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ORIGINAL

An Evaluation of the Physical Condition of Public Housing Stock

Energy Conservation

March 31, 1980

Prepared by

Perkins & Will
The Ehrenkrantz Group

For the

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

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Introduction

Due in large part to the rapid escalation of energy costs during the past several years, more than 2700 Public Housing Authorities thoughout the country are confronted with the problem of an ever-widening gap between income and operating expenses.

The largest factor contributing to the overall operating cost of PHAs has been energy. Energy costs now average over $670 per dwelling unit per year, varying substantially between individual projects. In 1980 the cost of energy for the total public housing stock will exceed $740 million.

Based on historic price trends it can be estimated that energy costs in public housing have risen some 400 percent since 1970 -- from $185 million spent for energy in 1970 to $740 million estimated to be spent in 1980. Most of this increase has ocurred during the last few years and fuel costs are expected to increase over general inflation for many years to come.

The projects vary from single-family wood frame homes to steel and concrete high-rise structures. Since the inception of Public Housing in 1937, almost $20 billion have been spent on the development of these projects. The design of most buildings, which were constructed during the late 1940's through the 1960's, however, reflects the low energy costs of that time.

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 these costs many actions that could reduce energy consumption by only a small percentage would yield significant energy cost savings. In addition, any energy savings would reduce dependence on foreign sources of fuel and reduce the demand for new power generation plants. Unfortunately, there are few incentives for PHA tenants to conserve energy; significant energy savings can, therefore, be accomplished only with energy conservation retrofit at substantial cost, effort and time.

This part of the study "An Evaluation of the Physical Condition of Public Housing Stock", has been prepared to assess the existing energy consumption and energy conservation potential in the United States Public Housing Stock. It presents recommended levels of energy saving investment costs based on a cost/benefit analysis.

E1.0 Energy Conservation Summary of Results

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1.1 Executive Summary

1.1.0 Introduction

The cost of energy in the public housing stock for 1980 is expected to exceed $740 million. This averages over $670 per dwelling unit. This average varies widely, more than five to one in some cases, between building types, climates and user characteristics. It is within this context that energy conservation retrofit is being recommended at an investment level of over $2 billion to save about half of this existing usage. On a per dwelling unit basis, this investment typically averages between $500 and $2500, depending on type and location. Expected return on this investment will be over 15% with a combined payback of about 6 years for all actions having a payback within 15 years.

An undertaking of this magnitude will require substantial effort and time, and will be subject to many additional concerns aside from economic ones.

This section is organized into major topics summarizing methodology and the major conclusions of this study.

1.1.1 Analysis Methodology

The analysis of the total public housing stock for existing energy use and potential energy savings was completed in two phases. Phase I was the survey process and Phase II the analysis process. The following overview of these two phases is diagrammed in Illustration 2.1.

During the survey phase three major tasks were completed before the actual survey could begin. The first was to research energy use factors and criteria applicable to public housing. Next, a classification system for projects was developed to create a manageable number of housing prototypes for detailed analysis. Finally, the survey instruments were developed to record utility data and significant features of a project in order to calculate energy use. When the survey instruments were completed and tested, 350 randomly selected projects were surveyed.

From project data gathered in the field, building types were analyzed for distribution of dwelling units and physical characteristics. Ninety-five projects were selected to represent the public housing stock based on dwelling unit distribution and representative physical characteristics. The data on these projects were entered in the computer for detailed energy analysis.

A set of algorithms were developed to determine existing energy use. Following this, potential energy conservation opportunities (ECOs) were analyzed and refined. Energy savings, cost and discounted payback were estimated for each ECO for all ninety-five projects producing over 5000 results.

Based on the results of this analysis, ECOs were ranked according to greatest benefit-to-cost ratios and grouped into the following four categories:

1. Operation and maintenance ECOs (No cost ECOs)
2. Less than five-year payback ECOs
3. Less than ten-year payback ECOs
4. Less than fifteen-year payback ECOs.

Since some ECOs are mutually exclusive and others are interdependent, each payback category was reanalyzed as a group to show diminishing returns of combined ECOs.

These results were then extrapolated to the total Public Housing stock for each building type and the United States as a whole.

A more detailed discussion of the approach can be found in Chapter 2.

In addition to this energy conservation analysis, a separate but coordinated solar analysis to assess potential solar retrofit in public housing was also completed and is presented in Chapter 5.

1.1.2 Public Housing Classification

A method to organize the projects by significant cate-categories of building type and climate was needed for the following reasons:

1. To show the significant energy uses and savings profiles of the Public Housing Stock

2. To develop a manageable number of theoretical housing prototypes for detailed analysis of energy conservation retrofit savings

3. To eliminate and include groups of ECOs for consideration

4. To extrapolate detailed survey data and analytical results to the total housing stock.

Based upon available data for the majority of housing projects, the following four classifications were developed:

- Building Configuration (high-rise or low-rise) (H,L)
- Heating System Configuration (space or central) (S,C)
- Heating Energy Source (oil, gas or electric) (O,G,E)
- Climate Zone (5 degree day zones) (1,2,3,4,5)

When building configuration, heating configuration and heating fuel are combined in all possible ways, twelve "building types" are created, each possibly occurring in all climate zones. This combination of twelve building types and five climate zones creates a matrix of sixty cells as illustrated below:

	Climatic Zone				
Building Type	1	2	3	4	5
LSO	-	-	Θ	-	-
LSG	Θ	Θ	Θ	Θ	Θ
LSE	Θ	Θ	Θ	-	-
LCO	-	-	Θ	Θ	-
LCG	-	Θ	Θ	Θ	-
LCE	-	-	-	-	-
HSO	-	-	-	-	-
HSG	-	-	-	-	-
HSE	-	-	Θ	Θ	-
HCO	-	-	Θ	Θ	-
HCG	-	-	Θ	Θ	Θ
HCE	-	-	-	-	-
Total Cells	12	12	12	12	12

Building type legend:	Climate zone legend:
L = Low Rise	1 = 0-2000 heating degree days
H = High Rise	2=2000-4000 heating degree days
S = Space Heating	3=4000-6000 heating degree days
C = Central Heating	4=6000-8000 heating degree days
O = Oil Fuel	5=8000+ heating degree days
G = Gas Fuel	Θ accounts for over 5% of public housing
E = Electric	

A random sample of approximately 30% of the total public housing stock provided information on number of projects, number of dwelling units and building types for each state. This sample was then extrapolated to the total for each state for each building type. In this way estimates of the total number of dwelling units in each cell was made.

Only cells with a significant number of dwelling units were chosen (those with more than .5 percent of the total). These resulting in 22 cells representing the total public housing stock, indicated by Θ above.

1.1.3 Existing Energy Use in Public Housing

Existing energy use was calculated using standard algorithms such as those described in the American Society of Heating, Refrigeration and Air-Conditioning Engineers' Handbooks and other engineering manuals. Simplifying assumptions were made when data were not available for detailed analysis. Weather data were based on average years and projects were matched to the nearest city with available weather data. This process is detailed in the following section, (section 1.2).

The following are the major findings of this analysis:

- 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.

- 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.

- 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%

- 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 prorated to the dwelling unit averages.

1.1.4 Energy Conservation Opportunity Analysis

After yearly energy consumption was calculated for each project and prototype, 58 Energy Conservation Opportunities (ECOs) were analyzed individually for each project.

The ECOs selected for analysis were divided into the following two categories:

1. ECOs that are maintenance or no-capital-cost items (11 ECOs)
2. ECOs that require an initial capital cost investment (47 ECOs).

These classifications are referred to as "no cost" and "cost" ECOs, a listing of these ECOs can be found in Chapter 2 of this volume.

Energy savings analyses were performed in two steps to reflect the "no cost" and "cost" distinction between ECOs. To enhance the accuracy of the ECO savings predictions, all of the no cost ECOs were analyzed as a group. The resulting energy usage with the no cost ECOs implemented was used as the base for calculating the savings of all cost ECOs. It was therefore assumed that all operational and maintenance ECOs would be implemented before capital investments were made.

The following is a summary of the major findings of this analysis:

- Because of the relatively high energy usage by public housing, there is significant potential for savings. These potential savings are summarized below:

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 Conservtion Opportunities in a randomly selected representative sample of public housing projects.

- A more detailed result of the ECO analysis can be found in section 1.3 of this volume.

- An Economic Analysis of all ECO savings and costs was performed using a discounted payback method. All ECOs with a discounted payback of less than fifteen years were considered.

- This level of savings can be accomplished with an investment in material and labor of typically between $500 and $2500 depending on building type, systems types and location. Expected return on this investment will be over 15% with a combined payback of about 6 years for all actions having a payback within 15 years.

- 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 only since active solar space heating retrofit systems were found to be only marginally economical. It was found that 5 percent of the public housing stock would have solar domestic hot water systems that pay back in less than 15 years, and 17 percent would pay back in 30 years. Energy cost savings to the total public housing stock would be 1.4% and 4.2% respectively.

Details of the solar energy analysis can be found in Chapter 5.

1.1.5 Recommended Levels of Investment

Based upon the ECOs analysis, graphs were produced to illustrate diminishing return of investment. Such a graph, shown in Illustration 1.5 (Section 1.3), plots investment cost versus energy savings for the average dwelling unit. A marginal cost/benefit analysis suggests a level of investment at the tangent of the curve equal to a fifteen-year payback. Further energy savings are possible beyond this point but on a cost/benefit basis any further reduction in energy savings would require a capital investment yielding greater than 15-year payback.

This fifteen-year marginal payback level yields an average construction investment for a dwelling unit of $1347 (1980 exclusive of fees, profit, or contingencies) with a corresponding energy savings of $324 per dwelling unit. Individual investment and savings for specific building types or projects will vary widely according to existing conditions.

This investment would reduce the energy consumption for the average dwelling unit by 78 million BTUs a year to 68 million BTUs per year.

The variation in investment level and savings between building types can be seen in Illustration 1.1.

This illustration shows that between the eight major building/system types energy savings will vary on average between $117 to $696 with capital costs for construction ranging from $550 to $2100. When fees, profits and contingencies are included the investment costs will increase. Individual projects will vary in energy savings and investment costs even more then these building/system type averages, especially in extreme hot or cold climates and areas with high utility costs.

This investment level per average dwelling unit will be less than a corresponding private housing sector energy retrofit because a public housing dwelling unit is smaller in size and because of the corresponding lower unit costs of ECO items due to the large number of dwelling units being retrofitted at one time (quantity discount).

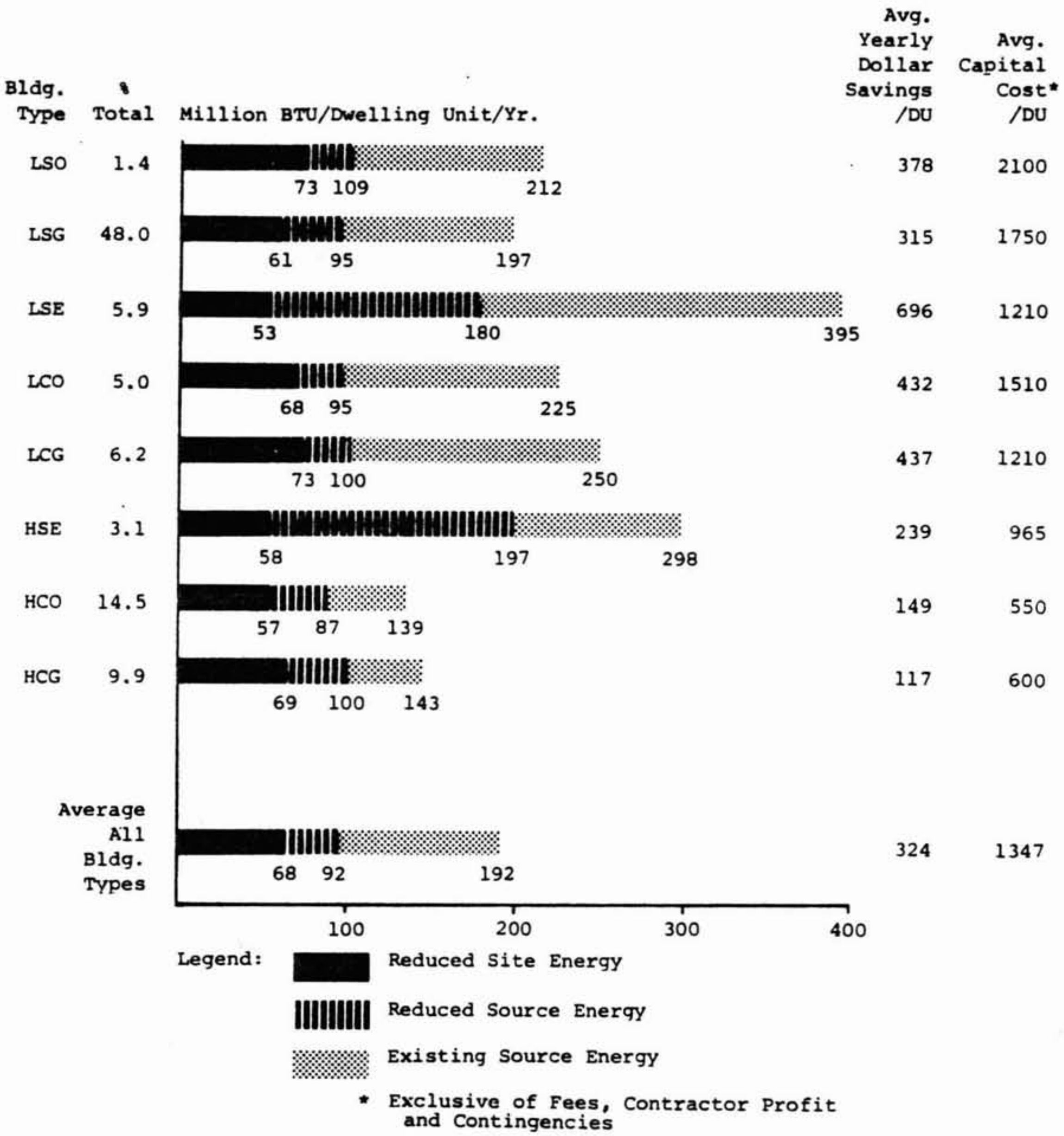
As an example of the $1750 investment level for a low-rise, space heating, gas heating fuel dwelling unit (LSG), which represents almost half of the entire U.S. Public Housing Stock, the following items might be installed.

Example of Energy Retrofit Needs of a Low Rise, Space Heated, Gas Fueled, Dewelling Unit

1.	Maintenance and operational items	$ 70*
2.	Storm windows w/window weatherstripping	$ 510
3.	Storm door w/door weatherstripping	$ 112
4.	Attic insulation	$ 530
5.	Flow restrictors, shower and faucets	$ 30
6.	Setback thermostat	$ 70
7.	Fluorescent light conversions	$ 72
8.	Flue damper w/electric pilot	$ 350
9.	Timed light switching in public spaces and site lighting (prorated to D.U.)	$ 5
	Total all items	$1749

Illustration 1.1

<u>Summary of Energy and Dollar Savings for Recommended Energy Conservation Investment Levels per Building Type</u>



Existing energy consumption varies within building types by climate. In general warmer climates use less energy and colder climates use more. Energy savings would be less in warmer climates and more in colder climates, both as percent of total and in magnitude. Individual projects may exceed these average.

*The cost for operation and maintenance items is assessed to be equal to the first year savings to account for training and increased maintenance efforts.

When the totals of all building systems are extrapolated to the total public housing stock these figures yield the following totals:

Energy conservation opportunity installation -	$1.50 billion
Construction management fees @ 15%	.23 billion
A/E fees @ 5%	.09 billion
Contingency fees @ 20%	.36 billion
Total investment	$2.18 billion
Contract authority	$199 million

This total is exclusive of government overhead and includes a 20% contingency. Allocating a time frame of five years would have to account for inflation.

Total energy savings per year would be $324 million (1980 dollars) after retrofit. Since energy costs can be expected to rise above general inflation for the next decade these savings would increase yearly.

A cost-effectiveness analysis of this program yields a combined payback period (for all ECOs with less than 15 years) of between 6 and 7 years. A discount payback analysis would decrease payback to about 6 years, yielding a return of investment of over 15 percent. The discounted analysis takes into account the rising cost of energy above inflation and the opportunity cost of money (discount rate).

Savings from this program would accrue annually yielding the following totals by the year 2000:

Energy Savings	= 1.5 quads
Barrels of oil equivalent savings	= 250 million
Total energy cost savings	= $8.6 billion
Total implementation cost	= $2.2 billion
Net dollar savings	= $6.4 billion

(Dollar amounts are 1980 constant dollars.) Illustration 1.2 shows these savings.

This analysis assumes a three-year implementation program starting in 1981 and assumes a 4% replacement rate of existing housing.

Illustration 1.2 shows how energy costs have risen in public housing since 1970 and how it is expected to increase (in 1980 dollars) for the next twenty years. The lower line shows how energy costs can be expected to decrease with an energy conservation program with an implementation period of five years.

1.1.6 Solar Energy

In addition to the recommended investment level for energy conservation retrofit, selective solar energy retrofit systems are also 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 that 5 percent of the public housing stock would have solar domestic hot water systems that payback in less than 15 years, and 17 percent would payback in 30 years.

Solar retrofit in public housing depends on unique building specific characteristics which make any attempt to generalize about solar potential subject to numerous assumptions and simplifications. Ultimately, solar energy feasibility reports must be made individually, at the specific building site, possibly as part of the comprehensive modernization program.

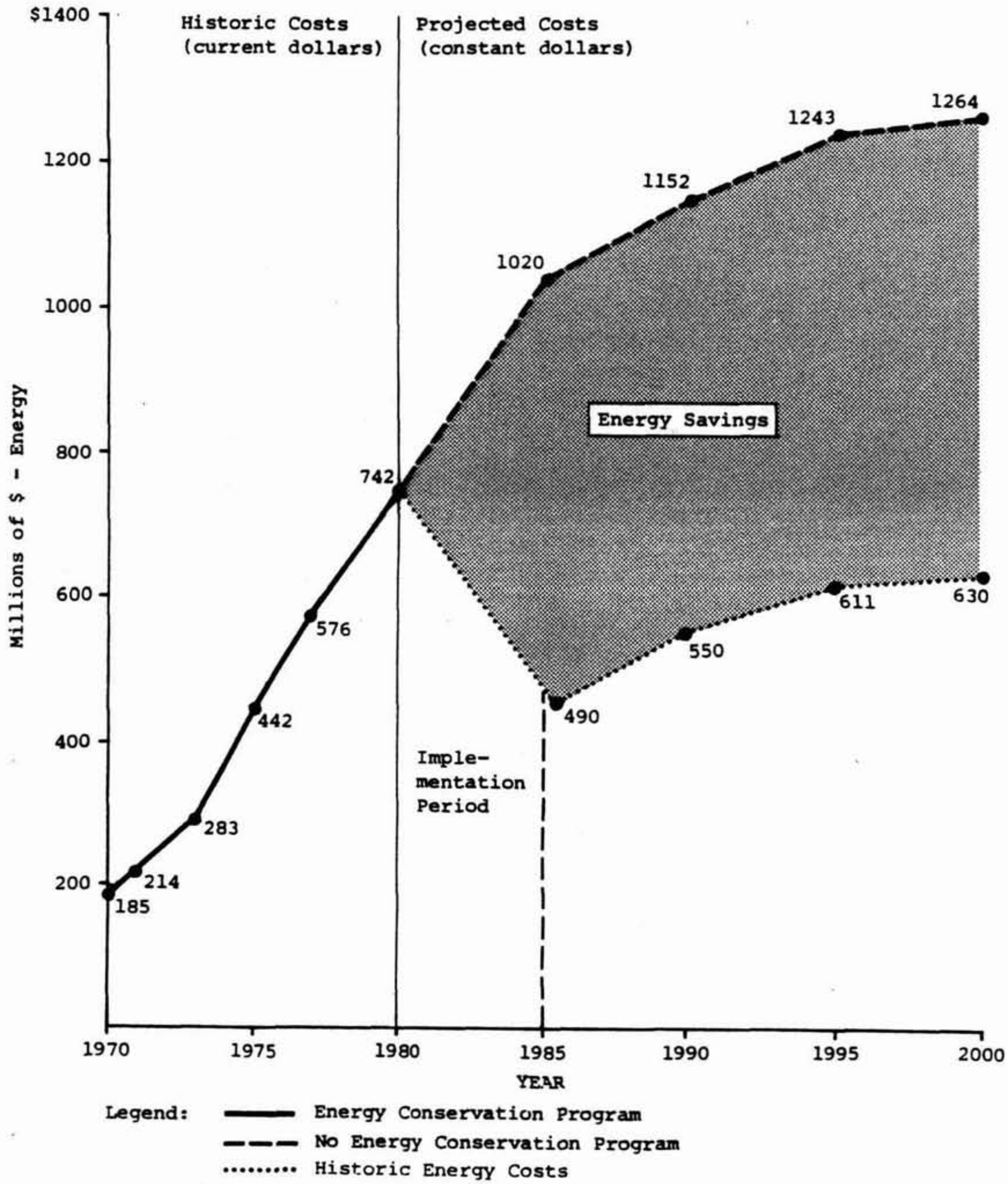
In any event, solar retrofit must be viewed as integrated with energy conservation efforts, since energy conservation measures will initially be more cost effective. Solar retrofit should be considered only after energy conservation is addressed.

Although solar heating retrofit is generally not cost effective, a number of applications were found to payback in less than 30 years. These are generally located in favorable climates and where fuel prices are high. In addition to these "active" (requiring mechanical equipment) solar retrofits for heating, it is recommended that "passive" (utilizing non-mechanical methods) retrofit be analyzed as part of the comprehensive energy program.

The following results were obtained by assuming energy conservation opportunities were already installed and are based on the best available data.

Illustration 1.2

Twenty-Year Projection of Energy Costs for the Total Public Housing Stock



NOTE: All numbers are based on calculated energy use and savings of a random sample of public housing projects extrapolated to the universe.

These recommended investment levels with their corresponding energy savings are presented for both a minimum solar retrofit program (all systems with less than 15 year payback), and a "maximum" program (all systems with less than 30 year payback).

Summary of Solar Energy Analysis for Public Housing

	Less than 15 yr. payback	Less than 30 year payback
Energy Savings MMBTU	642,124	3,140,542
Cost Savings - $/yr	9,884,326	31,013,104
Capital Cost - $	121,125,000	688,921,000
Combined Payback - yrs.	12.1	22.2

In addition to the savings quantified above, it is expected that "passive solar" retrofit could reduce energy use still further cost effectively, but requires more analysis for quantitative results.

1.1.7 Limitations of Energy Conservation Analysis

The maximum limit of cost effective energy conservation retrofit cannot be determined for a specific project without a detailed survey of its unique physical, climatic and user characteristics, in addition to its specific fuel rate structure and local construction costs. Actual public housing projects vary significantly in their need and application of energy conservation retrofit. A broad overview of the public housing stock's energy conservation potential, such as this report, can only begin to suggest this need.

Because every project is unique, a limited sample of projects, no matter how large, can only be used to develop regional and national averages. There is no possibility that these averages represent specific buildings beyond the most general sense.

Other studies of residential energy conservation retrofit programs indicate that although energy savings of over half of the existing use are technically and economically feasible, results are dependent on accurate assessments and knowledgable actions for specific buildings. This level of expertise and quality is an unknown factor in the analysis.

For these reasons the potential energy savings have been discounted 10 percent to account for normal contingencies in implementation. This number, however, is still only a potential for energy conservation and assumes that implementation will include an accurate assessment of individual projects and a well-managed implementation program with a good quality retrofit construction.

1.1.8 Additional Benefits

Energy consumption cost savings are important, but are not the only reasons to conserve energy. The following benefits would accrue with energy conservation measures both to individual projects and to the country as a whole:

- Energy conservation retrofit would increase occupant comfort by reducing unwanted heat gain through walls and windows and reducing drafts.

- Reduces the need for oil imports and dependency on foreign governments.

- It can increase the reserve capacity of existing power generating and distributing systems, decreasing pressures to build new ones.

- Energy conservation conserves limited natural resources.

- It can extend the useful life of existing equipment in public housing, reducing future replacement costs.

- Energy conservation reduces environmental pollution by reducing fuel combustion by-products.

- Energy conservation can enhance economic opportunity by providing jobs for building improvements.

- Energy conservation can help reduce inflation since future fuel costs are expected to exceed the general inflation rate.

- Extensive solar retrofit will show government commitment towards meeting the goal of 20% solar for the nation's energy needs by the year 2000.

1.1.9 Additional Concerns

In addition to dollar costs associated with a national energy conservation program, there are other potential costs that must be addressed.

- Reducing air infiltration beyond a certain point could create problems of moisture, odor and comfort. This point is not precisely understood at present and should be taken into consideration in the implementation program.

- Health effects of various insulation materials have to be addressed.
- The effects of moisture and humidity on the durability of materials must be considered as well as insuring proper ventilation of attic and condensation control in walls.

- Possible conflicts with fire and health codes must be reviewed.

- Highly visible energy conservation retrofits such as storm windows, exterior wall insulation and fixture replacements must consider appearance, durability, and security issues.

- Lifestyle changes such as nightime set back thermostats, lower temperatures, or individual metering must be introduced with sensitivity to tenant needs and ability to cooperate with energy conserving efforts.

1.1.10 The Implementation Program

Retrofitting the diverse characteristics of the public housing stock for energy conservation cannot be accomplished through oversimplified emphasis on any one approach such as insulation or individual metering. What this study has found is that every climate and building type will have its unique mix and order of energy conservation measures.

An effective retrofit program must emphasize individual assessments of specific projects that will identify its unique needs. For example, the most cost-effective of all specific measures was found to be the "tune-up" procedures involving operation and maintenance of the equipment and building. These "tune-up" procedures could involve over fifty specific items, each unique to a specific project.

For this reason it is recommended that a uniform analysis procedure be developed that would be based on a survey of the project to identify its specific needs. In addition to this it is reccommended that this effort be coordinated with a multi-year master plan for funding and integration with modernization efforts. This master plan should take into account the start up requirements of the learning curve that will be necessary by every one involved.

Such a comprehensive uniform plan is being developed by this contractor at the present time.

The following items are suggested to speed up the learning curve for energy conservation implementation:

- Create an Energy Task Force within HUD to run a five-year energy conservation program in public housing.
- Assess the savings, costs and other concerns associated with prior energy conservation retrofits in public housing such as individual metering, and added insulation.

- Implement a pilot program immediately for the 1980-81 winter in representative projects whose results will feed into the comprehensive modernization and energy program scheduled for completion in 1981.

  The pilot program should assess the following issues:

  - Management procedures
  - Energy audit methods
  - Role of professional auditors vs. self-assessment by project staff
  - Energy monitoring programs
  - User/Tenant conflicts
  - Administrative and personnel skill levels
  - Savings and costs of select ECOs that are most promising

- Monitor the progress of energy conservation measures being installed in public housing under the rules dated May 7, 1980 and June 23, 1980, that set aside $5 million and $25 million for testing energy conservation measures.

- Set up a central clearing house of energy information relevant to public housing. This would include creating a monitoring program of energy consumption and conservation efforts in public housing with regular feedback to housing authorities.

- Test selected passive solar retrofits in representative projects for cost-effectiveness and social implications.

- Install solar domestic hot water systems in selected projects as part of community job training programs to determine the extent to which existing job assistance programs can be used to reduce costs of installing solar systems while providing beneficial effects on community employment.

1.2.1 Existing Energy Use in Public Housing

It was necessary to calculate the existing energy usage rather than using actual fuel data for two reasons. The first reason was that a large portion of the projects surveyed could not provide actual energy consumption data because of individual tenant billing. The second reason was that yearly fuel consumption data, even if available, did not provide a breakdown of energy consumption by end use such as lighting, heating or domestic water, which is desirable for energy savings estimates. Calculating energy consumption had the further benefit of providing a common method of comparison between projects since the same calculations and weather data source and use profiles were normalized to eliminate abberations. Energy consumption calculations however, were correlated with actual consumption data where they were available.

Existing energy use was calculated using standard algorithms such as those described in the American Society of Heating, Refrigeration and Air-Conditioning Engineers' Handbooks and other engineering manuals. simplifying assumptions were made when data were not available for detailed analysis. Weather data were based on average years and projects were matched to the nearest city with available weather data.

It is estimated that the existing yearly energy consumption for all public housing averages 146.1 million BTUs per dwelling unit. This figure includes all office/public/community space energy use, allocated to the dwelling units they serve in addition to the energy used by the dwelling unit for heating, lights, etc.

Illustration 1.3 shows the energy profile of the average dwelling unit. The major categories of energy use as percent of total energy dollars are as follows:

Heating	52%
Domestic Hot Water	18%
Lights and Appliances	26%
Miscellaneous	4%

This average varies widely between climates and building types.

Illustration 1.4 shows how this profile varies between low rise and high rise buildings. Low rise buildings use more energy with a greater percentage for heating. Gas as a heating fuel is used for 75% of low rises and only in 31% of high rise buildings.

Average dwelling unit energy use is equal to 192 million BTUs of source energy, that is, the actual total energy used to deliver the 146.1 million BTUs to the dwelling unit. This number takes into account conversion and transmission losses for electricity and refining and transportation energy use for gas and oil. The following multipliers based on DOE national averages were used:

Gas = 1.11
Oil = 1.16
Electricity = 3.4

The distinction between the energy used at the building (site energy) and total energy (source energy) is important as can be seen in the example of an electrically heated building.

Two identical dwellng units located next to each other, one electric and one gas, might use 100 million BTUs (MMBTUs) and 120 million BTUs respectively. The electric dwelling unit seems to use less energy. When total energy is taken into account however, it requires an average of 340 MMBTUs of fuel to deliver 100 MMBTUs of electricity at the building, and only 132 MMBTUs of fuel to deliver 120 MMBTUs of gas. It can be seen from this example that an electric building uses far more total energy than a gas or oil building when conversion and distribution losses are taken into account. This difference is reflected in the much higher cost of electricity per unit of energy. This analysis is based on national averages and would differ for electricity from hydrogeneration.

Conversion to source energy, although based on national averages, is used here as a common denominator to compare energy consumption between different fuel types.

Based on collected utility rate data, energy use figures were converted to dollars. Since utility rates collected ranged from 1977 to 1979 data, all rates were normalized to first half of 1979. The average energy cost per dwelling unit for 1979 was $547. Assuming a 23 percent cost increase, this amount is estimated to increase to $672 per dwelling unit for 1980.

Table 1.1 summarizes total existing energy use in United States public housing stock.

Among other things, it can be seen from Table 1.1 that electricity, although accounting for only 11% of the energy use in a dwelling, accounts for 27 percent of the energy cost. This is because electricity costs much more per BTU than oil and gas.

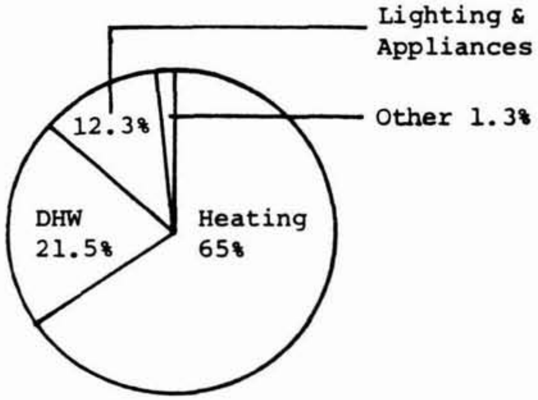
Illustration 1.3

Profile of Existing Energy Use in Public Housing by End Use and Fuel Type

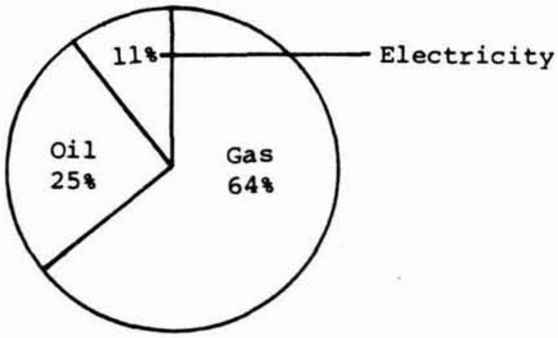
By End Use

By Fuel Type

Existing energy use by percent of site energy consumption (%BTU)



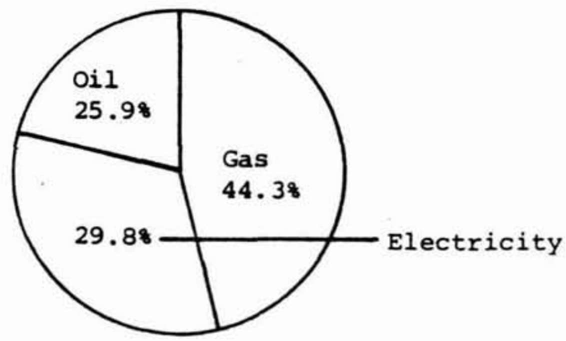
Average - 146.1 million BTU/D.U./Yr.
Total - 162.7 trillion BTU/Yr.



Total - 17.4 million barrels
of oil equivalent

Existing energy use by percent of energy costs (%$)

Average - $672/D.U. - 1980
Total - $749 million - 1980



Average cost of fuel - $4.56/million BTU

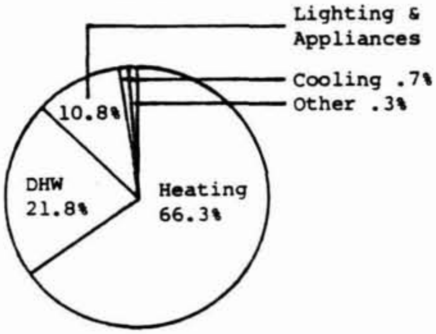
Illustration 1.4

Profile of Energy Use in Low Rise Versus High Rise Public Housing

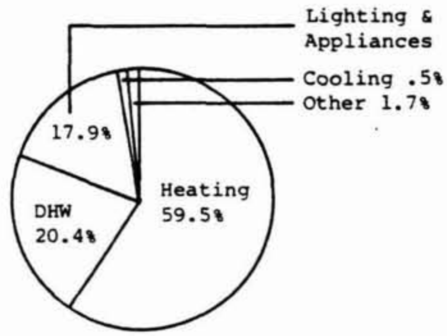
Low Rise - 70% Total D.U.s

High Rise - 30% Total D.U.s

Site Energy by end use

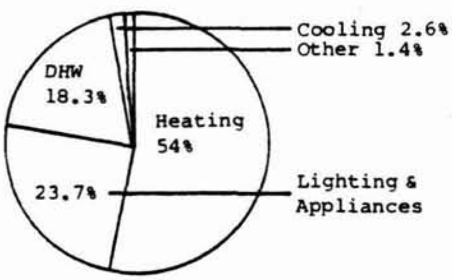


Total - 164.4 million BTU/D.U./Yr.

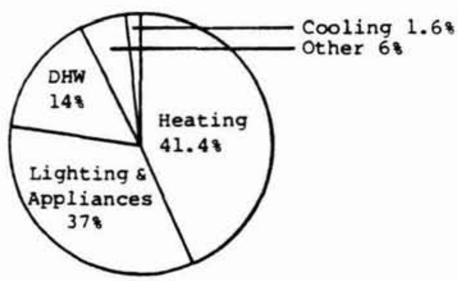


Total - 100.9 million BTU/D.U./Yr.

Energy Cost by end use

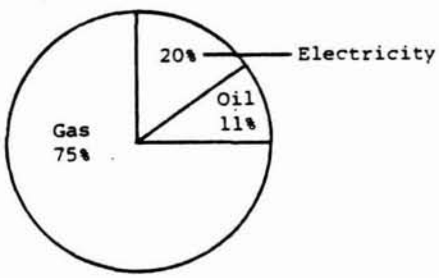


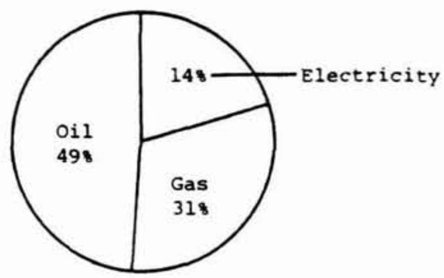
Total $621.38/D.U./Yr.



Total $383.00D.U./Yr.

Site Energy use by Fuel Type





Because individual tenant billing data for energy use were not available to the project team, the energy use and costs estimated here include both project and tenant paid energy use.

It can also be seen that public housing pays less for energy than private housing. This is due primarily to larger quantities purchased.

It should be noted that the figures given above for an average dwelling unit do not reflect the great diversity that exists between different types of dwelling units and climates. The range in usage between the prototype dwelling units is over five to one, with individual dwelling unit variations even greater.

These differences can be seen in Tables 1.2 and 1.3 where energy use and energy profile are illustrated by building type and climate zone. Table 1.2 illustrates the differences in energy consumption and energy cost between different building types and climate zones.

Table 1.3 illustrates the difference in use of the energy by showing the percent of total energy dollars spent on heating, domestic hot water and electricity for lighting and appliances.

Table 1.1

Annual Existing Energy Use and Energy Data

Annual Energy Use	Dwelling Unit	Total Housing Stock
Site Energy		
MMBTU	146.1	162,721,650
Barrels of oil equivalent	25.2	28,100,000
Gas	62%	1040 million therms
Oil	25%	289.1 million gallons
Electricity	11%	5.3 billion kilowatts
Source Energy		
MMBTU	192	214,000,000
Barrels of oil equivalent	33.1	36,896,390
Gas	51.5%	115.4 trillion BTU
Oil	21%	47.0 trillion BTU
Electricity	27.5%	61.5 trillion BTU
1980 Energy Cost (Est.)	$ 672	$749 million
Gas	44.3%	$332 million
Oil	25.9%	$194 million
Electricity	29.8%	$223 million

Energy Data	Unit Cost	Cost Per Million BTU
Cost of Energy - Early 1979		$3.90/million BTU
Gas	$.285/therm	$ 2.85/million BTU
Oil	.461/gallon	3.30/million BTU
Electricity	.04/kilowatt hr.	11.72/million BTU
Cost of Energy - Early 1980 (based on DOE fuel price escalation factors)		$ 4.56/million BTU
Gas	$.32/therm	$ 3.15/million BTU
Oil	$.67/gallon	4.74/million BTU
Electricity	$.042/kilowatt hr.	12.20/million BTU

Note: Includes both project and tenant paid energy use.
Site energy: Energy used at the project.
Source energy: Takes into account total energy including production losses, distribution losses, and transportation costs.

Table 1.2

Annual Energy Use and Cost Per Dwelling Unit

Bldg Type	Climatic Zone: 1	2	3	4	5
LSO			E 160.1 $ 635		
LSG	E 98.7 $347	E 148.7 $ 534	E 218.4 $ 706	E 447.5 $1221	E 219.0 $ 784
LSE	E 92.0 $1221	E 174.5 $1547	E 122.3 $ 791		
LCO			E 156.2 $ 451	E 220.1 $1107	
LCG		E 224.3 $ 684	E 195.6 $ 656	E 220.4 $ 585	
LCE					
HSO					
HSG					
HSE			E 84.2 $ 302	E 95.6 $1219	
HCO			E 100.0 $ 389	E 100.1 $ 377	
HCG		E 97.3 $ 312	E 95.4 $ 397	E 103.5 $ 388	E 109.9 $ 330
HCE					

E = Energy Consumption (MMBTU/yr.)
$ = Dollars spent on energy per average dwelling unit per year.
L = Low Rise O = Oil Heating
H = High Rise G = Gas Heating
S = Space Heating E = Electric Heating
C = Central Heating

Table 1.3

End Use Categories as Percent (%) of Total Energy Cost

Bldg Type	Climatic Zone: 1	2	3	4	5
LSO			57.7 19.8 21.6		
LSG	30.0 22.4 89.5	46.9 19.8 25.1	62.1 11.8 20.0	79.0 7.7 11.8	58.2 13.3 26.5
LSE	43.5 38.0 15.5	71.6 16.4 7.8	63.6 16.6 12.1		
LCO			46.4 18.7 34.2	71.7 16.7 11.6	
LCG		60.5 17.9 21.0	62.13 17.9 19.5	64.8 13.5 19.5	
HSE			53.1 18.8 23.8	64.0 15.2 19.5	
HCO			37.7 15.5 40.0	52.4 22.4 23.2	
HCG		27.3 18.1 37.2	41.1 10.3 41.8	40.5 10.3 39.8	42.4 10.4 37.1

Top number = Heating % of Dollars
Middle number = DHW % of Dollars
Bottom number = Lighting and Appliances % of Dollars

Note:

Lighting and appliances percent is high because electrical costs are much higher than fossil fuel per energy unit. As percent of total energy use lighting and appliances are a much smaller percent.

Table 1.4 presents existing energy use by building type and climate zone. For both dwelling unit and for the total public housing stock.

Table 1.5 presents a detailed profile of calculated existing energy end use as a percent of total energy cost.

Table 1.6 shows the average cost of fuel obtained from the survey of 95 projects.

Table 1.4

Existing Energy Use in 1979

		AVERAGE PER DWELLING UNIT:					TOTAL FOR U.S. PUBLIC HOUSING STOCK:				
		Total MMBTU (Oil & Gas)	Total Kilo-watts (Elec-tricity)	Total Site Energy (MMBTU)	Total Source Energy (MMBTU)	Total Cost ($-'79)	Total MMBTU (Oil & Gas)	Total Kilo-watts (Elec-tricity)	Total Site Energy (MMBTU)	Total Source Energy (MMBTU)	Total Cost ($-'79)
LSO	3	148.3	3471	160.1	212.3	635	2248079	52616880	2426955	3218255	9625965
LSG	1	86.8	3502	98.7	137.0	347	9021384	363973300	10258187	14238821	36064751
	2	135.8	3791	148.7	194.7	534	20370271	568657500	22305297	29205389	80101068
	3	207.0	3334	218.4	268.4	706	35274249	568136900	37216888	45737238	120307300
	4	436.9	3121	447.5	521.2	1221	23256187	166130800	23820425	27743476	64993830
	5	208.9	2945	219.0	266.1	784	1770845	24998673	1856463	2255729	6645968
	Average	140.7	3525	152.7	197.1	529	68387235	1713326000	74219835	95800455	257120400
LSE	1	0	26970	92.0	312.9	1221	0	558305900	1904492	6477342	25275921
	2	0	51150	174.5	593.3	1547	0	844537600	2881169	9795976	25542517
	3	0	35837	122.3	415.8	791	0	990570500	3380494	11493127	21864031
	Average	0	34081	116.3	395.4	1113	0	2210255000	7542403	25642876	72181389
LCO	3	148.1	2382	156.2	199.4	451	5773678	92862270	6089457	7773609	17582235
	4	211.5	2517	220.1	274.5	1107	3453372	41097576	3593792	4482036	18075096
	Average	169.8	2428	178.1	225.1	676	9392147	134299900	9851245	12450956	37391588
LCG	2	214.9	2768	224.3	270.7	684	1436821	18506848	1499669	1809900	4573224
	3	186.7	2604	195.6	237.4	656	8053864	112331300	8437792	10240961	28298528
	4	211.2	2684	220.4	265.6	585	1400953	43220452	3549101	4276956	9420255
	Average	197.5	2657	206.6	250.0	652	13020582	175168000	13620518	16481750	42984404
HSE	3	0	24682	84.2	286.3	302	0	585975300	1998992	6797048	7169782
	4	0	28027	95.6	325.0	1219	0	215920100	907052	3083600	11565872
	Average	0	25666	87.6	297.8	572	0	852855500	2910860	9895596	19006988
HCO	3	89.3	3141	100.0	140.0	389	10574280	371935200	11841300	16577820	46062657
	4	91.3	2567	100.1	135.7	377	3866737	108717500	4239435	5747166	15966704
	Average	89.8	2992	100.0	138.9	383	14436697	481008800	16076500	22330258	61572995
HCG	2	81.6	4607	97.3	144.0	312	1511966	85363103	1802871	2668176	5781048
	3	82.8	3688	95.4	134.7	397	3517675	156680400	4052973	5722594	16866148
	4	89.9	3976	103.5	146.0	388	2887408	127701100	3324213	4689228	12461784
	5	98.7	3276	109.9	147.6	330	1129029	37474164	1257146	1688396	3774870
	Average	89.1	3791	102.0	142.9	366	9317187	396424800	10666140	14943053	38272620
ALL BLDG TYPES	Average	129.8	4781	146.1	191.8	547	144567200	5324929589	162721650	213620894	609231643

NOTES:

Table 1.5

Existing Energy Use by End Use

PERCENT OF TOTAL ENERGY COST ($) BY END USE:

		Heating	Domestic Hot Water	Interior Lighting	Appli-ances	Cool-ing	Venti-lation	Site Light-ing	Water Supply	Eleva-tors	Total
LSO	3	57.70%	19.75	8.09	13.46	0	0	1.00	0	0	100.00
LSG	1	29.95	22.43	13.54	26.02	5.04	0.03	3.00	0	0	100.00
	2	46.93	19.79	7.43	17.72	7.15	0.01	0.97	0	0	100.00
	3	62.11	11.80	5.85	14.26	1.43	0	4.55	0	0	100.00
	4	79.04	7.71	3.73	8.05	0.52	0	0.96	0	0	100.00
	5	58.15	13.31	9.71	17.80	0.30	0	0.73	0	0	100.00
	Average	48.72	17.45	8.76	18.67	4.27	0.01	2.12	0	0	100.00
LSE	1	43.47	37.98	4.82	10.70	2.39	0	0.64	0	0	100.00
	2	71.55	16.41	2.14	5.66	1.35	0	2.91	0	0	100.00
	3	63.58	16.57	3.54	8.52	7.18	0.08	0.53	0	0	100.00
	Average	54.93	27.61	3.89	9.02	3.42	0.02	1.11	0	0	100.00
LCO	3	46.36	18.73	9.06	25.21	0.23	0.05	0.36	0	0	100.00
	4	71.72	16.68	2.93	8.57	0	0	0.10	0	0	100.00
	Average	60.60	17.58	5.61	15.86	0.10	0.02	0.22	0	0	100.00
LCG	2	60.50	17.85	6.44	14.61	0.14	0.11	0.35	0	0	100.00
	3	62.13	17.92	4.90	14.39	0.15	0.01	0.40	0.10	0	100.00
	4	64.83	13.51	4.81	14.72	0.52	0.36	0.91	0.28	0	100.00
	Average	62.11	17.27	5.28	14.49	0.20	0.09	0.46	0.10	0	100.00
HSE	3	53.13	18.84	12.09	11.71	0	0.04	0.06	0.46	3.68	100.00
	4	63.97	15.19	9.20	10.32	1.20	0	0.13	0	0	100.00
	Average	59.93	16.55	10.26	10.84	0.75	0.01	0.10	0.17	1.37	100.00
HCO	3	37.65	15.50	11.84	28.51	0.27	0.69	1.00	3.24	1.30	100.00
	4	52.38	22.41	5.88	17.54	0.05	0	0.41	0	1.34	100.00
	Average	41.31	17.22	10.36	25.78	0.21	0.52	0.85	2.43	1.31	100.00
HCG	2	27.27	18.05	14.37	22.84	10.87	0.89	1.09	1.99	2.62	100.00
	3	41.10	10.28	16.02	25.88	2.31	0.88	0.70	0.05	2.78	100.00
	4	40.48	10.28	15.85	23.89	1.96	1.43	0.55	0.77	4.78	100.00
	5	42.43	10.42	11.58	25.65	0	3.13	1.23	3.37	2.18	100.00
	Average	39.72	11.14	14.75	24.81	2.56	1.60	0.81	1.28	3.32	100.00
ALL BLDG TYPES	Average	52.15%	17.60	8.12	17.74	2.11	0.26	1.13	0.37	0.52	100.00

NOTES:

Table 1.6

Existing Energy Cost - Average for 1979 by Building Type

EXISTING ENERGY COSTS:

		Average* Square Feet per Dwelling Unit	Average Gas Cost $/Therm.	Average Oil Cost $/Gallon	Average Electric Cost $/Kilowatt Hour	Average Cost of Energy $/MMBTU
LSO	3	1,650	0.364	0.499	0.032	3.96
LSG	1	845	0.238		0.030	3.51
	2	802	0.233		0.042	3.59
	3	804	0.259		0.047	3.23
	4	1,082	0.257		0.045	2.72
	5	910	0.278		0.068	3.57
	Average	832	0.268		0.047	3.46
LSE	1	912			0.045	13.27
	2	803			0.029	8.86
	3	557			0.019	6.46
	Average	762			0.033	9.57
LCO	3	528	0.417	0.353	0.054	2.88
	4		0.284	0.688	0.042	5.02
	Average		0.371	0.468	0.050	3.79
LCG	2	797	0.258		0.044	3.04
	3	701	0.299		0.039	3.35
	4	764	0.203		0.039	2.65
	Average	734	0.274		0.040	3.15
HSE	3	795			0.012	3.58
	4	736			0.044	12.75
	Average	777			0.021	6.52
HCO	3	876		0.352	0.048	3.89
	4	454		0.461	0.035	3.76
	Average	767		0.380	0.045	3.83
HCG	2	810	0.185		0.033	3.20
	3	693	0.276		0.047	4.16
	4	789	0.245		0.042	3.74
	5	635	0.187		0.041	3.00
	Average	724	0.226		0.042	3.58
ALL BLDG TYPES	Average	850	0.285	0.461	0.040	3.74

NOTES: * Includes public/office space prorated to the dwelling units.

1.3.1 Energy Conservation Opportunities in Public Housing

There are hundreds of ways to save energy in the residential and non-residential buildings and spaces making up the United State Public Housing stock. These range from such widely applicable measures as installing storm windows to very specific retrofits like installing hydro-pneumatic pumping systems in high rise buildings without roof tanks.

Fifty-eight Energy Conservation Opportunities (ECOs) were found to represent significant energy savings modifications that can be made to the existing Public Housing stock. These fifty eight ECOs are not meant to encompass every possible retrofit, but only those that are expected to be widely applicable and save substantial energy. There is no doubt that there will be additional ECOs that will save energy on a cost-effective basis in a specific project. These additional ECOs were not included in the study in the attempt to analyze only the major ECOs within the limitations of the time and effort available.

It is not the intention of the study to limit funding to only the ECOs mentioned. It is expected that all energy-saving retrofits will be considered when individual projects are surveyed for energy conservation.

The fifty-eight ECOs are grouped into twelve major categories:

Major ECO Group	ECOs
Architectural	AR 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Space Heating	SH 1, 2, 3, 4, 5
Space Hot Water	SW 1, 2, 3, 4
Space Lighting	SL 1, 2, 3, 4, 5
Space Cooling	SC 1, 2
Central Radiation	CR 1, 2, 3, 4, 5
Central Air	CA 1, 2, 3, 4, 5, 7, 9
Central Heating	CH 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Central Heating Distribution	HD 1
Central Water Supply	WS 1, 2, 3
Central Cooling	CC 1, 2, 3
Exterior Lighting	EL 1, 2, 3

The final list of fifty-eight ECOs underwent further refining as a result of their use in the energy analysis. It should be noted that AR 1 and AR 2, as well as CA 3, 4 and 5 were analyzed in combination and will be listed as such in subsequent sections of this report. Combining these ECOs was necessary because of calculation techniques.

A listing of ECOs is included in Table 1.7. A detailed description of each ECO can be found in Chapter 2 of this volume.

Energy Conservation Opportunities (ECOs) were analyzed individually to determine savings and capital cost per dwelling unit. A discounted payback analysis was made of each to determine relative economic value.

The significant energy-saving ECOs with low payback included many modifications to the structure such as installing weatherstripping, storm doors and windows and increased insulation. Other major ECOs included setback thermostats for night time temperature reductions and modifications to the central plant to increase efficiency of older equipment. Of major importance were the energy savings attributable to operation and maintenance items (No Capital Cost).

Table 1.8 is a summary of the major ECOs with less than 15 year payback, listed in order of greatest potential dollar savings for the entire public housing stock. Note that these are only presented for comparison; individual projects were found to vary substantially.

The savings presented here are for ECO analyzed individually and are not additive because many of these are mutually exclusive of others when installed in the same project. Others are affected by combinations with other ECOs. For example: weatherstripping savings are only applicable if storm windows and storm doors are not installed because both of these have weatherstripping built into them therefore separate weatherstripping is not necessary.

Since some ECOs are mutually exclusive of one another or are dependent on other ECOs, the total energy savings of combined ECOs would therefore result in less than the total for the ECOs independently. To take this into account, each payback group is reanalyzed to show diminished savings of combined ECOs.

The resulting savings and costs of these three categories, in addition to the "No Cost" ECO savings are shown in Illustration 1.5 along with the curve of diminishing returns that it creates. Note that these results are for the national average, and building types as well as individual projects may vary widely from national averages.

Table 1.7

Energy Conservation Opportunities (ECO)

Architectural

AR1 Door Weather Stripping
AR2 Window Weather Stripping
AR3 Attic Insulation
AR4 Floor Insulation
AR5 Roof Insulation
AR6 Storm Windows
AR7 Insulating Glass
AR8 Storm Doors
AR9 Wall Insulation
AR10 Vestibules

Space Heating

SH1 Reduce Temperature
SH2 Nightime Set Back Thermostat
SH3 Automatic Flue Damper
SH4 Flue Heat Recovery
SH5 Electric Automatic Pilots

Space Domestic Hot Water

SW1 Reduce Temperature
SW2 Flow Restrictors
SW3 New Domestic Hot Water Heater
SW4 Refurbish/Replace Fixture

Space Lighting

SL1 Delamping
SL2 Reduce Lighting Level
SL3 Automatic Time Control
SL4 Incandescent to Fluorescent
SL5 High Efficiency Ballast

Space Cooling

SC1 Clean Condensors and Evaporators
SC2 Require High EER Units

Central Radiation/Convector System

CR1 Individual Room Control
CR2 Zone Control Retrofit
CR3 Radiation Pump Control
CR4 Hot Water Reset Control
CR5 Radiation Part Load Pump

Central Air Handling Systems

CA1 Reduce Outdoor Air Intake
CA2 Reduce Supply Air Quantities
CA3 Reduce Outdoor Air Damper Leakage
CA4 Automatic Start and Stop
CA5 Warm-Up Cycle
CA7 Zone Reset Control
CA8 Heat Recovery

Central Heating Boiler

CH1 Boiler Water Maintenance
CH2 Burner Adjustment
CH3 Boiler Control Adjustment
CH4 Automatic Cycling
CH5 Lead/Lag Control
CH6 Reduce Burner Size
CH7 Modulating Burner
CH8 Part Load Boiler
CH9 Automatic Breeching Damper
CH10 Flue Gas Heat Recovery
CH11 Fuel Conversion

Central Heating Distribution

HD1 Refurbish Steam Traps

Central Domestic Water Supply

WS1 Hydro-pneumatic System
WS2 Variable Speed Pumping
WS3 Separate Domestic Hot Water Heater

Central Cooling

CC1 Chiller Control Adjustment
CC2 Ambient Control
CC3 Timed Control

Exterior Lighting

EL1 Timed Switching
EL2 Photocell Switching
EL3 Sodium Vapor Conversion

It can be seen that at some point the cost of installing energy conservation opportunities is beyond an incremental fifteen year payback. This point is shown in Illustration 1.5 as a dotted line. At this point investment costs would equal $1347 per dwelling unit and would save $324 per year. Individual projects and building types would, of course, vary substantially depending on their climate and specific characteristics.

Table 1.8

Summary of Major Energy Conservation Opportunities (ECOs) Analyzed Individually*

Rank	ECO	Expected(1) Applica-Bility To Bldg Type	Actual(2) Applica-Bility Found	Percent Savings Energy Use	Percent Savings Energy Cost
1.	Operation and Maintenance ECOs	100%	100%	14.4%	11.2%
2.	Storm Windows	100	67	10.9	10.3
3.	Storm Doors	70	52	9.2	8.8
4.	Weatherstripping	100	47	8.8	8.2
5.	Setback Thermostat	100	95	10.8	9.9
6.	Automatic Flue Damper	48	45	8.5	7.2
7.	Wall Insulation	70	46	5.6	5.2
8.	Upgrade Faucet Plumbing	100	98	4.3	3.4
9.	Flow Restrictors-Shower	100	98	3.4	3.1
10.	Replace D.H.W. Heater	61	25	2.6	3.1
11.	Flue Heat Recovery	48	3	2.6	2.5
12.	Radiator Room Control	39	13	1.4	1.4
13.	Central Heating Flue Heat Recovery	39	36	1.8	1.8
14.	Roof Insulation	100	33	1.2	1.2
15.	Separate DHW Heater	39	23	.6	.7
16.	Conversion to Fluorescent	100	95	.5	.7
17.	Electric Automatic Pilots	48	45	.8	.74
18.	Vestibules	30	18	.7	.6
19.	Floor Insulation	70	17	.7	.6
20.	Modulating Burner	39	7	.6	.5
21.	Sodium-Vapor Conversion	100	71	.3	.3
22.	Automatic Lighting Level	100	40	.1	.1
				*	*

Notes:

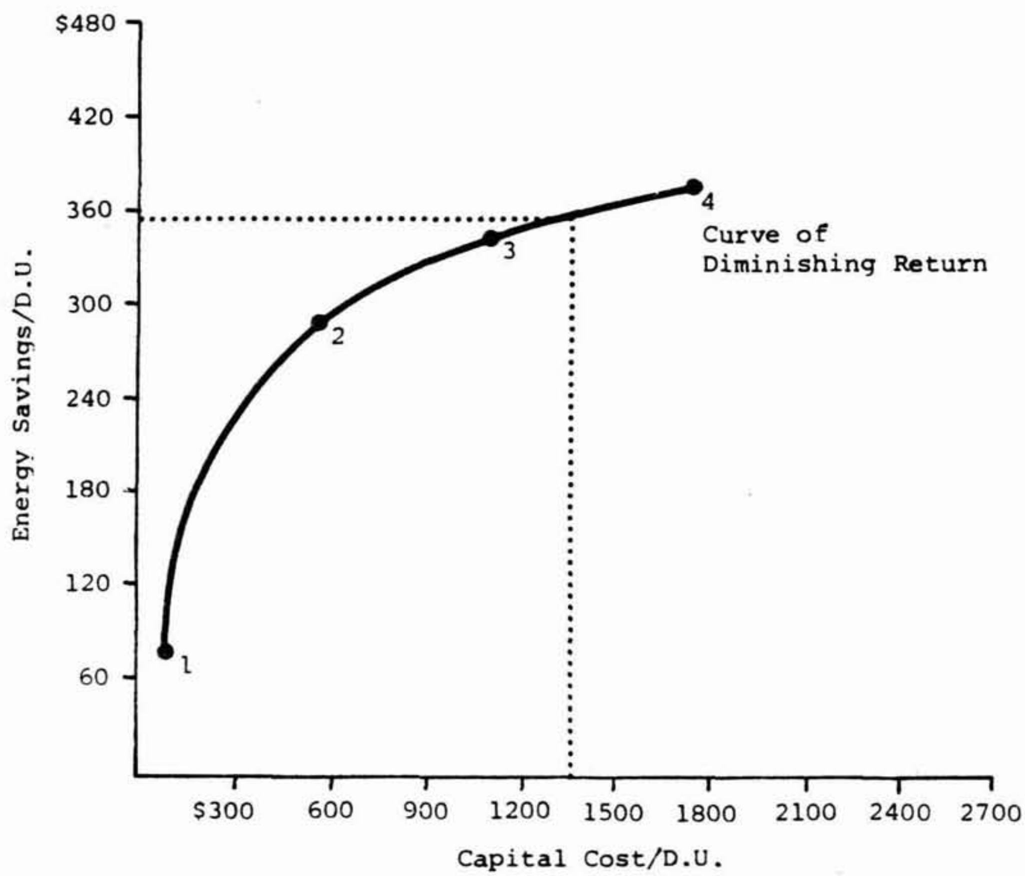
1. This is the percent of the total public housing stock that an ECO is targeted for. Example: Radiator room control is only aplicable to central heating systems which account for 39 percent of the public housing.
2. The percent applicability actually found is the actual number of buildings that this ECO was found to be applicable, not already having it and is cost effective.

* Many ECOs are mutually exclusive or affected by combination with other ECOs which could negate or significantly reduce savings. Because of this individual ECOs are presented here for comparison only and results are not additive. Actual energy savings through a comprehensive energy conservation retrofit program would reflect these combinations and the results are discussed elsewhere in this report.

All ECOs listed above have payback periods of less than fifteen years but are not listed in order of least-to-greatest payback.

Illustration 1.5

Cost/Benefit Analysis of Combined Energy Conservation Opportunities (ECOs)



See facing page for reference to Points 1 - 4 on graph.

Illustration 1.5 (continued)

Cost/Benefit Analysis of Combined Energy Conservation Opportunities (ECOs)

Average per DU	Site Energy Savings (MMBTU)	Source Energy Savings (MMBTU)	Dollar Savings (%)	Dollar Savings (%)	Capital Cost*** ($)
1. All 'no cost' ECOs	21.97	27.57	11.2	75.36	(75.36)*
2. All ECOs with 5 yr individual payback	75.64	94.55	43.4	291.79	576.10
3. All ECOs with 10 yr individual payback	86.13	108.45	50.5	339.95	1068.90
4. All ECOs with 15 yr individual payback	95.90	120.16	56.0	376.50	1745.27
Marginal payback analysis (dotted line ....)	78**	100.4**	48	324**	1347.00

Total					***
Marginal Payback+	88,880,000	111,822,000	48	460,860,000	1,500,240,000

+ These totals are extrapolations of 1,113,769 dwelling units(i.e. total PHA stock)
* Cost of maintenance ECOs is assumed to be equal to first year savings
**Discounted 10% for implementation contingencies.
*** Exclusive of fees and contingencies

Table 1.9 shows the applicability found for each energy conservation opportunity by building types. Major and minor applicability are shown as well as those that do not apply at all.

Table 1.10 illustrates the payback category each ECO was found to belong to by building type.

Table 1.11 presents in more detail the actual results for each ECO and building in terms of payback.

Table 1.12 presents the ECOs for each building in order of payback.

Table 1.9

Energy Conservation Opportunities Applicability to Building Types

		AR1&2 Weather Strip'g	AR3 Attic Insulation	AR4 Floor Insulation	AR5 Roof Insulation	AR6 Storm Windows	AR7 Insulat'g Glass	AR8 Storm Doors	AR9 Wall Insulation	AR10 Vestibules	SH2 Lower Temperat.	SH3 Auto.Flue Damper	SH4 Flue Heat Recov.	SH5 Elec.Auto.Pilots	SW2 Flow Restrictors	SW3 New DHW.Heaters	SW4 Upgrade Plumbing	SL2 Auto.Light Level	SL3 Auto.Timer Contr	SL4 Conv.to Fluores.	SL5 High Eff.Ballast	CR1 Room Control	CR2 Zone Control	CR3 Pump Control	CR4 H.W.Reset Cont.	CR5 Part Load Pump	CA2 Reduce Sup.Air	CA3-5 Upgrade Air Sys.	CA7 Zone Reset Cont.	CA9 Heat Recovery	CH4 Auto Cycling	CH5 Lead/Lag Control	CH6 Reduce Burner Sz	CH7 Modulat'g Burner	CH8 Part Load Burner	CH9 Auto.Breech Damp	CH10 Flue Heat Recov.	CH11 Fuel Conversion	WS1 Hydro-Pneu Sys.	WS2 Var.Speed Pump	WS3 Sep.DHW.Heater	CC2 Ambient Control	CC3 Timed Control	EL1 Timed Switching	EL2 Photo Switching	EL3 Sod-Vapor Conver
LSO	3				o	o	o	o	o		o		o		o		o																													o
LSG	1	o	o	●	●	o	o	o	o		o	o	o	o	o	o	o	o	o	o	●						●	●	●	●														●	●	o
	2	o	o	●	●	o	o	o	o		o	o	o	o	o	o	o	●	o	o	●						●	●	●	●												●	●	●	●	●
	3	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	●	o	o	●							●																●	●	●
	4	o	o	o		o	o	o	o		o	o	o	o	o	o	o			o													o													o
	5				o				o		o	o	o	o	o	o	o	o	o	o	o																									o
LSE	1		o			o	o	o	o		o				o	o	o		o	o								o																o	o	o
	2	o	o			o	o	o	o		o				o	o	o		o	o																								●	●	●
	3	o	o	●	●	o	o	o	o		o				o	o	o	o	o	o	o						●			●												●	●			o
LCO	3	o	o		●	o	o	o	o		o		o		o	o	o	●	●	o	●	o	o	●	●	o	●	●	●	●	o		●	o			o				●					●
	4	o	o	o	o	o	o	o	o		o		o		o		o		o	o		o	o	o	o	o					o						o				o					o
LCG	2	o	o		o	o	o	o	o		o		o		o		o	o	o	o	o	o	o	o	o	o	o	o		o	o		o				o							o	o	o
	3	●	o	o	o	o	o	o	o		o		o		o	o	o	●	o	o	●	o	o	●	o	o	●	●		●	o		●	o	o	o	o				o					o
	4	o	o	●		o	o	o	o		o		o		o		o			o		●	●		●	o	●	●		●	●			●	o		o				●					●
HSE	3	o			o	o	o		o		o				o	o	o	o	o	o	o						o	o										o	o							o
	4				o	o	o		o	o	o				o	o	o	o	o	o	o																									o
HCO	3	●			o	o	o		o	o	o				o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	●		●	●			o	o	o	o	●					o
	4	o			o	o	o		o		o				o		o	o	o	o	o	o	o	o	o	o					o					o	o			o						o
HCG	2				o	o	o		o	o	o				o		o	o	o	o	o	o	o	o	o	o	o	o		o	o					o	o		o	o	o	o	o			o
	3	o			o	o	o		o	●	o				o		o	o	o	o	o	o		o	o	o	o	o	●	o			●	●	●	●	o		●	●	o	●	●			o
	4				o	o	o		o	o	o				o		o	●	o	o	●	o		o	o	o	o	o	●	o			●			o	o		●	●	o					o
	5				o	o	o		o	o	o				o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o				o		o	o	o					o
ALL BLDG TYPES Average																																														

NOTES:

o Applies

● Minor application (applies to less than 50% of projects)

Table 1.10

Energy Conservation Opportunities Payback Summary

Bldg Type		AR1&2 Weather Strip'g	AR3 Attic Insulat.	AR4 Floor Insulat.	AR5 Roof Insulat.	AR6 Storm Windows	AR7 Insulat'g Glass	AR8 Storm Doors	AR9 Wall Insulation	AR10 Vestibules	SH2 Lower Temperat.	SH3 Auto.Flue Damp.	SH4 Flue Heat Recov	SH5 Elec.Auto.Pilot	SW2 Flow Restrictor	SW3 New DHW.Heaters	SW4 Upgrade Plumb.
LSO	3				◐	◐		◐	◐		○		●		○	◐	○
LSG	1	◐				●		◐			○	○		●	○		○
	2	○		○		◐	●	○	●		○	○		●	○	●	○
	3	○		●	◐	○	◐	○	●		○	○	●	●	○	◐	○
	4	○				○	◐	○			○	○	●	●	○	○	○
	5				◐				○		○	○	●	◐	○	●	○
	Average	○		●	●	◐	●	○	●		○	○		●	○	●	○
LSE	1					●		●	●		○				○	●	○
	2	○				○	○	○			○				○	○	○
	3	○	●	●	●	○	○	○	●		○				○	●	○
	Average	○		◐	●	○	○	○	●		○				○	●	○
LCO	3	○	●			○	◐	○	●		○		●		○		○
	4	○		○	○	○	○	○	◐		○		◐		○		○
	Average	○	●	○	●	○	○	○	◐		○		◐		○		○
LCG	2	○				○	●	○	●		○		●		○		○
	3	○	●	◐	●	◐		○			○		◐		○		○
	4	○		●		◐	●	○	●		○		●		○		○
	Average	○		◐	●	○	◐	○	●		○		●		○		○
HSE	3	◐			●	○	◐				○				○		●
	4				○	○	◐			○	○				○	◐	○
	Average	◐			◐	○	◐			○	○				○	●	●
HCO	3	○			◐	○	◐			○	○				○		◐
	4	○			○	○	○				○				○		◐
	Average	○			◐	○	◐			○	○				○		●
HCG	2				◐	●				●	○				○		◐
	3	○			◐	○	◐			◐	○				○		●
	4				○	◐				◐	○				◐		●
	5					●				◐	○				◐		●
	Average	○			◐	◐	●			◐	○				○		●
ALL BLDG TYPES	Average	○	◐		◐	○	◐	○	●	○	○	○	●	●	○	○	○

Bldg Type		SL2 Auto.Light Lev.	SL3 Auto.Timer Cont	SL4 Conv.To Fluores	SL5 High Eff.Ballas	CR1 Room Control	CR2 Zone Control	CR3 Pump Control	CR4 H.W.Reset Contr	CR5 Part Load Pump	CA2 Reduce Sup.Air	CA3-5 Upgrade Air Sys	CA7 Zone Reset Cont	CA9 Heat Recovery
LSO	3			◐										
LSG	1	●	◐	◐	◐							◐		
	2	●	◐	◐	◐							●		
	3	●	●	◐	●									
	4			◐										
	5	●	○	○	●									
	Average	●	●	●	●							●		
LSE	1		○	◐								○		
	2			◐										
	3	●	●	●	◐							○		
	Average	●	●	◐	◐							○		
LCO	3	●	○	◐	○	●	●		●	◐		●		
	4		○	◐		●			◐	●				
	Average	●	○	◐	○	●			◐	●		●		
LCG	2	●	○	◐	●				◐	◐				
	3	●	●	◐	●	●		◐	●					
	4			◐			●		○	●		●		
	Average	●	◐	◐	●	●		◐	●	◐		●		
HSE	3		○									○		
	4	●	○	◐	◐									
	Average		○	●	●							○		
HCO	3	●	○	◐	◐		●	◐	○	●		●	●	
	4	●	◐	◐	●		○		○					
	Average	●	●	◐	◐		○	●	○	●		●	●	
HCG	2	●	○	◐	◐		●	◐	○	◐		●		
	3	●	○	◐	◐			●	○	●		◐		
	4	●	○	◐	◐			●	○	●		●		
	5	●	○	◐	◐		◐	○	○			◐	●	
	Average	●	○	◐	◐		◐	○	○	●		●		
ALL BLDG TYPES	Average	●	○	◐	◐	●			◐	◐		◐		

Bldg Type		CH4 Auto Cycling	CH5 Lead/Lag Contr	CH6 Reduce Burner Sz	CH7 Modulat'g Burn	CH8 Part Load Burn	CH9 Auto.Breech Damp	CH10 Flue Heat Recov	CH11 Fuel Conversion	WS1 Hydro-Pneu Sys	WS2 Var.Speed Pump	WS3 Sep.DHW.Heater	CC2 Ambient Control	CC3 Timed Control	EL1 Timed Switching	EL2 Photo Switching	EL3 Sod-Vapor Conve
LSO	3																○
LSG	1														○	○	●
	2												○	○	●	○	●
	3															●	◐
	4																◐
	5																○
	Average												○	○	○	○	●
LSE	1														○	○	●
	2															◐	●
	3												○	●			●
	Average												○	●	●	○	●
LCO	3	○		●	○			○				○					◐
	4	○						○				○					◐
	Average	○		●	○			○				○					◐
LCG	2	○		◐				○								●	●
	3	○		●	○	○	○	○				○					●
	4	○		○	○	●		○				◐					●
	Average	○		◐	○	○	○	○				○				●	●
HSE	3									●	●						
	4			○													◐
	Average									●	●						●
HCO	3	○		○	○			○		○	○	○	◐				◐
	4	○					○	○				○					◐
	Average	○		○	○		○	○		○	○	○	◐				◐
HCG	2	○					◐	○		○	○		○	○			●
	3			○	○	○	○	○			●	◐	○	◐			◐
	4			●			◐	○		○	○	●					◐
	5	○		○				○		○	○	○					
	Average	○		○	○	○	◐	○		○	○	●	○	○			◐
ALL BLDG TYPES	Average	○		○	○	○	○	○		○	○	○	○	○	◐	○	●

NOTES:

○ Payback in 5 years or less
◐ Payback in 10 years or less
● Payback in 15 years or less

Table 1.11

Energy Conservation Opportunities Discounted Payback in Years

		Weather Strip'g AR1&2	Attic Insulation AR2	Floor Insulation AR4	Roof Insulation AR5	Storm Windows AR6	Insulat'g Glass AR7	Storm Doors AR8	Wall Insulation AR9	Vestibules AR10	Set Back Thermos SH2	Auto Flue Damper SH3	Flue Heat Recov SH4	Elec Auto Pilots SH5	Flow Restrictors SW2	New DHW Heaters SW3	Upgrade Plumbing SW4
LSO	3	-	-	-	7.5	9.5	16.6	5.4	10.0	-	0.6	-	10.7	-	0.4	7.5	1.9
LSG	1	9.9	*	21.3	44.4	11.9	19.2	7.0	22.2	-	2.2	4.0	32.3	11.5	1.0	17.4	4.0
	2	3.8	18.9	4.2	36.0	8.1	14.6	3.6	14.6	-	1.0	2.7	16.5	9.7	0.8	10.4	3.1
	3	2.3	23.1	9.7	6.0	2.7	5.2	1.3	10.6	-	1.0	1.9	11.3	10.6	0.9	9.7	3.6
	4	3.1	*	15.9	-	3.3	6.1	0.2	18.2	-	0.6	1.8	6.6	10.6	0.8	5.0	3.3
	5	-	-	-	7.3	-	-	-	6.7	-	0.9	1.3	10.6	10.0	0.8	8.1	3.1
	Average	4.4	21.2	11.0	11.3	6.9	11.5	3.2	12.3	-	1.2	2.5	16.3	10.4	0.9	11.4	3.5
LSE	1	-	47.6	-	-	12.1	28.5	10.6	10.8	-	0.4	-	-	-	0.2	6.4	0.8
	2	1.0	22.7	-	-	1.1	2.1	0.4	19.9	-	0.4	-	-	-	0.3	4.1	1.3
	3	1.6	12.1	6.3	13.6	1.5	3.0	0.6	11.3	-	0.8	-	-	-	0.9	7.4	3.0
	Average	1.2	22.5	6.3	13.6	2.8	5.4	1.0	10.8	-	0.5	-	-	-	0.3	6.2	1.2
LCO	3	4.6	10.4	-	25.9	2.8	5.6	0.7	10.3	-	1.3	-	14.9	-	1.1	-	4.5
	4	1.1	*	3.0	3.0	1.7	3.5	0.6	5.9	-	0.5	-	5.6	-	0.5	-	1.9
	Average	2.0	12.2	3.0	5.6	2.0	4.0	0.6	7.6	-	0.8	-	9.5	-	0.8	-	3.1
LCG	2	2.4	17.6	-	30.3	2.7	5.1	0.7	10.1	-	0.7	-	11.5	-	1.0	-	3.9
	3	1.5	10.8	9.5	11.1	8.1	22.6	0.7	16.9	-	1.1	-	9.9	-	0.8	-	3.2
	4	2.4	*	12.3	-	5.8	12.3	0.8	10.9	-	1.3	-	11.5	-	1.3	-	4.9
	Average	1.9	16.1	9.5	11.3	4.2	8.2	0.7	12.5	-	1.0	-	10.5	-	0.9	-	3.5
HSE	3	7.1	-	-	11.5	4.6	8.0	-	-	-	2.1	-	-	-	3.7	19.0	8.3
	4	-	-	-	3.9	2.4	5.3	-	-	3.1	0.6	-	-	-	1.1	5.3	2.7
	Average	7.1	-	-	5.3	3.9	7.2	-	-	3.1	1.2	-	-	-	2.1	10.8	5.2
HCO	3	3.4	-	-	7.1	4.4	8.2	-	-	2.2	2.4	-	-	-	2.0	-	6.1
	4	1.7	-	-	3.1	1.5	2.9	-	-	-	1.4	-	-	-	1.7	-	5.2
	Average	3.0	-	-	5.1	3.7	6.7	-	-	2.2	2.0	-	-	-	1.9	-	5.8
HCG	2	-	-	-	9.0	10.2	16.9	-	-	11.3	3.0	-	-	-	2.6	-	8.5
	3	3.8	-	-	6.8	5.0	9.2	-	-	5.4	2.7	-	-	-	4.6	-	10.1
	4	-	-	-	13.0	10.0	18.3	-	-	8.9	2.6	-	-	-	5.2	-	11.2
	5	-	-	-	16.1	12.0	23.2	-	-	8.7	4.5	-	-	-	6.2	-	12.9
	Average	3.8	-	-	9.4	8.9	14.7	-	-	8.4	3.0	-	-	-	4.7	-	10.8
ALL BLDG TYPES	**Average**	2.4	19.0	8.5	7.7	4.1	7.5	1.3	10.4	3.7	1.1	2.5	11.6	10.4	0.9	3.7	3.9

NOTES:

* Payback over 50 years
\- Not applicable

Table 1.11 (continued)

Energy Conservation Opportunies Discounted Payback in Years

		Auto Light Level SL2	Auto Timer Contr SL3	Conv to Fluoresc SL4	High Eff Ballast SL5	Room Control CR1	Zone Control CR2	Pump Control CR3	H.W. Reset Contr CR4	Part Load Pump CR5	Reduce Sup Air CA2	Upgrade Air Sys CA3-5	Zone Reset Contr CA7	Heat Recovery CA9
LSO	3	-	16.9	8.0	-	-	-	-	-	-	-	-	-	-
LSG	1	10.5	5.3	7.0	7.5	-	-	-	-	-	*	7.2	*	*
	2	11.1	9.3	7.0	8.6	-	-	-	-	-	*	5.7	*	*
	3	11.2	12.5	6.4	8.3	-	-	-	-	-	-	-	-	-
	4	-	-	6.6	-	-	-	-	-	-	-	-	-	-
	5	7.1	1.3	4.3	5.2	-	-	-	-	-	-	-	-	-
	Average	10.0	6.6	6.2	7.2	-	-	-	-	-	*	6.6	*	*
LSE	1	-	4.0	6.5	-	-	-	-	-	-	-	2.8	-	-
	2	-	16.5	9.5	-	-	-	-	-	-	-	-	-	-
	3	12.0	8.8	11.1	8.8	-	-	-	-	-	*	2.3	-	*
	Average	12.0	7.3	7.7	8.8	-	-	-	-	-	*	2.7	-	*
LCO	3	10.1	0.9	6.1	4.9	11.3	14.2	17.1	11.6	6.1	*	13.7	27.5	*
	4	-	3.4	6.9	-	13.0	*	19.8	5.8	11.6	-	-	-	-
	Average	10.1	1.4	6.1	4.9	12.6	26.2	19.1	5.9	6.9	*	13.7	27.5	*
LCG	2	10.3	4.9	6.4	8.3	19.9	26.1	*	7.1	6.1	*	16.1	-	*
	3	10.7	5.3	7.1	7.8	10.7	24.4	5.1	13.4	24.5	*	*	-	*
	4	-	-	7.3	-	19.0	12.7	-	0	12.0	*	7.6	-	26.8
	Average	10.5	5.1	6.5	7.8	14.5	21.7	5.3	11.0	8.7	*	14.1	-	35.7
HSE	3	25.3	3.7	15.9	18.0	-	-	-	-	-	*	1.2	-	-
	4	10.3	3.0	6.4	7.5	-	-	-	-	-	-	-	-	-
	Average	17.5	3.3	11.0	13.1	-	-	-	-	-	*	1.2	-	-
HCO	3	9.9	4.5	6.1	7.6	42.2	7.0	6.8	1.3	12.6	*	6.2	10.3	19.8
	4	14.4	6.8	8.1	10.6	16.2	2.7	*	0.7	19.7	-	-	-	-
	Average	11.0	5.3	6.2	7.9	22.2	4.0	9.8	0.9	12.8	*	6.2	10.3	19.8
HCG	2	12.0	3.8	8.4	8.8	42.7	6.4	6.6	2.0	7.9	*	12.6	-	*
	3	11.4	3.0	6.3	8.9	*	-	14.1	1.5	14.3	*	7.6	*	36.1
	4	12.5	2.3	6.8	9.9	*	-	5.8	3.5	12.8	*	11.8	22.8	32.9
	5	10.8	2.5	7.1	8.3	40.1	6.4	2.2	1.2	15.6	*	9.5	11.9	21.4
	Average	11.4	2.7	6.5	8.4	34.8	6.4	5.0	2.3	14.3	*	10.3	17.9	27.3
ALL BLDG TYPES	Average	11.0	4.7	6.5	8.0	12.3	21.7	15.3	6.2	9.7	*	7.4	19.7	27.5

NOTES: * Payback over 50 years
- Not applicable

Table 1.11 (continued)

Energy Conservation Opportunies Discounted Payback in Years

		Auto Cycling CH4	Lead Lag Control CH5	Reduce Burner Sz CH6	Modulat'g Burner CH7	Part Load Boiler CH8	Auto Breech Damp CH9	Flue Heat Recov CH10	Fuel Conversion CH11	Hydro-Pneu Syst WS1	Var Speed Pump WS2	Sep DHW Heater WS3	Ambient Control CC2	Timed Control CC3	Timed Switching EL1	Photo Switching EL2	Sod-Vapor Conver EL3
LSO	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0
LSG	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1.5	0.5	7.3
	2	-	-	-	-	-	-	-	-	-	-	-	0.6	3.6	6.7	2.1	7.9
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	*	10.7	7.6
	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.7
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0
	Average	-	-	-	-	-	-	-	-	-	-	-	0.6	3.6	3.9	1.1	6.9
LSE	1	-	-	-	-	-	-	-	-	-	-	-	-	-	3.5	1.0	15.0
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	23.4	9.0	9.7
	3	-	-	-	-	-	-	-	-	-	-	-	1.9	9.2	-	-	12.4
	Average	-	-	-	-	-	-	-	-	-	-	-	1.9	9.2	12.7	1.8	12.7
LCO	3	0.6	-	5.9	2.3	-	-	0.2	-	-	-	2.2	-	-	-	-	9.5
	4	0.8	-	-	-	-	-	0.1	-	-	-	0.3	-	-	-	-	8.8
	Average	0.7	-	5.9	2.3	-	-	0.2	-	-	-	0.8	-	-	-	-	8.8
LCG	2	1.3	-	5.8	-	-	-	0.5	-	-	-	-	-	-	27.4	11.3	13.4
	3	0.5	-	5.6	0.5	1.5	0.4	0.3	-	-	-	0.5	-	-	-	-	11.7
	4	0.5	-	4.2	1.7	6.1	-	0.8	-	-	-	8.7	-	-	-	-	10.4
	Average	0.6	-	5.4	0.5	1.7	0.4	0.4	-	-	-	0.8	-	-	27.4	11.3	11.2
HSE	3	-	-	-	-	-	-	-	-	11.9	5.6	-	-	-	-	-	18.3
	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.7
	Average	-	-	-	-	-	-	-	-	11.9	5.6	-	-	-	-	-	11.8
HCO	3	1.7	-	2.7	3.8	-	-	0.6	-	1.3	0.3	2.0	5.4	-	-	-	5.7
	4	0.7	-	-	-	-	3.2	0.7	-	-	-	2.2	-	-	-	-	7.8
	Average	1.0	-	2.7	3.8	-	3.2	0.7	-	1.3	0.3	2.1	5.4	-	-	-	5.7
HCG	2	3.3	-	-	-	-	5.8	1.1	-	2.5	1.3	41.3	0.1	0.3	-	-	7.4
	3	-	-	1.2	3.3	2.3	4.5	1.6	-	27.7	10.7	8.3	1.0	7.2	-	-	6.9
	4	-	-	10.8	-	-	8.0	1.5	-	2.0	1.0	7.9	-	-	-	-	8.4
	5	1.6	-	4.4	-	-	-	0.7	-	1.4	0.6	2.0	-	-	-	-	6.8
	Average	2.1	-	3.8	3.3	2.2	6.5	1.3	-	2.1	1.0	7.1	0.1	0.5	-	-	6.9
ALL BLDG TYPES	Average	4.2	-	4.5	1.0	2.4	2.9	0.4	-	1.6	0.6	1.3	0.2	1.0	6.1	1.7	8.6

NOTES: * Payback over 50 years
- Not applicable

Table 1.12

Energy Conservation Opportunities Listed in Order of Least to Greatest Payback
ECO's With Less Than 5 Year Payback

Bldg Type	Climate Zone	ECO
LSO	3	SW2, SH2, SW4, EL3
LSG	1	EL2, SW2, EL1, SH2, SH3, SW4
	2	CC2, SW2, SH2, EL2, SH3, SW4, AR8, CC3, AR1&2, AR4
	3	SW2, SH2, AR8, SH3, AR1&2, AR6, SW4
	4	AR8, SH2, SW2, SH3, AR1&2, AR6, SW4, SW3
	5	SW2, SH2, SH3, SL3, SW4, SL4, EL3
LSE	1	SW2, SH2, SW4, EL2, CA3-5, EL1, SL3
	2	SW2, AR8, SH2, AR1&2, AR6, SW4, AR7, SW3
	3	AR8, SH2, SW2, AR6, AR1&2, CC2, CA3-5, AR7, SW4
LCO	3	CH10, CH4, AR8, SL3, SW2, SH2, WS3, CH7, AR6, SW4, AR1&2, SL5
	4	CH10, WS3, SH2, SW2, AR8, CH4, AR1&2, AR6, SW4, AR4, AR5, SL3, AR7
LCG	2	CH10, AR8, SH2, SW2, CH4, AR1&2, AR6, SW4, SL3
	3	CH10, CH9, CH7, CH4, WS3, AR8, SW2, SH2, CH8, AR1&2, SW4
	4	CH4, CH10, AR8, SH2, SW2, CH7, AR1&2, CH6, SW4
HSE	3	CA3-5, SH2, SW2, SL3, AR6
	4	SH2, SH5, AR6, SW4, SL3, AR10, AR5
HCO	3	WS2, CH10, CR4, WS1, CH4, WS3, SW2, AR10, SH2, CH6, AR1&2, CH7, AR6, SL3
	4	CR4, CH4, CH10, SH2, AR6, AR1&2, WS2, WS3, CR2, AR7, AR5, CH9
HCG	2	CC2, CC3, CH10, WS2, CR4, WS1, SW2, SH2, CH4, SL3
	3	CC2, CH6, CR4, CH10, CH8, SH2, SL3, CH7, AR1&2, CH9, SW2, AR6
	4	WS2, CH10, WS1, SL3, SH2, CR4
	5	WS2, CH10, CR4, WS1, CH4, WS3, CR3, SL3, CH6, SH2

NOTES: AR1&2 Weather Strip'g, AR3 Attic Insulation, AR4 Floor Insulation, AR5 Roof Insulation, AR6 Storm Windows, AR7 Insulat'g Glass, AR8 Storm Doors, AR9 Wall Insulation, AR10 Vestibules, SH2 Set Back Thermos, SH3 Auto Flue Damper, SH4 Flue Heat Recov, SH5 Elec Auto Pilots, SW2 Flow Restrictors, SW3 New DHW Heaters, SW4 Upgrade Plumbing, SL2 Auto Light Level, SL3 Auto Timer Contr, SL4 Conv to Fluoresc, SL5 High Eff Ballast, CR1 Room Control, CR3 Pump Control, CR4 H W Reset Contr, CR5 Part Load Pump, CA2, Reduce Sup Air, CA3-5 Upgrade Air Syst, CA7 Zone Reset Contr, CA9 Heat Recovery, CH4 Auto Cycling, CH5 Lead/Lag Control, CH6 Reduce Burner Sz, CH7 Modulat'g Burner, CH8 Part Load Burner, CH9 Auto Breech Damp, CH10, Flue Heat Recov, CH11 Fuel Conversion, WS1 Hydro-Pneu Syst, WS2 Var Speed Pump, WS3 Sep DHW Heater, CC2 Ambient Control, CC3 Timed Control, EL1 Timed Switching, EL2 Photo Switching, EL3 Sod-Vapor Conver.

Table 1.12 (continued)

Energy Conservation Opportunities Listed in Order of Least to Greatest Payback
ECO's with 5 Through 10 Year Payback

Bldg Type	Climate Zone	ECO
LSO	3	AR8, AR5, SW3, AR6, SL4, AR9
LSG	1	SL3, SL4, AR8, CA3-5, EL3, SL5, AR1&2
	2	CA3-5, EL1, SL4, EL3, AR6, SL5, SL3, SH5
	3	AR7, AR5, SL4, EL3, SL5, AR4, SW3
	4	AR7, SH4, SL4, EL3
	5	SL5, AR9, SL2, AR5, SW3, SH5
LSE	1	SW3, SL4
	2	EL2, SL4, EL3
	3	AR4, SW3, SL3, SL5, CC3
LCO	3	AR7, CH6, SL4, CR5, EL3
	4	SH4, CR4, AR9, SL4, EL3
LCG	2	AR7, CH6, CR5, SL4, CR4, SL5
	3	CR3, SL3, CH6, SL4, SL5, AR6, AR4, SH4
	4	AR6, CH8, SL4, CA3-5, WS3
HSE	3	WS2, AR1&2, AR7, SW4
	4	SW3, AR7, SL4, SL5, EL3
HCO	3	CC2, EL3, SW4, SL4, CA3-5, CR3, CR2, AR5, SL5, AR7, SL2
	4	SW4, SL3, SL4, EL3
HCG	2	CH9, CR2, CR3, EL3, CR5, SL4, SW4, SL5, AR5
	3	AR10, SL4, AR5, EL3, CC3, CA3-5, WS3, SL5, AR7
	4	SW2, CR3, SL4, WS3, CH9, EL3, AR10, SL5, AR6
	5	SW2, CR2, EL3, SL4, SL5, AR10, CA3-5

Table 1.12 (continued)

Energy Conservation Opportunities Listed in Order of Least to Greatest Payback
ECO's With Between 10 to 15 Year Payback

Bldg Type	Climate Zone	ECO
LSO	3	SH4
LSG	1	SL2, SH5, AR6
	2	SW3, SL2, AR7, AR9
	3	AR9, SH5, EL2, SL2, SH4, SL3
	4	SH5
	5	SH4
LSE	1	AR8, AR9, AR6, EL3
	2	
	3	SL4, AR9, SL2, AR2, EL3, AR5
LCO	3	SL2, AR9, AR2, CR1, CR4, CA3-5, CR2, SH4
	4	CR5, CR1
LCG	2	AR9, SL2, EL2, SH4, EL3
	3	SL2, CR1, AR2, AR5, EL3, CR4
	4	EL3, AR9, SH4, CR5, AR4, AR7, CR2
HSE	3	AR5, WS1
	4	SL2
HCO	3	CA7, CR5
	4	SL5, SL2
HCG	2	AR6, AR10, SL2, CA3-5
	3	SW4, WS2, SL2, CR3, CR5
	4	CH6, SW4, CA3-5, SL2, CR5, AR5
	5	SL2, CA7, AR6, SW4

Table 1.13 summarizes the energy savings, costs and paybacks for each ECO for the total public housing stock.

Tables 1.14, 1.15, 1.16, 1.17 show the results of combined ECO analysis for each payback category:

1. Operation and Maintenance ECO Savings (no cost)
2. All ECOs with less than 5 year payback
3. All ECOs with less than 10 year payback
4. All ECOs with less than 15 year payback

Energy savings and capital cost is shown for both the average dwelling unit and the total public housing stock by building type.

Table 1.13

Savings Summaries, Averages for All Building Types

		AVERAGE SAVINGS PER DWELLING UNIT:				ANALYSIS:			PAYBACK:
		Averaged Total Site Energy Savings (MMBTU)	Averaged Total Source Energy Savings (MMBTU)	Averaged Total Dollar Savings ($-'79)	Averaged Total Capital Cost ($-'79)	Percent Applica-bility Found (%)	Percent Source Energy Savings (%)	Percent Dollar Savings (%)	Discounted Payback Period (Years)
AR1&2	WEATHER STRIP'G	13.70	16.93	44.98	127.71	47	8.8	8.2	2.4
AR3	ATTIC INSULATION	1.05	1.24	2.70	109.10	9	0.6	0.5	19.0
AR4	FLOOR INSULATION	1.21	1.39	3.34	40.14	17	0.7	0.6	8.5
AR5	ROOF INSULATION	1.97	2.29	6.82	73.16	33	1.2	1.2	7.7
AR6	STORM WINDOWS	16.49	20.84	56.29	274.56	67	10.9	10.3	4.1
AR7	INSULAT'G GLASS	14.26	18.09	49.09	509.97	39	9.7	9.0	7.5
AR8	STORM DOORS	14.42	17.67	48.22	73.82	52	9.2	8.8	1.3
AR9	WALL INSULATION	9.10	10.68	28.41	452.91	46	5.6	5.2	10.4
AR10	VESTIBULES	1.12	1.36	3.05	13.63	18	0.7	0.6	3.7
SH2	LOWER TEMPERAT	16.95	20.74	53.99	65.00	95	10.8	9.9	1.1
SH3	AUTO FLUE DAMPER	14.62	16.22	39.17	114.46	45	8.5	7.2	2.5
SH4	FLUE HEAT RECOV	4.48	5.08	13.46	223.24	33	2.6	2.5	11.6
SH5	ELEC AUTO PILOTS	1.33	1.48	9.57	51.73	45	0.8	0.7	10.4
SW2	FLOW RESTRICTORS	5.30	6.46	17.15	17.00	98	3.4	3.1	0.9
SW3	NEW DHW HEATERS	3.74	4.99	17.08	74.81	25	2.6	3.1	3.7
SW4	UPGRADE PLUMBING	6.63	8.17	18.50	88.97	98	4.3	3.4	3.9
SL2	AUTO LIGHT LEVEL	0.08	0.28	0.98	15.05	40	0.1	0.2	11.0
SL3	AUTO TIMER CONTR	0.08	0.26	0.87	4.88	73	0.1	0.2	4.7
SL4	CONV TO FLUORESC	0.29	0.97	3.60	31.08	95	0.5	0.7	6.5
SL5	HIGH EFF BALLAST	0.04	0.13	0.46	5.14	42	0.1	0.1	8.0
CR1	ROOM CONTROL	2.39	2.71	7.58	136.93	13	1.4	1.4	12.3
CR2	ZONE CONTROL	0.72	0.81	1.87	80.86	18	0.4	0.3	21.7
CR3	PUMP CONTROL	0.33	0.37	0.96	23.62	13	0.2	0.2	15.3
CR4	H W RESET CONTR	0.74	0.85	3.34	25.51	14	0.4	0.6	6.2
CR5	PART LOAD PUMP	0.58	0.67	1.82	24.01	20	0.3	0.3	9.7
CA2	REDUCE SUP AIR	0.01	0.13	0.03	6.63	0	0.1	0.1	*
CA3-5	UPGRADE AIR SYST	0.13	0.23	0.32	3.02	17	0.1	0.1	7.4
CA7	ZONE RESET CONTR	0.04	0.05	0.10	3.67	4	0.1	0.1	19.7
CA9	HEAT RECOVERY	0.15	0.17	0.36	24.40	0	0.1	0.1	27.5
CH4	AUTO CYCLING	0.71	0.81	1.87	9.40	26	0.4	0.3	4.2
CH5	LEAD/LAG CONTROL	0	0	0	0	0	0	0	-
CH6	REDUCE BURNER SZ	0.09	0.10	0.28	1.50	10	0.1	0.1	4.5
CH7	MODULAT'G BURNER	0.98	1.10	2.63	2.87	7	0.6	0.5	1.0
CH8	PART LOAD BURNER	0.28	0.31	0.76	2.15	9	0.2	0.1	2.4
CH9	AUTO BREECH DAMP	0.11	0.12	0.38	1.27	7	0.1	0.1	2.9
CH10	FLUE HEAT RECOV	3.31	3.77	9.72	4.72	36	2.0	1.8	0.4
CH11	FUEL CONVERSION	0	0	0	0	0	0	0	-
WS1	HYDRO-PNEU SYST	0.07	0.24	0.98	1.83	16	0.1	0.2	1.6
WS2	VAR SPEED PUMP	0.07	0.23	0.91	0.56	20	0.1	0.2	0.6
WS3	SEP DHW HEATER	1.07	1.22	4.04	5.72	23	0.6	0.7	1.3
CC2	AMBIENT CONTROL	0.03	0.08	0.25	0.05	5	0.1	0.1	0.2
CC3	TIMED CONTROL	0.01	0.03	0.10	0.11	5	0.1	0.1	1.0
EL1	TIMED SWITCHING	0.02	0.02	0.02	0.15	3	0.1	0.1	6.1
EL2	PHOTO SWITCHING	0.01	0.01	0.02	0.04	4	0.1	0.1	1.7
EL3	SOD-VAPOR CONVER	0.15	0.50	1.69	20.84	71	0.3	0.3	8.6

NOTES: These averages include the results of all dwelling units analyzed including those with no savings and therefore, do not reflect the results from any typical dwelling unit. They are meant for use as extrapolation to the total USPHS. Except in the case where applicability is 100%, since projects that have no savings are averaged with those that do, all amounts are lower than the results or any applicable project. Actual savings and costs were found to vary widely.

Table 1.14

Operation and Maintenance ECO Savings (No Cost)

		AVERAGE PER DWELLING UNIT:			TOTAL FOR U.S. PUBLIC HOUSING STOCK:			PERCENT SAVINGS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Percent Savings (%) Source Energy	Percent Savings (%) Dollars
LSO	3	9.0	10.5	29	136431	159170	439611	4.9	4.6
LSG	1	14.2	25.5	38	1475849	2650292	394945	18.6	10.95
	2	25.1	28.1	58	3765050	4215056	8700116	14.4	10.9
	• 3	33.1	36.8	83	5640472	6270978	14143781	13.7	11.8
	4	76.0	84.4	187	4045480	4492612	9954010	16.2	15.3
	5	33.2	37.1	95	281436	314497	805315	13.9	12.1
	Average	24.1	27.1	60	11713805	13171955	29163000	13.8	11.4
LSE	1	25.4	86.3	337	525805	1786496	6976237	27.6	27.6
	2	32.8	111.5	277	541561	1840977	4573547	18.8	17.9
	3	9.7	32.9	48	268118	909389	132677	7.9	6.1
	Average	20.7	70.5	220	1347457	4572137	14267660	17.8	19.8
LCO	3	7.1	8.5	22	276794	331373	857670	4.2	4.9
	4	28.0	32.6	60	457184	532293	979680	11.9	5.4
	Average	25.1	29.3	45	1388356	1620671	2489085	13.0	6.7
LCG	2	70.2	78.2	184	469357	522845	1230224	28.9	26.9
	3	39.1	43.5	97	1686696	1876503	4184386	18.3	14.8
	4	43.0	47.8	99	692429	769723	1594197	17.9	16.9
	Average	48.1	53.5	118	3171089	3527095	7779386	21.4	18.2
HSE	3	6.5	22.2	23	154317	527050	546043	7.8	7.6
	4	9.6	32.6	122	91085	309309	1157536	10.0	10.0
	Average	7.4	25.6	52.1	245895	850662	1731231	8.4	8.3
HCO	3	7.1	8.5	22	840732	1006511	2605086	6.0	5.7
	4	18.1	21.3	69	766571	902098	2922288	15.7	18.3
	Average	10.1	11.9	34	1623727	1913104	5466010	8.6	8.9
HCG	2	22.6	26.5	52	418755	491019	963508	18.4	16.7
	3	16.5	21.2	50	700986	900661	2124200	15.7	12.6
	4	10.4	12.2	29	334027	391840	931422	8.4	7.5
	5	15.4	17.9	31	176161	204758	354609	12.1	9.4
	Average	14.5	19.0	39	1516265	1986830	4078230	13.3	10.6
ALL BLDG TYPES	Average	21.97	27.57	61.27	24469505	30706611	68240627	14.37	11.2

NOTES:

Table 1.15

Savings and Cost: Less than 5 Year Payback

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SUMMARY:
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollar Savings ($)	Total Capital Cost ($-'79)	Total Dollar Savings (%)
LSO	3	48.73	57.28	172.38	225.29	730698	868307	2613108	3415171	27.1
LSG	1	45.72	48.88	110.26	711.81					31.8
	2	46.43	51.98	139.98	598.05					26.2
	3	80.49	89.49	222.89	627.06					31.6
	4	200.71	223.77	483.54	1775.85					39.6
	5	40.05	45.63	120.74	221.64					15.4
	Average	52.53	57.98	144.25	617.32	25532207	28181179	70112713	300050000	27.3
LSE	1	23.67	80.46	315.06	195.17					25.8
	2	87.41	297.98	774.43	1316.04					50.1
	3	53.90	183.26	275.87	418.67					34.9
	Average	44.95	152.96	373.24	455.33	2915142	9919914	24205734	2952951	33.5
LCO	3	78.39	91.97	175.57	444.08					38.9
	4	103.63	121.42	541.69	1047.21					48.9
	Average	87.04	102.06	301.04	650.77	4814443	5645244	16651426	35996041	44.5
LCG	2	95.07	107.65	255.05	686.28					37.2
	3	84.07	94.66	246.04	336.58					37.5
	4	81.29	97.73	191.19	487.63					32.7
	Average	86.30	98.31	239.47	445.89	5689500	6481283	15787539	29396190	36.7
HSE	3	21.78	74.08	78.22	331.96					25.9
	4	23.09	78.48	294.51	734.04					24.2
	Average	22.17	75.37	141.84	450.22	736686	2504469	4713201	14960360	24.8
HCO	3	31.29	37.67	85.42	261.10					22.0
	4	28.35	33.36	101.02	215.07					26.8
	Average	30.53	36.55	89.47	249.15	4908155	5875960	14383645	40054600	23.4
HCG	2	20.89	27.40	55.03	195.74					17.6
	3	17.62	20.46	54.00	231.51					13.6
	4	13.05	15.34	35.81	96.26					9.2
	5	11.89	14.46	29.27	88.27					8.9
	Average	15.04	18.09	41.75	145.49	1572732	1891671	4365797	15213889	11.4
ALL BLDG TYPES	Average	53.67	66.98	175.96	424.36	59775982	74600248	195980000	472640000	32.2

NOTES:

Table 1.16

Savings and Cost: Less than 10 Year Payback

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SUMMARY:
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollar Savings ($-'79)	Total Capital Cost ($-'79)	Total Dollar Savings (%)
LSO	3	79.07	93.79	282.35	1586.11	1198622	1421762	4280143	24043841	44.4
LSG	1	55.69	64.56	146.35	1237.97					42.2
	2	58.99	68.00	187.58	1129.09					35.1
	3	87.16	98.33	243.90	766.48					34.5
	4	211.88	238.05	522.09	2249.43					42.8
	5	90.45	102.03	269.11	1957.07					34.3
	Average	67.23	77.08	194.24	1212.94	32677142	37464734	94410352	589550000	36.7
LSE	1	27.13	92.24	360.87	674.54					29.6
	2	87.77	299.00	777.51	1357.57					50.2
	3	60.75	206.54	318.28	940.99					40.2
	Average	49.18	167.29	411.03	881.31	3189470	10849258	26656529	57155597	36.9
LCO	3	81.99	98.34	188.54	507.46					41.8
	4	116.12	137.04	616.11	1620.73					55.7
	Average	93.69	111.60	335.07	888.98	5182275	6172930	18533727	49172151	49.6
LCG	2	96.07	109.68	261.43	751.02					38.2
	3	95.20	106.29	281.17	745.80					42.9
	4	95.62	114.90	227.28	650.75					38.9
	Average	95.48	108.49	267.75	731.88	6294710	7152420	17651954	48250653	41.1
HSE	3	27.77	94.43	99.70	653.22					33.0
	4	24.17	82.13	308.21	855.66					25.3
	Average	26.71	90.81	161.03	712.76	887546	3017525	5350865	23684302	28.2
HCO	3	37.58	46.12	107.30	445.78					27.6
	4	32.60	39.37	113.83	325.15					30.2
	Average	36.29	44.37	109.00	414.46	5834161	7133143	17523385	66630662	28.5
HCG	2	23.36	31.53	65.10	306.92					20.9
	3	21.60	26.20	70.86	363.02					17.8
	4	20.96	25.10	59.44	392.63					15.3
	5	15.73	19.90	42.64	225.84					12.9
	Average	20.09	24.87	59.08	330.23	2100811	2600655	6177995	34532151	16.1
ALL BLDG TYPES	Average	64.16	80.88	215.11	841.99	71459419	90081637	239580000	937780000	39.3

NOTES:

Table 1.17

Savings and Cost: Less than 15 Year Payback

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SUMMARY:
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollar Savings ($-'79)	Total Capital Cost ($-'79)	Percent Dollar Savings (%)
LSO	3	103.78	123.57	370.86	2268.42	1573201	1873197	5621866	34386979	58.4
LSG	1	65.99	76.40	167.37	1636.15					48.2
	2	79.28	91.57	242.42	2796.98					45.4
	3	117.10	133.40	333.85	2743.42					47.3
	4	221.26	248.89	548.94	3112.59					45.0
	5	103.80	118.57	311.38	2836.00					39.7
	Average	84.62	97.30	240.87	2390.72	41129551	47292665	117070000	1162000000	45.5
LSE	1	32.77	101.20	436.34	2087.95					35.7
	2	87.77	299.22	777.51	1357.57					50.3
	3	65.60	223.04	345.71	1452.46					43.7
	Average	53.63	177.66	456.76	1737.00	3478066	11521784	29622256	112650000	41.0
LCO	3	94.04	111.43	213.33	1038.58					47.3
	4	117.13	138.30	626.25	2428.33					56.6
	Average	101.95	120.64	354.84	1514.85	5639160	6672960	19627265	83790898	52.5
LCG	2	109.66	128.45	300.41	1393.96					43.9
	3	101.30	113.76	303.16	1198.83					46.2
	4	112.18	132.87	266.77	1447.12					45.6
	Average	105.08	120.39	296.67	1286.04	6917609	7936951	19558563	84784759	45.5
HSE	3	28.10	95.53	100.86	676.56					33.4
	4	25.08	85.23	319.83	1021.42					26.2
	Average	27.21	92.50	165.26	777.99	904161	3073682	5491424	25851830	28.9
HCO	3	37.58	46.12	107.30	445.78					27.6
	4	32.67	39.28	114.44	341.62					30.4
	Average	36.31	44.34	109.15	418.74	5837377	7128320	17547500	67318736	28.5
HCG	2	28.36	37.70	77.63	510.39					24.9
	3	22.81	27.99	75.76	477.74					19.1
	4	26.20	31.27	73.01	618.83					18.8
	5	24.17	29.74	61.14	585.96					18.5
	Average	24.97	30.74	71.31	556.22	261112	3214481	7456886	58163925	19.5
ALL BLDG TYPES	Average	73.93	92.59	244.83	1415.18	82340942	103120000	272680000	1576200000	44.8

NOTES:

1.4 Individual ECO Table	Tables 1.18 to 1.62 present the individual results of the 58 ECOS.

Notes for Tables: * Payback over 50 years
- Not applicable

Table 1.18

AR1&2 Weatherstripping Door and Window

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings ($-'79)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	0
LSG	1	8.42	9.35	18.42	250.67	875116	972813	1914446	26052885	6.0	9.9
	2	8.51	9.44	29.78	132.99	1276517	1416019	4467050	19948766	6.3	3.8
	3	34.75	38.57	98.79	269.10	5921643	6572598	16834508	45856524	15.9	2.3
	4	129.10	143.30	310.33	1138.09	6871993	7627859	16518866	60580531	30.0	3.1
	5	0	0	0	0	0	0	0	0	0	
	Average	13.01	14.44	36.51	192.90	6323511	7018562	17745686	93759045	7.8	4.4
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	39.35	133.79	348.42	384.26	649708	2209007	5752763	6344517	27.4	1.0
	3	19.37	65.87	84.26	159.83	535406	1820713	2329031	4417861	11.3	1.6
	Average	13.40	45.57	86.34	120.00	869030	2955351	5599408	7782360	9.7	1.2
LCO	3	18.38	21.32	38.47	211.14	716544	831160	1499753	8231293		4.6
	4	35.60	41.29	210.13	259.77	581277	674183	3431003	4241525	2.0	1.1
	Average	24.28	28.16	97.30	227.80	1342999	1557614	5381955	12600301		2.0
LCG	2	42.31	46.97	109.82	301.42	282885	314041	734257	2015294	22.0	2.4
	3	29.71	32.98	80.61	137.49	1281630	1422691	3477354	5931044	14.4	1.5
	4	45.94	51.00	103.20	289.29	739772	821253	1661830	4658437	21.2	2.4
	Average	35.38	39.27	91.33	201.68	2332497	2588953	6021113	13296157	17.1	1.9
HSE	3	6.82	23.19	24.48	218.57	161914	550554	581180	5189070	8.8	7.1
	4	0	0	0	0	0	0	0	0	0	-
	Average	4.81	16.37	17.28	154.29	159831	543959	574197	5126902	3.3	7.1
HCO	3	5.37	6.23	13.10	52.45	635878	737713	1551210	6210762	3.6	3.4
	4	1.99	2.31	11.84	22.81	84281	87833	501448	966049	3.8	1.7
	Average	4.50	5.22	12.77	44.76	723443	839193	2052969	7195841	3.7	3.0
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	2.32	2.57	7.61	33.75	98563	109184	323303	1433835	2.9	3.8
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.67	0.74	2.19	9.70	70062	77382	229008	1014329	0.7	3.8
ALL BLDG TYPES	Average	13.70	16.93	44.98	127.71	15258635	18856109	50097330	142240000	8.8	2.4

NOTES:

Table 1.19

AR3 Attic Insulation

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost)$-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed-Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0.29	0.33	0.78	265.00	30141	34298	81068	27542245	0.3	*
	2	6.59	7.32	13.51	461.31	988513	1098015	2026527	69197422	2.8	18.9
	3	1.33	1.47	4.48	197.09	226641	250498	763423	33585515	0.7	23.1
	4	1.18	1.31	3.10	647.04	62811	69731	165013	34441939	0.3	*
	5	0	0	0	0	0	0	0	0	0	-
	Average	2.84	3.15	6.16	306.98	1380382	1531058	2994068	149207620	1.3	21.2
LSE	1	0.45	1.52	6.02	639.35	9315	31466	124620	13235184	0.7	47.6
	2	1.01	3.44	8.93	383.30	16676	56798	147443	6328666	0.7	22.7
	3	0.92	3.12	9.01	157.91	25430	86240	249045	4364790	1.2	12.1
	Average	0.71	2.41	7.59	420.52	46217	156879	494071	27373749	0.8	22.5
LCO	3	1.99	2.31	4.19	60.65	77580	90055	163347	2364440	1.0	10.4
	4	0.08	1.00	0.23	48.73	1306	16328	3755	795663	0.1	*
	Average	1.34	1.55	2.83	56.57	74119	85735	156536	3129056	0.4	12.2
LCG	2	1.93	2.14	5.01	178.20	12904	14308	33497	1191445	1.0	17.6
	3	1.26	1.39	4.58	69.85	54354	59962	197572	3013189	0.8	10.8
	4	0.48	0.53	1.09	259.08	7729	8535	17552	4171965	0.2	*
	Average	1.30	1.44	4.13	126.49	85705	94935	272279	8339106	0.8	16.1
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
ALL BLDG TYPES	Average	1.05	1.24	2.70	109.10	1169457	1381074	3007176	121512190	0.6	19.0

NOTES:

Table 1.20

AR4 Floor Insulation

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	2.02	2.24	4.00	154.78	209944	232809	415732	16086749	1.29	21.3
	2	2.40	2.67	6.30	32.83	360004	400505	945012	4924565	1.3	4.2
	3	1.10	1.22	3.94	56.49	187447	207896	671403	9626291	0.6	9.7
	4	1.59	1.77	3.66	109.99	84635	94217	194821	5854767	0.4	15.9
	5	0	0	0	0	0	0	0	0	0	-
	Average	1.81	2.01	4.45	76.57	879750	976960	2162922	37216848	0.9	11.0
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	1.16	3.94	5.56	46.55	32063	108905	153683	1286688	0.7	6.3
	Average	0.43	1.46	2.06	17.24	27886	94685	133597	1118065	0.2	6.3
LCO	3	0	0	0	0	0	0	0	0	0	-
	4	4.73	5.49	13.42	48.73	77231	89640	2190121	795663	1.3	3.0
	Average	1.62	1.88	4.60	16.70	89607	103988	254439	923727	0.7	3.0
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	4.78	5.30	14.52	185.61	31959	35435	97080	1240988	2.6	9.5
	4	5.02	5.58	11.27	226.80	80837	89854	181480	3652160	2.3	12.3
	Average	3.65	4.05	10.46	147.00	240633	267004	689596	9691269	2.0	9.5
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
ALL BLDG TYPES	Average	1.21	1.39	3.34	40.14	1347660	1548138	3719988	44706687	0.7	8.5

NOTES:

Table 1.21

AR5 Roof Insulation

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	7.15	8.29	25.05	257.78	108387	125668	379733	3907687	4.1	7.5
LSG	1	0.49	0.54	0.97	95.94	50927	56124	100815	9971332	2.3	44.4
	2	0.28	0.31	0.47	36.88	42001	46501	70501	5532074	0.2	36.0
	3	5.89	6.54	13.13	96.26	1003697	1114462	2237444	16403377	2.1	6.0
	4	0	0	0	0	0	0	0	0	0	-
	5	7.69	8.53	21.43	213.89	65188	72309	181662	1813146	3.1	7.3
	Average	1.97	2.19	4.73	84.52	957519	1064450	2299017	41080946	1.0	11.3
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0.42	1.44	1.35	31.74	11609	39803	37315	877325	0.2	13.6
	Average	0.16	0.53	0.50	11.75	10415	34500	32548	764866	0.1	13.6
LCO	3	0.42	0.49	0.88	56.27	16374	19103	34307	2193686	0.1	25.9
	4	4.34	5.03	25.62	90.97	70864	82130	418323	1485358	2.4	3.0
	Average	1.77	2.05	9.36	68.16	97904	113392	517730	3770134	1.5	5.6
LCG	2	0.02	0.03	0.06	5.02	133	201	401	33564	0.1	30.3
	3	1.70	1.89	4.86	84.93	73335	81531	209651	3663710	0.9	11.1
	4	0	0	0	0	0	0	0	0	0	0
	Average	1.02	1.13	2.91	51.89	67246	74498	191848	3420952	0.5	11.3
HSE	3	0.36	1.21	1.28	23.34	8547	28727	30388	554115	0.5	11.5
	4	1.41	4.78	17.92	86.48	13378	45353	170025	820522	1.6	3.9
	Average	0.67	2.26	6.17	41.91	22263	75098	205023	1392627	1.2	5.3
HCO	3	1.25	1.45	3.31	29.91	148016	171699	391947	3541733	0.9	7.1
	4	2.06	2.39	8.18	29.34	87245	101221	346439	1242608	2.7	3.1
	Average	1.46	1.69	4.57	29.76	234717	271693	734696	4784366	1.3	5.1
HCG	2	1.22	1.35	2.58	31.07	22605	25014	47805	575696	1.0	9.0
	3	1.22	1.36	3.30	28.27	51830	57778	140197	1201023	0.3	6.8
	4	0.78	0.87	1.91	36.97	25052	27943	61345	1187402	0.5	13.0
	5	0.31	0.34	0.62	16.43	3546	3889	7092	187943	0.2	16.1
	Average	0.84	0.93	2.06	28.41	87839	97250	215414	2970834	0.6	9.4
ALL BLDG TYPES	Average	1.97	2.29	6.82	73.16	2194125	2550531	7595905	81483340	1.2	7.7

NOTES:

Table 1.22

AR6 Storm Windows

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings ($-'79)	Discount-ed Payback Period (Years)
LSO	3	10.25	11.89	35.93	460.76	155380	180241	544663	6984661	5.9	9.5
LSG	1	10.60	11.77	23.38	401.38	1101690	1223291	2429954	41716627	7.6	11.9
	2	13.93	15.46	44.32	469.36	2089528	2319031	6648089	70404938	9.3	8.1
	3	33.59	37.29	100.19	309.95	5723971	6354477	17073077	52817649	16.1	2.7
	4	121.64	135.03	279.50	1090.16	6474897	7187647	14877785	58029216	27.0	3.3
	5	0	0	0	0	0	0	0	0	0	-
	Average	15.59	17.30	43.64	380.17	7577520	8408665	21211222	184781620	9.3	6.9
LSE	1	2.29	7.78	30.18	532.00	47405	161054	624756	11012932	3.4	12.1
	2	48.73	167.69	431.49	522.77	804581	2768730	7124331	8631455	34.0	1.1
	3	23.62	80.30	102.54	174.05	652880	2219572	2834308	4810916	13.8	1.5
	Average	17.54	59.63	120.49	397.96	1141766	3881615	7843297	25905206	13.5	2.8
LCO	3	29.19	33.86	61.06	199.85	1137972	1320032	2380424	7791152	14.3	1.8
	4	55.54	64.43	292.31	582.06	906857	1052013	4772838	9503876	27.9	1.7
	Average	38.22	44.34	140.31	330.83	2114063	2452578	7760967	18299199	22.2	2.0
LCG	2	49.71	55.17	128.99	399.67	332361	368867	862427	2672194	25.8	2.7
	3	4.82	5.35	17.46	184.99	207925	230788	753189	7980099	3.1	8.1
	4	2.10	2.33	5.25	37.29	33816	37520	84541	600481	1.1	5.8
	Average	15.32	17.01	42.67	213.66	1010002	1121418	2813105	14085962	8.0	4.2
HSE	3	12.13	41.26	43.55	239.17	287978	979554	1033921	5678135	15.6	4.6
	4	4.14	14.08	52.77	145.60	39280	133591	500682	1381453	4.8	2.4
	Average	9.78	33.26	46.26	211.65	324980	1105197	1537174	7032918	8.9	3.9
HCO	3	8.47	9.82	21.51	113.21	1002958	1162816	2547064	13405535	5.9	4.4
	4	3.26	3.78	19.42	33.24	138068	160091	822476	1407780	6.3	1.5
	Average	7.12	8.26	20.97	92.45	1144647	1327919	3371242	14862724	6.0	3.7
HCG	2	3.53	3.92	6.89	96.91	65407	72634	127665	1795645	2.7	10.2
	3	6.21	6.89	18.18	109.18	263826	292715	772359	4638403	5.2	5.0
	4	5.96	6.61	14.63	200.86	191423	212300	469887	6451221	4.1	10.0
	5	6.38	7.08	12.57	219.19	72981	80988	143788	2507314	4.2	12.0
	Average	5.84	6.48	14.15	166.27	610689	677614	1479666	17386853	4.3	8.9
ALL BLDG TYPES	Average	16.49	20.84	56.29	274.56	18366050	23210945	62694057	305796410	10.8	4.1

NOTES:

Table 1.23

AR7 Insulating Glass

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	7.62	8.83	26.69	855.70	115512	133854	404594	12971556	4.4	16.6
LSG	1	9.66	10.72	21.19	745.43	100399	1114162	2202340	77474776	6.9	19.2
	2	11.44	12.70	37.74	871.67	1716023	1905025	5661075	130650000	7.9	14.6
	3	30.38	33.72	51.23	575.61	5176965	5746124	8729951	98087973	14.6	5.2
	4	110.06	122.16	252.88	2024.59	5858494	502577	13460802	107737520	24.5	6.1
	5	0	0	0	0	0	0	0	0	0	-
	Average	13.68	15.18	38.68	706.04	6649164	7378239	18800414	343151300	8.25	11.5
LSE	1	1.26	4.27	16.66	988.00	26083	88393	344879	20452588	1.9	28.5
	2	45.83	155.82	405.81	970.85	756699	2572744	6700329	16029704	31.95	2.1
	3	21.69	73.76	94.09	323.23	599533	2038800	2600742	8934400	12.7	3.0
	Average	15.88	53.99	106.92	739.07	1033709	3514479	6959957	48109761	12.0	5.4
LCO	3	25.75	29.86	53.87	371.15	1003864	1164092	2100122	14469282	12.6	5.6
	4	48.48	56.23	264.16	1080.96	791581	918123	4313204	17649914	25.2	3.5
	Average	33.54	38.91	125.94	614.40	1855198	2152229	6966119	33984307	20.0	4.0
LCG	2	45.91	50.96	119.15	742.25	306954	340719	796637	4962683	23.8	5.1
	3	2.24	2.49	8.08	343.56	96629	107414	348555	14820491	1.4	22.6
	4	1.55	1.72	3.84	69.25	24960	27697	61836	1115133	0.8	12.3
	Average	12.77	14.17	34.45	396.80	841888	934186	2271185	26159833	6.5	8.2
HSE	3	11.10	37.75	39.85	444.17	263525	896223	946079	10545039	14.3	8.0
	4	3.13	10.65	39.90	270.40	29697	101047	378571	2565555	3.6	5.3
	Average	8.76	29.78	39.86	393.06	291086	989560	1324508	13060990	7.7	7.2
HCO	3	7.73	8.98	19.55	210.25	915332	1063349	2314974	24896333	5.3	8.2
	4	3.02	3.51	17.99	61.74	127903	148656	761912	2614812	5.8	2.9
	Average	6.51	7.55	19.15	171.69	1046580	1213776	3078650	27601742	5.49	6.7
HCG	2	3.24	3.59	6.30	179.97	60034	66519	116733	3334664	2.4	16.9
	3	5.56	6.17	16.41	202.77	236211	262126	697162	8614481	4.7	9.2
	4	4.67	5.18	11.46	373.02	149991	166371	368072	11980656	3.2	18.3
	5	4.68	5.20	9.23	407.06	53535	59483	105582	4656359	3.1	23.2
	Average	4.75	5.27	11.66	308.78	496708	551084	1219286	32289124	3.6	14.7
ALL BLDG TYPES	Average	14.26	18.09	49.09	509.97	15882345	20148081	54674920	566908420	9.4	7.5

NOTES:

Table 1.24

AR8 Storm Doors

		AVERAGE PER DWELLING UNIT				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	7.05	8.18	24.72	162.91	106871	124001	374731	2469553	4.1	5.4
LSG	1	9.68	10.74	21.14	188.22	1006071	1116240	2197144	19567269	6.8	7.0
	2	9.24	10.26	33.23	141.61	1386019	1539021	4984567	2124178	7.0	3.6
	3	38.37	42.60	107.77	160.75	6538517	7259338	18364762	27392925	17.3	1.3
	4	96.43	107.03	221.56	59.02	5132969	5697207	11793638	3141635	21.4	0.2
	5	0	0	0	0	0	0	0	0	0	-
	Average	13.88	15.41	39.04	144.98	6746374	7490031	18975392	70467529	8.3	3.2
LSE	1	0.62	2.12	7.98	117.64	12835	43886	165194	2435266	0.9	10.6
	2	41.89	142.41	370.91	166.60	691646	2351332	6124095	2750733	29.2	0.4
	3	20.56	69.90	93.69	67.09	568299	1932106	2589685	1854435	12.6	0.6
	Average	14.54	49.42	97.16	106.67	946481	3216995	6324630	6943684	10.9	1.0
LCO	3	19.23	22.31	40.27	29.95	749682	869755	1569926	1167601	9.4	0.7
	4	41.28	47.88	234.72	144.69	674020	781785	3832508	2362498	22.4	0.6
	Average	26.79	31.08	106.91	69.27	1481835	1719128	5913513	3831532	16.9	0.6
LCG	2	44.18	49.04	114.66	90.92	295387	327881	766617	607891	22.9	0.7
	3	31.77	35.26	87.46	63.11	1370494	1521046	3772849	2722439	15.6	0.7
	4	48.42	53.75	108.71	90.47	779707	865536	1750557	1456838	22.4	0.8
	Average	37.45	41.57	97.48	74.25	2468966	2740585	6426564	4895080	18.25	0.7
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
ALL BLDG TYPES	Average	14.42	17.67	48.22	73.82	16060548	19680298	53705941	82218427	9.2	1.3

NOTES:

Table 1.25

AR9 Wall Insulation

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	25.21	29.24	88.34	1335.19	382158	443249	1339146	20240145	14.6	10.0
LSG	1	6.66	7.39	15.06	621.30	692194	768065	1565231	64573572	4.9	22.2
	2	9.75	10.82	28.06	644.96	1462520	1623022	4209056	96745289	5.9	14.6
	3	19.22	21.34	48.55	715.15	3275223	3636485	8273260	121866560	7.8	10.6
	4	9.27	10.29	24.86	799.96	493442	547737	1323298	42581870	2.4	18.2
	5	31.96	35.47	89.11	794.30	270925	300679	755385	6733281	12.9	6.7
	Average	12.41	13.78	32.93	664.74	6031881	6697769	16005626	323096870	7.0	12.3
LSE	1	3.73	12.67	50.90	726.91	77215	262282	1053681	15047763	5.8	10.3
	2	2.12	7.20	18.76	701.27	35003	118879	309746	11578668	1.5	19.9
	3	3.92	13.34	17.92	287.88	108353	368731	495327	7957291	2.4	11.3
	Average	3.54	12.05	33.60	560.25	230436	784395	2187192	36469473	3.8	10.8
LCO	3	13.85	16.07	28.96	409.86	539942	626489	1129006	15978392	6.7	10.3
	4	10.78	12.50	61.73	447.64	176016	204100	1007927	7309066	5.9	5.9
	Average	12.80	14.85	40.19	422.81	708006	821398	2223029	23386889	6.4	7.6
LCG	2	16.35	18.15	42.41	586.91	109316	121351	283553	3924080	8.5	10.1
	3	7.19	7.98	20.74	594.09	310162	344241	894682	25627854	3.7	16.9
	4	15.33	17.01	34.97	538.23	246859	273912	563122	8667118	7.2	10.9
	Average	10.72	11.90	28.29	583.41	706737	784531	1865075	38462471	5.3	12.5
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
ALL BLDG TYPES	Average	9.10	10.68	28.41	452.91	10135297	11895052	31642177	504437110	5.5	10.4

NOTES:

Table 1.26

AR10 Vestibules

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	6.50	22.11	82.88	300.00	61672	209779	786365	2846400	7.5	3.1
	Average	1.91	6.50	24.38	88.24	63467	215988	810123	2932126	4.7	3.1
HCO	3	6.49	7.52	15.81	40.83	768500	890465	1872109	4834802	4.3	2.2
	4	0	0	0	0	0	0	0	0	0	-
	Average	4.80	5.57	11.71	30.23	771672	895461	1882558	4859925	3.4	2.2
HCG	2	1.96	2.17	4.10	65.63	36316	40207	75968	1216058	1.6	11.3
	3	0.86	0.95	2.49	16.30	36536	40359	105785	692489	0.7	5.4
	4	2.49	2.76	6.08	78.38	79973	88645	195277	2517408	1.7	8.9
	5	2.10	2.33	4.14	47.51	24021	26652	47357	543466	1.4	8.7
	Average	1.85	2.05	4.30	50.96	193454	214368	449651	5328887	1.3	8.4
ALL BLDG TYPES	Average	1.12	1.36	3.05	13.63	1087191	1320161	2960656	13230736	0.6	3.7

NOTES:

Table 1.27

SH2 Nighttime Setback Thermostat

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discounted Payback Period (Years)
LSO	3	26.78	31.07	93.87	64.86	405958	470990	1422975	983213	15.5	0.6
LSG	1	11.05	12.27	25.60	66.19	1148460	1275258	2660685	6879325	8.3	2.2
	2	20.59	22.85	61.33	66.73	3088541	3427546	9199623	10009633	12.9	1.0
	3	19.01	21.10	43.48	50.36	3239437	3595588	7409296	8581697	7.0	1.0
	4	45.46	50.46	116.01	72.30	2419836	2685986	6175212	3848529	11.2	0.6
	5	24.10	26.75	67.19	64.86	204296	226760	569570	549818	9.8	0.9
	Average	17.59	19.52	47.43	63.95	8549620	9487696	23053351	31082897	10.1	1.2
LSE	1	10.09	34.30	133.49	66.27	208873	710044	2763376	1371855	15.1	0.4
	2	20.17	68.43	178.34	72.30	333027	1129848	2944572	1193745	14.0	0.4
	3	12.24	41.61	75.96	64.82	338326	1150142	2099610	1791690	10.2	0.8
	Average	12.47	42.41	119.28	66.69	811735	2760679	7764532	4341186	13.4	0.5
LCO	3	20.93	24.28	43.83	64.93	815956	946556	1708713	2531296	10.2	1.3
	4	24.92	28.91	125.66	64.86	406894	472042	2051776	1059034	12.0	0.5
	Average	22.30	25.87	71.88	64.91	1233480	1430947	3975898	3590367	11.4	0.8
LCG	2	30.52	33.88	79.19	65.16	204057	226522	529464	435660	15.8	0.7
	3	18.12	20.12	53.98	65.05	781661	867937	2328589	2806127	9.7	1.1
	4	20.58	22.84	46.73	66.00	331400	367793	752493	1062798	9.6	1.3
	Average	21.54	23.91	58.96	65.23	1420068	1576315	3887056	4300418	11.0	1.0
HSE	3	7.53	25.61	27.03	64.86	178770	608007	641719	7680267	9.7	2.1
	4	8.41	28.59	107.16	72.30	79794	271262	1016734	3062050	9.8	0.6
	Average	7.79	26.48	50.60	67.05	258854	879904	1681387	10779293	9.7	1.2
HCO	3	9.19	10.66	23.59	65.24	1088215	1262283	2793363	7725264	6.4	2.4
	4	13.10	15.20	40.44	65.81	554811	643750	1712715	2787185	13.1	1.4
	Average	10.20	11.83	27.97	65.39	1639803	1901850	4496597	10512423	8.0	2.0
HCG	2	9.73	10.80	18.54	64.86	180287	200113	343528	1201791	7.1	3.0
	3	7.39	8.21	21.10	66.01	313957	348794	896412	2804369	6.1	2.7
	4	8.86	9.84	21.79	65.21	284565	316041	699851	2094415	6.1	2.6
	5	6.03	6.70	12.13	64.86	68977	76641	138755	741934	4.1	4.5
	Average	7.82	8.68	18.69	65.31	817737	907668	1954413	6829467	5.7	3.0
ALL BLDG TYPES	Average	16.95	20.74	53.99	65.00	18878384	23099569	60132388	72394985	10.8	1.1

NOTES:

Table 1.28

SH3 Automatic Flue Damper

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	47.53	52.76	113.12	539.55	4939935	5483505	11756900	56077050	36.6	4.0
	2	78.11	86.70	182.00	562.40	11716656	13005173	27300364	84361124	38.2	2.7
	3	101.94	113.16	264.03	568.47	17371289	19283256	44992560	96871267	42.4	1.9
	4	111.82	124.12	287.38	613.16	5952178	6606907	15297237	32638506	27.8	1.8
	5	126.23	140.11	350.91	532.16	1070051	1187712	2974664	4511120	50.9	1.3
	Average	70.59	78.35	189.17	552.78	34310269	38082017	91946078	268678700	40.3	2.5
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
ALL BLDG TYPES	Average	14.62	16.22	39.17	114.46	16283302	18065333	43626331	127482000	8.4	2.5

NOTES:

Table 1.29

SH4 Flue Heat Recovery

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	7.19	8.34	23.09	347.12	108993	126426	350021	5261992	3.8	10.7
LSG	1	2.15	2.39	5.12	356.42	223455	248399	532136	37043799	1.7	32.3
	2	5.67	6.30	13.22	366.61	850511	945012	1983026	54992233	2.8	16.5
	3	8.93	9.91	23.12	370.53	1521734	1688733	3939809	63140905	3.7	11.3
	4	18.77	20.84	48.24	399.62	999127	1109313	2567815	21271772	4.7	6.6
	5	8.43	9.36	23.43	347.12	71461	79344	198616	2942536	3.4	10.6
	Average	4.99	5.54	13.37	362.00	2425389	2692717	6498488	175950100	2.9	16.3
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	5.80	6.73	14.65	347.63	226113	262369	571130	13552355	3.4	14.9
	4	10.35	12.01	50.91	347.12	168994	196099	831258	5667775	4.9	5.6
	Average	8.09	9.38	27.07	347.46	447482	518835	1497322	19219054	4.2	9.5
LCG	2	8.20	9.10	21.15	349.27	54825	60842	141408	2335219	4.2	11.5
	3	8.57	9.51	25.62	348.43	369692	410242	1105195	15030573	4.6	9.9
	4	10.62	11.78	21.55	355.06	171013	189693	347019	5717531	4.4	11.5
	Average	8.72	9.67	23.88	349.70	574883	637514	1574336	23054671	4.5	10.5
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
ALL BLDG TYPES	Average	4.48	5.08	13.46	223.24	4348767	4931191	13065716	216700600	2.3	11.6

NOTES:

Table 1.30

SH5 Electric Automatic Pilot

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	- -
LSG	1	6.33	7.02	15.06	247.47	657895	729609	1565230	25720299	4.9	11.5
	2	8.54	9.48	19.90	250.63	1281017	1422018	2985039	37595001	4.0	9.7
	3	6.57	7.29	17.01	253.07	1119573	1242267	2898623	43124899	2.7	10.6
	4	6.56	7.28	16.85	250.00	349721	387514	896925	13307500	1.6	10.6
	5	6.59	7.31	18.32	250.00	55863	61966	155298	2119250	2.7	10.0
	Average	6.43	7.13	17.22	249.82	3125301	3465536	8369781	121425011	3.7	10.4
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
ALL BLDG TYPES	Average	1.33	1.48	3.57	51.73	1481312	1648378	3976155	5715270	0.7	10.4

NOTES:

Table 1.31

SW2 Flow Restrictors

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	10.13	11.75	35.52	17.00	153561	178118	538448	257703	5.9	0.4
LSG	1	6.26	6.94	14.61	17.00	650621	721295	1518461	1766861	4.7	1.0
	2	6.53	7.25	19.45	17.00	979513	1087515	2917539	2550034	4.1	0.8
	3	6.34	7.04	16.14	17.00	1080380	1199665	2750369	2896919	2.6	0.9
	4	7.21	8.01	18.56	17.00	383788	426372	987949	904910	1.8	0.8
	5	7.02	7.79	19.56	17.00	59509	66036	165810	144109	2.8	0.8
	Average	6.46	7.17	17.26	17.00	3139883	3484979	8389223	8262850	3.7	0.9
LSE	1	5.83	19.81	78.32	17.00	120687	410087	1621302	351917	8.9	0.2
	2	5.10	17.33	45.16	17.00	84206	286136	745637	280687	3.6	0.3
	3	2.77	9.42	17.42	17.00	76566	260378	481506	469897	2.3	0.9
	Average	4.58	15.57	50.52	17.00	298135	1013529	3288599	1106615	5.7	0.3
LCO	3	6.34	7.35	13.28	17.00	247165	286540	517721	662745	3.1	1.1
	4	6.56	7.61	32.65	17.00	107112	124256	533109	277576	3.1	0.5
	Average	6.41	7.44	19.92	17.00	354556	411529	1101835	940321	3.2	0.8
LCG	2	6.15	6.82	15.94	17.00	41119	45599	106575	113662	3.2	1.0
	3	6.39	7.09	19.14	17.00	275652	305848	825661	733346	3.4	0.8
	4	5.24	5.82	11.78	17.00	84380	93719	189693	273751	2.4	1.3
	Average	6.15	6.83	17.18	17.00	405451	450281	1132626	1120759	3.2	0.9
HSE	3	1.06	3.60	3.80	17.00	25165	85468	90216	403597	1.4	3.7
	4	1.09	3.70	13.88	17.00	10342	35106	131693	161296	1.3	1.1
	Average	1.07	3.63	6.76	17.00	35555	120621	224628	564893	1.3	2.1
HCO	3	2.94	3.41	7.33	17.00	348134	403788	867967	2013021	2.0	2.0
	4	3.12	3.62	8.78	17.00	132138	153314	371851	719984	2.9	1.7
	Average	2.98	3.46	7.70	17.00	479080	556247	1237891	2733005	2.2	1.9
HCG	2	2.67	2.96	5.46	17.00	49472	54846	101168	314993	2.1	2.6
	3	1.08	1.19	2.96	17.00	45883	50556	125753	722228	0.9	4.6
	4	1.04	1.15	2.55	17.00	33403	36936	81901	546006	0.7	5.2
	5	1.05	1.16	2.09	17.00	12011	13269	23908	194463	0.7	6.2
	Average	1.26	1.40	2.91	17.00	131758	146398	304299	1777690	0.9	4.7
ALL BLDG TYPES	Average	5.30	6.49	17.15	17.00	5902976	7228361	19101138	18934073	3.4	0.9

NOTES:

Table 1.32

SW3 New Domestic Hot Water Heater

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($'-79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	13.22	15.34	46.34	448.37	200401	232539	702468	6796840	7.6	7.5
LSG	1	6.52	7.24	14.88	448.37	677643	752474	1546523	46600439	4.8	17.4
	2	10.35	11.49	30.95	448.37	1552520	1723523	4642562	67256396	6.5	10.4
	3	13.02	14.46	34.16	448.37	2218699	2464085	5821103	76405386	5.5	9.7
	4	30.15	33.47	74.57	448.37	1604884	1781608	3969361	23866735	7.2	5.0
	5	15.17	16.84	42.29	448.37	128596	142752	358492	3800832	6.1	8.1
	Average	10.16	11.28	27.53	448.37	4938268	5482644	13380956	217930200	5.9	11.4
LSE	1	4.23	14.38	55.97	448.37	87565	297680	1158634	9281707	6.3	6.4
	2	10.32	35.10	91.42	448.37	170393	579536	1509435	7403037	7.2	4.1
	3	7.41	25.20	47.15	448.37	204819	696553	1303273	12393395	6.3	7.4
	Average	6.37	21.67	58.31	448.37	413113	1405364	3781578	29078139	6.5	6.2
LCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HSE	3	3.63	12.34	13.02	448.37	86179	292963	309107	1064475	4.7	19.0
	4	5.45	18.52	69.40	448.37	51709	175717	658467	4254134	6.3	5.3
	Average	4.16	14.15	29.61	448.37	138232	470190	983910	14898886	5.7	10.8
HCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
ALL BLDG TYPES	Average	3.74	4.99	17.08	74.81	3630444	4843827	16579675	72618590	2.2	3.7

NOTES:

Table 1.33

SW4 Refurbish/Replace Fixture

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	11.49	13.33	40.28	89.00	174177	202069	610605	1349151	6.6	1.9
LSG	1	7.74	8.59	18.02	89.00	804441	892784	1872873	9250037	5.8	4.0
	2	7.96	8.84	23.73	89.00	1194016	1326018	3559547	13350178	5.0	3.1
	3	7.78	8.64	19.84	89.00	1325766	1472316	3380875	15166223	3.2	3.6
	4	8.57	9.51	22.03	89.00	456181	506217	1172657	4737470	2.1	3.3
	5	8.42	9.35	23.48	89.00	71376	79260	199040	754453	3.4	3.1
	Average	7.91	8.78	21.10	89.00	3844656	4267519	10255655	43258450	4.5	3.5
LSE	1	7.23	24.58	96.82	89.00	149668	508831	2004271	1842389	11.0	0.8
	2	6.56	22.31	58.12	89.00	108312	368360	959619	1469479	4.6	1.3
	3	3.87	13.17	24.92	89.00	106971	364032	688814	2460049	3.4	3.0
	Average	5.88	20.00	64.06	89.00	382759	1301900	4169986	5793455	7.2	1.2
LCO	3	7.66	8.88	16.04	89.00	298625	346187	625319	3469666	3.7	4.5
	4	7.87	9.12	39.14	89.00	128501	148911	639078	1453192	3.7	1.9
	Average	7.72	8.96	23.98	89.00	427016	495604	1326406	4922857	3.8	3.1
LCG	2	7.28	8.08	18.86	89.00	48674	54023	126098	595054	3.8	3.9
	3	7.72	8.58	23.15	89.00	333025	370124	998645	3839282	4.1	3.2
	4	6.39	7.09	14.37	89.00	102898	114170	231400	1433167	3.0	4.9
	Average	7.40	8.21	20.70	89.00	487860	541261	1364689	5867503	3.9	3.5
HSE	3	2.12	7.19	7.59	89.00	50331	170698	180194	2112949	2.7	8.3
	4	2.18	7.41	27.76	89.00	20684	70306	263387	844432	2.5	2.7
	Average	2.13	7.25	13.52	89.00	70778	240910	449256	2957381	2.6	5.2
HCO	3	4.46	5.18	11.18	89.00	528122	613379	1323857	10538757	3.0	6.1
	4	4.56	5.39	13.41	89.00	193125	228277	567940	3769328	4.4	5.2
	Average	4.51	5.23	11.76	89.00	725050	840801	1890596	14308085	3.4	5.8
HCG	2	3.74	4.15	7.38	89.00	69298	76895	136744	1649081	2.8	8.5
	3	2.12	2.36	5.85	89.00	90066	100262	248531	3781076	1.7	10.1
	4	2.06	2.28	5.05	89.00	66163	73229	162196	2858502	1.4	11.2
	5	2.07	2.30	4.13	89.00	23679	26310	47243	1018071	1.4	12.9
	Average	2.29	2.54	5.33	88.76	239465	265608	557358	9281633	1.6	10.8
ALL BLDG TYPES	Average	6.63	8.17	18.50	88.97	7384288	9099493	20604726	99092027	4.3	3.9

NOTES:

Table 1.34

SL2 Reduce Lighting Level

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACK:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0.14	0.46	1.71	24.77	14551	47809	177725	2574420	0.6	10.5
	2	0.07	0.23	0.78	12.16	10500	34500	117002	1824024	0.2	11.1
	3	0.02	0.07	0.23	3.74	3408	11928	39194	637322	0.1	11.2
	4	0	0	0	0	0	0	0	0	0	-
	5	0.13	0.44	2.58	23.37	1102	3730	21871	198107	0.4	7.1
	Average	0.09	0.31	1.20	16.33	43745	150676	583260	7937197	0.3	10.0
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0.18	0.61	1.90	32.84	4975	16861	52518	907730	0.3	12.0
	Average	0.06	0.23	0.70	12.16	3906	14972	45567	791555	0.1	12.0
LCO	3	0.08	0.26	1.66	14.04	3119	10136	64715	547349	0.4	10.1
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.05	0.17	1.09	9.23	2766	9403	60291	510539	0.2	10.1
LCG	2	0.11	0.37	1.39	19.93	735	2474	9294	133252	0.3	10.3
	3	0.01	0.03	0.13	1.87	431	1294	5608	80668	0.1	10.7
	4	0	0	0	0	0	0	0	0	0	0
	Average	0.03	0.11	0.41	5.97	1978	7252	27030	393584	0.1	10.5
HSE	3	1.08	3.67	3.88	196.00	25640	87129	92115	4653236	1.4	25.3
	4	0.91	3.10	11.62	165.76	8634	29413	110251	1572731	1.1	10.3
	Average	1.03	3.50	6.16	187.11	34226	116302	204691	6217478	1.2	17.5
HCO	3	0.05	0.17	0.69	9.24	5921	20130	81705	1094136	1.4	9.9
	4	0.07	0.23	0.55	12.27	2965	9741	23294	519659	1.1	14.4
	Average	0.06	0.19	0.65	10.02	9646	30545	104497	1610865	1.2	11.0
HCG	2	0.18	0.61	1.88	32.73	3335	11303	34835	606454	0.7	12.0
	3	0.22	0.78	2.57	41.47	9346	33138	109184	1761811	0.7	11.4
	4	0.04	0.15	0.42	7.85	1285	4818	13490	252126	0.1	12.5
	5	0.17	0.58	2.05	31.00	1945	6635	23450	354609	0.7	10.8
	Average	0.15	0.50	1.64	26.61	15686	52285	171495	2782608	0.5	11.4
ALL BLDG TYPES	Average	0.08	0.28	0.98	15.05	89102	311855	1091494	16762223	0.1	11.0

NOTES:

Table 1.35

SL3 Automatic Timed Control

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Period (Years)
LSO	3	0.01	0.03	0.09	2.50	152	455	1364	37898	0.1	16.9
LSG	1	0.10	0.33	1.27	8.15	10393	34298	131995	847054	0.4	5.3
	2	0.06	0.20	0.70	8.69	9000	30000	10500	1303517	0.1	9.3
	3	0.04	0.13	0.51	9.49	6816	22153	86908	1617162	0.1	12.5
	4	0	0	0	0	0	0	0	0	0	-
	5	0.08	0.26	1.52	2.28	678	2204	12885	19328	0.2	1.3
	Average	0.07	0.24	0.95	7.85	34024	116652	461748	3815493	0.2	6.6
LSE	1	0.13	0.45	1.79	8.45	2691	9316	37055	174924	0.2	4.0
	2	0.10	0.35	0.91	25.17	1651	5779	15025	415582	0.1	16.5
	3	0.19	0.65	1.39	16.13	5252	17967	38421	445849	0.2	8.8
	Average	0.15	0.51	1.50	13.94	9728	33075	97280	904051	0.2	7.3
LCO	3	0.05	0.15	0.98	0.99	1949	5848	38205	38595	0.2	0.9
	4	0.03	0.11	0.47	1.90	653	1796	7674	31023	0.1	3.4
	Average	0.04	0.14	0.80	1.30	2213	7744	44250	21226	0.1	1.4
LCG	2	0.06	0.22	0.82	4.84	401	1471	5483	32360	0.2	4.9
	3	0.04	0.13	0.46	2.96	1726	5608	19844	127688	0.1	5.3
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.04	0.13	0.48	2.95	2637	8571	31645	194485	0.1	5.1
HSE	3	0.64	2.16	2.28	9.86	15194	51281	54130	234086	0.8	3.7
	4	0.54	1.82	6.84	23.66	4124	17268	64898	224486	0.6	3.0
	Average	0.61	2.06	3.62	13.92	20270	68452	120289	462548	0.7	3.3
HCO	3	0.04	0.13	0.53	2.84	4737	15394	62759	336293	0.1	4.5
	4	0.07	0.23	0.63	5.40	2965	9741	26682	228701	0.2	6.8
	Average	0.05	0.16	0.55	3.51	8038	25722	88421	564285	0.2	5.3
HCG	2	0.17	0.58	1.64	7.39	3150	10747	30388	136929	0.6	3.8
	3	0.22	0.75	2.80	9.64	9347	31863	118955	409546	0.8	3.0
	4	0.21	0.72	2.64	7.02	6745	23125	84792	225468	0.7	2.3
	5	0.10	0.34	1.21	3.57	1144	3889	13841	40837	0.4	2.5
	Average	0.18	0.62	2.19	6.93	18823	64833	229008	724670	0.7	2.7
ALL BLDG TYPES	Average	0.08	0.26	0.87	4.88	89102	289580	968979	543519	0.1	4.7

NOTES:

Table 1.36

SL4 Incandescent to Fluorescent

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0.30	1.01	2.79	31.00	4548	15311	42294	469929	0.5	8.0
LSG	1	0.40	1.37	3.55	31.11	41573	142388	368962	3233356	1.1	7.0
	2	0.29	0.98	3.53	31.17	43501	147002	529507	4675562	0.7	7.0
	3	0.29	0.97	3.95	31.33	49418	165295	673108	5338851	0.6	6.4
	4	0.29	0.99	3.84	31.66	15437	52698	204403	1685262	0.4	6.6
	5	0.29	0.99	5.79	31.00	2458	8392	49082	262787	0.8	4.3
	Average	0.28	0.95	3.84	31.16	136094	461748	186643	15145318	0.8	6.2
LSE	1	0.29	0.99	3.83	31.00	6003	20494	79285	641731	0.4	6.5
	2	0.30	1.03	2.57	33.00	4953	17006	42433	544863	0.2	9.5
	3	0.36	1.21	1.98	31.18	9951	33446	54729	861846	0.3	11.1
	Average	0.31	1.04	2.95	31.38	20179	67699	192030	2042681	0.3	7.7
LCO	3	0.26	0.89	4.14	31.13	10136	34697	161398	1213603	1.0	6.1
	4	0.29	0.99	3.57	31.00	4735	16165	58291	506168	0.3	6.9
	Average	0.27	0.91	3.94	31.08	14935	50335	217933	1719128	0.6	6.1
LCG	2	0.30	1.03	3.92	31.08	2006	6887	26209	207801	0.8	6.4
	3	0.30	1.04	3.48	31.05	12941	44864	150120	1339435	0.6	7.1
	4	0.29	1.00	3.35	31.28	4669	16103	53945	503702	0.7	7.3
	Average	0.30	1.04	3.57	31.09	19778	68564	235359	2049670	0.7	6.5
HSE	3	0.30	1.01	1.04	31.00	7122	23978	24691	735971	0.4	15.9
	4	0.29	0.97	3.69	31.00	2752	9203	35011	294128	0.3	6.4
	Average	0.30	1.01	1.82	31.00	9969	33561	60477	1030099	0.4	11.0
HCO	3	0.29	1.00	4.13	31.00	34340	118413	489046	3670803	1.1	6.1
	4	0.29	0.97	2.93	31.00	12282	41081	124091	1312912	1.0	8.1
	Average	0.29	0.98	3.81	31.00	46622	157550	612515	4983715	1.1	6.2
HCG	2	0.29	0.99	2.83	31.00	5373	18344	52437	574399	1.0	8.4
	3	0.29	0.98	3.99	31.00	12320	41634	169511	1317004	1.1	6.3
	4	0.29	1.00	3.61	31.00	9314	32118	115946	995658	1.0	6.8
	5	0.28	0.96	3.39	31.00	3203	10981	38778	354609	1.1	6.6
	Average	0.29	0.98	3.56	31.03	30325	102479	372269	3244807	1.1	6.5
ALL BLDG TYPES	Average	0.29	.97	3.60	31.08	322993	1080356	4009568	34615940	0.5	6.5

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Table 1.37

SL5 High Efficiency Ballast

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discounted Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	
LSG	1	0.06	0.22	0.80	8.20	6236	22865	83146	852251	0.3	7.5
	2	0.03	0.11	0.37	4.18	4500	16500	55501	627008	0.1	8.6
	3	0.01	0.03	0.11	1.28	1704	5112	18745	218121	0.1	8.[illegible]
	4	0	0	0	0	0	0	0	0	0	-
	5	0.06	0.21	1.21	8.03	509	1780	10257	68070	0.2	5.2
	Average	0.04	0.14	0.56	5.50	19442	68047	272188	2673275	0.1	7.2
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0.09	0.29	0.89	11.27	2488	8016	24600	311514	0	8.8
	Average	0.03	0.11	0.33	4.18	1953	7160	21481	272097	0.1	8.8
LCO	3	0.04	0.12	0.78	4.81	1559	4678	30408	187518	0.2	4.9
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.02	0.08	0.51	3.16	1106	4425	28210	174789	0.1	4.9
LCG	2	0.05	0.18	0.66	6.84	334	1203	4413	45732	0.1	8.3
	3	2.01	0.02	0.06	0.64	86707	863	2588	27608	0.1	7.8
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.02	0.05	0.19	2.05	1319	3296	12526	135150	0.1	7.8
HSE	3	0.51	1.73	1.83	67.20	12108	41072	43446	1595395	0.7	18.0
	4	0.43	1.46	5.47	56.64	4080	13852	51899	537400	0.5	7.5
	Average	0.49	1.65	2.90	64.09	16282	54828	96364	2129647	0.6	13.1
HCO	3	0.02	0.08	0.32	3.16	2368	9473	37892	374185	0.1	7.6
	4	0.03	0.11	0.26	4.20	1271	4659	11012	177878	0.1	10.6
	Average	0.03	0.09	0.31	3.43	4823	14469	49837	551424	0.1	7.9
HCG	2	0.08	0.29	0.88	11.25	1482	5373	16306	208451	0.3	8.8
	3	0.11	0.37	1.21	14.22	4673	15719	51406	604122	0.3	8.9
	4	0.02	0.07	0.20	2.70	642	2248	6424	86719	0.1	9.9
	5	0.08	0.27	0.96	10.62	915	3089	10981	121482	0.3	8.3
	Average	0.07	0.24	0.77	9.13	7320	25097	80519	54724	0.2	8.4
ALL BLDG TYPES	Average	0.04	0.13	0.46	5.14	44551	144790	512334	5724773	0.1	8.0

NOTES:

Table 1.38

CR1 Individual Room Control

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	3.12	3.62	6.56	105.03	121633	141125	255741	4094594	1.5	11.3
	4	8.56	9.93	41.69	807.60	139767	162137	680714	13186492	4.0	13.0
	Average	4.98	5.78	18.60	345.80	275458	319709	1028821	19127235	2.9	12.6
LCG	2	8.01	8.89	20.79	774.57	53554	59438	139000	5178775	4.2	19.9
	3	7.88	8.75	23.67	352.93	339927	377457	1021076	15224694	4.2	10.7
	4	8.98	9.96	20.14	694.39	144604	160385	324314	11181762	4.1	19.0
	Average	8.09	8.98	22.40	510.20	533349	592024	1476764	33635955	4.2	14.5
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0.42	0.48	1.37	128.67	49733	56838	162225	15236200	0.4	42.2
	4	3.22	3.73	10.52	283.10	136373	151972	445543	11989851	3.4	16.2
	Average	1.14	1.27	3.74	168.77	183272	204171	601261	27132309	1.1	22.2
HCG	2	2.09	2.32	3.80	361.44	38725	42987	70410	6697121	1.5	42.7
	3	0.69	0.77	2.17	247.99	29313	32712	92190	10535607	0.6	*
	4	0.77	0.85	1.90	292.54	24730	27300	61024	9395799	0.5	*
	5	1.07	1.18	2.20	197.33	12239	13498	25165	2257257	0.7	40.1
	Average	0.99	1.10	2.29	263.70	103524	115027	239465	27575109	0.7	34.8
ALL BLDG TYPES	Average	2.39	2.71	7.58	136.93	2661907	3018313	8442369	152508300	1.4	12.3

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Table 1.39

CR2 Zone Control Retrofit

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	1.07	1.24	2.25	49.57	41713	48341	87716	1932486	0.5	14.2
	4	0.96	1.11	2.71	337.57	15675	18125	44248	5511842	0.3	*
	Average	1.03	1.19	2.41	148.27	56972	65822	133304	8201258	0.4	26.2
LCG	2	2.38	2.64	6.18	326.33	15912	17651	41320	2181842	1.2	26.1
	3	3.07	3.40	9.24	440.12	132433	146670	398595	18985896	1.7	24.4
	4	4.48	4.97	10.05	189.50	72141	80032	161835	3051518	2.1	12.7
	Average	3.13	3.47	8.62	372.35	206351	228766	568290	24547918	1.6	21.7
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0.12	0.14	0.38	3.36	14209	16577	44996	397867	0.1	7.0
	4	1.11	1.28	2.84	8.96	47010	54210	120279	379473	0.9	2.7
	Average	0.37	0.43	1.02	4.82	59483	69128	163980	774887	0.3	4.0
HCG	2	0.51	0.56	0.77	6.13	9449	10376	14267	113582	0.3	6.4
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0.38	0.42	0.79	6.33	4346	4804	9036	72408	0.3	6.4
	Average	0.16	0.18	0.30	2.41	16731	18822	31371	252013	0.1	6.4
ALL BLDG TYPES	Average	0.72	0.81	1.87	80.86	801913	902152	2082748	90059361	0.4	21.7

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Table 1.40

CR3 Radiation Pump Control

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings ($-'79)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	0.55	0.64	1.40	40.94	21442	24950	54579	1596046	0.3	17.1
	4	1.36	1.58	6.69	247.95	22206	25798	109234	4048528	0.6	19.8
	Average	0.96	1.11	3.21	111.88	53100	61397	177555	6188418	0.5	19.1
LCG	2	0.01	0.01	0.01	1.75	67	67	67	11701	0.1	*
	3	0.63	0.69	1.87	11.44	27177	29765	80668	493499	0.3	5.1
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.41	0.45	1.12	7.25	27030	29667	73838	477971	0.2	5.3
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	
HCO	3	0.11	0.13	0.28	2.40	13025	15394	33156	284191	0.1	6.8
	4	0.01	0.01	0.02	3.91	424	424	847	165596	0.1	*
	Average	0.08	0.09	0.21	2.79	12861	14469	33761	448534	0.1	9.8
HCG	2	0.35	0.39	0.65	5.36	6485	7226	12044	99315	0.2	6.6
	3	0.10	0.11	0.27	5.82	4248	4673	11471	247257	0.1	14.1
	4	0.67	0.74	1.64	11.70	21519	23767	52674	375781	0.5	5.8
	5	1.21	1.34	2.26	5.81	13841	15328	25852	66461	0.8	2.2
	Average	0.57	0.63	1.28	7.69	59605	65879	133850	804143	0.4	5.0
ALL BLDG TYPES	Average	0.33	0.37	0.96	23.62	367544	412095	1069218	26307223	0.2	15.3

NOTES:

Table 1.41

CR4 Hot Water Reset Control

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACK:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	0.02	0.02	0.04	0.59	779	779	1559	23000	0.1	11.6
	4	6.64	7.70	36.25	259.60	108417	125725	591890	4238748	3.5	5.8
	Average	2.29	2.66	12.4	89.35	126666	147132	685881	4942216		5.9
LCG	2	2.38	2.64	6.18	55.99	15912	17651	41319	374349	1.2	7.1
	3	0.95	1.05	3.49	70.91	40981	45294	150551	3058915	0.6	13.4
	4	0.01	0.02	0.02	0	161	322	322	0	0.1	0
	Average	1.15	1.28	3.59	55.94	75816	84386	236677	3687956	0.7	11.0
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0.23	0.26	0.75	1.12	27234	30787	88809	132622	0.2	1.3
	4	0.66	0.77	3.95	3.21	27952	32611	167290	135949	1.3	0.7
	Average	0.34	0.39	1.58	1.66	54660	62698	254008	266869	0.5	0.9
HCG	2	0.86	0.96	1.92	4.39	15934	17787	35575	81342	0.7	2.0
	3	0.69	0.77	2.17	3.82	29313	32712	92190	162288	0.6	1.5
	4	0.79	0.87	1.94	7.92	25373	27942	69696	254374	0.5	3.5
	5	0.38	0.42	0.79	1.06	4346	4804	9036	12125	0.3	1.2
	Average	0.66	0.74	1.71	4.52	69016	77381	178814	472656	0.5	2.3
ALL BLDG TYPES	Average	0.74	0.85	3.34	25.51	824189	946703	3719988	28412247	0.4	6.2

NOTES:

Table 1.42

CR5 Radiation Part Load Pump

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	0
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	3.12	3.62	7.88	59.76	121633	141126	307202	2329744	1.8	6.1
	4	0.44	0.51	2.16	35.97	7184	8327	35268	587318	0.2	11.6
	Average	1.77	2.05	5.92	51.61	97904	113392	327453	2854704	0.9	6.9
LCG	2	0.76	0.84	1.95	14.64	5081	5616	13038	97883	0.4	6.1
	3	0.01	0.01	0.04	2.17	431	431	1726	93609	0.1	24.5
	4	0.48	0.53	0.97	16.87	7729	8535	15620	271658	0.2	12.0
	Average	0.24	0.27	0.66	7.56	15822	17800	43512	498408	0.1	8.7
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0.45	0.52	1.12	20.87	53286	61575	132623	2471279	0.3	12.6
	4	0.02	0.03	0.08	2.96	847	1271	3388	125362	0.1	19.7
	Average	0.31	0.36	0.85	16.22	49837	57875	136650	2607608	0.2	12.8
HCG	2	0.96	1.07	1.78	18.32	17788	19826	32982	339451	0.7	7.9
	3	0.33	0.37	0.91	20.31	14020	15719	38660	862850	0.3	14.3
	4	1.20	1.34	2.95	55.96	38542	43038	94748	1797323	0.8	12.8
	5	4.21	4.67	7.87	199.23	48158	53420	90025	2278992	2.5	15.6
	Average	1.22	1.36	3.49	78.10	127575	142215	364949	8166917	1.1	14.3
ALL BLDG TYPES	Average	0.58	0.67	1.82	24.01	645986	746225	2027060	26741593	0.3	9.7

NOTES:

Table 1.43

CA2 Reduce Supply Air Quantities

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACK:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0.01	0.01	0.01	3.34	1039	1039	1039	347136	0.1	*
	2	0.01	0.01	0.01	1.14	1500	1500	1500	171002	0.1	*
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.01	0.01	0.01	1.61	4860	4860	4860	782540	0.1	*
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0.01	0.01	0.01	6.61	276	276	276	182707	0.1	*
	Average	0.01	0.01	0.01	2.45	648	648	648	158889	0.1	*
LCO	3	0.01	0.01	0.01	1.83	389	389	389	71342	0.1	*
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.01	0.01	0.01	1.20	553	553	553	66375	0.1	*
LCG	2	0.01	0.01	0.01	5.94	66	66	66	39714	0.1	*
	3	0.01	0.01	0.01	1.82	431	431	431	78511	0.1	*
	4	0.01	0.01	0.04	6.79	161	161	644	109339	0.1	*
	Average	0.01	0.01	0.01	3.62	659	659	659	238655	0.1	*
HSE	3	0.01	0.01	0.01	6.06	237	237	237	143870	0.1	*
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.01	0.01	0.01	4.62	332	332	332	141887	0.1	*
HCO	3	0.01	0.01	0.04	13.38	1184	1184	4736	1584365	0.1	*
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.01	0.01	0.03	9.91	1607	1607	4822	1593181	0.1	*
HCG	2	0.01	0.03	0.09	18.17	185	555	1667	336671	0.1	*
	3	0.01	0.01	0.08	19.74	424	424	3398	838634	0.1	*
	4	0.01	0.04	0.14	27.61	321	1284	4496	886777	0.1	*
	5	0.02	0.07	0.22	40.55	228	800	2516	463851	0.1	*
	Average	0.01	0.04	0.14	27.52	1045	4182	14639	2877766	0.1	*
ALL BLDG TYPES	Average	0.01	0.13	0.03	6.63	11137	144789	33413	7384288	0.1	*

NOTES:

Table 1.44

CA3-5 Reduce Outdoor Damper Ledge, Automatic Start and Stop, Warm-up Cycle

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0.14	0.15	0.24	2.26	14551	15590	24944	234889	0.1	7.2
	2	0.07	0.08	0.20	1.36	10500	12000	30000	204003	0.1	5.7
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.08	0.09	0.16	1.32	38884	43745	77768	641586	0.1	6.6
LSE	1	0.36	1.22	4.30	14.04	7452	25255	89014	290642	0.5	2.8
	2	0	0	0	0	0	0	0	0	0	-
	3	0.19	0.65	2.23	5.96	5252	17967	61639	164740	0.3	2.3
	Average	0.24	0.82	2.85	8.83	15623	53378	185521	574789	0.3	2.7
LCO	3	0.05	0.06	0.10	2.19	1949	2339	3899	85377	0.1	13.7
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.03	0.04	0.07	1.44	1659	2213	3872	79651	0.1	13.7
LCG	2	0.04	0.04	0.10	2.68	267	267	669	17918	0.1	16.23
	3	0.01	0.01	0.01	1.09	431	431	431	47020	0.1	*
	4	0.17	0.19	0.41	4.08	2738	3060	6602	65700	0.1	7.6
	Average	0.04	0.04	0.09	1.96	2638	2637	5933	129217	0.1	14.1
HSE	3	2.24	7.61	8.03	10.93	53180	180670	190640	259489	2.9	1.2
	4	0	0	0	0	0	0	0	0	0	-
	Average	1.57	5.37	5.67	7.71	52170	178440	188408	256196	1.1	1.2
HCO	3	0.21	0.23	0.54	4.20	24867	27235	63943	497335	0.1	6.2
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.16	0.19	0.40	3.11	25722	30545	64306	499979	0.1	6.2
HCG	2	0.24	0.24	0.44	8.20	4447	4447	8153	151938	0.2	12.6
	3	0.17	0.19	0.55	5.34	7222	8072	23366	226865	0.2	7.6
	4	0.34	0.37	0.83	14.02	10920	11884	26658	450294	0.2	11.8
	5	0.24	0.26	0.46	5.93	2745	2974	5262	67833	0.2	9.5
	Average	0.25	0.27	0.61	8.70	26143	28234	63788	909759	0.2	10.3
ALL BLDG TYPES	Average	0.13	0.23	0.31	3.02	144790	256167	345268	3363582	0.1	7.4

NOTES:

Table 1.45

CA7 Zone Reset Control

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACK:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0.01	0.01	0.01	6.09	1039	1039	1039	632950	0.1	*
	2	0.01	0.01	0.01	6.45	1500	1500	1500	967515	0.1	*
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.01	0.01	0.01	3.55	4860	4860	4860	1725477	0.1	*
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	0.05	0.06	0.10	5.93	1949	2339	3898	231181	0.1	27.5
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.03	0.04	0.07	3.90	1659	2212	3872	215720	0.1	27.5
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0.06	0.07	0.20	2.83	7104	8288	23682	335108	0.1	10.3
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.04	0.05	0.15	2.10	6430	8038	24114	337606	0.1	10.3
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	0.01	0.01	0.03	4.80	424	424	1274	203923	0.1	*
	4	0.24	0.26	0.59	25.20	7708	8350	18949	809373	0.2	22.8
	5	0.47	0.52	0.93	16.00	5376	5948	10638	183024	0.3	11.9
	Average	0.20	0.22	0.44	13.81	20914	23005	46010	1444111	0.1	17.9
ALL BLDG TYPES	Average	0.04	0.05	0.10	3.67	44550	55688	111376	4087532	0.1	19.7

NOTES:

Table 1.46

CA9 Heat Recovery

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0.01	0.01	0.01	9.92	1039	1039	1039	1031015	0.1	*
	2	0.01	0.01	0.01	7.70	1500	1500	1500	1155015	0.1	*
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.01	0.01	0.01	6.42	4860	4860	4860	3120441	0.1	*
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0.01	0.03	0.15	66.67	276	830	4146	1842825	0.1	*
	Average	0.01	0.01	0.06	24.69	648	648	3891	1601220	0.1	*
LCO	3	0.05	0.06	0.10	12.29	1949	2339	3898	479125	0.1	*
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.03	0.04	0.07	8.08	1659	2212	3872	446929	0.1	*
LCG	2	0.08	0.09	0.20	35.32	534	601	1337	236149	0.1	*
	3	0.01	0.01	0.01	12.24	431	431	431	528009	0.1	*
	4	0.35	0.39	0.83	45.69	5636	6280	13365	735746	0.2	26.8
	Average	0.08	0.09	0.19	23.21	5274	5933	12526	1530165	0.1	35.7
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0.38	0.44	1.01	37.56	44996	52101	119597	4447592	0.2	19.8
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.28	0.32	0.75	27.81	45014	51444	120573	4470874	0.2	19.8
HCG	2	0.29	0.32	0.54	99.81	5373	5929	10005	1849379	0.2	*
	3	0.33	0.37	1.01	80.13	14019	15719	42908	3404242	0.3	36.1
	4	0.66	0.74	1.65	117.25	21197	23767	52994	3765835	0.5	32.9
	5	0.98	1.09	1.94	75.27	11210	12468	22191	861013	0.6	21.4
	Average	0.60	0.67	1.40	93.54	62742	70062	146398	9781477	0.4	27.3
ALL BLDG TYPES	Average	0.15	0.17	0.36	24.40	167065	189340	400956	27175963	0.1	27.5

NOTES:

Table 1.47

CH4 Automatic Cycling

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	1.07	1.24	2.25	1.59	41714	48341	87716	61986	1.4	0.6
	4	0.96	1.11	2.71	2.29	15675	18124	44249	37391	0.2	0.8
	Average	1.03	1.19	2.41	1.83	56972	65823	133304	101223	0.4	0.7
LCG	2	2.39	2.65	6.19	8.74	15980	17718	41386	58436	1.2	1.3
	3	3.07	3.41	9.25	5.16	132434	147101	399027	222592	1.7	0.5
	4	4.48	4.97	10.05	5.92	72141	80032	161835	95330	3.3	0.5
	Average	3.13	3.47	8.62	6.15	203772	225907	561188	400384	1.6	0.6
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0.12	0.14	0.38	0.76	14210	16578	44997	89994	0.1	1.7
	4	1.11	1.28	2.84	2.16	47011	54211	120280	91480	0.9	0.7
	Average	0.37	0.43	1.02	1.13	59483	69129	163980	181665	0.3	1.0
HCG	2	0.51	0.56	0.77	2.97	9450	10376	14267	55031	0.3	3.3
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0.38	0.42	0.79	1.44	4347	4804	9037	16472	0.2	1.6
	Average	0.10	0.18	0.30	0.74	10457	18823	31371	77382	0.1	2.1
ALL BLDG TYPES	Average	0.71	0.81	1.87	9.40	790776	902153	2082748	10469429	0.4	4.2

NOTES:

Table 1.48

CH5 Lead/Lag Control

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	0
LSG	1	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
LSE	1	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
LCO	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
LCG	2	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
HSE	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
HCO	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
HCG	2	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
ALL BLDG TYPES	Average	0	0	0	0	0	0	0	0	0	0

NOTES:

Table 1.49

CH6 Reduce Burner Size

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discounted Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	0.04	0.04	0.07	.53	1559	1559	2729	20662	0.1	5.9
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.02	0.02	0.05	.35	1106	1106	2766	19360	0.1	5.9
LCG	2	0.66	0.74	1.72	12.18	4413	4948	11500	81435	0.3	5.8
	3	0.16	0.17	0.58	3.97	6902	7333	25020	171258	0.1	5.6
	4	0.56	0.62	1.50	7.41	9018	9984	24155	119323	0.3	4.2
	Average	0.26	0.29	1.00	6.51	17141	19119	65927	429185	0.2	5.4
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0.10	0.11	0.31	1.01	11841	13025	36708	119597	0.1	2.7
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.07	0.08	0.23	.74	11254	12861	36976	118966	0.1	2.7
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	0.42	0.47	1.23	1.62	17843	19967	52255	68824	0.3	1.2
	4	0.15	0.17	0.32	5.65	4818	5460	10278	181467	0.1	10.8
	5	0.44	0.48	0.85	2.69	5033	5491	9723	30771	0.3	4.4
	Average	0.28	0.32	0.68	3.02	29280	33462	71108	315801	0.2	3.8
ALL BLDG TYPES	Average	0.09	0.10	0.28	1.50	10239	111376	311855	1670654	0.1	4.5

NOTES:

Table 1.50

CH7 Modulating Burner

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	0.83	0.96	1.73	4.57	32358	37426	67444	178162	0.4	2.3
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.55	0.64	1.13	3.00	30422	35400	62504	165939	0.2	2.3
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	9.16	10.16	25.40	13.78	395144	438282	1095705	594441	4.5	0.5
	4	0.84	10.94	2.02	3.95	13527		32528	636607	0.4	1.7
	Average	5.59	6.20	15.45	8.84	368532	408747	1018572	582795	2.9	0.5
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0.15	0.18	0.49	2.18	17762	21314	58022	258140	0.1	3.8
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.11	0.13	0.36	1.61	17684	20899	57875	258832	0.1	3.8
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	2.13	2.37	5.34	20.78	90491	100687	226865	882818	1.5	3.3
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.61	0.68	1.53	5.97	63788	71108	159992	624283	0.5	3.3
ALL BLDG TYPES	Average	0.98	1.10	2.63	2.87	1091494	1225146	2929213	3196517	0.6	1.0

NOTES:

Table 1.51

CH8 Part Load Boiler

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	4.55	5.05	12.73	21.28	196278	217847	549147	917977	2.2	1.5
	4	0.77	0.85	1.92	19.44	12399	13688	30918	313042	0.4	6.1
	Average	1.67	1.85	4.59	13.16	110098	121965	302605	867599	0.9	1.7
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	1.31	1.45	3.28	8.48					0.9	2.3
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.38	0.42	0.94	2.44					0.3	2.2
ALL BLDG TYPES	Average	0.28	0.31	0.76	2.15	311855	345268	846464	2394603	0.1	2.4

NOTES:

Table 1.52

CH9 Automatic Breeching Damper

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost (4-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	0.66	0.73	2.35	1.07	28471	31491	101374	46158	0.4	0.4
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.39	0.43	1.40	0.64	25712	28349	92298	42193	0.3	0.4
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0	0	0	0	0	0	0	0	0	-
	4	0.28	0.33	1.69	6.30	11859	13976	71575	266818	0.5	3.2
	Average	0.07	0.08	0.44	1.64	11254	12861	70737	263655	0.1	3.2
HCG	2	0.54	0.60	1.21	8.62	10006	11117	22420	159720	0.4	5.8
	3	0.30	0.34	0.98	5.20	12745	14445	41634	220917	0.3	4.5
	4	0.49	0.55	1.22	12.67	15738	17665	39184	406935	0.3	8.0
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.31	0.35	0.83	6.73	32417	36600	86793	703756	0.3	6.5
ALL BLDG TYPES	Average	0.11	0.12	0.38	1.27	122515	133652	423232	1414487	0.1	2.9

NOTES:

Table 1.53

CH10 Flue Gas Heat

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	5.84	6.77	12.22	2.77	227672	263929	476397	107989	2.8	0.2
	4	8.39	9.73	42.42	5.71	126992	158871	692634	93233	4.1	0.1
	Average	6.71	7.78	22.56	3.78	371150	430335	1247861	209083	3.6	0.2
LCG	2	6.81	7.56	17.66	10.95	45532	50546	142947	73212	3.5	0.5
	3	7.19	7.98	21.38	7.38	310162	344241	922290	318358	3.8	0.3
	4	7.92	8.79	17.96	16.47	127536	141545	289210	265216	3.7	0.8
	Average	7.20	7.99	19.90	9.70	474674	526757	1311947	639492	3.7	0.4
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	3.71	4.31	9.48	6.69	439312	510360	1122555	792183	2.5	0.6
	4	3.25	3.77	10.75	8.28	137644	159667	455284	350675	3.5	0.7
	Average	3.59	4.16	9.80	7.10	577146	668782	1575497	1141432	2.8	0.7
HCG	2	2.57	2.85	4.87	6.02	47620	52808	90236	111545	1.8	1.1
	3	2.58	2.86	7.21	12.82	109609	121504	306310	544645	2.0	1.6
	4	3.59	3.99	8.79	14.75	115304	128151	282317	473741	2.5	1.5
	5	3.45	3.83	6.90	5.36	39465	43811	78929	61313	2.3	0.7
	Average	3.13	3.48	7.36	10.67	327304	363904	769635	1115762	2.3	1.3
ALL BLDG TYPES	Average	3.31	3.77	9.72	4.72	3686575	4198909	10825835	5256990	1.9	0.4

NOTES:

Table 1.54

CH11 Fuel Conversion

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discounted Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	0
LSG	1	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
LSE	1	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
LCO	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
LCG	2	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
HSE	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
HCO	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
HCG	2	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0	0	0	0
ALL BLDG TYPES	Average	0	0	0	0	0	0	0	0	0	0

NOTES:

Table 1.55

WS1 Hydro-Pneumatic System

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HSE	3	0.16	0.55	0.58	10.13	3799	13058	13770	240496	0.2	11.9
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.11	0.39	0.41	7.15	3655	12959	13624	237587	0.1	11.9
HCO	3	0.36	1.24	5.25	7.89	42629	146832	621668	934279	1.4	1.3
	4	0	0	0	0	0	0	0	0	0	0
	Average	0.27	0.92	3.88	5.77	43407	147904	623769	927614	1.1	1.3
HCG	2	0.28	0.97	2.58	7.60	5188	17973	47805	140820	1.0	2.5
	3	0.01	0.03	0.86	4.95	425	1275	36536	210296	-	27.7
	4	0.09	0.32	1.25	2.88	2891	10278	40148	92500	0.3	2.0
	5	0.35	1.20	4.64	7.34	4004	13727	53077	83962	1.5	1.4
	Average	0.16	0.54	2.18	5.22	16731	56468	227963	545855	0.7	2.1
ALL BLDG TYPES	Average	0.07	0.24	0.98	1.83	77964	267305	1091494	2038197	1.3	1.6

NOTES:

Table 1.56

WS2 Variable Speed Pumping

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HSE	3	0.15	0.53	0.56	3.83	3561	12583	13295	90928	0.2	5.6
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.11	0.37	0.40	2.71	3655	12295	13292	90051	0.1	5.6
HCO	3	0.35	1.19	5.03	1.78	41446	140911	595617	210775	1.3	0.3
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.25	0.88	3.73	1.32	40191	141473	599653	212210	1.1	0.3
HCG	2	0.27	0.93	2.48	3.59	5003	17232	45952	66519	0.9	1.3
	3	0.01	0.03	0.08	1.25	425	1275	3399	53105	0.1	10.7
	4	0.09	0.30	1.20	1.36	2891	9635	38542	43680	0.3	1.0
	5	0.34	1.15	4.45	3.36	3889	13155	50904	38435	1.5	0.6
	Average	0.15	0.52	1.88	2.13	15686	54376	196592	222734	0.6	1.0
ALL BLDG TYPES	Average	0.07	0.23	0.91	0.56	77964	256167	1013530	623711	0.1	0.6

NOTES:

Table 1.57

WS3 Separate Domestic Hot Water Heater

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCO	3	1.26	1.46	2.62	3.29	49121	56918	102141	128261	0.6	2.2
	4	2.83	3.28	16.70	6.32	46208	53556	272678	103193	1.6	0.3
	Average	1.05	1.23	7.45	4.33	58079	68035	412082	239505	1.2	0.8
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	4.43	4.91	16.29	6.57	191101	211808	702718	283417	2.9	0.5
	4	0.71	0.79	1.59	12.25	1145	1274	25604	197262	0.3	8.7
	Average	2.75	3.05	9.96	5.88	181299	201077	656633	387651	1.9	0.8
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	2.18	2.53	5.35	9.45	258140	299585	633510	1119003	1.5	2.0
	4	2.39	2.78	7.16	17.96	101221	117739	303240	760642	2.3	2.2
	Average	2.23	2.59	5.82	11.66	358506	416381	935652	1874520	1.7	2.1
HCG	2	0.16	0.18	0.26	24.58	2965	3335	4818	455443	0.1	41.3
	3	0.47	0.52	1.48	16.03	19967	22092	62876	681019	0.4	8.3
	4	0.75	0.84	1.83	18.68	24089	26979	58776	599964	0.5	7.9
	5	1.28	1.42	2.52	5.93	14642	16243	28826	67833	0.8	2.0
	Average	0.73	0.81	1.71	15.36	76336	84702	178815	1606195	0.5	7.1
ALL BLDG TYPES	Average	1.07	1.22	4.04	5.72	1191733	1358798	4499627	6370759	0.1	1.3

NOTES:

Table 1.58

CC2 Ambient Control

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0.01	0.03	0.13	0.09	1500.02	4500.06	19500.26	13500.18	0.1	0.6
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.01	0.01	0.05	0.03	4860.50	4860.50	24302.50	14581.50	0.1	0.6
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0.03	0.10	0.33	0.75	829.23	2764.10	9121.53	20730.75	0.1	1.9
	Average	0.01	0.04	0.12	0.28	648.53	2594.12	7782.36	18158.84	0.1	1.9
LCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0.01	0.01	0.02	0.13	1184.13	1184.13	2368.26	15393.69	0.1	5.4
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.01	0.01	0.01	0.10	1607.65	1607.65	1607.65	16076.50	0.1	5.4
HCG	2	1.32	4.48	13.73	0.52	24458.28	83009.92	9635.08		5.2	0.1
	3	0.02	0.08	0.20	0.22	849.68	3398.72	8496.68	9346.48	0.1	1.0
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.17	0.58	1.77	0.13	17776.90	60650.60	185088.90	13594.10	0.5	0.1
ALL BLDG TYPES	Average	0.03	0.08	0.25	0.05	3341.31	89101.56	27844.2	55688.35	0.1	0.2

NOTES:

Table 1.59

CC3 Timed Control

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discounted Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0	0	0	0	0	0	0	0	0	-
	2	0.01	0.02	0.06	0.27	1500.02	3000.04	9000.12	40500.54	0.1	3.6
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	. 0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.01	0.01	0.02	0.10	4860.50	4860.50	9721.0	48605.0	0.1	3.6
LSE	1	0	0	0	0	0	0	0	0	0	-
	2	0	0	0	0	0	0	0	0	0	-
	3	0.02	0.06	0.19	2.37	553	1658	5252	65509	0.1	9.2
	Average	0.01	0.02	0.07	0.88	651	1302	4557	57284	0.1	9.2
LCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCG	2	0.52	1.76	5.38	1.62	9635	32611	99686	30017	2.0	0.3
	3	0.01	0.03	0.08	0.71	425	1275	3399	30164	-	7.2
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.07	0.23	0.69	0.41	7320	24051	72153	42874	0.2	0.5
ALL BLDG TYPES	Average	0.01	0.03	0.10	0.11	11138	33413	111377	122515	.01	1.0

NOTES:

Table 1.60

EL1 Timed Switching

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discounted Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0.01	0.03	0.13	0.23	1039.33	3117.99	13511.29	23904.59	0.1	1.5
	2	0.01	0.02	0.05	0.42	1500.02	3000.04	7500.10	63000.84	0.1	6.7
	3	0.01	0.01	0.01	0.54	1704.07	1704.07	1704.07	92019.78	0.1	*
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.01	0.01	0.07	0.32	4860.50	4860.50	34023.50	155536.0	0.1	3.9
LSE	1	0.03	0.10	0.35	1.44	621.03	2070.1	7245.35	29809.44	0.1	3.5
	2	0.01	0.04	0.10	4.28	165.11	660.44	1651.10	70667.08	0.1	23.4
	3	0	0	0	0	0	0	0	0	0	-
	Average	0.02	0.05	0.18	1.35	1297	3242	11673	87551	0.1	12.7
LCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCG	2	0.1	0.1	0.01	0.82	668	668	67	5482	0.1	27.4
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.1	0.1	0.01	0.20	6592	6592	659	13185	0.1	27.4
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
ALL BLDG TYPES	Average	0.02	0.02	0.02	0.15	22275	22275	22275	167065	0.1	6.1

NOTES:

Table 1.61

EL2 Photocell Switching

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (Years)
LSO	3	0	0	0	0	0	0	0	0	0	-
LSG	1	0.01	0.03	0.13	0.07	1039.33	3117.99	13511.29	7275.31	0.1	0.5
	2	0.01	0.02	0.05	.12	1500.02	3000.04	7500.10	18000.24	0.1	2.1
	3	-	-	0.01	0.15	-	-	1704.07	25561.05	0.1	10.7
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0.01	0.01	0.07	0.09	4860.5	4860.5	34023.5	43744.5	0.1	1.1
LSE	1	0.03	0.10	0.35	0.41	621.03	2070.10	7245.35	8487.41	0.1	1.0
	2	0.01	0.04	0.10	1.21	165.11	660.44	1651.10	19978.31	0.1	9.1
	3	0	0	0	0	0	0	0	0	0	-
	Average	0.02	0.05	0.18	0.38	1302	3255	11717	24736	0.1	1.8
LCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
LCG	2	0.01	0.01	0.01	0.23	67	67	67	1538	0.1	11.3
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0.01	0.01	0.01	0.06	659	659	659	3956	0.1	11.3
HSE	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCO	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
HCG	2	0	0	0	0	0	0	0	0	0	-
	3	0	0	0	0	0	0	0	0	0	-
	4	0	0	0	0	0	0	0	0	0	-
	5	0	0	0	0	0	0	0	0	0	-
	Average	0	0	0	0	0	0	0	0	0	-
ALL BLDG TYPES	Average	0.01	0.01	0.02	0.04	11138	11138	22275	44551	0.1	1.7

NOTES:

Table 1.62

EL3 Sodium Vapor Conversion

		AVERAGE PER DWELLING UNIT:				TOTAL FOR U.S. PUBLIC HOUSING STOCK:				SAVINGS PAYBACKS:	
		Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Total Site Energy Savings (MMBTU)	Total Source Energy Savings (MMBTU)	Total Dollars Savings ($-'79)	Total Capital Cost ($-'79)	Percent Savings (%)	Discount-ed Payback Period (years)
LSO	3	0.33	1.13	2.65	54.43	5002	17130	40171	825104	0.1	3.0
LSG	1	0.29	1.01	4.05	37.55	30141	104972	420929	3902684	1.3	7.3
	2	0.12	0.43	1.59	16.32	18000	64501	238503	2448033	0.3	7.9
	3	0.08	0.26	1.08	10.55	13633	44306	184040	1797794	0.1	7.6
	4	0.32	1.10	4.30	42.30	17034	58553	228889	2251629	0.4	7.7
	5	0.14	0.49	2.87	17.50	1187	4154	24329	148348	0.4	5.0
	Average	0.18	0.62	2.53	23.32	87489	301351	1229707	11334686	0.5	6.9
LSE	1	0.17	0.58	2.05	49.14	3519	12007	42437	1017247	0.2	15.0
	2	0.06	0.22	0.55	7.32	991	3632	9081	120861	0.1	9.7
	3	0.40	1.37	1.81	32.84	11056	37868	50030	907730	0.2	12.4
	Average	0.24	0.82	1.72	36.48	15623	53378	111963	2374666	0.2	12.7
LCO	3	0.01	0.02	0.05	0.58	390	780	1949	22611	0.1	9.5
	4	0.03	0.10	0.47	5.53	490	1633	7674	90294	0.1	8.8
	Average	0.01	0.05	0.19	2.27	553	2766	10509	125561	0.1	8.8
LCG	2	0.13	0.44	1.76	35.87	869	2942	11767	239827	0.3	13.4
	3	0.14	0.48	1.68	28.38	6039	20706	72472	1224256	0.3	11.7
	4	0.09	0.30	1.01	14.47	1449	4831	16264	233010	0.2	10.4
	Average	0.13	0.44	1.59	27.98	8571	29008	104824	1844637	0.3	11.2
HSE	3	0.04	0.13	0.13	4.30	950	3086	3086	102086	0.1	18.3
	4	0.06	0.21	0.78	10.32	569	1992	7101	97916	0.1	9.7
	Average	0.04	0.15	0.32	6.07	1329	4984	10633	201700	0.1	11.8
HCO	3	0.15	0.50	2.08	14.68	17762	59207	246299	1738303	0.6	5.7
	4	10.01	0.02	0.74	7.49	423944	847	31340	317216	0.2	7.7
	Average	0.13	0.44	1.74	12.81	20899	70737	279731	2059400	0.5	5.7
HCG	2	0.26	0.87	2.61	23.11	4818	16120	48361	428205	1.0	7.4
	3	0.15	0.50	1.96	17.12	6373	21242	83269	727326	0.6	6.9
	4	0.10	0.35	1.22	13.46	3211	11241	39184	432308	0.3	8.4
	5	0.24	0.82	2.92	25.11	2745	9380	33402	287233	1.0	6.8
	Average	0.17	0.57	2.02	18.73	17777	59605	211231	1958596	0.6	6.9
ALL BLDG TYPES	Average	0.15	0.50	1.69	20.84	167065	556885	1882270	23210945	0.3	8.6

NOTES:

E2.0 Energy Conservation Summary of Analysis

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2.1 Methodology

2.1.1 Overview

The analysis of the total United States Public Housing stock for existing energy use and potential energy savings was completed in two phases. Phase I was the survey process and Phase II the analysis process. The following overview is diagrammed in Illustration 2.1.

During the survey phase, three major tasks were completed before the actual survey could begin. The first was to research, analyze and establish energy use factors and criteria applicable to public housing. This analysis was then applied to create the survey instruments. The survey instruments would be used to record utility data and the significant features of a project to calculate energy use. A classification system for projects was also developed to create a manageable number of housing prototypes for detailed analysis. This classification consisted of twelve building types and five climate zones. These prototypes would show the significant energy use and potential savings profile of the Public Housing stock. When the survey instruments were complete and tested, 350 randomly selected projects were surveyed.

From project data gathered in the field, prototypes were analyzed for distribution of dwelling units and physical characteristics. Of sixty possible prototypes (twelve building types by five climate zones), only 22 were found to be significant. Ninety-five projects, based on dwelling unit distribution and representative physical characteristics, were selected to represent these prototypes. The data on these projects were entered in the computer for detailed energy analysis.

A set of algorithms was developed to determine existing energy use for each prototype. As projects were surveyed and analyzed for energy use, a list of potential energy conservation opportunities (ECOs), with corresponding costs and energy saving algorithms, was analyzed and refined. Energy savings, cost and discounted payback were estimated for each applicable ECO and prototype on a per dwelling unit basis. Based on the results of the economic analysis, ECOs were ranked according to greatest benefit-to-cost and grouped into the following four categories:

1. Operation and maintenance ECOs (No cost ECOs);
2. Less than five-year payback ECOs;
3. Less than ten-year payback ECOs; and
4. Less than fifteen-year payback ECOs.

Illustration 2.1

Project Methodology Flow Chart

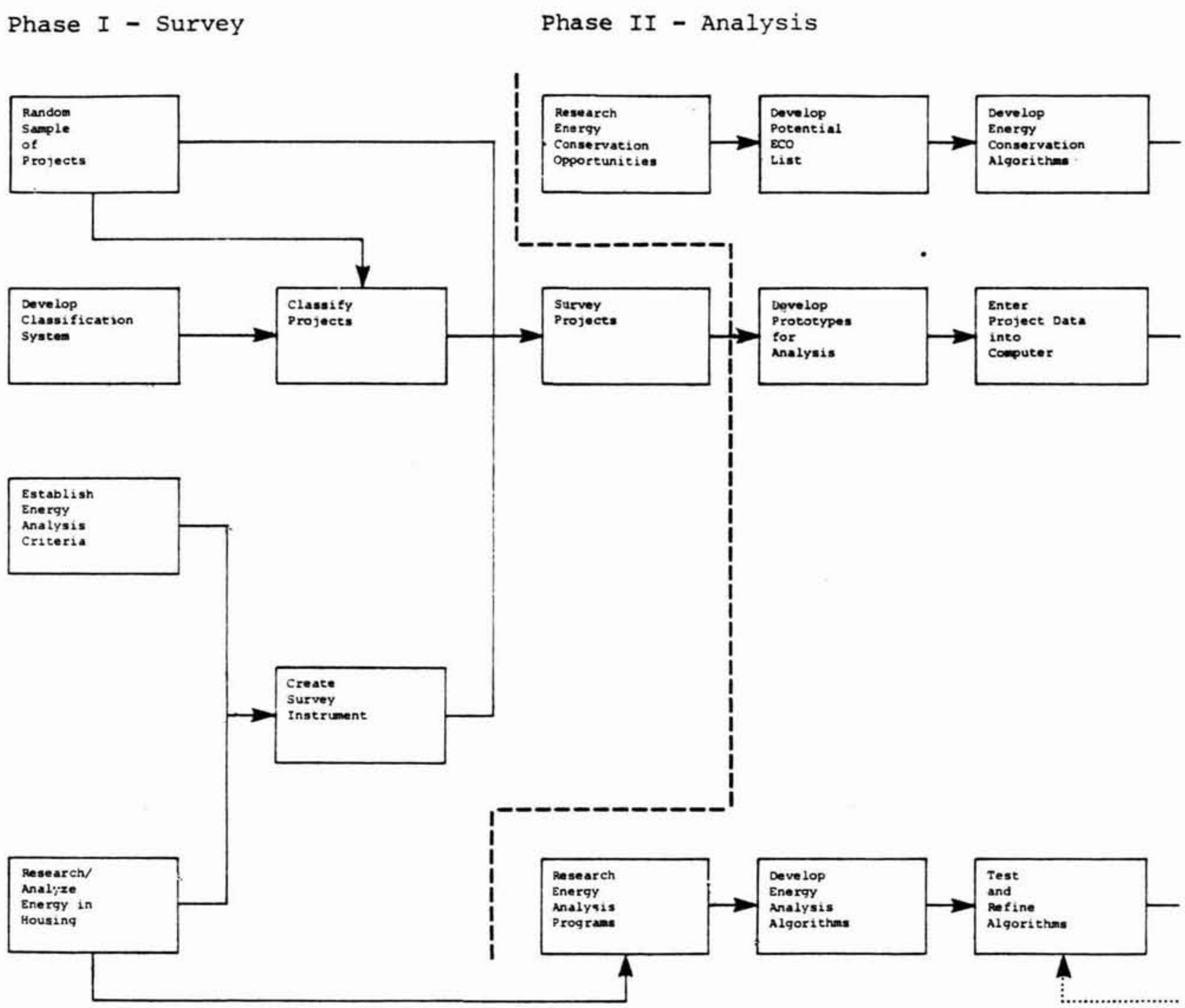
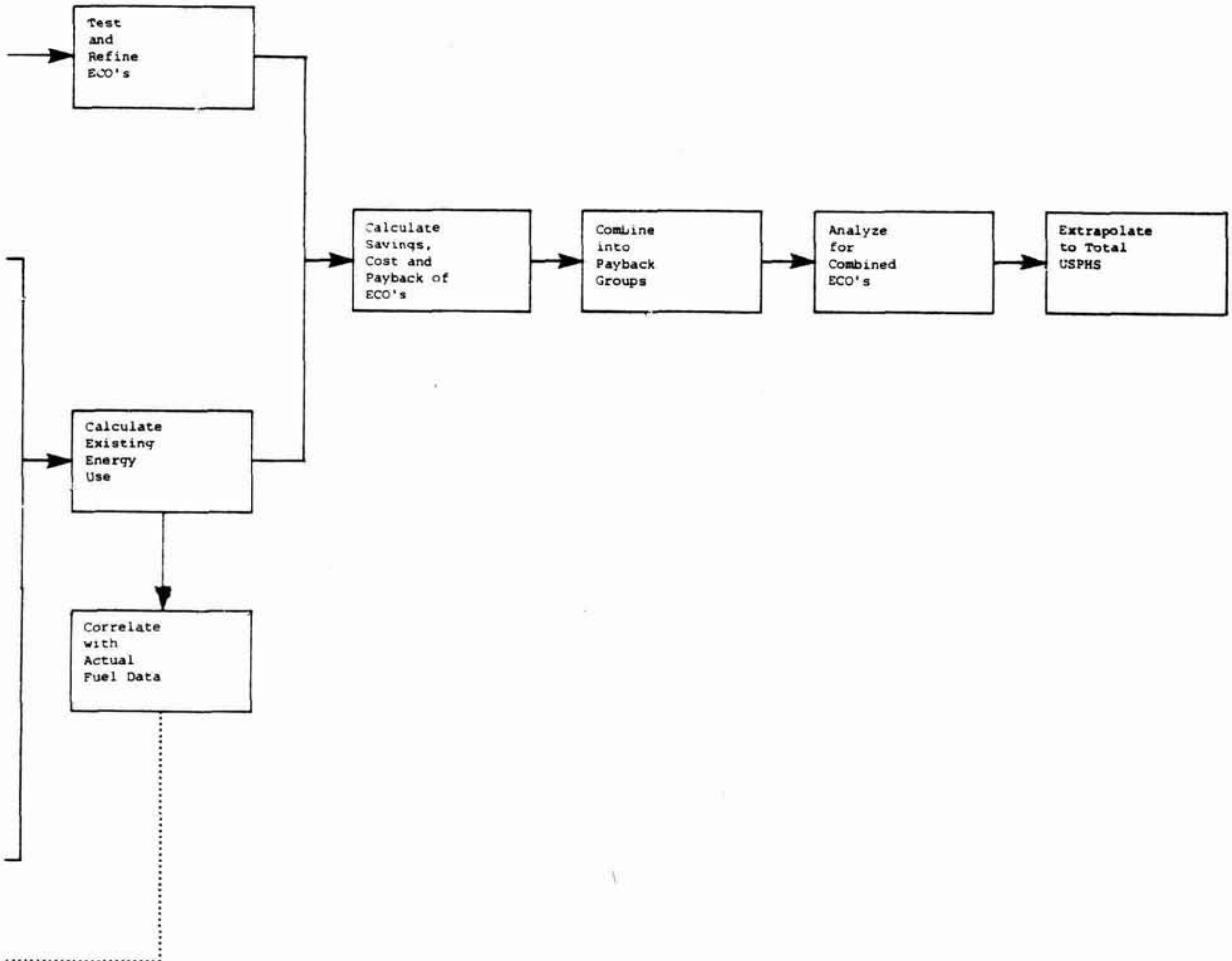


Illustration 2.1 (continued)

Project Methodology Flow Chart



Since some ECOs are mutually exclusive or interdependent, each payback category was reanalyzed as a group, to show diminishing returns of combined ECOs. The results are four final totals of energy savings and cost, corresponding to the three payback categories and the "No Capital Cost" maintenance ECOs category. These results were then extrapolated to the total Public Housing stock for each prototype and the United States as a whole.

A more detailed discussion of these following topics will follow: Classification of the Public Housing Stock, Survey Instruments, Prototype Development, Existing Energy Estimates, ECO Development, ECO Savings and Cost Estimates, Economic Analysis and Combined ECOs Savings.

2.1.2 Public Housing Classification

Classification of Public Housing Projects is required to perform the following functions:

1. To show the significant energy use and savings profiles of the Public Housing Stock.

2. Development of a manageable number of theoretical housing prototypes for detailed analysis of energy conservation retrofit savings.

3. Elimination and inclusion of groups of ECOs for consideration.

4. Extrapolation of detailed survey data and analytical results to the total housing stock.

A classification system must be sufficiently detailed to describe uniquely the major energy usage and conservation potential characteristics of a housing project. It cannot, however, be so detailed that the population of projects in each cell of the classification system matrix is restricted. The primary purpose of a classification system is to provide an organizational link between the projects for which there is detailed survey data and those projects for which there are only abbreviated physical characteristics.

Based upon available data for the majority of housing projects, the following four classifications were developed:

- Building Configuration (high-rise or low-rise)
- Heating System Configuration (space or central)
- Heating Energy Source (oil, gas or electric)
- Climate Zone (5 degree day zones)

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Building configuration was determined primarily by the presence or absence of an elevator, but other general distinctions are also present.

	High-Rise	Low-Rise
Elevator	Yes	No
System Complexities	Air handling systems, central radiation	Simple, usually space heating systems
Control	Complex central temperature control	Simple, local control
Thermal Characteristics	Exterior surface-to-square-footage ratio of .8 to 1.2	Exterior surface-to-square-footage ratio of 1.3 to 2.0
ECO Selection	Central and secondary systems are predominant	Architectural and space heat are predominant

Heating System Configuration was determined primarily by whether the primary heating source was located within the dwelling unit and controlled by the tenant (space) or whether it was centrally located with no or limited control by the tenants (central). A secondary characteristic is that space heating systems are relatively simple and central systems more complex, involving heavy transfer mediums and more sophisticated controls.

A general division between gas, oil, and electric energy in conjunction with the two categories above yields a direct correlation to the cost of supplying heating energy. Cost of heating energy in turn will help determine the applicablility and economic feasibility of many of the energy conservation opportunities.

The advantage of including climate characteristics in the classification system is that the primary energy use in housing is heating, which is directly related to climate. Since the primary determinant of heating energy use is outside temperature a climate, classification based on heating degree days was selected.

The five heating degree day zones are established geographically to create 0 to 2000, 2000 to 4000, 4000 to 6000, 6000 to 8000, and 8000 to 10,000 degree day ranges (zones 1 through 5 respectively). These zones are based on weather data from the United States Weather Bureau.

When building configuration, heating configuration and heating fuel are combined in all possible ways, twelve "building types" are created, each possibly occurring in all climate zones. This combination of twelve building types and five climate zones creates a matrix of sixty cells as illustrated below:

	Climatic Zone				
Building Type	1	2	3	4	5
LSO	x	x	x	x	x
LSG	x	x	x	x	x
LSE	x	x	x	x	x
LCO	x	x	x	x	x
LCG	x	x	x	x	x
LCE	x	x	x	x	x
HSO	x	x	x	x	x
HSG	x	x	x	x	x
HSE	x	x	x	x	x
HCO	x	x	x	x	x
HCG	x	x	x	x	x
HCE	x	x	x	x	x
Total Cells	12	12	12	12	12

Building type code:
L = Low Rise
H = High Rise
S = Space Heating
C = Central Heating
O = Oil Fuel
G = Gas Fuel
E = Electric

2.1.3 Survey Instrument

Several energy conservation survey instruments were developed during the early period of building audits. The purpose of developing these survey instruments or "building audit questionnaires" was to standardize data collection and organization in order to collect the information required for energy and retrofit savings assessment of the 350 public housing projects surveyed.

The four types of energy conservation questionnaires developed were:

1. Original Long Form
2. Revised Long Form
3. Original Short Form
4. Revised Short Form

Long and short forms differed in the amount of information required to be obtained by the building auditor during site visit. Completion of both of these forms required the use of building drawings. Revised forms were developed from the original survey forms as a result of a refinement in data requirements. See Chapter 3 for samples of survey forms.

The overall data required in the survey instrument consists of the following four major groups.

1. Utility Data
2. Building Envelope Data
3. Specific Area Data
4. Central Systems Data

Following completion of the survey forms, the data were transcribed to computer data entry forms which simulate Hollerith data cards. These data forms were developed as computer input forms consisting of the essential data required for energy and economic analysis of Energy Conservation Opportunities (ECOs).

2.1.4 Prototype Development

Based on a classification of projects by building type and climate characteristics, prototypes were developed for extrapolation of energy usage, savings and cost to the total U.S. Public Housing Stock.

This classification system consists of twelve building characteristics and five climate zones forming a matrix of 12X5 and consisting of 60 cells. Although each cell represents a possible prototype, it was found by analyzing the total public housing stock that only twenty-two cells or prototypes were significant.

This analysis of the total public housing stock estimated the total number of dwelling units applicable to each cell. A random sample of approximately 30% of total public housing stock provided information on number of projects, number of dwelling units and building types on a per state basis. The sample was extrapolated to the total for each state for each building type.

In order to determine building type distribution within climate zones, an estimate was made of the percent of the state population located in each climate zone. Population per climate zone was estimated by referring to the climate zone map. Building types were assumed to be distributed by climate zone the same way population was.

The results are illustrated in Table 2.1. It can be seen that four building types do not occur in the sample: LCE, HSO, HSG, HCE. This was expected because these combinations, although possible, are not commonly used. Most of the other dwelling units fall into the remaining eight building types and represent 95% of the total. The remaining 5% are abberations that could not be classified within this system, but were included in the total on the assumption that they have approximately the same average energy use as the other 95%.

Further, it can be noted that not all climate zones have a significant percent of dwelling units occurring within a building type. Since the sample of surveyed buildings was limited, it was decided that all cells which have less than one-half percent (.5%) of the total dwelling units would not be used. These cells total 8 percent of total dwelling units.

The twenty-two cells remaining were considered to represent the significant building type/climate zone classifications. These can be seen in Table 2.2.

Public Housing in Hawaii, Puerto Rico and the U.S. Virgin Islands is not included in the analysis due to the significant differences in energy usage resulting from their unique climate and physical characteristics. Public Housing in these locations accounts for 5% of the total and requires individual analysis for assessment of savings.

The 350 projects surveyed were classified as described above and were analyzed for dwelling unit (DU) distribution and physical characteristics to determine the profile of each significant prototype. Of these surveyed projects 95 were selected for detailed energy analysis based upon their representative characteristics and correlation of DUs to the total public housing stock DU distribution. These projects were grouped by type and were used to develop the twenty-two prototypes for extrapolation. Prototypes are averages of the surveyed projects that comprise them.

Table 2.3 illustrates the distribution of dwelling units per prototype for both the total U.S. Public Housing Stock, and the surveyed projects used to develop the prototypes. Differences in percent distribution are attributable to the limited size of the sample.

Extrapolation to the total United States Public Housing Stock is accomplished by multiplying the number of total dwelling units estimated in the Public Housing Stock per prototype by the per dwelling estimated energy use or savings.

Example:
Prototype LSE average energy cost (1979) per dwelling unit = $1113, estimated LSE dwelling units in the total USPHS = 64,853. Total yearly energy cost for this building type: 64,853 dwelling units X $1113/ dwelling unit = $72,181,000/year.

2.1.5 Existing Energy Usage Calculations

It was necessary to calculate the existing energy usage of the HUD projects, as opposed to using actual fuel data. This approach was required for two reasons. The first reason was that a large portion of the projects surveyed could not provide actual energy consumption data because of incomplete records, or because of individual tenant billing. The second reason was that yearly total fuel consumption data, even if available, did not provide a breakdown of energy consumption by end use such as lighting, heating or domestic water, which is required for energy savings calculations. Calculating energy consumption had the further benefit of providing a common method of comparison between projects since all used the same calculations and weather data source and use profiles were normalized to eliminate abberations. Energy consumption calculations were based on standard algorithms and results were correlated with actual consumption data where they were available.

All energy calculations were based on standard algorithms such as those described in the ASHRAE Handbooks and other engineering manuals. Simplifying assumptions were made when data were not available for detailed analysis. Weather data were based on average years and projects were matched to the nearest city with available weather data.

Existing energy use was calculated by end use category for all prototypes selected for analysis. Existing energy calculations were divided into nine sets of algorithms corresponding to the nine energy end use categories

1. Heating
2. Ventilation
3. Domestic Hot Water
4. Cooling
5. Interior Lights
6. Appliances
7. Exterior Lights
8. Water Supply
9. Elevators

The following is a brief overview of the existing energy use algorithms. All algorithms were programmed into a computer for analysis.

Table 2.1

Breakdown of Total Public Housing Units by Building Type and Climate Zone

Bldg Type	Climate Zone: 1	2	3	4	5	Total
LSO	6,124	2,653	15,159	4,200	767	28,903
	.5%	.3%	1.36%	.4%	.1%	2.7%
LSG	103,933	150,002	170,407	53,230	8,477	486,049
	9.5%	13.5%	15.5%	4.8%	.8%	46.0%
LSE	20,701	16,511	27,641	8,240	3,682	76,775
	1.9%	1.5%	2.5%	.7%	.33%	7.3%
LCO	0	4,259	38,985	16,328	5,599	65,191
	0	.4%	3.5%	1.5%	.5%	6.2%
LCG	1,568	6,686	43,138	16,103	5,348	72,843
	.1%	.6%	4.1%	1.4%	.5%	6.9%
LCE	0	0	0	0	0	0
HSO	0	0	0	0	0	0
HSG	0	0	0	0	0	0
HSE	6,055	9,105	23,741	9,488	1,148	49,537
	.5%	.81%	2.1%	.9%	.1%	4.7%
HCO	0	971	118,413	42,352	5,593	167,329
		.1%	10.7%	3.8%	.5%	15.8%
HCG	5,606	18,529	42,484	32,118	11,439	110,176
	.5%	1.7%	3.9%	2.9%	1.0%	10.4%
HCE	0	0	0	0	0	0

Total	1,056,803
Percent of Total Public Housing	95%
Total Public Housing (100%)	1,113,769*

*This is the number used to extrapolate to the total U.S. Public Housing Stock and is exclusive of Hawaii, Puerto Rico and U.S. Virgin Islands but inclusive of miscellaneous building types.

Table 2.2

Significant Building Types / Climate Zones Only

Bldg Type	Climate Zone: 1	2	3	4	5	Total
LSO			15,159 1.4%			15,159 1.4%
LSG	103,933 9.5%	150,002 13.5%	170,407 15.5%	53,230 4.8%	8,477 .8%	486,049 46%
LSE	20,701 1.9%	16,511 1.5%	27,641 2.5%	*		64,853 5.9%
LCO			38,985 3.5%	16,328 1.5%		55,313 5%
LCG		6,686 .6%	43,138 4.1%	16,103 1.4%		65,927 6.2%
LCE						
HSO						
HSG						
HSE		*	23,741 2.1%	9,488 .9%		33,229 3.1%
HCO			118,413 10.7%	42,352 3.8%		160,765 16%
HCG		18,529 1.7%	42,484 3.9%	32,118 2.9%	11,439 1.0%	104,570 9.9%
HCE						
Total						970,707
Percent of Total Public Housing						87.2%

*This cell was not used because preliminary numbers used to determine prototypes indicated less than .5 percent of total. Final estimates raised percentages slightly.

Table 2.3

Distribution of Significant Building Types/Climate Zone for Total and Sample

		Total Public Housing:		Sample:	
Bldg Type	Zone	# of Units	% Total	# of Units	% Total
LSO	3	15,159	1.4	622	4.2
LSG	1	103,933	9.5	1,696	11.5
	2	150,002	13.5	1,913	12.9
	3	170,407	15.5	748	5.1
	4	53,230	4.8	746	5.0
	5	8,477	.8	520	3.5
Total		486,050	46.0	5,623	38.0
LSE	1	20,701	1.9	280	1.9
	2	16,511	1.5	94	.6
	3	27,641	2.5	382	2.6
Total		64,853	5.9	1,433	5.1
LCO	3	38,985	3.5	1,193	8.1
	4	16,328	1.5	240	1.6
Total		55,313	5.0	1,433	9.7
LCG	2	6,686	.6	489	3.3
	3	43,138	4.1	1,198	8.1
	4	16,103	1.4	320	2.2
Total		65,927	6.2	2,007	13.6
HSE	3	23,741	2.1	120	.8
	4	9,488	.9	70	.5
Total		33,229	3.1	190	1.3
HCO	3	118,413	10.7	1,258	8.5
	4	42,352	3.8	438	3.0
Total		160,765	14.5	1,696	11.5
HCG	2	18,529	1.7	321	2.2
	3	42,484	3.9	736	5.0
	4	32,118	2.9	745	5.0
	5	11,439	1.0	663	4.5
Total		104,570	9.9	2,465	16.7
All Bldg. Types Tot.		970,707	87.2%	14,792	100%

Note: Percent distribution of total DUs and prototype DU differ because of limited sample size.

Heating

Heating is the first category of analysis with a set of algorithms divided into two parts. The first part estimates the heating demand of the project; the second part estimates the actual energy consumption by taking into account the heating equipment efficiencies. This calculation procedure is diagrammed in Illustration 2.2 below.

The first step is to determine the weather data that are applicable to a project. Temperature "groups" were used to represent hours of temperature occurrence. These take the form of five degrees groups, called "bins", for which number of hours of occurrence are assigned. For example, there may be 35 hours of temperatures between $0^{\circ} \pm 5^{\circ}$ a year. For calculating heating energy use, only temperatures below 65° are considered, because internal heat gain from people, lights and incident solar radiation are expected to be sufficient to satisfy heating requirements between 65° F and 70° F (70° F being considered the desirable indoor temperature). Each temperature bin is assigned a temperature differential, called delta temperature, the difference between the mean of the temperature bin and the base, 65°F. For example, the delta temperature of the 0°-5° temperature bin is $65^{\circ} - 2.5^{\circ} = 62.5^{\circ}$F.

This temperature differential is used to directly approximate heat loss of the building(s) through envelope and infiltration losses. Heat loss is estimated for eight building components representing the major areas of building heat loss.

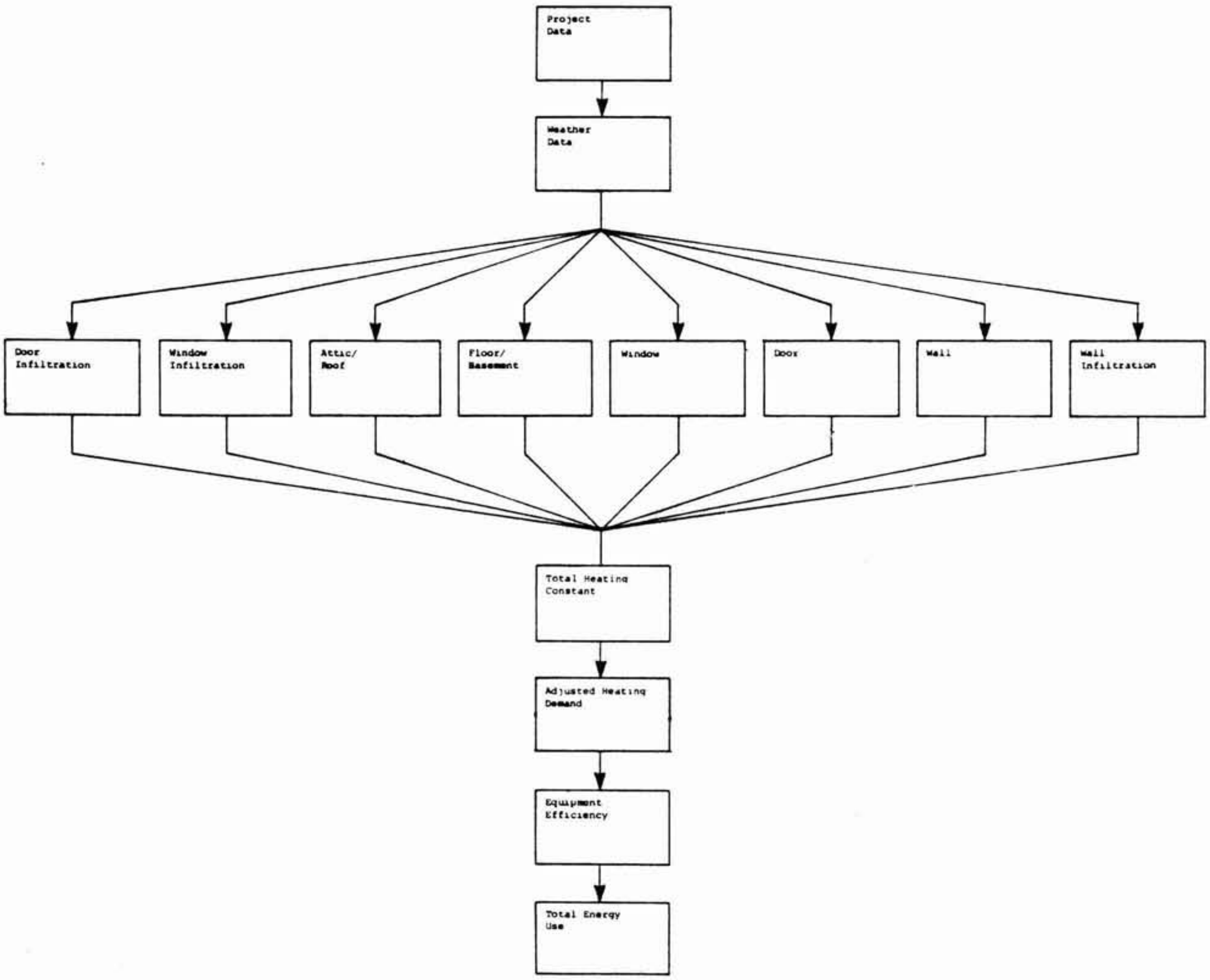
The sum of these eight components comprises the total heating constant which, when multiplied by the hours of occurrences for each temperture bin, results in the total heating demand. Adjusting for the type of heating control, the heating demand represents the heat needed to balance the heat loss through the building envelope and through infiltration.

If the heating system consists of a central boiler that also provides the ventilation and domestic hot water requirements for the building, these loads are included to obtain a total heating demand for all loads.

Equipment efficiencies are estimated based upon percent load of total capacity. If multiple boilers are used then efficiency is calculated based on proper sequence of units. The heating demand is divided by this percent to obtain the total heat energy used. This load is expressed in 10^6 BTUs if the fuel source is oil or gas and in kilowatts if the fuel source is

Illustration 2.2

Heating Energy Analysis



electricity. Energy units are multiplied by fuel rates obtained from project fuel bills adjusted for inflation to 1979 dollars to finally obtain total dollars spent of heating energy.

Ventilation

Ventilation energy use was calculated only when applicable. Projects with public space were applicable and field data determined whether ventilation was used. Ventilation energy use consisted of the fan energy used to circulate the air and the energy required to heat the outdoor air.

Exhaust fans were estimated as increased air infiltration loads in the heating load section.

Fan energy usage was determined by horsepower data collected in the field and an approximate schedule of use. Heating energy use was calculated by the temperature "bin" method previously described. Outdoor air requirements were assumed to be those recommended by ASHRAE since accurate field data were not available.

Domestic Hot Water

Domestic hot water energy use was applicable to all projects. Energy use was dependent on water temperature, gallons of water used per day, and type of heating equipment.

Domestic hot water energy consumption was calculated by estimating hot water use as a function of type of occupancy, namely family, elderly, or mixed. Hot water temperature data obtained in the field were then used to determine the heating load. Equipment efficiency determined by type, water condition, and age was divided into the load, to determine total consumption.

Cooling

Cooling energy was calculated for individual dwelling unit air-conditioners and central chillers for public spaces. Dwelling unit air-conditioning energy was estimated by data collected at every project. The data included the number of air-conditioners and BTUH ratings by which energy consumption could be estimated. Central chiller calculations used the temperature "bin" method and took into account actual field data on existing chillers and the schedule of operation.

Interior Lights

Interior light energy was calculated for both dwelling units and public areas. Average watts per square foot of lighting in dwelling unit areas was derived from a detailed survey of 50 representative projects. Public area lighting was based on field observations and estimated watts per square foot.

Applicance

Appliance energy was based on average watts per square foot derived from observed field conditions.

Exterior Lights

Exterior light energy was calculated by multiplying the number of site lighting fixtures and average watts per fixture by hours of use per year.

Water Supply

Water supply applied only to high-rise buildings that did not use city water pressure or a roof tank. The motor horsepower of the water pumps was multiplied by a kilowatt conversion factor and the estimated hours of operation per year.

Elevators

Elevator energy usage was calculated in the same way as water supply based upon observed elevator motor horsepower.

2.1.6 Energy Conservation Opportunities

Fifty-eight Energy Conservation Opportunities (ECOs) were found to represent the significant energy savings modifications that can be made to the existing Public Housing. These ECOs are less than the original preliminary seventy-seven ECOs established for analyses. After detailed analyses of calculations, methods, and required data, in addition to studies on the applicability of ECOs to the Public Housing stock, eighteen ECOs were either combined with existing ECOs or eliminated from the list. ECOs are grouped into twelve major categories:

Major ECO Group	ECOs
Architectural	AR 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Space Heating	SH 1, 2, 3, 4, 5
Space Hot Water	SW 1, 2, 3, 4
Space Lighting	SL 1, 2, 3, 4, 5
Space Cooling	SC 1, 2
Central Radiation	CR 1, 2, 3, 4, 5
Central Air	CA 1, 2, 3, 4, 5, 7, 9
Central Heating	CH 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Central Heating Distribution	HD 1
Central Water Supply	WS 1, 2, 3
Central Cooling	CC 1, 2, 3
Exterior Lighting	EL 1, 2, 3

The final list of fifty-nine ECOs underwent further refining as a result of their use in the energy analysis. It should be noted that AR 1 and AR 2, as well as CA 3, 4 and 5 were analyzed in combination and will be listed as such in subsequent sectors of this report.

A listing of ECOs, Table 2.4, followed by a series of ECO descriptions, Table 2.5, is included.

Table 2.4

Energy Conservation Opportunities (ECO) - Key

Architectural

- AR1 Door Weather-stripping
- AR2 Window Weather-stripping
- AR3 Attic Insulation
- AR4 Floor Insulation
- AR5 Roof Insulation
- AR6 Storm Window Retrofit
- AR7 Insulating Glass
- AR8 Storm Doors
- AR9 Wall Insulation
- AR10 Vestibules

Space Heating

- * SH1 Reduce Temperature
- SH2 Nighttime Set Back Thermostat
- SH3 Automatic Flue Damper
- SH4 Flue Heat Recovery
- SH5 Electric Automatic Pilots

Space Domestic Hot Water

- * SW1 Reduce Temperature
- SW2 Flow Restrictors
- SW3 New Hot Water Heaters
- SW4 Refurbish/Replace Fixtures

Space Lighting

- SL1 Delamping
- * SL2 Reduce Lighting Level
- SL3 Automatic Time Control
- SL4 Incandescent to Fluorescent
- SL5 High Efficiency Ballasts

Space Cooling

- * SC1 Clean Condensors and Evaporators
- * SC2 Require High EER Units

Central Radiation/Convector System

- CR1 Individual Room Control
- CR2 Zone Control Retrofit
- CR3 Radiation Pump Control
- CR4 Hot Water Reset Control
- CR5 Radiation Part Load Pump

Central Air Handling Systems

- * CA1 Reduce Outdoor Air Intake
- CA2 Reduce Supply Air Quantities
- CA3 Reduce Outdoor Air Damper Leakage
- CA4 Automatic Start and Stop
- CA5 Warm-Up Cycle
- CA6 Not used
- CA7 Zone Reset Control
- CA8 Not used
- CA9 Heat Recovery

Central Heating Boiler

- * CH1 Boiler Water Maintenance
- * CH2 Burner Adjustment
- * CH3 Boiler Control Adjustment
- CH4 Automatic Cycling
- CH5 Lead/lag Control
- CH6 Reduce Burner Size
- CH7 Modulating Burner
- CH8 Part Load Boiler
- CH9 Automatic Breeching Damper
- CH10 Flue Gas Heat Recovery
- CH11 Fuel Conversion

Central Heating Distribution

- * HD1 Refurbish Steam Traps

Central Domestic Water Supply

- WS1 Hydro-pneumatic System
- WS2 Variable Speed Pumping
- WS3 Separate Domestic Hot Water Heater

Central Cooling

- * CC1 Chiller Control Adjustment
- CC2 Ambient Control
- CC3 Timed Control

Exterior Lighting

- EL1 Timed Switching
- EL2 Photocell Switching
- EL3 Sodium Vapor Conversion

* Operation and Maintenance Items

Table 2.5

Energy Saving Rationale

ECO	DESCRIPTION
AR1 and 2 Install Door and Window Weatherstripping	Improving weatherstripping at all operable windows and doors decreases infiltration thereby reducing heating energy required to bring the infiltrated air to room temperature.
AR 3, 4 and 5 Add Attic, Floor or Roof Insulation	Addition of insulation in attic, floor and roof spaces would increase the thermal resistance of the space and reduce heat transfer during the winter.
AR6 Storm Window Retrofit	Storm windows will reduce thermal and infilatration losses during the winter months.
AR7 Insulating Glass Retrofit	New insulating glass window provides for a reduced heat flow through windows during heating and cooling seasons and reduces infiltration.
AR8 Install Storm Doors	Storm doors will, like storm windows, decrease thermal and infiltration losses from the space.
AR9 Add Wall Insulation	Addition of wall insulation would increase the thermal resistance of the exterior walls and reduce winter heat transfer through wall surfaces.
AR10 Install Vestibules	Vestibules should be considered in high rise buildings to reduce heat losses from entrance infiltration where there is frequent door usage.
SH1 Reduce Space Temperatures	Energy savings result from reduced heat transfer through exterior surfaces and reduced infiltration heating losses due to the smaller temperature differential between inside and outside temperatures.
SH2 Night Set Back Thermostats	Night set back thermostats allow the space temperature to fall approximately 8 to 10°F during normal sleeping hours. Energy savings result from reduced transmission and infiltration heating losses due to a smaller temperature differential between inside and outside temperatures.

Table 2.5 (continued)

Energy Saving Rationale

ECO	DESCRIPTION
SH3 Automatic Flue Damper	The flue of a residential furnace or space heater discharges unwanted combustion gases to the atmosphere. However, when the furnace is not operating, the flue continues to discharge room air from the space surrounding the furnace because of the stack effect. This air flow is facilitated by the presence of the draft diverter in the gas furnace flue and the air lost has to be replaced by outside air which infiltrates through the building envelope. Installation of an automatic flue damper will essentially eliminate this loss of warm air. When the furnace shuts off, the damper closes and stops the flow of heated air. The energy saved is that energy required to heat cold infiltration air to room temperature.
SH4 Flue Heat Recovery	Approximately 30 percent of the fuel input to the space heater or furnace burners is lost in the combustion gases which go up the flue. Heat exchangers can be installed in furnace flues to recover a portion of the heat lost up the stack. This ECO may also apply to water heaters.
SH5 Electric Automatic Pilots	Energy can be saved by using electrically activated burner pilot lighters in place of gas pilot lights which burn constantly. This ECO may also apply to cooking stoves.
SW1 Reduce Domestic Hot Water Temperature	If the hot water supply temperature to lavatories and showers is reduced, energy can be saved because of the decrease in temperature rise required through the hot water heater and reduced heat loss from stored water through the walls of he heater. Energy savings were calculated based on a reduction of water temperature to 120°F.
SW2 Flow Restrictors-Showers	If the present hot water flows are reduced to showerheads energy saings would result because less water needs to be heated.
SW3 New Hot Water Heaters	As water heaters age, their efficiency tends to decrease through the buildup of deposits which are impossible to remove from the heater. In addition, new hot water heaters are much more efficient and better insulated.

Table 2.5 (continued)

Energy Saving Rationale

ECO DESCRIPTION	
SW4 Refurbish/Replace Plumbing	Flow restrictors on kitchen and bathroom sink faucets will use less water. Sometimes flow restrictors cannot be retrofited to existing faucets, requiring plumbing fixtures to be replaced. New plumbing fixtures will use less water than older, less efficient fixtures. If booster pumps are in use, electrical energy will also be saved due to the smaller pumping load.
SL1 Reduce Lighting Levels (De-Lamping)	Many of the public spaces in housing projects have been designed with excessive lighting capacity. Much of the excess lighting can be taken out of service thereby reducing energy consumption while still maintaining minimum lighting level requirements.
SL2 Reduce Lighting Level (Automatic Control)	Inexpensive devices are now available which use photocells to control the light output of fluorescent fixtures. These devices are preset to maintain a given light level (lower in hallways than offices, for example). The photocell reduces the power to the lighting fixture in proportion to the amount of daylight contribution. Automatic control is applicable to public areas.
SL3 Automatic Timer Control	Time clocks can be used to operate lighting only when required by occupancy. This would prevent lights from being left on after hours. Lighting circuits must be adaptable for retrofit of timers. This action is applicable to public areas.
SL4 Incandescent to Fluorescent Conversion	Fluorescent lighting is approximately three times as efficient in converting electricity to light. Fluorescent fixtures use 55 to 65 percent less electricity than the incandescents they replace. Installation is applicable to both public spaces and dwelling units.
SL5 High Efficiency Ballast	Installation of high efficiency ballasts on existing fluorescent fixtures will reduce ballast energy consumption while maintaining present lighting levels.
SC1 Clean Tenant Air Conditioners, Condensers and Evaporators	Most tenant air conditioners have never had their heat exchangers cleaned. The heat transfer efficiency is reduced if this maintenance item is not attended to.

Table 2.5 (continued)

Energy Saving Rationale

ECO DESCRIPTION	
SC2 Replace Window AC Units with High Efficiency Units	If the present standard type window air conditioning units are replaced with high energy efficient units as they need replacement, electrical energy could be saved. This could be accomplished by minimum standards set by the housing authority.
CR1 Individual Room Control	If automatic control valves are installed at individual radiators of overheated rooms, heating energy is saved by controlling the introduction of steam or hot water to radiators and convectors in proporation to the need for heat to maintain a set temperature. If there is no control of radiation, tenants typically open doors and windows to control space temperature, therby wasting energy.
CR2 Zone Control Retrofit	The retrofit of central control valves at the base of distribution risers allows one valve to control heat distribution to the dwelling units and public spaces served by that riser. This retrofit will not provide as accurate control of temperature as individual room control would (CR1), but may be comparable in overall economic benefit if central control valve retrofit is less costly than individual room temperature control.
CR3 Radiation Pump Start/Stop Control	Buildings with central radiation systems will often have only manual start/stop control of the central radiation pumps. Pumps controlled in this manner will continue to operate during outdoor conditions which do not require hot water supply to radiation. An outdoor air temperature controller can be interlocked to the pump starter which will stop the pump(s) when the outdoor air temperature exceeds a preset temperature. The controller's sensing element may be mounted so that it senses both the air temperature and the effect of solar radiation further increasing the number of hours for which the pumps may be stopped.
CR4 Hot Water Reset Control	The temperature of hot water supplied to the radiator need only be warm enough to satisfy the building zone with the greatest heating requirement. Supplying heating water at a temperature higher than that causes unnecessary thermal loss through the piping system and contributes to overheating of the building. In addition, excessive supply temperature inhibits the proper control action of room control or zone control systems which may have been installed.

Table 2.5 (continued)

Energy Saving Rationale

ECO DESCRIPTION	
CR5 Radiation Part-Load Pump	It is possible to reduce the annual pumping energy requirements by installing pumps of reduced capacity (part-load pumps) which will deliver less supply water during periods of partial heating requirements (typically between 35 and 65°F in temperate climates). When the radiation heating load begins to exceed the capacity of the part-load pump the associated pump controller stops the part-load pump(s) and starts the existing radiation pump(s).
CA1 Reduce Outdoor Air Intake	The heating and cooling of outdoor air brought into a building is a significant building load. If the amount of outside air brought in can be reduced, energy savings will result in proportion to the reduction in air. This reduction in outdoor air quantity often can be accomplished through an adjustment of existing temperature control systems.
CA2 Reduce Air Supply Quantities	Energy savings result from reductions in fan power for both supply and return/exhaust fans when air supply quantities can be reduced within code limitations. This action is accomplished by reducing the speed of both fans through pulley replacement or adjustment. Heating and cooling coils should be cleaned before performing these changes.
CA3 Reduce Outdoor Air Damper Leakage	Heating energy will be saved if outside air intake dampers close tightly when outdoor air is not required. Outdoor air leakage can be reduced in most installations by replacing the damper blade seals and caulking and flashing around the damper frame. Outdoor air dampers which are irreparable should be replaced.
CA4 Automatic Start/Stop	Savings from an automatic supply fan start/stop retrofit arise from timed starting and stopping of fan systems, reducing periods when fans run unnecessarily. This results in savings of fan power and heating and cooling energy.
CA5 Warm-Up Cycle	Implementation of a warm-up cycle will reduce outdoor air intake during fan start up on cold mornings. Energy savings will result from heating indoor air instead of colder outdoor air to bring the building up to temperature.

Table 2.5 (continued)

Energy Saving Rationale

ECO DESCRIPTION	
CA7 Zone Reset Control	Air handling systems which use simultaneous heating and cooling to control temperature can use a zone reset system to limit amount of heating and cooling energy required. Zone thermostat signals are used to adjust the cooling coil temperature so that no more cooling energy is expended than required for the hottest building zone. The same zone signals are also used to adjust the heating coil temperature(s) so that no more heating energy is expended than required for the coolest building zone. When cooling is not in operation (or nonexistent) the zone signals are used to adjust the mixed air temperature.
CA9 Heat Recovery	Heat from exhaust air will be recovered and transferred to the supply air to reduce energy consumption by installing a coil run around cycle, heat recovery wheel, cross flow heat exchanger or heat pipe recovery. In the coil run around cycle, a coil is placed in the exhaust air stream and a similar coil is placed in the make-up supply air stream. A pump circulates water or antifreeze through a piping loop between both coils to accomplish heat transfer, when the make-up air temperature is lower than the fan discharge air temperature setting. The heating energy savings are slightly offset by the heat recovery system fan loss and the pump enery usage. Heat recovery wheels, cross flow heat exchanges and heat pipe systems all operate on an air-to-air cycle, eliminating the need for a pump. They require, however, that the supply and exhaust duct work be directly adjacent.
CH1, 2, and 3 Boiler Water and Fireside Maintenance (CH1) Burner Adjustment (CH2) Boiler Control Adjustment (CH3)	Energy can be saved by operating boilers at their peak efficiency. The annual cleaning of boiler heat transfer surfaces, boiler blow down, proper adjustment of fuel oil or gas-to-air mixtures, and water treatment will each improve boiler efficiency. Boiler efficiency should be monitored by CO_2 and temperature measurements of stack gases. These actions are assumed to have been implemented before any of the other Central Heating ECOs are evaluated.

Table 2.5 (continued)

Energy Saving Rationale

ECO DESCRIPTION	
CH4 Automatic Cycling	The heat load on a boiler is dependent on numerous factors, such as outdoor air temperature, building and system mass and occupancy. The heat output of the boiler should vary as the load changes. If it does not do so, space conditions will deteriorate and energy will be wasted. A boiler (especially a steam boiler) with only internal (i.e, steam pressure) controls will tend to overheat spaces when the weather gets warmer, wasting energy in the process. Installation of a boiler cycling control system can minimize this problem. The control system senses outdoor air temperature and the presence of condensate return at a point in the system that may be remote from the boiler. The control then cycles the boiler on a timed basis according to outdoot air temperature and the condensate sensor ensures that heat reaches all parts of the building. Energy savings will depend on reduction of the degree of overheating, thermal losses from the boiler and the distribution system and to some degree on the higher level of firing efficiency due to a somewhat higher load on the boiler with less frequent firing.
CH5 Lead Lag Control	A lead lag control sequences multiple boilers so that only the number of boilers needed to satisfy heating demand are in operation. The energy savings result from minimizing standby losses caused by boilers running unnecessarily and from operating boilers close to their full load capacities.
CH6 Reduced Burner Size	If an existing burner on a boiler is oversized, it will operate below full capacity more often than a smaller burner. At low loads, efficiency of a burner decreases. Therefore, the oversized burner will be less efficient than a properly sized burner.
CH7 Modulating Burner	As the heat load on a boiler decreases below full load, the firing rate of the burner should decrease accordingly. One way to do this is with a modulating burner. This type burner will burn less fuel at part load than will a conventional on-off or high-low-off burner. As the load decreases, the conventional burner continues to burn full fuel while the modulating burner will be burning fuel at a rate that more closely matches the load.

Table 2.5 (continued)

Energy Saving Rationale

ECO DESCRIPTION	
CH8 Part Load Boiler	In a system with large boilers, there may be light load conditions when the boilers are running at small percentages of their full-load capacities. Radiative and convective losses remain near full load levels and become a larger percentage of the energy input. If such part load operation is frequent throughout the year, installation of a small boiler to handle the reduced loads will save energy by allowing the larger boilers to be shut down, reducing losses and inefficiencies.
CH9 Automatic Breeching Damper	When a boiler is not being fired, breeching and stack become excellent natural ventilators. They promote the flow of warm air up the stack and out of the building. The cold infiltration air replacing it must then be heated, wasting energy. This air flow up the stack may be stopped by installation of automatic breeching dampers. When the boilers are not operating, the dampers automatically close, sealing room air from the stack. This action applies to boilers which are located in conditioned building spaces.
CH10 Flue Gas Heat Recovery	The exhaust gases from a boiler are normally at fairly high temperatures. This high temperature gas, when exhausted to the atmosphere, carries a significant amount of energy with it. It is possible to install a heat exchanger to recover some of this waste heat and use it to preheat incoming combustion air, returning boiler water and/or DHW. The energy savings would be the amount of preheating that is not already done by the boiler. A drawback of installing such a device is that it presents a flow restriction. This may require stack alterations or mechanical draft generation.
CH11 Burner Fuel Conversion	In buildings which heat with oil and have gas available to them, conversion of the burner from oil to gas firing may be considered if local gas costs are less than oil costs. Heating energy may also be saved through potentially higher boiler operating efficiencies achievable when burning gas.

Table 2.5 (continued)

Energy Saving Rationale

ECO DESCRIPTION	
	Note: Although this ECO has the potential for reducing energy costs in some projects, this study found that it could not be fully analyzed at this time. The following factors contributed to this situation: - In many cases conversion to gas burners within an oil combustion chamber might decrease efficiency thereby increasing total energy use. This is not considered energy conservation even it it might save money. - Accurate cost estimation of this retrofit is very difficult to assess because of the many unknown factors not attainable from the site survey including cost of installing a gas line to a central plant and exact combustion chamber type. - Cost of gas per unit of energy (BTU) is expected to rise faster than oil with some estimates predicting gas will equal oil prices in five years because of deregulation. This fast rise of gas prices would make fuel conversion not cost-effective.
HD1 Refurbish Steam Traps	Faulty steam traps reduce a heating system's efficiency by allowing steam to pass into the condensate return system. Steam in the condensate lines causes higher condensate temperature than normal, which causes greater heat loss from the condensate piping and receivers. Faulty steam traps also cause higher steam consumption by not controlling the flow of steam at the individual radiators. Energy savings will result from lower steam consumption and smaller heat losses from the condensate return system.
WS1 and 2 Hydro-Pneumatic System (WS1) Variable Speed Pumping (WS2)	High-rise projects require pumping systems to deliver domestic water to the upper floors. Many of these systems run constantly, using the same amount of energy input during both conditions of low or high water demand.

Table 2.5 (continued)

Energy Saving Rationale

ECO	DESCRIPTION
	It is possible to reduce the pumping energy requirements by initiating one of the following retrofits: 1. Hydro-pneumatic systems pump domestic water into a pressurized tank. The tank pressure provides the force required to deliver water to the upper floors. During the periods of low demand the pumps are not required and may be turned off. 2. Variable speed pumping adjusts the pump speed to match the demand for water.
WS3 Separate Domestic Hot Water Heater	In a system where heat for domestic hot water heating is supplied from large heating system boilers, the boilers must remain in operation at all times when domestic hot water is needed. In the summer this may mean that a large boiler is running only to supply domestic hot water. Operation in this manner is wasteful. As the output of a boiler drops to fractional load levels, say 10 percent of full loads, boiler losses increase an additional 10 to 20 percent of the total energy used by the boiler. At these low load percentages, burner combustion efficiency is also decreased, further increasing unnecessary energy losses. For these reasons, installation of a separate domestic hot water heater should be considered.
CC1 Chiller Control Adjustment	Chiller control adjustments will result in energy savings due to increased chiller efficiency.
CC2 Ambient Control	Cooling systems without ambient control will circulate cooling media at a constant temperature regardless of outside air temperature. Installing an ambient control will allow adjustment of the cooling media temperature to supply only the amount of cooling needed to meet loads based on outside temperature.
CC3 Timed Control	Timed control of public area central cooling will allow the system to run only during periods of occupancy. Energy savings will result proportional to the cutback in running time of the system.

Table 2.5 (continued)

Energy Saving Rationale

ECO	DESCRIPTION
EL1 Time Switching	If exterior lighting is manually controlled, additional electrical energy is required to operate those lights which remain on longer than required. Time clocks may be installed to more accurately control the periods during which the lights are turned on. An astrological timer which continually resets its own starting and stopping times according to the day of the year may be used for this operation. The timer installation may also require the installation of contactors to switch the power to the lighting circuits.
EL2 Photocell Switching	A photocell actuated controller can be installed to replace manual switching of exterior lighting. This retrofit may not save quite as much energy as an astrological timer (EL1), for the photocell may cause additional operation of the lights during periods of inclement weather.
EL3 Sodium Vapor Conversion of Fixtures	Sodium vapor fixtures produce approximately twice as much light per watt as mercury vapor lighting and approximately five times as much light per watt as incandescent lighting.

2.1.7 Energy Conservation Opportunity Analysis

After yearly energy consumption was calculated for each project and prototype, ECOs were analyzed individually.

The ECOs selected for analysis were divided into the following two categories:

1. ECOs that are maintenance or no capital cost items (11 ECOs)
2. ECOs that require an initial capital cost (47 ECOs).

These classifications are referred to as "no cost" and "cost" ECOs. "No cost" ECOs are noted in Table 2.6. Energy savings analyses were performed in two steps to reflect the "no cost" and "cost" distinction between ECOs. It is assumed that all operational and maintenance ECOs (no cost) would be implemented before capital investments were made.

ECO savings analysis was based on the existing energy usage calculations outlined previously. Energy savings estimates were computed by creating temporary data sets with selected data points modified to reflect the implementation of the ECO being analyzed. The predicted savings were the difference between the existing usage and the usage resulting from the ECO (temporary data).

It was possible that an existing project would have some or all of the energy conservation opportunities implemented. Thus, the existing energy program was written to account for the occurrence of most ECOs. With discrete modifications to project data, the performance of most of the ECOs could be simulated.

For example, the "U" value of a window is used to calculate existing use - i.e., 1.13 for single glazing. This is changed to .6 to simulate retrofit of storm windows.

To permit maximum flexibility, the existing energy programs were not altered to calculate ECO savings. A short program was written for each ECO that would create a temporary data set with appropriate changes to the data, run the existing energy program using the temporary data set, and compare the new output to the original existing energy output to find the savings.

Certain ECOs could not be analyzed by changing data. In these cases a direct savings calculation was done.

To enhance the accuracy of the ECO savings predictions, all of the no cost ECOs were analyzed as a group. The resulting energy usage with the no cost ECOs implemented was used as the base for calculating the savings of all cost ECOs.

Cost ECOs were analyzed individually except where experience or physical constraints dictated that more than one ECO would be implemented at the same time. In those cases the designation of the ECOs are shown together, for example, AR1/AR2.

Table 2.6 gives the applicability of the ECOs, indicating compatibility to building type and fuel source, and whether an ECO is to be analyzed independently or not. Table 2.7 shows the relationship of dependent ECOs for beneficial or reduced energy savings effects on one another if implemented together.

Table 2.6

ECO Characteristics

Applicable ECO Characteristics:

		No Capital Cost	Indep-dent	Building Type: Low Rise	High Rise	Heating System: Space Heating	Central Heating	Heating Fuel: Oil	Gas	Electricity
AR1&2	Weather Strip'g			•	•	•	•	•	•	•
AR3	Attic Insulation			•		•	•	•	•	•
AR4	Floor Insulation			•		•	•	•	•	•
AR5	Roof Insulation				•	•	•			
AR6	Storm Windows			•	•	•	•	•	•	•
AR7	Insulating Glass			•	•	•	•	•	•	•
AR8	Storm Doors			•		•	•	•	•	•
AR9	Wall Insulation			•		•	•	•	•	•
AR10	Vestibules				•	•	•	•	•	•
SH1	Reduce Temperature	•		•	•	•	•	•	•	•
SH2	Set Back Thermostat			•	•	•	•	•	•	•
SH3	Auto Flue Damper			•		•		•	•	
SH4	Flue Heat Recovery		•	•		•		•	•	
SH5	Elec Auto Pilots		•	•		•		•	•	
SW1	Reduce Temperature	•		•	•	•	•	•	•	•
SW2	Flow Restrictors			•	•	•	•	•	•	•
SW3	New D.H.W. Heaters			•	•	•		•	•	•
SW4	Upgrade Plumbing			•	•	•	•	•	•	•
SL1	Delamping	•		•	•	•	•	•	•	•
SL2	Auto Light Level		•	•	•	•	•	•	•	•
SL3	Auto Timer Control		•	•	•	•	•	•	•	•
SL4	Conv To Fluorescent		•	•	•	•	•	•	•	•
SL5	High Eff Ballast		•	•	•	•	•	•	•	•
SC1	Clean Cooling System	•		•	•	•				•
SC2	Require High Eer Units	•		•	•	•				•
CR1	Room Control			•	•		•	•	•	
CR2	Zone Control			•	•		•	•	•	
CR3	Pump Control			•	•		•	•	•	
CR4	H.W. Reset Control			•	•		•	•	•	
CR5	Part Load Pump			•	•		•	•	•	
CA1	Reduce Out Air Intake	•	•	•	•		•			
CA2	Reduce Supply Air		•	•		•	•			
CA3-5	Upgrade Air System		•	•	•		•			
CA7	Zone Reset Control		•	•	•		•			
CA9	Heat Recovery		•	•	•		•			
CH1	Boiler Water Maint'ce	•		•	•		•	•	•	
CH2	Adjust Burner	•		•	•		•	•	•	
CH3	Adjust Burner Control	•		•	•		•	•	•	
CH4	Auto Cycling			•	•		•	•	•	
CH5	Lead/Lag Control			•	•					
CH6	Reduce Burner Size			•	•		•	•	•	
CH7	Modulating Burner			•	•		•	•	•	
CH8	Part Load Burner			•	•		•	•	•	
CH9	Auto Breech Damper			•	•		•	•	•	
CH10	Flue Heat Recovery			•	•		•	•	•	
CH11	Fuel Conversion			•	•		•	•	•	
HD1	Upgrade Stem Traps	•		•	•		•	•	•	
WS1	Hydro-Pneu System				•	•	•	•	•	•
WS2	Var Speed Pump				•	•	•	•	•	•
WS3	Sep D.H.W. Heater			•	•	•	•	•	•	•
CC1	Adjust Chiller Control	•		•	•	•	•	•	•	•
CC2	Ambient Control		•	•	•	•	•	•	•	•
CC3	Timed Control		•	•	•	•	•	•	•	•
EL1	Timed Switching		•	•	•	•	•	•	•	•
EL2	Photo Switching		•	•	•	•	•	•	•	•
EL3	Sod-Vapor Conversion		•	•	•	•	•	•	•	•

Table 2.7

Energy Conservation Opportunity Relationship Matrix

	AR1&2 Weather Strip'g	AR3 Attic Insulation	AR4 Floor Insulation	AR5 Roof Insulation	AR6 Storm Windows	AR7 Insulat'g Glass	AR8 Storm Doors	AR9 Wall Insulation	AR10 Vestibules	SH2 Set Back Thermos	SH3 Auto.Flue Damper	SH4 Flue Heat Recov.	SH5 Elec.Auto.Pilots	SW2 Flow Restrictors	SW3 New DHW Heaters	SW4 Upgrade Plumbing	SL2 Auto.Light Level	SL3 Auto.Timer Contr	SL4 Conv.to Fluoresc	SL5 High Eff.Ballast	CR1 Room Control	CR2 Zone Control	CR3 Pump Control	CR4 H.W. Reset Contr	CR5 Part Load Pump	CA2 Reduce Sup. Air	CA3-5 Upgrade Air Syst	CA7 Zone Reset Contr	CA9 Heat Recovery	CH4 Auto Cycling	CH5 Lead/Lag Control	CH6 Reduce Burner Sz.	CH7 Modulat'g Burner	CH8 Part Load Boiler	CH9 Auto.Breech Damp	CH10 Flue Heat Recov.	CH11 Fuel Conversion	WS1 Hydro-Pneu Syst.	WS2 Var. Speed Pump	WS3 Sep. DHW Heater	CC2 Ambient Control	CC3 Timed Control	EL1 Timed Switching	EL2 Photo Switching	EL3 Sod-Vapor Conver
AR1&2 Weather Strip'g		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
AR3 Attic Insulation	o		o	●	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
AR4 Floor Insulation	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
AR5 Roof Insulation	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
AR6 Storm Windos	●	o	o	o		●	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
AR7 Insulat'g Glass	●	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
AR8 Storm Doors	●	o	o	o	o	o		o	●	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
AR9 Wall Insulation	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
AR10 Vestibules	●	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
SH2 Set Back Thermos	•	•	•	•	•	•	•	•	•		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
SH3 Auto.Flue Damper	•	•	•	•	•	•	•	•	•	•		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	●	o	o	o	o	o	o	o	o	o	o
SH4 Flue Heat Recov.	•	•	•	•	•	•	•	•	•	•	•		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
SH5 Elec.Auto.Pilots	•	•	•	•	•	•	•	•	•	•	•	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
SW2 Flow Restrictors	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
SW3 New DHW Heaters	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	●	o	o	o	o	o
SW4 Upgrade Plumbing	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
SL2 Auto.Light Level	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
SL3 Auto.Timer Contr	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
SL4 Conv.to Fluoresc	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
SL5 High Eff.Ballast	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
CR1 Room Control	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		●	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
CR2 Zone Control	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
CR3 Pump Control	+	+	+	+	+	+	+	+	+	o	o	o	o	o	o	o	o	o	o	o	●	●		●	●	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
CR4 H.W. Reset Contr	+	+	+	+	+	+	+	+	+	o	o	o	o	o	o	o	o	o	o	o	●	●	o		●	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
CR5 Part Load Pump	+	+	+	+	+	+	+	+	+	o	o	o	o	o	o	o	o	o	o	o	●	●	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
CA2 Reduce Sup. Air	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
CA3-5 Upgrade Air Syst	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
CA7 Zone Reset Contr	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
CA9 Heat Recovery	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
CH4 Auto Cycling	+	+	+	+	+	+	+	+	+	o	o	o	o	o	o	o	o	o	o	o	•	•	•	•	•	o	o	o	o		●	o	o	●	o	o	o	o	o	o	o	o	o	o	o
CH5 Lead/Lag Control	+	+	+	+	+	+	+	+	+	o	o	o	o	o	o	o	o	o	o	o	•	•	•	•	•	o	o	o	o	o		o	o	●	o	o	o	o	o	o	o	o	o	o	o
CH6 Reduce Burner Sz.	+	+	+	+	+	+	+	+	+	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o
CH7 Modulat'g Burner	+	+	+	+	+	+	+	+	+	o	o	o	o	o	o	o	o	o	o	o	•	•	•	•	•	o	o	o	o	●	●	o		o	o	o	o	o	o	o	o	o	o	o	o
CH8 Part Load Boiler	+	+	+	+	+	+	+	+	+	o	o	o	o	o	o	o	o	o	o	o	•	•	•	•	•	o	o	o	o	o	o	o	●		o	o	o	o	o	●	o	o	o	o	o
CH9 Auto.Breech Damp	•	•	•	•	•	•	•	•	•	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o	o
CH10 Flue Heat Recov.	•	•	•	•	•	•	•	•	•	o	o	o	o	o	o	o	o	o	o	o	•	•	•	•	•	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o
CH11 Fuel Conversion	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o
WS1 Hydro-Pneu Syst.	o	o	o	o	o	o	o	o	o	o	o	o	o	•	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		●	o	o	o	o	o	o
WS2 Var. Speed Pump	o	o	o	o	o	o	o	o	o	o	o	o	o	•	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o
WS3 Sep. DHW Heater	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o
CC2 Ambient Control	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o
CC3 Timed Control	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o
EL1 Timed Switching	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		●	o
EL2 Photo Switching	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o
EL3 Sod-Vapor Conve	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	•	

Legend:
- ● Downgrades Savings Significantly
- • Downgrades Savings
- o No Effect
- + Increases Savings

2.1.8 Economic Analysis

Based upon the information gathered and analyzed as indicated in previous sections, an economic evaluation was performed for each applicable ECO to determine whether it provided adequate economic benefit or whether it was only marginally effective in reducing energy consumption and costs.

There were a number of investment decision methods considered to determine ECO economic feasibility, including simple and discounted payback, net present worth and internal rate of return. The discounted payback method was selected for economic evaluation of energy conservation opportunities. This method takes into account the time value of cash flows and is used as an indicator for prioritizing investment decisions. This method is also used in existing HUD policy to determine economic worth. Its diasdvantage is that it ignores benefits which accrue after the payback date and therefore does not reflect the total net benefit for the life of the project.

The discounted payback period is the number of years, k, it takes for the following conditions to be satisfied:

$$Co = \sum_{t=1}^{k} \frac{B_o \times (1 + i_f)^t - M_o \times (1 + i_g)^t}{(1 + i_d)^t}$$

where

Co = Initial capital cost of ECO including material and labor costs

k = Number of years to payback

t = Year

B_o = Fuel savings in first year

= (Annual BTUH saved) x (Rate) + (Annual KWH saved) x (Rate)

i_f = Fuel escalation factor

i_g = Inflation rate

m_o = Maintenance costs in first year

i_d = Discount rate

In other words, it is the time period in years for an investment to pay for itself through yearly savings taking into consideration yearly fuel escalation, maintenance costs, general inflation, and the discount rate. An Energy Conervation Opportunity (ECO) is considered feasible if its payback is less than its useful life.

It should be noted that this algorithm is a simplification of a complete discounted payback analysis which takes into account income tax, tax credits and energy credits. It was decided that since the Public Housing Stock is an ongoing HUD administered program not subject to taxes, sale or eligible for tax credits, these features did not apply. In addition, salvage value was ignored, since by definition discounted payback only considers ECOs feasible if they payback in less than their useful life.

If in certain cases, such as wall insulation, there were no annual maintenance costs, the equation simplifies as follows: solving for k,

$$C_o = \sum_{t=1}^{k} \frac{B_t \, (1 + 1_f^t)}{(1 = i_d)^t}$$

To reflect short-term and long-term projections of fuel escalation and general inflation, the following values were used:

Fuel escalation	=	12% above inflation for the first two years of analysis, 8.8% thereafter
General inflation	=	11% for the first two years, 9% thereafter
Discount rate	=	10% constant

Due to the rapidly changing economic and fuel cost picture, these rates might not coincide exactly with recent rates, but it is felt that they represent an adequate forecast for the analysis.

In general, if fuel escalation was less than used in this analysis the discounted payback of the ECOs would be longer than shown. This would put some of the marginal ECOs, those with 13 or 14 year paybacks, over the 15 year cutoff and would tend to shift the energy savings and capital costs of each payback category lower. This, however, would produce approximately the same curve as obtained in this analysis showing the effect of savings versus capital investment. This curve would then produce the same relationships of cost to benefits and a similar recommended level of investment would be derived.

Combined Analysis

Detailed energy savings and capital cost analyses were performed on each prototype (22) for applicable ECOs (58). Resulting savings and cost with corresponding payback period for each ECO are arranged by prototype in order of best-to-worst payback. These individual ECOs are then grouped in the following three categories:

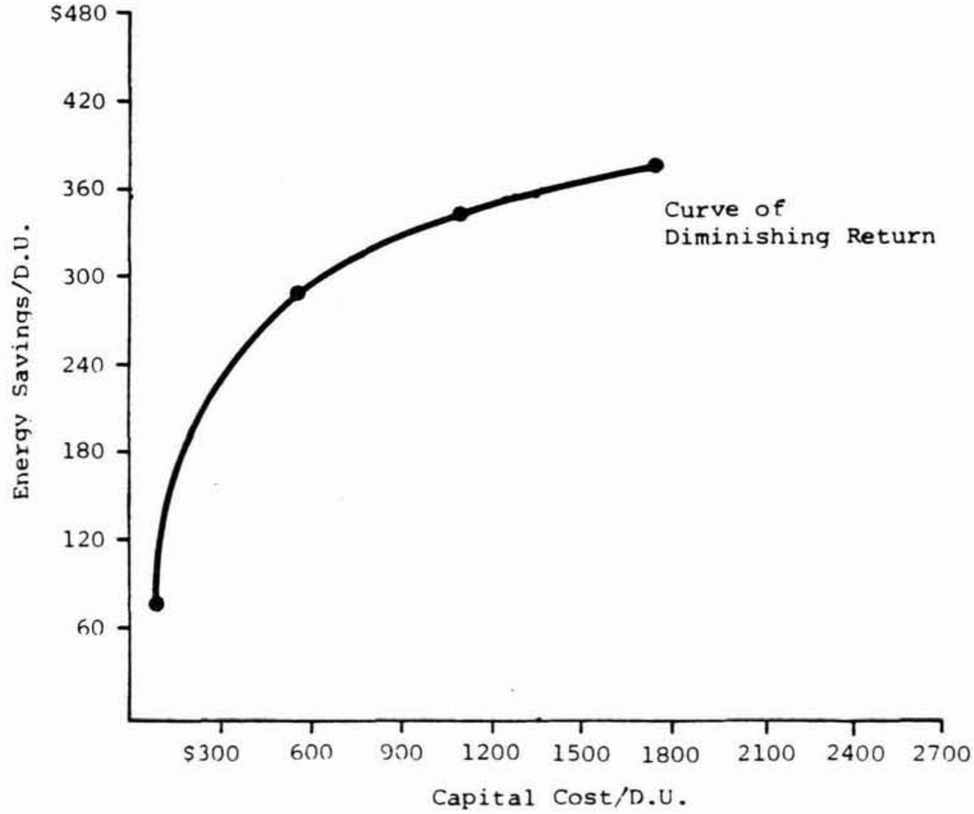
1. Less than 5 years discounted payback
2. Less than 10 years discounted payback
3. Less than 15 years discounted payback

Since some ECOs are mutually exclusive and interdependent, total energy savings and cost would therefore result in less than a total for the ECOs taken independently. To take this into account, each payback group is reanalyzed to show diminishing returns of combined ECOs resulting in three final totals for each prototype corresponding to the payback groupings.

The final results of this analysis can be plotted on a graph with capital cost investment per dwelling on the bottom axis and dollar savings per dwelling unit on the vertical axis as shown in Illustration 2.3.

Illustration 2.3

Curve of Diminishing Return



By connecting these points through an approximate linear regression a curve can be derived illustrating the function of capital cost investment to energy savings. This curve will show diminishing return as higher capital cost investments yield smaller energy savings. The magnitude of this curve will vary between prototypes, illustrating their unique cost/benefit relationships. From these curves the appropriate level of investment can be estimated.

2.2 Cost Data

This section consists of tables listing all the ECOs that require some amount of initial capital outlay for implementation. Maintenance items are not considered in these tables.

Each capital ECO is listed and described along with the work items required to complete the installation. Work items include the necessary materials and the labor required for installation. Pricing units are listed along with labor and material estimates for installation of various quantities of a particular item, thereby reflecting any quantity discounts available. The cost estimates were developed by Berger & Associates Cost Consultants, Inc., New York, New York.

Note that these costs do not include A/E fees, construction management fees, contractor profit, or contingencies. Prices are for 1979.

The major group of ECOs presented in these tables and the specific ECOs describedin each group are the following:

Major ECO Group	ECOs Described
Architectural	AR 1, 2, 3, 4, 5A, 5B, 6A, 6B, 6C, 7, 8, 9, 10
Space Heating	SH 2, 3, 4, 5
Space Hot Water	SW 2, 3, 4
Space Lighting	SL 2, 3, 4, 5
Space Cooling	SC 2
Central Radiation	CR 1, 2, 3, 4, 5
Central Air	CA 2, 3, 4, 5, 6, 7, 9
Central Heating Boiler	CH 1, 2, 3, 4, 6, 7, 8, 9, 10, 11
Central Water Supply	WS 1, 2, 3
Central Cooling	CC 2, 3
Exterior Lighting	EL 1, 2, 3
Power Distribution	PW 1, 3

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ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
AR1	DESCRIPTION: Door weather stripping	LF	10			5.00
			84			2.50
			150			2.45
	LABOR: Install.					
AR2	DESCRIPTION: Window weather stripping	LF	10			5.00
			84			2.50
			150			2.45
	LABOR: Install.					
AR3	DESCRIPTION: Attic insulation	SF	500			.70
	EQUIPMENT: 4" Batt					
	LABOR: Cut & install.					
AR4	DESCRIPTION: Floor insulation	SF	500			.70
	EQUIPMENT: 4" Batt					
	LABOR: Cut & install.					
AR5A	DESCRIPTION: Roof insulation	SF	50			2.10
			300			.51
			1000			.47
	EQUIPMENT: 1" Rigid, Flat roof					
	LABOR: Cut & install.					
AR6A	DESCRIPTION: Storm window retrofit	EA				
	EQUIPMENT: 2'2" X 3'4" Aluminum storm		8			70.00
	2'10" x 3'4" Aluminum storm		8			80.00
	LABOR: Fit & install.					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
AR6B	DESCRIPTION: Storm window retrofit	EA				
	EQUIPMENT: 2'2" x 3'4" Aluminum, double hung with storm & screen		1			250.00
			4			142.00
			25			130.00
	2'10" x 3'4" Aluminum, double hung with storm & screen		1			270.00
			4			160.00
			25			152.00
	LABOR: Remove old window, fit & install.					
AR6C	DESCRIPTION: Storm window retrofit	EA				
	EQUIPMENT: 3'0" x 2'0" Aluminum, sliding with storm & screen		1			221.00
			4			125.00
			25			118.00
	LABOR: Remove old window, fit & install.					
AR7	DESCRIPTION: Insulating glass	EA	10			12.60
			25			9.33
			60			9.28
	EQUIPMENT: Clear, 1/2" air space					
	LABOR: Remove old windows, fit & install.					
AR8	DESCRIPTION: Storm doors	EA				
	EQUIPMENT: 3'0" x 7'0" Aluminum		1			140.00
			4			90.00
			20			95.00
	3'0" x 7'0" Wood		1			150.00
			4			100.00
	LABOR: Fit & install.		20			81.00

				Installed Unit Price		
ECO#	Description	Units	Qty	Material	Labor	Total
AR9	DESCRIPTION: Wall insulation EQUIPMENT: Foam LABOR: Install.	SF	500			1.25
AR10	DESCRIPTION: Vestibule EQUIPMENT: 4'0" x 6'0", 2 sides, door, roof, s.o.g., steps, tailing, wood frame, metal frame LABOR: Install.	EA	1 1			500.00 1500.00
SH2	DESCRIPTION: Setback thermostat EQUIPMENT: Honeywell Chronothurm T882A or Penn Bass Timetrol A51AA-1 or White Rogers Automatic Comfort Set 1F70-1 LABOR: Mount new thermostat, rewire.	per Stat	1 20 80 100	49.62 47.14 44.65 39.70	25.16 25.16 25.16 25.16	74.70 72.30 69.80 64.80
SH3	DESCRIPTION: Automatic flue damper on space heaters or furnace EQUIPMENT: Johnson Control "Mizer"*, Johnson Controls, Milwaukee or Advent Stack Master, Advent Industries, Norriston, Pa. or	per furnace or space heater	1 20 80 100	540.00 513.00 486.00 432.00	100.16 100.16 100.16 100.16	640.10 613.10 586.10 532.10

				Installed Unit Price		
ECO#	Description	Units	Qty	Material	Labor	Total
	Trionic Heating System Sentinel, Trionic Industries, Harrisburg, Pa.					
	LABOR: Cutsection from flue & install device, Wire device to burner controls.					
SH4	DESCRIPTION: Flue heat recovery on space heaters & furnaces	per furnace or space heater	1	340.00	75.12	415.10
			20	324.50	75.12	399.60
			80	306.00	75.12	381.00
			100	272.00	75.12	347.00
	EQUIPMENT: "Save O Heat", Atlanta Store Works					
	LABOR: Cut section from flue & install device; wire device to 100.A.					
SH5	DESCRIPTION: Electric automatic pilot	per furnace or space heater	1			300.00
			20			250.00
	EQUIPMENT: Johnson Control "Mizer"*, Johnson Controls, Milwaukee, Wisc.					
	* - "Mizer" includes flue damper & electric pilot in one kit					
SW2	DESCRIPTION: Flow restrictors					
	EQUIPMENT: 1 GPM screwed connection both basin bubbler & gaskets	per basin	1	212.66	25.16	47.80
			20	453.20	503.20	956.40
			80	1812.80	2012.80	3825.60
			400	9064.00	10064.00	19128.00
	3 GPM screwed connection shower head & required fittings	per shower	1	22.66	25.16	47.80
			20			
			80			
			400			
	LABOR: Mounting.					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
SW3	DESCRIPTION: New hot water					
	EQUIPMENT: (a) Gas 30 gal. heater complete.	per heater	1	266.73	100.64	448.30
			20	5334.60	2012.80	7347.00
			80	21338.40	8051.20	29389.00
	(b) 50 gal. heater complete	per heater	1	347.73	100.64	448.30
			20	6954.60	2012.80	8967.40
			80	27818.40	8051.20	35869.60
			400	139092.00	40256.00	179348.00
	(c) Electric 30 gal. heater complete	per heater	1	238.33	75.48	313.80
			20	4766.60	1509.60	
			80	19066.40	6038.40	
			400	95332.00	30192.00	
	(d) 50 gal. heater complete	per heater	1	299.20	75.48	374.60
			20	5984.60	1509.60	7493.60
			80	23936.00	6038.40	29974.00
			400	119680.00	30192.00	149872.00
	(e) Solar hot water heater complete with storage tank, controls & pump, Solaron Corp., Denver, Co. Solar Kit, Tampa, Fla. Sun Works, New Haven, Cn. Northrup Inc., Hutchings, Texas	per heater	1	1752.00	801.28	2553.00
			20	35040.00	16025.60	51065.00
	LABOR: (a) Installation & fittings.					
	(b) Installation & fittings.					
	(c) Installation & electric access.					
	(d) Installation & electric access.					
	(e) Install tank, collectors, wiring & piping.					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
SW4	DESCRIPTION: (a)Refurbish plumbing fixtures					
	(b) Replace plumbing fixtures					
	EQUIPMENT: (a) New faucet washers & toilet flush valve for 2 basins & 1 toilet (typical dwelling unit)	per dwelling unit	1 20 100	134.08 2681.60 13408.00	50.32 1006.40 5032.00	184.00 3688.00 18440.00
	(b) New faucet fixtures with washerless valves for kitcen & bath basins & fittings (typical dwelling unit)	per dwelling	1 20 100	194.66 3893.20 19466.00	50.32 1006.40 5032.00	244.90 4899.60 24498.00
	LABOR: (a) Installation, Toilet flush valve = \$50.20 X 2 = 100.40 100.40 + .16 = 100.56.					
	(b) Installation Bath \$31.50 + Basin \$76.70 (2x\$38.50) + Kit \$37.80= \$146.00.					
SL2	DESCRIPTION: Reduced lighting level					
	EQUIPMENT: Install 1 automatic dimming device per fluorescent fixture type					
	(a) 2 - tube fixtures	per 2-tube fixture	1 50	32.50 29.00	25.00 20.00	57.50 49.00
	(b) 4 - tube fixtures ECALO Fluorescent Lamp System. Controlled Environment Systems, Rockville, MD	per 4-tube fixture	1 50	45.85 41.00	28.00 22.00	73.80 63.00

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
	LABOR: (a) Wire in series with ballast.					
	(b) Wire in series with ballast.					
SL3	DESCRIPTION: Timer control					
	EQUIPMENT: (a) Install 7 day timer (Paragon 7 day timer manufactured by Paragon Div., AMF Inc.)	per lighting circuit	1	165.15	36.00	201.10
	(b) Install contactor in lighting circuits with high (20 amp) current draw	per lighting circuit	1	245.75	50.00	295.70
	LABOR: (a) Wire timer in existing circuit.					
	(b) Wire contactor in lighting circuit, wire contactor to timer.					
SL4	DESCRIPTION: Incandescent to fluorescent conversion	per fixture	1 10 40	26.00 23.00 22.00	22.00 10.00 9.00	48.00 33.00 31.00
	EQUIPMENT: Replace incandescent with fluorescent replacement fixtures as manufactures by: Vivacon, Inc., Hollywood, Ca.					
	LABOR: Replaceent & rewiring.					
SL5	DESCRIPTION: High efficiency ballasts	per ballast	1 20 100	18.00 16.00 15.00		18.00 16.00 15.00
	EQUIPMENT: High efficiency ballast					
	LABOR: None, to be performed on a need for replacement basis.					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
SC2	DESCRIPTION: Require high EEr A/C units					
	EQUIPMENT: 4000 BTUH high EER unit	per unit	1	285.00		
	4000 BTUH regular EER unit	per unit	1	248.00		
	7000 BTUH high EER unit	per unit	1	437.00		
	7000 BTUH regular EER unit	per unit	1	380.00		
	12000 BTUH high EER unit	per unit	1	566.00		
	12000 BTUH regular EER unit	per unit	1	492.00		
	4000 BTUH high EER unit	per unit	20	285.00		
	4000 BTUH regular EER unit	per unit	20	248.00		
	7000 BTUH high EER unit	per unit	20	437.00		
	7000 BTUH regular EER unit	per unit	20	380.00		
	12000 BTUH high EER unit	per unit	20	566.00		
	12000 BTUH regular EER unit	per unit	20	492.00		
	4000 BTUH high EER unit	per unit	100	256.50		
	4000 BTUH regular EER unit	per unit	100	223.20		
	7000 BTUH high EER unit	per unit	100	393.30		
	7000 BTUH regular EER unit	per unit	100	342.00		
	12000 BTUH high EER unit	per unit	100	509.00		
	12000 BTUH regular EER unit	per unit	100	492.80		
	4000 BTUH high EER unit	per unit	400	228.00		
	4000 BTUH regular EER unit	per unit	400	198.40		
	7000 BTUH high EER unit	per unit	400	349.60		
	7000 BTUH regular EER unit	per unit	400	304.00		
	12000 BTUH high EER unit	per unit	400	452.80		
	12000 BTUH regular EER unit	per unit	400	393.60		
	LABOR: None.					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
CR1	DESCRIPTION: Individual room control					
	EQUIPMENT: (a) Hot water &	per	1	353.48	50.32	403.80
	2- pipe systems install	radiator	20	7069.00	1006.40	8076.00
	automatic control valves	1/2" pipe	100	35348.00	5032.00	40380.00
	at radiators &/or con-	•	400	141392.00	20128.00	161520.00
	vectors. These valves					
	shall have self contained	per	1	368.53	50.32	418.80
	thermostatic elements,	radiator	20	7370.60	1006.40	8377.00
	Danfoss IVT series valves,	3/4" pipe	100	36853.00	5032.00	41885.00
	Danfoss, Inc. Mahwah, N.J.		400	147412.00	20128.00	167540.00
	(b) 1-pipe steam systems	per	1	29.00	50.32	79.30
	install automatic, self	radiator	20	580.00	1006.40	1586.40
	contained valve at radi-		100	2900.00	5032.00	7932.00
	ator air vent, Danfoss		400	11600.00	20128.00	36728.00
	1-PS Valve, Danfoss, Inc. Mahwah, NJ					
	LABOR: (a) Cut section from radiation pipe, thread & install with unions or bronze if copper. 1/2" = 331.60 X .75 = 248.25 3/4" = 340.00 x .75 = 255.00.					
	(b) Remove existing air vent & replace with control valve 29.00 x .75 = 21.75.					
CR2	DESCRIPTION: Zone control retrofit					
	EQUIPMENT: (a) Electric	per zone	ea	697.80	201.28	899.00
	Control Systems install 2	system	1"	185.47	75.49	260.00
	or 3 way zone valve &		1 1/2"	275/53	75.49	351.00
	electric controls, M945		2"	357.60	150.96	508.50
	control accessories, M945		2 1/2"	676.40	201.28	87.60
	actuator T991 Thermostat		3"	872.13	226.44	1098.50
	with insertion well, T991					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
CR2 ct'd	Outdoor air thermostate, T921 Space thermostat steam only), V5013 3-way valve (hot water) or V5011 2-way valve (Steam) 1", 1 1/2", 2", 2 1/2". 3"		1"	127.27	88.07	215.30
			1 1/2"	206.49	176.12	382.60
			2"	289.27	201.28	490.50
			2 1/2"	388.53	201.28	589.80
			3"	507.29	251.60	758.80
	(b) Pneumatic Control System; install 2 or 3 way valve & pneumatic controls MP953 actuator, LP914 insertion sensor wall, LP914 outdoor air sensor, RP908B reset controller, TP971		ea	958.63	239.02	1197.60
			1"	185.47	75.49	260.90
			1 1/2"	237.53	75.49	351.00
			2"	357.60	150.96	508.50
			2 1/2"	676.40	201.28	877.60
			3"	872.13	226.44	1098.40
	space sensor (steam only), V5011 2-way valve (steam) V5013 3-way valve (hot water) 1", 1 1/2", 2", 2 1/2", 3"		1"	127.27	88.07	215.30
			1 1/2"	206.49	176.12	382.60
			2"	289.27	201.28	490.50
			2 1/2"	388.53	201.28	589.80
			3"	507.24	251.60	758.80
	(c) New Zone Pump, Install new hot water circulating pump complete with fittings & electrical accessories when required, 1 hp in line, 2 hp in line, 5 hp base mounted, 7.5 hp base mounted 10 hp base mounted	per zone system	1 hp	626.66	72.16	698.80
			2 hp	693.33	176.12	869.40
			5 hp	3438.00	251.60	3689.60
			7.5 hp	5182.67	251.60	5434.20
			10 hp	7525.33	301.92	7827.20
	LABOR: (a) Wire line voltage to new controls, wire 3-16# from actuator to each of the other devices (40" per device). Cut existing piping & install valve. Install 20' of new return piping from valve (hot water) mount insertion well &stat in zone supply & insulate new pipe.					
	(b) Connect control devices with 1/4" copper pipe (50' per device. Cut existing heating piping & install valve. Install 20' of new					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
CR2 ct'd	return piping from valve (hot water sys.). Mount insertion well & sensor in zone supply. In zone supply insulate new pipe.					
	(c) Install pump & required fittings & wiring.					
CR3	DESCRIPTION: Radiation pump control					
	EQUIPMENT: (a) Instsll ambient control of heating pump(s). LP914 outdoor air sensor, RP908A controller, P658A Pneumatic electric switch, R480 Relay.	per pump control system	1	378.32	50.08	428.40
	(b) Install magnetic starter if required.	per pump starter	1	213.33		213.30
	LABOR: (a) Mount sensor at north building exposure. Pipe pneumatic devices (50' copper/device). Wire P/E relay to electric relay; electric relay to pump starter.					
	(b) Install magnetic starter if required.					
CR4	DESCRIPTION: Hot water reset control	per zone	ea			
	EQUIPMENT: For hot water radiation systems: (a) See CR2 for electric control.					
	(b) See CR2 for pneumatic control.					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
CR5	DESCRIPTION: Radiation part load pump	per pump system	ea			
	EQUIPMENT: For hot water radiation systems add the approximate costs from CR2 (c) and CR3.					
CA2	DESCRIPTION: Reduce supply air quantities					
	EQUIPMENT: (a) adjustable sheave					
	(b) Air balancing for 20 outlets, 35 outlets, 100 outlets	for each system size listed in (b)	per 1000 CFM each system size			363.00 363.00 1532.00
	LABOR: (a) Install & test air flow.					
	(b) Check air flow at each grille & register; adjust flows as required.					
CA3	DESCRIPTION: Reduce outdoor air damper leakage					
	EQUIPMENT: (a) replace seals & edging on outdoor air damper. Caulk around damper frame. Repair damper actuator(s).	per sq. ft. of damper surface	1 sf 10 sf 20 sf 30 sf	2.66 3.00 3.33 4.00	37.56 37.56 62.60 62.60	40.00 40.00 65.00 66.00
	(b) Install new outdoor air damper & operator(s), D642 Damper, MP903A (one per 15 sf of damper).	per sq. foot of damper surface	1 sf 10 sf 20 sf 30 sf	 418.67	 62.60	 481.00
	(c) Electric controls.					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
CA3 ct'd	LABOR: (a) Repair. (b) Remove old damper. Install new damper. Repipe actuators.					
CA4	DESCRIPTION: Automatic start/stop					
	EQUIPMENT: (a) Install Paragon 7 day timer (AMF Inc., Twin Rivers, Wis.).	per fan system	1 2 5	521.33 1042.66 2606.65		521.00 1042.00 2606.00
	(b) Install Magnetic Starter, if required.	per fan system	1 2 5	133.00 266.00 665.00		133.00 266.00 665.00
	LABOR: (a) Wire line voltage to timer. Wire timer to fan motor starter. (b) Wire new starter.					
CA5	DESCRIPTION: Warm up cycle/night cycle					
	EQUIPMENT: (a) Pneumatic Control, RP417 Electric/ Pneumatic Paragon 7 day timer	per fan system	1 2 5	 565.33 2826.65	 50.08 250.40	 615.00 3077.00
	(b) Electric control, R482 Electric Relay Paragon 7 day timer	per fan system	1 2 5	571.38 1142.76 2856.90		571.00 1142.76 2856.00
	(c) To add night cycle control to warm up cycle (both) pneumatic & electric control) T42 Electric Thermostat	per fan system	1 2 5	174.15 348.30 870.75		174.15 348.00 870.00
	LABOR: (a) Wire line voltage to timer. Wire timer to E/P relay. Pipe outdoor air damper control to E/P relay.					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
CA5 ct'd	(b) Wire line voltage to timer. Wire timer to electric relay. Wire electric relay in damper control circuit.					
	(c) Wire electric thermostat to timer.					
CA5	DESCRIPTION: Economizer control					
	EQUIPMENT: (a) Pneumatic Control systems, LP914 outdoor air sensor RP908 controller.	per fan system	1	214.64	50.08	264.00
			2	429.28	100.16	529.00
			5	1073.20	250.00	1323.00
	(b) Electric Control Systems T675 outdoor air thermostat R482 Electric relay.	per fan system	1			318.00
			2			636.00
			5			1590.00
	LABOR: (a) Pipe controller to existing mixed air controller. Pipe sensor to new controller.					
	(b) Wire outdoor air thermostat to electric relay. Wire electric relay in damper control circuit.					
CA7	DESCRIPTION: Zone reset control	per fan system by number of zones	1	633.33	250.40	884.00
			2 zones	1267.26	500.80	1768.00
			4 zones	2534.42	501.60	3536.00
	EQUIPMENT: Pneumatic Control Systems, RP908B Mixed Air Controller, RP908B Colddect Controller, RP908B Hot deck Controller, RP913A Load Relay		6 zones	301.68	1002.40	5304.00
	LABOR: Pipe zone stats to load relay. Pipe load relay output to each of the controller. Pipe controllers to existing devices.					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
CA9	DESCRIPTION: Heat Recovery					
	EQUIPMENT: (a) Heat Pipe Unit, 6 row thermal heat pipe unit (manufactured by Q-Dot Corp., Dallas, Tx.)	per system for each CFM listed in quantity column. Assume 500 FPM face velocity	3M CFM	4538.67	350.56	4889.23
			5M CFM	7142.00	350.56	7492.56
			7.5M CFM	9430.67	450.72	9881.39
			10M CFM	9580.00	450.72	10030.72
			15M CFM	15372.00	450.72	15822.72
			(or) 12 SF 20 SF 30 SF 60 SF of coil surface			
	(b) Hydronic "Run Around" System (2) six row coils circulating pump, starter & control. Control Valve & Controller Piping (Manufactured by TraneCo., LaCrosse, Wis.)	same units as Heat Pipe estimate	3"	4360.00	501.52	4861.52
			5"	7040.00	501.52	7541.52
			7.5"	10006.67	501.52	10508.19
			10"	12340.00	501.52	12841.52
			15"	17826.76	704.48	18531.24
	LABOR: (a) Add duct work to bring exhaust adjacent to outdoor air intake. Cut outdoor & exhaust ductwork to mount unit.					
	(b) Add coils & piping system to exhaust & outdoor air ductwork. Wire pump & install controls.					
CH1, 2,&3	DESCRIPTION: Boiler Maintenance					
	EQUIPMENT: (a) Hays 3 tube Orsat & chemicals.	unit	1	50.00	37.56	87.00
			10	500.00	375.60	875.00
			100	4500.00	2504.00	7004.00
	(b) 0-700°F insertion thermostat.	unit	1	48.00	37.56	85.00
			10	480.00	375.60	855.00
			100	4320.00	2504.00	6824.00

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
CH4	DESCRIPTION: Automatic Cycling					
	EQUIPMENT: (a) Ambient start/stop control (all boilers) T675A outdoor air thermostat	per central boiler system	1	437.43	37.56	474.00
	(b) Ambient Control (Hot Water Boilers) T678 outdoor air thermostat	per boiler	1	437.43	37.56	474.00
	(c) Ambient Control (steam boilers only). May replace zone control. "Cleveland Fuel Saver", Cleveland Controls Inc., Cleveland, Oh.	per boiler	1	2133.33	187.80	2321.00
	LABOR: (a) Wire outdoor air thermostat to boiler control panel.					
	(b) Wire outdoor air thermostat to boiler control panel.					
	(c) Install central control panel & wire to boiler control panel. Mount outdoor, indoor & condensate return sensors & wire to new central panel.					
CH6	DESCRIPTION: Reduce burner size					
	EQUIPMENT: (a) Gas burners complete with controls to replace existing burner capacities listed.	per burner size listed in quantity column	100MBTUH	406.67	187.80	594.00
			200MBTUH	""	""	""
			400MBTUH	""	""	""
			600MBTUH	""	""	""
			800MBTUH	""	""	""
			1000MBTUH	""	""	""
			2000MBTUH	""	""	""

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
CH6 ct'd	(b) Oil burners with controls & accessories to replace existing burner for capacities listed.	per burner size listed in quantity column	100MBTUH	440.00	187.80	627.00
			200MBTUH	""	""	""
			400MBTUH	""	""	""
			600MBTUH	""	""	""
			800MBTUH	""	""	""
			1000MBTUH	""	""	""
			2000MBTUH	""	""	""
	LABOR: (a) Gas piping, control, wiring, mounting.					
	(b) Oil piping, control wiring, mounting.					
CH7	DESCRIPTION: Modulating Burner					
	EQUIPMENT: (a) Modulating gas burners complete with accessories for capacities listed in CH6 (a) above.	per burner size listed in quantity column	100MBTUH	1080.00	187.80	1267.00
			200MBTUH	""	""	""
			400MBTUH	""	""	""
			600MBTUH	""	""	""
			800MBTUH	""	""	""
			1000MBTUH	""	""	""
			1000MBTUH	""	""	""
	(b) Modulating oil burners complete with accessories for capacities listed in CH6 (a) above.	per burner size listed in quantity column	100MBTUH	1173.33	187.80	1361.00
			200MBTUH	""	""	""
			400MBTUH	""	""	""
			600MBTUH	""	""	""
			800MBTUH	""	""	""
			1000MBTUH	""	""	""
			2000MBTUH	""	""	""
	LABOR: (a) Gas piping, control wiring mounting.					
	(b) Oil piping, control wiring mounting.					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
CH8	DESCRIPTION: Part load boiler					
	EQUIPMENT: (a) Gas steam boilers complete with safety controls, burner & accessories for the output sizes listed.	per boiler size listed in quantity column	10 hp	2920.00	200.32	3120.32
			20 hp	4480.00	200.32	4680.32
			40 hp	10606.53	200.32	10806.85
			60 hp	13264.40	400.64	13665.04
			100 hp	17649.97	400.64	17650.61
	(b) Gas hot water boiler complete.		10 hp	2920.00	200.32	3120.32
			20 hp	4480.00	200.32	4680.32
			40 hp	10606.53	200.32	10806.85
			60 hp	13264.40	400.64	13665.04
			100 hp	17649.97	400.64	17650.61
	(c) Oil-fired steam boiler complete.		10 hp	3447.87	200.32	3648.19
			20 hp	5121.33	200.32	5321.65
			40 hp	8478.67	200.32	8678.99
			60 hp	10131.60	400.64	10532.24
			100 hp	14968.67	400.64	15369.31
	(d) Oil-fired hot water boiler complete.		10 hp	3447.87	200.32	3648.19
			20 hp	5121.33	200.32	5321.65
			40 hp	8478.67	200.32	8678.99
			60 hp	10131.60	400.64	10532.24
			100 hp	14968.67	400.64	15369.31
	LABOR: (a) Mounting. Piping to existing header. Gas piping wiring.					
	(b) Mounting. Piping to existing header. Gas piping wiring.					
	(c) Mounting. Piping to existing header. Oil piping wiring.					
	(d) Mounting. Piping to existing header. Oil piping wiring.					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
CH9	DESCRIPTION: Automatic breeching damper EQUIPMENT: Automatic breeching damper with safety control interlocks to burner. LABOR: Cut existing breeching. Install damper & actuator wire actuator to burner controls.	per boiler capacities listed	10 hp 20 hp 40 hp 60 hp 100 hp	540.00 740.00 773.33 906.67 1140.00	100.16 100.16 100.16 125.20 240.50	640.00 840.00 873.00 1031.00 1380.00
CH10	DESCRIPTION: Flue gas heat recovery EQUIPMENT: Flue gas to combustion air heat recovery device complete with controls. LABOR: Cut existing breeching.	per boiler for capacities listed	40 hp 80 hp 120 hp	340.00 473.33 706.67	75.12 75.12 200.32	415.00 548.00 906.00
CH11	DESCRIPTION: Boiler fuel conversion. EQUIPMENT: Use appropriate burner prices listed in CH6 & CH7.					
WS1	DESCRIPTION: Hydropneumatic system	500 gal.	1 tank & piping	640.00	216.00	856.00
	EQUIPMENT: Tank & controls		Controls	125.00	235.00	360.00
	LABOR: Install controls, piping.					
WS2	DESCRIPTION: Variable speed pumps	5 (hp)	1 (5hp) Repl.	400.00	60.00	460.00
			Motor (10hp)	600.00	90.00	690.00
	EQUIPMENT: Variable speed pumps, controls.	10 (hp)	1 control	125.00	180.00	305.00

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
WS2 ct'd	LABOR: Install new pump motor & motor control.					
WS3	DESCRIPTION: Separate domestic hot water heater					
	EQUIPMENT: (a) Gas domestic hot water heater complete with burner, controls & connection to stack.	per heater capacities listed	200 gal	893.33	150.24	1043.50
			300 gal	1326.67	150.24	1476.90
			400 gal	1766.67	175.28	1941.90
			500 gal	2200.00	175.28	2375.20
			750 gal	3283.33	175.28	3458.60
	(b) Oil fired domestic water heater complete with burner, controls & connection to a stack.	"	200 gal	893.33	150.24	1043.50
			300 gal	1326.67	150.24	1476.90
			400 gal	1766.67	175.28	1941.90
			500 gal	2200.00	175.28	2375.20
			750 gal	3283.33	175.28	3458.60
	LABOR: (a) Mounting. connect to existing domestic hot water supply. Gas or oil piping. control wiring. Connect to stack.					
	(b) Mounting. Connect to existing domestic hot water supply. Gas or oil piping. Control wiring. Connect to stack.					
CC2	DESCRIPTION: Ambient chiller control	per chiller	1	165.47		165.00
	EQUIPMENT: T675 outdoor air thermostat, R482 relay.					
	LABOR: Wire outdoor air stat to relay. Wire relay to chiller control panel.					
CC3	DESCRIPTION: Timed chiller control	per chiller	1	521.33		521.00
	EQUIPMENT: Paragon 7-day timer, R482 relay.					

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
CC3 ct'd	LABOR: Wire line voltage to timer. Wire timer to relay. Wire relay to chiller control panel.					
EL1	DESCRIPTION: Timed switching EQUIPMENT: Paragon 7 day timer. LABOR: Wire line voltage to timer. Wire timer to lighting relay or contactor.	per lighting circuit	1	165.15	36.00	201.10
EL2	DESCRIPTION: Photo cell switching EQUIPMENT: Selenium sulfide cell, enclosure & control circuit. LABOR: Mount photo cell. Wire control circuit to lighting contactor.	per lighting circuit	1 5 10 15	25.00	32.00	57.00
EL1 &2	DESCRIPTION: Contactor EQUIPMENT: Install contactor. Control to facilitate automatic switching. LABOR: Mount contactor. Wire to lighting circuit.	per lighting circuit for capacities listed in quantity column	20 amp 50 amp 100 amp 150 amp 200 amp	60.00 115.00 185.00 400.00 400.00	32.00 32.00 32.00 40.00 48.00	92.00 147.00 217.00 440.00 448.00
EL3	DESCRIPTION: Sodium vapor conversion	per 100w lamp & fixture	1 10 40	160.00	32.00	192.00 172.00

ECO#	Description	Units	Qty	Installed Unit Price Material	Labor	Total
EL3 ct'd	EQUIPMENT: New sodium vapor lamp & fixture for various sizes.	per 150w lamp & fixture	1	180.00	32.00	212.00
			10			182.00
			40			
	LABOR: Remove existing fixture. Replace with new sodium vapor fixture & rewire.	per 250w lamp & fixture	1	200.00	32.00	232.00
			10			220.00
			40			
		per 400w lamp & fixture	1	250.00	32.00	282.00
			10			250.00
			40			
PW1	DESCRIPTION: Checkmetering		1	210.00	90.00	300.00
	EQUIPMENT: Watt hr. checkmeter 15 kw maximum demand (Allan Bradley, Milwaukee, Wis.)					
	LABOR: Mount checkmeter near dwelling unit power distribution panel. Wire in series with D.U. wiring.					
PW3	DESCRIPTION: Power factor correction					
	EQUIPMENT: (a) Capacitors at individual equipment.	per connected load for KVAC (Corrective capacitance) Values listed in quantity column	1.5 KVAC	160.00	40.00	200.00
			3.0 KVAC	220.00	55.00	275.00
			5.0 KVAC	240.00	60.00	300.00
			7.5 KVAC	300.00	75.00	375.00
			10.0 KVAC	340.00	85.00	425.00
	(b) Capacitors at Main Service plus controlled switching of capacitance capacity.		3.0 KVAC	225.00	60.00	285.00
			5.0 KVAC	250.00	65.00	315.00
			7.5 KVAC	315.00	80.00	395.00
			10.0 KVAC	356.00	90.00	446.00
			15.0 KVAC	380.00	120.00	600.00
	LABOR: (a) Wire capacitors to individual loads (fans, chillers lighting cirucits, etc.).					
	(b) Wire capacitors at Main discount.					

E3.0 Energy Conservation Survey Instrument

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3.1 Revised Long Form

Project Number

A-1

Utility Audit - Electric
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	**Metering**	Individual metering			Present	Utility will provide	Utility won't provide			
2		Cost of ind. metering by utility (per meter)		$						
4	**Schedule**	Year		19 ——						
5	(Complete 2 consecutive yrs.)	Rate			Supply KWx10[3]	Demand (KW)	Cost ($)			
6		January								
7		February								
8		March								
9		April								
10		May								
11		June								
12		July								
13		August								
14		September								
15		October								
16		November								
17		December								
19	**Surcharges**	Utility surcharges			Demand	Excess capacity	Power factor	Fuel adj.		
20		Tenant charge for air conditioner use		$/yr.						
21		Tenant charge for washer use		$/yr.						
22		Tenant charge for electric dryer use		$/yr.						
24	**HUD &**	HUD Allowance Schedule attached			Yes	No				
25	**Utility**	Rate Schedule attached			Yes	No				
26	**Company**	Project Utility Account Number								
27	**Data**	Utility Name								
28		Utility Address								
29		Utility Phone Number								
30		Utility Account Representative								
32										
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Project Number

A-2

Utility Audit - Electric
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
42	Schedule	Year		19 ____						
43		Rate			Supply KWx10^3	Demand (KW)	Cost ($)			
44		January								
45		February								
46		March								
47		April								
48		May								
49		June								
50		July								
51		August								
52		September								
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Project Number

Utility Audit – Gas
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	Consumption	Fuel type			Natural	LP				
2		Consumption unit			Therms	CFX 1000	Lbs.			
4	Metering	Individual metering			Present	Utility will provide	Utility won't provide			
5		Cost of ind. metering by utility (per meter)		$						
7	Schedule (Complete 2 consecutive yrs.)	Year		19 ———						
8		Rate			Quantity	Cost				
9		January								
10		February								
11		March								
12		April								
13		May								
14		June								
15		July								
16		August								
17		September								
18		October								
19		November								
20		December								
22	Interruptable Services	Months on			December	January	February	March		
23					April					
24		Outdoor air temp. for interruption		°F						
26	Alternate Fuel	Type			LP	Natural	Oil	Coal		
27					Electric					
28		Estimated days used/years		ea.						
30	HUD & Utility Company	HUD Allowance Schedule Attached			Yes	No				
31		Rate Schedule Attached			Yes	No				
32		Project Utility Account Number								
33		Utility Name								
34		Utility Address								
35		Utility Phone Number								
36		Utility Account Representative								
38										
39										
40										
41										

Project Number

Utility Audit – Gas
Energy Conservation Survey

A-4

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
42	Schedule	Year		19 ———						
43		Rate			Quantity	Cost				
44		January								
45		February								
46		March								
47		April								
48		May								
49		June								
50		July								
51		August								
52		September								
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Utility Audit – Oil
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	**Consumption**	Fuel type			Kerosene	#2	#4	#5		
2			•		#6					
3		Calorific content		btu/gal.						
4		Storage capacity		gal.						
6	**Schedule**	Year		19 ——						
7	(Complete 3 consecutive yrs.)	Rate			Quantity (gallons)	Cost ($)				
8		January								
9		February								
10		March								
11		April								
12		May								
13		June								
14		July								
15		August								
16		September								
17		October								
18		November								
19		December								
21	**Additives**	Type			Corrosion	Improve efficiency				
22		Cost/year		$						
24	**Utility**	Supplier Name								
25	**Company**	Supplier Address								
26	**Data**	Supplier Phone Number								
28										
29										
30										
31										
32										
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Utility Audit – Oil
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
42	Schedule	Year		19 ———						
43		Rate			Quantity (gallons)	Cost ($)				
44		January								
45		February								
46		March								
47		April								
48		May								
49		June								
50		July								
51		August								
52		September								
53		October								
54		November								
55		December								
57	Schedule	Year		19 ———						
58		Rate			Quantity (gallons)	Cost ($)				
59		January								
60		February								
61		March								
62		April								
63		May								
64		June								
65		July								
66		August								
67		September								
68		October								
69		November								
70		December								
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Project Number

Utility Audit – Coal
Energy Conservation Survey

A-7

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	Consumption	Type			Anthracite	Bituminous	Lignite			
2		Heat content		btuh/ton						
4	Schedule	Year		19 ———						
5	(Complete 3 consecutive yrs.)	Rate			Quantity (tons)	Cost ($)				
6		January								
7		February								
8		March								
9		April								
10		May								
11		June								
12		July								
13		August								
14		September								
15		October								
16		November								
17		December								
19	Utility Company Data	Supplier Name								
20		Supplier Address								
21		Supplier Phone Number								
23										
24										
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Utility Audit – Coal
Energy Conservation Survey

A-8

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
42	Schedule	Year		19 ——						
43		Rate			Quantity (tons)	Cost ($)				
44		January								
45		February								
46		March								
47		April								
48		May								
49		June								
50		July								
51		August								
52		September								
53		October								
54		November								
55		December								
57	Schedule	Year		19 ——						
58		Rate			Quantity (tons)	Cost ($)				
59		January								
60		February								
61		March								
62		April								
63		May								
64		June								
65		July								
66		August								
67		September								
68		October								
69		November								
70		December								
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Project Number

Utility Audit - Water
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity– Dimension Variables					Photo Reference	Comment
1	Schedule	Year		19 ———						
2		Rate		Quantity Cubic Feet	Quantity gal. x 10^6	Sewage Cost ($)	Water Cost ($)	Total Cost ($)		
3		January								
4		February								
5		March								
6		April								
7		May								
8		June								
9		July								
10		August								
11		September								
12		October								
13		November								
14		December								
16	Utility Company Data	Utility Name								
17		Utility Address								
18		Utility Phone Number								
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Power Distribution
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	General	PF correction capacitors installed			Primary circuits	Secondary circuits				
2		Predominate circuit protection			Breaker	Fuse	Other			
3		Main disconnect input		kva.						
4		Secondary voltage supply		v.						
5		Secondary circuits			120 V, 2 W	120/240, 3 W	120/208, 3 W	120/208, 4 W		
6					277/480, 4 W	480, 4 W	240, 2 W			
7		# DU's/local distribution panel		ea.						
9	Retrofit Information	Clear wall space at local dist. panels		sf.						
10		Is wall space secure access			Yes	No				
12	Tenant Supplied Air – Conditioning	# Room air conditioner in Project		ea.						
13		# Months air conditioner permitted		ea.						
14		Voltage available			110v.	220v.				
15		Maximum size allowed @ 110v.		amps.						
16		Maximum size allowed @ 220v.		amps.						
17		Average estimated unit capacity			0-4000 btuh	4000-7000 btuh	7000-10000 btuh	over 10000 btuh		
18		Are units removed in winter			Yes	No				
20										
21										
22										
23										
24										
25										
26										
27										
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Project Number

Exterior Lighting
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	Fixture	Serves			Walkways	Driveways	Parking lot	Plazas/ recreation		
2	Type A				Other					
3		Fixture type			Metal halide	Mercury vapor	High pressure sodium	Low pressure sodium		
4					Incandescent					
5		Switching			Manual	Time clock	Photocell	Astronomical clock		
6		Watts per fixture		w.						
7		# of fixtures installed		ea.						
8		# of fixtures operated		ea.						
9		Lights turned on # hours before sunset		hrs.						
10		Lights turned on # hours after sunset		hrs.						
11		Lights turned off # hours before sunrise		hrs.						
12		Lights turned off # hours after sunrise		hrs.						
14	Fixture	Serves			Walkways	Driveways	Parking lot	Plazas/ recreation		
15	Type B				Other					
16		Fixture type			Metal halide	Mercury vapor	High pressure sodium	Low pressure sodium		
17					Incandescent					
18		Switching			Manual	Time clock	Photocell	Astronomical clock		
19		Watts per fixture		w.						
20		# of fixtures installed		ea.						
21		# of fixtures operated		ea.						
22		Lights turned on # hours before sunset		hrs.						
23		Lights turned on # hours after sunset		hrs.						
24		Lights turned off # hours before sunrise		hrs.						
25		Lights turned off # hours after sunrise		hrs.						
27	Fixture	Serves			Walkways	Driveways	Parking lot	Plazas/ recreation		
28	Type C				Other					
29		Fixture type			Metal halide	Mercury vapor	High pressure sodium	Low pressure sodium		
30					Incandescent					
31		Switching			Manual	Time clock	Photocell	Astonomical clock		
32		Watts per fixture		w.						
33		# of fixtures installed		ea.						
34		# of fixtures operated		ea.						
35		Lights turned on # hours before sunset		hrs.						
36		Lights turned on # hours after sunset		hrs.						
37		Lights turned off # hours before sunrise		hrs.						
38		Lights turned off # hours after sunrise		hrs.						
40										
41										

Project Number

Exterior Lighting
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	Fixture	Serves			Walkways	Driveways	Parking lot	Plazas/ recreation		
2	Type D				Other					
3		Fixture type			Metal halide	Mercury vapor	High pressure sodium	Low pressure sodium		
4					Incandescent					
5		Switching			Manual	Time clock	Photocell	Astronomical clock		
6		Watts per fixture		w.						
7		# of fixtures installed		ea.						
8		# of fixtures operated		ea.						
9		Lights turned on # hours before sunset		hrs.						
10		Lights turned on # hours after sunset		hrs.						
11		Lights turned off # hours before sunrise		hrs.						
12		Lights turned off # hours after sunrise		hrs.						
14	Fixture	Serves			Walkways	Driveways	Parking lot	Plazas/ recreation		
15	Type E				Other					
16		Fixture type			Metal halide	Mercury vapor	High pressure sodium	Low pressure sodium		
17					Incandescent					
18		Switching			Manual	Time clock	Photocell	Astronomical clock		
19		Watts per fixture		w.						
20		# of fixtures installed		ea.						
21		# of fixtures operated		ea.						
22		Lights turned on # hours before sunset		hrs.						
23		Lights turned on # hours after sunset		hrs.						
24		Lights turned off # hours before sunrise		hrs.						
25		Lights turned off # hours after sunrise		hrs.						
27	Fixture	Serves			Walkways	Driveways	Parking lot	Plazas/ recreation		
28	Type F				Other					
29		Fixture type			Metal halide	Mercury vapor	High pressure sodium	Low pressure sodium		
30					Incandescent					
31		Switching			Manual	Time clock	Photocell	Astonomical clock		
32		Watts per fixture		w.						
33		# of fixtures installed		ea.						
34		# of fixtures operated		ea.						
35		Lights turned on # hours before sunset		hrs.						
36		Lights turned on # hours after sunset		hrs.						
37		Lights turned off # hours before sunrise		hrs.						
38		Lights turned off # hours after sunrise		hrs.						
40										
41										

Project Number

Building Orientations
Energy Conservation Survey

A-13

No.	Item	Master Building Identification No.	No. Typical Buildings (incl. master)	No. of Building Front Orientations (incl. master building)				Photo Reference	Comment
1		ID#	ea.						
2				N ea.	NE ea.	E ea.	SE ea.		
3				S ea.	SW ea.	W ea.	NW ea.		
4		ID#	ea.						
5				N ea.	NE ea.	E ea.	SE ea.		
6				S ea.	SW ea.	W ea.	NW ea.		
7		ID#	ea.						
8				N ea.	NE ea.	E ea.	SE ea.		
9				S ea.	SW ea.	W ea.	NW ea.		
10		ID#	ea.						
11				N ea.	NE ea.	E ea.	SE ea.		
12				S ea.	SW ea.	W ea.	NW ea.		
13		ID#	ea.						
14				N ea.	NE ea.	E ea.	SE ea.		
15				S ea.	SW ea.	W ea.	NW ea.		
16		ID#	ea.						
17				N ea.	NE ea.	E ea.	SE ea.		
18				S ea.	SW ea.	W ea.	NW ea.		
19		ID#	ea.						
20				N ea.	NE ea.	E ea.	SE ea.		
21				S ea.	SW ea.	W ea.	NW ea.		
22		ID#	ea.						
23				N ea.	NE ea.	E ea.	SE ea.		
24				S ea.	SW ea.	W ea.	NW ea.		
25		ID#	ea.						
26				N ea.	NE ea.	E ea.	SE ea.		
27				S ea.	SW ea.	W ea.	NW ea.		
28		ID#	ea.						
29				N ea.	NE ea.	E ea.	SE ea.		
30				S ea.	SW ea.	W ea.	NW ea.		
31		ID#	ea.						
32				N ea.	NE ea.	E ea.	SE ea.		
33				S ea.	SW ea.	W ea.	NW ea.		
34		ID#	ea.						
35				N ea.	NE ea.	E ea.	SE ea.		
36				S ea.	SW ea.	W ea.	NW ea.		
37		ID#	ea.						
38				N ea.	NE ea.	E ea.	SE ea.		
39				S ea.	SW ea.	W ea.	NW ea.		
40									
41									

Project Number
Master Building Number

Building Envelope
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	General	Associated space			Total Public Areas	Total Building	Lobby	Office/ Administrative		
2					Laundry	Community Rooms	Attached Garage	Other (describe)		
3		Gross square feet area serves		sf.						
4		Floor to floor height		ft.						
5		Ceiling to floor height		ft.						
6		# of stories		ea.						
8	Exterior Wall	Exposure			Front	Left	Rear	Right		
9		Degrees from true north clockwise			°	°	°	°		
10	Front R L Rear	Total exposure area (incl. doors & windows)			sf.	sf.	sf.	sf.		
11		Color			Light	Light	Light	Light		
12					Medium	Medium	Medium	Medium		
13					Dark	Dark	Dark	Dark		
14		Mass			Low	Low	Low	Low		
15					Medium	Medium	Medium	Medium		
16					High	High	High	High		
17		Section #'s (Back of this sheet)			#	#	#	#		
18		Composite U-value			u.	u.	u.	u.		
19		Window Type A			ea.	ea.	ea.	ea.		
20		B			ea.	ea.	ea.	ea.		
21		C			ea.	ea.	ea.	ea.		
22		D			ea.	ea.	ea.	ea.		
23		E			ea.	ea.	ea.	ea.		
24		F			ea.	ea.	ea.	ea.		
25		Door Type A			ea.	ea.	ea.	ea.		
26		B			ea.	ea.	ea.	ea.		
27		C			ea.	ea.	ea.	ea.		
28		D			ea.	ea.	ea.	ea.		
29		E			ea.	ea.	ea.	ea.		
30		F			ea.	ea.	ea.	ea.		
32	Roof	Exposure			Front	Left	Rear	Right		
33		Slope			°	°	°	°		
34		Ceiling at roof				Directly exposed	Attic above	Plenum ceiling		
35		Area of ceiling (top floor)			sf.	sf.	sf.	sf.		
36		Color			Light	Light	Light	Light		
37					Medium	Medium	Medium	Medium		
38					Dark	Dark	Dark	Dark		
39		Mass			Light	Light	Light	Light		
40					Medium	Medium	Medium	Medium		
41					Heavy	Heavy	Heavy	Heavy		

Project Number

Master Building Number

Building Envelope
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	Roof	Section #'s (Back of this sheet)			#	#	#	#		
2	(cont.)	Composite U-value			u.	u.	u.	u.		
3		# of skylights			ea.	ea.	ea.	ea.		
4		Total area of skylights			sf.	sf.	sf.	sf.		
5		U-value of skylights			u.	u.	u.	u.		
7	Floor	Area of slab on grade		sf.						
8		Area of slab below grade		sf.						
9		Slab U-value		u.						
10		Area of basement walls		sf.						
11		Basement wall U-value		u.						
12		Area above cellar or crawl space		sf.						
13		Floor U-value		u.						
14		Section #		#						
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
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41										

Project Number

Windows
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	Window A	Unit size		w.						
2				h.						
3		Free area		%						
4		Window set-back from exterior wall		in.						
5		Operable crack length		in.						
6		Type			Double hung	Casement	Sliding	Single hung		
7					Jalousie	Pivot	Arch projected	Awning hopper		
8					Fixed	Other				
9		Frame material			Wood	Aluminum	Steel			
10		Glazing			Single	Insulating	Frosted tinted	Separate storm windows		
11					Integral storm windows					
12		Shading device			None	Present	Missing			
13		Type			Venetian blinds	Shades	Operable shutters	Awnings		
14					Overhung	Drapes				
15		Weatherstripping			Good condition	Poor condition	None			
16		Fit			Tight	Fair	Loose			
17		Estimated crack width greater than			1/32 in.	1/16 in.	1/8 in.	1/4 in.		
19	Window B	Unit size		w.						
20				h.						
21		Free area		%						
22		Window set-back from exterior wall		in.						
23		Operable crack length		in.						
24		Type			Double hung	Casement	Sliding	Single hung		
25					Jalousie	Pivot	Arch. projected	Awning hopper		
26					Fixed	Other				
27		Frame Material			Wood	Aluminum	Steel			
28		Glazing			Single	Insulating	Frosted tinted	Separate storm windows		
29					Integral storm windows					
30		Shading device			None	Present	Missing			
31		Type			Venetian blinds	Shades	Operable shutters	Awnings		
32					Overhung	Drapes				
33		Weatherstripping			Good condition	Poor condition	None			
34		Fit			Tight	Fair	Loose			
35		Estimated crack width greater than			1/32 in.	1/16 in.	1/8 in.	1/4 in.		
37										
38										
39										
40										
41										

Project Number

Windows
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	Window C	Unit size		w.						
2				h.						
3		Free area		%						
4		Window set-back from exterior wall		in.						
5		Operable crack length		in.						
6		Type			Double hung	Casement	Sliding	Single hung		
7					Jalousie	Pivot	Arch projected	Awning hopper		
8					Fixed	Other				
9		Frame material			Wood	Aluminum	Steel			
10		Glazing			Single	Insulating	Frosted tinted	Separate storm windows		
11					Integral storm windows					
12		Shading device			None	Present	Missing			
13		Type			Venetian blinds	Shades	Operable shutters	Awnings		
14					Overhung	Drapes				
15		Weatherstripping			Good condition	Poor condition	None			
16		Fit			Tight	Fair	Loose			
17		Estimated crack width greater than			1/32 in.	1/16 in.	1/8 in.	1/4 in.		
19	Window D	Unit size		w.						
20				h.						
21		Free area		%						
22		Window set-back from exterior wall		in.						
23		Operable crack length		in.						
24		Type			Double hung	Casement	Sliding	Single hung		
25					Jalousie	Pivot	Arch. projected	Awning hopper		
26					Fixed	Other				
27		Frame Material			Wood	Aluminum	Steel			
28		Glazing			Single	Insulating	Frosted tinted	Separate storm windows		
29					Integral storm windows					
30		Shading device			None	Present	Missing			
31		Type			Venetian blinds	Shades	Operable shutters	Awnings		
32					Overhung	Drapes				
33		Weatherstripping			Good condition	Poor condition	None			
34		Fit			Tight	Fair	Loose			
35		Estimated crack width greater than			1/32 in.	1/16 in.	1/8 in.	1/4 in.		
37										
38										
39										
40										
41										

Project Number

Windows
Energy Conservation Survey

A-10

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	Window E	Unit size		w.						
2				h.						
3		Free area		%						
4		Window set-back from exterior wall		in.						
5		Operable crack length		in.						
6		Type			Double hung	Casement	Sliding	Single hung		
7					Jalousie	Pivot	Arch projected	Awning hopper		
8					Fixed	Other				
9		Frame material			Wood	Aluminum	Steel			
10		Glazing			Single	Insulating	Frosted tinted	Separate storm windows		
11					Integral storm windows					
12		Shading device			None	Present	Missing			
13		Type			Venetian blinds	Shades	Operable shutters	Awnings		
14					Overhung	Drapes				
15		Weatherstripping			Good condition	Poor condition	None			
16		Fit			Tight	Fair	Loose			
17		Estimated crack width greater than			1/32 in.	1/16 in.	1/8 in.	1/4 in.		
19	Window F	Unit size		w.						
20				h.						
21		Free area		%						
22		Window set-back from exterior wall		in.						
23		Operable crack length		in.						
24		Type			Double hung	Casement	Sliding	Single hung		
25					Jalousie	Pivot	Arch. projected	Awning hopper		
26					Fixed	Other				
27		Frame Material			Wood	Aluminum	Steel			
28		Glazing			Single	Insulating	Frosted tinted	Separate storm windows		
29					Integral storm windows					
30		Shading device			None	Present	Missing			
31		Type			Venetian blinds	Shades	Operable shutters	Awnings		
32					Overhung	Drapes				
33		Weatherstripping			Good condition	Poor condition	None			
34		Fit			Tight	Fair	Loose			
35		Estimated crack width greater than			1/32 in.	1/16 in.	1/8 in.	1/4 in.		
37										
38										
39										
40										
41										

Project Number

Exterior Doors
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	Door A	% of total building entry/egress		%						
2		Unit size		w.						
3				h.						
4		U-value		u.						
5		Type			Wood	Metal	Glass	Storm door		
6					Single	Double	Revolving			
7		Vestibule			None	Unheated	Heated			
8		Weatherstripping			None	Good condition	Poor condition			
9		Fit			Snug	Fair	Loose			
10		Estimated crack width greater than			1/32 in.	1/16 in.	1/8 in.	1/4 in.		
12	Door B	% of total building entry/egress		%						
13		Unit size		w.						
14				h.						
15		U-value		u.						
16		Type			Wood	Metal	Glass	Storm door		
17					Single	Double	Revolving			
18		Vestibule			None	Unheated	Heated			
19		Weatherstripping			None	Good condition	Poor condition			
20		Fit			Snug	Fair	Loose			
21		Estimated crack width greater than			1/32 in.	1/16 in.	1/8 in.	1/4 in.		
23	Door C	% of total building entry/egress		%						
24		Unit size		w.						
25				h.						
26		U-value		u.						
27		Type			Wood	Metal	Glass	Storm door		
28					Single	Double	Revolving			
29		Vestibule			None	Unheated	Heated			
30		Weatherstripping			None	Good condition	Poor condition			
31		Fit			Snug	Fair	Loose			
32		Estimated crack width greater than			1/32 in.	1/16 in.	1/8 in.	1/4 in.		
34										
35										
36										
37										
38										
39										
40										
41										

Project Number

Exterior Doors
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	Door D	% of total building entry/egress		%						
2		Unit size		w.						
3				h.						
4		U-value		u.						
5		Type			Wood	Metal	Glass	Storm door		
6					Single	Double	Revolving			
7		Vestibule			None	Unheated	Heated			
8		Weatherstripping			None	Good condition	Poor condition			
9		Fit			Snug	Fair	Loose			
10		Estimated crack width greater than			1/32 in.	1/16 in.	1/8 in.	1/4 in.		
12	Door E	% of total building entry/egress		%						
13		Unit size		w.						
14				h.						
15		U-value		u.						
16		Type			Wood	Metal	Glass	Storm door		
17					Single	Double	Revolving			
18		Vestibule			None	Unheated	Heated			
19		Weatherstripping			None	Good condition	Poor condition			
20		Fit			Snug	Fair	Loose			
21		Estimated crack width greater than			1/32 in.	1/16 in.	1/8 in.	1/4 in.		
23	Door F	% of total building entry/egress		%						
24		Unit size		w.						
25				h.						
26		U-value		u.						
27		Type			Wood	Metal	Glass	Storm door		
28					Single	Double	Revolving			
29		Vestibule			None	Unheated	Heated			
30		Weatherstripping			None	Good condition	Poor condition			
31		Fit			Snug	Fair	Loose			
32		Estimated crack width greater than			1/32 in.	1/16 in.	1/8 in.	1/4 in.		
34										
35										
36										
37										
38										
39										
40										
41										

Project Number
Master Building Number

Space Heating & Lighting
Dwelling Units
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	General	Central heating type			Hot water/ radiation	Steam radiation	Central air handling	Fan coil unit		
2		Space heating type			Electric radiation	Space heater	Forced air furnace	Other		
3					Electric & space heater	Space heater & furnace				
4		Kitchen exhaust fan			None	Exhausts to space	Exhausts to outdoors			
5		Bathroom exhaust fan			None	Exhausts to space	Exhausts to outdoors			
6		Additional heating sources			Non-cooking stove use	Tenant space heaters				
8	Control	Thermostat type			2 Position	Modulating	Setback			
9					Heating-cooling	Manual valve	None			
10		Thermostat power			Pneumatic	Electric	Self-contained			
11		Thermostat controls			Valve	Burner	Fan			
12		Comfort			Overheated	Underheated	Windows open for control	Normal		
13		Temperature maintained in winter		°F						
15	Space Heater Furnace	Pilot type			Gas	Electric				
16		Fuel type			Gas	Oil	Electric			
17		Capacity Schedule			#Units/D.U.	Total Input Btuh/D.U.	Total Input KW/D.U.	Total Output Btuh/D.U.		
18		0 Bedroom								
19		1 Bedroom								
20		2 Bedrooms								
21		3 Bedrooms								
22		4 Bedrooms								
23		5 Bedrooms								
25	Space Lighting	Lighting Schedule			Total Watts Incandescent	# Ceiling Incandes. Fxts	Total Watts Flourescent			
26		0 Bedroom			w.	ea.	w.			
27		1 Bedroom			w.	ea.	w.			
28		2 Bedrooms			w.	ea.	w.			
29		3 Bedrooms			w.	ea.	w.			
30		4 Bedrooms			w.	ea.	w.			
31		5 Bedrooms			w.	ea.	w.			
33	HVAC System Insulation	Uninsulated heating Pipe Schedule			Length Unins. Riser Pipe	Average Riser Dia.	Length Unins. Runout Pipe	Average Runout Dia.		
34		0 Bedroom			ft.	in.	ft.	in.		
35		1 Bedroom			ft.	in.	ft.	in.		
36		2 Bedrooms			ft.	in.	ft.	in.		
37		3 Bedrooms			ft.	in.	ft.	in.		
38		4 Bedrooms			ft.	in.	ft.	in.		
39		5 Bedrooms			ft.	in.	ft.	in.		
41										

Project Number
Master Building Number

Domestic Hot Water – Space
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	General	Space type serves			Dwelling Unit(s)	Laundry	Community Kitchen	Restrooms		
2					Other					
3		Heater location			Tenant has access	No Tenant access				
4		Tank type			Glass	Steel	Tankless			
5		Energy source			Oil	Gas	Electric			
6		Pilot			Gas	Electric				
7		Energy input		btuh.						
8				kw.						
10	Schedule	Tank Capacity Schedule			Tank Capacity	#D.U.'s per Hotwater Heatr				
11		0 Bedroom			gal.	ea.				
12		1 Bedroom			gal.	ea.				
13		2 Bedrooms			gal.	ea.				
14		3 Bedrooms			gal.	ea.				
15		4 Bedrooms			gal.	ea.				
16		5 Bedrooms			gal.	ea.				
17		Average Hot Water temperature		°F						
18		Life expectancy of heaters		yrs.						
19		App. % of Hot Water heaters replaced		%						
20		Average age of hot water heaters		yrs.						
22	Fixtures	Toilet type			Water closet	Flush valve				
23		Adaptability to flow restrictors			Kitchen faucet	Bath sink faucet	Shower			
24		Water condition			Hard	Medium	Soft			
25		Average age kitchen plumbing fixtures		yrs.						
26		Average age bath plumbing fixtures		yrs.						
28										
29										
30										
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Project Number
Master Building Number

A-23

Space Heating & Cooling - Public Areas
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	General	Space type serves			Total public areas	Community rooms	Office/ Administrative	Attached Garage		
2					Laundry	Lobby	Other			
3		Heating			Hot water radiation	Steam radiation	Central air handling	Fan coil unit		
4					Electric radiation	Space heater	Forced air heater	Other		
5		Cooling			Through wall	Window unit	Central air handler	Fan coil unit		
6		Typical occupancy (average # of people)		ea.						
7		Weekday time (24 hrs.) of occupancy From		hrs.						
8		To		hrs.						
9		Weekend time (24 hrs.) of occupancy From		hrs.						
10		To		hrs.						
12	Control	Thermostat type			2 Position	Modulating	Setback	Heating/ cooling		
13		Thermostat power			Pneumatic	Electric	Self-contained			
14		Thermostat controls			Valve	Burner	Fan			
15		Winter comfort			Overheated	Underheated	Windows open for control	Normal		
16		Temperature maintained in winter		°F						
17		Temperature maintained in summer		°F						
19	Space Heating Units	Number of units		ea.						
20		Pilot type			Gas	Electric				
21		Fuel type			Gas	Oil	Electric			
22		Total input capacity		btuh.						
23				kw.						
24		Accessory electrical unit		w.						
26	Space Cooling Units	Number of units		ea.						
27		Total units capacity		tons						
28		Average unit age		yrs.						
30	Pipe Insulation	App. #Ft. uninsulated heating riser piping		ft.						
31		Average riser pipe diameter		in.						
32		App. #Ft. uninsulated heating runout piping		ft.						
33		Average runout pipe diameter		in.						
35	Duct Insulation	Est.sf. of exposed sup. duct in mech space		sf.						
36		Duct supplies			Heating only	Cooling only	Heating & cooling			
38										
39										
40										
41										

Project Number
Master Building Number

A-24

Space Lighting – Public Areas
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	General	Space type serves			Total public areas	Community rooms	Office/ Administrative	Attached Garage		
2					Laundry	Lobby	Other			
3		Average floor and wall color			Light	Medium	Dark			
5	Incandescent	Switching			Local	Central	Automatic			
6		Total # of fixtures		ea.						
7		Total watts installed		w.						
8		% of lights used		%						
9		# of circuits		ea.						
10		Typical operating schedule Hours/Day		hrs/day						
11		Typical operating schedule Hrs/Weekend		wk. hrs/end						
12		Off at		hrs.						
13		% On during "off" hrs.		%						
15	Fluorescent	Switching			Local	Central	Automatic			
16		Total # fixtures-1 tube		ea.						
17		-2 tubes		ea.						
18		-3 tubes		ea.						
19		-4 tubes		ea.						
20		Total watts installed		w.						
21		% of lights used		%						
22		# of circuits		ea.						
23		Typical operating schedule Hours/Day		hrs/day						
24		Typical operating schedule Hrs/Weekend		wk. hrs/end						
25		% On during "off" hrs.		%						
27										
28										
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Appliances - Public Areas
Energy Conservation Survey

A-25

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	Community Kitchen	Total food cooking equipment		ea.						
2		Elec. Input		kw.						
3		Gas Input (btuh x 1000)		btuh.						
4		Total portable cooking equipment		ea.						
5		Elec. Input		kw.						
6		Gas Input (btuh x 1000)		btuh.						
7		# of hot meals cooked per week		ea.						
8		Exhaust system			None	Local	Central			
9		Local exhaust control			Switch	Time clock				
10		Local exhaust fan cfm/hp.		cfm.						
11				hp.						
13	Community Laundry	Average weekly use		hrs/wk.						
14		Dryer type			Gas	Electric				
15		# of dryers		ea.						
16		Individual dryer input		btuh.						
17				w.						
18		# of washers		ea.						
19		Washer type			Commercial	Residential				
20		Exhaust system			None	Local	Central			
21		Local exhaust control			Switch	Time clock				
22		Local exhaust cfm./hp.		cfm.						
23				hp.						
25										
26										
27										
28										
29										
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Project Number

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Central Radiation Convector
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	General	Space serves			Dwelling Unit	Total public building	Total building			
2		System type			Hot water	1 Pipe steam	2 Pipe steam	Electric		
3		Predominate radiation type			Convertor	Radiator	Baseboard	Fan coil		
5	Space Control	Room control			Pneumatic	Electric	Manual rad. Valve			
6		Room shut-off valve			Concealed	Exposed				
7		Avg. space heating pipe size at radiation		in.						
9	Zone Control	Type			Constant temperature	Temperature reset	Solar compensation			
10		Control power			Pneumatic	Electric				
11		Control sensing point			In space	Outdoor air	Hot water supply			
12		Controlled device			Convertor valve	H.W. mixing valve	Steam dist. valve			
13		# of zones of control		ea.						
14		Total convertors		ea.						
15		Total active convertors		ea.						
16		Total pumps		ea.						
17		Total active pumps		ea.						
18		Total pump hp.		hp.						
19		Total active pump hp.		hp.						
20		Hot water pump start/stop control			Manual	Ambient control				
22	Installed Radiation Schedule	Dwelling Units			Typical # of units/DU	Average total capacity/DU	Average total capacity/DU	Avg. fan coil elec./DU		
23		0 Bedroom			ea.	btuh.	EDR	hp		
24		1 Bedroom			ea.	btuh.	EDR	hp		
25		2 Bedrooms			ea.	btuh.	EDR	hp		
26		3 Bedrooms			ea.	btuh.	EDR	hp		
27		4 Bedrooms			ea.	btuh.	EDR	hp		
28		5 Bedrooms			ea.	btuh.	EDR	hp		
29		Building totals				Total capacity	Total capacity	Total fan coil elec./DU		
30		Dwelling Units			ea.	btuh x 1000	EDR	hp		
31		Public areas			ea.	btuh x 1000	EDR	hp		
32		Total building			ea.	btuh x 1000	EDR	hp		
34										
35										
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A-27

Central Air Handling
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	General	Unit serves			Dwelling unit(s)	Administrative	Lobby	Corridor		
2					Stairs	Basement/ Mechanical	Restroom(s)	Laundry		
3					Community room(s)	Other				
4		System type			Built-up	Packaged	Packaged with DX cooling	Packaged with gas heating		
5					Packaged with oil heating	Return air fan	Roof top			
6		Identification #			S1	S2	S3	S4		
7					S5	S6	S7	S8		
8					S9					
9		System age		yrs.						
10		Air handling unit manufacturer								
11		Model #		#						
13	Configuration	Configuration			1 outdoor air damper	Max. & min. outd. air damp	Mixed air control	Steam preheat		
14					HW preheat	Preht. w/face & bypass cont.	Low temp. protection	Filter section		
15					Electric preheat	DX cooling coil	Chilled water cooling coil	Steam heating coil		
16					HW heating coil	Blow-through	Draw-through	Electric heating		
18	Air Supply Return Capabilities	Fan ratings			Supply Fan	Return Fan				
19		Motor horsepower			hp	hp				
20		Maximum air quantity			cfm	cfm				
21		Total static pressure			H_2O	H_2O				
22		Maximum outdoor air			cfm	N/A				
23		Minimum outdoor air			cfm	N/A				
25	Control	Zone control			Steam terminal reht.	Hot water terminal reht.	Multizone	Mixing boxes (double duct)		
26					Electric terminal reht.	Variable air volume	VAV with electric reht.			
27		# of controlled zones		ea.						
28		Temperature control type			Pneumatic	Electric	Electronic			
29		Temperature control systems present			Mixed air control	Economizer	Enthalpy economizer	Zone reset		
30					Ambient heating reset	Discharge control	Warm-up cycle			
31		Temperature control age		yrs.						
32		Preheating coil control			Valve	Valve bypass dmpr.	Modulating electric	2 Position electric		
33		Heating coil control			Throttling valve	Bypass valve	Modulating electric	2 Position electric		
34		Cooling coil control			Throttling valve	Bypass valve	Expansion valve (DX)			
35		Cooling control sensing point			Return air	Discharge air	Space air			
36		Heating control sensing point			Return air	Discharge air	Space air			
37		Heating design discharge temperature		°F						
38		Cooling design discharge temperature		°F						
39		Mixed air design temperature		°F						
40		Simultaneous heating and cooling			Yes	No				
41		Reheat operation			Winter only	Summer only	Winter & summer			

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Central Air Handling
Energy Conservation Survey

A-28

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	Control (cont.)	Outdoor air damper condition			Seals tight	Fair seal	Poor seal			
2		Condition of frame			No leaks	Fair fit	Poor fit			
3		Estimated % outdoor air w/damper closed		%						
5	Heating & Cooling Capacities Schedule	Heating type			Heat pump	Self-contained gas/oil	Central steam	Central hot water		
6		Cooling type			Heat pump	Self-contained	Central CHW	Central DX		
7		Capacity Schedule			Heating Capacity	Cooling Capacity	Input Capacity			
8		Oil heater			btuh	N/A	gph			
9		Gas heater			btuh	N/A	cfm			
10		Heat pump			btuh	btuh	kw			
11		DX coil			N/A	btuh	N/A			
12		CHW coil			N/A	btuh	gpm			
13		Elec. preheat coil			N/A	N/A	kw			
14		Elec. heating coil			N/A	N/A	kw			
15		Total elec. reheat coils			N/A	N/A	kw			
16		Steam reheat coil			btuh	N/A	#/hr			
17		Steam heating coil			btuh	N/A	#/hr			
18		Total steam reheat coils			btuh	N/A	#/hr			
19		Hot water preheat coil			btuh	N/A	gpm			
20		Hot water heating coil			btuh	N/A	gpm			
21		Total hot water reheat coils			btuh	N/A	gpm			
22		Hot water heating coil sec. pump horsepower		hp.						
23		Control type			Manual	Ambient control	Interlock to AHU			
24		Chilled water coil sec. pump horsepower		hp.						
25		Control type			Manual	Interlock to chiller	Interlock to AHU			
26		Hot water reheat pump horsepower		hp.						
27		Control type			Manual	Ambient	Interlock to AHU			
29	Operation	Start/stop control			Time clock	Manual	Switched			
30		Interlock to assoc. return fan			Yes	No				
31		Dampers close when fans are off			Yes	No				
32		Manual schedule			Summer weekdays	Summer weekends	Winter weekdays	Winter weekends		
33		-on at		hrs.						
34		-off at		hrs.						
35		Timer setting -on at		hrs.						
36		-off at		hrs.						
37		Outdoor air -on at		hrs.						
38		-off at		hrs.						
40										
41										

Project Number
Master Building Number

Central Exhaust Fan Schedule
Energy Conservation Survey

A-29

No.	Item	Exhaust Fan ID Number	Horsepower	CFM	Weekly Operating Hours*	Interlock or Time Clock Operation*	Areas Served**	*	Photo Reference	Comment
1	(*Check if pertains,	ID#			hrs.	Yes				
2	do not check if									
3	manual operation).	ID#			hrs.	Yes				
4										
5	**Area Code:	ID#			hrs.	Yes				
6	1-D.U.Kitchen 2-D.U.Bath									
7	3-Stairs/ Corridors	ID#			hrs.	Yes				
8	4-Laundry 5-Public									
9	Restroom	ID#			hrs.	Yes				
10										
11		ID#			hrs.	Yes				
12										
13		ID#			hrs.	Yes				
14										
15		ID#			hrs.	Yes				
16										
17		ID#			hrs.	Yes				
18										
19		ID#			hrs.	Yes				
20										
21		ID#			hrs.	Yes				
22										
23		ID#			hrs.	Yes				
24										
25		ID#			hrs.	Yes				
26										
27		ID#			hrs.	Yes				
28										
29		ID#			hrs.	Yes				
30										
31		ID#			hrs.	Yes				
32										
33		ID#			hrs.	Yes				
34										
35		ID#			hrs.	Yes				
36										
37		ID#			hrs.	Yes				
38										
39		ID#			hrs.	Yes				
40										
41		ID#			hrs.	Yes				

Project Number
Master Building Number

Central Exhaust
Energy Conservation Survey

No.	Item-	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	General	Space serves			Lobby	Corrdior	Stairs	Mechanical/ Basement		
2					Restrooms	Laundry	Community rooms	Dwelling unit toilets		
3					Dwelling unit kitchen	Other				
4		Exhaust capacity		cfm.						
5		Total static pressure		H_2O						
6		Fan power		hp.						
7		ID#		#						
8		Manufacturer								
9		Model Number		#						
11	Operation	Control type			Manual	Interlocks to airhandler	Independent time clock			
12		Operates with air handling unit			S1	S2	S3	S4		
13					S5	S6	S7	S8		
14					S9					
15		Electrical interlock to air handling unit			S1	S2	S3	S4		
16					S5	S6	S7	S8		
17					S9					
19	Retrofit Information	Location rel. to assoc. air handling unit			Same equip. room	Same floor	Different floor			
20		Make-up if no assoc. air handling unit			Space air	Outdoor air	Transfer grille			
21		Possible supply unit interlock			S1	S2	S3	S4		
22					S5	S6	S7	S8		
23					S9					
24		Distance betw. poss. heat recovery coils		ft.						
26										
27										
28										
29										
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Project Number |_|_|_|_|_|_|_|_|

Master Building Number ________

Domestic Water – Central
Energy Conservation Survey

A-31

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	General	Heater serves			Total building	Dwelling unit	Laundry	Community kitchen		
2					Restrooms	Other				
4	Hot Water Generation	Independent			Gas burner	Oil burner	Electric			
5		Boiler			Boiler HW and convertor	Boiler steam and convertor				
6		Independent heater input		btuh.						
7				kw.						
8		Independent heater output		btuh.						
9				kw.						
10		Tank capacity		gal.						
12	Hot Water Control	Type			Pneumatic	Electric	Self-contained			
13		Set		°F						
14		Temperature maintained at tank		°F						
15		Temperature at fixs. furthest from tank		°F						
16		Make-up water temp. summer		°F						
17		winter		°F						
19	Water Supply	Domestic water supply pressure source			Street pressure	Booster pumps	Hydro-pneumatic	Roof tank		
20		Variable speed pumping			Yes	No				
21		# Water supply pumps		ea.						
22		Pumps total hp.		hp.						
23		Pumps total gpm		gpm.						
24		Feet of head		ft.						
25		Hot water recirculation			Yes	No				
26		Recirculation pipe insulated			Yes	No				
28	Plumbing Fixtures	Toilet type			Water closet	Flush valve				
29		Adaptability to flow restrictors			Kitchen faucet	Bath sink faucet	Showers			
30		Water condition			Hard	Medium	Soft			
31		Average age fixtures		yrs.						
33										
34										
35										
36										
37										
38										
39										
40										
41										

Project Number
Master Building Number

Central Heating
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	General (Boiler)	Type			Sectional	Water tube	Fire tube	Forced draft		
2					Natural draft	Induced draft				
3		# of fire tube passes			1	2	3	4		
4		Heating medium			Steam	Hot water				
5		# Typical boilers		ea.						
6		Steam operating pressure		psig.						
7		Hot water operating temperature		°F						
8		Existing energy source			Natural gas	Propane	Coal	Electricity		
9					#2 Oil	#4 Oil	#6 Oil			
10		If converted, original energy source			Natural gas	Propane	Coal			
11					#2 Oil	#4 Oil	#6 Oil			
12		Heating surface		sf.						
13		Capacity-input btuh X 1000		btuh.						
14		-input		hp.						
15		Gross-output btuh X 1000		btuh.						
16		-output		hp.						
17		Age		yrs.						
18		Manufacturer								
19		Model Number		#						
21	Burner	Oil atomization			Compressed air	Steam	Pressure nozzle	Rotary cup		
22		Control			High/low fire	Modulating	On/Off			
23		Burner fuel input capacity (units)			Btuh	CF/hr	Gal/hr.	Tons/hr.		
24		Maximum								
25		Minimum								
26		Total burner electric input power		kw.						
27				hp.						
28		Age		yrs.						
29		Manufacturer								
30		Model Number		#						
32	Accessories	Type			Oil pumps sep. from burner	Boiler feed	De-aerator	Other		
33		Total input power		kw.						
34				hp.						
36	Maintenance	Flue gas sampling port			Yes	No				
37		Excess CO_2/O_2 test frequency (times/yr.)		ea.						
38		Burner fuel/air adjusted seasonally			Fall	Winter	Spring			
39		Burner adjustment frequency (times/yr.)		ea.						
40		Fire side cleaning frequency (times/yr.)		ea.						
41										

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Project Number
Master Building Number

Central Heating
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	Maintenance	Water treatment type			Automatic blowdown	Manual blowdown	Automatic chemical feed	Manual chemical feed		
2		Water treatment contract			Yes	No				
3		Water testing frequency (times/yr.)		ea.						
4		% of plugged tubes		%						
5		% of leaking tubes		%						
6		Treatment contractor name, phone								
7		address								
9	Operation	Lead boiler start/stop			Manual	Ambient (auto) conditions	Remote	Other		
10		Lag boiler start/stop			Manual	Ambient (auto) conditions	Remote	Other		
11		Total number of boilers in operation		ea.						
12		# of months of operation		ea						
13		Average # of operating personnel req'd (24hrs)		ea.						
15	Retrofit Information	Automatic breeching damper			Can be installed	Cannot be installed				
16		Breeching shape @ poss. damper location			Round	Rectangular				
17		Approximate size at poss. damper location		sf.						
18		Draft control type			Barometric control	Sequence draft control	(describe) Other			
19		Available space for addt'l equip.-length		ft.						
20		-width		ft.						
21		-height		ft.						
23	Heating Distribution System	If central plant, # of buildings served		ea.						
24		Period since last strainer cleaning		yrs.						
25		Total heating distribution pumping		hp.						
26		Estimated % faulty traps		%						
27		Condensate return system type			Vacuum return	Pressure return				
28		Steam vents from condensate receivers			Yes	No				
29		If cen. plant, control @ individ.bldg. supply			None	Modulating by load	On/Off			
30		Underground distribution piping			Yes	No				
31		Type			Trench	Tunnel	Conduit	Direct Burial		
32		Insulated			Yes	No				
33		Insulation thickness		in.						
34		Age of underground distribution system		yrs.						
36	Pipe Insulation in Mechanical Rooms	Approx. length of exposed steam piping								
37		1-3in. Dia.		ft.						
38		3-5in. Dia.		ft.						
39		5-7in. Dia.		ft.						
40		7-10in.Dia.		ft.						
41		over 10in. Dia.		ft.						

Project Number

Master Building Number

Central Cooling
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity–Dimension	Variables				Photo Reference	Comment
1	General	Type			Package	Built-up	DX	Chilled water		
2					Reciprocating	Centrifugal	Tower water cooled	City water cooled		
3					Air cooled	Gas absorption	Steam absorption	Other		
4		Unit serves air handling systems			S1	S2	S3	S4		
5					S5	S6	S7	S8		
6					S9	Fan coil units				
7		Capacity		tons						
8		Chilled water pump input power		hp.						
9		Condensor water pump input power		hp.						
10		Tower input power		hp.						
11		Air cooled condensor input power		hp.						
12				kw.						
13		Manufacturer								
14		Model Number								
16	Operation	Chiller cycled by			Chilled water supply temp.	Chilled water return temp.	Space temperature	Return air temperature		
17		Chiller turned on/off			Ambient temp.	Time clock	Manual			
18		Capacity control			On/Off	In steps	Modulating	Hot gas by pass		
19		Chilled water supply temp.		^{o}F						
20		Condenser water supply temp.		^{o}F						
21		Months of operation Start month			February	March	April	May		
22					June					
23		Stop month			July	August	September	October		
24					November					
25		Weekday start time		hrs.						
26		stop time		hrs.						
27		Weekend start time		hrs.						
28		stop time		hrs.						
29		Outdoor air start temp.		^{o}F						
31	Chilled Water Pipe Insulation	Approx. length of exposed piping								
32		1/2-1in.		ft.						
33		1-2in.		ft.						
34		2-3in.		ft.						
35		over 3in.		ft.						
37										
38										
39										
40										
41										

Project Number
Master Building Number

Elevators and Misc. Systems
Energy Conservation Survey

No.	Item	Characteristics	None	Quantity-Dimension	Variables				Photo Reference	Comment
1	Elevators	Type			Hydraulic	AC	AC/DC			
2		Operation			M-G turns off at night	M-G runs at night				
3		# of Units		ea.						
4		Drive Motor (ea.)		hp.						
5		Motor generator (ea.)		hp.						
6				kw.						
7		Time elevators can be turned off- from (24hr)		hrs.						
8		- to		hrs.						
9		# of elevators which can be turned off		ea.						
11	Miscellaneous Electric	# of sewage ejectors		ea.						
12		Total input		hp.						
13		# of sump pump(s)		ea.						
14		Total input		hp.						
15		# of temp. control air compressor(s)		ea.						
16		Total input		hp						
17		# of central compactors		ea.						
18		Total input		hp.						
19		Approximate hrs/wk operation		hrs/wk.						
20		Other systems -describe								
21		Total input power		hp.						
22				kw.						
24	Incinerator	Fuel			Gas	Oil				
25		Burner input ($btuhx10^3$)		btuh.						
26		Burner electrical input		hp.						
27				kw.						
28		Primary constituent			Paper	Garbage	Other			
29		Average lbs.burned/hr.		lbs./hr.						
30		Operation hours weekdays - from (24hr)		hrs.						
31		- to		hrs.						
33										
34										
35										
36										
37										
38										
39										
40										
41										

3.2 Revised Short Form

HUD PROJECT
ENERGY SHORT FORM
REQUIRED INFORMATION

Directions For Each of the Following Items

1) Circle appropriate option in parentheses.

2) Provide data requested in blank space.

Project Number ______________________________

Project location ______________________________

Total Number Of Dwelling Units __________________

Name of Project Director ______________________

Project Office Telephone Number _________________

HUD Project Energy Short Form Required Information

Physical Characteristics

Number Of Floors In Building ____________________

Primary Heating Fuel (gas, oil, electric, coal)

Type Of Heating System (space, central)

Envelope Data

Wall Color (light, medium, dark)

Roof Color (light, medium, dark)

Window Frame Material (wood, steel, aluminum)

Window Glazing (single, insulated, tinted, storm windows)

Shading Devices (none, venetian blinds, shades, shutters, awnings, roof overhang, drapes)

Window Weather Stripping (good, poor, none)

Window Fit (snug, fair, loose)

Door Weather Stripping (good, poor, none)

Door Fit (snug, fair, loose)

Has roof insulation been added to project? (yes, no)

Has building been caulked recently? (yes, no)

Space Heating And Cooling: Dwelling Units (D.U.)

D.U. Heating Type (central, individual)

D.U. Heating System (high-pressure steam, low-pressure steam, hot water, forced warm air furnace, space heater)

D.U. Cooling Type (central, individual)

D.U. Cooling System (fan coil unit, wall air conditioner, window air conditioner)

Number Of Air Conditioner In Project ____________________

Available Voltage (100V, 220V)

Average Cooling Unit Capacity ____________________BTUH

Heating Thermostat Type (2 position, modulating, setback, heating/cooling, manual valve, none)

Space Heating And Cooling: Dwelling Units

Thermostat Power (pneumatic, electric, self-contained)

Thermostat Controls (valve, burner, fan)

Comfort Level (overheated, underheated, normal)

Fuel For Space Heaters (gas, electric)

Average Heating Unit Input Capacity _______________BTUH

Average Heating Unit Input Capacity _______________KW

Average Heating Unit Output ________________BTUH

Temperature Maintained In The Winter And The Summer _____________^{o}F

Space Heating And Cooling: Public Areas (P.A.)

P.A. Heating Type (central, individual)

P.A. Heating System (high-pressure steam, low-pressure steam, hot water, forced warm air furnace, space heater)

P.A. Cooling Type (central, individual)

P.A. Cooling System (fan coil unit, wall air conditioner, window air conditioner)

Heating Thermostat Type (2 position, modulating, setback, heating/cooling, manual valve, none)

Thermostat Power (pneumatic, electric, self-contained)

Thermostat Controls (valve, burner, fan)

Comfort Level (overheated, underheated, normal)

Fuel For Space Heaters (gas, electric)

Average Heating Unit Input Capacity ________________BTUH

Average Heating Unit Input Capacity________________KW

Average Heating Unit Output ____________________BTUH

Temperature Maintained In The Winter And The Summer ______________ ^{o}F

Laundry And Kitchen Equipment: Dwelling Units And Public Areas

Is there a public laundry? (yes, no)

If yes: Number Of Washers ______________

Number Of Dryers ______________

Dryer Type (gas, electric)

If no: Percentage Of D.U.'s With Washers ____________%

Percentage Of D.U.'s With Dryers ____________%

Dryer Type (gas, electric)

Type Of Stove In Typical D.U. (gas, electric)

Electric Utility Data

Utility Name ______________________________________

Utility Address ___________________________________

Utility Telephone Number ___________________________

Are tenants charged for window air conditioner use? (yes, no)

If yes, how much? $_____________(month) or $_____________(year)

Total Project Electrical Usage Per Year ______________________KW

Total Project Electrical Cost Per Year $______________________

Electrical Metering

Meter Type (individual pays, tenant pays, central, central with check meters,

other ____________________)

Are exterior lights on a flat rate? (yes, no)

Project Electrical Data

Power Factor Correction ____________________

Approximate Number Site Lighting Fixtures ______________

Average Fixture Watts ________________

Predominant Exterior Fixture Type (incandescent, mercury vapor, sodium vapor)

Exterior Lighting Control (manual, time clock, photocell)

Predominant Interior Public Area Fixture Type (incandescent, fluorescent)

Gas Utility Data

Utility Name ________________________________

Utility Address ______________________________

Utility Telephone Number ________________________

Gas Type (liquid propane, natural)

Total Project Gas Usage Per Year _______________CF

Total Project Gas Cost Per Year $_______________

Oil Utility Data

Utility Name ________________________________

Utility Address ______________________________

Utility Telephone Number ________________________

Oil Type (light, heavy)

Total Project Oil Usage Per Year _______________GAL

Water Utility Data

Utility Name ______________________________

Utility Address ____________________________

Utility Telephone Number ____________________

Water Unit Type (cubic feet, gallons)

Total Project Water Usage Per Year ___________

Total Project Water Cost Per Year $___________

Domestic Hot Water and Plumbing

Water Condition (hard, medium, soft)

Hot Water Heating System Type (central, individual)

For Individual Heating System:

Average Tank Capacity __________GALS

Tank Type (glass, steel, tankless)

Fuel Type (oil, gas, electric)

Energy Input Of Water Heaters (BTUH, KW)

Hot Water Temperature ____________ ^{o}F

E4.0 Energy Conservation Project Data

4.1 Individual Projects

Table 4.1.1

Project Listing and Data/Energy Profile for 1LSG Projects

Project #	1	2	3	4	5
Discrete Level	1LSG	1LSG	1LSG	1LSG	1LSG
Building Type	Low Rise	Low Rise	Low Rise	Low Rise	Low Rise
Mechanical System	Space	Space	Space	Space	Space
Fuel Type	Gas	Gas	Gas	Gas	Gas
State	Ca.	Fl.	Fl.	Ga.	La.
Number of DU's	449	130	125	61	140
Number of Buildings	23	61	55	38	70
DU's/Building	19.5	2.13	2.3	1.6	2
Total Area of Project (sf)	246,000	124,000	121,000	63,500	117,000
Area/DU (sf)	548	954	966	1,250	835
Public Space Area (sf)	11,110	3,800	1,134	360	5,900
Public Space Area/DU (sf)	24.7	29.2	9.1	5.9	42.1
Year Built	1943	1969	1951	1969	1973
Construction Type	Masonry	Masonry	Masonry	Wd. Fr. Br. Vnr.	Wd. Fr. Br. Vnr.
Window Area (sf)	15,600	20,500	14,400	8,510	13,900
Window Area/DU (sf)	34.7	157.7	115.2	139.5	99.3
Roof Area	82,000	124,000	121,000	63,500	117,000
Roof "u" Value	.20	.06	.11	.07	.06
Wall Area	147,000	65,500	66,600	41,900	77,900

Table 4.1.1 (continued)

Project Listing and Data/Energy Profile

Project #	1	2	3	4	5
Wall "u" Value	.35	.81	.39	.33	.22
Number of Stories	3	1	1	1	1
Elderly/Family/Both	F	E/F	F	F	E/F
Site Energy Use (MMBTU/DU/yr)	84	80	112	155	96
Source Energy Use (MMBTU/DU/yr)	116	120	147	200	147
Energy Cost ($/DU/yr)	422.	474.	587.	586.	417.
Electrical Rate ($/kw)	.0	.052	.038*	.035*	.035
Gas Rate ($/therm)	.261	.218	.282	.223	.178*
Oil Rate ($/gal)	-	-	-	-	-
Seasonal Efficiency	.635	.659	.665	.654	.672

Notes:

* Indicates 1979 utility costs. All other utility data is 1978 costs.
** Indicates 1977 utility costs.
Wd.Fr.
Br.Vnr. = Wood Frame, Brick Veneer
\- Indicates not applicable

L = Low Rise
H = High Rise
S = Space Heating Systems
C = Central Heating Systems

O = Oil Heating Fuel
G = Gas Heating Fuel
E = Electric Heating Fuel
1-5 = Climatic Zones

Table 4.1.2

Project Listing and Data/Energy Profile

Project #	6	7	8	9	10
Discrete Level	1LSG	1LSG	1LSG	1LSG	1LSG
Building Type	Low Rise	Low Rise	Low Rise	Low Rise	Low Rise
Mechanical System	Space	Space	Space	Space	Space
Fuel Type	Gas	Gas	Gas	Gas	Gas
State	La.	La.	Tx.	Tx.	Tx.
Number of DU's	12	40	564	50	80
Number of Buildings	6	20	81	18	32
DU's/Building	2	2	6.96	2.8	2.5
Total Area of Project (sf)	13,000	52,000	606,000	41,400	57,900
Area/DU (sf)	1,090	436	1,070	828	724
Public Space/ Area (sf)	700	1,700	0	778	1,135
Public Space/ Area/DU (sf)	58.3	42.5	0	15.6	14.2
Year Built	1963	1963	1941	1966	1954
Construction Type	Wd. Fr. Br. Vnr.	Wd. Fr. Br. Vnr.	Masonry	Masonry	Masonry
Window Area (sf)	978	1,520	49,200	4,280	8,260
Window Area/DU (sf)	81.5	38	87.2	85.6	103.25
Roof Area	130,000	174,000	303,000	41,400	57,900
Roof "u" Value	.21	.06	.07	.12	.09
Wall Area	8,030	17,600	330,000	22,900	34,800

Table 4.1.2 (continued)

Project Listing and Data/Energy Profile

Project #	6	7	8	9	10
Wall "u" Value	.30	.20	.30	.30	.27
Number of Stories	1	1	2	1	1
Elderly/Family Both	F	F	F	E/F	F
Site Energy Use (MMBTU/DU/yr)	183	102	107	73	99
Source Energy Use (MMBTU/DU/yr)	270	146	145	110	137
Energy Cost ($/DU/yr)	960.	462.	376.	274.	880.
Electrical Rate ($/kw)	.028*	.039*	.041*	.021	.039
Gas Rate ($/therm)	.276*	.243*	.178*	.221	.328
Oil Rate ($/gal)	-	-	-	-	-
Seasonal Efficiency	.674	.683	.667	.658	.633

See Table 4.1.1 for notes

Table 4.1.3

Project Listing and Data/Energy Profile

Project #	11	12	13
Discrete Level	1LSG	1LSG	1LSG
Building Type	Low Rise	Low Rise	Low Rise
Mechanical System	Space	Space	Space
Fuel Type	Gas	Gas	Gas
State	Tx.	Tx.	Tx.
Number of DU's	20	30	50
Number of Buildings	4	13	19
DU's/Building	5	2.3	2.6
Total Area of Project (sf)	11,400	22,100	41,000
Area/DU (sf)	570	737	821
Public Space Area (sf)	165	0	2,450
Public Space Area/DU (sf)	8.25	0	49
Year Built	1964	1965	1966
Construction Type	Wd. Fr.	Wd. Fr. Br. Vnr.	Wd. Fr.
Window Area (sf)	1,220	4,320	5,560
Window Area/DU (sf)	61	144	111.2
Roof Area	11,400	22,100	41,000
Roof "u" Value	.09	.05	.21
Wall Area	6,140	17,400	29,100

Table 4.1.3 (continued)

Project Listing and Data/Energy Profile

Project #	11	12	13
Wall "u" Value	.37	.09	.08
Number of Stories	1	1	1
Elderly/Family/ Both	E	E/F	E/F
Site Energy Use (MMBTU/DU/yr)	53	100	98
Source Energy Use (MMBTU/DU/yr)	92	130	141
Energy Cost ($/DU/yr)	325.	428.	568.
Electrical Rate ($/kw)	.053*	.053*	.053*
Gas Rate ($/therm)	.238*	.238*	.238*
Oil Rate ($/gal)	-	-	-
Efficiency	.619	.629	.625

Table 4.1.4

Project Listing and Data/Energy Profile for 1LSE Projects

Project #	14	15
Discrete Level	1LSE	1LSE
Building Type	Low Rise	Low Rise
Mechanical System	Space	Space
Fuel Type	Electric	Electric
State	Fl.	Fl.
Number of DU's	200	80
Number of Buildings	103	40
DU's/Building	1.94	2
Total Area of Project (sf)	183,000	72,400
Area/DU (sf)	917	905
Public Space Area (sf)	9,400	775
Public Space Area/DU (sf)	47.4	9.7
Year Built	1964	1971
Construction Type	CMU	Wd. Fr. Br. Vnr.
Window Area (sf)	28,800	6,480
Window Area/DU (sf)	144	82.0
Roof Area	183,000	72,400
Roof "u" Value	.12	.06
Wall Area	115,000	48,100

Table 4.1.4 (continued)

Project Listing and Data/Energy Profile

Project #	14	15
Wall "u" Value	.35	.06
Number of Stories	1	1
Elderly/Family/ Both	F	E/F
Site Energy Use (MMBTU/DU/yr)	94	88
Source Energy Use (MMBTU/DU/yr)	318	299
Energy Cost ($/DU/yr)	1584.	1295.
Electrical Rate ($/kw)	.047*	.037
Gas Rate ($/therm)	-	-
Oil Rate ($/gal)	-	-
Efficiency	.633	.672

Notes:

1LSE : Climatic zone 1, low rise, space heat, electric heat.

Table 4.1.5

Project Listing and Data/Energy Profile for 2LSG Projects

Project #	16	17	18	19	20
Discrete Level	2LSG	2LSG	2LSG	2LSG	2LSG
Building Type	Low Rise	Low Rise	Low Rise	Low Rise	Low Rise
Mechanical System	Space	Space	Space	Space	Space
Fuel Type	Gas	Gas	Gas	Gas	Gas
State	Al.	Al.	Ar.	Ar.	Ca.
Number of DU's	30	16	20	66	86
Number of Buildings	10	8	11	33	40
DU's/Building	3	2	1.8	2	2.15
Total Area of/ Project.(sf)	18,900	14,000	16,000	49,500	60,900
Area/DU (sf)	628	875	806	750	708
Public Space Area (sf)	0	0	0	1,860	1,300
Public Space Area/DU (sf)	0	0	0	28.2	15.1
Year Built	1966	1958	1975	1951	1942
Construction Type	Masonry	Wd. Fr. Br. Vnr.	Wd. Fr. Br. Vnr.	Wd. Fr. Br. Vnr.	Wd. Fr. Br. Vnr.
Window Area (sf)	1,870	1,600	2,130	6,650	3,360
Window Area/DU (sf)	62.5	100.0	106.5	100.8	39.1
Roof Area	18,900	14,000	16,100	49,500	60,900
Roof "u" Value	.15	.11	.06	.06	.07
Wall Area	15,000	9,120	11,500	34,100	47,800

Table 4.1.5 (continued)

Project Listing and Data Energy Profile

Project #	16	17	18	19	20
Wall "u" Value	.30	.33	.06	.22	.04
Number of Stories	1	1	1	1	1
Elderly/Family/ Both	E	E/F	E/F	E/F	F
Site Energy Use (MMBTU/DU/yr)	93	125	118	163	137
Source Energy Use (MMBTU/DU/yr)	128	173	175	217	205
Energy Cost ($/DU/yr)	376.	497.	512.	510.	387.
Electrical Rate ($/kw)	.037	.035*	.034*	.038*	.021
Gas Rate ($/therm)	.196	.209*	.190*	.137**	.128
Oil Rate ($/gal)	-	-	-	-	-
Efficiency	.650	.677	.686	.680	.697

Notes:

2LSG: Climatic zone 2, low rise, space heat, gas fuel.

Table 4.1.6

Project Listing and Data/Energy Profile

Project #	21	22	23	24	25
Discrete Level	2LSG	2LSG	2LSG	2LSG	2LSG
Building Type	Low Rise	Low Rise	Low Rise	Low Rise	Low Rise
Mechanical System	Space	Space	Space	Space	Space
Fuel Type	Gas	Gas	Gas	Gas	Gas
State	Ca.	Ca.	Ca.	Ca.	Ca.
Number of DU's	70	60	270	200	80
Number of Buildings	40	30	111	155	20
DU's/Building	1.75	2	2.43	1.3	4
Total Area of Project (sf)	53,600	73,100	235,000	209,000	77,600
Area/DU (sf)	766	1,220	871	1,050	970
Public Space Area (sf)	1,300	924	4,900	0	2,035
Public Space Area/DU (sf)	18.6	15.4	18.1	0	25.4
Year Built	1942	1969	1943	1962	1961
Construction Type	Wd. Fr.	CMU	Wd. Fr.	Wd. Fr. Br. Vnr.	Wd. Fr.
Window Area (sf)	3,360	5,430	43,000	15,200	9,480
Window Area/DU (sf)	48	90.5	159.3	76	118.5
Roof Area	53,600	73,100	235,000	209,000	77,600
Roof "u" Value	.07	.04	.27	.21	.10
Wall Area	41,500	41,800	122,000	170,000	38,000

Table 4.1.6 (continued)

Project Listing and Data/Energy Profile

Project #	21	22	23	24	25
Wall "u" Value	.09	.49	.36	.07	.34
Number of Stories	1	1	1	1	1
Elderly/Family/ Both	F	F	F	F	F
Site Energy Use (MMBTU/DU/yr)	141	217	151	166	135
Source Energy Use (MMBTU/DU/yr)	209	328	190	209	174
Energy Cost ($/DU/yr)	388.	1,042.	420.	567.	2,419.
Electrical Rate ($/kw)	.020	.045*	.038	.046*	.034
Gas Rate ($/therm)	.128	.120*	.141	.200*	.120**
Oil Rate ($/gal)	-	-	-	-	-
Efficiency	.693	.679	.665	.706	.636

Table 4.1.7

Project Listing and Data/Energy Profile

Project #	26	27	28	29	30
Discrete Level	2LSG	2LSG	2LSG	2LSG	2LSG
Building Type	Low Rise	Low Rise	Low Rise	Low Rise	Low Rise
Mechanical System	Space	Space	Space	Space	Space
Fuel Type	Gas	Gas	Gas	Gas	Gas
State	N.C.	N.C.	S.C.	S.C.	Tx.
Number of DU's	253	65	68	58	24
Number of Buildings	29	33	19	13	19
DU's/Building	8.7	2	3.6	4.5	1.26
Total Area of Project (sf)	179,000	53,500	39,400	50,900	22,600
Area/DU (sf)	707	822	580	878	942
Public Space Area (sf)	1,200	1,200	1,640	0	380
Public Space Area/DU (sf)	4.7	18.5	24.1	0	15.8
Year Built	1942	1967	1964	1953	1963
Construction Type	Masonry	Wd. Fr. Br. Vnr.	Masonry	Masonry	Wd. Fr. Br. Vnr.
Window Area (sf)	26,100	7,900	3,490	6,660	3,670
Window Area/DU (sf)	103.2	121.5	51.3	114.8	152.9
Roof Area	89,400	53,500	39,400	50,900	22,600
Roof "u" Value	.04	.06	.05	.06	.23
Wall Area	99,300	35,800	30,100	24,900	17,400

Table 4.1.7 (continued)

Project Listing and Data/Energy Profile

Project #	26	27	28	29	30
Wall "u" Value	.26	.20	.20	.29	.06
Number of Stories	2	1	1	1	1
Elderly/Family/ Both	F	E/F	E	F	F
Site Energy Use (MMBTU/DU/yr)	140	136	125	156	165
Source Energy Use (MMBTU/DU/yr)	176	174	161	195	221
Energy Cost ($/DU/yr)	527.	758.	517.	936.	1081.
Electrical Rate ($/kw)	.030	.039	.046*	.059*	.056
Gas Rate ($/therm)	.238	.354	.246	.372	.356
Oil Rate ($/gal)	-	-	-	-	-
Efficiency	.658	.675	.672	.664	.636

Table 4.1.8

Project Listing and Data/Energy Profile

Project #	31	32	33	34	35
Discrete Level	2LSG	2LSG	2LSG	2LSG	2LSG
Building Type	Low Rise	Low Rise	Low Rise	Low Rise	Low Rise
Mechanical System	Space	Space	Space	Space	Space
Fuel Type	Gas	Gas	Gas	Gas	Gas
State	Tx.	Tx.	Tx.	Tx.	Va.
Number opf DU's	130	8	52	56	294
Number of Buildings	32	4	26	27	125
DU's/Building	4.1	2	2	2.1	2.4
Total Area of Project (sf)	84,400	5,260	40,800	35,100	210,000
Area/DU (sf)	665	658	785	627	713
Public Space Area (sf)	1,700	0	840	2,650	4,400
Public Space Area/DU (sf)	13.1	0	16.2	47.3	15
Year Built	1942	1952	1953	1970	1941
Construction Type	CMU	Wd. Fr. Br. Vnr.	Masonry	CMU	Masonry
Window Area (sf)	17,600	724	6,540	2,860	28,700
Window Area/DU (sf)	135.4	90.5	125.8	51.1	97.6
Roof Area	86,400	5,260	40,800	35,100	210,000
Roof "u" Value	.64	.06	.33	.06	.08
Wall Area	46,400	3,910	26,300	36,400	133,000

Table 4.1.8 (continued)

Project Listing and Data/Energy Profile

Project #	31	32	33	34	35
Wall "u" Value	.39	.06	.48	.36	.25
Number of Stories	1	1	1	1	1
Elderly/Family/ Both	F	F	E/F	E/F	F
Site Energy Use (MMBTU/DU/yr)	233	188	164	113	117
Source Energy Use (MMBTU/DU/yr)	284	229	213	150	159
Energy Cost ($/DU/yr)	680.	801.	685.	495.	643.
Electrical Rate ($/kw)	.036	.038	.053*	.033*	.051*
Gas Rate ($/therm)	.173	.277	.230*	.257	.319*
Oil Rate ($/gal)	-	-	-	-	-
Efficiency	.651	.653	.671	.665	.686

Table 4.1.9

Project Listing and Data/Energy Profile for 2LSE Projects

Project #	36	37	38
Discrete Level	2LSE	2LSE	2LSE
Building Type	Low Rise	Low Rise	Low Rise
Mechanical System	Space	Space	Space
Fuel Type	Electric	Electric	Electric
State	Al.	Tn.	Tn.
Number of DU's	40	20	34
Number of Buildings	24	8	14
DU's/Building	1.7	2.5	2.4
Total Area of Project (sf)	37,900	13,600	24,000
Area/DU (sf)	948	678	706
Public Space Area (sf)	1,116	0	1,620
Public Space Area/DU (sf)	27.9	0	47.6
Year Built	1961	1975	1971
Construction Type	Masonry	Wd. Fr.	Wd. Fr. Br. Vnr.
Window Area (sf)	6,050	1,670	3,810
Window Area/DU (sf)	151.3	83.5	112.1
Roof Area	37,900	13,600	24,000
Roof "u" Value	.15	.05	.03
Wall Area	25,000	8,880	18,900

Table 4.1.9 (continued)

Project Listing and Data/Energy Profile

Project #	36	37	38
Wall "u" Value	.10	.07	.06
Number of Stories	1	1	1
Elderly/Family/ Both	F	E/F	E/F
Site Energy Use (MMBTU/DU/yr)	191	154	168
Source Energy Use (MMBTU/DU/yr)	649	522	570
Energy Cost ($/DU/yr)	2,069.	1,734.	1,806.
Electrical Rate ($/kw)	.027*	.029	.027
Gas Rate ($/therm)	-	-	-
Oil Rate ($/gal)	-	-	-
Efficiency	.674		

Notes:

2LSE: Climatic zone 2, low rise, space heat, electric fuel

Table 4.1.10

Project Listing and Data/Energy Profile for 2LCG Projects

Project #	39	40
Discrete Level	2LCG	2LCG
Building Type	Low Rise	Low Rise
Mechanical System	Central	Central
Fuel Type	Gas	Gas
State	Ca.	Tx.
Number of DU's	469	20
Number of Buildings	38	1
DU's/Building	12.3	20
Total Area of Project (sf)	374,000	15,700
Area/DU (sf)	796	783
Public Space Area (sf)	3,726	3,275
Public Space Area/DU (sf)	7.9	163.75
Year Built	1942	1968
Construction Type	CMU	Masonry
Window Area (sf)	39,000	1,320
Window Area/DU (sf)	83.2	66
Roof Area	124,000	5,220
Roof "u" Value	.21	.05
Wall Area	222,000	7,480

Table 4.1.10 (continued)

Project Listing and Data/Energy Profile

Project #	39	40
Wall "u" Value	.31	.23
Number of Stories	3	3
Elderly/Family/ Both	F	E/F
Site Energy Use (MMBTU/DU/yr)	229	105
Source Energy Use (MMBTU/DU/yr)	275	162
Energy Cost ($/DU/yr)	855.	545.
Electrical Rate ($/kw)	.042	.036*
Gas Rate ($/therm)	.236	.221*
Oil Rate ($/gal)	-	-
Efficiency	.630	.585

Notes:

2LCG: Climatic zone 2, low rise, contral heat, gas fuel.

Table 4.1.11

Project Listing and Data/Energy Profile for 2HCG Projects

Project #	41	42
Discrete Level	2HCG	2HGC
Building Type	High Rise	High Rise
Mechanical System	Central	Central
Fuel Type	Gas	Gas
State	Ak.	Ca.
Number of DU's	220	100
Number of Buildings	1	1
DU's/Building	220	100
Total Area of Project (sf)	190,000	69,100
Area/DU (sf)	864	691
Public Space Area (sf)	7,500	5,710
Public Space Area/DU (sf)	34.1	57.1
Year Built	1971	1971
Construction Type	Concrete	Concrete
Window Area (sf)	8,630	9,160
Window Area/DU (sf)	39.2	91.6
Roof Area	15,800	5,320
Roof "u" Value	.06	.50
Wall Area	47,000	25,300

Table 4.1.11 (continued)

Project Listing and Data/Energy Profile

Project #	41	42
Wall "u" Value	.25	.35
Number of Stories	12	13
Elderly/Family/ Both	E	E/F
Site Energy Use (MMBTU/DU/yr)	69	160
Source Energy Use (MMBTU/DU/yr)	114	209
Energy Cost ($/DU/yr)	311.	543.
Electrical Rate	.032	.026
Gas Rate ($/therm)	.138*	.203*
Oil Rate ($/gal)	-	-
Efficiency	.654	.639

Notes:

2HCG: Climatic zone 2, high rise, central heat, gas fuel.

Table 4.1.12

Project Listing and Data/Energy Profile for 3LSO Projects

Project #	43
Discrete Level	3LSO
Building Type	Low Rise
Mechanical System	Space
Fuel Type	Oil
State	Md.
Number of DU's	474
Number of Buildings	78
DU's/Building	6.1
Total Area of Project (sf)	780,000
Area/DU (sf)	1,650
Public Space Area (sf)	1,200
Public Space Area/DU (sf)	2.53
Year Built	1974
Construction Type	Wd. Fr. Br. Vnr.
Window Area (sf)	37,400
Window Area/DU (sf)	79.1
Roof Area	260,000
Roof "u" Value	.07
Wall Area	506,000

Table 4.1.12 (continued)

Project Listing and Data/Energy Profile

Project #	43
Wall "u" Value	.17
Number of Stories	3
Elderly/Family/ Both	F
Site Energy Use (MMBTU/DU/yr)	160
Source Energy Use (MMBTU/DU/yr)	212
Energy Cost ($/DU/yr)	781.
Electrical Rate ($/kw)	.027**
Gas Rate ($/therm)	.302**
Oil Rate ($/gal)	.409
Efficiency	.668

Notes:

3LSO: Climatic zone 3, low rise, space heat, oil fuel.

Table 4.1.13

Project Listing and Data/Energy Profile for 3LSG Projects

Project #	44	45	46	47	48
Discrete Level	3LSG	3LSG	3LSG	3LSG	3LSG
Building Type	Low Rise	Low Rise	Low Rise	Low Rise	Low Rise
Mechanical System	Space	Space	Space	Space	Space
Fuel Type	Gas	Gas	Gas	Gas	Gas
State	Co.	Ct.	Il.	Il.	In.
Number of DU's	16	50	16	14	278
Number of Buildings	8	24	16	7	32
DU's/Building	2	2	1	2	8.7
Total Area of Project (sf)	14,800	26,100	18,800	12,000	202,000
Area/DU (sf)	927	523	1,180	861	727
Public Space Area (sf)	290	2,000	1,050	0	2,000
Public Space Area/DU (sf)	18.1	40	65.6	0	7.2
Year Built	1966	1962	1961	1967	1941
Construction Type	Wd. Fr. Br. Vnr.	Masonry	Masonry	Wd. Fr. Br. Vnr.	CMU
Window Area (sf)	1,320	2,520	1,840	438	19,400
Window Area/DU (sf)	82.5	50.4	115	31.3	69.8
Roof Area	14,800	26,100	18,800	12,000	101,000
Roof "u" Value	.09	.06	.06	.04	.21
Wall Area	9,730	28,300	16,300	8,540	120,000

Table 4.1.13 (continued)

Project Listing and Data/Energy Profile

Project #	44	45	46	47	48
Wall "u" Value	.06	.08	.20	.22	.37
Number of Stories	1	1	1	1	2
Elderly/Family/ Both	E/F	E	F	E/F	F
Site Energy Use (MMBTU/DU/yr)	242	82	260	166	211
Source Energy Use (MMBTU/DU/yr)	338	127	380	265	254
Energy Cost ($/DU/yr)	1,472.	531.	1,464.	978.	649.
Electrical Rate ($/kw)	.088	.044*	.051*	.051*	.035
Gas Rate ($/therm)	.147	.349*	.272*	.208*	.192
Oil Rate ($/gal)	-	-	-	-	-
Efficiency	.649	.640	.654	.656	.649

Notes:

3LSG: Climatic zone 3, low rise, space heat, gas fuel.

Table 4.1.14

Project Listing and Data/Energy Profile

Project #	49	50	51	52	53
Discrete Level	3LSG	3LSG	3LSG	3LSG	3LSG
Building Type	Low Rise	Low Rise	Low Rise	Low Rise	Low Rise
Mechanical System	Space	Space	Space	Space	Space
Fuel Type	Gas	Gas	Gas	Gas	Gas
State	In.	Ks.	Ky.	Mo.	Pa.
Number of DU's	24	42	30	44	150
Number of Buildings	8	21	13	14	19
DU's/Buildings	3	2	2.3	3.1	7.9
Total Area of Project (sf)	40,000	24,200	20,400	36,700	121,000
Area/DU (sf)	1,670	575	679	834	805
Public Space Area (sf)	0	0	489	0	1,390
Public Space Area/DU (sf)	0	0	16.3	0	9.3
Year Built	1951	1973	1966	1965	1943
Construction Type	Masonry	Wd. Fr.	Wd. Fr. Br. Vnr.	Wd. Fr. Br. Vnr.	Masonry
Window Area (sf)	2,270	5,540	2,370	5,600	14,100
Window Area/DU (sf)	94.5	131.9	79	127.3	94
Roof Area	400,000	12,100	20,400	18,300	60,400
Roof "u" Value	.11	.05	.04	.06	.23
Wall Area	16,500	27,100	14,000	35,000	70,000

Table 4.1.14 (continued)

Project Listing Data/Energy Profile

Project #	49	50	51	52	53
Wall "u" Value	.37	.09	.07	.10	.25
Number of Stories	1	2	1	2	2
Elderly/Family/ Both	F	F	E/F	F	F
Site Energy Use (MMBTU/DU/yr)	292	266	221	152	275
Source Energy Use (MMBTU/DU/yr)	350	318	266	192	326
Energy Cost ($/DU/yr)	1,232.	772.	839.	551.	1,352.
Electrical Rate ($/kw)	.051*	.041	.043	.050*	.053*
Gas Rate ($/therm)	.296*	.156**	.238	.210*	.236*
Oil Rate ($/gal)	-	-	-	-	-
Efficiency	.650	.658	.649	.658	.645

Table 4.1.15

Project Listing and Data/Energy Profile

Project #	54	55
Discrete Level	3LSG	3LSG
Building Type	Low Rise	Low Rise
Mechanical System	Space	Space
Fuel Type	Gas	Gas
State	Ut.	W.V.
Number of DU's	24	60
Number of Buildings	24	30
DU's/Building	1	2
Total Area of Project (sf)	26,600	58,800
Area/DU (sf)	1,110	980
Public Space Area (sf)	0	0
Public Space Area/DU (sf)	0	0
Year Built	1974	1966
Construction Type	Wd. Fr. Br. Vnr.	Wd. Fr. Br. Vnr.
Window Area (sf)	3,050	3,600
Window Area/DU (sf)	127.1	60
Roof Area	13,300	58,800
Roof "u" Value	.05	.06
Wall Area	42,900	39,100

Table 4.1.15 (continued)

Project Listing and Data/Energy Profile

Project #	54	55
Wall "u" Value	.07	.10
Number of Stories	2	1
Elderly/Family/ Both	F	F
Site Energy Use (MMBTU/DU/yr)	242	196
Source Energy Use (MMBTU/DU/yr)	293	240
Energy Cost ($/DU/yr)	1,141.	700.
Electrical Rate ($/kw)	.050*	.045
Gas Rate ($/therm)	.231*	.219
Oil Rate ($/gal)	-	-
Efficiency	.659	.666

Table 4.1.16

Project Listing and Data/Energy Profile for 3LSE Projects

Project #	56	57	58	59
Discrete Level	3LSE	3LSE	3LSE	3LSE
Building Type	Low Rise	Low Rise	Low Rise	Low Rise
Mechanical System	Space	Space	Space	Space
Fuel Type	Electric	Electric	Electric	Electric
State	Ks.	Ks.	Or.	Wa.
Number of DU's	80	20	50	70
Number of Buildings	5	10	11	1
DU's/Building	16	2	4.5	70
Total Area of Project (sf)	35,000	13,600	29,300	44,570
Area/DU (sf)	438	681	585	637
Public Space Area (sf)	3,800	1,370	0	5,200
Public Space Area/DU (sf)	47.5	63.5	0	74.3
Year Built	1974	1974	1969	1970
Construction Type	Wd. Fr.	Masonry	Wd. Fr.	Wd. Fr.
Window Area (sf)	9,650	1,330	8,150	4,170
Window Area/DU (sf)	120.6	61.5	163	59.6
Roof Area	35,000	13,600	14,600	14,900
Roof "u" Value	.15	.04	.05	.06
Wall Area	6,100	10,100	24,000	62,600

Table 4.1.16 (continued)

Project Listing and Data/Energy Profile

Project #	56	57	58	59
Wall "u" Value	.08	.06	.13	.26
Number of Stories	1	1	2	3
Elderly/Family/ Both	E	E/F	F	E
Site Energy Use (MMBTU/DU/yr)	104	94	187	105
Source Energy Use (MMBTU/DU/yr)	352	319	637	358
Energy Cost ($/DU/yr)	1,286.	1,343.	1,107.	413.
Electrical Rate ($/kw)	.031	.040	.016	.011*
Gas Rate ($/therm)	-	-	-	-
Oil Rate ($/gal)	-	-	-	-
Efficiency	.662	.592	.591	.679

Notes:

3LSE: Climatic zone 3, low rise, space heat, electric fuel.

Table 4.1.17

Project Listing and Data/Energy Profile for 3LCO Projects

Project #	60	61	62
Discrete Level	3LCO	3LCO	3LCO
Building Type	Low Rise	Low Rise	Low Rise
Mechanical System	Central	Central	Central
Fuel Type	Oil	Oil	Oil
State	Wash.,DC	Or.	R.I.
Number of DU's	440	9	744
Number of Buildings	57	1	28
DU's/Building	7.7	9	26.6
Total Area of Project (sf)	428,640	5,367	196,000
Area/DU (sf)	974	596	264
Public Space Area (sf)	11,978	0	7,670
Public Space Area/DU (sf)	27.2	0	10.3
Year Built	1946	1964	1940
Construction Type	Masonry	Wd. Fr. Br. Vnr.	Masonry
Window Area (sf)	75,600	509	19,600
Window Area/DU (sf)	171.8	56.5	26.3
Roof Area/DU (sf)	143,000	5,370	98,000
Roof "u" Value	.05	.10	.28
Wall Area/DU (sf)	274,000	2,170	115,000

Table 4.1.17 (continued)

Project Listing and Data/Energy Profile

Project #	60	61	62
Wall "u" Value	.30	.08	.26
Number of Stories	3	1	2
Elderly/Family/ Both	F	E	F
Site Energy Use (MMBTU/DU/yr)	179	127	143
Source Energy Use (MMBTU/DU/yr)	232	168	180
Energy Cost ($/DU/yr)	688.	397.	447.
Electrical Rate ($/kw)	.067	.024	.035**
Gas Rate ($/therm)	.391	.391	.338**
Oil Rate ($/gal)	.265	.277	.322**
Efficiency	.582	.534	.578

Notes:

3LCO: Climatic zone 3, low rise, central heat, oil fuel.

Table 4.1.18

Project Listing and Data/Energy Profile for 3LCG Projects

Project #	63	64	65	66
Discrete Level	3LCG	3LCG	3LCG	3LCG
Building Type	Low Rise	Low Rise	Low Rise	Low Rise
Mechnical System	Central	Central	Central	Central
Fuel Type	Gas	Gas	Gas	Gas
State	Ne.	Pa.	Pa.	R.I.
Number of DU's	30	802	104	262
Number of Buildings	8	44	10	95
DU's/Building	3.75	18.2	10.4	2.75
Total Area of Project (sf)	18,376	556,000	62,500	202,350
Area/DU (sf)	612	693	601	772
Public Space Area (sf)	2,304	8,448	0	1,632
Public Space Area/DU (sf)	76.8	10.5	0	6.2
Year Built	1965	1941	1943	1942
Construction Type	Wd. Fr. Br. Vnr.	Masonry	Wd. Fr. Br. Vnr.	Wd. Fr.
Window Area (sf)	1,730	50,200	7,960	29,300
Window Area/DU (sf)	57.6	62.6	76.5	111.8
Roof Area	18,400	185,000	31,300	101,000
Roof "u" Value	.06	.18	.07	.23
Wall Area	12,900	301,000		221,000

Table 4.1.18 (continued)

Project Listing and Data/Energy Profile

Project #	63	64	65	66
Wall "u" Value	.08	.21	.09	.06
Number of Stories	1	3	2	2
Elderly/Family/ Both	E	F	F	F
Site Energy Use (MMBTU/DU/yr)	128	215	132	171
Source Energy Use (MMBTU/DU/yr)	176	258	165	210
Energy Cost ($/DU/yr)	486.	819.	666.	862.
Electrical Rate ($/kw)	.033**	.035	.032	.037
Gas Rate ($/therm)	.164**	.247	.335	.334
Oil Rate ($/gal)	-	-	-	-
Efficiency	.564	.587	.586	.603

Notes:

3LCG: Climatic zone 3, low rise, central heat, gas fuel.

Table 4.1.19

Project Listing and Data/Energy Profile for 3HSE Projects

Project #	67
Discrete Level	3HSE
Building Type	High Rise
Mechanical System	Space
Fuel Type	Electric
State	Wa.
Number of DU's	120
Number of Buildings	1
DU's/Building	120
Total Area of Project (sf)	95,341
Area/DU (sf)	795
Public Space Area (sf)	16,831
Public Space Area/DU (sf)	140.3
Year Built	1968
Construction Type	Masonry
Window Area	9,150
Window Area/DU (sf)	76.25
Roof Area	5,960
Roof "u" Value	.07
Wall Area	36,400

Table 4.1.19 (continued)

Project Listing and Data/Energy Profile

Project #	67
Wall "u" Value	.06
Number of Stories	16
Elderly/Family/ Both	E
Site Energy Use (MMBTU/DU/yr)	85
Source Energy Use (MMBTU/DU/yr)	288
Energy Cost ($/DU/yr)	372
Electrical Rate ($/kw)	.011
Gas Rate ($/therm)	-
Oil Rate ($/gal)	-
Efficiency	-

Notes:

3HSE: Climatic zone 3, high rise, space heat, electric fuel.

Table 4.1.20

Project Listing and Data/Energy Profile for 3HCG Projects

Project #	68	69	70	71	72
Discrete Level	3HCG	3HCG	3HCG	3HCG	3HCG
Building Type	High Rise	High Rise	High Rise	High Rise	High Rise
Mechanical System	Central	Central	Central	Central	Central
Fuel Type	Gas	Gas	Gas	Gas	Gas
State	Il.	Ky.	Mo.	N.Y.	Pa.
Number of DU's	202	140	112	66	48
Number of Buildings	2	1	1	1	1
DU's/Building	101	140	112	66	48
Total Area of Project (sf)	145,134	75,000	97,584	40,800	31,400
Area/DU (sf)	718	536	871	618	654
Public Space Area (sf)	5,700	8,260	12,198	1,394	1,667
Public Space Area/DU (sf)	28.2	59	108.9	21.1	34.7
Year Build	1969	1970	1963	1973	1974
Construction Type	Concrete	Concrete	Concrete	Masonry	Concrete
Window Area (sf)	10,600	2,910	4,320	2,470	3,650
Window Area/DU (sf)	52.5	20.8	38.6	37.4	76
Roof Area	13,200	7,500	12,200	5,100	6,280
Roof "u" Value	.15	.29	.06	.10	.12
Wall Area	55,000	29,000	28,200	18,500	10,800

Table 4.1.20 (continued)

Project Listing and Data/Energy Profile

Project #	68	69	70	71	72
Wall "u" Value	.35	.33	.10	.21	.10
Number of Stories	11	10	8	8	5
Elderly/Family/ Both	E	E	E	E	E
Site Energy Use (MMBTU/DU/yr)	109	78	94	91	119
Source Energy Use (MMBTU/DU/yr)	146	119	136	124	161
Energy Cost ($/DU/yr)	525.	349.	493.	542.	738.
Electrical Rate ($/kw)	.055	.028	.042	.052	.045**
Gas Rate ($/therm)	.219	.230	.270*	.303	.332
Oil Rate ($/gal)	-	-	-	-	-
Efficiency	.545	.577	.567	.617	

Notes:

3HCG: Climatic zone 3, high rise, central heat, gas fuel.

Table 4.1.21

Project Listing and Data/Energy Profile for 3HCG Projects

Project #	73
Discrete Level	3HCG
Building Type	High Rise
Mechanical System	Central
Fuel Type	Gas
State	Pa.
Number of DU's	168
Number of Buildings	1
Du's/Building	168
Total Area of Project (sf)	120,084
Area/DU (sf)	715
Public Space Area (sf)	10,560
Public Space Area/DU (sf)	62.8
Year Built	1973
Construction Type	Concrete
Window Area (sf)	4,270
Window Area/DU (sf)	25.4
Roof Area	10,900
Roof "u" Value	.02
Wall Area	37,800

Table 4.1.21 (continued)

Project Listing and Data/Energy Profile

Project #	73
Wall "u" Value	.15
Number of Stories	11
Elderly/Family/ Both	E
Site Energy Use (MMBTU/DU/yr)	90
Source Energy Use (MMBTU/DU/yr)	132
Energy Cost ($/DU/yr)	469.
Electrical Rate ($/kw)	.036
Gas Rate ($/therm)	.265
Oil Rate ($/gal)	-
Efficiency	-

Notes:

3HCG: Climatic zone 3, high rise, central heat, gas fuel.

Table 4.1.22

Project Listing and Data/Energy Profile for 3HCO Projects

Project #	74	75	76	77
Discrete Level	3HCO	3HCO	3HCO	3HCO
Building Type	High Rise	High Rise	High Rise	High Rise
Mechanical System	Central	Central	Central	Central
Fuel Type	Oil	Oil	Oil	Oil
State	N.J.	N.J.	N.Y.	R.I.
Number of DU's	104	95	925	125
Number of Buildings	1	1	7	1
DU's/Building	104	95	132.1	125
Total Area of Project (sf)	89,400	61,248	830,200	113,760
Area/DU (sf)	860	645	898	910
Public Space Area (sf)	0	0	3,000	4,048
Public Space Area/DU (sf)	0	0	3.2	32.4
Year Built	1970	1967	1964	1966
Construction Type	Masonry	Concrete	Masonry	Masonry
Window Area (sf)	5,220	4,100	22,100	6,470
Window Area/DU (sf)	50.2	43.2	23.9	51.8
Roof Area	8,940	10,200	46,100	14,200
Roof "u" Value	.17	.10	.16	.06
Wall Area	29,500	18,200	355,000	282,00

Table 4.1.22 (continued)

Project Listing and Data/Energy Profile

Project #	74	75	76	77
Wall "u" Value	.23	.24	.27	.17
Number of Stories	10	10	18	8
Elderly/Family/ Both	E	E	E/F	E
Site Energy Use (MMBTU/DU/yr)	102	106	100	112
Source Energy Use (MMBTU/DU/yr)	142	150	139	161
Energy Cost ($/DU/yr)	567.	491.	461.	522.
Electrical Rate ($/kw)	.046	.038	.044	.046
Gas Rate ($/therm)	.402	.333	.340	-
Oil Rate ($/gal)	.377**	.436	.339	.340
Efficiency	.559	.553	.573	.537

Notes:

3HCO: Climatic zone 3, high rise, central heat, oil fuel.

Table 4.1.23

Project Listing and Data/Energy Profile for 4LSG Projects

Project #	78	79
Discrete Level	4LSG	4LSG
Building Type	Low Rise	Low Rise
Mechanical System	Space	Space
Fuel Type	Gas	Gas
State	Pa.	Wi.
Number of DU's	20	41
Number of Buildings	5	36
DU's/Building	4	1.1
Total Area of Project (sf)	19,175	46,800
Area/DU (sf)	959	1,141
Public Space Area (sf)	0	0
Public Space Area/DU (sf)	0	0
Year Built	1975	1974
Construction Type	Wd. Fr. Br. Vnr.	Wd. Fr.
Window Area (sf)	1,440	6,480
Window Area/DU (sf)	72	158
Roof Area	9,590	46,800
Roof "u" Value	.06	.06
Wall Area	2,910	36,100

Table 4.1.23 (continued)

Project Listing and Data/Energy Profile

Project #	78	79
Wall "u" Value	.07	.11
Number of Stories	2	1
Elderly/Family/ Both	F	F
Site Energy Use (MMBTU/DU/yr)	758	296
Source Energy Use (MMBTU/DU/yr)	865	354
Energy Cost ($/DU/yr)	2,281.	1,123.
Electrical Rate ($/kw)	.041	.045*
Gas Rate ($/therm)	.209	.270*
Oil Rate ($/gal)	-	-
Effective Rate	.672	.679

Notes:

4HLSG: Climatic zone 4, low rise, space heat, gas fuel.

Table 4.1.24

Project Listing and Data/Energy Profile for 4LCO Projects

Project #	80	81
Discrete Level	4LCO	4LCO
Building Type	Low Rise	Low Rise
Mechanical System	Central	Central
Fuel Type	Oil	Oil
State	Co.	Ma.
Number of DU's	422	200
Number of Buildings	24	50
DU's/Building	17.6	4
Total Area of Project (sf)	361,200	86,600
Area/DU (sf)	856	433
Public Space Area (sf)	0	5,480
Public Space Area/DU (sf)	0	27.4
Year Built	1941	1954
Construction Type	Wd. Fr.	Wd. Fr.
Window Area (sf)	48,500	38,900
Window Area/DU (sf)	114.9	194.5
Roof Area/DU (sf)	120,000	43,300
Roof "u" Value	.13	.06
Wall Area/DU (sf)	151,000	71,700

Table 4.1.24 (continued)

Project Listing and Data/Energy Profile

Project #	80	81
Wall "u" Value	.23	.06
Number of Stories	3	2
Elderly/Family/ Both	F	F
Site Energy Use (MMBTU/DU/yr)	210	242
Source Energy Use (MMBTU/DU/yr)	263	300
Energy Cost ($/DU/yr)	1,542.	984.
Electrical Rate ($/kw)	.034	.046
Gas Rate ($/therm)	.193	.395
Oil Rate ($/gal)	.826*	.361
Efficiency	.584	.605

Notes:

4LCO: Climatic zone 4, low rise, central heat, oil fuel.

Table 4.1.25

Project Listing and Data/Energy Profile for 4LCG Projects

Project #	82	83	84
Discrete Level	4LCG	4LCG	4LCG
Building Type	Low Rise	Low Rise	Low Rise
Mechanical System	Central	Central	Central
Fuel Type	Gas	Gas	Gas
State	Il.	Oh.	Wi.
Number of DU's	12	276	33
Number of Buildings	3	31	1
DU's/Building	4	8.9	33
Total Area of Project (sf)	14,136	208,010	23,200
Area/DU (sf)	1,178	754	703
Public Space Area (sf)	0	0	0
Public Space Area/DU (sf)	0	0	0
Year Built	1970	1941	1971
Construction Type	Wd. Fr.	Wd. Fr.	Wd. Fr.
Window Area (sf)	1,830	24,100	1,680
Window Area/DU (sf)	152.5	87.3	50.9
Roof Area	7,070	104,000	7,130
Roof "u" Value	.06	.06	.06
Wall Area		119,000	9,090

Table 4.1.25 (continued)

Project Listing and Data/Energy Profile

Project #	82	83	84
Wall "u" Value	.13	.20	.30
Number of Stories	2	2	3
Elderly/Family/ Both	F	F	E
Site Energy Use (MMBTU/DU/yr)	151	233	136
Source Energy Use (MMBTU/DU/yr)	195	279	178
Energy Cost ($/DU/yr)	659.	743.	548.
Electrical Rate ($/kw)	.040	.035	.040
Gas Rate ($/therm)	.250	.204	.239
Oil Rate ($/gal)	-	-	-
Efficiency	.497	.637	.573

Notes:

4LCG: Climatic zone 4, low rise, contral heat, gas fuel.

Table 4.1.26

Project Listing and Data/Energy Profile for 4HSE Projects

Project #	85
Discrete Level	4HSE
Building Type	High Rise
Mechanical System	Space
Fuel Type	Electrical
State	Mi.
Number of DU's	70
Number of Buildings	1
DU's/Building	70
Total Area of Project (sf)	36,800
Area/DU (sf)	525
Public Space Area (sf)	2,000
Public Space Area/DU (sf)	28.6
Year Built	1970
Construction Type	Concrete
Window Area (sf)	2,968
Window Area/DU (sf)	42.4
Roof Area	
Roof "u" Value	
Wall Area	

Table 4.1.26 (continued)

Project Listing and Data/Energy Profile

Project #	85
Wall "u" Value	
Number of Stories	4
Elderly/Family/ Both	E
Site Energy Use (MMBTU/DU/yr)	96
Source Energy Use (MMBTU/DU/yr)	325
Energy Cost ($/DU/yr)	1,499.
Electrical Rate ($/kw)	.040
Gas Rate ($/therm)	-
Oil Rate ($/gal)	-
Efficiency	-

Notes:

4HSE: Climatic zone 4, high rise, space heat, electric fuel.

Table 4.1.27

Project Listing and Data/Energy Profile for 4HCO Projects

Project #	86	87
Discrete Level	4HCO	4HCO
Building Type	High Rise	High Rise
Mechanical System	Central	Central
Fuel Type	Oil	Oil
State	Me.	N.Y.
Number of DU's	84	354
Number of Buildings	1	2
DU's/Building	84	177
Total Area of Project (sf)	61,784	137,340
Area/DU (sf)	736	388
Public Space Area (sf)	3,864	3,531
Public Space Area/DU (sf)	46	9.9
Year Built	1962	1974
Construction Type	Masonry	Masonry
Window Area (sf)	2,910	10,900
Window Area/DU (sf)	34.6	30.8
Roof Area	7,720	19,600
Roof "u" Value	.20	.13
Wall Area	22,900	40,100

Table 4.1.27 (continued)

Project Listing and Data/Energy Profile

Project #	86	87
Wall "u" Value	.06	.35
Number of Stories	8	7
Elderly/Family/ Both	E	E
Site Energy Use (MMBTU/DU/yr)	112	97
Source Energy Use (MMBTU/DU/yr)	155	131
Energy Cost ($/DU/yr)	820.	363.
Electrical Rate ($/kw)	.025	.033
Gas Rate ($/therm)	.274*	-
Oil Rate ($/gal)	.833*	.339
Efficiency	.566	.591

Notes:

4HCO: Climatic zone 4, high rise, central heat, oil fuel.

Table 4.1.28

Project Listing and Data/Energy Profile for 4HCG Projects

Project #	88	89	90	91	92
Discrete Level	4HCG	4HCG	4HCG	4HCG	4HCG
Building Type	High Rise	High Rise	High Rise	High Rise	High Rise
Mechanical System	Central	Central	Central	Central	Central
Fuel Type	Gas	Gas	Gas	Gas	Gas
State	Il.	Il.	Il.	N.Y.	N.Y.
Number of DU's	40	187	350	164	101
Number of Buildings	1	1	2	1	1
DU's/Building	40	187	175	164	101
Total Area of Project (sf)	35,850	115,800	340,000	108,108	64,350
Area/DU (sf)	896	619	971	659	637
Public Space Area (sf)	4,750	4,315	5,900	4,880	8,970
Public Space Area/DU (sf)	118.75	23.1	16.9	29.8	88.8
Year Built	1971	1969	1971	1970	1971
Construction Type	Concrete	Concrete	Concrete	Masonry	Concrete
Window Area (sf)	2,250	8,870	28,000	5,450	10,500
Window Area/DU (sf)	56.25	47.4	82.3	33.2	103.9
Roof Area	5,980	8,910	37,800	7,720	5,850
Roof "u" Value	.06	.05	.07	.07	.13
Wall Area	14,600	36,200	61,800	40,000	20,300

Table 4.1.28 (continued)

Project Listing and Data/Energy Profile

Project #	88	89	90	91	92
Wall "u" Value	.06	.26	.21	.10	.22
Number of Stories	6	13	9	14	11
Elderly/Family/ Both	E	E	E	E	E
Site Energy Use (MMBTU/DU/yr)	140	100	107	83	123
Source Energy Use (MMBTU/DU/yr)	220	145	151	118	170
Energy Cost ($/DU/yr)	682.	439.	496.	379.	562.
Electrical Rate ($/kw)	.030	.041	.039	.035	.039
Gas Rate ($/therm)	.227	.223	.220	.232	.217
Oil Rate ($/gal)	-	-	-	-	-
Efficiency	.603	.607	.604	.665	.590

Notes:

4HCG: Climatic zone 4, high rise, central heat, gas fuel.

Table 4.1.29

Project Listing and Data/Energy Profile for 5LSG Projects

Project #	93
Discrete Level	5LSG
Building Type	Low Rise
Mechanical System	Space
Fuel Type	Gas
State	Mn.
Number of DU's	520
Number of Buildings	102
DU's/Building	5.1
Total Area of Project (sf)	473,280
Area/DU (sf)	910
Public Space Area (sf)	8,700
Public Space Area/DU (sf)	16.7
Year Built	1952
Construction Type	Masonry
Window Area (sf)	62,200
Window Area/DU (sf)	119.6
Roof Area	237,000
Roof "u" Value	.10
Wall Area	330,000

Table 4.1.29 (continued)

Project Listing and Data/Energy Profile

Project #	93
Wall "u" Value	.25
Number of Stories	2
Elderly/Family/ Both	F
Site Energy Use (MMBTU/DU/yr)	219
Source Energy Use (MMBTU/DU/yr)	266
Energy Cost ($/DU/yr)	964.
Electrical Rate ($/kw)	.062
Gas Rate ($/therm)	.253
Oil Rate ($/gal)	-
Efficiency	.687

Notes:

5LSG: Climatic zone 5, low rise, space heat, gas fuel.

Table 4.1.30

Project Listing and Data/Energy Profile for 5HCG Projects

Project #	94	95
Discrete Level	5HCG	5HCG
Building Type	High Rise	High Rise
Mechanical System	Central	Central
Fuel Type	Gas	Gas
State	Mn.	Mn.
Number of DU's	501	162
Number of Buildings	3	1
DU's/Building	167	162
Total Area of Project (sf)	315,000	106,284
Area/DU (sf)	629	656
Public Space Area (sf)	9,340	5,365
Public Space Area/DU (sf)	18.6	33.1
Year Built	1971	1970
Construction Type	Concrete	Concrete
Window Area (sf)	34,800	12,000
Window Area/DU (sf)	69.5	74.1
Roof Area	14,300	8,860
Roof "u" Value	.05	.07
Wall Area	133,000	29,300

Table 4.1.30 (continued)

Project Listing and Data/Energy Profile

Project #	94	95
Wall "u" Value	.06	.15
Number of Stories	22	12
Elderly/Family/ Both	E	E
Site Energy Use (MMBTU/DU/yr)	105	126
Source Energy Use (MMBTU/DU/yr)	140	172
Energy Cost ($/DU/yr)	370.	515.
Electrical Rate ($/kw)	.032**	.042
Gas Rate ($/therm)	.164	.188
Oil Rate ($/gal)	(.464*)	(.439)
Efficiency	.591	.583

Notes:

5HCG: Climatic zone 5, high rise, central heat, gas fuel.

4.2 Building Types Climate Zone Averages

Table 4.2.1

Averages for Building/Mechanical/Fuel Types by Climate Region
Low Rise, Space Heating with Oil Heating Fuel (LSO)

			1 Proj.		
Discrete Level	1LSO	2LSO	3LSO	4LSO	5LSO
Climate Zone	1	2	3	4	5
Building Type			Low Rise		
Mechanical System			Space		
Fuel Type			Oil		
Number of DU's			474		
Number of Buildings	0	0	78	0	0
DU's/Building			6.1		
Total Area of Project (sf)			780,000		
Area/DU (sf)			1,650		
Public Space Area (sf)			1,200		
Public Space Area/DU (sf)			2.53		
Year Built			1974		
Construction Type			Wd. Fr.		
Window Area (sf)			37,400		
Window Area/DU (sf)			79.1		
Roof Area/DU (sf)			548.5		
Roof "u" Value			.07		
Wall Area/DU (sf)			1,067.5		

Table 4.2.1 (continued)

Averages for Building/Mechanical/Types by Climate Region

	1 Proj.
Wall "u" Value	.17
Number of Stories	3
Elderly/Family Both	F
Site Energy Use (MMBTU/DU/yr)	160
Source Energy Use (MMBTU/DU/vr)	212
Energy Cost ($/DU/yr)	781.
Electrical Rate ($/kw)	.027
Gas Rate ($/therm)	.302
Oil Rate ($/gal)	.409
Efficiency Rating	.660

Table 4.2.2

Averages for Building/Mechanical/Fuel Types by Climate Region
Low Rise, Space Heating with Gas Heating Fuel (LSG)

	13 Proj.	20 Proj.	12 Proj.	2 Proj.	1 Proj.
Discrete Level	1LSG	2LSG	3LSG	4LSG	5LSG
Climate Zone	1	2	3	4	5
Building Type	Low Rise	Low Rise	Low Rise	Low Rise	Low Rise
Mechanical System	Space	Space	Space	Space	Space
Fuel Type	Gas	Gas	Gas	Gas	Gas
Number of DU's	135	95	62	31	520
Number of Buildings	34	39	18	21	102
DU's/Building	4.0	2.4	3.4	1.5	5.1
Total Area of Project (sf)	116,638	76,428	50,117	32,988	473,280
Area/DU (sf)	864	805	808	1,064	910
Public Space Area (sf)	116,638	1,316	602	0	8,700
Public Space Area/DU (sf)	864.0	13.9	9.7	0	16.7
Year Built	1961	1956	1961	1975	1952
Construction Type	Wd. Fr. Masonry	Wd. Fr.	Wd. Fr.	Wd. Fr.	Masonry
Window Area (sf)	11,404	9,816	5,171	3,960	62,200
Window Area/DU (sf)	84.5	103.3	83.4	127.7	119.6
Roof Area/DU (sf)	578.2	758.5	532.3	909.5	455.8
Roof "u" Value	.11	.16	.15	.06	.10
Wall Area/DU (sf)	492.8	518.1	574.6	629.2	634.6

Table 4.2.2 (continued)

Averages for Building/Mechanical/Fuel Types by Climate Region

	13 Proj.	20 Proj.	12 Proj.	2 Proj.	1 Proj.
Wall "u" Value	.34	.27	.24	.10	.25
Number of Stories	1	1	1	2	2
Elderly/Family/ Both	F	F	F	F	F
Site Energy Use (MMBTU/DU/yr)	98.	150.	220.	440.	219.
Source Energy Use (MMBTU/DU/yr)	136.	196.	270.	513.	266.
Energy Cost ($/DU/yr)	452.	659.	876.	1,478.	964.
Electrical Rate ($/kw)	.033	.046	.045	.043	.062
Gas Rate ($/therm)	.224	.217	.221	.246	.253
Oil Rate ($/gal)	-	-	-	-	-
Efficiency Rating	.653	.675	.654	.660	.682

Table 4.2.3

Averages for Building/Mechanical/Fuel Types by Climate Region
Low Rise, Space Heating with Electric Heating (LSE)

	2 Proj.	3 Proj.	4 Proj.		
Discrete Level	1LSE	2LSE	3LSE	4LSE	5LSE
Climate Zone	1	2	3	4	5
Building Type	Low Rise	Low Rise	Low Rise		
Mechanical System	Space	Space	Space		
Fuel Type	Electric	Electric	Electric		
Number of DU's	140	31	55		
Number of Buildings	72	15	7	0	0
DU's/Building	1.94	2.1	7.9		
Total Area of Project (sf)	127,700	25,167	30,618		
Area/DU (sf)	912	812	557		
Public Space Area (sf)	5,128	912	3,457		
Public Space Area/DU (sf)	36.6	29.4	62.8		
Year Built	1968	1969	1972		
Construction Type	CMU Wd. Fr.	Wd. Fr.	Wd. Fr.		
Window Area (sf)	17,640	3,843	5,825		
Window Area/DU (sf)	126.0	123.9	105.9		
Roof Area/DU (sf)	912.1	811.8	355.0		
Roof "u" Value	.10	.09	.09		
Wall Area/DU (sf)	582.5	567.5	467.3		

Table 4.2.3 (continued)

Averages for Building/Mechanical/Fuel Types by Climate Region

	2 Proj.	3 Proj.	4 Proj.
Wall "u" Value	.27	.08	.15
Number of Stories	1	1	2
Elderly/Family/ Both	F,E/F	E/F	E,E/F
Site Energy Use (MMBTU/DU/yr)	92.	177.	122.
Source Energy Use (MMBTU/DU/yr)	313.	600.	416.
Energy Cost ($/DU/yr)	1,501.	1,923.	973.
Electrical Rate ($/kw)	.044	.028	.022
Gas Rate ($/therm)	-	-	-
Oil Rate ($/gal)	-	-	-
Efficiency Rating	.644	.677	.645

Table 4.2.4

Averages for Building/Mechanical/Fuel Types by Climate Region
Low Rise, Central Heating, Oil Heating Fuel (LCO)

			3 Proj.	2 Proj.	
Discrete Level	1LCO	2LCO	3LCO	4LCO	5LCO
Climate Zone	1	2	3	4	5
Building Type			Low Rise	Low Rise	
Mechanical System			Central	Central	
Fuel Type			Oil	Oil	
Number of DU's			398	311	
Number of Buildings	0	0	29	37	0
DU's/Building			13.7	8.4	
Total Area of Project (sf)			210,002	223,900	
Area/DU (sf)			528	720	
Public Space Area (sf)			6,549	2,740	
Public Space Area/DU (sf)			16.5	8.8	
Year Built			1950	1948	
Construction Type			Masonry Wd. Fr.	Wd. Fr.	
Window Area (sf)			31,903	43,700	
Window Area/DU (sf)			80.2	140.5	
Roof Area/DU (sf)			206.3	262.5	
Roof "u" Value			.19	.11	
Wall Area/DU (sf)			327.6	358.0	

Table 4.2.4 (continued)

Averages for Building/Mechanical/Fuel Types by Climate Region

	3 Proj.	2 Proj.
Wall "u" Value	.27	.18
Number of Stories	2	3
Elderly/Family/ Both	F	F
Site Energy Use (MMBTU/DU/yr)	156.	220.
Source Energy Use (MMBTU/DU/yr)	199.	275.
Energy Cost ($/DU/yr)	535.	1,363.
Electrical Rate ($/kw)	.047	.038
Gas Rate ($/therm)	.358	.258
Oil Rate ($/gal)	.300	.676
Seasonal Efficiency	.579	.592

Table 4.2.5

Averages for Building/Mechanical/Fuel Types by Climate Region
Low Rise, Central Heating, Gas Heating Fuel (LCG)

		2 Proj.	4 Proj.	3 Proj.	
Discrete Level	1LCG	2LCG	3LCG	4LCG	5LCG
Climate Zone	1	2	3	4	5
Building Type		Low Rise	Low Rise	Low Rise	
Mechanical System		Central	Central	Central	
Fuel Type		Gas	Gas	Gas	
Number of DU's		245	300	107	
Number of Buildings	0	20	39	12	0
DU's/Building		12.3	7.7	8.9	
Total Area of Project (sf)		194,850	209,807	81,782	
Area/DU (sf)		795	699	764	
Public Space Area (sf)		3,501	3,096	0	
Public Space Area/DU (sf)		14.3	10.3	0	
Year Built		1955	1948	1961	
Construction Type		Masonry	Wd. Fr.	Wd. Fr.	
Window Area (sf)		20,160	22,298	9,203	
Window Area/DU (sf)		82.3	74.3	86.0	
Roof Area/DU (sf)		263.7	279.8	370.1	
Roof "u" Value		.20	.18	.06	
Wall Area/DU (sf)		468.3	594.3	598.6	

Table 4.2.5 (continued)

Averages for Building/Mechanical/Fuel Types by Climate Region

	2 Proj.	4 Proj.	3 Proj.
Wall "u" Value	.31	.16	.21
Number of Stories	3	2	2
Elderly/Family/ Both	F	F	F
Site Energy Use (MMBTU/DU/yr)	223	196	220
Source Energy Use (MMBTU/DU/yr)	270	237	265
Energy Cost ($/DU/yr)	841.	805.	720.
Electrical Rate ($/kw)	.042	.035	.036
Gas Rate ($/therm)	.235	.271	.209
Oil Rate ($/gal)	-	-	-
Efficiency Rating	.627	.588	.625

Table 4.2.6

Averages for Building/Mechanical/Fuel Types by Climate Region
High Rise, Space Heating with Electric Heating (HSE)

			1 Proj.	1 Proj.	
Discrete Level	1HSE	2HSE	3HSE	4HSE	5HSE
Climate Zone	1	2	3	4	5
Building Type			High Rise	High Rise	
Mechanical System			Space	Space	
Fuel Type			Electric	Electric	
Number of DU's			120	70	
Number of Buildings	0	0	1	1	0
DU's/Building			120	70	
Total Area of Project (sf)			95,341	36,800	
Area/DU (sf)			795	525	
Public Space Area (sf)			16,831	2,000	
Public Space Area/DU (sf)			140.3	28.6	
Year Built			1968	1970	
Construction Type			Concrete	Concrete	
Window Area (sf)			9,150	2,968	
Window Area/DU (sf)			76.3	42.4	
Roof Area/DU (sf)			49.7		
Roof "u" Value			.07		
Wall Area/DU (sf)			303.3		

Table 4.2.6 (continued)

Averages for Building/Mechanical/Fuel Types by Climate Region

	1 Proj.	1 Proj.
Wall "u" Value	.06	
Number of Stories	16	4
Elderly/Family/ Both	E	E
Site Energy Use (MMBTU/DU/yr)	85.	96.
Source Energy Use (MMBTU/DU/yr)	288.	325.
Energy Cost ($/DU/yr)	372.	1,499.
Electrical Rate ($/kw)	.011	.040
Gas Rate ($/therm)	-	-
Oil Rate ($/gal)	-	-
Efficiency Rating	.594	

Table 4.2.7

Averages for Building/Mechanical/Fuel Types by Climate Region
High Rise, Central Heating with Oil Heating (HCO)

			4 Proj.	2 Proj.	
Discrete Level	1HCO	2HCO	3HCO	4HCO	5HCO
Climate Zone	1	2	3	4	5
Building Type			High Rise	High Rise	
Mechanical System			Central	Central	
Fuel Type			Oil	Oil	
Number of DU's			312	219	
Number of Buildings	0	0	3	2	0
DU's/Building			104	110	
Total Area of Project (sf)			273,652	99,562	
Area/DU (sf)			877.	455	
Public Space Area (sf)			1,762	3,698	
Public Space Area/DU (sf)			5.6	16.9	
Year Built			1967	1968	
Construction Type			Masonry	Masonry	
Window Area (sf)			9,473	6,905	
Window Area/DU (sf)			30.4	31.5	
Roof Area/DU (sf)			63.7	62.4	
Roof "u" Value			.15	.14	
Wall Area/DU (sf)			345.3	143.8	

Table 4.2.7 (continued)

Averages for Building/Mechanical/Fuel Types by Climate Region

	4 Proj.	2 Proj.
Wall "u" Value	.25	.29
Number of Stories	12	8
Elderly/Family/ Both	E	E
Site Energy Use (MMBTU/DU/yr)	102.	100.
Source Energy Use (MMBTU/DU/yr)	142.	136.
Energy Cost ($/DU/yr)	479	451
Electrical Rate ($/kw)	.044	.031
Gas Rate ($/therm)	.414	.274
Oil Rate ($/gal)	.350	.434
Efficiency Rating	.567	.586

Table 4.2.8

Averages for Building/Mechanical/Fuel Types by Climate Region
High Rise, Central Heating with Gas Heating (HCG)

		2 Proj.	6 Proj.	5 Proj.	2 Proj.
Discrete Level	1HCG	2HCG	3HCG	4HCG	5HCG
Climate Zone	1	2	3	4	5
Building Type		High Rise	High Rise	High Rise	High Rise
Mechanical System		Central	Central	Central	Central
Fuel Type		Gas	Gas	Gas	Gas
Number of DU's		160	123	168	332
Number of Buildings		1	1	1	2
DU's/Building		160	123	168	165
Total Area of Project (sf)		129,550	85,000	132,822	210,642
Area/DU (sf)		810	691	791	634
Public Space Area (sf)		6,605	6,630	5,763	7,353
Public Space Area/DU (sf)		41.3	53.9	34.3	22.1
Year Built		1971	1970	1970	1971
Construction Type		Concrete	Concrete	Concrete	Concrete
Window Area (sf)		8,895	4,703	11,174	23,400
Window Area/DU (sf)		55.6	38.2	66.5	70.5
Roof Area/DU (sf)		66.0	74.8	78.9	34.9
Roof "u" Value		.20	.13	.09	.05
Wall Area/DU (sf)		225.9	243.0	205.8	244.4

Table 4.2.8 (continued)

Averages for Building/Mechanical/Fuel Types by Climate Region

	2 Proj.	6 Proj.	5 Proj.	2 Proj.
Wall "u" Value	.28	.23	.19	.08
Number of Stories	13	9	11	17
Elderly/Family/ Both	E,E/F	E	E	E
Site Energy Use (MMBTU/DU/yr)	97.	95.	105.	110.
Source Energy Use (MMBTU/DU/yr)	144.	135.	149.	148.
Energy Cost ($/DU/yr)	364	488	478	405
Electrical Rate ($/kw)	.030	.043	.051	.034
Gas Rate ($/therm)	.158	.254	.224	.170
Oil Rate ($/gal)	-	-	-	.457
Efficiency Rating	.649	.576	.616	.588

4.3 Building Type Averages

Table 4.3.1

Averages for Building/Mechanical/Fuel Type

Number of Projects	1 Proj.	48 Proj.	9 Proj.	5 Proj.	9 Proj.
Discrete Level	LSO	LSG	LSE	LCO	LCG
Building Type	Low Rise	Low Rise	Low Rise	Low Rise	Low Rise
Mechanical System	Space	Space	Space	Central	Central
Fuel Type	Oil	Gas	Electric	Oil	Gas
Number of DU's	474	104	66	363	223
Number of Buildings	78	33	24	32	26
DU's/Building	6.1	3.2	2.8	11.3	8.6
Total Area of Project (sf)	780,000	87,200	50,374	215,561	163,808
Area/DU (sf)	1,650	838	763	594	735
Public Space Area (sf)	1,200	1,489	2,596	5,026	2,154
Public Space Area/DU (sf)	2.53	14.3	288.4	13.8	9.7
Year Built	1974	1949	1970	1949	1954
Construction Type	Wd. Fr.	Wd. Fr. Masonry	Wd. Fr.	Wd. Fr.	Wd. Fr.
Window Area (sf)	37,400	9,932	7,790	36,622	14,202
Window Area/DU (sf)	79.1	95.5	118.0	100.9	63.7
Roof Area/DU (sf)	548.5	630	688.6	225.7	290.8
Wall Area/DU (sf)	1067.5	530.0	536.5	338.2	571.7
Roof "u" Value	.07	.13	.09	.16	.17

Table 4.3.1 (continued)

Averages for Building/Mechanical/Fuel Type

Number of Projects	1 Proj.	48 Proj.	9 Proj.	5 Proj.	9 Proj.
Wall "u" Value	.17	.28	.18	.24	.21
Number of Stories	3	2	1	2	2
Elderly/Family/ Both	F	F/EF	E/F	F	F
Site Energy Use (MMBTU/DU/yr)	160	152	116	178	207
Source Energy Use (MMBTU/DU/yr)	212	195	395	225	244
Energy Cost ($/DU/yr)	781	632	1,298	819	802
Electrical Rate ($/kw)	.027	.042	.033	.044	.037
Gas Rate ($/therm)	.302	.224	-	.324	.251
Oil Rate ($/gal)	.409	-	-	.429	-
Efficiency Rating	.660	.663	.648	.583	.605

Table 4.3.1 (continued)

Averages for Building/Mechanical/Fuel Type

Number of Projects	2 Proj.	6 Proj.	15 Proj.
Discrete Level	HSE	HCO	HCG
Building Type	High Rise	High Rise	High Rise
Mechanical System	Space	Central	Central
Fuel Type	Electric	Oil	Gas
Number of DU's	95	281	171
Number of Buildings	1	2.2	1.3
DU's/Building	95	129.7	135
Total Area of Project (sf)	66,071	215,633	123,633
Area/DU (sf)	695	767	723
Public Space Area (sf)	9,416	2,407	6,434
Public Space Area/DU (sf)	99	8.6	37.6
Year Built	1969	1967	1970
Construction Type	Concrete	Masonry	Concrete
Window Area (sf)	6,095	8,617	9,912
Window Area/DU (sf)	63.8	30.7	57.9
Roof Area/DU (sf)		167.9	64.6
Wall Area/DU (sf)		292.9	228.8
Roof "u" Value		.15	.10

Table 4.3.1 (continued)

Averages for Building/Mechanical/Fuel Type

Number of Projects	2 Proj.	6 Proj.	15 Proj.
Wall "u" Value	.18	.26	.19
Number of Stories	10	10	11
Elderly/Family/ Both	E	E	E
Site Energy Use (MMBTU/DU/yr)	89	101	102
Source Energy Use (MMBTU/DU/yr)	302	141	144
Energy Cost ($/DU/yr)	787	471	450
Electrical Rate ($/kw)	.022	.041	.042
Gas Rate ($/therm)	-	.337	.210
Oil Rate ($/gal)	-	.372	.452
Efficiency Rating		.572	.601

E5.0

Energy Conservation Solar Energy Study

Introduction

The largest single factor contributing to the operating costs of PHA's is energy. Energy costs totaled over $740 million dollars for 1980 of $670 per dwelling unit. According to the conclusions reached in "An Evaluation of the Physical Condition of Public Housing Stock" energy conservation can be expected to substantially reduce this amount, by up to 48% if a successful full scale program is completed.

Solar energy retrofit has the potential to further reduce this energy use beyond what is cost-effectively possible with energy conservation alone.

This study was prepared to develop an estimate of energy and dollar savings, along with the associated capital costs, that would be accrued through cost-effective levels of solar retrofit in Public Housing. These estimates were developed by building type on a state by state basis for the three major energy use categories, heating, domestic hot water and lighting. A representive solar energy retrofit system was developed for each energy use catagory and used to approximate

1. Total energy savings
2. Total dollar savings
3. Total capital costs
4. Payback

These results were then extrapolated to the total dwelling units in each state and nationwide. Totals by state and nation were developed for all solar retrofits for two payback categories; less than 15 years and less than 30 years.

The quantative results of this study are limited to an analysis of three representative solar retrofit systems which represent the most significant economic applications. Other solar retrofit applications are discussed but savings and costs of these are not quantified.

It should be realized that even slight changes in the dozens of major assumptions used to estimate solar potential could alter the results significantly. All assumptions outlined in this study and are based on surveyed data and the professional experience of the contractor. Where simplification or professional judgement was required every attempt was made to give a conservative estimate of savings while fairly representating its potential.

Although different assumptions for any major variable could significantly alter the results, a sensitivity study to determine the effect of the three alternative assumptions was beyond the scope of this study.

It can be expected that a more thorough analysis of individual projects would optimize system performance thereby bringing many of the marginally non-cost-effective retrofits within economic criteria of less than fifteen or thirty year payback.

5.1 Summary of Results

Public housing, as in most housing, is already partially heated by solar energy which enters through windows (and to a lesser extent through walls) and contributes to the heating of the space. The magnitude of this contribution varies and on average accounts for 5-15% of the annual heating load. The energy conservation analysis in this report took this solar contribution into consideration by assuming that no mechanical heating is needed until the outside temperature drops below 65°F. The heat from occupants, applicances and the sun warms the house until this point.

Increasing this solar contribution through solar energy retrofit involves many alternative techniques varying from adding south facing windows to the use of photovoltaics. Solar has the technical ability to provide 100% of the energy needs for public housing. Although this is possible, it is not cost-effective. What is cost-effective is to selectively use solar technologies in appropriate applications. Table 5.1 summarizes the results of the solar feasibility study performed as part of this study.

Table 5.1

Summary of Solar Retrofit Feasibility Study

Application	All Systems With 15 Yr Payback	%	All Systems With 30 Yr Payback	%
Domestic Hot Water (17.6)				
No. of D.U. applic.	51,714	5%	185,907	17%
Energy Savings - MMBTU(1)	642,125(1)		2,646,008	
Cost Savings - $/yr	9,884,326	1.33%	23,345,493	3.15%
Capital Cost - $	121,126,000		449,121,000	
Combined Payback	12.3		19.2	
Combined Heating (52) and Domestic Hot Water				
No of D.U. applic.	0(2)	0	34,421	3.1%
Energy Savings - MMBTU(1)	0(2)		926,370	
Cost Savings - $/yr	0(2)	0	14,473,636	2.0%
Capital Cost - $	0		326,042,398	
Combined Payback	0		22.5	
Lighting (2)				
No of projects applic.		90%		100%
Energy Savings - MMBTU(1)	52,703(1)		16,354,243	
Cost Savings - $/yr	893,512	.1%	924,096	.1%
Capital Cost - $	9,790,327		10,347,617	
Combined Payback	11.0		11.2	
Electricity - (Applicance and Lighting) (24)				
Energy Savings	0		0	
	(photovoltaics expected to become cost-effective around 1985)			
Cooling (2.1)				
Energy Savings	0		0	
	(solar cooling retrofiting not cost-effective at this time)			
Total 3,4				
Energy Savings MMBTU(1)	642,124		3,140,542	3%
Cost Savings - $/yr	9,884,326	1.4%	31,013,104	4.2%
Capital Cost	121,125,000		688,921,000	
Combined Payback	12.1		22.2	

Table 5.1 (continued)

Summary of Solar Retrofit Feasibility Study

Notes

(1) Energy savings are presented as site energy use per year. Source energy savings would be on the order of 3 times greater because the majority of solar savings is for electricity.

(2) Although no 'active' solar heating system retrofits were found to pay back in less than 15 years it is expected that 'passive' solar heating retrofits have a large potential to save heating energy but because of many unquantified factors effecting 'passive' retrofit no results could be presented in this limited study. It is recommended that passive solar be studied in greater detail in representative projects and pursued in all energy conservation audit programs.

(3) These totals take into account duplicating systems between the domestic hot water analysis and the combined heating and domestic hot water analysis.

(4) Totals do not include daylighting results because they are included in the energy conservation opportunities section of the study as ECO-SL2.

Numbers in parentheses ( ) indicate the percent of total energy dollars that the application accounts for.

The physical and economic feasibility of solar retrofit is dependent on a large number of variables that affect system performance (savings), installed cost, maintenance costs and user compatibility. The major variables include:

- climate
- building type
- physical condition of the building and systems
- system type
- building orientation
- roof type and area
- shading conditions
- fuel type
- fuel cost
- user characteristics
- maintenance system.

In order to provide a preliminary study on solar's potential savings and costs and since it was not possible within this study to analyze all 27,000 projects individually, significant prototypes were developed and analyzed in each state to attempt to incorporate the major variables of physical and system characteristics, climate and fuel costs. Each of these was analyzed at a level of detail that was practically feasible and where necessary, simplified assumptions were made.

The state level was chosen to represent the major variables effecting solar energy performance and cost.

- Climate - a representative city in each state is used to model solar and climate data for that state.

- Fuel price - DOE fuel price data are available on a state basis for 1977 which is then escalated to 1980 costs using DOE projections by region.

- Construction Cost - Estimates of system costs for each solar retrofit system based on published national averages are modified using a construction multiplier for every state to reflect local cost differences.

- Extrapolation to Public Housing Totals was based on state estimates of public housing broken down by building type.

- Characteristics of prototypes were used in the state-by-state analysis by assuming the major climatic zone of each state as the best approximation. Prototype characteristics of that climate zone are then used for that state.

Three typical solar retrofit systems were chosen for each major application - heating, domestic hot water, lighting - and analyzed for energy savings by state. Active solar systems for domestic hot water and combination heating/domestic hot water systems were modeled using the F-chart computer program developed at the University of Wisconsin. Daylighting estimates were modeled based on an in-house computer program - Daylight II. Energy savings, cost savings, capital cost and payback are estimated for each building type in each state.

In recognition of limited funds for energy conservation and solar retrofit applications, a method of ranking opportunities according to cost/benefit (simple payback) analysis is used. This simple payback method is based on existing HUD regulation requiring energy conservation measures to be implemented in order of least-to-greatest payback.

Utilizing this method, as described in the HUD rule dated May 7, 1980, two levels of payback are established.

The first, all systems with paybacks of less than 15 years and the second is for all systems with less than 30 year payback. All results are shown for these 'minimum' and 'maximum' investment categories.

The largest single factor influencing the economics of solar retrofit systems is existing fuel costs. For this reason most cost-effective solar retrofits were in electric projects where electricity prices are high. Fuel prices range over 7 to 1 when compared on a per BTU basis. Highest prices for electricity and fossil fuels were found in the industrial northeast and north central states. It is here that most of the solar retrofits with less than 15 and 30 year payback periods were found, outweighing the Sunbelt states even though their climate is better suited for solar. It can be said in general that all states with electrically heated domestic hot water systems (except for Washington) can be retrofitted with solar, having a payback of less than 30 years, and most states that have electrically heated dwelling units can be retrofitted with "active" solar combined space heating and domestic hot water systems with less than 30 year payback. In addition, only a handful of states with relatively high fossel fuel costs (above $7 per million BTUs) were found to be cost-effective for domestic hot water.

Although it is difficult to generalize because of differences in climate and project's specific characteristics, solar is competitive for domestic hot water systems when fuel costs are above $7/million BTUs while for combined heating and domestic hot water systems it is competitive only when fuel prices are above $13/million BTU. Other types of solar retrofit, such as "passive" solar heating can be expected to show much better cost benefit results after more detailed analysis is made of this application than was possible in this study.

Domestic hot water accounts for about 18 percent of the energy costs in public housing. It is here that solar energy retrofit systems have their largest immediate potential. Domestic solar hot water systems have been in existence for over 50 years in the United States. Examples of these long-lived systems, in operation since the 1930's, can be found in Georgia's public housing.

Systems that were found to pay back in less than 15 years were always the electrically heated units. Most low-rise electric domestic hot water systems, 5 percent of public housing, were found to pay back in less than 15 years. (High-rise electric systems are not feasible because of the extensive plumbing retrofit required.) All-electric systems and some gas and oil systems were found to pay back in less than 30 years, about 17 percent of the dwelling units.

Space heating is the largest user of energy in public housing, accounting for 52 percent of the total. Typical combination space heating and domestic hot water retrofit systems were found to be only marginally cost-effective when replacing electric heating systems and do not compete with oil and gas. A more promising solar heating retrofit strategy would be to install simple "passive" solar systems (systems integral to the building design requiring no mechanical systems) where it is compatible with existing structures and tenant needs. Since passive solar retrofit analysis requires a much more detailed study of project-specific characteristics, no quantitative results were estimated. Published results of other residential "passive" solar retrofit applications show that with sensitive design these strategies can be very cost-effective.

It is recommended that "passive" solar retrofit applications be analyzed by individual project during any comprehensive conservation auditing program. In addition to this, it is recommended that a representative sample of projects be analyzed and retrofitted for passive solar based on economic optimization.

A pilot program to accomplish this can be expected to cost $1 million and would assess possible tenant conflicts and cost/benefits.

Lighting is a large user of energy in public housing and accounts for 8 percent of the total. Solar energy lighting retrofit was analyzed in office/public spaces where lighting levels are high and constant during the daytime hours. "Daylighting", as it is called, supplements the electric lighting systems by sensing solar energy entering the space through the windows.

When solar light is sufficient electric lights are automatically dimmed. This "daylighting" technique always maintains desired lighting levels while taking advantage of the sunlight existing in the room.

Daylighting is almost always cost-effective in offices and public spaces and would require a pro rated investment of $10 per dwelling unit to install and would save about 10% of the office/public space lighting energy.

Electricity for appliances and lights accounts for only 11% of the enrgy use in public housing but over 30% of the dollars spent on energy. Alternative energy systems such as photovoltaics are being developed to use solar energy to create electricity.

Photovoltaics is the direct conversion of sunlight into electricity. This is typically done with a silicon cell having an efficiency today of from 12-16 pecent. These solar cells are mounted on panels and angled toward the sun. Storage of the electricity they generate can be either in batteries or manufacturing of hydrogen to be used in fuel cells. Photovoltaics is a proven technology having been used to power satellites and remote weather stations for over twenty years.

There is an extensive research and development effort underway by government and private industry to bring down the cost of photovoltaic systems. Substantial progress has been made to date and a goal of $1-2/peak watt installed price is set for 1983-84. This cost level is considered the point where photovoltaics can begin to compete with existing electric costs. A large residential market is seen for photovoltaics after 1984.

The government has been very supportive of photovoltaic technology development and has enacted legislation to encourage its development through direct government purchases. Public housing is a potential market for photovoltaics and should be considered in any government purchasing program to demonstrate the technology.

<u>Cooling</u> is not a large energy user in public housing. It represents less than 3 percent of the total energy use. This small cooling energy use is the major difference in the energy profile between public and private housing. It is attributable to its classification as a luxury. This is changing as new housing is built and many new high-rise elderly projects incorporate central cooling.

This small use and the high cost of solar cooling technology is why solar cooling is not considered in this report. It is felt that a minimum of a 30 year payback would never be obtained.

5.2 Approach

The physical and economic feasibility of solar retrofit is dependent on a large number of variables that effect system performance (savings), installed cost, maintenance costs and user compatibility. The major variables include:

- climate
- building type
- physical condition of the building and systems
- system type
- building type
- roof type and area
- shading conditions
- fuel type
- fuel cost
- user characteristics
- maintenance system

Within these major categories are additional variables that add up to make every project unique.

The existing energy profile of public housing is important to understand when analyzing the potential contribution of solar energy retrofit. It illustrates the diversity and scope of the problem.

Existing energy use in public housing varies considerably between building types, climatic regions, user characteristics, physical condition and level of energy conservation measures that exist in the buildings. This not only creates yearly energy use that ranges over 10 to 1 between individual dwelling units but also produces a unique profile of energy end use as shown in Table 5.2. We can see that total energy use varies greatly and that heating is the primary cause of this difference. In general, heating is the largest use of energy and represents an average of 52 perent of the total; domestic hot water is usually the next largest user followed by lighting and appliances. Cooling is not a large energy user in public housing at this time. This profile changes slightly when costs are scrutnized since electricity costs more than gas or oil per unit of lighting and cooling and represents a larger percentage of total energy costs.

Table 5.2

Example of Energy Use in an Average Low Rise Gas Heated Dwelling Unit in Five Climate Zones

Climate Zone	Total Energy Use MMBTU/YR/DU	Heating %	DHW %	Lighting %	Cooling %
1	98	46	34	4	1.5
2	149	61	24	2.2	2.3
3	218	76	15	1.4	1.3
4	448	88	8	.8	.2
5	2193	75	17	1.8	0

Notes

1. Climate zone 1 is the hottest and 5 the coldest.
2. Low rise-gas heated building types represent about 50% of the public housing stock.
3. Reduced energy use in climate zone 5 is due to better insulation characteristics of housing in this region.
4. Appliances account for the majority of the remaining energy use.

Solar retrofit in public housing depends on unique building specific characteritics which make any attempt to generalize about solar possibilities subject to many variables. Ultimately, solar energy feasibility reports must be made specific to the individual building site. In any event solar retrofit must be viewed as integral to energy conservation efforts since energy conservation is considered.

In order to provide a preliminary study on solar potential savings and costs this report uses building prototypes based on average building data collected in the field. Simplifications were made in order to provide perspective within the scope of this limited study. In general, since it is not possible to analysis all 27,000 projects individually, significant prototypes were developed and analysized in each state to attempt to incorporate the major variables of physical and system characteristics, climate, and fuel cost. Each of these were analyzed at a level of detail that was practically feasible.

The state level is chosen to represent the major variables affecting solar energy performance and cost.

- Climate - a representative city in each state is used to model solar and climatic data for that state.
- Fuel price - DOE data is available on a state basis for 1977 which is then escalated to 1980 costs using DOE projections.
- Construction cost - estimates of system costs for each solar retrofit system based on published national averages are modified using a construction multiplier for every state.
- Extrapolation to public housing totals - were based on state estimates of public housing broken down by building type.

The following tables give the values of the above variables by state:

Table 5.3

Climatic Data

State	Reference City	Latitude	Radiation BTU/SF/DAY	Heating Degree Days	Climatic Zone
Alabama	Birmingham	33.6	1,549	2,844	2
Alaska	Fairbanks	64.8	826	14,344	5
Arizona	Phoenix	33.4	1,917	1,552	1
Arkansas	Little Rock	34.7	1,419	3,354	2
California	Los Angeles	34.0	1,770	1,800	1
Colorado	Denver	39.8	1,622	6,016	4
Connecticut	Hartford	41.9	1,290	6,350	4
Delaware	Wilmington	39.7	1,290	4,940	3
D.C.	Washington	38.9	1,290	5,010	3
Florida	Tampa	28.0	1,696	718	1
Georgia	Macon	32.7	1,549	2,240	2
Hawaii	Honolulu	21.3	1,880	0	1
Idaho	Twin Falls	40.6	1,327	5,883	3
Illinois	Chicago	41.7	1,327	6,098	4
Indiana	Indianopolis	39.7	1,254	5,511	3
Iowa	Ames	42.0	1,254	6,710	4
Kansas	Topeka	39.1	1,475	5,243	3
Kentucky	Louisville	38.2	1,401	4,645	3
Louisiana	Shreveport	32.4	1,475	2,167	2
Maine	Portland	45.6	1,198	7,498	4

Table 5.3 (continued)

Climatic Data

State	Reference City	Latitude	Radiation BTU/SF/DAY	Heating Degree Days	Climatic Zone
Maryland	Baltimore	39.2	1,327	4,729	3
Massachusetts	Boston	42.4	1,180	5,621	3
Michigan	Lansing	42.8	1,180	6,904	4
Minnesota	St. Cloud	45.6	1,254	8,868	5
Mississippi	Jackson	32.3	1,549	2,300	2
Missouri	Columbia	39.0	1,401	5,083	3
Montana	Great Falls	47.5	1,327	7,652	4
Nebraska	Lincoln	40.9	1,383	6,218	4
Nevada	Ely	39.3	1,733	7,814	4
New Hampshire	Concord	43.2	1,106	7,360	4
New Jersey	Trenton	40.2	1,254	4,952	3
New Mexico	Alberquerque	35.2	-	4,292	3
New York	New York	41.0	-	4,848	3
No. Carolina	Raleigh	35.8	1,475	3,514	2
No. Dakota	Bismark	46.8	1,327	9,044	5
Ohio	Columbus	40.0	1,254	5,702	3
Oklahoma	Oklahoma City	35.4	1,584	3,695	2
Oregon	Medford	42.4	1,401	4,930	3
Pennsylvania	Philadelphia	39.9	1,180	4,865	3

Table 5.3 (continued)

Climatic Data

State	Reference City	Latitude	Radiation BTU/SF/DAY	Heating Degree Days	Climatic Zone
Rhode Island	Providence	41.7	1,254	5,972	3
So. Carolina	Charleston	32.9	1,512	2,154	2
So. Dakota	Sioux Falls	43.6	1,401	4,838	4
Tennessee	Oak Ridge	36.0	1,364	3,949	2
Texas	San Antonio	29.5	1,622	1,590	1
Utah	Salt Lake City	41.0	-	5,983	3
Vermont	Burlington	44.5	1,106	7,876	4
Virginia	Richmond	37.8	1,364	3,959	2
Washington	Seattle	47.5	1,180	4,727	3
West Virginia	Charleston	38.4	1,327	4,590	3
Wisconsin	Madison	43.1	1,180	7,730	4
Wyoming	Lander	42.8	1,622	7,869	4

Table 5.4

Fuel Price Data = ($/Million BTU)

State	Electric	Gas	Oil
Alabama	12.80	3.43	6.26
Alaska	14.73	2.77	6.31
Arizona	17.78	4.68	6.18
Arkansas	14.94	3.42	5.85
California	15.71	3.38	6.48
Colorado	13.36	2.81	6.20
Connecticut	17.91	7.69	6.41
Delaware	20.47	5.50	6.21
D.C.	16.81	5.38	6.53
Florida	14.84	5.23	6.39
Georgia	13.22	2.91	6.43
Hawaii	20.75	0	6.48
Idaho	7.51	4.61	6.25
Illinois	16.22	3.87	6.26
Indiana	13.49	3.55	6.26
Iowa	15.84	3.35	6.18
Kansas	14.77	2.97	6.18
Kentucky	11.15	2.65	6.31
Louisiana	11.30	3.40	5.70
Maine	15.19	6.41	6.93

Table 5.4 (continued)

Fuel Price Data = ($/Million BTU)

State	Electric	Gas	Oil
Maryland	16.81	5.38	6.57
Massachusetts	20.54	7.00	6.91
Michigan	16.60	3.89	6.26
Minnesota	14.57	3.75	6.15
Mississippi	13.35	3.12	6.31
Missouri	14.83	3.80	6.20
Montana	9.24	3.15	6.01
Nebraska	12.87	3.12	6.18
Nevada	12.79	4.99	6.13
New Hampshire	18.76	6.41	6.59
New Jersey	23.10	5.99	6.59
New Mexico	15.72	3.65	6.32
New York	23.19	5.74	6.55
No. Carolina	13.73	4.16	6.43
No. Dakota	12.99	3.65	6.10
Ohio	15.79	3.87	6.26
Oklahoma	13.31	3.08	5.06
Oregon	8.31	5.51	6.31
Pennsylvania	17.63	4.25	6.67
Rhode Island	21.03	7.49	6.97

Table 5.4 (continued)

Fuel Price Data = ($/Million BTU)

State	Electric	Gas	Oil
So. Carolina	14.02	4.25	6.50
So. Dakota	12.65	3.17	6.16
Tennessee	9.03	3.11	6.29
Texas	13.95	4.13	5.79
Utah	13.48	2.85	6.25
Vermont	15.94	6.41	6.78
Virginia	15.98	5.12	6.44
Washington	5.22	5.05	6.59
West Virginia	13.75	4.32	6.40
Wisconsin	4.54	4.38	6.26
Wyoming	9.94	2.76	6.20

Note: Fuel cost data developed from DOE information.

Table 5.5

Building Type Data - Number of D.U./Building Type/State

State	LSO	LSG	LSE	LCO	LCG	HSE	HCO	HCG	Misc.
Alabama		36,269	2,227			413			
Alaska				1,526					
Arizona		7,765							145
Arkansas		8,605						4,190	
California		61,030				3,747		2,222	
Colorado		4,780			440			2,265	
Connecticut	1,050	350		1,216	540	2,300	12,601	420	
Delaware									
D.C.		5,015			205		6,685		
Florida	5,821	10,000	17,177			4,416			3,648
Georgia	1,010	42,805	15			3,190		2,076	
Hawaii									
Idaho						974			
Illinois		17,905		8,520	4,935	2,340	16,923	17,840	2,720
Indiana		1,264	462			471		6,946	
Iowa		1,160	1,500					1,105	
Kansas		2,345	485		2,975	1,215		560	
Kentucky	170	11,716	1,370	55	4,670	365		2,255	
Louisiana		24,805	246					4,575	
Maine			885	1,205	1,187		437		

Table 5.5 (continued)

Building Type Data - Number of D.U./Building Type/State

State	LSO	LSG	LSE	LCO	LCG	HSE	HCO	HCG	Misc.
Maryland	2,000	7,055		11,445	890		1,095	1,650	
Massachusetts	6,888	8,335	4,015	3,917		6,828	8,830	2,985	
Michigan		17,262	245		1,385	865		6,330	
Minnesota		720	725	1,442	1,235	178		11,350	2,779
Mississippi		7,476	2,140		2,622			295	
Missouri		13,271	1,310		2,003			5,580	
Montana		1,994			747				308
Nebraska		6,825	115		306		672	792	
Nevada		2,200	1,378						
New Hampshire			356	2,285	356	292	297		
New Jersey	1,867	1,696	585	10,170	2,161	1,107	24,598	2,037	1,778
New Mexico		2,909			3,106				1,515
New York		2,912	1,446	14,868	8,824	4,685	80,745	10,798	
No. Carolina	690	17,593	8,928			6,837	1,177	717	
No. Dakota		1,460	467		1,481		437		
Ohio		19,706	1,642		5,404	2,284		10,313	1,085
Oklahoma		9,580						9,580	
Oregon	430	130	2,742	618	2,338	2,783			
Pennsylvania	2,710	35,073	850	1,886	2,215		11,101	18,728	
Puerto Rico	(49,510 Total)								

Table 5.5 (continued)

Building Type Data - Number of D.U./Building Type/State

State	LSO	LSG	LSE	LCO	LCG	HSE	HCO	HCG	Misc.
Rhode Island	2,100	4,500	900	2,000			1,500		
So. Carolina		5,958	3,364	210	2,464				
So. Dakota		2,533	866		1,153		666		
Tennessee		21,954	10,760			2,889			
Texas	2,014	43,288	583		2,747	715		4,656	
Utah		227						1,136	
Vermont			850	904		181	178		
Virginia		7,525	3,125	243	6,663			780	1,880
Washington	4,261	1,365	5,362	1,454	552	2,130	890	587	
West Virginia		2,984			1,613			1,070	
Wisconsin			628	685	9,838			550	
Wyoming		695							
Virgin Islands (4,564 Total)									

Note: Dwelling unit totals based on sampling of total public housing type.

Since the survey sample was limited, an analysis of building characteristics on a state by state basis was not possible. Therefore a more general approach was used, utilizing the actual project data available to create prototypes representing significant differences of the public housing studies. From data obtained in a survey of 95 representative projects prototypes were developed for the following three building types:

- o single/twin
- o row house/multi-family low-rise
- o high rise

and the following five climatic zone catagories:

- o zone 1 - 0-2,000 heating degree days
- o zone 2 - 2,000-4,000 heating degree days
- o zone 3 - 4,000-6,000 heating degree days
- o zone 4 - 6,000-8,000 heating degree days
- 0 zone 5 - 8,000 + heating degree days

The prototypes developed are summarized in Table 5.6. It can be seen that no single/twin building type in our survey were found in climatic zone five and no high rise building types were found in climatic zone one. Although these building types do exist in these climates they represent a very small percent of the total and were therefore not considered in the study.

Characteristics of these prototypes were used in the state-by-state analysis by assuming the major climatic zone of each state as the best approximation. For example, Kentucky falls mainly in climatic zone 3, with 4,000-6,000 heating degree days. For the analysis of low rise, space gas dwelling units which are primarily single/twin building types the "climate zone 3, single/twin" prototype was used to estimate solar potential.

In addition, all prototypes were assumed to have major energy conservtion retrofit prior to solar retrofit. This is illustrated in Table 5.6 by the "actual" data as surveyed versus the "assumed" data after energy conservation retrofit. This refinement will better estimate real solar cost benefits since energy conservation retrofit should be accomplished first.

Table 5.6

Building Type: Single/Twin

	1	2	3	4	5
Dwelling unit area - sf	918	809	904	1141	NA
Roof area - sf/DU	881	848	850	1141	
Roof 'U' value - actual	.1	.12	.06	.06	
Roof 'U' value - assumed	.08	.05	.05	.05	
Wall area - sf/DU	541	564	631	1002	
Wall 'U' value - actual	.32	.20	.15	.11	
Wall 'U' value - assumed	.10	.07	.07	.07	
Window area - sf/DU	117	105	84	158	
Window 'U' value - actual	1.1	1.1	1.1	1.1	
Window 'U' value - assumed	1.1	1.1	.6	.6	
Volume - cubic feet/DU	7344	6472	7232	9128	
Infiltration rate - actual	1.5	1.5	1.5	1.5	
Infiltration rate - assumed	.75	.75	.75	.75	
Envelope VA	253	198	137	222	
Infiltration VA	99.1	87	98	123	
Total VA (plus 10% for slab loss)	387	314	259	380	
Hot water usage - actual	100	100	100	100	
Hot water usage - assumed	75	75	75	75	
System efficiency - actual	.660	.676	.647	.670	
System efficiency - assumed	.693	.710	.679	.704	
Public space/DU	28	13	14	0	
Assumed heating collector area - sf	varies with state				
Assumed DHW collector area - sf	50	50	50	50	

Note: Building type data based on averages of 95 randomly selected projects.

Table 5.6 (continued)

Building Type: Row House/Low-Rise Multi-Family

	1	2	3	4	5
Dwelling unit area - sf	830	749	766	737	910
Roof area - sf/DU	412	459	311	302	456
Roof 'U' value - actual	.12	.14	.12	.07	.10
Roof 'U' value - assumed	.08	.05	.05	.05	.03
Wall area - sf/DU	475	448	556	439	635
Wall 'U' value - actual	.24	.27	.16	.17	.25
Wall 'U' value - assumed	.10	.07	.07	.07	.07
Window area - sf/DU	68	93	80	120	120
Window 'U' value - actual	1.1	1.1	1.1	1.1	1.1
Window 'U' value - assumed	1.1	1.1	.6	.6	.6
Volume - cubic feet/DU	6640	5992	6128	5896	7280
Infiltration rate - actual	1.5	1.5	1.5	1.5	1.5
Infiltration rate - assumed	.75	.75	.75	.75	.75
Envelope VA	155	157	102	118	130
Infiltration VA	90	81	83	80	98
Total VA (plus 10% for slab loss)	270	262	204	218	250
Hot water usage - actual	100	100	100	100	100
Hot water usage - assumed	75	75	75	75	75
System efficiency - actual	.636	.647	.617	.595	.682
System efficiency - assumed	.668	.679	.648	.625	.716
Public space/DU	12.3	15	13	6	17
Assumed heating collector area - sf	varies with state				
Assumed DHW collector area - sf	50	50	50	50	50

Table 5.6 (continued)

Building Type: High Rise

	1	2	3	4	5
Dwelling unit area - sf	NA	809	809	665	634
Roof area - sf/DU		66	67	79	35
Roof 'U' value - actual		.28	.12	.10	.06
Roof 'U' value - assumed		.05	.05	.05	.03
Wall area - sf/DU		226	307	199	244
Wall 'U' value - actual		.30	.20	.18	.11
Wall 'U' value - assumed		.07	.07	.07	.07
Window area - sf/DU		56	36	54	71
Window 'U' value - actual		1.1	1.1	1.1	1.1
Window 'U' value - assumed		1.1	.6	.6	.6
Volume - cubic feet/DU		6472	6472	5320	5072
Infiltration rate - actual		1.5	1.5	1.5	1.5
Infiltration rate - assumed		.75	.75	.75	.75
Envelope VA		81	47	51	61
Infiltration VA		87	87	72	68
Total VA (plus 10% for slab loss)		184	147	135	142
Hot water usage - actual		60	60	60	60
Hot water usage - assumed		45	45	45	45
System efficiency - actual		.647	.576	.604	.587
System efficiency - assumed		.679	.606	.634	.616
Public space/DU		41	30	28	22
Assumed heating collector area - sf	varies with state				
Assumed DHW collector area - sf		50	50	50	50

Three typical solar retrofit systems were chosen for each major application, heating, domestic hot water, lighting and analyzed for energy savings by state. Active solar systems for domestic hot water and combination heating/domestic hot water systems were modeled using the F-chart computer program developed at the University of Wisconsin. Daylighting estimates were modeled based on an in-house computer program: Daylight II. Energy savings, cost savings, capital cost and payback are estimated for each building type in each state.

Two categories of payback are considered in this report - less than 15 year simple payback and less than 30 year simple payback per HUD guidelines. All state building types that have payback periods less than 15 years are extrapolated to the total number of dwelling units they represent and to obtain total savings and costs for solar retrofit. The same is done for the 30 year category.

Descriptions of the three typical systems used and a more detailed discussion of their analysis can be found in the following three sections: heating, domestic hot water, and lighting.

5.2.1 Economic Analysis

In recognition of limited funds for energy conservation and solar retrofit applications, a method of ranking opportunities according to cost/benefit (simple payback) analysis is used. The "simple payback" method is based on existing HUD regulations requiring energy conservation measures to be implemented in order of least to greatest payback. Although this method does not take into account fuel escalating costs or the discount rate of money it is adequate for prioritizing energy conservation opportunities and establishing cut-off criteria beyond which energy conservation opportunities are not considered.

Utilizing this method, as described in the HUD rule dated May 7, 1980, two levels of payback were established. The first is all energy conservation opportunities exclusive of solar that requires a payback of less than 15 years. The second is a regulation allowing solar retrofit applications to have a payback of less than thirty years. This favors solar energy over other energy conservation opportunities because of these added benefits: environmental cleanliness, freedom from rising costs of conventional fuels and the national interest in renewable energy sources.

This study presents the results using criteria of less than fifteen year payback and less than thirty year payback in order to illustrate the minimum and maximum levels of investment desired to implement solar retrofit of public housing. According to HUD policy the maximum investment level, or thirty year payback level, is required by public housing. The minimum, or less than fifteen year payback, level results are presented to illustrate savings and costs of solar if analyzed as other energy conservation opportunities.

Heating

Heating is the largest end use of energy in public housing typically accounting for 40-70% of the total, depending on the climate. There are many ways of using the sun to satisfy heating demand in housing. These are generally classified as either active or passive systems.

Active systems are a mechanical equipment approach that utilize component collectors, piping controls and pumps to collect, store and distribute solar heat. These systems are generally more suitable for retrofit applications than passive systems because they are more flexible with regard to existing structures and components.

Active solar heating systems are broadly classified by liquid or air distribution mediums. Both have advantages and disadvantaes depending on the application. Liquid systems have an advantage in public housing because they are more compatible with existing hot water systems and usually have a higher efficiency requiring less roof area.

Passive solar systems involve utilizing the architectural elements of a building to capture, store and distribute solar heat without mechanical equipment. They have successfully employed to provide up to 70% solar heating with a payback of less than 10 years in new housing around the country. These systems involve orienting the building to the south and increasing south glazing.

Direct gain systems use south facing windows to collect heat in the dwelling unit. Exposed masonary floor and walls on the interior store heat for night-time use and prevent excessive overheating.

Trombe walls are south facing masonry walls glazed on the exterior. The wall collects solar heat and radiates it to the space on the interior. Sunspaces are similar to south facing greenhouses (and can be used as such). They collect solar heat as direct gain. Heat can then be removed by fans to heat the house. Sunspaces are built with their north walls (the shared wall of house and sunspace) of masonry which in turn acts as trombe wall radiating heat to the house interior.

Although passive solar heating can be very cost effective and suitable to public housing when incorporated into new public housing designs, their retrofit application is difficult to assess on a large scale. The following factors contribute to this problem:

a. Passive solar systems involve the interrelationship of architectural elements not easily or cost effectively altered in existing buildings.

b. Increased glazing in public housing is dependent on the social implications of:

- need for privacy
- need for security
- vandalism
- lifestyle

c. Passive systems often involve user participation for simple daily or monthly operations which would be acceptable in private sector housing but would have to be individually assessed by project or dwelling unit in public housing by someone familiar with the project's tenents.

For these reasons active solar heating systems seem more applicable on a wide scale retrofit basis and are used for analysis in this study. It is, however, recommended that passive retrofit be assessed on a project by project basis as part of a comprehensive energy conservation program since in those projects where it is applicable the cost effectiveness can be significantly better than active solar system.

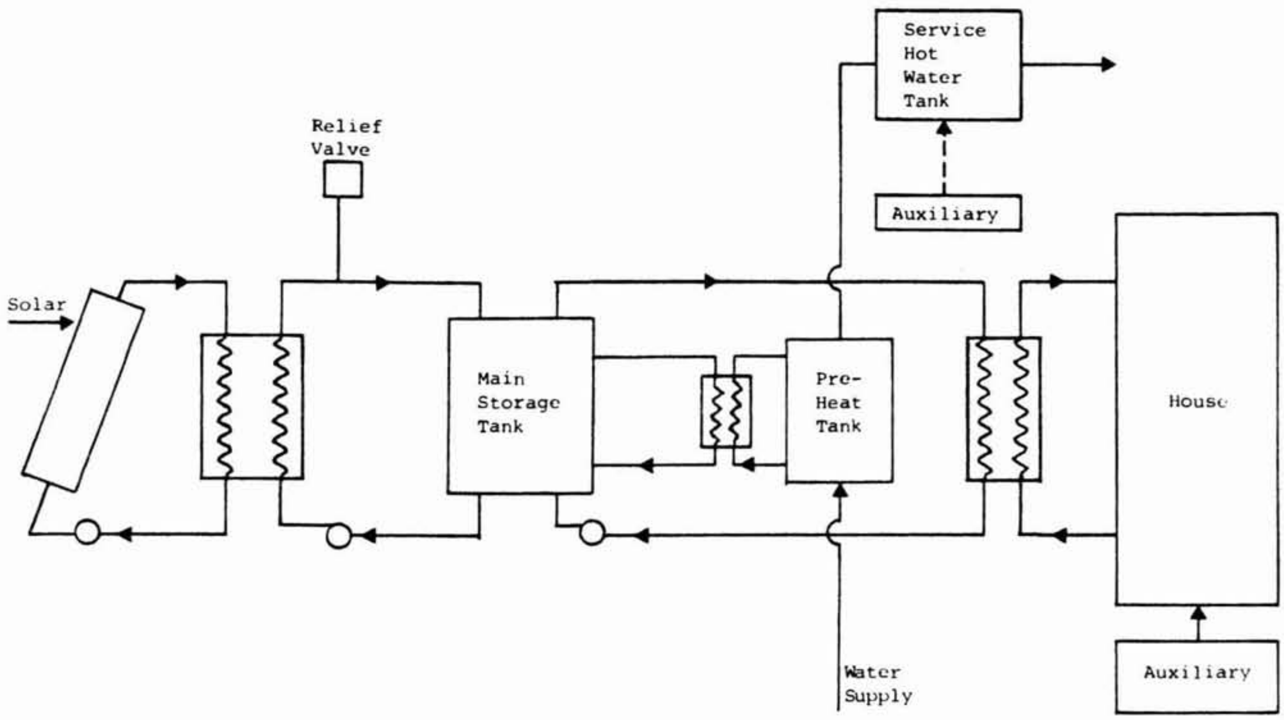
5.3.1 System Description

An example is a typical liquid working fluid solar heating system shown in Illustration 5.1. The system is designed to provide space and domestic hot water heating. A flat plate collector is used to transform incident solar radiation into thermal energy. This energy is stored in the form of heat and used as needed to supply the space and water heating loads. In this case, antifreeze solution is circulation through the collector to avoid the problems of freezing and corrosion. A heat exchanger is used between the collector and the tank as it is generally more economical than using the antifreeze solution as the energy storage medium. A second heat exchanger is used to transfer energy from the main storage tank to the smaller domestic hot water tank. Conventional auxiliary heaters are provided to supply energy for both the space and water heating loads when the energy in the storage tank is depleted. Controllers, relief valves, pumps and piping make up the remaining equipment. All heat losses from the solar energy system are assumed to contribute to the building heating load.

Table 5.7 is an example of the state-by-state analysis method.

Illustration 5.1

Liquid System: Space Heating and Domestic Hot Water



Characteristics of system used in the study

Collector sf	UA - LC ratio (from LASL recommendations for 50% solar)
System type	Liquid flat plate collectors
Storage/collector rate	1.8 (15 BTU/sf collector)
Collector Glazing	Double
Absorber surface	Flat black
Collector tilt	Latitude plus 15o
Cost/Sf collector	$60/sf

Table 5.7

Solar Heating and Hot Water System Assumptions: F-Chart version 3.0

Code	Variable Description	Value	Units	Footnote
1	AIR SH+WH=1,LIQ SH+WH=2, SIR OR LIQ WH ONLY=3	2.00		
2	IF 1,WHAT IS (FLOW RATE/COL.AREA)(SPEC.HEAT)?	NA		
3	IF 2,WHAT IS (EPSILON)(CMIN)/(UA)?	2.00		
4	COLLECTOR AREA	____	sf	(1)
5	FRPRIME-TAU-ALPHA PRODUCT(NORMAL INCIDENCE)	.70		
6	FRPRIME-UL PRODUCT	.83	BTU/H-F-F2	
7	INCIDENCE ANGLE MODIFIER (ZERO IF NOT AVAIL.)	0.00		
8	NUMBER OF TRANSPARENT COVERS	2.00		
9	COLLECTOR SLOPE	____	DEGREES	(2)
10	AZIMUTH ANGLE (E.G. SOUTH=0, WEST=90)	0.00	DEGREES	
11	STORAGE CAPACITY	15.00	BTU/F-FT2	
12	EFFECTIVE BUILDING UA	____	BTU/F-DAY	(3)
13	CONSTANT DAILY BLDG HEAT GENERATION	0.00	BTU/DAY	
14	HOT WATER USAGE	____	GAL/DAY	(4)
15	WATER SET TEMP.(TO VARY BY MONTH,INPUT NEG)	120	F	
16	WATER MAIN TEMP(TO VARY BY MONTH,INPUT NET)	51.80	F	
17	CITY CALL NUMBER	____		(5)
18	THERMAL PRINT OUT BY MONTH=1, BY YEAR=2	2.00		
19	ECONOMIC ANALYSIS? YES=1, NO-2	2.00		

(1) Varies with building type and climate based on load/collector ratios developed at Las Alomos Solar Laboratories. Fifty (50) percent solar used as target for collector sizing. Values found in Table 5.8.
(2) Latitude plus 15 degrees. Values found in Table 5.8.
(3) Based on average field data for building type and climate zone. Values used can be found in Table 5.8.
(4) 75 gals./day for low-rise and 45 gals./day for high-rise use.
(5) Varies.

Table 5.8

Heating and DHW System Solar Analysis Data

State		General		LSO	LSG	LSE	LCO	LCG	HCO		HCG
Code	9	15	17	4	12	14	4	12	4	12	14
Alabama	49	120	27	108	7536	75	-	-	-	-	-
Alaska	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arizona	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arkansas	50		123	151	7536	75	-	-	71	3528	45
California	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Colorado	55		62	203	9120	75	116	5232	72	3240	45
Connecticut	57		97	276	9120	75	159	5232	98	3240	45
Delaware	55		249	155	6216	75	-	-	-	-	-
D.C.	54		245	155	6216	75	122	4896	88	3528	45
Florida	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Georgia	47		131	108	7536	75	-	-	-	-	-
Hawaii	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Idaho	56		243	-	-	75	122	4896	-	-	-
Illinois	57		47	304	9120	75	174	5232	108	3240	45
Indiana	55		103	200	6216	75	-	-	114	3528	45
Iowa	57		7	276	9120	75	-	-	98	3240	45
Kansas	55		238	138	6216	75	109	4896	78	3528	45
Kentucky	53		126	178	6216	75	140	4896	100	3528	45
Louisana	47		220	94	7536	75	-	-	55	4416	45
Maine	61		182	304	9120	75	174	5232	108	3240	45
Maryland	55		20	155	6216	75	122	4898	88	3528	45
Massachusetts	57		31	183	6216	75	144	4896	104	3528	45
Michigan	58		116	338	9120	75	194	5232	120	3240	45
Minnessota	60		204	351	9120	75	231	6000	131	3408	45
Mississippi	47		107	108	7536	75	90	6288	63	4416	45
Missouri	54	120	50	155	6216	75	122	4896	88	3528	45
Montana	62		91	246	9120	75	141	5232	88	3240	45
Nebraska	56		122	246	9120	75	141	5232	88	3240	45
Nevada	54		74	182	9120	75	-	-	-	-	-
New Hampshire	58		53	304	9120	75	175	5232	108	3240	45
New Jersey	55		240	178	6216	75	140	4896	101	3528	45
New Mexico	50		4	89	6216	75	70	4896	50	3528	45
New York	55		158	207	6216	75	163	4896	117	3528	45
No. Carolina	51		190	151	7536	75	-	-	88	4416	45
No. Dakota	52		28	304	9120	75	175	6000	108	3408	45
Ohio	55		52	207	6216	75	163	4896	117	3528	45
Oklahoma	50		165	137	7536	75	-	-	80	4416	45
Oregon	57		137	155	6216	75	122	4896	-	-	-
Pennsylvania	55		176	207	6216	75	163	4896	118	3528	45
Puerto Rico	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rhode Island	57		186	178	6216	75	140	4896	101	3528	45

Table 5.8 (continued)

Heating and DHW System Solar Analysis Data

State			General		LSO	LSG	LSE	LCO	LCG	HCO		HCG
	Code	9	15	17	4	12	14	4	12	4	12	14
So. Carolina		48		41	108	7536	75	90	6288	-	-	-
So. Dakota		59		223	304	9120	75	175	6000	108	3408	45
Tennessee		51		164	167	7536	75	-	-	-	-	-
Texas		N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Utah		56		207	203	9120	75	-	-	72	3240	45
Vermont		59		35	365	9120	75	209	5232	130	3240	45
Virginia		53		196	167	7536	75	140	6288	98	4416	45
Washington		63		218	163	6216	75	129	4896	93	3528	45
West Virginia		53		42	178	6218	75	140	4896	101	3528	45
Wisconsin		58		132	338	9120	75	193	5232	120	3240	45
Wyoming		58		115	228	9120	75	-	-	-	-	-
Virgin Islands		N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 5.9

Solar Retrofit Potential of Heating and Domestic Hot Water Systems

Combined Level of Investment	Energy Savings MMBTU/DU	Dollar Savings $/YR	Capital Cost $	Payback Years
All dwelling units with less than 15 year payback	0	0	0	0
All dwelling units with less than 30 year payback	926,370	14,477,636	326,042,398	22.5

Table 5.10

Summary by State of All Systems with Less than 30 Year Payback

	# of D.U.	Total Energy Savings MMBTU/YR	Total Dollar Savings $/YR	Total Capital Cost $	Simple Payback
Alabama	2,226	45,410	580,986	13,342,644	22.9
Arizona	-	-	-	-	-
Arkansas	-	-	-	-	-
Alaska	-	-	-	-	-
California	-	-	-	-	-
Colorado	-	-	-	-	-
Connecticut	-	-	-	-	-
Delaware	-	-	-	-	-
D.C.	-	-	-	-	-
Florida	-	-	-	-	-
Georgia	15	307	4,050	89,715	22.2
Idaho	-	-	-	-	-
Illinois	-	-	-	-	-
Indiana	-	-	-	-	(34.6)
Iowa	1,500	63,000	1,009,500	23,970,000	23.7
Kansas	485	12,610	184,785	3,887,275	21.0
Kentucky	-	-	-	-	(40.0)
Louisana	246	4,747	53,628	1,272,312	23.7
Maine	-	-	-	-	(30.7)
Maryland	-	-	-	-	-
Massachusetts	4,015	99,155	1,959,320	43,731,380	22.3
Michigan	245	10,045	166,355	4,854,430	29.1
Minnesota	725	42,775	621,325	14,520,300	23.4
Mississippi	2,140	44,420	592,780	12,437,680	20.9
Missouri	1,310	32,488	482,080	12,061,170	25.0
Montana	-	-	-	-	-
Nebraska	115	4,888	62,905	1,677,045	26.6
Nevada	1,378	69,313	886,054	16,868,098	19.0
New Jersey	585	16,965	388,440	6,391,710	16.5
New Hampshire	356	12,424	233,536	6,253,140	26.8
New Mexico	-	-	-	-	-
New York	1,446	35,716	827,112	18,714,132	22.6
No. Carolina	8,928	222,307	3,053,376	69,799,104	22.8
No. Dakota	467	22,229	288,606	8,049,679	27.9
Ohio	-	-	-	-	(33.5)
Oklahoma	-	-	-	-	(52.9)
Oregon	-	-	-	-	-
Pennsylvania	850	22,440	396,100	10,557,000	26.6
Rhode Island	900	22,140	465,300	9,410,400	20.2
So. Carolina	3,364	67,616	948,648	18,942,684	19.9
So. Dakota	-	-	-	-	(30.1)

Table 5.10 (continued)

Summary by State of All Systems with Less than 30 Year Payback

	# of D.U.	Total Energy Savings MMBTU/YR	Total Dollar Savings $/YR	Total Capital Cost $	Simple Payback
Tennessee	-	-	-	-	(38.6)
Texas	-	-	-	-	-
Utah	-	-	-	-	-
Vermont	-	-	-	-	(31.9)
Virginia	3,125	79,375	1,268,750	29,212,500	23.0
W. Virginia	-	-	-	-	-
Wisconsin	-	-	-	-	(31.2)
Washington	-	-	-	-	(100.7)
Wyoming	-	-	-	-	-
Puerto Rico	-	-	-	-	-
Virgin Islands	-	-	-	-	-
Total	34,421	926,370	14,473,636	326,042,398	22.5

Table 5.11

Heating Analysis by State: Virginia

Building Type	LSO	LSG	LSE	LCO	LCG	HCO	HCG
Total UA x 24		7,536			6,288		4,416
Collector Area		67			140		98
Hot Water Usage		75			75		45
Number of Dwelling Units		7,525	3,125	843	6,663	800	780
Fuel Cost - MMBTU/$			15.98	6.44	5.12	6.44	5.12

Per Dwelling Unit Per Year	45
Energy Use - MMBTU	50
Energy Cost - $	799
Percent Solar %	.508
Energy Savings - MMBTU	25.4
Cost Savings - $	406
Base Cost - $60/sf	10,020
Construction Mult.	.993
Total Cost - $	9,348
Payback Years	23.0

Total Per Building Type	
Energy Use - MMBTU	156,250
Energy Savings - MMBTU	79,375
Cost Savings - $	1,268,750
Capital Cost - $	29,212,500
Payback Years	23.0

Total Per State	All systems with less than 15 year payback	All systems with less than 30 year payback
Energy Savings - MMBTU	0	79,375
Cost Savings - $	0	1,268,750
Capital Cost - $	0	29,212,500
Payback Years	0	23.0

Domestic Hot Water

Domestic hot water is the second largest energy use in public housing and accounts for 15-20% of the total. A typical family uses about 36,000 gallons of hot water a year. This will cost anywhere between $100/yr if it is heated with gas costing $.36/therm to $560/yr if heated with electricity costing 7.5 cents per kilowatt.

Solar domestic hot water systems (SDHW) have been in existence for over 50 years in the United States. There is currently public housing in Georgia using functional SDHW systems installed in 1930.

SDHW systems consist of 30-60 sf of solar collectors usually roof mounted. Solar heat is transfered to a storage tank via a pump (active system) or by natural convection (passive system). In general, passive systems can deliver high efficiency at lower costs than active systems, in those locations where they are appropriate. The reason the majority of existing SDHW systems are active is the ease with which they can be retrofited and their freeze protection capability in winter. For these reasons a typical active SDHW system was chosen for analysis. It is recommended that all projects in states where freezing is infrequent consider passive SDHW systems

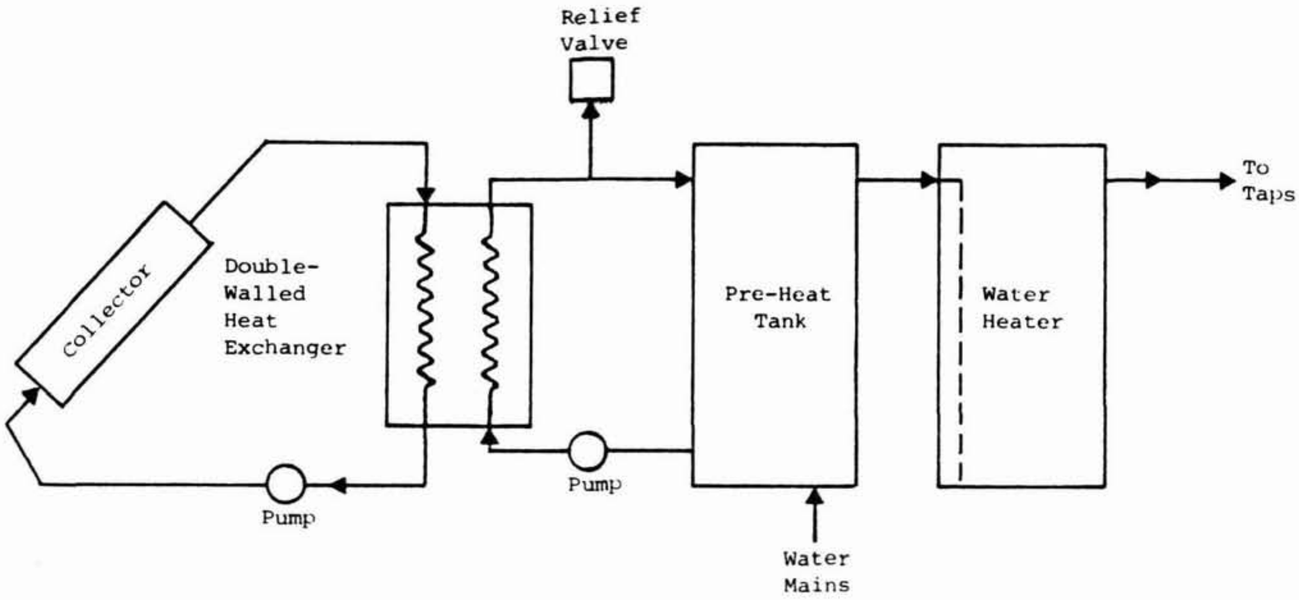
5.4.1 System Description

The typical solar energy system for a domestic hot water heating application is a relatively simple device consisting of a collector, hot water storage or preheater tank and associated pumps, piping and controls as depicted in Illustration 5.2. The design of a solar energy hot water differs from a building air-conditioning system because the demand is not a function of seasonal ambient temperature and the collector operating temperature can be lower. Either liquid or air collecting systems are available for use with domestic hot water heating. Liquid is used in our system.

A double glazed flat black type collector was chosen because of the relatively good thermal performance in the range of 100 to 140°F. the use of corrosion inhibited water in the collector loop implies the need for a double wall heat exchanger to transfer the heat to the stored domestic hot water.

Illustration 5.2

Liquid System: Domestic Hot Water Only



Characteristics of system used in this study:

	Climate Zone 1	2	3	4	5
Collectors sf	50	50	50	50	50
Storage/collector rate	1.8	1.8	1.8	1.8	1.8
Glazing	double	double	double	double	double

5.4.2 DHW Assumptions

1. Low Rise, Oil, Gas, Central and Space (family units)

average # occ/d.u.	= 5
H.W.gals/day/occ	= 20 without energy conservation measures
H.W.gals/day/occ	= 15 with energy conservation measures
total daily H.W. use	= 75 gals.
total load/day	= 75 x T(50-120) x 8.33
	= 43732.5
total energy/day	= total load ÷ efficiency (.65)
	= 67280.8
yearly HW use	= 27,375 gals.
yearly load	= 16.0 MMBTU
yearly energy use	= 24.6 MMBTU

2. Low Rise, Space, Electric
same as above except:

total daily energy use	= total load (43732.5) - efficiency (.85) = 51450
total yearly energy use	= 18.8 MMBTU

3. High Rise, Central, Oil and Gas

average # occ/d.u.	= 3 (higher proportion of electricity and smaller families)
total daily HW use	= 3 x 15 ga.s/occ = 45 gals
total daily load	= 45 gals x T(70°F) x 8.33 = 26239.5
total daily energy use	= total load ÷ efficiency (.65) = 40368.5
yearly HW use	= 16,425 gals.
yearly load	= 9.6 MMBTU
yearly energy use	= 14.7 MMBTU

Table 5.12

DHW Analysis Assumptions: F-Chart Version 3.0

Code	Variable Description	Value	Units	
1	AIR SH+WH=1,LIQ SH+WH=2,AIR OR LIQ WH ONLY=3	3.00		(a)
2	IF 1,WHAT IS (FLOW RATE/COL. AREA) (SPEC.HEAT)?	0.00	BTU/H-F-F2	
3	IF 2,WHAT IS (EPSILON) (OMIN)/(UA)?	0.00		
4	COLLECTOR AREA	50.00	FT2	(b)
5	FRPRIME-TAU-ALPHA PRODUCT (NORMAL INCIDENCE)	.70		(c)
6	FRPRIME-UL PRODUCT	.83	BTU/H-F-F2	(c)
7	INCIDENCE ANGLE MODIFIER (ZERO IF NOT AVAIL.)	0.00		
8	NUMBER OF TRANSPARENT COVERS	2.00		
9	COLLECTOR SLOPE	34.00	DEGREES	(d)
10	AZIMUTH ANGLE (E.G. SOUTH=0, WEST=90)	0.00	DEGREES	
11	STORAGE CAPACITY	15.00	BTU/F-FT2	(e)
12	EFFECTIVE BUILDING UA	0.00	BTU-F-DAY	
13	CONSTANT DAILY BLDG HEAT GENERATION	0.00	BTU/DAY	
14	HOT WATER USAGE	75.00	GAL/DAY	(f)
15	WATER SET TEMP. (TO VARY BY MONTH,INPUT NEG.*)	120.00	F	
16	WATER MAIN TEMP (TO VARY BY MONTH,INPUT NEG.*)	51.80	F	
17	CITY CALL NUMBER	27.00		(g)
18	THERMAL PRINT OUT BY MONTH=1, BY YEAR=2	2.00		
19	ECONOMIC ANALYSIS? YES=1, NO=2	2.00		

TYPE IN CODE NUMBER AND NEW VALUE

NOTES:

(a) Liquid solar domestic hot water system

(b) 50 net sf of collectors - constant for all analysis

(c) Values for typical liquid flat plate collector

(d) Collector slope equals latitude of city

(e) Storage capacity held constant at about 90 gallons

(f) Water usage 75 gallons/day for low rises/D.U.
45 gallons/day for high rises/D.U.

(g) City chosen to best represent state, see climatic data table 5.3.

Table 5.13

Summary of Solar Domestic Hot Water Retrofit Results

Combined Level of Investment	# of DU's (% of Total DU's)	Energy Savings MMBTU/DU	Dollar Savings (% Total Energy Costs)	Capital Cost $	Payback Years
All systems with less than 15 year simple payback	51,714 (5%)	642,125	9,884,326 (1.33%)	121,126,000	12.3
All systems with less than 30 year simple payback	185,907 (17%)	2,646,008	23,345,493 (3.15%)	449,112,000	19.2

Table 5.14

Domestic Hot Water Systems with Less than 15 Year Payback

State	# of D.U.	Total Energy Savings MMBTU/YR	Total Dollar Savings $/YR	Total Capital Cost $	Simple Payback
Alabama	2,226	27,470	351,708	5,119,800	14.5
Alaska	0				
Arizona	0				
Arkansas	0				
California	0				
Colorado	0				
Connecticut	0				
Delaware	0				
D.C.	0				
Florida	17,177	243,913	3,607,170	39,902,171	11.1
Georgia	15	185	2,445	34,620	14.2
Hawaii	0				
Idaho	0				
Illinois	0				
Indiana	0				
Iowa	1,500	17,850	283,500	3,619,500	12.8
Kansas	485	6,257	92,150	1,173,700	12.7
Kentucky	0				
Lousiana	246	3,321	37,392	548,580	14.6
Maine	0				
Maryland	0				
Massachusetts	4,015	38,946	803,000	9,957,200	12.4
Michigan	245	2,646	43,855	598,535	13.6
Minnesota	725	8,917	129,725	1,724,050	13.3
Mississippi	2,140	27,820	372,360	4,800,020	12.9
Missouri	1,310	15,720	233,180	3,242,250	13.9
Montana	0				
Nebraska	115	1,506	19,320	284,050	14.7
Nevada	1,378	21,221	270,088	3,883,204	14.4
New Hampshire	356	3,168	59,452	857,248	14.4
New Jersey	585	7,196	165,555	1,459,595	8.8
New Mexico	0				
New York	1,446	14,026	323,904	3,766,830	11.6
No. Carolina	8,928	106,243	1,464,192	19,266,624	13.2
No. Dakota	0				
Ohio	0				
Oklahoma	0				
Oregon	0				
Pennsylvania	850	8,925	157,250	2,125,000	13.5
Puerto Rico	0				
Rhode Island	900	8,730	184,500	2,203,200	11.9

Table 5.14 (continued)

Domestic Hot Water Systems with Less than 15 Year Payback

State	# of D.U.	Total Energy Savings MMBTU/YR	Total Dollar Savings $/YR	Total Capital Cost $	Simple Payback
So. Carolina	3,364	42,050	559,428	7,309,972	12.3
So. Dakota	0				
Tennessee	0				
Texas	583	8,103	113,102	1,329,240	11.7
Utah	0				
Vermont	0				
Virginia	3,125	35,938	575,000	7,920,700	12.7
Washington	0				
West Virginia	0				
Wisconsin	0				
Wyoming	0				
Virgin Islands	0				

Table 5.15

Domestic Hot Water Systems with Less than 30 Year Payback

State	# of D.U.	Total Energy Savings MMBTU/YR	Total Dollar Savings $/YR	Total Capital Cost $	Simple Payback
Alabama	2,226	27,470	351,708	5,119,800	14.5
Alaska	0				
Arizona	7,765	174,713	851,325	21,532,345	26.4
Arkansas	0				
California	0				
Colorado	0				
Connecticut	890	10,591	80,990	2,183,170	26.9
Delaware	0				
D.C.	0				
Florida	33,998	555,102	5,382,048	78,977,354	14.7
Georgia	1,025	16,346	106,475	2,365,700	22.2
Hawaii	0				
Idaho	100	1,630	10,200	239,300	23.5
Illinois	8,520	120,132	749,760	21,129,600	28.2
Indiana	462	4,666	62,832	1,129,590	17.9
Iowa	1,500	17,850	283,500	3,619,500	12.8
Kansas	485	6,257	92,150	1,173,700	12.7
Kentucky	1,595	17,809	184,200	3,955,600	21.5
Louisiana	246	3,321	37,392	548,580	14.6
Maine	2,090	21,855	217,080	4,859,250	22.4
Maryland	13,445	193,608	1,277,275	32,335,225	25.3
Massachusetts	23,155	282,025	2,495,655	57,424,400	23.0
Michigan	245	2,646	43,855	598,535	13.6
Minnesota	2,167	32,133	272,533	5,153,126	18.9
Mississippi	2,140	27,820	372,360	4,800,020	12.9
Missouri	1,310	15,720	233,180	3,242,250	13.9
Montana	0				
Nebraska	115	1,506	19,320	284,050	14.7
Nevada	3,578	65,441	490,088	10,082,804	20.6
New Hampshire	356	3,168	59,452	857,248	14.4
New Jersey	18,250	282,640	1,981,785	45,533,750	22.9
New Mexico	1,515	33,330	210,585	3,693,570	17.5
New York	1,446	14,026	323,904	3,766,830	11.6
No. Carolina	10,795	131,906	1,628,529	23,295,610	14.3
No. Dakota	467	5,371	69,583	1,110,526	15.9
Ohio	1,642	15,599	246,300	4,105,000	16.6
Oklahoma	0				
Oregon	3,790	47,737	366,582	10,517,250	28.7
Pennsylvania	5,452	71,972	580,634	13,630,000	23.5
Puerto Rico	0				
Rhode Island	9,500	117,950	972,800	23,256,000	23.9

Table 5.15 *(continued)*

Domestic Hot Water Systems with Less than 30 Year Payback

State	# of D.U.	Total Energy Savings MMBTU/YR	Total Dollar Savings $/YR	Total Capital Cost $	Simple Payback
So. Carolina	3,574	45,515	617,898	7,766,302	12.6
So. Dakota	866	10,132	128,168	2,013,450	15.7
Tennessee	10,760	129,120	1,172,840	23,865,680	20.3
Texas	2,597	44,758	324,572	5,921,160	18.2
Utah	0				
Vermont	1,754	19,901	210,398	4,121,900	19.6
Virginia	4,768	58,263	719,171	11,753,819	16.3
Washington	0				
West Virginia	0				
Wisconsin	1,318	15,979	154,366	3,151,200	20.4
Wyoming	0				
Virgin Islands	0				

Table 5.16

Domestic Hot Water Analysis by State: Virginia

Building Type	LSO	LSG	LSE	LCO	LCG	HCO	HCG
Number of Dwelling Units	27	7,525	3,125	843	6,663	800	
Fuel Cost - MMBTU/$		5.12	15.98	6.44	5.12	6.44	
Per Dwelling Unit per Year							
Energy Use - MMBTU		24.6	18.8	24.6	24.6	14.7	
Energy Cost - $		126	300	158	126	95	
Percent Solar %		61.1	61.1	61.1	61.1	82.5	
Energy Savings - MMBTU		15.00	11.50	15.00	15.00	12.1	
Cost Savings - $		77.00	184	97	77.00	78	
Base Cost - $		2500	2500		2500	2500	
Construction Mult.		93.3	2500		93.3	93	
Total Cost - $		2333	2333	2333	93.3		
Payback Years		30.3	12.7	24.1	93.3	24.9	
Total Per Building Type							
Energy Use - MMBTU			58,750	20,738		11,760	
Energy Savings - MMBTU			35,938	12,645		9,680	
Cost Savings - $			575,000	81,771		62,400	
Capital Cost - $			7,920,700	1,966,719		1,866,400	
Payback Years			12.7	24.1		29.9	

Total Per State	All systems with less than 15 year payback	All systems with less than 15 year payback
Energy Savings - MMBTU	35,983	58,263
Cost Savings - $	575,000	719,171
Capital Cost - $	7,920,700	11,753,819
Payback Years	12.7	16.3

Lighting

Lighting is the largest single user of electricity in public housing. A typical dwelling unit uses upward of 800 kw/yr for lighting. Public and office space within public housing averages 3 watts per square foot or 8 kilowatts a year per square foot.

Solar energy can help satisfy this load by utilizing photovoltaic energy or daylighting techniques. Photovoltaic energy is the direct conversion of sunlight into electricity. Silicon cells having an efficiency of from 12-16 percent are mounted on panels and angles toward the sun. Storage of the electricity generated is either in batteries or the manufacture of hydrogen used in fuel cells. Photovoltaic energy is a technology which has been used to power satellites and remote weather stations for over twenty years.

There is an extensive research and development effort under way by government and private industry to reduce the cost of photovoltaic systems. Substantial progress has been made and a goal of $1-2/peak watt installed price is set for 1983-84. This level is considered the point where photovoltaic cells can begin to compete with current electric rates. A large residential market is seen for photovoltaics after 1984.

The Government has encouraged development of photovoltaic technology by legislating direct government purchases. Public housing is a potential market for photovoltaic technology and should be considered in any government purchasing program.

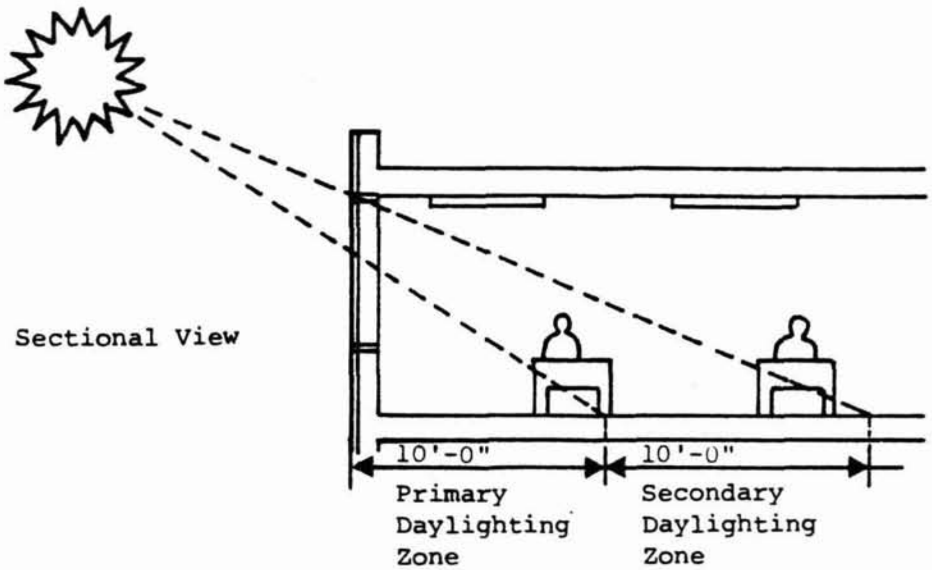
Photovoltaic technology is not cost effective today and its cost benefit is not analyzed in this report. When costs have been reduced then it should be investigated.

Daylighting involves using sunlight entering through windows to replace electric lighting. This is done routinely in residences when lights are shut off in the morning. In this case lighting is needed but the sun provides it. In office spaces where a high uniform light level is required during the daytime hours, daylighting has been demonstrated to be cost effective. In this report a simple retrofit daylighting system is analyzed for costs and benefits.

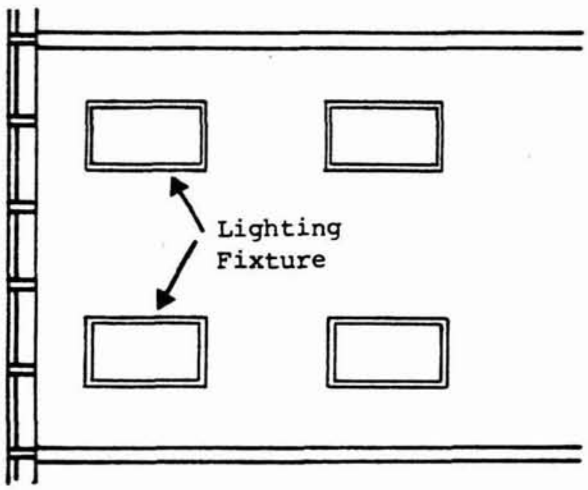
Illustration 5.3

Daylighting Analysis

Sectional View



Ceiling Plan



Daylighting is accomplished using a system consisting of a photo-electric 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 flourescent tubes as much as possible, while maintaining the same lighting levels as an adjacent space where fluorescent tubes are operating at full capacity. Installation of the required dimming equipment is relatively inexpensive since it can usually be done on an individual fixture and requires no rewiring of existing circuits.

The amount of daylight available for use depends on several factors. These include window area above desk height, type of glass, presence of exterior overhangs, and the spacing of windows. It should be noted that orientation (direction which window faces, such as north or east) has little effect on the amount of available diffuse daylight.

Based on previous in-house computer analysis of daylighting available a range of values were obtained. For this analysis the lowest value was used: a conservative estimate of .48. Based on analysis of floor plans of existing public spaces, it was conservatively estimated that 10% of the floor space is located wthin 10 feet of an exterior window. It was assumed that all other cost effective energy conservation opportunities will have been instituted, reducing lighting energy use to 2 watts per square foot.

Total public area per dwelling unit for each building type was estimated to obtain the total area per state. A state by state analysis was then possible using local electric rates and typical savings per state.

Table 5.17

Summary of Daylighting Retrofit Results

Combined Level of Investment	Energy Savings MMBTU/YR	Dollar Savings (% Total Energy Costs)	Capital Cost $	Payback Years
All systems with less than 15 year simple payback	52,703	893,512	9,790,327	11.0
All systems with less than 30 year simple payback	16,354,243	924,096	10,347,617	11.2

Table 5.18

Daylighting Summary by State of All Systems with Less than 15 Year Payback

State	Total Energy Savings KWH/yr	Total Dollar Savings $/yr	Total Capital Cost $	Simple Payback
Alabama	538,916	23,481	346,446	14.7
Alaska	-	-	-	-
Arizona	108,710	6,631	77,495	11.7
Arkansas	208,460	10,632	121,145	11.4
California	901,082	48,658	665,513	13.7
Colorado	118,489	5,449	74,140	13.6
Connecticut	309,020	18,851	194,241	10.3
Delaware	40,670	2,847	25,913	9.1
D.C.	212,461	11,837	133,243	11.3
Florida	417,072	24,024	282,643	11.8
Georgia	657,216	29,575	389,635	13.2
Hawaii	-	-	-	-
Idaho	910	24	560	23.0
Illinois	1,103,322	60,682	702,974	11.6
Indiana	282,024	13,274	177,275	13.7
Iowa	60,445	3,264	37,475	11.5
Kansas	428,649	21,433	266,986	12.5
Kentucky	275,991	10,487	175,845	16.8
Louisiana	446,789	17,424	255,946	14.7
Maine	-	-	-	-
Maryland	296,664	16,909	183,083	10.8
Massachusetts	552,882	38,701	352,263	9.1
Michigan	390,632	22,266	244,981	11.0
Minnesota	282,971	14,148	172,998	12.2
Mississippi	164,679	7,575	95,043	12.5
Missouri	339,541	17,317	216,335	12.5
Montana	41,182	1,317	25,709	19.5
Nebraska	131,235	5,812	83,427	14.4
Nevada	50,092	2,204	36,280	16.5
New Hampshire	40,168	2,571	24,847	9.7
New Jersey	745,745	58,912	478,341	8.1
New Mexico	82,777	4,469	51,795	11.6
New York	2,199,012	173,721	1,473,338	8.5
No. Carolina	420,728	19,774	233,203	11.8
No. Dakota	49,641	2,184	30,352	13.9
Ohio	744,374	40,197	478,526	11.9
Oklahoma	335,300	15,088	207,407	13.7
Oregon	73,128	2,047	52,130	25.4
Pennsylvania	1,194,174	71,651	767,684	10.7
Puerto Rico	-	-	-	-
Rhode Island	154,700	11,138	97,240	8.7

Table 5.18 (continued)

Daylighting Summary by State of All Systems with Less than 15 Year Payback

State	Total Energy Savings KWH/yr	Total Dollar Savings $/yr	Total Capital Cost $	Simple Payback
So. Carolina	154,841	7,432	86,490	11.6
So. Dakota	72,064	3,098	43,136	13.9
Tennessee	-	-	-	-
Texas	763,253	36,634	447,049	12.2
Utah	27,034	1,234	16,606	13.4
Vermont	23,864	1,289	14,421	11.2
Virginia	250,585	13,782	150,351	10.9
Washington	457,996	14,198	261,057	18.4
West Virginia	78,924	3,709	48,482	13.1
Wisconsin	116,101	5,806	71,651	12.3
Wyoming	9,730	331	6,269	18.9
Virgin Islands	-	-	-	-

Table 5.19

Daylighting Analysis by State: Virginia

Building Type	LSO	S/T LSG	LSE	LCO	RH LCG	HSE	HR HCO	HCG
Number of Dwelling Units		7,525	3,125	843	6,663		800	
Fuel Cost - MMBTU/$		.055						

Per Square Foot Per Year

Energy Use - KW/sf	7	7
Energy Cost - $	.385	.385
Percent Solar %	10	10
Energy Savings - KW	.7	.7
Cost Savings - $	.385	.385
Base Cost - $60/sf	.45	.45
Construction Mult.	.993	.993
Total Cost - $	.42	.42

Total Per Building Type

Energy Use - KW	1,491,000	683,046	331,800
Energy Savings - KW	149,100	68,305	33,180
Cost Savings - $	8,200	3,757	1,825
Capital Cost - $	89,460	40,983	19,908
Payback Years	10.9	10.9	10.9

Total Per State	All systems with less than 15 year payback	All systems with less than 30 year payback
Energy Savings - MMBTU	250,585	
Cost Savings - $	13,782	
Capital Cost - $	150,351	
Payback Years	10.9	