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LOW-INCOME HOUSEHOLDS AND ENERGY USE IN CALIFORNIA

E.L. Vine and S.J. Gold

March 1985

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Abstract

We examine in this report the relationship between energy consumption and income with a particular emphasis on low-income households in California. The low-income population constitutes 10-20% of California's population, and almost 20% of these people live in the rural areas of California. While home energy use (primarily electricity and natural gas) and payments of low-income households are less than those of other income groups, the former's "payment burden" (fraction of income spent on home energy) is as much as 350% greater than the burden for high-income households.

In comparison to the average household, the average low-income household owns only one vehicle that is likely to be an older and inefficient model. Low-income people drive their cars less than other people and usually use the car only for necessary trips. They also live closer to work and use public transit more often than other groups. Accordingly, the low-income population spend less money on gasoline and transportation costs than other income groups; however, low-income households spend a 2 to 3 times larger fraction of their income on transportation energy than do high-income households. Of course, low-income households also spend proportionately more of their income on public transportation than other income groups.

The differences in the consumption of goods (market basket) between low-income households and the average household are not large, although it appears that low-income households in California spend proportionately more of their budget on food and shelter and less on recreation, health care, and food consumed away from home than the average household. Indirect energy consumption (i.e., the energy use contained in products consumed by households) for low-income households is 45% less than for the average household. However, as a percentage of total expenditures, the total amount of energy required for providing the market basket is similar for both income groups with slight

regional differences in California. The indirect energy consumption of all income groups would be affected by changes in the cost of electricity and natural gas since these two fuels constitute almost 60% of the total cost of energy needed to produce the California market basket.

Data were not available to examine the determinants of energy use among low-income households. Based on previous work in analyzing energy use in the residential sector for all income groups, we believe that the following variables could be important in affecting energy use among low-income households: poorly constructed housing with little or no insulation in the walls and ceiling and large air infiltration rates; inefficient heating and cooling appliances; and energy intensive behavior. Appropriate remedies could include promoting the use of energy conservation measures: e.g., efficient appliances, low-flow showerheads, night setbacks, and insulation of water heaters. In addition, special outreach programs involving education, technical assistance, and financial incentives may be necessary for promoting the use of energy-conserving measures and making low-income people more aware of less energy intensive lifestyles. This is especially important for the rental sector in which low-income renters have little incentive for installing energy-conservation technologies in dwellings that are owned by landlords. Comprehensive programs may be needed to complement some of the on-going state agency programs in which financial subsidies are the common remedy for assisting low-income people.

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I. INTRODUCTION

We examine in this report the relationship between energy consumption and income with a particular emphasis on low-income households in California. Recent national, regional, and state data indicate that low-income households bear a greater burden of the impact of energy prices. Although low-income households consume less energy than other income groups, their expenditures on energy as a percentage of total household income are greater for low-income households than for other income groups. Moreover, current federal and state energy programs targeted to this group do not appear to be adequate in meeting their needs. Consequently, there is an urgent need for creating more effective energy conservation programs for low-income households.

We first define the "low-income" group and estimate their numbers in total and in urban/rural and owner/renter sub-categories. We then examine home energy use (primarily, electricity and natural gas use and billing data), estimate their price elasticity, and examine selected energy-related characteristics (e.g., heating and cooling systems) of low-income households. We next analyze transportation-related characteristics of low-income households: vehicle ownership and mileage, commuting distance, and transportation costs. In the last section, we examine the indirect energy consumption of low-income households by calculating the energy costs of market baskets for different income groups.

We limited the search for information on this topic to secondary data sources. We obtained most of the data on California from utility companies and state government agencies; national data was available from the federal government and its national laboratories. We focused on California data; however, we often had to rely on regional and national data for filling in some of our data needs. National data may not be representative of California due to California's climate and unique mix of private and public transportation infrastructure. We also relied on "old" (e.g., 1977) data when more recent data on a particular topic was unavailable.

II. DEFINING AND ESTIMATING THE LOW-INCOME POPULATION

A. Total Households

There are a number of methodological issues involved in the analysis of energy use and income. One of the first problems encountered in addressing this issue is one of definition: what constitutes a low-income household? We discovered a number of different definitions by researchers working in the field. For example, the 1984 federal definition of poverty for a family of four persons is $10,200 (Federal Register, 1984). For one person, the poverty level is $4,980. In some programs, 125% of the poverty level is used: $12,750

for a family of four in 1984. California uses the federal definition statewide.[1] Other researchers, relying on survey data collected by other groups, have used "less than $7500 per household" or "$10,000 or less per household" without regard to size of household (Feizollahi, 1982a, 1982b). Finally, some people use the "family" as the unit of definition while other use "person" (see below).

The second problem encountered was obtaining an accurate estimate of the number of people that fall in the "low-income" category. The source for this information was primarily U.S. Census data which have a number of inherent limitations. For example, household selection is biased: low-income households, renters, and minorities are often under-reported in surveys and censuses. Also, self-reported income data may not be accurate: many individuals do not report the total amount of money earned (cash transactions are usually not reported), and accurate records are often not kept. Another source--state income tax returns--also has problems and is considered "worthless" for estimating low-income people because the "real" poor don't file returns, and those who report adjusted gross incomes less than $4,000 are often upper-income households with tax write-offs.[2] Consequently, state income data from tax returns were not used.

In 1980, the percentage of persons in California below the poverty level (in 1979 dollars) was 11.4% (2,626,580) of the state population (U.S Department of Commerce, 1980, 1983b, 1984).[3] The percentage of families in California below the poverty level was 8.7% (521,138) of all California families.[4] In 1981, there were 1,299,500 households below 125% of the poverty level in California (Saul, et. al, 1983).

We obtained estimates of the percentage of low-income people in Northern and Southern California from utility company studies. Based on their 1981 Residential Appliance Saturation Survey, Pacific Gas and Electric (PG&E) estimated that 17.1% of their customers had incomes under $10,000 (Pacific Gas and Electric, 1983). Using the same data base, Feizollahi estimated that 19% of the PG&E sample had incomes below $10,000 (Feizollahi, 1982a). Using the 1979 Residential Appliance Saturation Survey, Feizollahi estimated that 24.7% of PG&E's customers were low-income households (Feizollahi, 1982a). Minimax estimated a lower percentage (19.5%) of PG&E low-income households (incomes less than $10,115) using PG&E's 1979 data base (Minimax, 1981). Based on their 1983 Residential Appliance Saturation Survey, Southern California Edison estimated that 25% of their households had household incomes below 150% of the poverty level, and 33% of their households had household incomes below 200% of the poverty level (Harbicht Research Inc., 1983). Based on San Diego Gas and Electric's 1979 Residential Appliance Saturation Survey, Feizollahi estimated that 16% of their customers had incomes of $10,000 or less (Feizollahi,

1982b). Thus, it appears that the low-income population constitutes 10-20% of the California population.

Regional data also provide some indication of the number of low-income households in California; however, because the regions are large and comprise several other states, they are less accurate for our purposes. For example, the U.S. Department of Energy estimated that families with income less than $10,000 comprised 27.1% of all households in the Pacific Region in 1979 (U.S. Department of Energy, 1983a). The Pacific Region includes California, Oregon, Washington, Alaska, and Hawaii. The U.S. Department of Commerce reported that housing units with income of less than $10,000 comprised 26% of all households in the West Region in 1981 (U.S. Department of Commerce, 1983a). The West Region includes California, Oregon, Washington, Montana, Idaho, Wyoming, Nevada, Utah, Colorado, and New Mexico. The large number of low-income households in these other states implies that the 26% figure overestimates the percentage of low-income households in California.

B. Urban/Rural Households

The geographical distribution of low-income households in California is an important factor for targeting energy programs. Using 1980 Census data, 91% (19,328,433) persons in California lived in an urban area in 1979, and 9% (1,998,735) lived in a rural area (U.S. Department of Commerce, 1983b). And 83% (2,174,345) of persons below the 1979 poverty level in California lived in an urban area in 1979, while 17% (224,191) lived in a rural area (U.S. Department of Commerce, 1983b). Persons below the 1979 poverty level constituted 11.3% of all rural persons. Using the same data base, 90% (4,948,122) of families in California lived in an urban area in 1979, and 10% (550,170) lived in a rural area (U.S. Department of Commerce, 1983b). And 82% (426,549) of families below the poverty level in California lived in an urban area in 1979, while 18% (47,937) lived in a rural area (U.S. Department of Commerce, 1983b). Families below the 1979 poverty level constituted 8.7% of all rural families. Thus, the low-income populations is proportionately more of a rural population than other income groups.

C. Owner/Renter Households

There is a high correlation between low-income households and rental units. Pacific Gas and Electric (PG&E) has extensively analyzed their low income customers using data from their 1981 Residential Appliance Saturation Survey (RASS) (Pacific Gas and Electric, 1983).[5] PG&E examined three groups of low-income RASS respondents: low-income households (as defined in U.S. Department of Energy (DOE) and other federal programs), low-income households with

elderly members, and those low-income households who have been targeted for PG&E's ZIP Direct Weatherization program of conservation financing:

DOE low-income - households with income less than 125% of the poverty level (20.7% of all PG&E households)

Elderly low-income - households with one or more members 65 years of age or older, with total household income less than $10,000 per year (8.0% of all PG&E households)

ZIP Direct Weatherization Target - single-family, owner-occupied homes that have incomes 150% of the poverty level (in some cases, 200% of the poverty level), are eligible for this program (7.6% of all PG&E households)

PG&E found that 43.5% of the DOE low-income group owned their dwelling (54.7% rented), and 62.8% of the elderly low-income group owned their dwelling (34.9% rented), in comparison to 63.4% of all PG&E individually metered households owning their dwelling (35.3% rented). All of the ZIP participants were homeowners, a requirement of the program.

Southern California Edison estimated that 22% of households with incomes below 150% of the poverty level that had electric space heating were owner-occupied while 78% were renter-occupied (Harbicht Research Inc., 1983). However, the pattern was different for low-income households that had central electric air conditioning: 49% owned their homes and 51% rented them. For the low-income population with incomes below 200% of the poverty level, the results were similar to households with incomes below 150% of the poverty level.

Using census data, 24% (12,774,000) of owner-occupied households in California had 1981 incomes below $10,000, and 43% (12,501,000) of renter-occupied households had 1981 incomes below $10,000 (U.S. Department of Commerce, 1983b). The total number of housing units in California in 1980 was 8,629,866 (U.S. Department of Commerce, 1982).[6] Of this total, 56% (4,825,252) were owner-occupied and 44% (3,804,614) were renter-occupied. In urban areas, these percentages were nearly identical: 54% (4,326,321) were owner-occupied and 46% (3,606,000) were renter-occupied. In rural areas, 71% (498,931) of total housing units were owner-occupied and 29% (198,524) were renter-occupied.

III. LOW-INCOME HOUSEHOLDS AND HOME ENERGY USE

One of the most detailed studies of income and home energy use was prepared by the California Energy Commission in an unpublished report (Feizollahi, 1982a). In this study, a sample of customers from Pacific Gas and Electric's (PG&E) Residential Appliance Saturation Survey was selected, and their energy use from May 1, 1979 to April 30, 1980 was examined (Table 1 and Figures 1-3).[7] Gas, electricity and total energy usage were examined in both energy units and dollars for low-income (less than $7,500), median income ($15,000-$17,500; for renters: $10,000-$12,500), and high income ($30,000 and above) households. In addition, their "utility burden" was estimated by dividing the sum of their gas and electricity bills by income.[8] Low-income households' total energy consumption (in million British Thermal Units (MBtus) of site energy) was 55% of high-income households' usage. In terms of capital outlay, low-income households spent 49% of what high-income households spent on energy bills. However, in terms of utility burden, low-income households' burden was 350% greater than the high-income households' burden. These differences were slightly less for renters and slightly more for homeowners, and the comparisons were similar for both natural gas and electricity.

In a second study of PG&E customers, the burden for low-income households (with household income below $10,115 in 1979 dollars) was greater for those families with electric air conditioners and electric heat than for those without these features (Table 2) (Minimax, 1981). The difference in electricity usage was over 1,000 kWh, or $40 per year; the utility burden for those with air conditioners was 133% greater than for those without air conditioners. The utility burden for gas customers was 2.7%.

Using their 1981 Residential Appliance Saturation Survey (RASS), PG&E analyzed billing and consumption data for three groups of low-income households (see above for definitions of groups) (Pacific Gas and Electric, 1983). In Table 3, average combined bills for monthly electricity and natural gas for three PG&E low-income groups and a group of individually metered PG&E households are compared. Individually metered households had the highest bills, followed by ZIP Direct Weatherization households (all single-family households), DOE low-income households, and the elderly low-income households. Table 3 includes information on the size of natural gas and electric bills separately; the same relative order of bill size was maintained for each fuel type, except that the individually metered and ZIP group reported the identical average gas bill. Overall, variation in the size of average electric bills was larger than the variation in the size of average gas bills. The difference in variation may be due to the larger number of electric appliances in a home in comparison to the number of gas appliances (often gas water heating and/or space heating) as well as a number of other factors discussed at

Table 1. Energy Consumption, Payment and Burden: Pacific Gas and Electric's Customers (1979)[a]

	Household Energy			Natural Gas			Electricity		
	Consumption[b] (MBtu)	Payment[c] ($)	Payment Burden[d] (%)	Consumption (therms)	Payment ($)	Payment Burden[d] (%)	Consumption (kWh)	Payment ($)	Payment Burden[d] (%)
Low Income (Less than $7,500)									
All households	84	377	5.3	620	164	2.3	5,930	213	3.0
Renters	72	316	4.6	538	143	2.1	4,786	173	2.5
Homeowners	91	408	5.8	668	177	2.5	6,454	231	3.3
Median Income ($15,000-$17,500)									
All households	114	572	3.5	784	213	1.3	9,701	359	2.2
Renters	80	369	3.3	579	154	1.4	5,842	215	1.9
Homeowners	118	591	3.6	800	216	1.3	10,161	375	2.3
High Income ($30,000 or more)									
All households	152	768	1.5	1,066	307	0.6	12,111	461	0.9
Renters	104	527	1.0	709	195	0.4	8,815	332	0.6
Homeowners	154	780	1.5	1,084	312	0.6	12,274	468	0.9

[a]Energy consumption is from May 1, 1979 to April 30, 1980.
[b]Household energy consumption is the sum of electricity (site electricity) and gas consumption.
[c]Household energy payment is the sum of electricity and gas bills in 1979 dollars.
[d]Payment burden is defined as the percentage of income paid for gas and/or electric bills (see text for income calculations).

Source: Feizollahi, 1982a, Table A

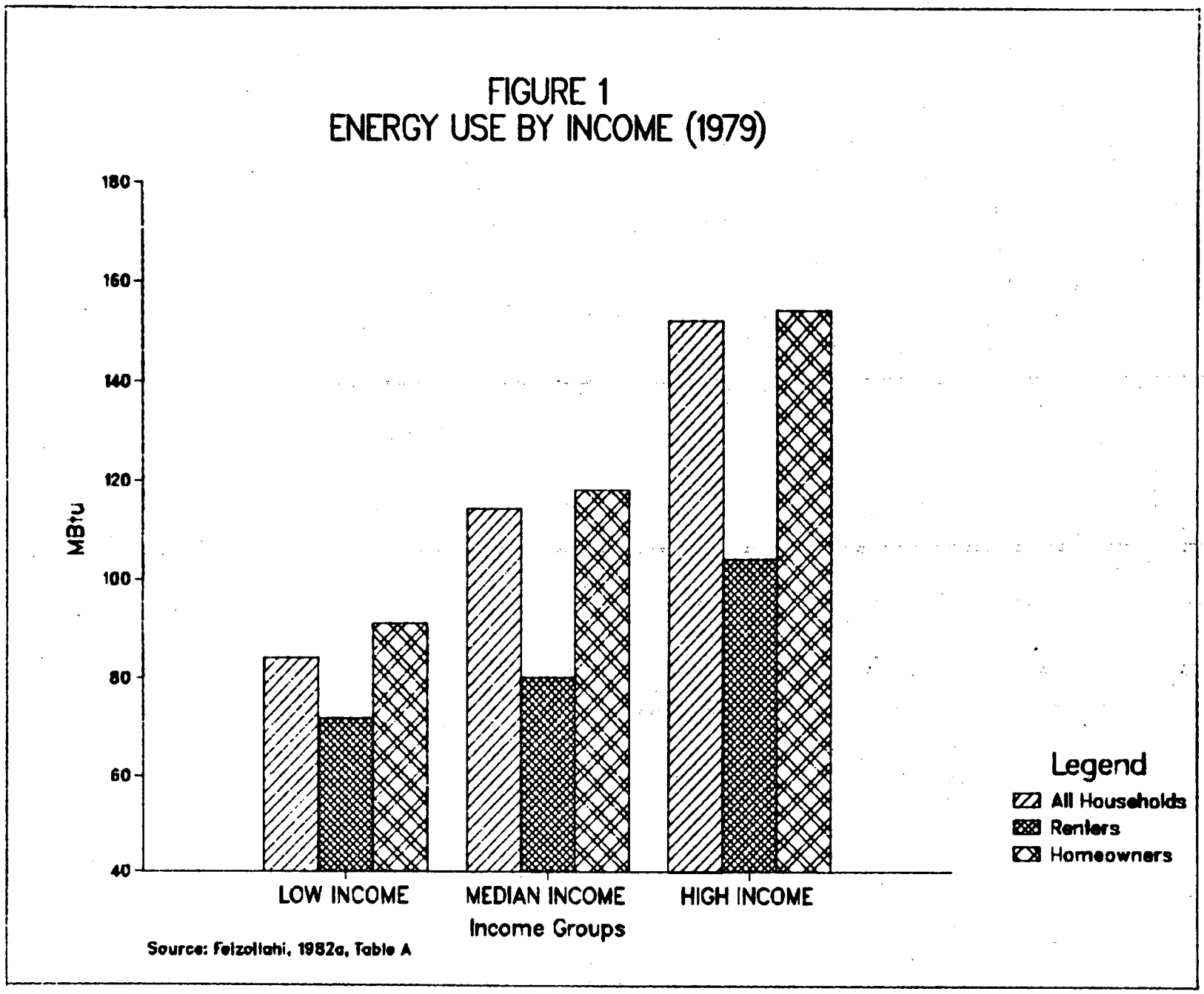


FIGURE 1
ENERGY USE BY INCOME (1979)
MBtu
180
160
140
120
100
80
60
40
LOW INCOME
MEDIAN INCOME
HIGH INCOME
Income Groups
Legend
All Households
Renters
Homeowners
Source: Feizollahi, 1982a, Table A

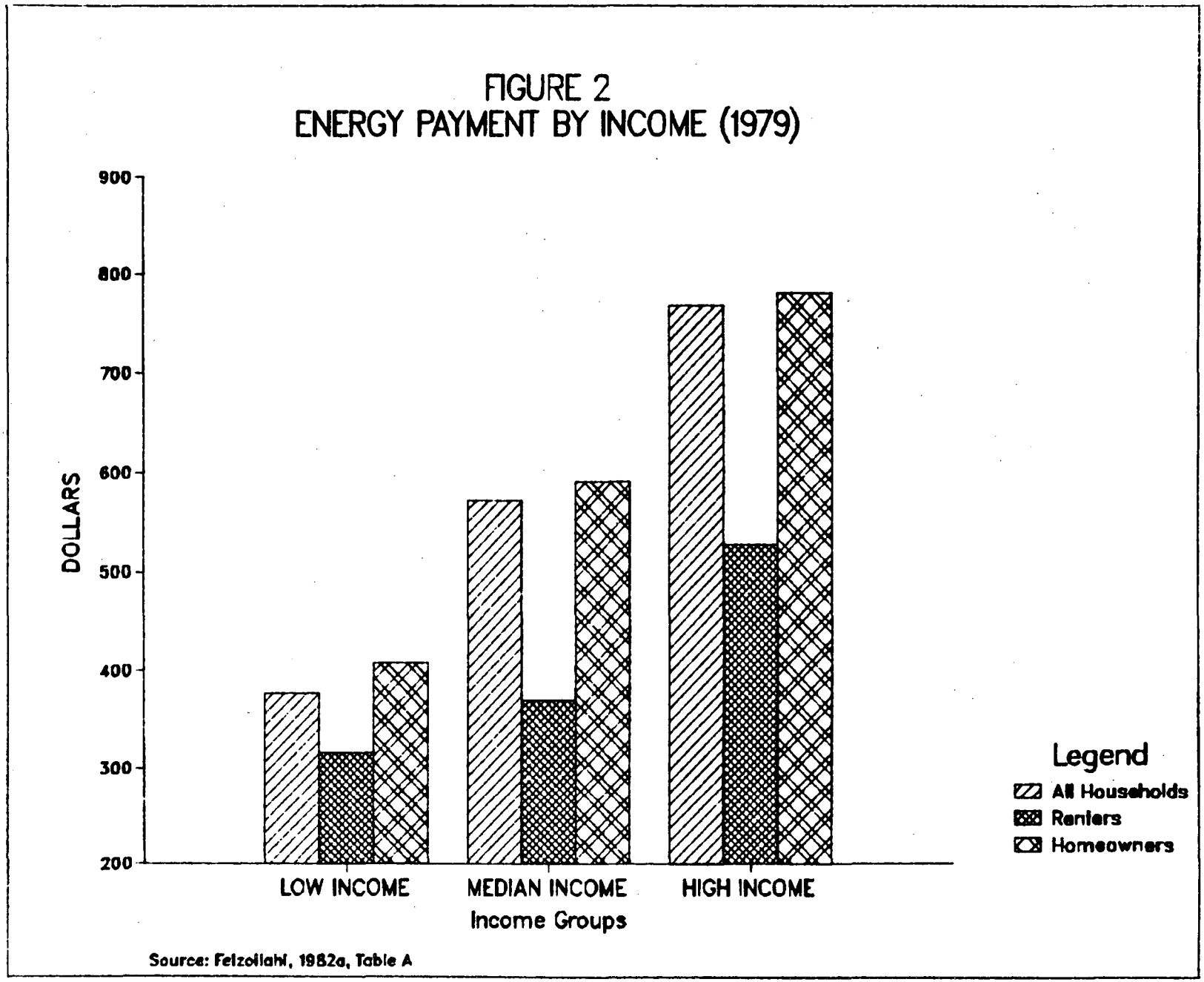


FIGURE 2
ENERGY PAYMENT BY INCOME (1979)
DOLLARS
900
800
700
600
500
400
300
200
LOW INCOME
MEDIAN INCOME
HIGH INCOME
Income Groups
Legend
All Households
Renters
Homeowners
Source: Feizollahi, 1982a, Table A

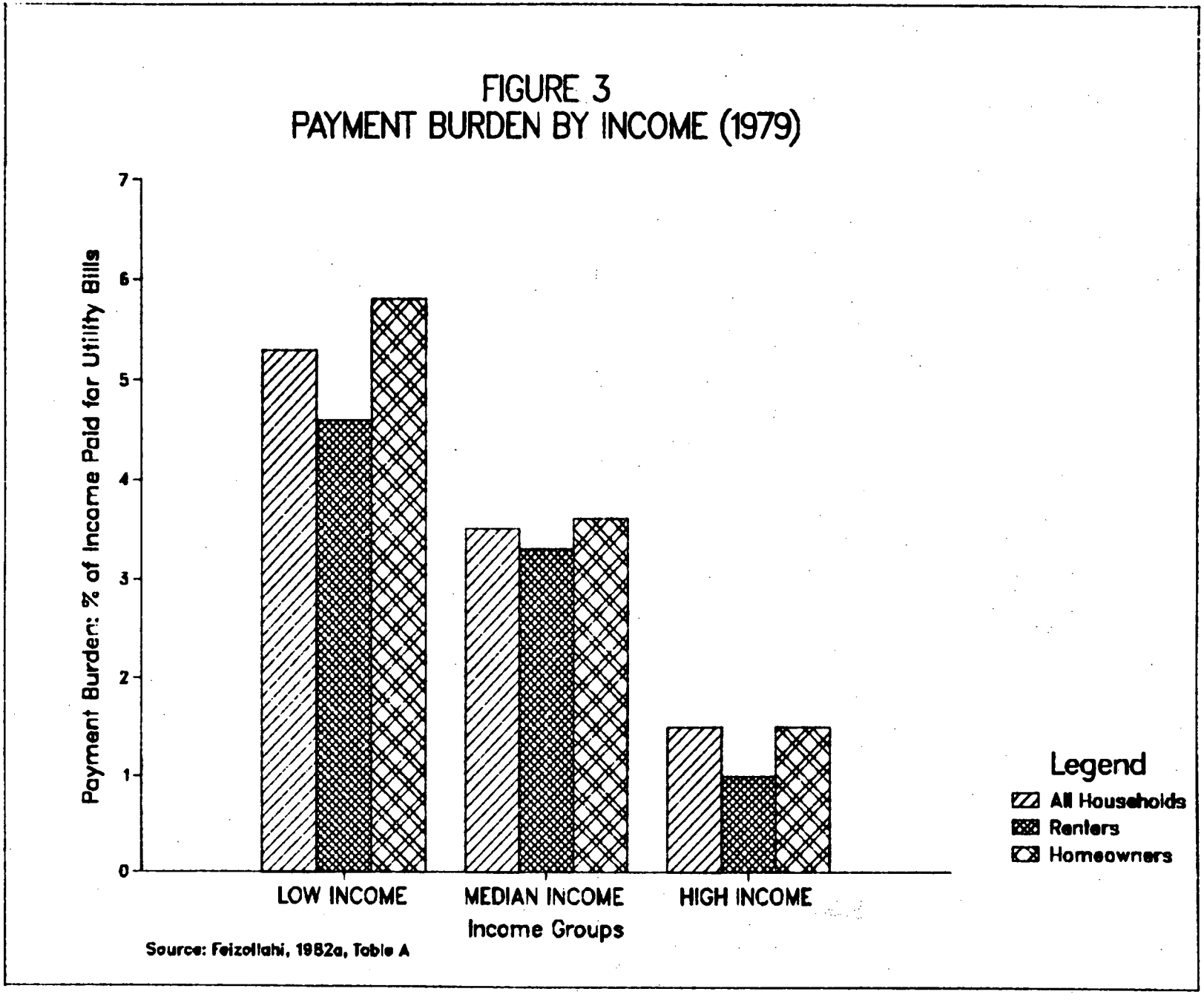


FIGURE 3
PAYMENT BURDEN BY INCOME (1979)
Payment Burden: % of Income Paid for Utility Bills
0
1
2
3
4
5
6
7
LOW INCOME
MEDIAN INCOME
HIGH INCOME
Income Groups
Legend
All Households
Renters
Homeowners
Source: Feizollahi, 1982a, Table A

Table 2. Annual Energy Consumption, Payment and Burden: Pacific Gas and Electric's Low-Income Customers (1979)

	Consumption (kWh)	Payment ($)	Payment Burden (%)
Users with Air Conditioner and Electric Heat	5,047	182	2.4
Users without Air Conditioner but with Electric Heat	3,927	141	1.8

	Consumption (therms)	Payment ($)	Payment Burden (%)
Natural gas users	765	203	2.7

Source: Minimax, 1981

Table 3. Average Monthly Bill and Bill as Percentage of Income for Low-Income and Individually Metered Households: Pacific Gas and Electric's Customers

	Electricity		Natural Gas		Gas & Electricity	
	Average Bill($)	Average Bill as % of Income	Average Bill($)	Average Bill as % of Income	Average Bill($)	Average Bill as % of Income
DOE Low Income	24	5.0	18	4.0	39	8.4
ZIP Direct Weatherization	31	5.9	21	4.4	49	9.6
Elderly Low Income	20	4.8	17	4.3	34	8.5
Individually Metered Households	32	2.4	21	1.7	51	3.8

Source: Pacific Gas and Electric Company, 1983, Table 25

the end of this chapter.

The combined bill for natural gas and electricity represented 3.8% of household income for all individually metered households. Combined bill as a percentage of income more than doubled for the elderly low-income (8.5%) and DOE low-income (8.4%) groups. The average bill constituted an even higher percentage of income for the ZIP Direct Weatherization target group (9.6%). For gas and electricity usage, the pattern was similar although the difference between individually metered households and the three low-income groups was larger for gas than for electricity.

Table 4 compares average monthly energy consumption and consumption per square foot for 1981 for the three low-income groups to all individually metered households. The average consumption figures for natural gas, electricity, and the combination of both fuels were highest for the ZIP target group, followed closely by those for all individually metered households. The DOE low-income group had much lower consumption rates of both fuels, and those of the elderly low-income group were by far the lowest. These group differences were particularly marked for electricity. When differences in dwelling size were accounted for, the group differences were reduced to a large extent. ZIP target households still consumed the most electricity per square foot, but this use rate was almost identical to that for DOE households. Elderly low-income and all individually metered households had the same use per square foot rate for electricity which in turn was slightly lower than that for the other two groups.

The monthly use per square foot rates for natural gas and the combination of gas and electricity did not vary dramatically by group, but in both cases the DOE low-income group had the highest rate and individually metered households the lowest rate. Thus, when adjustments for differences in size of residence were made, DOE low-income households consumed energy at a greater rate than the general population. These differences could be attributed to many factors including the following: low-income households live in poorly insulated buildings, possess inefficient appliances which are used heavily, and have larger households. Another detailed study of income and home energy use was prepared by the California Energy Commission in a second unpublished report (Feizollahi, 1982b). In Table 5, energy use from May 1, 1979 to April 30, 1980 is examined for a sample of customers from San Diego Gas and Electric's (SDG&E) Residential Appliance Saturation Survey. Total energy consumption (MBtus), payment, and utility burden were compared for low-income ($10,000 or less), median-income ($15,000-$20,000), and high-income ($40,000 and above) households. Low-income households' total energy consumption was 47% of high-income households' usage, and the former's utility bill was 38% of the latter. As in the PG&E sample, low-income households' utility burden was

Table 4. Average Monthly Energy Use and Use per Square Foot for Low-Income and Individually Metered Households: Pacific Gas and Electric's Customers

	Average Electricity Use		Average Natural Gas Use		Average Gas & Electricity Use (Site Energy)	
	kWh	kWh/ sq. ft.	Therms	Therms/ sq. ft.	Btu	Btu/ sq. ft.
DOE Low Income	433	0.49	49	0.049	61	0.064
ZIP Direct Weatherization	541	0.50	58	0.046	75	0.060
Elderly Low Income	371	0.43	48	0.047	58	0.059
All individually metered households	534	0.43	56	0.041	72	0.054

Source: Pacific Gas and Electric Company, 1983, Table 26

Table 5. Energy Consumption, Payment, and Burden: San Diego Gas and Electric's Customers (1979)[a]

	Household Energy		
	Consumption[b] (MBtu)	Payment[c] ($)	Payment Burden[d] (%)
Low income	47.0	319	5.3
Median income	67.1	489	2.3
High income	100.1	830	1.8

[a]Energy consumption is from May 1, 1979 to April 30, 1980.
[b]Consumption is the sum of electricity (site electricity) and gas consumption.
[c]Payment is the sum of electricity and gas bills in 1979 dollars.
[d]Burden is defined as the percentage of income paid for gas and electric bills (see text for income calculations).

Source: Feizollahi, 1982b, Table 3

350% greater than the high-income households' burden.

Regional data shows similar results to the California data. As shown in Table 6, gas use and expenditures were slightly lower and electricity use and expenditures were slightly higher for the Pacific Region, indicating the different availability and costs of these fuels throughout the region (U.S. Department of Energy, 1983a). Slightly higher amounts of gas ($276) and electricity ($348) expenditures per year were reported in 1981 for homeowners in the West Region with incomes below $10,000 (U.S. Department of Commerce, 1983a). However, low-income renters in this region had significantly lower monthly expenditures for these fuels: $156 for gas and $252 for electricity. Households with incomes less than $10,000 in the West Region also spent an average of $27 for propane (U.S. Department of Commerce, 1983a).

In two other regional studies, the amount of money spent on gas and electricity, as well as the percent of income spent on utilities, was higher for low- income households than reported in the other regional studies. The differences may be due to definitions of low-income households. For example, Cooper estimated that low-income households ($3,000 or less) in the West spent 13.4% of their income on home energy use in 1979-80 (in contrast to 2.6% for non-lower income households ($7,000 or more)), but he included infirm or unemployed young people and people 55 years or older on fixed incomes (Cooper, et. al, 1983). Energy assistance recipients of the Low Income Home Energy Assistance Program (LIHEAP) in the West Region in FY 1982 paid an average of $639 for natural gas and $625 for electricity which represented 8.5% and 8.3%, respectively, of their annual income (U.S. Department of Health and Human Services, 1983). The LIHEAP statute limits the provision of energy assistance to the following cases: households with incomes under the greater of 150% of the poverty income level for their State or 60% of the median income, or households with members receiving Aid to Families with Dependent Children (AFDC), Supplemental Security Income (SSI), food stamps, or need-tested veteran benefits.

Using national data, households meeting the 1979 poverty level spent $276 on gas, $346 on electricity, and a total of $732 on all forms of energy (U.S. Department of Energy, 1981). These households also spent 7.0% of their income on gas bills, 8.7% on electricity bills, and 18.9% of their income on total energy costs. As Table 7 indicates, these findings were somewhat higher than those reported for households in the West Region during 1980-81 (U.S. Department of Labor, 1983). In this study, households with incomes below $5,000 spent about $250 on electricity and gas while households with incomes between $5,000 and $9,000 spent $270.

Table 6. Annual Energy Consumption and Payment: Pacific Region

	Natural Gas		Electricity	
	Consumption (Therms)	Payment ($)	Consumption (kWh)	Payment ($)
Households below 1979 poverty level	620	221	6,153	260
Household income is less than $10,000	630	226	5,860	262

Source: U.S. Department of Energy, 1983, Tables 4 and 5

Table 7. Electricity and Gas Use: West Region

Income level	Annual expenditures($) of electricity and gas (1980-81)
Less than $5,000	252.20
$5,000 - $9,000	270.40
$10,000 - 14,999	478.92
$15,000 - 19,999	381.16
$20,000 - $29,000	617.76
$30,000 and over	806.00

Source: U.S. Department of Labor, 1983, Table 11

Table 8 shows that average energy expenditures per household increased (in real terms) 9% from 1978 to 1981 (U.S. Department of Energy, 1984). During this period, lower income groups (below $15,000) experienced increases in energy expenditures, while average and higher income groups ($15,000 and above) experienced declines. For example, energy expenditures for households with incomes below $5,000 increased from $678 to $766 during this period while energy expenditures for households with incomes in the $25,000 to $34,999 range decreased from $1,136 to $1,106 over the same time period.

In sum, low-income households pay a larger proportion of their income on direct energy use than other income groups. Moreover, this payment burden has been increasing at a greater rate for low income groups than for their counterparts. We discuss some possible factors affecting this particular burden for low-income households at the end of this chapter.

It is important to note that low-income households are often the beneficiaries of lifeline rates (other income groups also benefit from lifeline rates if their energy use is low). These rates make available a basic, minimum amount of electricity at a fair and reasonable cost, and rates increase beyond this amount. Lifeline rates do provide the most immediate and equitable remedy toward reducing the impact on the poor of increasing fuel costs as reflected in electric rates. However, if low-income households live in energy-inefficent homes and own energy-inefficient appliances, their energy use may be larger than the minimum amount permitted for lifeline rates.

A. Price and Income Elasticities and Demand

The price elasticity of demand is defined as the percent change in demand produced by a one percent change in price (everything else held constant). The magnitude of the price elasticity of demand for various forms of energy is subject to considerable uncertainty. There is also little agreement on (1) the best approaches to evaluate such elasticities, (2) the accuracy of such evaluations, and (3) whether energy demand elasticities are constant or change as energy prices or other variables change.

Surveys of electricity demand response to price changes indicate a wide range in elasticity estimates (e.g., -0.08 to -0.54 in the short run and from -0.45 to -1.56 in the long run (Bohi, 1981)). These estimates vary with the time period chosen for study, the geographic region, the frequency of observations (monthly or annual), weather, quality of data (averaged or interpolated data), method of statistical analysis, and model specification (Sathaye, et. al, 1984).

Table 8. Average Household Energy Expenditures by Income Level--1978 and 1981 (1981 Dollars)

	1978 ($)	1981 ($)	Change (%)
Less than $5,000	678	766	+13
$5,000-$9,999	814	906	+11
$10,000-$14,999	857	959	+12
$15,000-$19,999	999	986	-1
$20,000-$24,999	1,060	1,043	-2
$25,000-$34,999	1,136	1,106	-3
$35,000 and Over	1,361	1,333	-2
All Households	941	1,022	+9

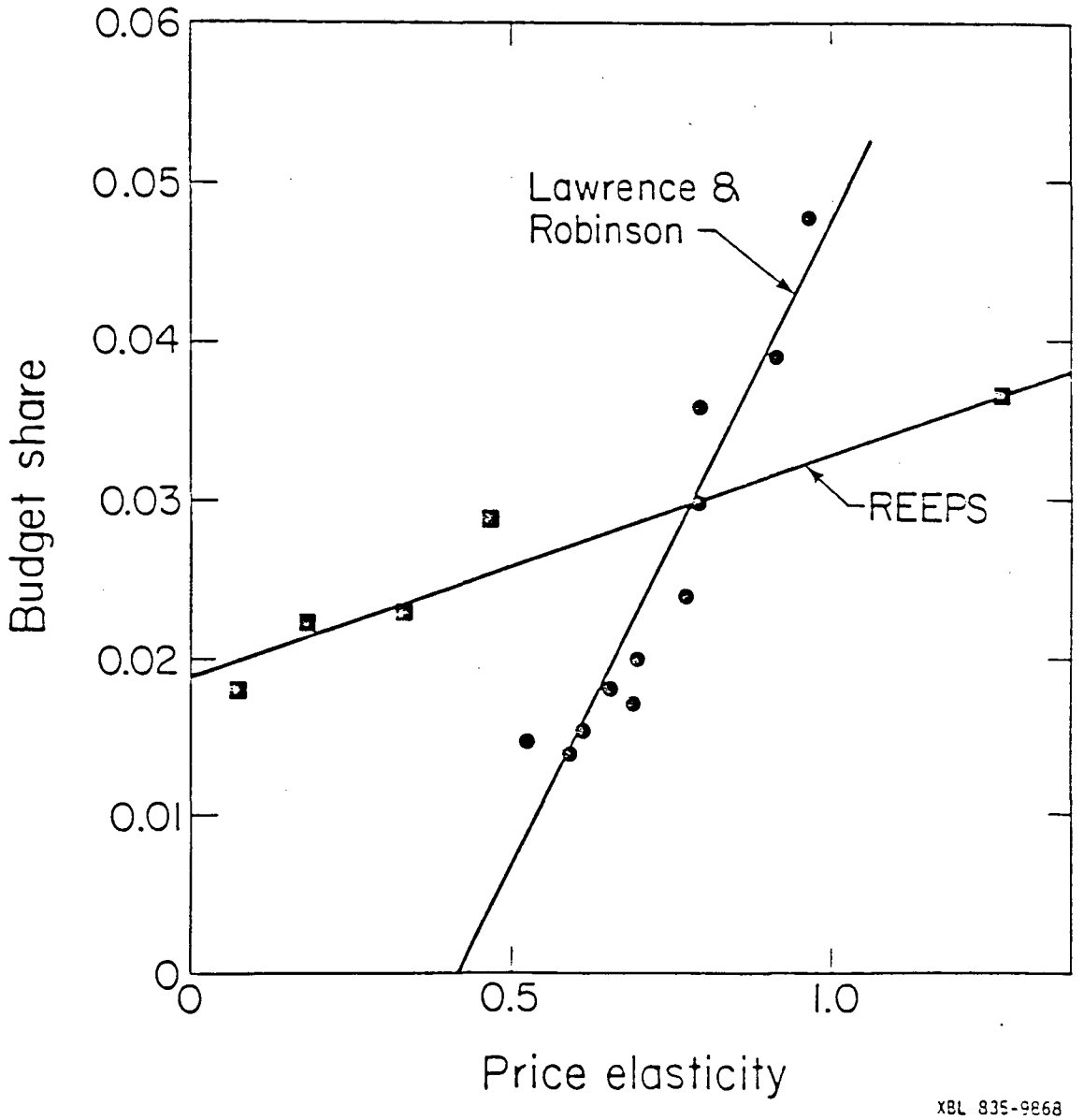
Source: U.S. Department of Energy, 1984, Table V-2

Price elasticity can be compared with utility burden, or budget share (the percent of income spent on energy bills), to see how price elasticity changes for income groups. In Figure 4, we present results from two studies showing the relationship between budget share and price elasticity (Lawrence and Robinson, 1982; Berkovec, Cowing, and McFadden, 1982). The empirical results reported by Lawrence and Robinson were based on the U.S. Department of Energy's 1979 National Interim Energy Consumption Survey (NIECS) that contained extensive survey data matched with energy consumption, and their approach was based on conditional demand modeling. Berkovec, et. al used the Residential End-Use Energy Planning System (REEPS) model to conduct simulations in natural gas price de-control and the imposition of federal appliance standards. The REEPS model is a large-scale model simulating residential appliance choice and utilization behavior, and the data for REEPS were similar to those used in conditional demand modeling (detailed surveys of consumer characteristics and behavior from a representative sample). Unlike the cross-sectional approach of conditonal demand models, however, REEPS reproduces the dynamics of appliance choice and consumption over time. Sathaye, et. al (1984) used the results from Berkovec's base case to calculate price elasticities for six income groups specified in REEPS over the 1979-1991 period, and these results are shown in Figure 4.

As noted previously, lower income groups spend a greater proportion of their income on energy payments than other income groups (i.e., they have higher budget shares). As seen in Figure 4, despite the different slopes in the two models, high budget shares (e.g., 0.04) are related to high price elasticities (approaching 1.0). Thus, it appears that low-income households are more sensitive than other income groups to changes in energy prices due to their higher price elasticities. If electricity rates increase, low-income households will suffer most.

Income elasticity is defined as the percent increase in demand produced by a one percent change in income (everything else held constant). We were unable to obtain empirical data on income elasticity for different income groups; however, we did obtain income elasticities for different regions in California. In Pacific Gas and Electric's (PG&E) service area, the short-run income elasticity for residential electricity was estimated to be 0.46 for 1983.[9] Long-run income elasticity for residential electricity was estimated to be 0.79 for 1981-83. For individually metered residential gas customers in PG&E's service area, the short-run income elasticity was estimated to be 0.09 for 1983 and the long-run income elasticity was estimated to be 0.51 for 1980-83.[10] For master metered residential gas customers in PG&E's service area, the short-run income elasticity was estimated to be 0.18 and the long-run income elasticity was estimated to be 1.07. Most of the master metered population was low-income. Long-run income elasticities for San Diego Gas and

Figure 4. Comparison of Price Elasticity and Budget Share



Source: Sathaye et al (1984)

Electric's service area were similar to PG&E's estimates: 0.80 for gas and 1.25 for electricity.[11] The larger income elasticity for electricity in Southern California was due to increased home electrification (e.g., home computer systems and video cassette recorders) and product differentiation of existing appliances (e.g., more energy-intensive, optional features in refrigerators).

B. Income and Home Energy-Related Characteristics

In addition to knowing about how much energy low-income households pay and consume, it is important to obtain better information on the determinants of residential energy use, so that energy programs can be targeted and marketed effectively for addressing the needs of low income people. We first present the results collected in Pacific Gas and Electric's 1981 Residential Appliance Saturation Survey (Pacific Gas and Electric, 1983) to describe selected energy-related characteristics of low-income households in PG&E's service area. Table 9 compares three low-income groups (see above for definitions of groups) and individually metered households served by PG&E for the following characteristics: dwelling type, residence built after 1969, home ownership, average number of residents, average length of occupancy, average square footage, type of space heating system, type of space heating fuel, type of space cooling system, and conservation measures taken.

Low-income groups were less likely to live in single-family homes, but more likely to live in older homes. DOE low-income households were more likely to rent; however, elderly low-income households were, like the general population, more likely to be owners than renters. As compared to other groups, elderly low-income households were likely to have fewer persons, to have resided longer in their residence, and to occupy a smaller living space.

The heating systems of the low-income groups were less likely to be central systems than for the general population of individually metered households. Approximately 70% of all groups used natural gas for space heating. The elderly low-income group had a higher proportion of bottled gas for heating, probably because of the higher proportion in mobile homes. Low-income households were more likely to use some kind of air conditioning than the general population of individually metered households (45% vs 40%). However, low-income groups were less likely to own one of the more energy intensive and expensive forms (central units or heat pumps), and were more likely to rely on window/wall or evaporative units. The saturations of the eight conservation measures included in the 1981 Residential Appliance Saturation Survey were approximately the same for the ZIP target group and all individually metered households, and were consistently higher than the other two low-income groups.

Table 9. Selected Statistics for Low Income and Individually Metered Households: Pacific Gas and Electric's Customers (1981)

	DOE Low Income	ZIP Direct Weatherization Target	Elderly Low Income	PGandE Individually Metered
Dwelling type:				
Single family	57.7%	100.0%	69.9%	68.2%
Multi-family				
2-4 units	19.1%	--	8.1%	12.4%
5 or more units	17.9%	--	8.7%	15.9%
Mobile home	4.2%	--	12.2%	2.6%
Residence built 1970 or later	16.5%	10.4%	15.0%	24.5%
Average number of residents	2.98	3.08	1.69	2.77
Average length of occupancy (years)	7.4	13.6	14.1	7.1
Average square footage	1144	1324	1113	1522
Space heating system:				
Central	28.0%	36.1%	28.7%	48.7%
Natural gas wall/floor	49.1%	43.2%	47.6%	30.5%
Electric baseboard	2.9%	2.9%	7.7%	4.6%
Space heating fuel:				
Natural gas	70.8%	71.8%	70.6%	71.7%
Electricity	5.7%	5.1%	10.9%	7.8%
Bottled gas	3.9%	3.4%	5.2%	3.1%
Space cooling system:				
Central electric	11.8%	13.3%	11.1%	19.1%
Electric heat pump	1.0%	1.0%	0.9%	1.2%
Ref. win/wall unit	15.3%	16.3%	17.6%	10.1%
Evaporative cooler	17.2%	18.1%	16.1%	8.7%
Conservation measures:				
Ceiling insulation	39.1%	63.5%	47.7%	54.2%
Wall insulation	28.0%	37.0%	31.5%	38.3%
Clock thermostat	8.0%	8.8%	6.4%	8.8%
Caulking/weatherstripping	33.2%	46.0%	36.7%	47.5%
Heating duct insulation	13.6%	24.2%	12.8%	26.5%
Low-flow shower heads	21.0%	30.5%	20.6%	31.9%
Hot water pipe insulation	9.9%	15.1%	11.1%	15.8%
Water heater blanket	8.7%	13.9%	9.4%	15.6%

Note: Not all groups sum to 100% because minor categories have been excluded from table.
Source: Pacific Gas and Electric Company, 1983

The energy-related characteristics of low-income households in Southern California were somewhat different than their counterparts in the North. Using data from their 1983 appliance saturation survey, Southern California Edison (SCE) reported that for those households with incomes below 150% of the poverty level, 12.6% had central electric air conditioners, 21.4% had window/wall air conditioners, and 19.1% had electric space heat (Table 10) (Harbicht, 1983). For those households with incomes below 200% of the poverty level, 16.0% had central electric air conditioners, 23.0% had window/wall air conditioners, and 21.9% had electric space heat (Harbicht, 1983). In comparison, 23.2% of all SCE customers possessed central electric air conditioners, 17.6% had room air conditioners, and 10.2% had electric space heaters (Harbicht, 1983). Thus, SCE's low-income households possessed fewer air conditioners but more electric space heaters than other income groups in their area. Low-income households in Southern California had about the same number of central air conditioners, but many more room units and electric space heating systems than Northern California households. The higher saturations of air conditioners in Southern California is undoubtedly due to the hotter climate and need for air conditioning in this region. For those households with incomes of $10,000 or less in 1983 (representing 13.9% of their sample), 53.4% lived in single-family homes, 42.0% lived in apartments/condominiums/townhouses, and 4.5% lived in mobile homes. These percentages are similar to those reported by PG&E.

IV. INCOME AND TRANSPORTATION

In addition to examining electricity and gasoline consumption within the home, we analyzed the following transportation-related characteristics and costs for the low-income sector: vehicle ownership, vehicle mileage, commuting characteristics, mode of transportation (including public transit), and transportation expenditures.

A. Vehicle Ownership

Data on vehicle ownership and mileage for 1973 were available for San Francisco and Los Angeles households. In 1973, 42.2% of San Francisco households with incomes under $6,000 owned at least one vehicle (U.S. Department of Labor, 1979). In the same year, 41.0% of Los Angeles households with incomes under $4,000 owned at least one vehicle; for Los Angeles households with incomes between $4,000 and $5,999, 62.7% owned at least one vehicle (U.S. Department of Labor, 1979).

Table 10. Space Conditioning Saturations for Low-Income Households: Southern California Edison's Customers (1983)

	Central Electric Air Conditioners	Room Air Conditioners	Electric Space Heaters
Incomes below 150% of poverty level	12.6%	21.4%	19.1%
Incomes below 200% of poverty level	16.0%	23.0%	21.9%
All households	23.2%	17.6%	10.2%

Source: Harbicht, 1983.

National data for 1974 for the number of vehicles per household, number of miles driven per household annually, and number of miles driven per motor vehicle annually for different income classes are shown in Table 11 (Shonka, et. al, 1977). Lower income groups had fewer vehicles per household and drove less than other income groups. Households with incomes below $10,000 were below the household average for number of vehicles per household and number of miles driven per household; most of these households were also below the household average for number of miles driven per motor vehicle.

From 1970 to 1980, the fuel efficiency of new automobiles increased by almost 100% (California Energy Commission, 1983). The average new automobile fuel economy was close to 13 miles per gallon in 1970 but by 1981 had increased to over 25 miles per gallon based on combined city/highway estimates developed by the U.S. Environmental Protection Agency. However, as shown in Table 12, national data indicated that low-income groups were less likely to buy a new car than other income groups during 1972-74. Only one-third of single-car households with incomes less than $5,000 (in 1970$) had purchased new cars. In comparison, three-quarters of single-car households with incomes greater than $15,000 had purchased new cars (Shonka, et. al, 1977). The age of the head of the household was also important: for households with incomes below $5,000 that owned only one car, almost 50% of the cars were purchased new if the head of the household was older than 64 while only 10% of the car were purchased new if the head of the household was between 25 and 34 years old.

Data from a national survey undertaken in May 1973 supported these findings and shed considerable light on very poor households (Newman and Wachtel, 1974).[12] As shown by Table 13, only half of the poor owned a car and the car was likely to be used and more than 5 years old. Moreover, the poor constituted 18% of the sample but had only 9% of the cars (Newman and Wachtel, 1974) (Table 14). In contrast, the well-off ($16,000 and over), 20% of all households, had 30% of the cars. The general model of the car people drove was similar. As indicated in Table 15, about 60% of all privately owned cars in use were standard models in all households, regardless of income. The well-off tended to have more compact cars than others and proportionately fewer vans and trucks than the poor. However, regional data in Table 16 indicate that truck ownership by households increases with income up to the $15,000 to $20,000 bracket and then declines such that a similar percentage of households with incomes of over $25,000 own trucks as do households earning $7,500 to $10,000 (Shonka, et. al, 1977).

Table 11. Number of Motor Vehicles Owned and Miles Driven per Household by Household Income (Fall 1974)

Annual income	Number of motor vehicles per household	Number of miles driven per household (in thousands)	Number of miles driven per motor vehicle (in thousands)
Under $3,000	0.62	5.7	9.2
$3,000 to $4,999	0.84	7.5	8.9
$5,000 to $7,499	1.11	12.2	10.9
$7,500 to $9,999	1.31	16.3	12.4
$10,000 to $14,999	1.60	18.5	11.5
$15,000 to $19,999	1.83	21.4	11.7
$20,000 to $24,999	1.98	25.5	12.9
$25,000 and over	2.13	28.7	13.5
All households	1.43	16.8	11.8

Source: D.B. Shonka et. al, 1977, Table 1-41

Table 12. Percent of Cars Purchased New, by Age of Household Head, Income, and Number of Cars Owned

Income	No. of autos owned	Age of head of household						
		24	25-34	35-44	45-44	55-64	65+	All ages
Up to $5,000	1	26.6%	11.5%	11.5%	33.3%	35.3%	49.1%	34.3%
	2							36.0
$5-$10,000	1	30.1	40.0	29.9	36.5	65.2	76.6	49.6
	2	30.6	29.2	28.2	29.0	29.4	65.5	32.2
$10-$15,000	1		60.6	51.8	59.4	77.1	85.7	72.7
	2	34.5	43.8	44.1	51.1	41.3	72.7	46.6
$15,000+	1		54.8	69.6	78.4	90.9	88.9	74.1
	2		49.4	51.5	56.2	63.5	75.0	55.7
All incomes		33.9	44.3	44.1	49.9	54.7	63.8	48.4
Average age of vehicles		4.9	5.0	5.3	5.0	5.3	5.8	5.2

Source: D.B. Shonka et. al, 1977, Table 1-43

Table 13. Number and Characteristics of Cars Owned (1973)

Car characteristics	Poor* (%)	Middle* (%)	Well-Off* (%)
Cars owned			
None	47	4	1
1 only	37	35	21
2 or more	16	61	79
Bought**			
New	23	58	78
Used	77	40	22
Model year**			
1968 or earlier	75	20	14
Since 1968	23	80	85

*Newman and Wachtel's definition of the poor was based on the U.S. definition of the poor and near poor in 1972, modified for use with survey data for which income was reported within a particular range rather than as a specific figure. The poverty thresholds were as follows: under $3,000 for 1 or 2 people; under $5,000 for 3-4 people; under $7,000 for 5-6 people; and under $9,000 for 7 or more people. The nonpoor were divided into 3 groups referred to as "lower", "middle", and "well-off". The "lower" group of nonpoor had incomes below $12,000 in 1972. The "middle" group had incomes between $12,000 and $15,999. The "well-off" were those with incomes of $16,000 and over.

**One car households in the case of the poor; the newest car in multi-car households for all other households.

Source: Newman and Wachtel, 1974, Table 1

Table 14. Car Ownership by Income Status (1973)

	All Cars (%)	All Households (%)
Poor	9	18
Nonpoor	91	82
Under $12,000	38	42
$12,000 - $15,999	23	18
$16,000 and over	30	20

Source: Newman and Wachtel, 1974, Table 2

Table 15. Type of Car in Households with Cars (1973)

Type of car	Poor* (%)	Middle* (%)	Well-Off* (%)
Standard	60	61	58
Compact/subcompact	19	20	26
Van or pick-up truck	15	10	9

*Newman and Wachtel's definition of the poor was based on the U.S. definition of the poor and near poor in 1972, modified for use with survey data for which income was reported within a particular range rather than as a specific figure. The poverty thresholds were as follows: under $3,000 for 1 or 2 people; under $5,000 for 3-4 people; under $7,000 for 5-6 people; and under $9,000 for 7 or more people. The nonpoor were divided into 3 groups referred to as "lower", "middle", and "well-off". The "lower" group of nonpoor had incomes below $12,000 in 1972. The "middle" group had incomes between $12,000 and $15,999. The "well-off" were those with incomes of $16,000 and over.

Source: Newman and Wachtel, 1974, Table 6

Table 16. Household Truck Ownership by Income (1974)

Household income	Truck ownership (%)
Under $3,000	8.9
4,000 - 4,999	12.2
5,000 - 7,499	16.2
7,500 - 9,999	19.4
10,000 - 14,999	25.2
15,000 - 19,999	27.1
20,000 - 24,999	24.3
25,000 and over	20.1
All households	20.1

Source: D.B. Shonka et. al, 1977, Table 1-48

B. Vehicle Mileage

Previously, we noted that households with incomes below $10,000 drove less (miles per vehicle or per household) than other income groups (Table 11). Poor households that own a car drive much more sparingly than others and chiefly for necessary trips--principally to their jobs (Newman and Wachtel, 1974). As shown in Table 17, almost one-half of poor households drove less than 5,000 miles in 1972-73. In contrast, over half of all middle-income and well-off families drove 10,000 miles or more that year. Average miles per gallon were higher among poor than other households both for short- and long-distance travel, but relatively few poor households used their cars for long trips (100 miles or more one way). All car owners got fewer miles per gallon locally, but the difference between the poor and others was striking. Almost 70% of all poor households reported 15 or more miles to the gallon locally compared with less than 50% of middle and higher-income families. More recent data (1980 and 1981-82) indicate that low-income households still drive less (miles per vehicle or per household); however, higher income households now possess more efficient vehicles than their counterparts (Tables 18 and 19) (U.S. Department of Transportation, 1984; U.S. Department of Energy, 1983b). For example, in 1981 households with incomes below $5,000 got 13.7 miles per gallon while households with incomes of $25,000 or more got 15.7 miles per gallon. Accordingly, on a per vehicle basis higher income households take longer trips in efficient cars resulting in total gasoline consumption that is only slightly greater than gasoline consumption for lower income households which drive less but in inefficient vehicles. On a household basis, higher income households drive many more miles and consume much more gasoline than their poorer counterparts because the former have more vehicles per household than the latter.

Table 17. Car Mileage (Spring 1972 - Spring 1973)

Car mileage**	Poor* (%)	Middle* (%)	Well-Off* (%)
Miles driven in past year			
Less than 5,000	49	19	22
5,000 - 9,999	28	24	25
10,000 - 14,999	***	34	34
15,000 and over	***	22	19
Miles per gallon locally			
0-14	31	54	62
15-19	47	30	24
20 and over	22	16	14
Miles per gallon long distance			
0-14	22	32	34
15-19	46	46	44
20 and over	32	22	22

*Newman and Wachtel's definition of the poor was based on the U.S. definition of the poor and near poor in 1972, modified for use with survey data for which income was reported within a particular range rather than as a specific figure. The poverty thresholds were as follows: under $3,000 for 1 or 2 people; under $5,000 for 3-4 people; under $7,000 for 5-6 people; and under $9,000 for 7 or more people. The nonpoor were divided into 3 groups referred to as "lower", "middle", and "well-off". The "lower" group of nonpoor had incomes below $12,000 in 1972. The "middle" group had incomes between $12,000 and $15,999. The "well-off" were those with incomes of $16,000 and over.

**Includes only cars owned at least 12 months and for which mileage was reported.

***Sample is too small to show data separately.

Source: Newman and Wachtel, 1974, Table 5

Table 18. Average Household Transportation Expenditures by Income Class (1980)

Income Level	Average Annual Miles	Total Gallons	Fuel Expenditures ($)	Maintenance Expenditures ($)	Total Household Transportation Expenditures($)
Less than $10,000	8,631	602	475.58	485.06	1,014.82
$10,000 to $19,999	16,596	1,158	914.82	1,015.68	2,034.72
$20,000 and Over	20,696	1,445	1,141.55	1,498.39	2,769.99

Source: U.S. Department of Transportation, 1984, Exhibit 12

Table 19. Average Vehicle Characteristics (January 1981 - September 1981)

Annual Averages per Vehicle	Family Income $0 to $4,999	$5,000 to $9,999	$10,000 to $14,999	$15,000 to $19,999	$20,000 to $24,999	$25,000 or more
Gallons Consumed	523	514	587	588	590	619
Miles Driven	7,181	7,370	8,608	8,556	8,905	9,732
Expenditures	$776	$680	$770	$778	$773	$824
Miles/Gallon	13.7	14.4	14.7	14.5	15.1	15.7

Source: U.S. Department of Energy, 1983b, Table 9

C. Commute to Work

National data indicate that in 1972-73 the vast majority of employed heads of households who are poor commute to work by car (Table 20) (Newman and Wachtel, 1974). They go to work by car almost as frequently as the well-off do: 84% of poor heads of households compared to 91% of the well-off. The poor are more likely to live closer to work than the well-off; 63% of poor heads of households compared to 48% of the well-off live less than 10 miles from work. Thus, employed poor heads of households use less energy commuting to work than employed household heads who are not poor both by making somewhat greater use of public transit and also by living closer to work.

D. Mode of Transportation

We were unable to analyze transportation modes by income group for California and relied on national surveys conducted in the 1970s. National data collected in the 1969-70 Nationwide Personal Transportation Survey indicated that as income increased the choice of the automobile as the mode of transportation from home-to-work increased (Table 21) (U.S. Department of Transportation, 1973). Over 75% of households with annual incomes of $15,000 and over used the automobile for home-to-work transportation. In contrast, fewer than half of the households with annual incomes of less than $4,000 commuted to work by automobile. Public transporation was favored more by lower income groups than other income groups.

In 1969-70, approximately 5.5% of all home-to-work trips were made by persons having no automobile available (U.S. Department of Transportation, 1973). For such households with income less than $4,000 and for those with more than $15,000, over half of the trips were made by private automotive transportation (Table 22) (U.S. Department of Transportation, 1973). Where household income was between $4,000 and $14,999, more than half of the trips were made by public transportation.

As indicated in Table 23, national data collected in the 1977 Nationwide Personal Transportation Survey confirmed that the proportion of workers using public transportation was greatest for income groups under $10,000 while the proportion of total work trips made in private vehicles increased as household income increased (U.S. Department of Transportation, 1980).[13] Thus, the poor continue to constitute a sizable proportion of total transit ridership -- much higher than their representation among auto users. This pattern of income differences is generally confirmed by the findings of numerous other surveys made over the past two decades (Pucher, 1981).

Table 20. Commuting Characteristics of Employed Household Heads (Spring 1972 - Spring 1973)

Commute	All households (%)	Poor* (%)	Middle* (%)	Well-Off* (%)
Car	89	84	89	91
With others	14	--	16	15
Miles to work				
Less than 10	57	63	59	48
10 or more	43	37	41	52
(median miles)	(8)	(5)	(8)	(11)
Minutes to work				
Less than 16	49	54	50	46
16 - 30	33	27	31	32
31 or more	19	19	19	22

*Newman and Wachtel's definition of the poor was based on the U.S. definition of the poor and near poor in 1972, modified for use with survey data for which income was reported within a particular range rather than as a specific figure. The poverty thresholds were as follows: under $3,000 for 1 or 2 people; under $5,000 for 3-4 people; under $7,000 for 5-6 people; and under $9,000 for 7 or more people. The nonpoor were divided into 3 groups referred to as "lower", "middle", and "well-off". The "lower" group of nonpoor had incomes below $12,000 in 1972. The "middle" group had incomes between $12,000 and $15,999. The "well-off" were those with incomes of $16,000 and over.

Source: Newman and Wachtel, 1974, Table 7

Table 21. Percent of Employed Persons in Each Household Income Group by Mode of Home-to-Work Transportation

Annual household income	Mode of transportation						
	Automobile						
	Driver	Passenger	Total	Public transportation	Combination of public trans. & auto & other	Walking	Other
Under $3,000	25.6%	20.1%	45.7%	12.8%	1.5%	11.9%	28.1%
$3,000-3,999	29.7	18.8	48.5	12.5	2.1	12.7	24.2
$4,000-4,999	34.7	21.4	56.1	11.6	1.9	7.0	23.4
$5,000-5,999	45.2	18.5	63.7	9.4	1.3	5.5	20.1
$6,000-7,499	46.4	20.8	67.2	6.9	3.1	5.3	17.5
$7,500-9,999	49.8	20.5	70.3	5.9	2.4	4.5	16.9
$10,000-14,999	54.9	19.2	74.1	5.1	3.3	2.9	14.6
$15,000 and over	58.8	16.4	75.2	6.5	4.5	3.3	10.5
All	48.4	19.1	67.5	7.2	2.9	5.0	17.4

Source: U.S. Department of Transportation, 1972, Table 10

Table 22. Distribution of Home-to-Work Person Trips by Persons Having No Automobile Available, by Annual Household Income, and Major Mode of Transportation Used

	Major mode of home-to-work transportation					
	Public transportation			Private transportation		
Household income group	Bus and streetcar	Train and subway	Total	Automobile (passenger) and taxi	Truck	Other
Under $3,000	33.6%	7.3%	40.9%	41.1%	16.9%	1.1%
$3,000-3,999	28.6	4.2	32.8	42.9	18.8	5.5
$4,000-4,999	35.7	19.6	55.3	30.2	11.4	3.1
$5,000-5,999	54.5	6.9	61.4	34.2	4.0	0.4
$6,000-7,499	50.3	8.1	58.4	36.8	3.2	1.6
$7,500-9,999	41.3	29.0	70.3	10.2	10.9	8.6
$10,000-14,999	49.5	29.6	79.1	-	20.9	-
$15,000 and over	41.6	6.0	47.6	37.5	6.4	8.5
All	40.4	10.4	50.8	35.1	12.0	2.1

Source: U.S. Department of Transportation, 1972, Table A-15

Table 23. Percent of Home-to-Work Trips by Major Mode and Annual Household Income

Mode*	Annual Household Income							
	Less than $5,000	$5,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 to $34,999	$35,000 to $49,999	$50,000 or More	All
Private Vehicle Driver	55.0	65.6	72.2	77.3	76.7	76.5	78.6	72.7
Private Vehicle Passenger	24.6	20.4	18.8	15.9	15.3	15.9	15.4	17.8
Public Transportation	7.2	7.2	4.1	3.3	3.9	4.5	3.4	4.5
Other	13.2	6.8	4.9	3.5	4.1	3.1	2.6	5.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Private vehicle includes: standard auto, station wagon, vanbus/minibus, camper coach, pickup, van, other truck, bicycle, private use taxi, motorcycle, and moped. Public transportation includes: bus, train, streetcar, subway, airplane, commercial use taxi, and truck. Other includes: walk, school bus, and other.

Source: U.S. Department of Transportation, 1980, Table 9.

E. Transportation Expenditures

The U.S. Department of Labor reported that San Francisco households with incomes under $6,000 (in 1973) had total transportation costs (including vehicle purchase, vehicle finance, vehicle operations, and other transportation costs) of $580.18 in 1972-73; their gasoline and other fuel costs were $121.62 (U.S. Department of Labor, 1979). In contrast, the average household in the San Francisco area spent $1,710.37 on total transportation costs and $322.73 on gasoline and other fuel costs. Los Angeles households with incomes under $4,000 had total transportation costs of $473.52 in 1972-73; their gasoline and other fuel costs were $97.53 (U.S. Department of Labor, 1979). Los Angeles households with incomes between $4,000 and $5,999 had total transportation costs of $586.95, and their gasoline and other fuel costs were $145.17. In contrast, the average household in the Los Angeles area spent $1,574.58 on total transportation costs and $337.34 on gasoline and other fuel costs.

As shown in Table 24, more recent data (1980-81) for the West Region indicated an increasing amount of money was spent on gasoline, motor oil, and additives as income increased (U.S. Department of Labor, 1983). Households with incomes below $5,000 spent $336 while households with incomes $30,000 and over spent $1496. National data supported this trend for fuel expenditures and maintenance expenditures (Tables 18 and 19) (U.S. Department of Transportation, 1984; U.S. Department of Energy, 1983b). For total household transportation expenditures, households with incomes less than $10,000 spent $1,015 while households with incomes $20,000 and over spent $2,770.

It is not surprising that low-income households spend less money on transportation than do other income classes. However, the ratio of transportation costs to household income presents a different and more meaningful picture of the plight of low-income households. Using U.S. Bureau of Labor Statistics' data, Cooper, et. al found that low-income households ($3,000 or less) in the West in 1972-73 spent 9.5% of their income on gasoline in 1972-73 while lower middle income groups ($3,000 to $6,999) spent 5.1%, and non-lower income groups ($7,000 or more) spent only 2.1% (Cooper, et. al, 1983). In 1979-80, low-income households spent 14.8% of their income on gasoline, lower middle-income households spent 7.7%, and non-lower income households spent 4.6%. These findings clearly supported the finding that differences among income groups were increasing over time with respect to the burden of transportation costs: from 1972 to 1979, the increase in burden for low-income households was 5.3% while it was only 2.5% for non-lower income households. As seen in Table 25 and Figures 5 and 6, national data on gasoline expenditures for 1979-80 also showed that low-income households (less than $7,400) spent 8.2% of their income on gasoline while high-income households ($36,900 or more) only spent 3.7% of their income on gasoline (U.S. Congress, 1981).

Table 24. Income and Gasoline Use: West Region

Income level	Annual expenditures($) of gasoline, motor oil, and additives (1980-81)
Less than $5,000	335.92
$5,000 - $9,000	483.08
$10,000 - 14,999	864.76
$15,000 - 19,999	968.24
$20,000 - $29,000	1082.64
$30,000 and over	1496.04

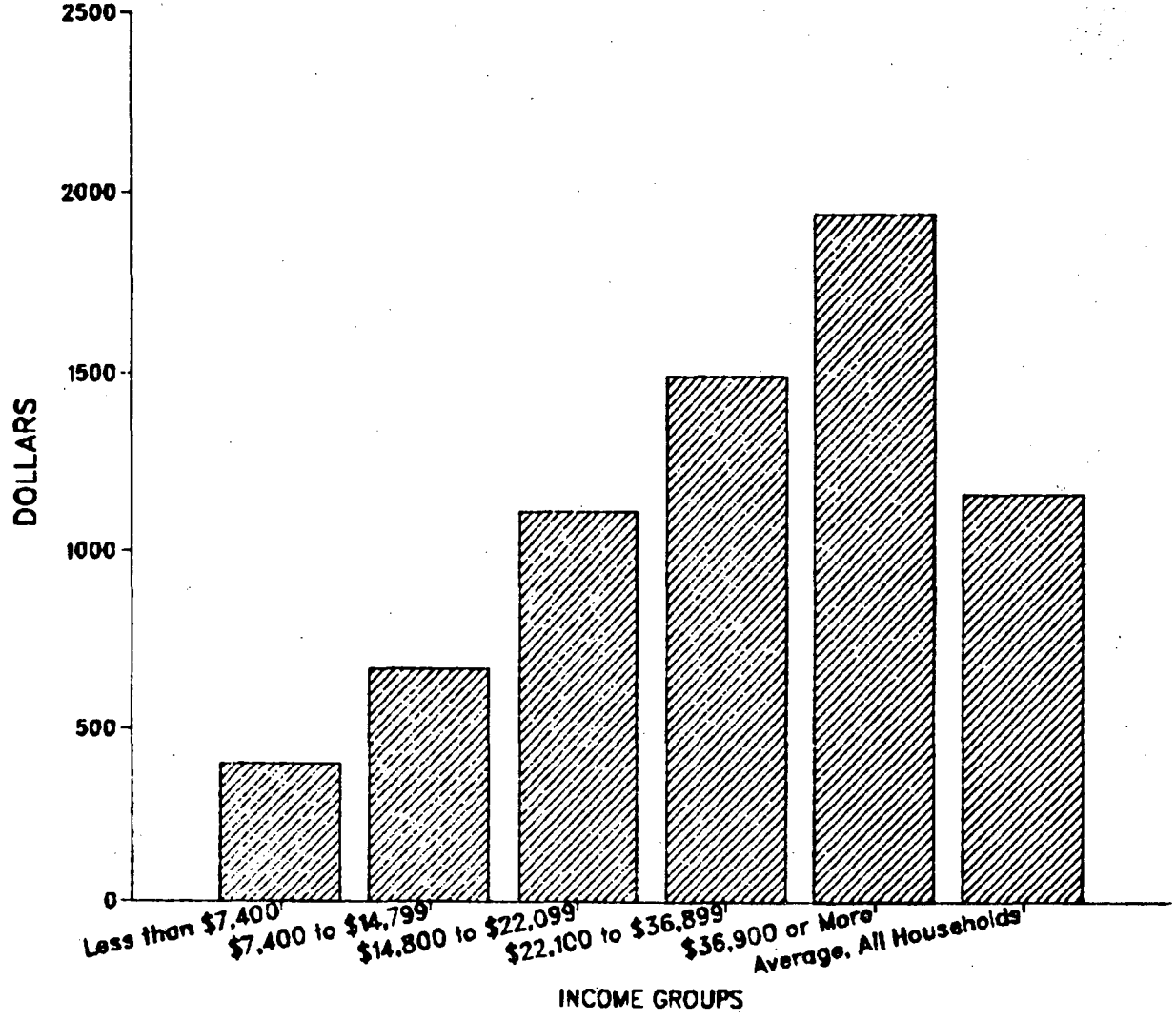
Source: U.S. Department of Labor, 1983, Table 11

Table 25. Estimated Average Annual Household Gasoline Expenditures By Income Class (1979-80)

Estimated Household Income	Estimated Average Gasoline Expenditures in Dollars	As Percent of Income
Less than $7,400	400	8.2
$7,400 to $14,799	670	6.0
$14,800 to $22,099	1,110	6.0
$22,100 to $36,899	1,490	6.2
$36,900 or More	1,940	3.7
Average, All Households	1,160	4.8

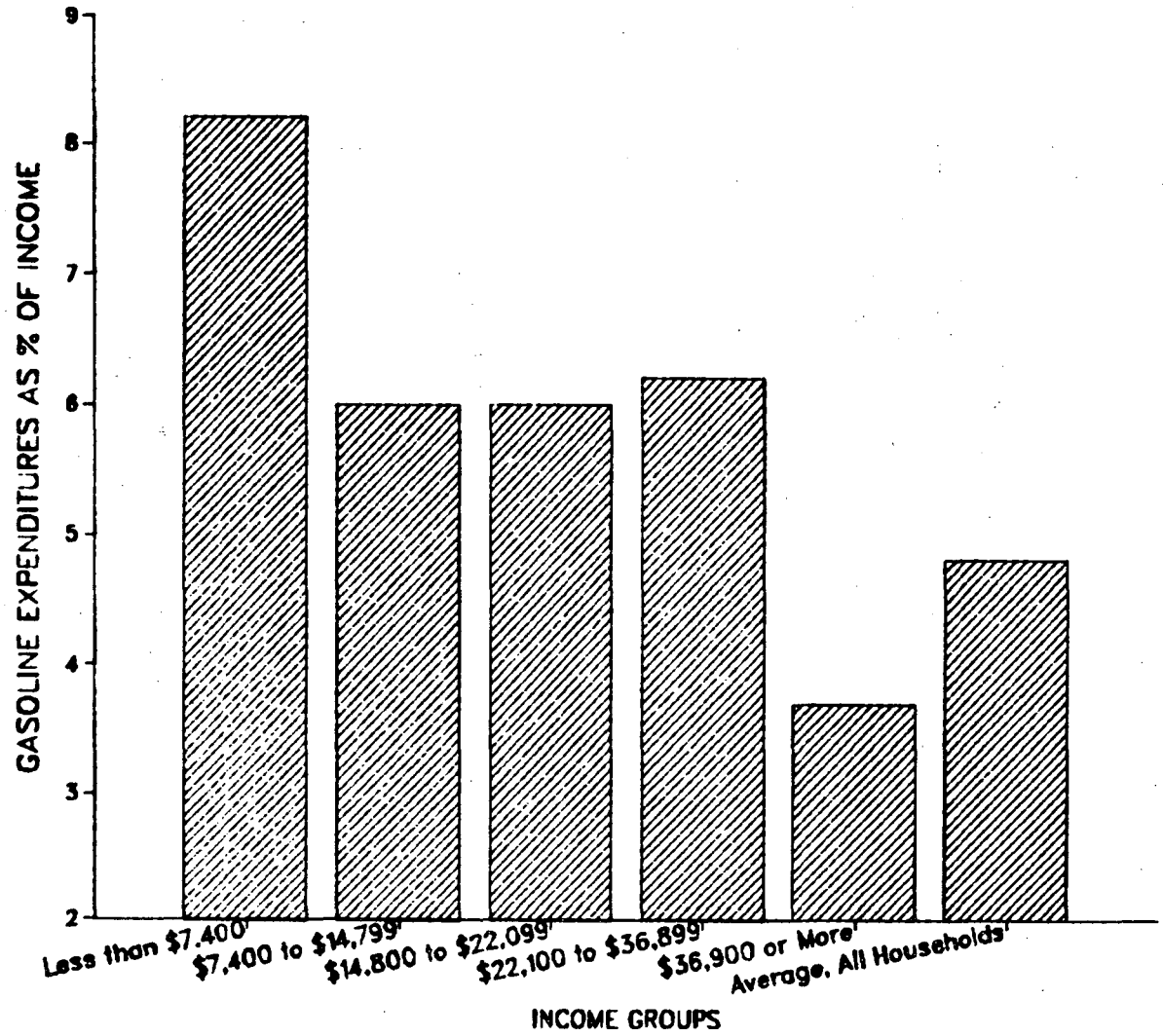
Source: U.S. Congress, Congressional Budget Office, 1981, Table 5

FIGURE 5
ESTIMATED AVERAGE ANNUAL HOUSEHOLD GASOLINE EXPENDITURES
BY INCOME CLASS (1979–1980)



Source: U.S. Congress, Congressional Budget Office, 1981, Table 5

FIGURE 6
ESTIMATED AVERAGE ANNUAL HOUSEHOLD GASOLINE EXPENDITURE BURDEN BY INCOME CLASS (1979–1980)



Source: U.S. Congress, Congressional Budget Office, 1981, Table 5

We estimated public transportation costs for low-income households by using the "non-car" category included in the market basket of goods developed by the U.S. Department of Labor (1979). The average household spent $120 on public transit in the San Francisco Bay area and $41 on public transit in the Los Angeles area during 1972-73. These amounts represented 1% or less of their total annual expenditures. Low-income households (see below for definitions) spent $90 on public transit in the San Francisco area, or 2% of their total expenditures. In the Los Angeles area, low-income households spent $55 on public transit (an amount above the average for all households), or 2% of their total annual expenditures. Thus, low-income households' public transportation payment burden was twice that of the average household in both regions in California during this period.

V. INDIRECT ENERGY CONSUMPTION

In previous sections, we reviewed existing data on direct energy consumption and payment burden among low-income households in the home and for transportation, and we concluded that the consumer's budget share of direct energy expenditures generally tends to decrease with increases in income. In this section, we examine indirect energy consumption and its impact on low-income households. We describe the market basket of goods consumed by low-income groups and by the average household and, using input-output tables, calculate the indirect energy costs of these goods. The market baskets are for households in the San Francisco and Los Angeles areas during 1972-73 while the indirect energy costs are calculated from national data collected in 1977.

A. Market Basket

We present data on the consumption of goods (market basket) and energy costs of those goods for the average household and for low-income households for households in the San Francisco (Table 26) and Los Angeles areas (Table 27) during 1972-73 (U.S. Department of Labor, 1979). When comparing results in the two regions, it is important to note the different definitions of low-income households: in the San Francisco region, households with incomes below $6,000 comprised the low-income group, and in the Los Angeles area, all low-income households had incomes below $4,000. For the San Francisco area, the items included in Table 26 represented 82% of total expenditures for low-income households and 85% for the average household. As seen in columns 4 and 8 ("expenditures per year"), low-income households spent a slightly larger percentage of their income on food compared to the average household (low-income = 21%, average = 18%). Low-income households also spent proportionately more on shelter (25% versus 20%). On the other hand, low-income households spent a smaller percentage of their income on household furnishings

Table 26. Indirect Energy Costs by Market Basket for San Francisco Bay Area Households (1972-73)[a]

	Output ($) Required per Dollar of Expenditure			Average Household[b]				Low Income Households[b] (Under $6,000)			
	1	2	3	4	5	6	7	8	9	10	11
Categories	Coal[c]	Electricity[d] & Gas[d]	Petroleum[e]	Expenditures($)/year[f]	Coal($)[c]	Electricity[d] & Gas($)[d]	Petroleum($)[e]	Expenditures($)/year[f]	Coal($)[c]	Electricity[d] & Gas($)[d]	Petroleum($)[e]
Food Total				1,773 (18%)				967 (21%)			
At home	0.006	0.047	0.037	1,155 (12%)	6.93	54.29	42.74	702 (16%)	4.21	32.99	25.97
Away From Home	0.004	0.048	0.023	592 (6%)	2.37	28.42	3.62	249 (5%)	1.00	11.95	5.73
Shelter	0.002	0.016	0.008	1,958 (20%)	3.68	29.41	14.70	1,189 (25%)	2.38	19.02	9.51
Household Operations				508 (5%)				253 (5%)			
Telephone	0.002	0.016	0.008	186 (2%)	0.35	2.80	1.40	124 (3%)	0.25	1.98	0.99
Domestic and Other Services	0.005	0.060	0.022	175 (2%)	0.89	10.74	3.94	69 (1%)	0.35	4.14	1.52
Household Furnishings				462 (5%)				134 (3%)			
Textiles	0.009	0.076	0.041	71 (1%)	0.49	4.10	2.21	22 (1%)	0.20	1.67	0.90
Furniture	0.008	0.043	0.029	156 (2%)	1.10	5.89	3.97	48 (1%)	0.38	2.06	1.39
Appliances	0.014	0.052	0.025	98 (1%)	1.15	4.26	2.05	28 (1%)	0.39	1.46	0.70
Clothing	0.005	0.045	0.027	603 (6%)	3.01	27.13	16.28	252 (5%)	1.26	11.34	6.80
Other Transport				1387 (14%)				459 (10%)			
Auto Repair Services	0.006	0.035	0.032	448 (5%)	2.70	15.75	14.40	197 (4%)	1.18	6.89	6.30
Motor Vehicles & Equipment	0.016	0.049	0.024	819 (8%)	11.94	36.55	17.90	172 (4%)	2.75	8.43	4.13
Non-Car	0.018	0.236	0.050	120 (1%)	2.16	28.32	6.00	90 (2%)	1.62	21.24	4.50
Health Care	0.004	0.039	0.022	578 (6%)	1.99	19.38	10.93	232 (5%)	0.93	9.05	5.10
Drugs & Supplies	0.007	0.046	0.035	75 (1%)	0.43	2.81	2.13	22 (g)	0.15	1.01	0.77
Recreation	0.004	0.043	0.022	913 (9%)	3.65	39.26	20.09	365 (8%)	1.46	15.70	8.03
TOTAL				8,182 (85%)	42.83	309.11	162.38	3,851 (82%)	18.51	148.94	82.36

[a] Market basket share data (expenditures per year) are for households in the San Francisco SMSA for 1972-73 (U.S. Department of Labor, 1979). Energy costs are derived from 1977 input-output matrices developed by the Department of Commerce, Bureau of Economic Analysis (1984).

[b] Average income was $13,173 before taxes for the average household and $3,223 for low income households.

[c] Refers to coal mining.

[d] Refers to electricity, gas, water, and sanitary services.

[e] Refers to petroleum refining and related industries.

[f] We have included the major categories of expenditures in this table, and they comprise 85% of total expenditures ($9,629) for the average household and 82% of total expenditures ($4,679) for low income households. The numbers in parentheses represent percentages of total expenditures.

[g] Less than 1% per year; too small to calculate.

Table 27. Indirect Energy Costs by Market Basket for Los Angeles Area Households (1972-73)[a]

	Output($) Required per Dollar of Expenditure			Average Household[b]				Low Income Households[b] (Under $4,000)			
	1	2	3	4	5	6	7	8	9	10	11
Categories	Coal[c]	Electricity & Gas[d]	Petroleum[e]	Expenditures($)/year[f]	Coal($)[c]	Electricity & Gas($)[d]	Petroleum($)[e]	Expenditures($)/year[f]	Coal($)[c]	Electricity & Gas($)[d]	Petroleum($)[e]
Food Total				1,782 (20%)				719 (18%)			
At home	0.006	0.047	0.037	1,174 (13%)	7.04	55.18	43.44	566 (14%)	3.90	26.60	20.94
Away From Home	0.004	0.048	0.023	600 (7%)	2.40	28.80	13.80	148 (4%)	0.59	7.10	3.40
Shelter	0.002	0.016	0.008	1,838 (20%)	3.68	29.41	14.70	1,350 (34%)	2.70	21.60	10.80
Household Operations				495 (6%)				272 (7%)			
Telephone	0.002	0.016	0.008	175 (2%)	0.35	2.80	1.40	85 (2%)	0.17	1.36	0.68
Domestic and Other Services	0.005	0.060	0.022	179 (2%)	0.89	10.74	3.94	115 (3%)	0.57	6.90	2.53
Household Furnishings				364 (4%)				130 (3%)			
Textiles	0.009	0.076	0.041	54 (1%)	0.49	4.10	2.21	20 (g)	0.18	1.52	0.82
Furniture	0.008	0.043	0.029	137 (2%)	1.10	5.89	3.97	38 (1%)	0.30	1.63	1.10
Appliances	0.014	0.052	0.025	82 (1%)	1.15	4.26	2.05	46 (1%)	0.64	2.39	1.15
Clothing	0.005	0.045	0.027	690 (8%)	3.45	31.06	18.63	173 (4%)	0.87	7.79	4.67
Other Transport				1238 (14%)				376 (9%)			
Auto Repair Services	0.006	0.035	0.032	450 (5%)	2.70	15.75	14.40	107 (3%)	0.64	3.75	3.42
Motor Vehicles & Equipment	0.016	0.049	0.024	746 (8%)	11.94	36.55	17.90	214 (5%)	3.42	10.49	5.14
Non-Car	0.018	0.236	0.050	41 (g)	0.74	9.68	2.05	55 (1%)	0.99	12.98	2.75
Health Care	0.004	0.039	0.022	497 (6%)	1.99	19.38	10.93	234 (6%)	0.94	9.13	5.15
Drugs & Supplies	0.007	0.046	0.035	61 (1%)	0.43	2.81	2.14	38 (1%)	0.27	1.75	1.33
Recreation	0.004	0.043	0.022	747 (8%)	2.99	32.12	16.43	14 (5%)	0.86	9.20	4.71
TOTAL				8,983 (86%)	41.32	288.52	168.00	3,989 (86%)	16.54	124.18	68.59

[a]Market basket share data (expenditures per year) are for households in the Los Angeles SMSA for 1972-73 (U.S. Department of Labor, 1979). Energy costs are derived from 1977 input-output matrices developed by the Department of Commerce, Bureau of Economic Analysis (1984).

[b]Average income was $12,419 before taxes for the average household and $870 for low income households.

[c]Refers to coal mining.

[d]Refers to electricity, gas, water, and sanitary services.

[e]Refers to petroleum refining and related industries.

[f]We have included the major categories of expenditures in this table, and they comprise 86% of total expenditures ($8,983) for the average household and 86% of total expenditures ($3,989) for low income households. The numbers in parentheses represent percentages of total expenditures.

[g]Less than 1% per year; too small to calculate.

compared to the average household (low-income = 3%, average = 5%). Low-income groups also spent slightly less on clothing (5% versus 6%), health care (5% versus 6%), and recreation (8% versus 9%). Aside from shelter, the differences in the market basket between low-income households and the average household in the San Francisco area were small.

For the Los Angeles area, the items included in Table 27 represented 86% of total expenditures for both low-income households and the average household. As in Northern California, low-income households spent proportionately more on shelter than the average household (34% versus 20%). On the other hand, low-income households spent proportionately less on food consumed away from home (4% versus 7%), clothing (4% versus 8%), other transport (9% versus 14%), and recreation (5% versus 8%). For the other categories, the low-income households were similar to the average household.

B. Indirect Energy Costs

Using U.S. input-output (I-O) accounts for 1977 (U.S. Department of Commerce, Bureau of Economic Analysis, 1984), we determined the indirect energy costs built into the prices of goods and services for the market baskets for San Francisco and Los Angeles area households (Tables 26 and 27, Columns 1-3).[14] These indirect energy costs were then weighted by the amounts of each type of good or service purchased to estimate the indirect energy cost contained in the market baskets of low-income households (Columns 9-11) and of the average household (Columns 5-7). For example, $0.006 of coal was needed to provide $1.00 worth of food eaten at home. For the average San Francisco area household, a total of $6.93 worth of coal must be produced based on their consumption of food at home (Col. 1 X Col. 4 = Col. 5); for low-income households, $4.21 of coal must be produced (Col. 1 X Col. 8 = Col. 9).

The total amount of energy required to provide the market basket for low-income households was about 45% less than for the average household ($249.81 for low-income households and $514.32 for the average household in Northern California; $209.31 for low-income households and $497.84 for the average household in Southern California). However, as a percentage of total expenditures, the total amount of energy required for providing the market basket was similar for both income groups with slight regional differences in California (6.5% for low-income households and 6.3% for the average household in Northern California; 5.2% for low-income households and 5.5% for the average household in Southern California). For producing the market basket of goods for low-income households in the San Francisco area, $18.51 of coal production was needed, $148.94 of electricity and natural gas, and $82.36 of petroleum; for the average household, $42.83 of coal, $309.11 of electricity and natural gas,

and $162.38 of petroleum was needed. For producing the market basket of goods for low-income households in the Los Angeles area, $16.54 of coal production was needed, $124.18 of electricity and natural gas, and $68.59 of petroleum; for the average household, $41.32 of coal, $288.52 of electricity and natural gas, and $168.00 of petroleum was needed. Electricity and gas constitute 60% of the total indirect energy costs for all income groups in California. Thus, it appears that changes in the cost of producing electricity and natural gas will have the greatest impact on the consumption of indirect energy goods for low-income households as well as for the average household. Regional differences in the market basket do not seem to be important in affecting the indirect energy costs of low-income households.

VI. SUMMARY AND CONCLUSIONS

We examined the relationship between energy consumption and income with a particular emphasis on low-income households in California. The low-income population constitutes 10-20% of California's population, and almost 20% of these people live in the rural areas of California. While home energy use (primarily electricity and natural gas) and payments of low-income households are less than those of other income groups, the former's "payment burden" is as much as 350% greater than the burden for high-income households.

In comparison to the average household, the average low-income household has only one vehicle that is likely to be an older and inefficient model. Low-income people drive their cars less than other people and usually use the car only for necessary trips. They also live closer to work and use public transit more often than other groups. Accordingly, the low-income population spend less money on gasoline and transportation costs than other income groups; however, low-income households spend a 2 to 3 times larger fraction of their income on transportation energy than did high-income households.

The differences in the market basket of goods between low-income households and the average household are not large, although it appears that low-income households in California spend proportionately more of their budget on food and shelter and less on recreation, health care, and food consumed away from home than the average household. Indirect energy consumption for low-income households is 45% less than for the average household. However, as a percentage of total expenditures, the total amount of energy required for providing the market basket is similar for both income groups with slight regional differences in California. The indirect energy consumption of all income groups would be affected by changes in the cost of electricity and natural gas since these two fuels constituted almost 60% of the total cost of energy needed to produce the California market basket.

Data were not available to examine the determinants of energy use among low-income households. Based on previous work in analyzing energy use in the residential sector for all income groups, we believe that the following variables could be important in affecting energy use among low-income households: poorly constructed housing with little or no insulation in the walls and ceiling and large air infiltration rates; inefficient heating and cooling appliances; and energy intensive behavior (Meyers and Schipper, 1984; Stobaugh and Yergin, 1979; U.S. Congress, Office of Technology Assessment, 1982). Appropriate remedies could include promoting the use of energy conservation measures: e.g., efficient appliances, low-flow showerheads, night setbacks, and insulation of water heaters. In addition, special outreach programs involving education, technical assistance, and financial incentives may be necessary for promoting the use of energy-conserving measures and making low-income people more aware of less energy intensive lifestyles. This is especially important for the rental sector in which low-income renters have little incentive for installing energy-conservation technologies in dwellings that are owned by landlords. Comprehensive programs may be needed to complement some of the on-going state agency programs in which financial subsidies are the common remedy for assisting low-income people.

NOTES

1. Telephone interview with Elizabeth Hoag, California Office of Finance, Department of Population Research (August 23, 1984). In the draft State Plan of the Office of Economic Opportunity's (OEO) Low-Income Home Energy Assistance Program (LIHEAP) for FY 1985, OEO will make payments to households with incomes which do not exceed the greater of: (a) an amount equal to 150% of the poverty level for California, or (b) an amount equal to 60% of the State median income (California Office of Economic Opportunity, 1984). Households may also obtain assistance if members of the household receive Aid to Families with Dependent Children (AFDC), Supplemental Security Income (SSI), food stamps, or need-tested veteran benefits.

2. Telephone interview with Erlinda Cruz, California Franchise Tax Board (August 23, 1984).

3. "Persons" are defined in the census literature to include all persons except inmates of institutions, persons in military group quarters and in college dormitories, and unrelated individuals under 15 years old (U.S. Department of Commerce, 1980, page B-22). These data are found in Tables 778 and 783 in Statistical Abstract of the U.S.: 1984; Table 72 in General Social and Economic Characteristics: California; and Table 234 in Detailed Population Statistics. All the tables are based on 1980 Census data. The 1979 federal definition of poverty for one person was $3,686 (U.S. Department of Commerce, 1984).

4. The average family size was 3.6 persons. The 1979 federal definition of poverty for a family of four persons was $7,412; 125% of the poverty level was $9,265 (U.S. Department of Commerce, 1984).

5. The 1981 survey used a two-phase design: two mailings to a stratified sample of approximately 27,000 PG&E residential households (response rate of 57%), followed by telephone or face-to-face interviews with a subsample of 2,331 nonrespondents to the mail surveys (response rate of 75%). The income question on RASS elicited a response of "choose not to answer" or simply omitting any answer from 27.4% of all respondents. PG&E asserts that internal and external evidence indicated that income statistics derived from this group were representative of all households served by PG&E.

6. This data came from Table 1 in General Housing Characteristics, California, 1980 (U.S. Department of Commerce, 1982).

7. The PG&E sample does not represent the total PG&E population because sample sizes have not been adjusted to represent the total service area. Because similar sample sizes were drawn from each county in PG&E's service area, urban counties were underweighted and rural counties were overweighted. Telephone interview with Tom Gorin, California Energy Commission, October 10, 1984.

8. Because income ranges were used in the surveys, Feizollahi used the following income averages for his income categories in calculating the payment burden: $7,000 for low-income, $16,250 for median income, and $53,000 for high income.

9. Telephone interview with Fred Coito, Pacific Gas and Electric Company (September 18, 1984).

10. Telephone interview with Bill Miller, Pacific Gas and Electric Company (September 18, 1984).

11. Telephone interview with Larry Schelhorse, San Diego Gas and Electric Company (September 19, 1984).

12. Newman and Wachtel's definition of the poor was based on the U.S. definition of the poor and near poor in 1972, modified for use with survey data for which income was reported within a particular range rather than as a specific figure. The poverty thresholds were as follows: under $3,000 for 1 or 2 people; under $5,000 for 3-4 people; under $7,000 for 5-6 people; and under $9,000 for 7 or more people. The nonpoor were divided into 3 groups referred to as "lower", "middle", and "well-off". The "lower" group of nonpoor had incomes below $12,000 in 1972. The "middle" group had incomes between $12,000 and $15,999. The "well-off" were those with incomes of $16,000 and over.

13. The 1977-78 Nationwide Personal Transportation Study (NPTS) is the most recent comprehensive source of information on transit rider incomes in the U.S.. The NPTS was conducted by the U.S. Bureau of the Census for the Federal Highway Administration. The NPTS data were based on a survey of 18,000 households during the 12-month period from April 1977 to March 1978. The interviewed households represented a random stratified sample roughly representative of the U.S. population as a whole (U.S. Department of Transportation, 1980; Pucher, 1981).

14. The input-output (I-O) tables for 1977 were based primarily on the detailed industry statistics collected by the Census Bureau in the 1977 economic censuses. The most important assumption generally made in I-O analysis is that the inputs used in production are proportional to output.

Moreover, these relations ("input coefficients") in general do not change rapidly. Accordingly, the input-output tables that are used to quantify these relations retain their usefulness for economic analysis over a period of several years (U.S. Department of Commerce, Bureau of Economic Analysis, 1984). For more information on using input-output tables to estimate indirect energy consumption, see Bullard and Herendeen (1975), Hannon (1975), and Krenz (1984).

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