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Residential Energy Consumption and Expenditure Patterns of Low-Income Households in the United States

E.L. Vine and I. Reyes

September 1987

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RESIDENTIAL ENERGY CONSUMPTION AND EXPENDITURE PATTERNS OF LOW-INCOME HOUSEHOLDS IN THE UNITED STATES†

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ABSTRACT

The principal objective of this study is to compare poor and non-poor households to see whether the two groups are similar or different with respect to energy consumption and expenditures, housing characteristics, and energy-related behavior. We based our study on an analysis of a national data base created by the U.S. Department of Energy, the 1982-83 Residential Energy Consumption Survey (RECS). RECS includes detailed information on individual households: demographic characteristics, energy-related features of the structure, heating equipment and appliances, recent conservation actions taken by the household, and fuel consumption and costs for April 1982 - March 1983. We found a number of statistically significant (at the 0.05 level) differences between the two income groups in terms of demographics, heating/cooling/water heating systems, appliance saturation, the thermal integrity of their home, energy conservation behavior, energy consumption, energy expenditures, and the percentage of income spent on energy costs. For example, the non-poor used 22% more energy and paid 25% more money on utilities than the poor; however, the poor spent 20% more energy per square foot than the non-poor and spent about 25% of their income on energy expenditures, compared to 7% for the non-poor. These differences suggest different approaches that might be taken for targeting energy conservation programs to low-income households. Since the poor's "energy burden" is large, informational, technical, and financial assistance to low-income households remains an urgent, national priority.

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INTRODUCTION

The energy needs of low-income households have been the focus of several state and federal government and utility programs since the early 1970s, when the cost of energy increased dramatically for all income groups and when scarcities and occasional shortages of fuels occurred. During the mid-1980s, however, these financial, informational, and technical programs have plateaued or decreased in their level of effort, partially due to state and federal budget constraints and also to the stabilization of the price of oil. For example, funding levels for the U.S. Department of Energy's (DOE) Weatherization Assistance Program (WAP), one of the primary assistance programs for low-income households, were $191 million for FY 1985, $182 million for FY 1986, and $161 million for FY 1987.* Moreover, in its FY 1987 and FY 1988 budget proposals, the administration proposed no funding for WAP, in part pointing to the states' receipt of almost $2.1 billion in Exxon oil overcharge funds, as justification for its position [1]. When the oil overcharge funds run out, the future of this program and other conservation programs may be in jeapordy, severely impacting the energy situation of low-income households.

While average household energy consumption stabilized in the early 1980s, the price of energy increased, resulting in an increase in energy expenditures for all households: for example, relative to 1970, the average price (in nominal dollars) in 1984 was 3.4 times higher for electricity, 5.6 times higher for natural gas, and 6.2 times higher for distillate fuel [2]. The energy burden (percentage of income spent on residential energy costs) of the poor has also been increasing: for example, the average residential energy expenditure by a poor household was 10.9% of household income in 1978-79 and rose to 13% in 1980-81 [3]. The services provided by the energy sector (for heating, cooking, washing, etc.) are necessities, and, if the cost of providing these services increases, a higher proportion of the budget of low-income households will be spent on these services. Some expect that poverty level families will either have to go into debt to purchase basic essentials or do without [4]. Also, some destitute families reportedly have foresaken food and medical care to pay for escalating electric and home heating bills [4].

Successful development and implementation of energy conservation programs for low-income households requires a detailed understanding of how energy is used in homes, the factors that influence energy consumption and energy burden, and the conservation measures adopted by households. Such information can be used to more carefully target

* Personal communication with Meg Power, Research Director, Economic Opportunity Research Institute, Arlington, Va., May 21, 1987.

conservation programs to low-income groups and to ensure that these programs offer the services needed by low-income households to conserve energy. Accordingly, this paper examines low-income households in detail by analyzing a national data base recently created by DOE, the 1982-83 Residential Energy Consumption Survey (RECS). This data base represents one of the most comprehensive and most recent, publicly available compilation of data on households in the country.* We analyze the patterns and differences in the use and cost of energy and in energy-related measures for poor and non-poor households in the country. In addition to statistically testing for differences between the poor and non-poor on these variables, we construct predictive models of energy consumption and energy burden for each income group. In the concluding section, we make policy recommendations, based on the findings from our models, for targeting energy conservation programs to low-income households.

This paper is organized into four sections. We first discuss how the data were collected, the kind of data analyzed, and the types of statistical tests used. The second section reviews the patterns and differences in energy-related characteristics and energy consumption and expenditures of poor and non-poor households. In the third section, we present models and discuss the principal determinants of energy consumption and energy burden for poor and non-poor households. The concluding section summarizes the key statistical findings and makes recommendations for targeting low-income households in energy conservation programs.

* The only other published national study of low-income households was conducted on an earlier RECS data base [5]. Studies of low-income households in more localized settings have been conducted in California [6] and Decatur, Illinois [7].

METHODOLOGY

RECS is based on a multistage probability sample of housing units, and it provides data on energy consumption and expenditures for the 12-month period of April through March. RECS has been conducted annually, starting in April 1978.* For the 1982-83 survey, of the 5,903 housing units chosen to be in the sample, 5,272 were eligible housing units, and the response rate for this survey was about 90% [9]. The sample size analyzed for this paper was 4660 households, representing all 50 States in the U. S., except Alaska and Hawaii. Most (95% of the sample) of the households were personally interviewed during the Fall of 1982, and mailed questionnaires were used for the remaining 5% of the sample. Detailed information on sample design and data collection is provided in Appendix A of the RECS report [9].

For our analysis, we divided the sample into "poor" and "non-poor" groups, using the U. S. Bureau of Labor and Statistics' definition of the actual poverty level in 1983, which considers income and family size. Total household income included wages, dividends, Social Security, and all other sources of income, before taxes and deductions. An individual living alone and with an annual income less than or equal to $4860 (the threshold level) was classified as poor. For those households with two or more members, the threshold level was increased by an additional annual income of $1680 for every added member. Those households above the threshold level were placed in the non-poor group. The threshold levels are presented in Table 1 for the income and family size variables used in the RECS data base. It is important to note that the definition of poor used in this study is more stringent than the ones used in the implementation of federal programs (e.g., the Weatherization Assistance Program and the Low-income Heating Assistance Program). We used a more restrictive definition because we wanted to focus on those households that were strictly low-income and not marginally low-income (e.g., 150% of poverty level).

* The results of a more recent RECS (for 1984-85) have recently been published, and a publicly available 1984-85 RECS data tape was released in July 1987 [8].

Table 1. Threshold Levels Used for Defining the Poor

Household Members	Household Income (1983)
1	Less than $5,000
2	$5,000 - $6,999
3	$7,000 - $7,999
4	$8,000 - $9,999
5	$10,000 - $11,999
6	$10,000 - $11,999
7	$12,000 - $14,999
8	$15,000 - $16,999
9	$15,000 - $16,999
10 or more	$17,000 - $19,999

We structured our analysis of the RECS data to reflect and assist ongoing energy research, program, and policy initiatives at DOE and at the national research laboratories. Currently, DOE addresses many residential energy issues by focusing on the type of dwelling, for example, single-family and multi-family homes. In our analysis of the RECS data, we used five housing types: mobile homes, single-family detached houses, single-family attached houses, buildings with 2-4 units, and buildings with 5 or more units. In this way, those interested in a particular housing type can focus on selected sections in the following tables that are of special interest to them.

We included the following variables for analysis: demographic characteristics (e.g., race, marital status, and size of household), fuel use (including space heating, cooling, and water heating), energy consumption and expenditures (by individual fuels and total fuels), house type, type of heating and air-conditioning equipment, thermal integrity of the house, appliance ownership, and energy conservation improvements and behavior. Information concerning the housing unit was collected through personal and mail interviews with adult residents. Data concerning energy consumption (fuel use and prices) were obtained from fuel records (electricity, natural gas, fuel oil/kerosene, and liquid petroleum gas) maintained by the household's utilities and fuel suppliers. DOE also added information on annual heating and cooling degree days to each household record.

The sample estimates were weighted by DOE to permit the expansion of the RECS data to the total housing stock. Each housing unit was assigned a "base" weight, the

inverse of the probability of selection for the housing unit. The official population values that were used to adjust the RECS estimates were taken from the Current Population Survey conducted by the U. S. Bureau of the Census. Detailed information on the weighting procedure is provided in Appendix A of the RECS report [9], and a discussion of the limitations of the weighting procedure is presented in another DOE report [10]. We present the results of our analysis in a series of tables, and the percentages in the tables are for the weighted sample. We used the unweighted sample for performing the statistical analyses.

For statistical analysis, we used the appropriate statistical tests and procedures contained in the Statistical Package for Social Sciences X (SPSS-X). For performing significance tests, we used the Chi-square statistic for comparing two nominal variables, as well as for comparing variables with nominal and ordinal levels of measurement. A significance level of 0.05 was used to decide whether the relationship was significant or not. For statistically significant variables involving nominal measurement, Cramer's V values were computed to examine the degree of relationship between the variables. However, since most of these values turned out to be very low and virtually negligible, Cramer's V values were excluded from the tables.

Gamma was computed to measure the strength of association of significantly related ordinal variables. Gamma is a 'proportionate reduction in error' measure which is concerned with the rank ordering of pairs of cases on one variable and is used to predict the rank order on the other variable. It is a symmetrical measure of association with limiting values of -1.0 (negative association) and +1.0 (positive association). A zero Gamma represents no association between the variables, indicating that knowledge of the ranking of pairs on one variable is not useful in predicting rank order on the other variable. Gamma values which were ± 0.40 and higher were included in the tables, otherwise, they were omitted.

The analysis of variance (ANOVA) test was used with interval and nominal or ordinal variables to test the differences among the means of the samples. For a single independent variable, a one-way ANOVA was used, while a two-way ANOVA was computed with two or more independent variables. A significance level of 0.05 was chosen for the analysis.

We used stepwise multiple regression analysis to construct energy-consumption and energy-burden models for poor and non-poor households, so that we could identify those significant variables that helped explain the variation in energy consumption and energy burden in these households. These models are described in detail near the end of this paper.

RESULTS

Distribution of Households

The poor comprise less than 10% of the total households in the country (Table 2). The poor and non-poor occupy similar housing types (over 50% of both groups live in single-family detached units); however, more poor households live in buildings with 5 or more units than the non-poor (23% and 15%, respectively), and there is a statistically significant relationship between house type and income group (Table 3).

Table 2. Distribution of Households by Income Classification

Income Classification	Number of Households	Percent
Poor	7,471,248	9.0
Non-poor	75,878,501	91.0
Total	83,349,749	100.0

Table 3. Distribution of Households by Housing Type and Income Classification (Percentage of Households)

	Income Classification		
Housing type	Total	Poor	Non-Poor
Mobile home	4.5	6.3	4.3
Single-family detached	64.2	51.8	65.4
Single-family attached	4.6	4.0	4.7
Buildings with 2-4 units	12.1	15.0	11.9
Buildings with 5 or more units	14.6	22.9	13.7

Based on Census regions, about 20 to 25% of the poor and non-poor live in the Northeast and Northcentral U.S.; however, there are statistically significant differences in the other regions of the U.S.: about 40% of the poor (versus 33% for the non-poor) live in the South while only 16% of them live in the West (versus 20% for the non-poor) (Table 4). When controlling for house type, the differences between the two income groups are not statistically significant except in single-family detached houses.

Table 4. Distribution of Households by Housing Type, Income Group, and Census Region (Percentage of Households)

Household characteristics	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Region	*				*							
Northeast	20.9	21.6	11.1	10.0	12.0	16.6	67.1	48.2	30.9	34.9	29.0	28.7
Northcentral	23.8	25.7	29.4	16.9	23.0	27.3	13.4	15.6	25.1	25.2	25.2	25.1
South	39.6	33.1	47.6	48.8	46.6	37.6	-	11.5	32.8	22.4	33.0	23.1
West	15.7	19.6	11.9	24.4	18.4	18.5	19.5	24.8	11.2	17.6	12.9	23.0

*Significant at 0.05 level using Chi-square test.

Demographic Characteristics

While more than 50% of both the poor and non-poor own their home, there is a statistically significant relationship between home ownership and income: the non-poor are more likely to be homeowners than the poor (Table 5). When housing type is taken into account, the relationship between home ownership and income is statistically significant only in mobile homes and buildings with 5 or more units: in the former, the non-poor tend to be homeowners, and in the latter, the poor are more likely to be renters.

The homes occupied by the poor and non-poor are mostly old, constructed before 1940, and very few of the homes (2% and 4% for non-poor and poor, respectively) are relatively new (constructed between 1980 and 1983) (Table 5). The main exception to this finding is for mobile homes, in which over 60% of both income groups reported the year of construction to be between 1970 and 1979. There is a statistically significant relationship between income and the age of the home: compared to the non-poor, poor households tend to occupy homes built before 1940, and this is particularly true in single-family detached houses. The poor are also more likely to live in older (1940-59) mobile homes than the non-poor.

A majority (more than 86%) of both the poor and non-poor have relatively few household members (1 to 4), and only 5% of the poor and 13% of the non-poor have 5 to 8 members in their household (Table 5). The relationship between size of household and income is statistically significant: the poor tend to have fewer household members than the non-poor. Moreover, the Gamma (measure of association) value of -0.53 indicates a relatively strong association between the two variables and implies that the more poor the respondents are, the smaller the size of the household. When taking housing type into account, the relationship between size of household and income remains statistically significant across all house types, except in single-family attached units.

A large percentage (39%) of the poor are widowed, followed by the 'now married' category (29%). On the other hand, a majority (65%) of non-poor are 'now married,' followed by the 'divorced/separated' category (14%) (Table 5). The relationship between the marital status of the head of the household and income is statistically significant: the non-poor tend to be currently married while the poor are widowed. When taking housing type into account, the relationship between the marital status of the head of the household and income remains statistically significant across all house types.

A majority of the poor (76%) and non-poor (86%) are white (Table 5). However, the relationship between the race of the head of the household and income is statistically significant: compared to the non-poor, a greater percentage of the poor is black, and this

Table 5. Household Characteristics by Housing Type and Income Classification (Percentage of Households)

Household characteristics	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Dwelling owned/ rented	*		*								*	
Own	50.6	65.9	65.8	81.4	79.0	84.4	62.7	71.0	17.8	21.6	1.7	9.2
Rent	46.9	32.1	20.5	18.6	18.0	13.4	37.3	26.9	82.2	76.5	98.3	88.7
Rent-free	2.4	2.0	13.7	-	3.1	2.1	-	2.1	-	1.9	-	2.2
Year house built	*		*		*							
Before 1940	38.2	27.3	-	-	46.4	26.3	43.0	30.3	50.3	50.7	21.2	19.6
1940-1959	23.6	24.5	30.1	3.4	27.8	30.2	25.1	21.3	17.1	17.3	16.3	10.9
1960-1969	17.3	20.2	5.8	24.2	12.3	20.2	10.9	15.0	19.8	16.1	31.0	23.7
1970-1979	18.9	24.5	64.2	67.1	13.4	20.3	20.9	31.1	7.8	12.2	25.7	39.3
1980-1983	2.1	3.6	-	4.9	-	3.0	-	2.3	5.0	3.8	5.9	6.5
Number of household members	*(- 0.53)		*(-0.57)		*(- 0.54)				*(-0.40)		*(-0.45)	
1	53.8	20.0	53.5	17.8	46.6	13.1	66.0	19.2	53.4	28.4	68.6	46.4
2	29.6	31.6	35.9	35.4	32.5	31.6	11.2	28.8	30.5	32.3	23.9	30.5
3	3.0	17.6	1.3	23.0	4.5	18.7	-	19.3	1.8	16.4	1.6	10.9
4	8.4	17.8	3.9	13.5	10.6	21.1	9.1	15.4	9.9	13.7	3.7	7.4
5	2.9	7.8	4.1	6.4	3.7	9.7	6.2	9.3	3.5	4.5	-	2.0
6	1.2	2.9	1.2	2.5	0.8	3.2	-	4.2	1.0	2.0	2.3	1.6
7	0.8	1.2	-	0.9	0.9	1.2	7.5	2.5	-	1.4	-	0.5
8	0.2	0.6	-	-	0.5	0.7	-	0.5	-	0.3	-	0.4
9 or more	-	0.6	-	0.4	-	0.7	-	0.8	-	1.0	-	0.2

*Significant at 0.05 level using Chi-square test. The figures in parentheses are Gamma values ranging from -1.0 (negative association) to +1.0 (positive association). Gamma is a measure of association.

Table 5. Continued.

Household characteristics	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Marital status of household head	*		*		*		*		*		*	
Now married	29.2	64.8	32.0	71.1	38.0	74.9	11.6	55.9	20.5	44.0	17.1	35.7
Widowed	39.0	11.3	27.8	10.8	39.7	10.7	48.6	14.0	34.3	13.4	41.8	11.1
Divorced/ separated	16.0	13.7	20.6	15.8	11.7	9.3	30.6	24.3	13.3	21.1	23.5	23.8
Never married	15.9	10.3	19.7	2.3	10.5	5.0	9.2	5.8	31.9	21.5	17.6	29.4
Race of household head	*				*						*	
White	75.5	86.2	96.1	94.2	78.3	89.4	85.9	73.4	68.1	78.3	66.2	79.6
Black	22.9	11.6	3.9	5.8	20.0	8.9	14.1	21.7	31.4	18.5	30.8	16.5
American Indian	0.1	0.3	-	-	0.1	0.4	-	-	-	0.3	-	0.1
Asian/Pacific	1.1	1.7	-	-	0.7	1.1	-	3.6	0.5	2.6	2.9	3.8
Other	1.4	0.2	-	-	0.8	0.2	-	1.2	-	0.4	-	-
Education	*		*		*				*		*	
No schooling	1.5	0.5	6.3	-	2.1	0.4	-	0.7	-	0.8	-	0.9
Elementary school	12.4	3.6	4.5	4.2	15.1	3.5	-	4.0	11.7	5.5	11.2	2.3
Junior high school	21.7	7.4	19.6	11.9	27.1	7.6	24.8	6.9	15.1	6.8	13.8	5.8
Some senior high school	18.7	14.5	32.3	17.5	19.2	13.9	35.8	19.9	22.0	16.3	8.6	13.1
Completed high school	27.7	36.4	16.4	47.0	21.0	37.5	30.2	35.1	25.6	30.4	46.9	33.5
Some college	12.4	19	14.0	13.2	18.4	19.0	18.7	20.2	20.5	21.2	12.8	18.9
Completed college	4.5	12.7	1.3	3.7	3.4	12.3	9.2	9.1	5.4	13.4	6.6	17.7
Graduate education	1.0	5.8	-	2.6	0.4	5.8	-	4.1	5.7	5.5	-	7.9

*Significant at 0.05 level using Chi-square test.

Table 5. Continued.

Household characteristics	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Income sources (1983)												
Paid employment	28.7*	73.4	14.3*	70.7	27.5*	73.7	68.6	75.0	35.7*	73.2	23.5*	73.0
Received income from AFDC	5.6	3.2	15.0	2.3	4.7	2.5	14.0	4.0	9.0	6.8	1.4	2.3
Received income from SSI	16.9*	3.8	4.7	4.3	16.8*	33.4	8.3	7.4	10.4	5.6	26.1*	2.6
Received other public aid	7.1*	1.8	20.7	3.2	3.2*	1.5	14.4*	2.6	9.4	2.8	8.8*	1.2
Received food stamps	26.4*	6.4	42.1*	7.0	25.4*	5.1	7.7	9.5	29.6*	12.6	25.6*	4.6
Received social security	67.0*	31.0	67.2*	28.5	74.3*	32.4	51.1	34.9	50.3*	26.7	65.1*	28.9
Received unemployment benefits	2.6*	8.9	-	14.3	3.0*	9.0	2.6	3.3	1.0*	9.2	3.5	8.6

*Significant at 0.05 level using Chi-square test.

is particularly true in single-family detached houses and in buildings with 5 or more units.

The relationship between the education of the head of the household and income is statistically significant: the non-poor are better educated than the poor (Table 5). In fact, over 50% of the poor have not completed a high school education, in contrast to 26% of the non-poor. Also, almost 38% of the non-poor have some education beyond high school (versus 18% of the poor), and almost 14% of the poor do not go beyond elementary school (versus 4% of the non-poor). This relationship remains statistically significant across all house types, except in single-family attached units.

The two income groups rely on different sources of income (Table 5). About 73% of the non-poor, but 29% of the poor derive their income from paid employment (statistically significant). The poor depend more heavily on other income sources (e.g., income from Aid to Families with Dependent Children (AFDC), Social Security Income (SSI), food stamps, social security, and other public aid) than the non-poor. After accounting for house type, the relationship remains statistically significant in many cases (especially in single-family detached houses and in buildings with 5 or more units). The one exception to this dependency is unemployment benefits (related to paid employment) in which a greater percentage of the non-poor (9%), compared to the poor (3%), use these benefits as a source of income.

Heating Fuels

More than 50% of the poor and non-poor use piped (natural) gas as their main home heating fuel (Table 6). The second most used main fuel for heating homes is fuel oil (16%) for the poor and electricity (16%) for the non-poor, and about 7% of each group use wood as their principal home heating fuel. There is no statistically significant relationship between type of heating fuel and income; however, when controlling for house type, a statistically significant difference occurs in mobile homes and in single-family attached houses. In the former, the poor tend to use more electricity and less liquid petroleum gas (lpg) than the non-poor, and, in the latter, the non-poor use less electricity and more lpg than the non-poor.

There is a statistically significant relationship between the use of secondary home heating fuels and income: about 21% of the poor use a secondary source, while almost 37% of the non-poor use such a source (Table 6). The poor tend to use electricity and wood equally (about 10%) as a secondary source, while the non-poor tend to use wood (24%) and some electricity (10%) as backup heat. Differences between the two groups are statistically significant in only one housing type: almost one-half of the non-poor use

Table 6. Fuel Use by Housing Type and Income Classification

(Percentage of Households)

Fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Main home heating fuel			*		*							
Piped gas	54.7	57.1	33.8	28.7	54.6	57.3	63.8	69.5	62.1	69.5	54.4	50.4
Electricity	13.9	16.2	42.9	20.9	5.8	13.5	11.7	16.4	5.8	11.4	29.9	31.4
Fuel oil	16.2	13.3	11.6	11.6	15.2	12.4	12.7	9.2	23.5	15.7	15.7	17.3
Lpg	7.2	4.3	6.3	26.4	12.2	4.5	11.7	1.9	-	0.8	-	0.1
Coal/kerosene	1.7	1.9	5.4	3.8	1.5	0.8	-	0.7	4.1	1.4	-	0.4
Wood	6.2	6.8	-	8.6	10.7	9.6	-	1.7	4.5	0.5	-	-
Others	-	0.1	-	-	-	0.3	-	-	-	0.1	-	-
No fuel used	-	0.2	-	-	-	0.1	-	0.5	-	0.7	-	0.5
Secondary home heating fuel												
Use	21.4*	36.8	6.3	28.0	33.2*	47.0	27.4	28.2	9.6	17.4	9.6	17.4
Piped gas	1.0	1.1	-	-	1.4	1.4	-	-	1.7	0.8	-	0.2
Lpg	1.8	0.9	-	3.5	3.2	1.0	-	1.1	-	-	-	-
Fuel oil	0.8	1.6	-	1.0	1.4	2.1	-	-	-	0.4	-	0.8
Kerosene	1.0	2.0	-	4.5	1.8	2.1	-	3.4	-	1.2	-	0.4
Electricity	10.3	9.8	-	10.1	13.7	10.7	7.7	9.6	10.0	9.7	4.7	5.0
Wood	9.3	23.6	13.6	9.5	13.7	31.2	15.4	16.4	1.7	6.8	1.2	3.1
Coal	0.5	0.2	-	-	0.9	0.3	-	-	-	-	-	-
Others/unknown	75.5	60.7	86.4	71.4	63.9	51.1	76.9	69.9	86.7	81.8	94.2	90.4

*Significant at 0.05 level using Chi-square test.

secondary heating fuels in single-family detached houses, while the poor use only 33%.

Heating Equipment

About 33% of the poor and 50% of the non-poor use central heating systems, followed by gas/oil heaters for the poor (19%) and radiators for the non-poor (15%) (Table 7). There is a statistically significant relationship between heating equipment and income: in contrast to the poor, the non-poor tend to use central units. When controlling for house type, significant differences between the two income groups remain in single-family units. In single-family detached dwellings, over 50% of the non-poor use central warm air, and 8% use gas/oil heaters, while one-third of the poor use central units, and one-third use gas/oil heaters. Also, twice as many of the poor than non-poor use pipeless furnaces. In single-family attached dwellings, the percentage of poor and non-poor using central units is about the same (46%); however, one-quarter of the poor use pipeless furnaces versus 9% of the non-poor. There are no statistically significant differences between the two income groups in the other housing units.

The non-poor are more likely to use secondary home heating equipment than the poor, and this difference (39% vs 25%) is statistically significant (Table 7). The most common type of secondary home heating equipment is a fireplace (16%) for the non-poor and a portable electric heater (7%) for the poor. When house type is controlled for, the relationship between income and secondary home heating equipment is no longer statistically significant, except in single-family detached housing. In this type of construction, almost one-half of the non-poor use secondary home heating equipment (compared to 38% of the poor).

Air-conditioning

There is a statistically significant relationship between income and central air-conditioning equipment: in contrast to the poor, the non-poor tend to have central air-conditioners (29% and 16%, respectively), and this is particularly evident in single-family dwellings (Table 8). In all but a few cases, electricity is the principal fuel used for air-conditioning.

On the other hand, the poor are more likely to have a room air-conditioner than the non-poor (35% and 31%, respectively), and this statistically significant difference continues in single-family dwellings and in buildings with 2-4 units (Table 8). However, in contrast to the total sample, the non-poor are more likely to have a window air-conditioner than the poor in buildings with 2-4 units (36% and 21%, respectively). More than 90% of the poor and the non-poor have only 1-2 window air-conditioners, and there is no

Table 7. Heating Equipment by Housing Type and Income Classification (Percentage of Households)

Heating equipment	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Main home heating equipment	*				*		*					
Hot water pipes	1.6	1.7	-	-	1.0	1.2	-	4.1	-	1.1	4.8	4.3
Radiators	16.6	15.1	-	0.3	3.8	8.6	17.5	25.3	30.7	30.1	40.7	34.7
Central warm air	32.7	48.9	62.6	71.2	33.4	54.0	46.1	46.3	30.0	38.5	22.2	27.3
Heat pump	3.3	4.5	5.9	4.7	2.3	4.4	-	1.3	-	3.0	7.7	6.3
Electric wall	5.3	6.0	-	0.7	2.2	4.6	11.7	8.3	0.8	4.6	15.4	14.9
Gas/oil heater	19.1	6.6	11.7	3.7	30.1	7.5	-	3.5	12.1	9.2	4.4	2.3
Wood/coal stove	5.5	6.4	-	8.6	9.3	9.1	-	1.5	4.5	0.5	-	-
Portable electric heater	1.6	0.9	9.5	2.8	0.7	1.0	-	0.8	3.9	0.4	-	-
Portable kerosene heater	-	0.3	-	3.5	-	0.1	-	-	-	0.5	-	-
Cooking stove	0.6	0.5	-	0.9	-	0.4	-	0.4	4.0	1.2	-	0.4
Pipeless furnace	12.8	8.6	5.2	3.6	16.1	8.3	24.7	8.5	14.0	11.0	4.7	9.8
Fireplace	0.6	0.4	-	-	1.2	0.6	-	-	-	-	-	-
Other	0.3	0.1	5.1	-	-	0.2	-	-	-	0.1	-	-

*Significant at 0.05 level using chi-square test.

Table 7. Continued.

Heating equipment	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Secondary home heating equipment												
Use	25.0*	38.9	6.3	30.9	38.2*	48.6	35.2	30.1	10.2	20.9	8.2	13.5
Hot water pipes	-	0.1	-	-	-	0.2	-	-	-	-	-	-
Radiators	0.3	0.4	-	-	0.5	0.5	-	-	-	0.2	-	0.4
Central furnace	1.3	2.3	-	5.5	2.3	3.0	-	-	-	0.4	-	-
Heat pump	0.3	0.3	-	-	0.5	0.4	-	-	-	-	-	-
Built-in Electric unit	4.0	2.7	-	0.5	5.5	3.2	-	1.1	-	1.6	4.7	1.9
Pipeless furnace	-	0.4	-	-	-	0.4	-	1.1	-	-	-	-
Room heaters	2.5	1.5	-	0.5	4.6	2.0	-	-	-	1.0	-	-
Heating stove	4.3	5.0	9.1	4.5	6.8	6.7	-	4.0	-	0.6	-	-
Fireplace	4.8	16.2	4.5	5.0	7.3	21.0	7.7	11.3	1.7	6.2	-	2.9
Portable electric heater	6.5	8.3	-	9.0	6.8	8.7	15.4	9.0	10.0	7.6	3.5	5.6
Portable kerosene heater	1.5	2.9	-	4.0	2.7	3.5	-	4.0	-	1.0	-	0.4
Cooking stove	2.8	1.1	-	1.5	3.2	0.7	7.7	0.6	3.3	3.3	1.2	1.3
Other/unknown	74.6	59.6	86.4	69.3	59.9	49.6	69.2	68.9	85.0	78.0	90.7	87.5

*Significant at 0.05 level using Chi-square test.

Table 8. Air Conditioning Equipment and Fuel Use by Housing Type and Income Classification (Percentage of Households)

Air conditioning equipment and fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Air conditioning (A/C)												
Central A/C	16.2*	29.2	20.7	24.0	12.4*	31.0	-*	29.1	11.9	14.7	29.1	34.4
Central A/C fuel												
Electricity	99.4	97.1	100.0	100	98.4	97.8	-	96.4	100.0	97.2	100.0	94.0
Piped gas	-	2.9	-	-	-	2.2	-	3.6	-	2.8	-	6.0
Lpg	0.6	-	-	-	1.6	-	-	-	-	-	-	-
Window/wall A/C	34.8*	30.7	30.5	25.9	39.9*	29.8	63.6*	27.3	21.1*	35.8	32.7	28.5
Number of window/wall A/C												
1-2	98.8	92.0	100.0	98.5	98.0	91.2	100.0	82.6	100.0	93.2	100.0	95.4
3-4	1.2	7.0	-	1.5	2.0	7.3	-	14.5		-	6.0	-
5 and above	-	1.1	-	-	-	1.0	-	2.9	-	0.8	-	1.0

*Significant at 0.05 level using Chi-square test.

statistically significant difference between the two groups, even after controlling for house type.

Wood Use

A similar percentage of poor (30%) and non-poor (33%) purchased wood during the year before the survey was taken (Table 9), and there is no statistically significant difference between the two groups. However, the non-poor are almost twice as likely to have burned wood the previous year than the poor (27% and 14%, respectively). This difference is statistically significant, and after controlling for house type, it remains significant in single-family detached dwellings. In terms of usage, which is always difficult for respondents to accurately remember, more than 50% of both the poor and non-poor burned one cord of wood or more during the previous year. No statistically significant difference is evident, even after controlling for house type.

Water Heating Fuel Use

Both the poor (57%) and non-poor (56%) use piped natural gas as their principal fuel source for heating water (Table 10). Electricity is the second most common water heating fuel, for 29% of the poor and 32% of the non-poor. However, there is a statistically significant relationship between the fuel used for water heating and income. There is a greater use of lpg by the poor than the non-poor (6% and 4%, respectively), and this difference is especially marked in single-family dwellings. A very small percentage of both the poor (1%) and non-poor (2%) use a secondary water heating fuel, and this fuel is usually lpg or wood for the poor, and electricity or wood for the non-poor. When housing type is taken into account, there is no significant relationship between fuel type and income.

Appliance Saturation

Almost every poor and non-poor household has at least one refrigerator in their house (Table 11). Of the few households that have more than one refrigerator, the non-poor tend to have more than one (14%), compared to the poor (6%), and this difference is statistically significant. This difference is particularly evident in single-family detached dwellings. However, in single-family attached dwellings, the poor tend to have more than one refrigerator, compared to the non-poor. Almost every poor and non-poor household has at least one freezer, with a small percentage having more than one (Table 11). There is no statistically significant relationship between income and number of freezers, even after controlling for house type. Almost every household has an oven, but

Table 9. Wood Consumption by Housing Type and Income Classification (Percentage of Households)

Wood consumption	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Wood purchased in past year	30.4	33.4	-	18.4	32.5	32.7	-	55.3	43.5	35.0	-	62.8
Wood burned in past year	13.9*	26.9	6.3	14.7	23.1*	37.4	16.5	12.0	5.2	6.6	0.5	3.2
Amount of wood burned in past year												
Less than one cord	34.7	44.7	59.8	29.0	31.8	43.4	84.8	51.6	13.2	61.7	100.0	96.9
One cord or more	65.3	55.3	40.2	71.0	68.2	56.6	15.2	48.4	86.8	38.3	-	3.1

*Significant at 0.05 level using chi-square test.

Table 10. Water Heating Fuel Use by Housing Type and Income Classification (Percentage of Households)

Water fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Main water heating fuel	*				*		*					
Piped gas	56.7	56.4	22.3	23.8	48.8	55.4	76.5	74.6	64.9	72.4	58.4	54.1
Lpg	6.1	3.8	11.7	17.4	9.9	4.3	11.7	0.4	-	1.3	-	0.1
Fuel oil	6.9	6.7	3.8	0.3	3.2	4.6	-	2.4	16.8	9.7	14.6	16.8
Electricity	28.6	32.1	62.3	58.5	35.6	34.2	11.7	22.2	16.0	16.2	27	28.9
Wood	0.4	0.4	-	-	0.6	0.7	-	-	-	-	-	-
Coal/coke/kerosene	0.3	0.1	-	-	-	0.2	-	-	2.2	0.2	-	-
Other	-	0.4	-	-	-	-	0.7	-	-	0.4	2.2	-
No fuel	0.9	0.1	-	-	1.8	0.1	-	-	-	0.3	-	-
Secondary water heating fuel use	1.2	1.8	-	1.0	2.0	2.0	100.0	-	0.9	0.4	-	1.9
Piped gas	11.4	14.3	-	29.5	-	4.2	-	49.2	100.0	-	-	47.1
Lpg	29.1	8.7	-	-	32.9	11.2	-	8.0	-	-	-	-
Fuel oil	-	12.4	-	-	-	4.5	-	42.8	-	68.3	-	48.0
Kerosene/coal	-	4.5	-	-	-	5.1	-	-	-	-	-	-
Electricity	10.5	39.6	70.5	11.8	46.9	-	-	-	-	-	4.9	
Wood	23.2	15.9	-	-	26.2	21.9	-	-	-	-	-	-
Other	25.8	4.5	-	-	29.1	6.1	-	-	-	31.7	-	-

*Significant at 0.05 level using Chi-square test.

Table 11. Appliance Use by Housing Type and Income Classification (Percentage of Households)

Appliance use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Use refrigerator	99.9	99.7	100.0	100.0	100.0	99.8	100.0	100.0	99.0	99.0	100.0	99.8
Number of refrigerators used	*(- 0.43)				*		*(- 0.53)					
One	94.1	85.9	100.0	89.8	90.8	81.8	73.3	88.9	100.0	95.1	100.0	99.0
Two	5.5	13.4	-	9.6	8.5	18.5	26.7	11.1	-	4.6	-	1.0
Three or more	0.4	0.6	-	0.5	0.7	0.8	-	-	-	0.3	-	0.1
Number of freezers used												
One	91.3	91.3	100.0	96.7	89.9	90.3	100.0	99.4	91.7	99.1	100.0	100.0
Two	8.7	8.4	-	3.3	9.4	10.1	0.6	-	8.3	0.9	-	-
Three or more	-	0.3	-	-	-	0.3	-	-	-	-	-	-
Number of ovens used	*(- 0.53)				*(- 0.53)		*(- 0.53)					
One	87.3	69.1	91.8	74.4	84.4	61.9	75.1	70.4	88.5	85.9	95.2	89.5
Two	11.4	27.8	8.2	24.3	13.1	33.8	24.9	28.9	11.5	12.6	4.8	10.5
Three or more	1.3	3.1	-	1.3	2.4	4.3	-	0.7	-	1.5	-	-

*Significant at 0.05 level using Chi-square test. The figures in parentheses are Gamma values ranging from -1.0 (negative association) to +1.0 (positive association). Gamma is a measure of association.

Table 11. Continued.

Appliance use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Electric range (stove top or burner)	43.3*	54.3	44.5	34.2	44.2*	60.5	44.6	33.3	24.0	36.1	53.7	53.8
Gas range (stove top)	56.6*	45.6	55.5	65.1	55.9*	39.6	55.4	66.7	75.0	63.4	46.8	45.6
Automatic clothes washer	48.0*	71.2	52.0*	73.8	66.6*	87.5	50.4*	80.6	40.5	43.7	9.5	13.4
Wringer clothes washer	7.0*	2.6	-	1.5	10.5*	3.4	7.7	3.0	4.1*	1.0	2.7*	0.6
Dishwasher	12.1*	38.5	11.1	20.9	11.7*	43.9	26.3	40.0	6.2*	20.7	14.6*	32.9
Electric clothes dryer	27.3*	47.2	45.6	57.2	40.2*	59.9	30.0	40.7	11.4	21.1	3.2	8.5
Gas clothes dryer	7.9*	15.2	-	5.5	13.4*	18.9	6.2	24.3	-*	10.3	3.1	1.7
Dehumidifier	3.0*	9.6	-	1.0	4.9*	13.5	10.9	5.2	-	4.0	-	0.5
Humidifier	5.7*	14.2	-	9.3	7.5*	18.3	-	7.6	5.6	5.9	4.3	5.8
Evaporative cooler	1.9*	4.5	5.2	16.2	3.0	5.0	-	6.4	-	1.8	0.3	0.1
Whole house cooling fan	6.5	7.9	-	0.8	9.2	11.0	34.1	6.0	2.5	3.5	-	0.2
Ceiling fans	27.2	28.2	12.3	24.0	34.3	30.8	31.6	31.8	24.3	26.9	16.6	17.3
Black and white television	47.4	46.4	45.3	48.7	45.0	47.6	55.4	47.4	63.5*	45.0	41.4	41.0
Color television	71.4*	86.1	64.2	79.1	75.4*	89.9	83.1	87.3	52.6*	77.5	74.6	77.1
Outdoor piped gas grill	1.3*	3.9	-	0.5	1.7	5.1	-	4.5	-	1.7	1.7	0.9
Outdoor lpg gas grill	1.8*	8.3	-	3.8	2.2*	10.9	-	8.2	3.3	2.4	0.5	1.7
Outdoor gas light	0.9	1.8	-	0.3	2.3	1.7	0.7	-	1.4	-	0.1	-

*Significant at 0.05 level using Chi-square test.

there is a statistically significant relationship between income and number of ovens (Table 11). The non-poor are more likely to have more than one oven (31% and 13%, respectively), particularly in single-family dwellings.

The proportion of households having other appliances were low (Table 11); however, statistically significant differences between the two income groups occasionally occur. For example, the non-poor are more likely than the poor to have electric ranges (54% versus 43%, respectively), automatic clothes washers (71% versus 48%), dishwashers (39% versus 12%), electric clothes dryers (47% versus 27%), gas clothes dryers (15% versus 8%), dehumidifiers (10% versus 3%), humidifiers (14% versus 6%), evaporative coolers (5% versus 2%), color televisions (86% versus 71%), outdoor piped gas grills (4% versus 1%), and outdoor lpg gas grills (8% versus 2%). In contrast, the poor are more likely than the non-poor to have gas ranges (57% versus 46%, respectively) and wringer clothes washers (7% versus 3%). When accounting for house type, many of these relationships remain statistically significant in single-family detached dwellings, but, in the other house types, most of the differences are no longer statistically significant.

Thermal Integrity of Home

Thermal integrity refers to those house characteristics (e.g., storm windows and doors, and insulation properties of walls, ceilings, attics, and floors) that limit the amount of heat that enters and leaves a house, and, therefore, give us an idea about the thermal performance of the house. About 40% of the poor and 50% of the non-poor have sliding glass storm doors (usually, one) (Table 12). Compared to the poor, the non-poor are more likely to have one or more sliding glass storm doors, but when controlling for house type, this statistical significance disappears in all house types except in single-family detached houses. Almost 60% of the poor and 50% of the non-poor have storm windows, but the poor tend to have more storm windows than their counterparts (Table 12). When controlling for house type, however, this statistically significant difference disappears in all house types except one: in single-family detached houses, the poor are more likely to have at least one storm window.

About 54% of the non-poor tend to have either all or some of their walls insulated compared to 36% of the poor (Table 12), and this difference is statistically significant. However, when house type is controlled for, these statistically significant differences disappear. There is a statistically significant relationship between income and the presence of attic/roof insulation (43% of the poor and 64% of the non-poor) (Table 12). However, when controlling for house type, the poor are more likely to have roof insulation than the non-poor in single-family homes. Most of those reporting the presence of

Table 12. Thermal Characteristics by Housing Type and Income Classification (Percentage of Households)

Thermal characteristics	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Number of sliding glass storm doors	*(- 0.52)				*(- 0.59)							
None	61.7	50.1	-	70.0	71.0	43.5	11.2	56.4	100.0	69.3	56.5	66.2
One	33.0	39.7	100.0	27.3	27.5	45.0	88.8	33.7	-	18.4	30.4	28.1
Two or more	5.4	10.3	-	2.8	1.5	11.4	-	10.0	-	12.1	13.1	5.7
Number of storm windows	*				*							
None	43.1	54.3	41.9	54.8	44.6	53.5	37.2	53.2	36.0	37.5	23.4	38.6
1-6	10.7	14.5	10.3	3.7	9.9	2.8	6.2	7.2	6.1	14.9	18.4	14.6
7-12	23.1	18.7	23.5	28.4	39.0	26.9	25.5	20.8	25.9	21.4	17.0	21.8
13-18	16.3	10.0	17.0	13.3	6.5	14.2	21.6	15.1	22.1	17.1	27.2	16.3
19 or more	6.8	2.5	7.3	1.2	-	1.3	9.5	3.8	10.0	9.1	14.0	8.6

*Significant at 0.05 level using Chi-square test. The figures in parentheses are Gamma values ranging from -1.0 (negative association) to +1.0 (positive association). Gamma is a measure of association.

Table 12. Continued.

Thermal characteristics	Housing Type by Income Classification							
	Total		Mobile home		Single-family detached		Single-family attached	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Presence of wall insulation	*							
None/No answer	63.9	46.2	8.1	4.8	41.0	24.4	51.0	33.8
All	30.7	44.9	81.0	88.2	49.5	62.7	45.6	50.5
Some	5.4	9.0	10.8	7.1	9.5	12.9	3.4	15.7
Attic/roof insulation	42.7*	63.6	84.2	91.4	87.5*	72.4	81.6*	52.1
% Roof Insulation	*				*			
Don't know	6.0	4.1	-	2.8	6.9	4.3	-	1.8
Less than 5%	2.2	1.7	-	2.2	1.8	1.4	19.2	5.4
5%-33% insulated	1.0	1.7	-	-	1.1	1.5	-	6.4
34%-66% insulated	1.6	3.0	-	1.6	1.8	2.9	-	5.9
67%-95% insulated	2.8	5.6	-	4.8	3.3	5.9	-	1.1
96%-100% insulated	86.4	84.0	100.0	88.5	85.0	84.0	80.8	79.4

*Significant at 0.05 level using Chi-square test.

roof insulation have 96-100% of their roof insulated.

Temperature Regulation and Thermostat Settings

There are several ways households can regulate the temperature in their home during the winter: open and close windows and/or doors, open and close hot air vents, turn heaters (radiators) on and off, adjust fuel usage, and/or use the oven (stove or range) to heat the home (Table 13). The primary means of regulating temperatures in the home for both the poor and non-poor is turning the heater on and off (60% and 50%, respectively). There are statistically significant differences between the poor and the non-poor: the latter are more likely to adjust the heater and fuel usage of wood and coal stoves. When controlling for house type, these differences remain statistically significant in only single-family detached houses. It is interesting to note that about 10% of each group use their ovens (stoves, ranges) to control indoor temperatures, and in mobile homes, this percentage increases to 23% for the poor and 32% for the non-poor. Studies of energy use in public housing have also indicated the frequent use of ovens for heating apartments [11].

One of the most effective and least expensive means of reducing household energy use is through thermostat management [12]. About 82% of the non-poor and 61% of the poor have thermostats, and this difference remains statistically significant in all house types (Table 13). For those households with thermostats, both the poor and the non-poor set similar thermostat temperatures for three different time periods (when someone is home during the day, when the house is vacant during the day, and at night) (Table 14). However, thermostat settings do change for both groups during these time periods. When someone is home during the day during the winter, the thermostat is usually set around 70 °F or above. However, when nobody is home during the day, many of the poor (26%) and non-poor (19%) turn their heat off, and many others set their thermostats in the low 60s (°F). At night, temperature setback is less severe; however, many of the poor (21%) and some of the non-poor (13%) do keep their heat off, and about 20% of each group set their thermostat at 63 °F or below.

Energy Audits

In the last ten years, energy audits have become one of the most important components of energy conservation programs in trying to influence households to invest in energy-efficiency improvements. However, not all households have participated in energy audits. In the RECS survey, residents of single-family houses and mobile homes were asked about their reasons for participating or not participating in energy audits (Table

Table 13. Temperature Regulation and Thermostats by Housing Type and Income Classification (Percentage of Households)

Thermostat and temperature control	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Methods of controlling temperature												
Open/close doors and/or windows	34.6	34.5	23.3	39.6	29.5	25.5	37.8	17.1	20.3	37.8	57.9	55.1
Opene/close hot air vents	1.8	4.3	-	2.4	1.9	3.5	-	-	2.9	9.7	1.4	3.2
Turn heater on/off	59.4*	50.0	94.1	66.2	83.0*	58.5	51.3	71.6	37.4	43.7	23.4	29.6
Turn radiator on/off	3.7	7.4	-	-	-	0.7	-	12.6	9.4	11.3	8.0	21.1
Adjust fuel use	10.5*	18.5	24.3	20.6	15.6*	31.0	-	11.6	9.1	3.3	-	-
Using oven/stove/range	11.3	9.4	23.3	31.6	7.9	7.8	-	-	17.4	14.6	12.8	7.8
Other	-	0.6	-	-	-	0.4	-	-	-	-	-	1.6
Have thermostat	61.2*	81.8	77.7*	87.4	62.1*	84.7	77.1*	89.2	50.5*	75.2	58.7*	69.1

*Significant at 0.05 level using Chi-square test.

Table 14. Room Temperature by Housing Type and Income Classification (Percentage of Households)

Room temperature	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Daytime temperature when someone is at home												
Unknown/no answer	11.0	5.5	-	3.2	11.6	3.4	-	2.3	11.0	10.5	14.9	12.7
Heat turned off	3.4	2.1	-	-	2.8	1.6	-	3.9	6.2	4.5	4.2	2.7
Heat turned on	85.7	92.4	100.0	96.8	85.7	95.0	99.0	93.8	82.7	85.0	80.9	84.6
63 °F and below	3.9	5.4	1.5	2.8	2.8	5.0	6.5	6.3	7.2	5.3	4.5	8.0
64-66 °F	13.4	12.1	17.4	16.0	12.3	12.5	16.9	12.7	13.4	13.7	14.1	7.4
67-69 °F	14.6	24.5	26.9	18.2	16.9	27.8	31.3	27.0	11.0	22.3	5.3	11.8
70 °F	26.7	25.7	21.0	34.4	29.5	25.4	22.0	26.5	25.4	21.2	23.4	28.1
71 °F and above	27.1	24.7	33.2	25.4	24.2	24.3	23.2	21.3	25.7	22.5	33.6	29.3
Daytime temperature when no one is at home												
Unknown/no answer	9.1	4.7	-	0.4	7.1	2.7	-	2.3	10.0	9.4	17.2	12.1
Heat turned off	26.4	18.6	26.7	26.7	31.3	16.9	26.0	19.0	14.5	19.5	23.2	23.4
Heat turned on	64.4	76.7	73.2	72.9	61.7	80.4	73.9	78.7	75.6	71.1	59.6	64.6
63 °F and below	18.9	24.9	25.6	30.6	20.4	26.5	9.2	27.2	21.5	21.0	13.5	17.7
64-66 °F	16.5	17.2	9.9	19.5	14.9	18.5	30.6	17.4	19.4	16.6	17.7	11.1
67-69 °F	8.3	13.1	6.4	5.5	9.9	15.0	13.4	11.8	7.2	12.3	5.3	7.7
70 °F	9.6	11.4	18.3	6.8	9.9	11.4	-	14.3	11.1	9.5	7.3	13.7
71 °F and above	11.1	10.1	13.0	10.5	6.6	9.0	20.7	8.0	16.4	11.7	15.8	14.4

Table 14. Continued.

Room temperature	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Night time temperature												
Unknown/ no answer	8.0	5.1	-	0.8	6.2	2.9	-	4.5	10.0	10.2	14.5	12.6
Heat turned off	21.4	12.8	18.2	14.2	26.6	11.5	19.5	14.5	8.5	13.0	19.3	17.6
Heat turned on	70.6	82.2	81.8	85.0	67.1	85.6	80.5	80.9	81.4	76.9	66.3	69.8
63 °F and below	20.0	23.1	9.9	26.1	20.1	25.5	24.9	27.3	20.7	17.6	21.2	14.2
64-66 °F	17.1	19.5	24.3	23.0	16.6	20.6	13.7	15.5	18.4	17.1	15.9	16.7
67-69 °F	14.7	16.7	22.8	10.5	15.6	18.2	35.2	18.2	14.9	17.5	6.6	9.9
70 °F	10.0	12.6	11.8	14.4	10.6	12.2	-	12.8	15.2	11.6	6.4	14.7
71 °F	8.8	10.3	13.0	11.0	4.2	9.1	6.7	7.1	12.2	13.1	16.2	14.3

15). Only 4% of the non-poor and 2% of the poor received an energy audit during the past year, and the difference between the two income groups is not statistically significant. A greater percentage of the poor have had energy audits in mobile homes than in single-family homes, and vice versa for the non-poor, but there are no statistically significant differences.

Households receiving an audit were asked which of the following reasons were important to them for requesting the audit: high fuel bills, uncomfortable home, planning other improvements at the same time, recommendation of audit by friends or neighbors, or inexpensive cost of audit (in some cases, audits are free or low-cost). A very high percentage of the poor (88%) and the non-poor (69%) felt that high fuel bills were very important for them in requesting an audit. However, about 16% of the poor in single-family detached houses and over 20% of the non-poor in mobile homes and single-family detached houses indicated that high fuel bills were not important, suggesting that noneconomic factors are important in requesting an audit. For example, the comfort of the house was very important for requesting an audit for 35% of the poor and 11% of the non-poor. Comfort may be more important for low-income groups, particularly in mobile homes, and to a lesser extent, in single-family attached homes. Planning other improvements, recommendations by friends or neighbors, and the minimal cost of the audit were not considered to be important reasons by both the poor and non-poor.

For those households not receiving an audit, a list of possible reasons for not participating in an audit was presented to them. The most common reason for not requesting an audit for both the poor and non-poor was that they had never heard about audits (44% and 38%, respectively) (Table 15). About 13% of both income groups also indicated that they did not want an audit because they didn't need outside advice. There is a statistically significant difference between the two income groups, especially in single-family detached homes. In these homes, the non-poor are more likely to be recent occupants, have enough energy conservation measures, have had a previous audit, or have never thought about getting an audit. In contrast, the poor are more likely to be renters, think that the audit costs are too expensive, or have never heard about an audit.

Energy Conservation Improvements

Respondents were asked a series of questions about specific energy conservation improvements taken since 1980 (Table 16). Over 20% of the non-poor added caulking and weatherstripping to their home; over 10% installed plastic sheets over windows, and insulated their roofs and ceilings; and over 5% placed insulation around their hot water tank and pipes, added shutters, drapes, or reflective film around their windows, insulated

Table 15. Energy Audit by Housing Type and Income Classification
(Mobile homes and single-family units only)
(Percentage of Households)

Energy audit	Housing Type by Income Classification							
	Total		Mobile home		Single-family detached		Single-family attached	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Energy audit performed in past year	2.2	3.8	5.1	3.2	2.0	3.9	-	2.9
REASONS FOR AUDIT								
High fuel bills								
Very important	88.1	69.0	100.0	71.2	84.5	67.3	100.0	-
Somewhat important	-	7.7	-	-	-	8.6	-	-
Not a reason	11.9	21.1	-	28.8	15.5	21.8	-	-
No answer	-	2.1	-	-	-	2.3	-	-
Home uncomfortable								
Very important	34.8	11.0	100.0	-	14.8	12.2	-	-
Somewhat important	-	15.8	-	25.3	-	11.9	79.1	-
Not a reason	65.2	65.1	-	53.1	85.2	68.1	20.9	-
No answer	-	8.1	-	21.6	-	7.8	-	-

Table 15. Continued.

Energy audit	Housing Type by Income Classification							
	Total		Mobile home		Single-family detached		Single-family attached	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Planning other improvements								
Very important	-	12.7	-	17.0	-	11.5	-	-
Somewhat important	-	9.2	-	-	-	9.8	-	-
Not a reason	100.0	70.0	100.0	61.4	100.0	71.0	100	78.4
No answer	-	8.1	-	21.6	-	7.8	-	21.6
Friends/neighbors recommended it								
Very important	-	6.5	-	-	-	7.2	-	-
Somewhat important	-	13.7	-	-	-	14.4	-	14.4
Not a reason	100.0	72.5	100.0	78.4	100.0	71.4	-	85.6
No answer	-	7.4	-	21.6	-	7.0	-	-
Audit was a bargain								
Very important	-	31.1	-	17.0	-	33.2	-	6.9
Somewhat important	-	11.3	-	25.3	-	11.1	-	-
Not a reason	100.0	49.6	100.0	36.1	100.0	48.0	-	93.1
No answer	-	8.1	-	21.6	-	7.8	-	-

Table 15. Continued.

Energy audit	Housing Type by Income Classification							
	Total		Mobile home		Single-family detached		Single-family attached	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
REASONS FOR NOT REQUESTING ENERGY AUDIT	*				*			
Utility doesn't offer energy audits	4.5	3.4	11.8	3.1	3.3	3.6	8.6	1.4
Have enough energy conservation items	8.4	12.8	9.0	6.5	8.2	13.6	10.9	6.8
Don't need outside advice	12.5	13.3	8.4	16.8	11.4	13.0	32.4	14.3
Audit costs too expensive	6.9	3.2	5.7	6.2	7.0	2.9	7.5	3.7
Planning on moving soon	0.6	0.7	6.2	1.2	-	0.7	-	-
Just moved in	2.0	4.2	-	4.4	1.7	4.2	9.2	4.4
Renting residence	9.0	6.8	15.2	6.3	8.4	6.3	7.7	14.7
Audit not worthwhile	5.9	6.6	9.8	3.7	6.0	6.9	-	4.5
Never heard about it	44.2	37.6	33.8	44.4	47.1	37.0	23.5	39.9
Had prior audit	0.6	1.8	-	0.5	0.7	2.0	-	0.5
Never thought of it	4.1	7.3	-	6.6	4.9	7.4	-	6.0
Planning to do it	0.4	1.3	-	-	0.5	1.3	-	2.5
Other reasons	0.3	0.3	-	-	0.3	0.4	-	1.2
No answer	0.5	0.4	-	0.2	0.5	0.5	-	0.2

*Significant at 0.05 level using Chi-square test.

Table 16. Energy Conservation Improvements/Installations Since September 1980 by Housing Type and Income Classification
Mobile homes and single-family units only
(Percentage of Households)

Conservation improvements	Housing Type by Income Classification							
	Total		Mobile home		Single-family detached		Single-family attached	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Add clock thermostat	0.8	3.8	-	2.0	1.0	3.8	-	5.1
Flame retention head burner added	1.1	1.0	-	0.9	1.3	0.9	-	1.2
Automatic flue door added	-	1.7	-	0.2	-	1.9	-	0.6
Spark ignition added	0.5	2.4	-	2.3	0.6	2.4	-	2.5
Insulation around heating and/or cooling ducts	1.5	2.8	-	5.4	0.7	2.7	14.0	2.0
Insulation around the hot water and/or cooling pipes	-	5.1	-	6.3	3.7	5.2	14.0	3.6
Insulation around the hot water heater	4.7	7.9	5.5	7.2	5.5	7.8	-	9.4
Closeable shutters, insulating drapes, reflective film added	1.3*	7.5	4.1	9.4	0.8*	7.1	2.6	9.0

*Significant at 0.05 level using Chi-square test.

Table 16. Continued.

Conservation improvements	Housing Type by Income Classification							
	Total		Mobile home		Single-family detached		Single-family attached	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Plastic sheets added over windows or other openings	9.9	13.7	16.4	17.9	9.8	13.5	-	11.7
Caulking added	13.5*	28.6	8.5	13.7	14.6*	29.8	21.2	25.6
Weatherstripping around windows or doors	12.3*	21.4	7.8	16.4	10.0*	21.8	49.4	21.8
Heat pump added	-	0.6	-	0.4	-	0.7	-	-
Woodburning stove added	3.4	5.8	-	7.1	4.0	6.1	-	1.8
Roof/ceiling insulated	6.3	12.6	5.1	8.6	6.9	12.8	-	12.5
Outside walls insulated	2.5	5.8	-	3.0	3.0	6.3	-	2.8
Floor insulated	1.2	4.2	-	3.0	0.7	5.0	10.9	2.9

*Significant at 0.05 level using Chi-square test.

their walls, or added a woodburning stove. In comparison, over 10% of the poor added caulking and weatherstripping to their home, and over 5% insulated their roof/ceiling, or installed plastic sheets over windows. The poor and non-poor were alike in their energy conservation improvements taken since 1980, although there are some statistically significant differences between the two income groups: the non-poor are more likely to have installed closeable shutters, insulating drapes, and reflective film, and added caulking and weatherstripping; these differences remain statistically significant in only single-family detached houses. In summary, the poor have been less active in installing energy conservation improvements than the non-poor since 1980.

Energy Consumption

In 1982-83, the poor's annual electricity consumption of 20 MBtu (million Btu) per household was less than the non-poor's consumption of 26 MBtu per household, and this difference is statistically significant (Table 17).* When housing type is controlled for, the difference is no longer statistically significant; however, the non-poor continue to use more electricity than their counterparts in all house types. The non-poor's annual consumption of piped natural gas is also greater compared to the poor: 78 MBtu per household and 72 MBtu per household, respectively. This difference is statistically significant and remains so after controlling for house type. The exception to the above trend is that the poor use more natural gas in mobile homes than the non-poor.

In contrast to the above fuels, the poor use more fuel oil (86 MBtu per household) than the non-poor (69 MBtu per household), but this difference is not statistically significant. However, when house type is controlled for, differences between the two income groups are statistically significant for all house types: the poor have higher consumption of fuel oil in all house types. However, the non-poor consume more liquid petroleum gas (lpg) than the poor: 41 MBtu per household and 20 MBtu per household, respectively, but this difference is not statistically significant. The poor use more lpg in single-family attached buildings and buildings with 2-4 units, but use less lpg in the other house types (no statistically significant differences).

We calculated total fuel consumption for both poor and non-poor households by adding the consumption of the four fuel types described above. For total consumption, non-poor households consume 22% more energy than poor households (105 MBtu and 86 MBtu, respectively), and this difference is statistically significant. When taking house

* All fuels were transformed into Btus (British thermal units) by DOE, and site electricity, rather than source electricity, was used [9].

Table 17. Average Annual Fuel Use by Housing Type and Income Classification
(Million Btu per household)
(1982-83)

Fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
(1) Electricity	20**	26	29*	30	23*	34	17*	26	14*	21	19*	22
(2) Piped gas	72**	78	78	66	88	102	92	94	59	78	42	53
(3) Fuel oil	86	69	73	32	75	77	100	74	90	87	94	82
(4) Lpg	20	41	13	36	35	43	52	40	2	21	-	64
Total (1&2&3&4)	86**	105	71	72	95	114	106	112	86	100	65	74

*Significant at 0.05 level using Analysis of Variance (ANOVA) test.

**Significant at 0.05 level using ONEWAY Analysis of Variance (ANOVA) test.

type into account, the differences between the two income groups are not statistically significant.

Because we thought energy consumption might be strongly affected by the size of the home, we divided fuel consumption by square footage of the home (Table 18) [7]. The poor have a greater (22% more) total consumption per square foot than the non-poor (0.089 MBtu/ft^2 per household and 0.073 MBtu/ft^2 per household, respectively), and this difference is statistically significant for all households, but the statistical difference disappears when house type is taken into account. For individual fuels, the poor and non-poor consume the same amount (MBtu per square foot per household) of electricity and lpg, but the poor use significantly more piped natural gas and fuel oil than their counterparts. When house type is taken into account, there is a statistically significant difference between the two income groups in electricity consumption and natural gas, however, the relationship is not consistent.

Energy Expenditures

In 1982-83, the non-poor paid $541 per household for their annual electricity consumption while the poor paid $424 per household (Table 19). This difference is statistically significant, and, when house type is controlled for, the differences between the two income groups continues to be statistically significant. For piped natural gas, the non-poor spend more than the poor ($460 per household and $419 per household, respectively), and this difference is statistically significant. However, the differences are no longer statistically significant after accounting for house type.

In contrast to the above fuels, the poor pay more for fuel oil than the non-poor ($733 per household and $586 per household, respectively), but the difference is not statistically significant, even after controlling for house type. For lpg, the non-poor pay more than the poor ($391 per household and $194 per household, respectively), and the only exception in the house types is for single-family attached where the poor pay $456 per household and the non-poor pay $415 per household. However, none of the lpg differences are statistically significant.

We calculated total fuel expenditures for both poor and non-poor households by adding the expenditures of the four fuel types described above. The non-poor spent 25% more than the poor in their total annual fuel expenditures ($1,068 per household and $852 per household, respectively), and this difference is statistically significant. When house type is taken into account, the differences in total expenditures are not statistically significant.

Table 18. Average Annual Fuel Use Per Home Area by Housing Type and Income Classification (Million Btu/ft^2 per household) (1982-83)

Fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
(1) Electricity	0.022	0.021	0.042*	0.036	0.017*	0.019	0.013*	0.017	0.016*	0.021	0.032*	0.029
(2) Piped gas	0.072**	0.062	0.162*	0.076	0.067*	0.054	0.050*	0.054	0.076*	0.081	0.073*	0.073
(3) Fuel oil	0.086**	0.051	0.152	0.045	0.049	0.033	0.049	0.043	0.104	0.076	0.158	0.118
(4) Lpg	0.030	0.032	0.032	0.048	0.029	0.028	0.045	0.029	0.001	0.023	-	0.084
Total (1&2&3&4)	0.089**	0.073	0.129	0.089	0.071	0.061	0.063	0.067	0.106	0.101	0.112	0.103

*Significant at 0.05 level using Analysis of Variance (ANOVA) test.

**Significant at 0.05 level using ONEWAY Analysis of Variance (ANOVA) test.

Table 19. Average Estimated Cost of Fuel Use by Housing Type and Income Classification
(Dollars per household)
(1982-83)

Fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
(1) Electricity	424**	541	549*	563	442*	647	414*	563	296*	467	419*	467
(2) Piped gas	419**	460	395	320	467	554	599	609	363	484	272	334
(3) Fuel oil	733	586	631	281	647	598	849	626	750	731	787	694
(4) Lpg	194	391	151	339	329	398	456	415	35	245	-	558
Total (1&2&3&4)	852**	1,068	822	867	904	1,137	1,034	1,151	796	996	746	833

*Significant at 0.05 level using Analysis of Variance (ANOVA) test.

**Significant at 0.05 level using ONEWAY Analysis of Variance (ANOVA) test.

As in the previous section on energy consumption, we divided fuel expenditures by square footage of the home (Table 20). The poor spent 20% more dollars per square foot than the non-poor. This difference is statistically significant, and the differences between the two income groups in each housing type are statistically significant. For individual fuels, the poor spend more money per square foot on electricity, piped natural gas, and fuel oil than the non-poor (all statistically significant differences).

Energy Burden

The percentage of income spent on residential energy (the "energy burden") was calculated by taking each household's total energy expenditures for 1982-83 and dividing that by the family's income in 1983. Because RECS collects income data in categories (i.e., a family's income is known only by a range), we used category midpoints when dividing expenditures by income. For example, $6,000 was used for each household in the category $5,000 to $6,999 (Table 21). Thus, the energy burden experienced by the households is a "crude" indicator of how much an impact energy expenditures has on their livelihood.

Table 21. Assigned Income Values

Household Income (1983)	Assigned Value
Less than $5,000	$2,500
$5,000 - $6,999	$6,000
$7,000 - $7,999	$7,500
$8,000 - $9,999	$9,000
$10,000 - $11,999	$11,000
$12,000 - $14,999	$13,500
$15,000 - $16,999	$16,000
$17,000 - $19,999	$18,500
$20,000 - $24,999	$22,500
$25,000 - $34,999	$30,000
$35,000 or more	$50,000

The energy burden is significantly higher for the poor than for the non-poor for all households and for all regions of the country (Table 22). The average energy burden is 24% for the poor versus 7% for the non-poor, and the poor's energy burden ranges from a low of 16% in the West to a high of 33% in the Northeast. When house type is taken

Table 20. Average Estimated Cost of Fuel Use Per Home Area by Housing Type and Income Classification (Dollars/ft^2 per household) (1982-83)

Fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
(1) Electricity	0.45**	0.42	0.82*	0.68	0.34*	0.36	0.31*	0.36	0.35*	0.47	0.71*	0.63
(2) Piped gas	0.42**	0.36	0.80*	0.38	0.36*	0.29	0.32*	0.34	0.46*	0.50	0.48*	0.48
(3) Fuel oil	0.74**	0.43	1.31	0.39	0.43	0.28	0.42	0.36	0.87	0.64	1.33	0.99
(4) Lpg	0.30	0.31	0.37	0.46	0.29	0.26	0.40	0.31	0.02	0.27	-	0.73
Total (1&2&3&4)	0.91**	0.76	1.39*	1.09	0.68*	0.62	0.66*	0.69	0.97*	1.00	1.28*	1.16

*Significant at 0.05 level using Analysis of Variance (ANOVA) test.

**Significant at 0.05 level using ONEWAY Analysis of Variance (ANOVA) test.

Table 22. Percentage of Income Spent on Household Energy
(In percent)

Region	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
All regions	24**	7	23	7	23	6	28	9	25	9	24	6
Northeast	33**	9	40	9	32	8	31	12	32	11	33	8
Northcentral	24**	7	19	6	25	7	38	7	26	10	20	6
South	23**	7	21	7	23	7	-	7	20	7	25	7
West	16**	4	23*	5	16*	4	11*	5	17*	4	13*	4

*Significant at 0.05 level using Analysis of Variance (ANOVA) test.

**Significant at 0.05 level using ONEWAY Analysis of Variance (ANOVA) test.

into account, the impact of house type is not statistically significant except in the West.

Determinants of Energy Consumption and Energy Burden

There is a considerable amount of variation in energy consumption and energy burden among poor and non-poor households, and it is important to try to explain this variation for both income groups and to identify the significant determinants of energy consumption and energy burden. Similar to another study of an earlier RECS data base, we examined energy consumption as a function of the capital stock (the structure in which people live and the energy-using equipment they own), the energy intensiveness of that stock, and the ways in which the household uses that stock [13]. These factors are also influenced by climate and demographic characteristics of the household which are also included in our analysis.

We structured our analysis of energy consumption and energy burden in ten analytical blocks, similar to the organization of the results presented in this paper: (1) demographic characteristics (e.g., family size, sex, age, education, and marital status of head of household, home ownership, and number of adults, children, and teenagers); (2) fuels and equipment (e.g., heating fuels, hot water fuels, heating and cooling equipment, and wood-related equipment and usage); (3) appliance saturation; (4) thermal integrity of home (e.g., wall and ceiling insulation); (5) thermostat settings for three conditions (described above) and temperature regulation (e.g., opening and closing windows and doors); (6) energy conservation improvements (e.g., adding time clocks and water heater insulation, or buying a new water heater or air-conditioner); (7) heating problems encountered in past year (e.g., power outages); (8) sources of financial assistance for paying energy bills (e.g., vouchers and governmental assistance); (9) income sources (e.g., wages, social security, and food stamps); and (10) house characteristics (e.g., house type, total floor area, area of heated space, age of home, regional location, and number of heating and cooling degree days (at base 65 °F)). Dummy variables were used in many cases (e.g., type of heating equipment, type of water heating fuel, and marital status). Fuel prices were not used in these models because marginal fuel prices were not available, and average fuel prices could only be calculated by dividing total fuel consumption by total fuel expenditures, and this product would be highly collinear with the dependent variables used in our analyses. The level of significance used for including independent variables in the equations was set at 0.05.

We developed separate regression equations for the poor and non-poor, and two types of dependent variables were used (untransformed and transformed (the natural log)). The model using the logarithmic transformation of dependent variable was used in

order to correct some of the violations in the assumptions used in conducting multiple regression analysis.* This transformation usually resulted in better fits of the regression equations. We first ran separate regression equations on the logarithmic form of the dependent variable in each of the ten blocks for the poor and non-poor. The statistically significant independent variables resulting from these analyses were placed together in a total of four equations for estimating total energy consumption and energy burden for the poor and for the non-poor. Ten independent variables were statistically significant in explaining one-half (the adjusted coefficient of determination (adjusted R^2) was 0.50) of the variation in total energy consumption for poor households when the logarithmic form of the dependent variable was used (Table 23, Model I). These variables included the type of principal home heating fuel (electricity or fuel oil), type of hot water fuel (natural gas or fuel oil), type of home heating equipment (wood or coal stove, or fireplace), use of an automatic clotheswasher, number of people in the household, the area of the home (heated and unheated areas), and whether the household was located in the Northcentral region of the U.S..

Because of the difficulty in interpreting logarthmic dependent variables, the statistically significant independent variables (and their associated dummy variables, where appropriate) were placed in a multiple regression equation where the dependent variable was untransformed (Table 23, Model II). The amount of variation in total consumption explained was 50%, and many of the variables from the first model remain statistically significant.

We conducted a similar analysis for the non-poor and obtained a larger number (19) of statistically significant variables in determining 57% of the variation in total energy consumption (Table 24, Model I). These variables included type of hot water fuel (natural gas, fuel oil, lpg, and electricity), type of home heating equipment (wood or coal stove, fireplace, electric wall units, heat pump, and pipeless furnace), use of an automatic clotheswasher, number of window/wall air-conditioners, presence of a thermostat, number of people in the household, the heated area of the home, the number of rooms in a home, the age of the house, the number of heating degree days, and the location of the home (Northcentral or South region). When these variables (and their associated dummy variables, where appropriate) were placed in a multiple regression equation where the dependent variable was untransformed (Table 24, Model II), the amount of variation in

* For example, the variance of the differences (errors) between estimated and actual energy consumption was not constant (the heteroscedasticity problem) when the untransformed dependent variable was used. This problem disappeared when the logarithmic form was used.

Table 23. Determinants of Energy Consumption for Poor Households

I. Dependent variable = log (total energy consumption (MBtu))

* Main home heating fuel is electricity
* Main home heating fuel is fuel oil
* Main hot water fuel is natural gas
* Main hot water fuel is fuel oil
* Main home heating equipment is a wood or coal stove
* Main home heating equipment is a fireplace
* Use an automatic clotheswasher
* Number of people in household
* Area of home
* Live in the Northcentral region

* Significant at the 0.05 level

Adjusted $R^2 = 0.50$

II. Dependent variable = total energy consumption (MBtu)

	Regression coefficient (b)
Main home heating fuel is natural gas	14.90
Main home heating fuel is lpg	-0.34
* Main home heating fuel is fuel oil	33.32
Main home heating fuel is electricity	-6.92
* Main hot water fuel is natural gas	42.55
* Main hot water fuel is lpg	35.91
* Main hot water fuel is fuel oil	53.22
Main hot water fuel is electricity	24.29
Main home heating equipment is hot water pipe	1.52
Main home heating equipment is radiator	5.04
Main home heating equipment is central warm air	9.05
Main home heating equipment is heat pump	13.73
Main home heating equipment is electric wall unit	4.86
Main home heating equipment is pipeless furnace	12.04
Main home heating equipment is gas or oil heater	8.46
Main home heating equipment is wood or coal stove	-24.16
Main home heating equipment is fireplace	-0.78
* Use an automatic clotheswasher	8.10
* Number of people in household	6.63
* Area of home	0.02
Live in the Northeast region	9.87
* Live in the Northcentral region	20.31
Live in the South region	5.85
Constant	-19.15

* Significant at the 0.05 level

Adjusted $R^2 = 0.50$

Table 24. Determinants of Energy Consumption for Non-poor Households

I. Dependent variable = log (total energy consumption (MBtu))

* Main hot water fuel is natural gas
* Main hot water fuel is fuel oil
* Main hot water fuel is lpg
* Main hot water fuel is electricity
* Main home heating equipment is a wood or coal stove
* Main home heating equipment is a fireplace
* Main home heating equipment are electric wall units
* Main home heating equipment is an heat pump
* Main home heating equipment is a pipeless furnace
* Use an automatic clotheswasher
* Number of window/wall air-conditioners
* Thermostat is present
* Number of people in household
* Heated area of home
* Number of rooms in home
* Age of house
* Live in the Northcentral region
* Live in the South region
* Number of heating degree days

* Significant at the 0.05 level

Adjusted $R^2 = 0.57$

Table 24 continued. Determinants of Energy Consumption for Non-poor Households

II. Dependent variable = total energy consumption (MBtu)

	Regression coefficient (b)
* Main hot water fuel is natural gas	54.76
* Main hot water fuel is lpg	36.43
* Main hot water fuel is fuel oil	54.84
* Main hot water fuel is electricity	28.66
Main home heating equipment is hot water pipe	20.77
* Main home heating equipment is radiator	27.02
* Main home heating equipment is central warm air	18.39
Main home heating equipment is heat pump	-1.31
Main home heating equipment is electric wall unit	-4.60
Main home heating equipment is pipeless furnace	7.01
Main home heating equipment is gas or oil heater	17.40
* Main home heating equipment is wood or coal stove	-32.50
Main home heating equipment is fireplace	-1.52
* Use an automatic clotheswasher	6.55
* Number of window/wall air-conditioners	3.55
* Thermostat is present	9.77
* Number of people in household	5.35
* Heated area of home	0.02
* Number of rooms in home	5.10
* Age of house	-2.73
Live in the Northeast region	2.50
* Live in the Northcentral region	9.45
* Live in the South region	8.23
* Number of heating degree days	0.004
Constant	49.95

* Significant at the 0.05 level

Adjusted $R^2 = 0.51$

total energy consumption was reduced to 51%.

We conducted a similar type of analysis for poor and non-poor in explaining the variation in the total energy burden, and encountered different levels of success for the two income groups. (Table 25). For the non-poor, we were unable to create an equation with any statistically significant variables, and, therefore, no results are presented.* For the poor, we were able to explain 53% of the variation in total energy burden when the logarithmic form of the dependent variable was used (Table 25, Model I). The thirteen statistically significant variables included main home heating fuel (fuel oil), main home heating equipment (wood or coal stove), use of central air-conditioning, installation of a new heating system since 1980, addition of floor insulation since 1980, whether person was married, number of people in household, whether they received income from AFDC, the age of the respondent, the location of the home (Northeast, Northcentral, or South region), and the number of heating degree days. When these variables (and their associated dummy variables, where appropriate) were included in the regression equation with the untransformed dependent variable, the amount of variation explain dropped to 42%, and some of the independent variables lossed their statistical significance (Table 25, Model II).

In summary, we were able to predict approximately one-half of residential energy use and one-half of the energy burden of low-income households with equations containing a few independent variables. By obtaining information on fuel type, heating equipment, location of home, and household composition, policy makers are able to predict the energy consumption and burden of low-income households. Forecasters are also able to see how energy consumption will change in the future for these households as changes in type of fuel and heating equipment, for example, are made.

The equations developed here represent exploratory work and should be regarded as an initial effort in using the RECS data. Additional analysis is likely to be fruitful by stratifying the data by region, housing type, primary heating fuel, etc. and developing separate equations for each stratum. Also, it would be useful if a measure of wood consumption (in MBtu) could be included in total consumption since 6-7% of both income groups use wood as their primary heating fuel and an additional 9-24% use wood as a secondary heating fuel.

Because of time constraints and concern for maintaining a large sample size for poor households, we decided to use all the households in the RECS sample. However, we

* In each of the blocks analyzed, statistically significant variables were discovered; however, when these variables were combined, their statistical significance disappeared.

Table 25. Determinants of Energy Burden for Poor Households

I. Dependent variable = log (total energy burden (%))

* Main home heating fuel is fuel oil
* Main home heating equipment is wood or coal stove
* Have central air-conditioning
* Bought a new heating system since Sept. 1980
* Added floor insulation since Sept. 1980
* Married
* Number of people in household
* Received income from AFDC
* Age of respondent
* Live in the Northeast region
* Live in the Northcentral region
* Live in the South region
* Number of heating degree days

* Significant at the 0.05 level

Adjusted $R^2 = 0.53$

Table 25 continued. Determinants of Energy Burden for Poor Households

II. Dependent variable = total energy burden (%)

	Regression coefficient (b)
Main home heating fuel is natural gas	-0.05
Main home heating fuel is lpg	-0.03
Main home heating fuel is fuel oil	0.06
Main home heating fuel is electricity	-0.08
Main home heating equipment is hot water pipe	-0.05
Main home heating equipment is radiator	-0.02
Main home heating equipment is central warm air	0.01
Main home heating equipment is heat pump	0.04
Main home heating equipment is electric wall unit	0.001
Main home heating equipment is pipeless furnace	-0.01
Main home heating equipment is gas or oil heater	-0.002
Main home heating equipment is wood or coal stove	-0.10
Main home heating equipment is fireplace	-0.01
* Have central air-conditioning	0.06
Bought a new heating system since Sept. 1980	-0.001
* Added floor insulation since Sept. 1980	0.23
* Married	-0.18
* Divorced	-0.06
* Widowed	-0.06
Number of people in household	
* Received income from AFDC	-0.11
* Age of respondent	0.002
* Live in the Northeast region	0.10
Live in the Northcentral region	0.04
* Live in the South region	0.05
Number of heating degree days	
Constant	0.20

* Significant at the 0.05 level

Adjusted $R^2 = 0.42$

could have excluded cases if we were more stringent about the quality of the data or about certain responses. For example, we could have dropped respondents: with mail questionnaire responses, whose main and secondary space fuels were imputed, who live in multi-family units, who were outliers on selected variables (e.g., energy use and floor area), who used wood as a primary heating fuel, whose energy costs were included in their rent, or whose fuel consumption was estimated (rather than based on actual readings). If we had filtered the data in this manner and had a large enough sample size for low-income households, we would expect to explain a greater amount of variation in our dependent variables.

DISCUSSION AND CONCLUSIONS

The principal objective of this study is to compare poor and non-poor households to see whether the two groups are similar or different with respect to energy consumption and expenditures, housing characteristics, and energy-related behavior. We based our study on an analysis of a national data base created by the U.S. Department of Energy, the 1982-83 Residential Energy Consumption Survey (RECS). We found a number of statistically significant (at the 0.05 level) differences between the two income groups, suggesting different approaches that might be taken for improving the targeting of energy conservation programs to low-income households. We've organized the following discussion of the results into eight sections: demographics, heating/cooling/water heating, other appliances, thermal integrity, energy conservation behavior, energy consumption, energy expenditures, and energy burden (Table 26).

Compared to the non-poor, the poor are more likely to live in multi-family housing, reside in the South, rent their home, live in very old (pre-1940) housing stock, have smaller households, be single, be black, have less education, and be more dependent on outside sources of financial assistance. Although there is no consistent relationship in the interaction between housing type and income for these demographic variables, the type of housing does significantly impact on all of these variables.

Compared to the non-poor, the poor tend to have different main and secondary heating equipment, have more window/wall cooling units, and use different fuels to heat water. On the other hand, the poor are less likely to use secondary heating, have central air-conditioning, burn wood, and have a thermostat to regulate the temperature in their homes. House type does have a significant impact on all of these variables: in particular, the main heating fuel used by the poor is statistically different than the non-poor in mobile homes and single-family detached housing; however, when house type is not accounted for, differences between the poor and non-poor are not statistically significant. The two income groups are alike in the fuel used for air-conditioning (electricity), the number of window air-conditioners (1-2), the amount of wood burned in the previous year, and in their use of secondary water heating (1-2%).

The poor are more likely to have gas ranges and wringer clothes washers than the non-poor. However, the poor are less likely to have more than one refrigerator or oven, electric ranges, automatic clothes washers, dishwashers, electric or gas clothes dryers, dehumidifiers, humidifiers, evaporative coolers, color televisions, outdoor piped gas grills, and outdoor lpg gas grills. House type has a significant impact on many of these variables (especially, in single-family detached housing).

Table 26. Summary Table of Significant Variables

	Total	Housing Type				
		Mobile home	Single-family detached	Single-family attached	Buildings with 2-4 units	Buildings with 5 or more units
Demographics						
Type of home	*					
Location (Region)	*		*			
Own/rent home	*	*				*
Age of home	*	*	*			
Number of people in home	*	*	*		*	*
Marital status	*	*	*	*	*	*
Race	*		*		*	
Education	*	*	*		*	*
Paid employment	*	*	*		*	*
Received SSI income	*		*			*
Received public aid	*		*	*		*
Received food stamps	*	*	*		*	*
Received social security	*	*	*		*	*
Received unemployment benefits	*		*		*	
Heating/Cooling/ Water Heating						
Main heating fuel		*	*			
Uses secondary heating	*		*			
Main heating equipment	*		*	*		
Uses secondary heating equip.	*		*			
Central air-conditioner	*		*	*		
Window air-conditioner	*		*	*	*	
Burned wood last year	*		*			
Main water heating fuel	*		*	*		
Have thermostat	*	*	*	*	*	*
Other Appliances						
Number of refrigerators	*		*	*		
Number of ovens	*		*	*		
Electric range	*		*			
Gas range	*		*			
Automatic clothes washer	*	*	*	*		
Wringer clothes washer	*		*		*	*
Dishwasher	*		*		*	*
Electric clothes dryer	*		*		*	
Dehumidifier	*		*			
Humidifier	*		*			
Evaporative cooler	*					
Black and white TV					*	
Color TV	*		*		*	
Outdoor piped gas grill	*					
Outdoor lpg gas grill	*		*			

Table 26 continued. Summary Table of Significant Variables

	Total	Housing Type				
		Mobile home	Single-family detached	Single-family attached	Buildings with 2-4 units	Buildings with 5 or more units
Thermal Integrity						
Number of sliding glass storm doors	*		*			
Number of storm windows	*		*			
Wall insulation	*		*	*		
Attic/roof insulation	*					
Percent of roof insulated	*		*			
Conservation Behavior						
Turn heater on/off	*		*			
Adjust fuel use	*		*			
Installed shutters/drapes/film	*		*			
Added caulking	*		*			
Added weatherstripping	*		*			
Reasons for no audit	*		*			
Energy Consumption						
Electricity	*	*	*	*	*	*
Gas	*	*	*	*	*	*
Fuel oil	*					
Total	*					
Energy Expenditures						
Electricity	*	*	*	*	*	*
Gas	*	*	*	*	*	*
Fuel oil	*					
Total	*	*	*	*	*	*
Energy Burden						
All regions	*					
Northeast	*					
Northcentral	*					
South	*					
West	*	*	*	*	*	*

Compared to the non-poor, the poor are more likely to have more than one storm window, but they are less likely to have more than one sliding glass storm door and insulation in their walls or attics. Also, the poor are less likely to have added caulking, weatherstripping, or window shutters and drapes. Poor households expressed different reasons than the non-poor for not having an energy audit: they are more likely to think that audit costs are too expensive, to have never heard about an audit, or to be renters. This was particularly true in single-family houses.

The poor used and spent less on electricity and natural gas than the non-poor. However, when these figures were standardized (divided by area of home), the poor used and spent more on energy than their counterparts. This was also true for total consumption and expenditures. In terms of total energy consumption (MBtu), the non-poor consumed 22% more energy than the poor, but in terms of total energy consumption per square foot (MBtu per ft^2), the poor consumed 22% more energy than the non-poor. In terms of total energy expenditures, the non-poor spent 25% more dollars than the poor, but in terms of total energy expenditures per square foot, the poor spent 20% more dollars than the non-poor.

The percentage of income spent on energy was much higher for the poor (24%) than for the non-poor (7%), and this was evident in all regions of the country. In the West, house type did have an additional significant impact on energy burden.

Approximately half the variation in energy use in low-income households can be explained with a regression model that includes 10 independent variables. The key determinants of total energy consumption in low-income households are: the type of principal home heating fuel (electricity or fuel oil), type of hot water fuel (natural gas or fuel oil), type of home heating equipment (wood or coal stove, or fireplace), use of an automatic clotheswasher, number of people in the household, the area of the home (heated and unheated areas), and whether the household was located in the Northcentral region of the U.S..

Approximately half the variation in energy burden for poor households can be explained with a regression model that includes 13 independent variables. The key determinants of energy burden in low-income households are: main home heating fuel (fuel oil), main home heating equipment (wood or coal stove), use of central air-conditioning, installation of a new heating system since 1980, addition of floor insulation since 1980, whether person was married, number of people in household, whether they received income from AFDC, the age of the respondent, the location of the home (Northeast, Northcentral, or South region), and the number of heating degree days.

In conclusion, the energy burden of the poor is very large as energy costs account for almost one-quarter of their household income. However, energy conservation programs targeted to the key determinants affecting energy consumption and energy burden can help improve the economic situation of low-income households. For example, program resources might be focused on households with fuel oil as their main heating fuel, large households, and houses located in colder climates. Also, if audits are to continue as a primary mechanism in assisting low-income households, then the benefits of improved comfort, as a result of improved energy efficiency, should be emphasized to low-income households as part of the audit marketing process. Finally, the results presented in this paper are "snapshots" taken over one period of time (1983-84). A longitudinal analysis of low-income households and their energy consumption and burden is needed to provide a more comprehensive and dynamic picture. This need will become ever more urgent if the cost of energy begins to escalate as it did in the 1970s.

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