Science Series 132. Energy Conservation in Buildings: An Economic Guidebook for Investment Decisions. Washington, D.C. U.S. Government Printing Office, 1980.

National Bureau of Standards Building Science Series 105. Retrofitting an Existing Wood-Frame Residence for Energy Conservation - An Experimental Study. Washington, D.C. U.S. Government Printing Office, 1978.

National Bureau of Standards Building Science Series 64. Retrofitting Existing Housing for Energy Conservation: An Economic Analysis. Washington, D.C. U.S. Government Printing Office, 1974.

National Electrical Contractors Association and National Electrical Manufacturers Association (Federal Energy Administration). Total Energy Management. 1976.

New Jersey Department of Energy. Energy Survey Manual for Multi-Family Dwellings. Newark, New Jersey: Department of Energy.

New Jersey Department of Energy. The R.E.M. Way to Lower Lighting Cost. New Jersey, 1980.

New York State Energy Office. Multi-Family Housing, Energy Conservation Handbook. Albany, New York: New York State Energy Office.

New York State Energy Office. Solar Workbook. Albany, New York: New York State Energy Office, February, 1980.

North Carolina Department of Commerce (Energy Division). Project Conserve Final Report. Raleigh, N.C., 1979.

Office of Energy Consevation/State of Colorado/Office of the Governor. Institutional Buildings Grants Program Energy Audit Workbook. Denver: Colorado Office of Energy Conservation, 1979.

Texas Energy and Natural Resources Advisory Council. A New Home Buyer's Guide to Energy Efficient Homes. Austin,Texas, 1980.

U.S. Departments of the Air Force, Army, and Navy. Engineer-Weather Data. Washington, D.C.: Government Printing Office, 1967

U.S. Department of Energy. Energy Audit Workbook for Apartment Buildings, Instructions for Energy Auditors Volumes I and II. Springfield, Virginia: National Technical Information Service, September, 1978.

U.S. Department of Energy. Tips for Energy Savers. Washington, D.C.: Government Printing Office.

U.S. Department of Housing and Urban Development. An Evaluation of the Physical Condition of Public Housing Stock. Washington, D.C.: Unpublished Report, March, 1980.

U.S. Department of Housing and Urban Development. In the Bank or Up the Chimney? A Dollars and Cents Guide to Energy-Savings Home Improvements. Washington, D.C.: Government Printing Office, 1977.

U.S. Department of Housing and Urban Development. The Energy-Wise Home Buyer. Washington, D.C.: Government Printing Office, March, 1979.

U.S. Office of Technology Assessment. Residential Energy Conservation, Volume 1. Washington, D.C.: U.S. Government Printing Office.

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