
**Energy Consumption and Expenditure Projections
by Income Quintile on the Basis of the *Annual
Energy Outlook 1997* Forecast**

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Energy Consumption and Expenditure Projections by Income Quintile on the Basis of the *Annual Energy Outlook 1997* Forecast

by D.A. Poyer and T. Allison

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ENERGY CONSUMPTION AND EXPENDITURE PROJECTIONS BY INCOME QUINTILE ON THE BASIS OF THE ANNUAL ENERGY OUTLOOK 1997 FORECAST

by

D.A. Poyer and T. Allison

ABSTRACT

This report presents an analysis of the relative impacts of the base-case scenario used in the *Annual Energy Outlook 1997*, published by the U.S. Department of Energy, Energy Information Administration, on income quintile groups. Projected energy consumption and expenditures, and projected energy expenditures as a share of income, for the period 1993 to 2015 are reported. Projected consumption of electricity, natural gas, distillate fuel, and liquefied petroleum gas over this period is also reported for each income group.

SUMMARY

This study provides a disaggregated analysis by income class of the *Annual Energy Outlook 1997* forecast. Energy consumption and expenditure estimates and forecasts from 1993 through 2015 are provided for five household income quintile groups. The analysis uses the Socio-Economic Research and Analysis Program's Distributive Impact and Assessment Model, an econometric model that uses population-specific energy demand systems. These energy demand systems were estimated from a sequence of Residential Energy Consumption Surveys produced by the U.S. Department of Energy's Energy Information Administration.

Projections show that residential energy use will shift substantially to electricity from distillate fuel and natural gas. This shift will occur disproportionately within the middle income quintile. The middle income quintile is expected to have the largest relative change in residential patterns of energy use. Some highlights of the forecast follow:

- Electricity
 - Of the major sources of energy for residential use, only average household electricity consumption will increase for each income group.

- The increase in average household electricity consumption will be the highest for the third and fourth quintile income groups, growing at an annual rate of slightly more than 0.6%.
- Because of the decreased cost of electricity, the average cost of electricity per household will decrease for each income group, despite the projected rise in electricity consumption.
- Natural Gas
 - Natural gas consumption will decrease slowly between 1993 and 2015 for each income group. The decrease will occur somewhat faster for the fourth and fifth quintile income groups.
 - The cost of natural gas will decline for each income group, but at a slightly higher rate for the fourth and fifth quintile groups.
- Distillate Fuel
 - The use of distillate fuel will decline dramatically. For example, distillate consumption for the average household will decline by 40% between 1993 and 2015.
 - The decrease in distillate fuel consumption will be largest for the middle income quintile group, where it will decline by 50% from 1993 through 2015.
 - The cost of distillate fuel for the average household will decline over the entire forecast period. The price decline will be largest for the middle income quintile group.
- Liquefied Petroleum Gas (LPG)
 - The average household consumption of LPG will fall for each income group, except for the fourth income quintile.
 - The projected change in average LPG expenditures will vary across income class. It will increase for the second and fourth income quintile groups and decrease for the other three. LPG expenditures will increase by 14% for the fourth income quintile group.

- Energy Expenditures
 - Energy expenditures will decline for each income group over the forecast period. The largest declines will be for the lowest and highest income quintiles.
 - The electricity share of total energy expenditures will increase dramatically, from 67% in 1993 to 73% in 2015. Likewise, expenditures for electricity will increase for each income class.
 - Expenditures for natural gas and fuel oil will fall for each income group. The overall LPG share will increase overall, except for the middle and highest income quintile groups, for which it will decrease.
 - During the forecast period, the share of income for energy expenditures will decline. The relative change in energy expenditure share will be approximately the same for each income group — declining by about 30%.
 - During the forecast period, the total energy expenditures for electricity will increase for each income quintile. The biggest increase will occur in the middle income quintile, where it will increase from 69% in 1993 to 75% in 2015.

1 INTRODUCTION

Patterns of energy consumption and expenditures differ across population groups because of social circumstances. For various reasons, the factors that influence patterns of energy use often differ among socioeconomic groups. Furthermore, even when various energy-related factors are controlled, differences in patterns of energy use still persist among population groups.¹ Because of these differences, the effect of changing energy markets on the economic welfare of different groups is probably unequal.

The U.S. Department of Energy (DOE), Office of Economic Impact and Diversity, supports research to develop methodologies and analytical tools that can be used to produce disaggregated forecasts of energy consumption and expenditures. The forecasts are made for various population groups consistent with the DOE/Energy Information Administration (EIA) *Annual Energy Outlook* (AEO) forecasts. This research is important because patterns of energy consumption and expenditures differ among these various population groups. Statistical analyses of the Residential Energy Consumption Surveys (RECSs) over the last 15 years indicate that patterns of energy consumption generally differ among population groups and income classes. Causes of these variations are the facts that populations are distributed differently over energy-related variables and that the residential energy demand structure is inconsistent. As a result, these groups have various degrees of vulnerability to changing energy prices. Consequently, these differences are likely to lead to disparate economic outcomes for these groups (Poyer and Williams 1993; Poyer et al. 1997).

In the following sections, information is presented on the distribution of income quintile and socioeconomic groups over important energy-related factors. It becomes apparent that substantial differences exist.

¹ Unobserved factors or the quality of data are possible explanations for differences in patterns of energy use, as are "preference" or "cultural" differences among population groups.

2 ENERGY CONSUMPTION AND INCOME CLASS

It is obvious to most people that demographics, location, and way of life are different for households with low and high incomes. What has not been considered is the effects of these differences on the level and patterns of energy use. Total energy consumption and expenditures increase as income increases (i.e., the higher income quintile), as shown in Tables 1 and 2 (DOE 1995a,b). However, patterns of consumption and expenditures for individual sources of residential energy are not as predictable. These data indicate that residential energy is a normal good because its consumption and expenditures increase as income increases.

Consumption and expenditures for electricity and distillate fuel increase with each income quintile, but consumption and expenditures for natural gas and liquefied petroleum gas (LPG) are less predictable. Consumption and expenditures for natural gas increase for each higher income quintile, except for the middle income group. On the other hand, consumption and expenditures for LPG peak in the middle income quintile and fall in the lowest and highest income quintiles (bell-shaped). Income quintiles are numbered 1–5, where quintile 1 represents the lowest income quintile group, and quintile 5 is the highest.

2.1 ENERGY EXPENDITURE SHARES FOR 1993

The energy expenditure shares for 1993 are shown for the four major residential energy sources for each income quintile group in Figures 1–5. These figures show a difference in energy expenditure fuel mix between the lower income and higher income groups. The natural gas expenditure share is nearly five percentage points higher for the two lower income groups than for the three higher income quintiles. On the other hand, the electricity expenditure share is about four percentage points lower for the two lower income groups than for the three higher income groups. Note that all sources of energy have been converted to millions of Btu for means of comparison.

Energy consumption and expenditure patterns differ by socioeconomic group (non-Hispanic whites and blacks and Hispanics), and these differences tend to prevail even after controlling for income (Poyer and Williams 1993; Poyer et al. 1997). This fact is particularly true for lower income groups; however, some convergence in energy consumption patterns occurs in the higher income groups. These differences are partly explained by differences in household population distribution over energy-related variables. Some important energy-related variables are geographic area of the United States, urban or rural location, number of household members, type of housing, age of housing, and home ownership or rental property. In the following sections, patterns of energy consumption and expenditures are cross-tabulated with these important energy-related variables by income class, race, and Hispanic ethnicity.

TABLE 1 Residential Energy Consumption by Income Quintile and Energy Source for 1993

Income Quintile	Annual Average Household Energy Consumption (10 ⁶ Btu/yr per household)				
	Electricity	Natural Gas	Distillate	LPG	Total
One	24.82	46.59	7.84	3.68	82.93
Two	28.57	53.47	10.14	3.86	96.04
Three	35.75	49.01	11.28	5.41	101.45
Four	37.78	55.41	12.38	3.74	109.31
Five	43.11	68.48	13.95	3.07	128.61
U.S. avg.	34.01	54.59	11.12	3.95	103.67

Source: DOE (1995a).

TABLE 2 Residential Energy Expenditures by Income Quintile and Energy Source for 1993

Income Quintile	Annual Average Household Energy Expenditures (\$/yr per household)				
	Electricity	Natural Gas	Distillate	LPG	Total
One	621	289	50	39	998
Two	702	319	65	39	1,126
Three	849	295	73	54	1,271
Four	933	338	81	36	1,388
Five	1,088	420	94	30	1,632
U.S. avg.	839	332	73	40	1,283

Source: DOE (1995b).

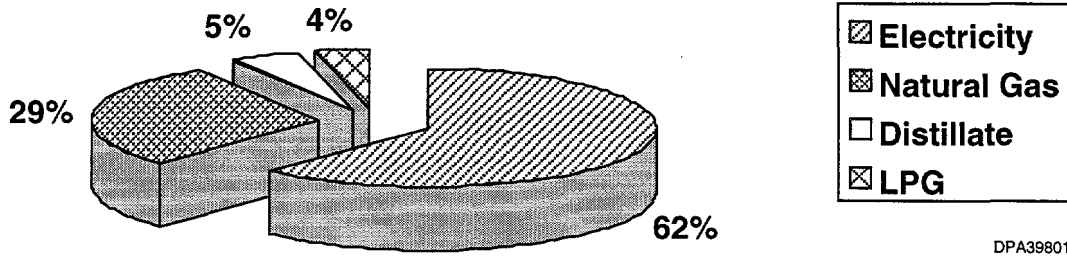


FIGURE 1 Average Household Energy Expenditure Shares for the First Income Quintile for 1993 (Source: DOE 1995a)

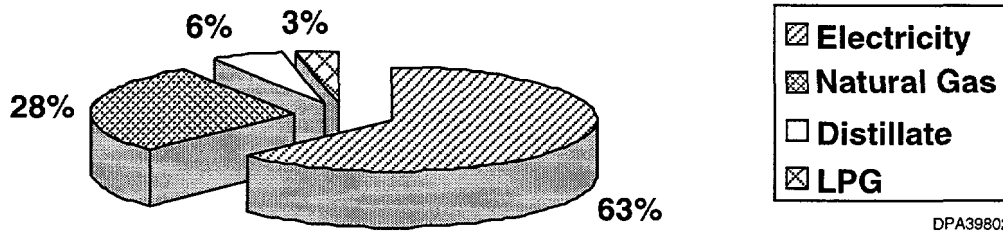


FIGURE 2 Average Household Energy Expenditure Shares for the Second Income Quintile for 1993 (Source: DOE 1995a)

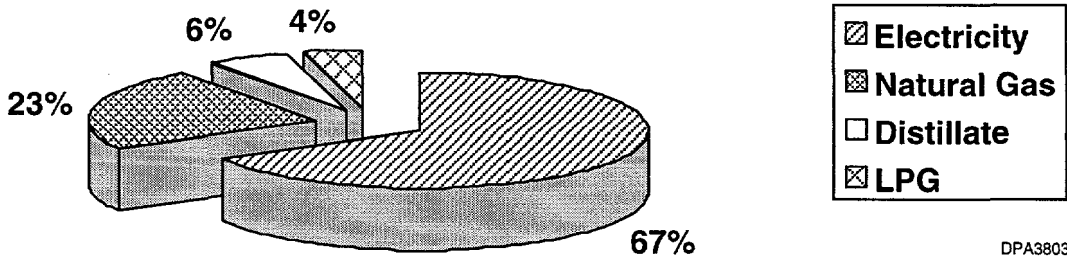


FIGURE 3 Average Household Energy Expenditure Shares for the Third Income Quintile for 1993 (Source: DOE 1995a)

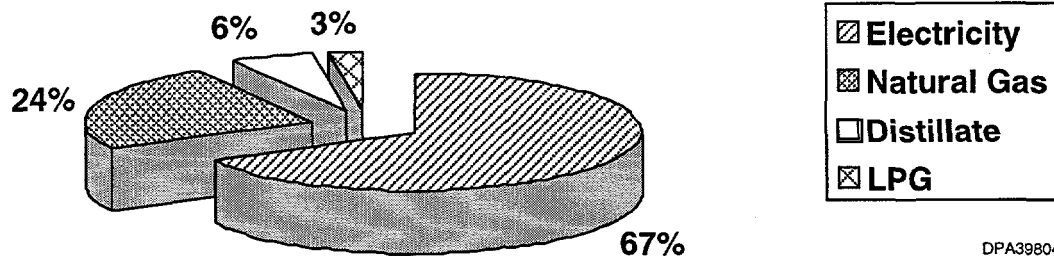


FIGURE 4 Average Household Energy Expenditure Shares for the Fourth Income Quintile for 1993 (Source: DOE 1995a)

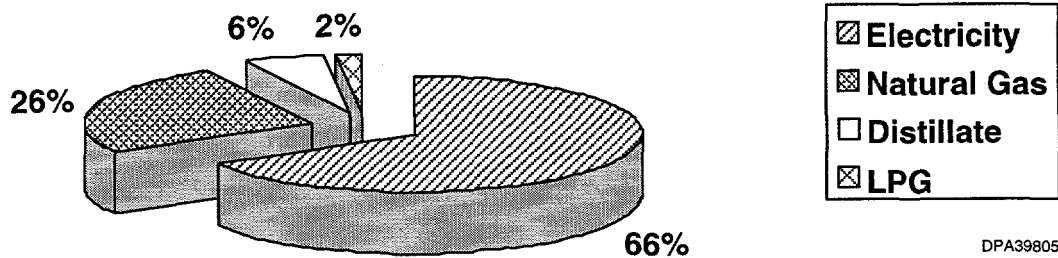


FIGURE 5 Average Household Energy Expenditure Shares for the Fifth Income Quintile for 1993 (Source: DOE 1995a)

2.2 HOME TYPE AND ENERGY CONSUMPTION

The relationship between home type and patterns of energy use is recognized explicitly by the EIA in its AEO forecast methodology. Changes in energy use in large part depend on forecasted changes in the composition of housing. Reasons for this relationship are shown in Figures 6 and 7. These figures show the striking relationship between energy consumption/expenditures and housing type.

Residents in detached single-family homes consume and spend more on energy. The composition of energy use varies widely across home types. The average consumption of electricity is highest in attached single-family homes and mobile homes, and electricity is a much larger fraction of overall residential consumption and expenditures in mobile homes. At the other extreme, electricity consumption and expenditures are both absolutely and relatively lower in small multifamily units.² It is important to distinguish among differences in energy consumption patterns by home type when assessing energy consumption patterns among different income and socioeconomic groups because of differences in the distribution of these groups over home types.

² Small multifamily housing is defined as multifamily buildings with four or fewer units, and large multifamily housing is defined as multifamily buildings with more than four units.

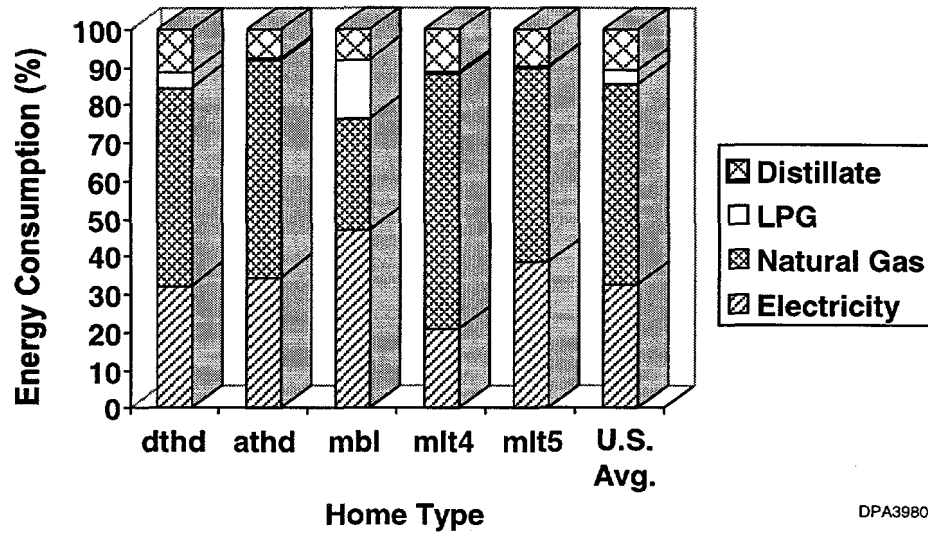


FIGURE 6 Average Energy Consumption by Home Type and Fuel Source (dthd = detached single-family home; athd = attached single-family home; mbl = mobile home; mlt4 = small multifamily [≤ 4] home; and mlt5 = large multifamily [> 4] home.) (Source: DOE 1995a)

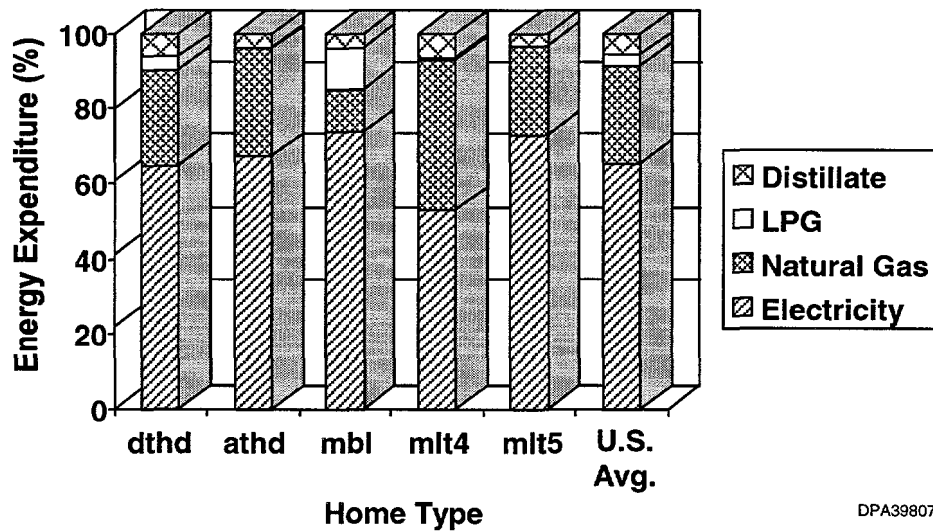


FIGURE 7 Average Energy Expenditures by Home Type and Fuel Source (dthd = detached single-family home; athd = attached single-family home; mbl = mobile home; mlt4 = small multifamily [≤ 4] home; and mlt5 = large multifamily [> 4] home.) (Source: DOE 1995a)

Table 3 gives the 1993 income and population group distributions by home type. In general, lower-income households tend to live in multifamily housing. More than 40% of all households in the first income quintile live in multifamily housing, with about 30% of all first income quintile households living in large multifamily dwellings. On the other hand, only about 11% of the households in the highest income quintile live in multifamily housing. As a consequence, it is expected that lower income households would consume less energy than higher income households would.

In addition, the 1993 RECS data show a substantial difference in the racial and ethnic home-type distribution of households regardless of income. These data indicate that minority households (non-Hispanic blacks and Hispanics) are more likely to live in multifamily housing than their nonminority counterparts within each income group. This imbalance is probably related to the disproportionate concentration of minorities in central cities.

2.3 URBAN/RURAL LOCATION AND ENERGY CONSUMPTION

Figures 8 and 9 give composition of energy consumption and expenditure patterns by urban/rural location in 1993 (DOE 1995a). The difference in the composition of energy use and the level of energy expenditures between urban and rural locations is striking. In rural areas, estimated household energy expenditures are substantially higher than they are in urban areas. Annual household energy expenditures were approximately 40% higher in rural areas than in urban areas in 1993.

The consumption of electricity, as well as distillate and LPG fuel, is substantially higher in rural communities. Rural areas use a large fraction of these energy sources for space heating, whereas urban areas primarily use natural gas.³

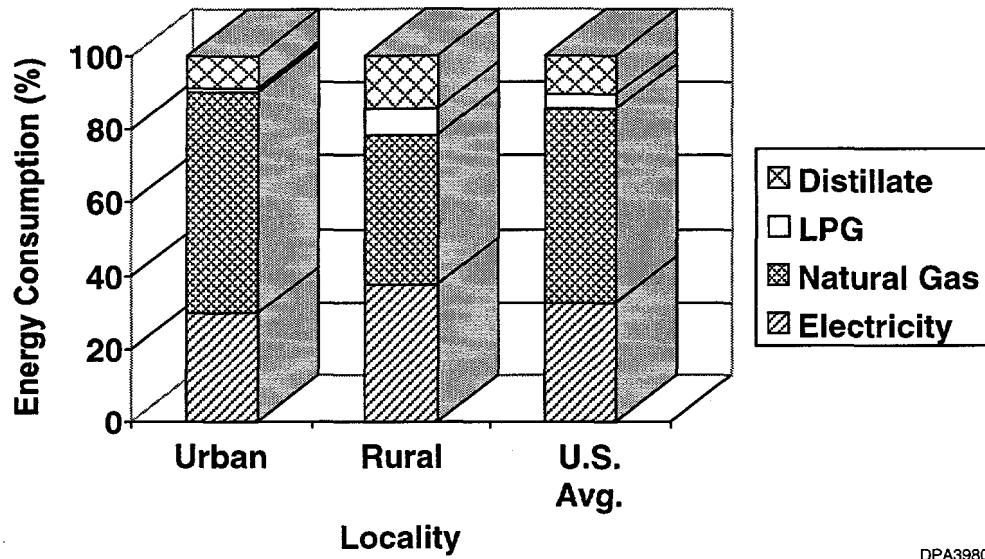
Table 4 gives the percentages of households by income and socioeconomic group living in urban and rural areas. Lower income households are more likely to reside in an urban area, and Hispanic and non-Hispanic black households are more likely to live in urban areas regardless of income quintile. The percentage of Hispanics and non-Hispanic blacks living in urban areas is higher than for non-Hispanic whites for each income quintile. The heavy concentration of minority households in urban areas contributes to their relatively higher consumption of natural gas.

³ Natural gas is the primary heating fuel in about 40% of all rural households and about 60% of all urban households (DOE 1995a).

TABLE 3 Household Percentages by Home Type for 1993

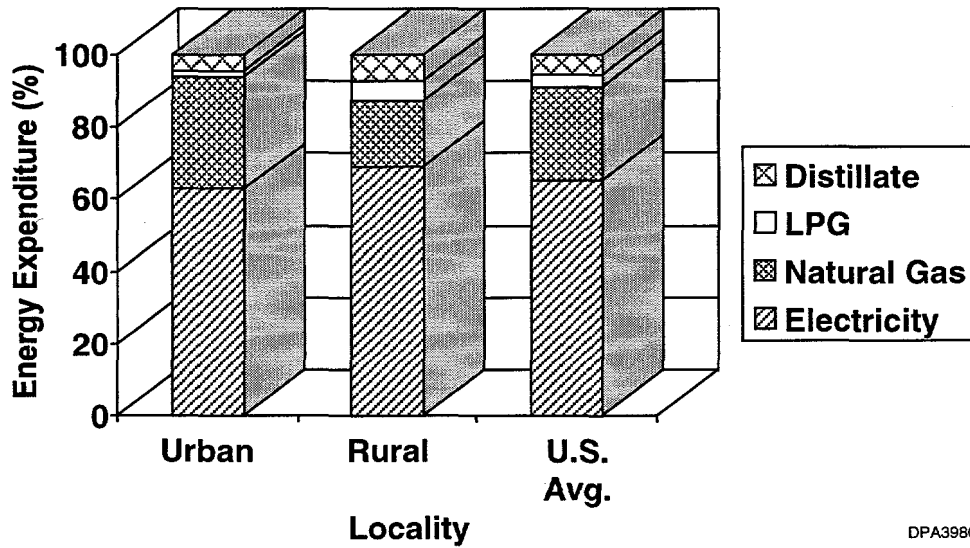
Income Quintile and Socioeconomic Group	Home Type				
	Detached Single- Family	Attached Single- Family	Mobile Home	Small Multifamily (≤4)	Large Multifamily (>4)
First	43	7	8	12	30
White	46	6	10	11	26
Black	41	9	2	14	35
Hispanic	31	8	7	16	39
Second	54	7	9	11	18
White	59	5	10	10	15
Black	43	13	4	17	23
Hispanic	41	8	8	18	25
Third	63	7	7	7	16
White	67	7	7	7	12
Black	42	11	4	10	33
Hispanic	41	7	10	6	36
Fourth	69	9	4	7	12
White	72	8	4	6	10
Black	47	10	2	22	20
Hispanic	59	9	8	7	18
Fifth	80	8	1	4	7
White	84	7	2	3	5
Black	53	21	0	9	17
Hispanic	63	10	1	9	17
U.S. average	62	8	6	8	17

Source: DOE (1995a).



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FIGURE 8 Average Energy Consumption by Locality and Source for 1993
(Source: DOE 1995a)



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FIGURE 9 Average Energy Expenditures by Locality and Source for 1993
(Source: DOE 1995a)

TABLE 4 Household Percentages by Location for 1993

Income Quintile and Socioeconomic Group	Location ^a		Income Quintile and Socioeconomic Group	Location ^a	
	Urban	Rural		Urban	Rural
First	74	26	Fourth	58	42
White	68	32	White	56	44
Black	86	14	Black	60	40
Hispanic	84	16	Hispanic	75	25
Second	68	32	Fifth	53	47
White	63	37	White	50	50
Black	85	15	Black	58	42
Hispanic	80	20	Hispanic	70	30
Third	60	40	U.S. average	62	38
White	56	44	White	58	42
Black	80	20	Black	78	22
Hispanic	73	27	Hispanic	78	22

^a For a definition of urban and rural, see DOE (1995a, pp. 309 and 312).

Source: DOE (1995a).

The differences are particularly pronounced among the lower income groups. Lower income minorities are more heavily concentrated in urban areas. As income rises, the urban/rural distribution for non-Hispanic blacks and whites becomes more similar. However, the same is not true for Hispanics; higher income Hispanics are still disproportionately concentrated in urban areas.

2.4 GEOGRAPHIC LOCATION AND ENERGY CONSUMPTION

Table 5 gives the average household energy consumption by energy source and Census region for 1993. The composition of energy use by Census region is shown in Figure 10. The level and composition of energy use vary widely by region. Electricity is used more heavily in the South, whereas natural gas is used more heavily in the Midwest, and distillate fuel is used more heavily in the Northeast.

Table 6 gives the average household energy expenditures by energy source and Census region for 1993. The composition of energy expenditures is shown in Figure 11. Overall household energy expenditures are highest in the Northeast and lowest in the West. Average

**TABLE 5 Average Household Energy Consumption
by Energy Source and Census Region for 1993**

Annual Average Household Energy Consumption (10 ⁶ Btu/yr per household)					
Census Region	Electricity	Natural Gas	Distillate Fuel	LPG	All
Northeast	24	57	40	1	122
Midwest	32	89	6	8	134
South	45	35	4	4	88
West	28	45	2	2	76
U.S. average	34	55	11	4	104

Source: DOE (1995a).

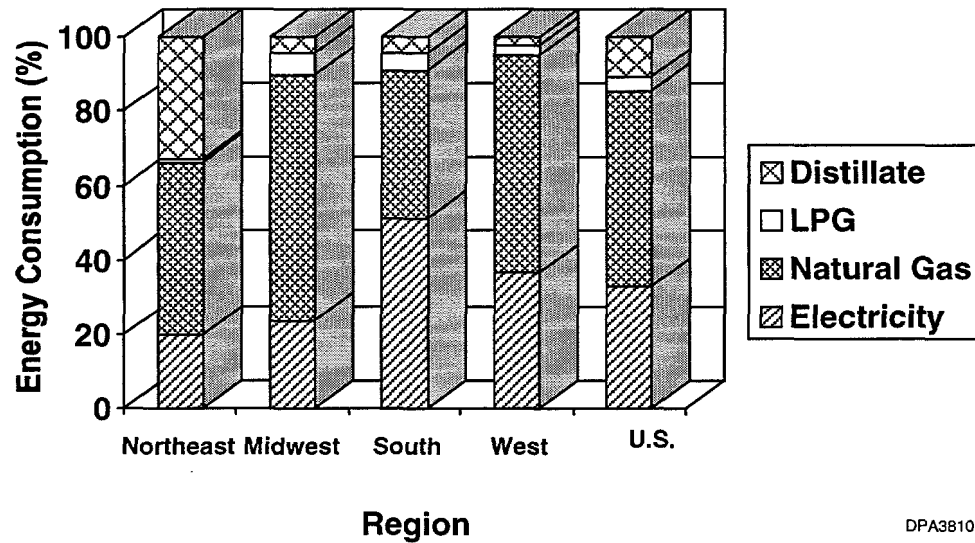


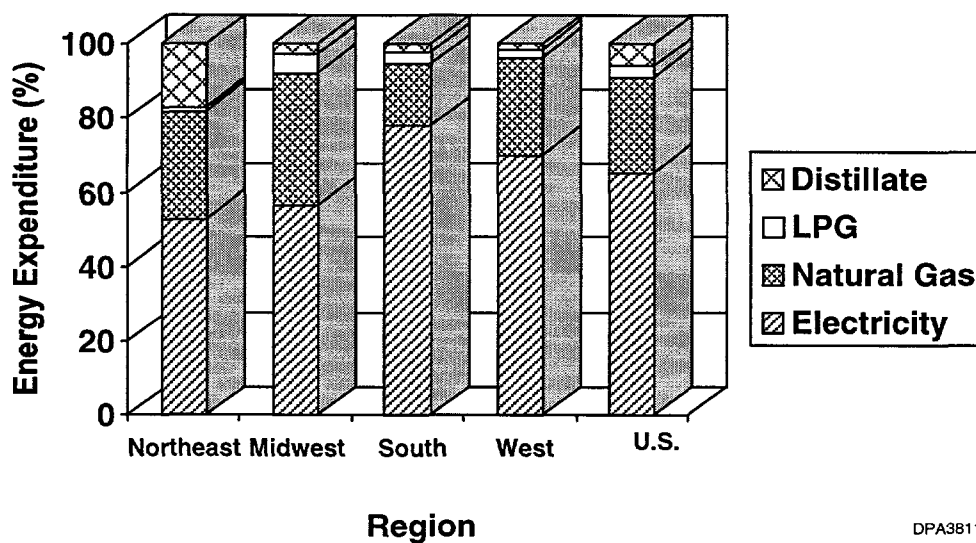
FIGURE 10 Average Energy Consumption by Region and Source for 1993
(Source: DOE 1995a)

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**TABLE 6 Average Household Energy Expenditures
by Energy Source and Census Region for 1993**

Census Region	Annual Average Household Energy Expenditures (\$/yr per household)				
	Electricity	Natural Gas	Distillate Fuel	LPG	All
Northeast	809	441	257	18	1,526
Midwest	753	488	36	68	1,336
South	1,017	216	27	43	1,304
West	667	250	12	21	953
U.S. average	839	332	40	73	1,283

Source: DOE (1995a).



**FIGURE 11 Average Energy Expenditures by Region and Source for 1993
(Source: DOE 1995a)**

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household energy expenditures in the Northeast are estimated to be more than 60% higher than expenditures in the West. Household energy expenditures in the Midwest and South are about the same — approximately \$1,300 per year in 1993.

Electricity expenditures are highest in the South, exceeding electricity expenditures in the Northeast, which has the second highest level of electricity expenditures, by more than 25%. Average household natural gas expenditures are the highest in the Northeast and Midwest. Natural gas expenditures in these regions are nearly twice their level in the South and West. Distillate fuel is consumed almost exclusively in the Northeast, where distillate fuel expenditures dwarf expenditures in any other region.

The Census regions show a marked difference in the relative electricity share of total energy expenditures. For example, while the share of electricity is substantially higher in the South, it is also high in all regions (more than 40%).

Table 7 gives the 1993 household population distributions by Census region. As expected, the national and non-Hispanic white distributions are very similar, with non-Hispanic whites slightly more concentrated than Hispanics and non-Hispanic blacks in the Northeast and Midwest. The distributions of minority households differ greatly from that of non-Hispanic whites. According to estimates from the 1993 RECS, the concentration of non-Hispanic blacks is heavier in the South; more than 50% of this population group lives in the South, whereas 33% of non-Hispanic whites live in that region. Concentrations of Hispanic households are primarily in the West. Approximately 37% of all Hispanic households are located there, compared with 19% of all non-Hispanic white households.

2.5 HOUSING VINTAGE AND ENERGY CONSUMPTION

Tables 8 and 9 give the average household energy consumption and expenditures, respectively, by housing vintage for 1993. The composition of energy use among homes of various ages differs greatly. For the most part, the consumption of electricity is relatively higher in new homes. However, natural gas consumption increases in homes built after 1989. The use of natural gas and distillate fuel is much less in homes built between 1970 and 1984 than in homes built before 1970.⁴ Estimates show that the 1993 consumption of natural gas and distillate fuel in homes built between 1970 and 1984 is half the estimates of consumption of those fuels in homes built before 1970.

⁴ The American economy experienced two large increases in energy prices between 1970 and 1984. The first increase occurred in late 1973 with the outbreak of the Yom Kippur War and the embargo on Arab oil, and the second increase occurred in 1978 with the revolution in Iran and the overthrow of the Shah of Iran.

TABLE 7 Household Percentages by Census Region for 1993

Income Quintile and Socioeconomic Group	Census Region			
	Northeast	Midwest	South	West
First	21	21	40	18
White	21	25	37	18
Black	17	19	59	5
Hispanic	31	9	21	40
Second	17	27	33	23
White	18	31	31	18
Black	20	22	47	11
Hispanic	12	11	33	44
Third	18	26	36	20
White	18	28	35	19
Black	16	12	55	17
Hispanic	22	18	31	29
Fourth	22	25	34	19
White	22	27	33	19
Black	20	26	49	5
Hispanic	22	13	29	36
Fifth	24	22	32	23
White	24	23	32	21
Black	27	18	41	14
Hispanic	24	12	32	32
U.S. average	20	24	35	21
White	21	27	33	19
Black	19	19	53	9
Hispanic	22	12	29	37

Source: DOE (1995a).

TABLE 8 Average Household Energy Consumption by Energy Source and Housing Vintage for 1993

Housing Vintage	Annual Average Household Energy Consumption (10 ⁶ Btu/yr per household)				
	Electricity	Natural Gas	Distillate Fuel	LPG	All
Before 1940	25	76	22	6	129
1940-1969	32	63	12	3	110
1970-1984	40	36	6	3	85
1985-1989	42	36	4	4	86
After 1989	39	44	4	4	91
U.S. average	34	55	11	4	104

Source: DOE (1995a).

TABLE 9 Average Household Energy Expenditures by Energy Source and Housing Vintage for 1993

Housing Vintage	Annual Average Household Energy Expenditures (\$/yr per household)				
	Electricity	Natural Gas	Distillate Fuel	LPG	All
Before 1940	655	471	140	58	1,324
1940-1969	811	383	78	33	1,305
1970-1984	948	211	39	31	1,229
1985-1989	1,005	216	26	47	1,294
After 1989	899	265	25	45	1,234
U.S. average	839	332	73	40	1,283

Source: DOE (1995a).

Interestingly, the changes in natural gas consumption are exactly the opposite of the movements in electricity consumption. Natural gas consumption in homes built in or before 1989 decreased, whereas electricity consumption increased. Likewise, natural gas consumption increased in homes built after 1989, whereas electricity consumption decreased in homes built during that period. Natural gas consumption in newer homes (built after 1989) is more than 20% higher than it is in homes built between 1970 and 1989.

Energy expenditures are slightly higher in older homes, but the costs of energy categorized by housing vintage type do not differ. Homes built between 1970 and 1984 show the lowest cost of energy. However, the difference in average household energy expenditures between the highest and lowest housing-vintage category is only 8%, or less than \$8/month.

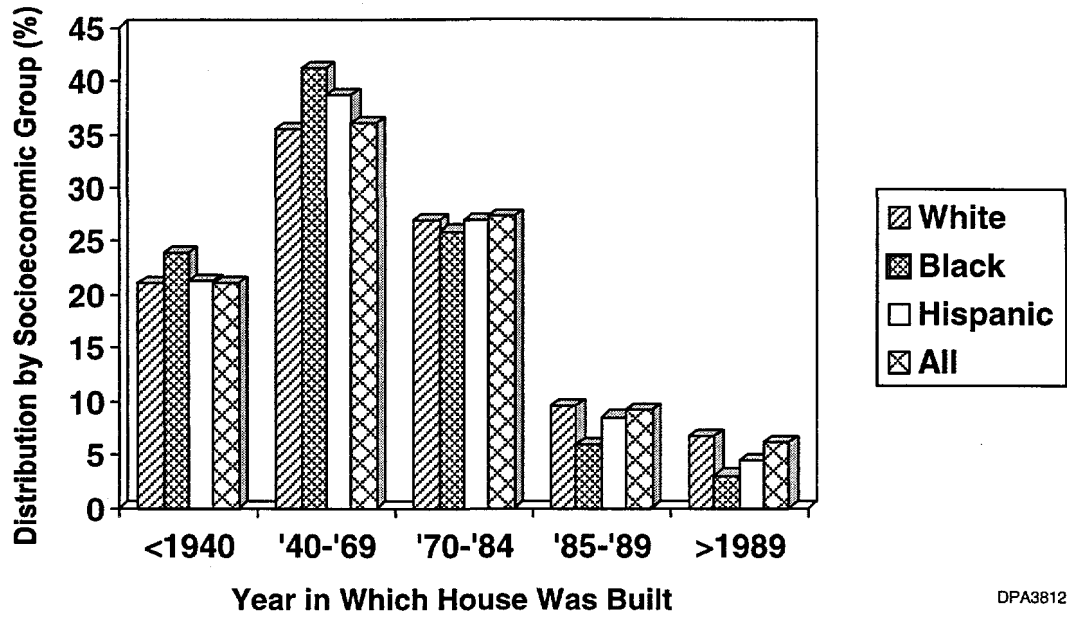
Table 10 gives the household distribution categorized by housing vintage for income quintile and socioeconomic population group. These data indicate that households with lower incomes typically live in older homes. For example, more than 60% of first income quintile households live in homes built before 1970, whereas only 48% of the highest income quintile households live in homes built before 1970. On the other hand, less than 10% of all first income quintile households live in homes built after 1984, whereas more than 20% of all fifth income quintile households live in homes built in that period.

These data also indicate differences in the distribution of households by housing vintage among different population categories. Minority households, especially non-Hispanic blacks, are more heavily concentrated in housing built before 1970. These data are also depicted in Figure 12.

TABLE 10 Household Percentages by Housing Vintage and Socioeconomic Group for 1993

Income Quintile and Socioeconomic Group	Housing Vintage				
	Before 1940	1940-1969	1970-1984	1985-1989	After 1989
First	27	36	27	6	3
White	28	33	29	7	3
Black	27	46	21	4	2
Hispanic	25	40	24	5	6
Second	24	39	25	7	4
White	25	38	24	8	4
Black	29	42	23	6	1
Hispanic	19	47	23	6	5
Third	23	36	28	9	5
White	23	36	27	9	5
Black	20	34	35	9	2
Hispanic	26	33	31	10	1
Fourth	17	36	26	11	9
White	18	36	25	11	9
Black	17	37	30	9	7
Hispanic	13	41	30	11	5
Fifth	14	34	30	12	9
White	14	34	30	13	10
Black	15	38	34	6	7
Hispanic	22	28	31	14	6
U.S. average	21	36	27	9	6
White	21	36	27	10	7
Black	24	41	26	6	3
Hispanic	21	39	27	9	5

Source: DOE (1995a).



DPA3812

FIGURE 12 Percentage of Households by Socioeconomic Group and Housing Vintage for 1993 (Source: DOE 1995a)

3 PROJECTIONS FOR ENERGY CONSUMPTION AND EXPENDITURES

3.1 ANNUAL ENERGY OUTLOOK 1997: ECONOMIC ASSUMPTIONS

The Socio-economic Research and Analysis Program Distributive Impact Assessment Model (DIAM) breaks down the AEO aggregate forecast by income quintile by using household income and energy price forecasts derived from the 1997 AEO reference case (DOE 1996a) and group-specific elasticities.

Energy price and household income forecasts provided by the 1997 AEO and population-specific energy demand systems⁵ are used to estimate energy consumption and expenditures. Relative changes in energy consumption and expenditures are influenced, in part, by differences in the marginal energy expenditure share over different energy sources across population groups. The marginal energy expenditure shares are shown in Table 11 for different income quintile and population groups from 1993 through 2015.⁶

The relative values of the marginal expenditure shares reflect the same relative differences seen in the average energy expenditure shares. Electricity marginal expenditure shares are generally higher for middle income households; natural gas marginal expenditure shares are higher for lower income minority households; and distillate and LPG shares are higher for nonminority households. These data indicate that as household energy expenditures increase, middle income households are more likely to spend a larger percentage of their income on electricity, whereas lower income minority households are more likely to spend a larger percentage of their income on natural gas.

Changes in average real energy prices are shown in Figure 13. They are projected to be modest over the forecast time period. Electricity and natural gas prices are projected to decline slightly, whereas distillate fuel and LPG are projected to increase slightly. These changes are not uniform over the forecast time horizon. For natural gas and electricity, price declines are larger in the near term. Between 1993 and 2000, the price of natural gas is estimated to decrease by about 1.5% per year, and the price of electricity is expected to decrease by 1% per year (DOE 1996a, pp. 8–10).

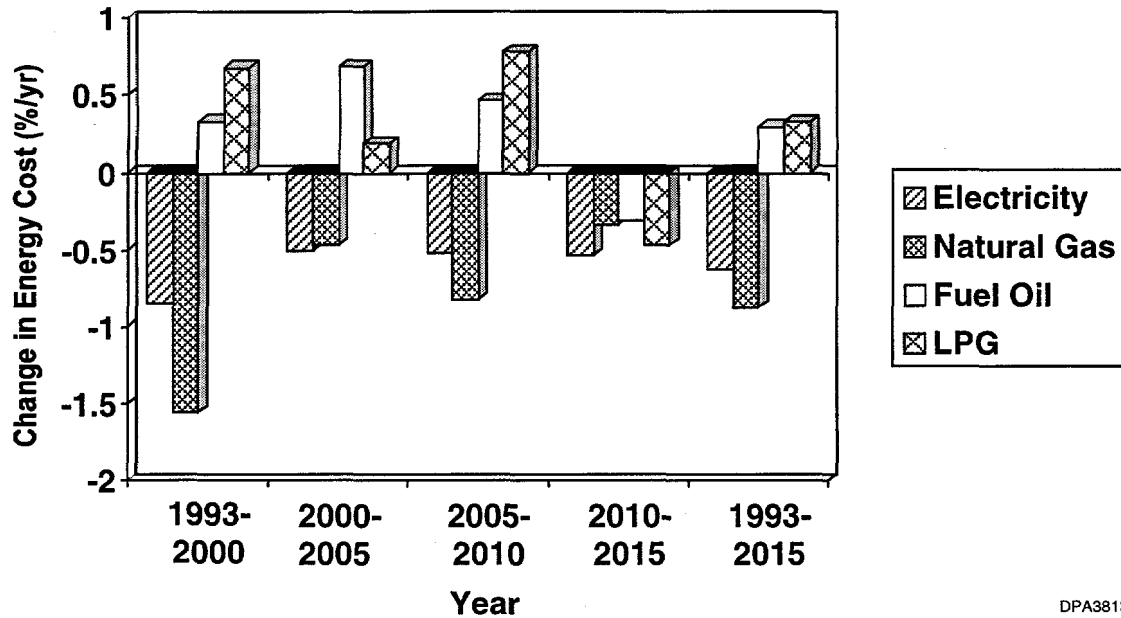
⁵ These systems are described in Poyer et al. (1997). These models were estimated by income quintile. Changes across population groups (non-Hispanic white and black and Hispanic) were captured with the inclusion of population-group dummy variables.

⁶ The size of the marginal energy expenditure share parameter is directly related to the size of the demand elasticities.

TABLE 11 Marginal Energy Expenditure Shares by Income and Population Class

Income Quintile and Socioeconomic Group	Marginal Energy Expenditure Share			
	Electricity	Natural Gas	Distillate Fuel	LPG
First				
White	0.4678	0.2521	0.1637	0.1164
Black	0.4030	0.4593	0.0697	0.0680
Hispanic	0.5315	0.2992	0.1180	0.0513
Second				
White	0.5033	0.2259	0.1880	0.0828
Black	0.3549	0.5339	0.0618	0.0494
Hispanic	0.4906	0.2614	0.1604	0.0876
Third				
White	0.6276	0.1459	0.1628	0.0637
Black	0.5909	0.2071	0.1558	0.0462
Hispanic	0.6441	0.1955	0.0989	0.0615
Fourth				
White	0.5737	0.1873	0.1648	0.0742
Black	0.2991	0.5222	0.1263	0.0524
Hispanic	0.7063	0.0952	0.1768	0.0217
Fifth				
White	0.5168	0.2747	0.1267	0.0818
Black	0.5097	0.3067	0.1589	0.0247
Hispanic	0.4873	0.3507	0.1197	0.0423
U.S. average				
White	0.5517	0.2211	0.1504	0.0768
Black	0.4455	0.3935	0.1083	0.0527
Hispanic	0.5717	0.2391	0.1323	0.0569

Source: DOE (1995a).



DPA3813

FIGURE 13 Annual Percentage Change in Real Energy Prices for 1993 through 2015 (Source: DOE 1996b)

The projected annual rate of change in real household income is shown in Figure 14. The rate of change is projected to increase over the entire forecast period. The rate of change is projected to decline over the forecast period as a result of the aging of the population.⁷

Taken by itself, and considering the modest changes in energy prices and the strong growth in household income, energy consumption would be expected to grow. However, the EIA incorporates into its forecast technological changes in residential energy consumption that reduce energy use independent of direct market factors.

Sections 3.2.1–3.2.4 give the consumption and expenditure forecast for each of the major residential energy sources by income quintile.

⁷ The change in real household income was derived from the AEO forecast on real disposable income and household population.

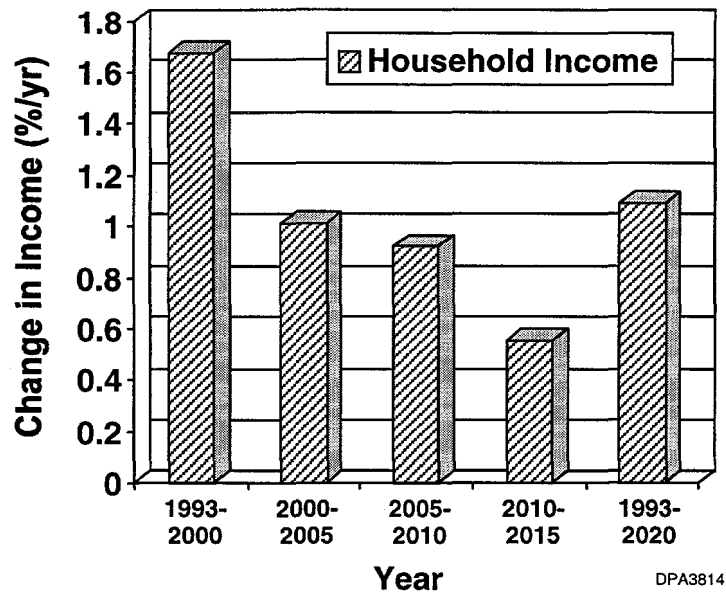
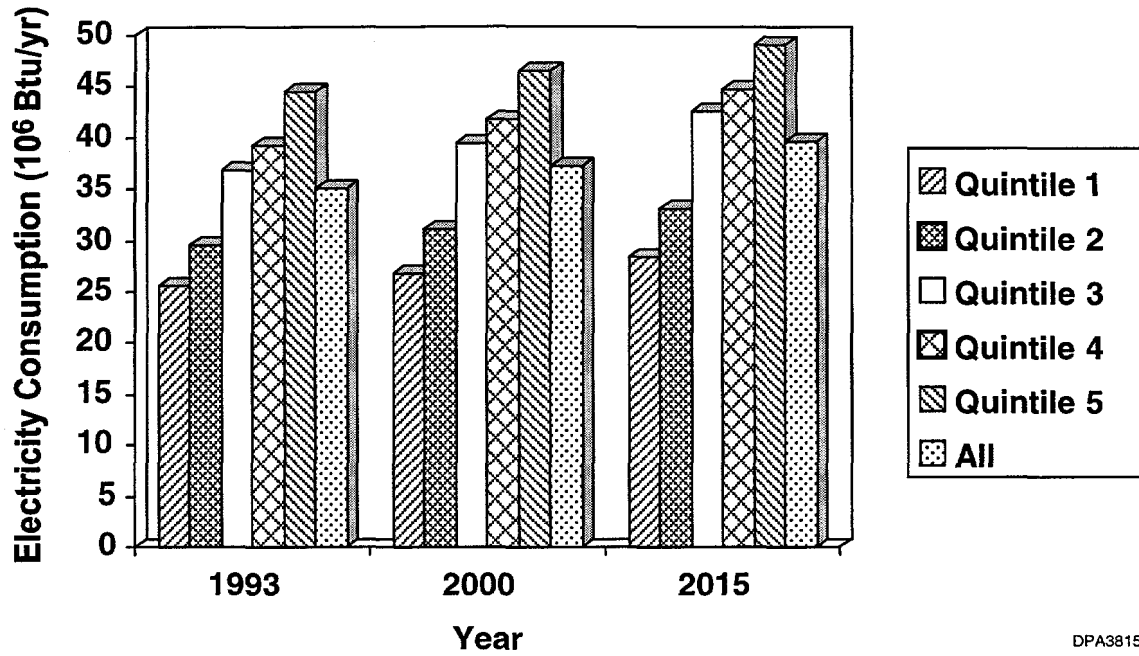


FIGURE 14 Annual Percentage Change in Real Household Income for 1993 through 2015 (Source: DOE 1996b)

3.2 ELECTRICITY CONSUMPTION AND EXPENDITURES

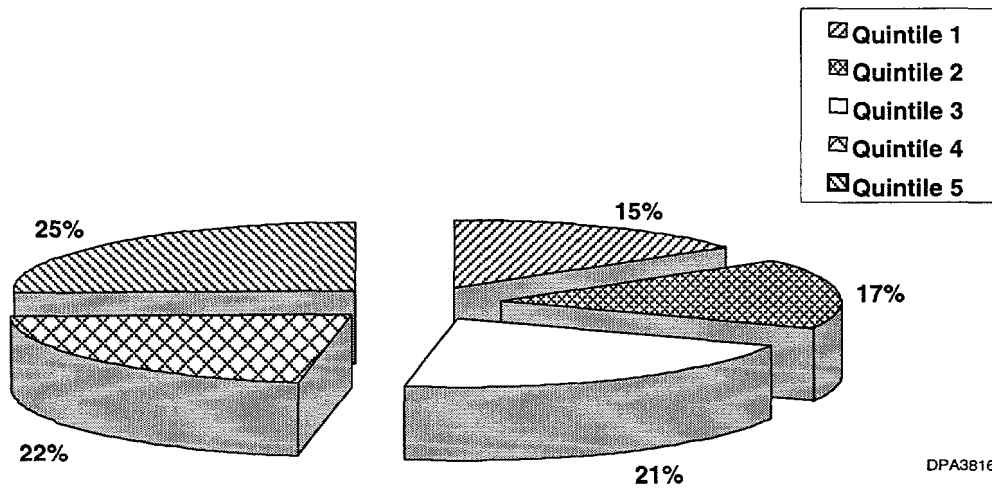
3.2.1 Electricity Consumption

Forecasts for electricity consumption are shown in Figure 15. Between 1993 and 2015, electricity consumption is projected to increase for each income group. This increase is projected to be the highest for the third and fourth income quintiles and the lowest for the lowest and highest income quintiles. Consumption levels for all households are estimated to increase from 35 million Btu per household per year in 1993 to 40 million Btu in 2015. Electricity consumption is projected to increase by more than 15% and 14% for the third and fourth income quintile groups, respectively, and to increase by slightly more than 10% for both the lowest and highest income quintile groups. As a result, the share of aggregate electricity for the third and fourth income quintile groups increases between 1993 and 2015, increasing from 21% to 22% for the third income group and 22% to 23% for the fourth income quintile group. The increase in aggregate electric shares for the third and fourth income quintiles is just offset by the decline in aggregate electric shares for the lowest and highest income quintile groups. The 1993 and 2015 aggregate electric shares are shown in Figures 16 and 17.



DPA3815

FIGURE 15 Electricity Consumption by Income Quintile for 1993, 2000, and 2015 (10⁶ Btu/yr)



DPA3816

FIGURE 16 Aggregate Electricity Consumption Shares by Income Quintile for 1993

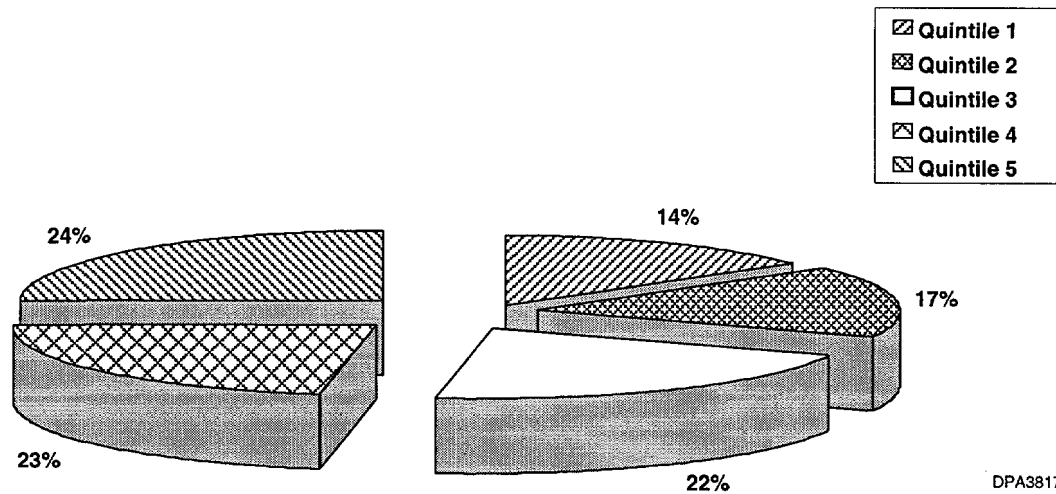


FIGURE 17 Aggregate Electricity Consumption Shares by Income Quintile for 2015

3.2.2 Electricity Expenditures

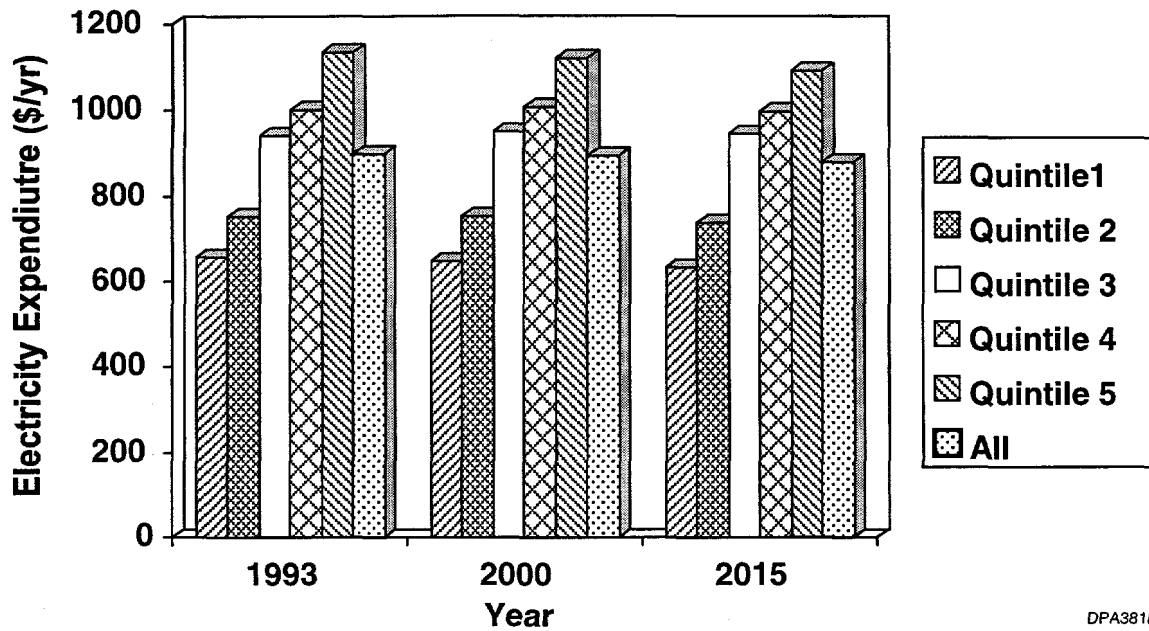
Forecasts for electricity expenditure are shown in Figure 18. Average household expenditures increase as income increases: expenditures for the highest income quintile are more than 70% higher than those for the lowest income quintile.

Projections show that average household expenditures (in 1993 dollars) on electricity should change slightly between 1993 and 2015, decreasing minimally for each income category, except for the middle income quintile. The average rate of change in electricity expenditures from 1993 through 2015 is projected to decrease by 0.08% per year. The rates of change for the lowest and highest income quintile groups also are projected to decrease by 0.16% and 0.19% per year, respectively, whereas for the middle income quintile, the rate of change is projected to increase by 0.02% per year.

3.3 NATURAL GAS CONSUMPTION AND EXPENDITURES

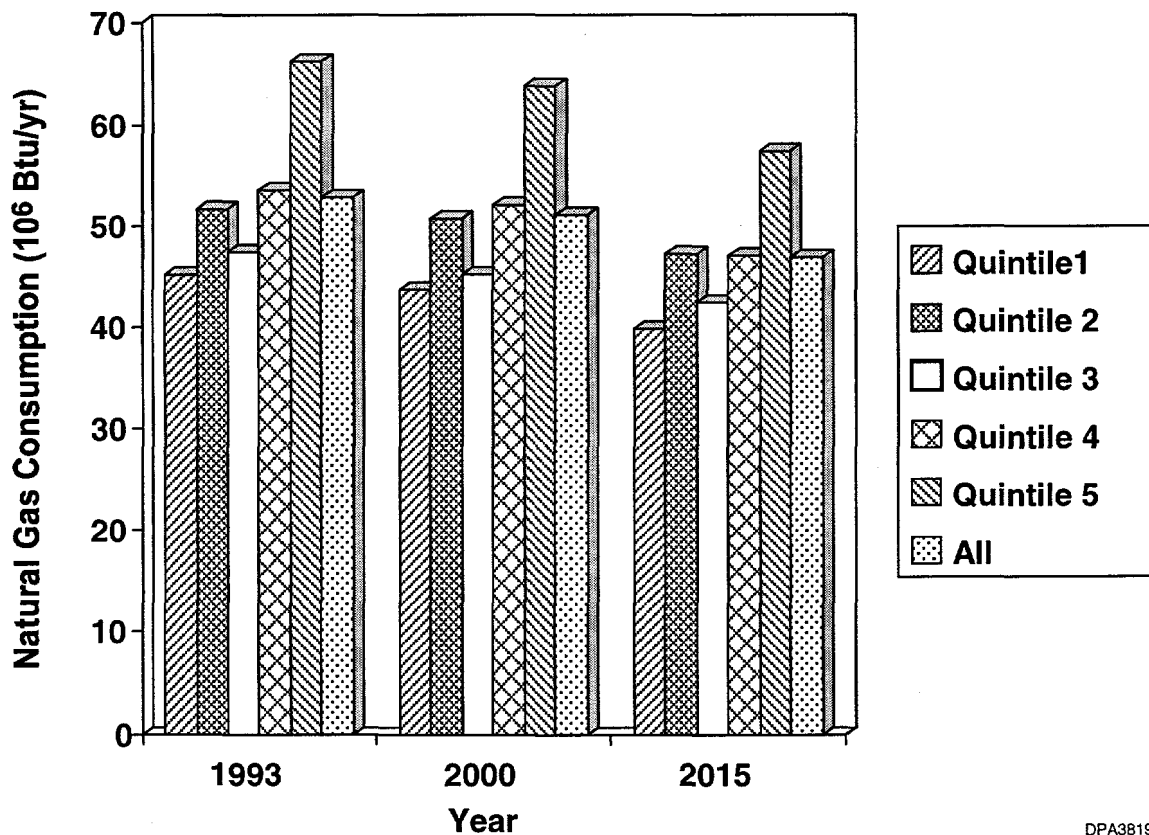
3.3.1 Natural Gas Consumption

Forecasts for natural gas consumption are shown in Figure 19. Except for the middle income quintile, natural gas consumption increases as income increases and decreases between the second and third income quintiles. Natural gas consumption is projected to decline slowly over the forecast time for each income group. However, natural gas consumption is projected to decline slightly faster for the highest income quintile and slower for the second and middle-income quintiles.



DPA3818

FIGURE 18 Electricity Expenditures by Income Quintile for 1993, 2000, and 2015 (\$/yr)



DPA3819

FIGURE 19 Natural Gas Consumption by Income Quintile for 1993, 2000, and 2015 (10⁶ Btu/yr per household)

The effect of changes in natural gas consumption at the household level on income quintile shares is almost imperceptible. The income quintile shares of aggregate natural gas consumption are shown in Figure 20 for 1993. No changes would occur for 2015. The highest income quintile accounts for about 25% of all natural gas consumption in both 1993 and 2015. The middle income quintile natural gas consumption share (18%) is smaller than that of the second income quintile (20%) and approximately equal to that of the lowest income quintile (17%). The modest differences in projected natural gas consumption among the different income groups do not affect the relative income quintile shares appreciably and are projected to remain about the same through 2015.

3.3.2 Natural Gas Expenditures

Forecasts for natural gas expenditures are shown in Figure 21. As a result of declining natural gas prices and consumption, natural gas expenditures are projected to fall for each income quintile. Overall, average household natural gas expenditures are projected to decline by 1.41% per year. They are projected to decline at a slightly higher rate (1.50% per year) for the highest income quintile and a slightly lower rate (1.28% per year) for the second-income quintile.

Natural gas expenditures are projected to fall at a faster rate in the near term, declining almost twice as fast from 1993 through 2000 as from 2001 through 2015. The difference in the rate of change between these two periods is most significant for the middle income group, which will show a decline of 2.24% to 0.96% per year.

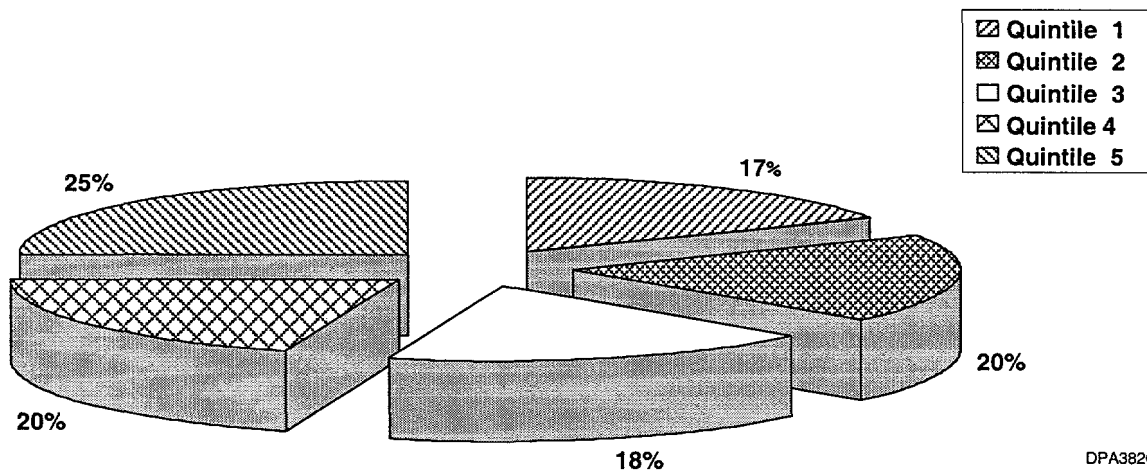
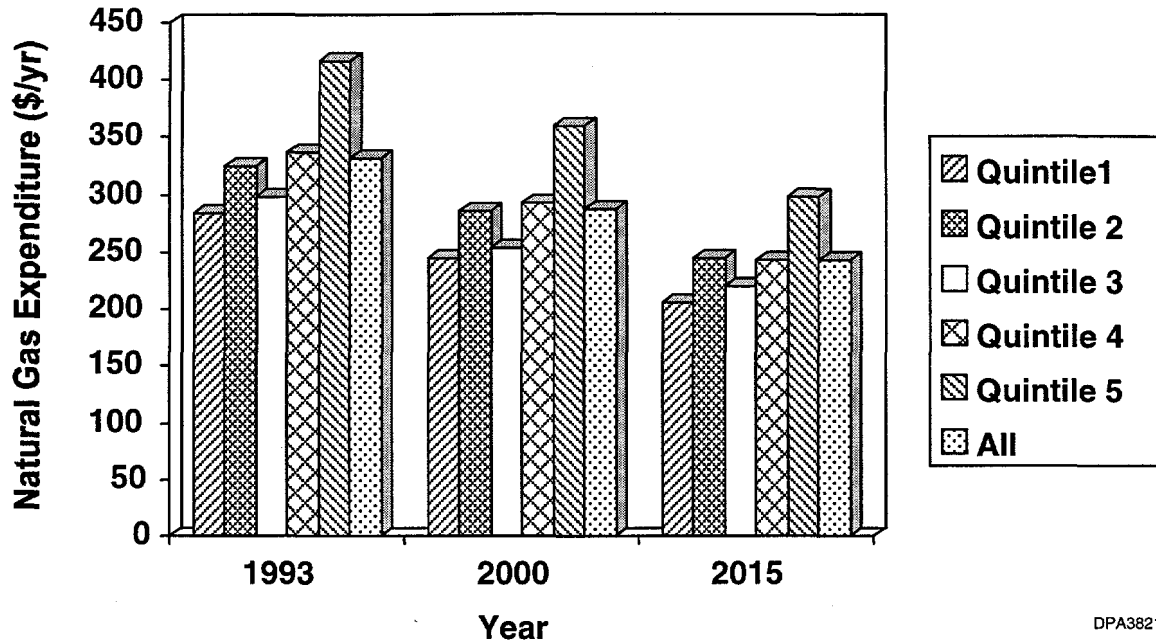


FIGURE 20 Aggregate Natural Gas Consumption Shares by Income Quintile for 1993 and 2015



DPA3821

FIGURE 21 Natural Gas Expenditures by Income Quintile for 1993, 2000, and 2015

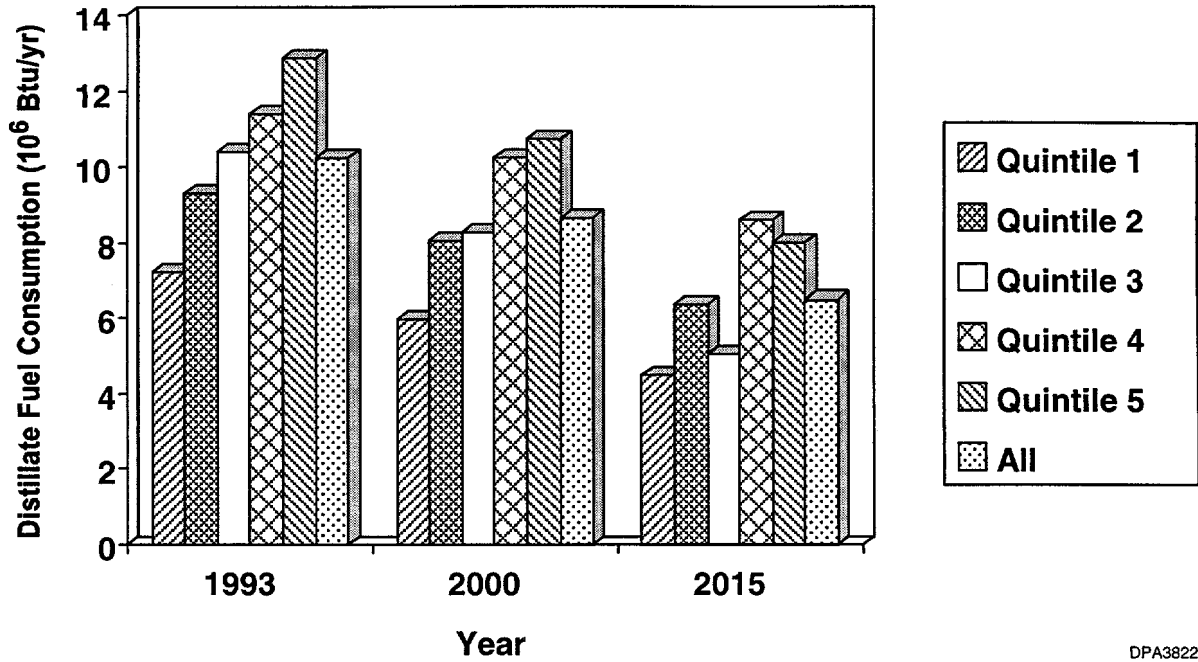
3.4 DISTILLATE FUEL CONSUMPTION AND EXPENDITURES

3.4.1 Distillate Fuel Consumption

Forecasts for distillate fuel consumption are shown in Figure 22. The consumption of distillate fuel is projected to fall dramatically (more than 2% per year) between 1993 and the end of 2015. Over the entire forecast period, average household use of distillate fuel is projected to fall by almost 40%.

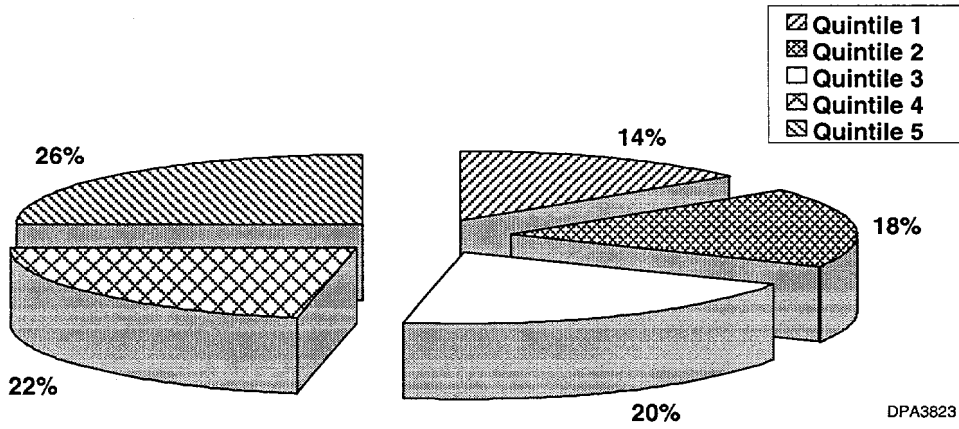
Average distillate fuel consumption is projected to drop for each income group. The decline is expected to be most dramatic for the middle income quintile — about 3.24% per year. This projected rate of change translates into a decline of more than 50% in average household distillate fuel consumption over the entire forecast period.

Aggregate distillate fuel consumption shares, by quintile, are shown in Figures 23 and 24 for 1993 and 2015, respectively. During this period, the share of distillate fuel consumption by the middle income quintile falls by 4 percentage points, whereas the shares for the second and fourth income quintiles increase by 2 and 3 percentage points, respectively. The shares for the lowest and highest income quintile groups remain about the same.



DPA3822

FIGURE 22 Distillate Fuel Consumption by Income Quintile for 1993, 2000, and 2015



DPA3823

FIGURE 23 Aggregate Distillate Fuel Consumption Shares by Income Quintile for 1993 (Source: DOE 1995a)

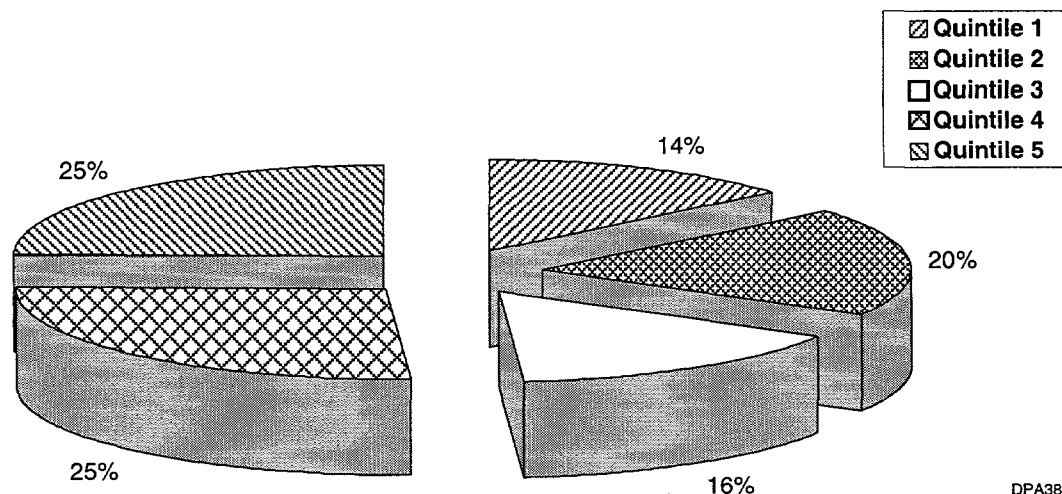


FIGURE 24 Aggregate Distillate Fuel Consumption Shares by Income Quintile for 2015 (Source: DOE 1995a)

3.4.2 Distillate Fuel Expenditures

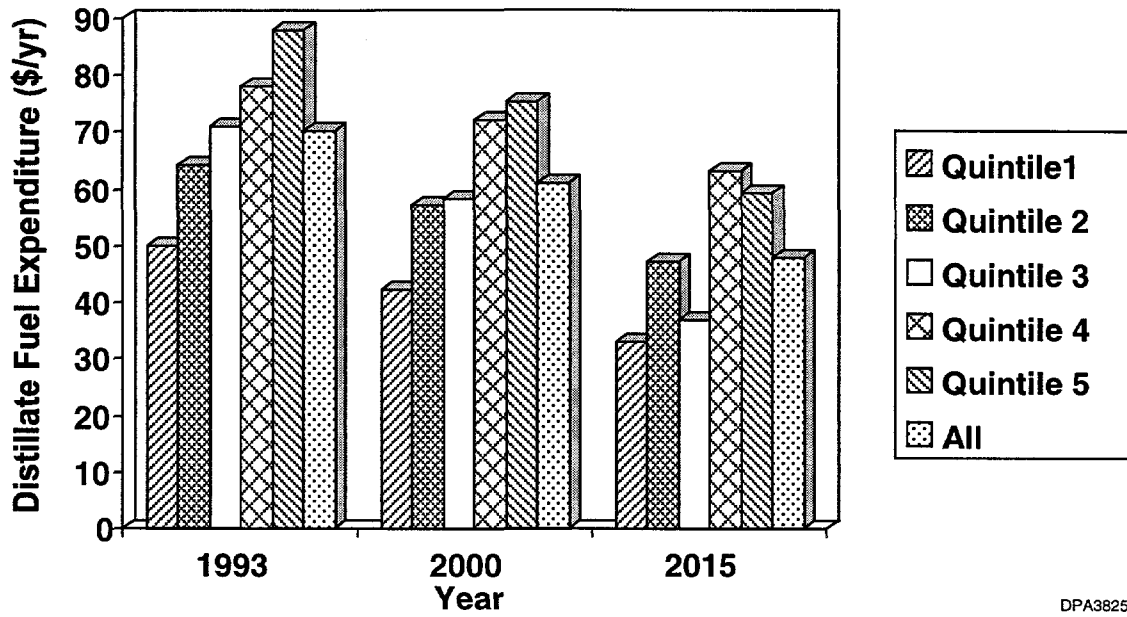
As does distillate fuel consumption, average household distillate fuel expenditures are projected to fall each year during the entire period. Projections show an average decline of 1.76% per year. For the typical household, this decrease amounts to lower (e.g., by more than 30%) annual distillate expenditures. By 2015, the average household is projected to spend less than \$4 per month (in 1993 dollars) on distillate fuel. Projected distillate fuel expenditures are shown in Figure 25.

While the annual decline in distillate fuel expenditures is substantial for each income quintile, it is projected to be particularly dramatic for the middle income quintile: approximately 1.6 times greater than the overall annual rate. Distillate fuel expenditures for the middle income quintile are projected to decline by nearly 50% between 1993 and 2015.

3.5 LPG CONSUMPTION AND EXPENDITURES

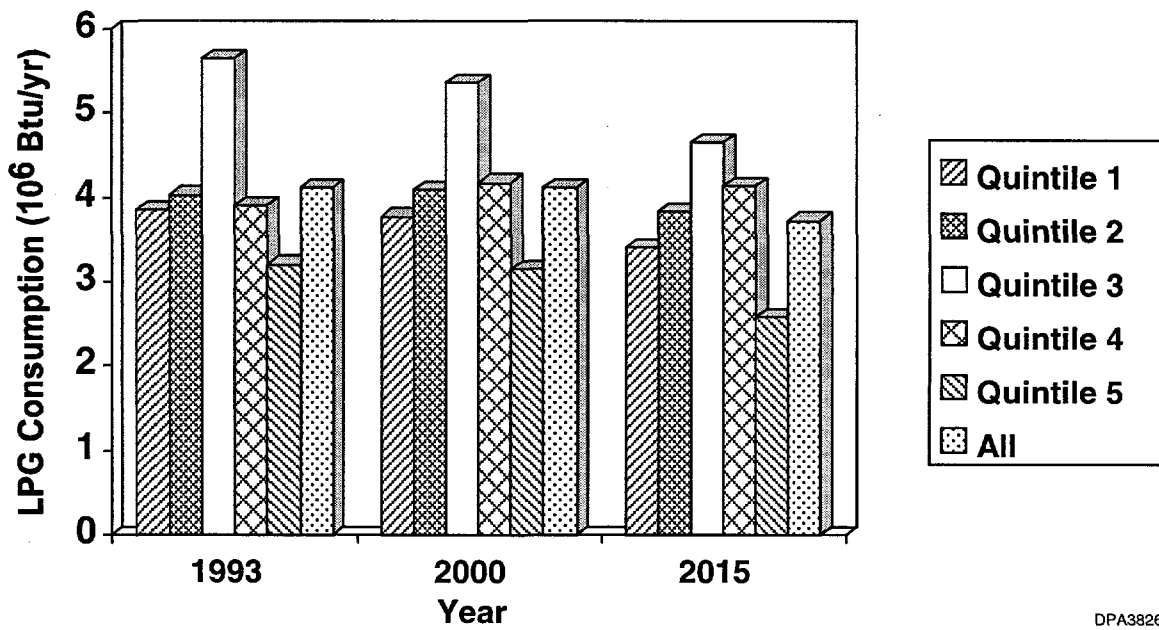
3.5.1 LPG Consumption

Moderate changes are projected for average household LPG consumption, with a slight decline projected for each income quintile except for the fourth income quintile. The average annual rate of decline in household LPG consumption is projected to be 0.47%. Between 1993 and 2015, the average household consumption is projected to decline by approximately 10% (Figure 26).



DPA3825

FIGURE 25 Distillate Fuel Expenditures by Income Quintile for 1993, 2000, and 2015



DPA3826

FIGURE 26 LPG Consumption by Income Quintile for 1993, 2000, and 2015

The change in LPG consumption varies across income groups. It is projected to increase slightly for the fourth income quintile group, whereas projections show a 1% per year decrease for the highest income quintile. Other income classes fall between these.

Estimated and projected income quintile consumption shares for 1993 and 2015 are shown in Figures 27 and 28, respectively. The consumption shares are projected to increase for the second and fourth income quintiles and decrease for the other three income groups. The increase is projected to be the largest for the fourth income quintile share — from 19% in 1993 to 22% in 2015. The consumption share changes are projected to be smaller for the other income groups.

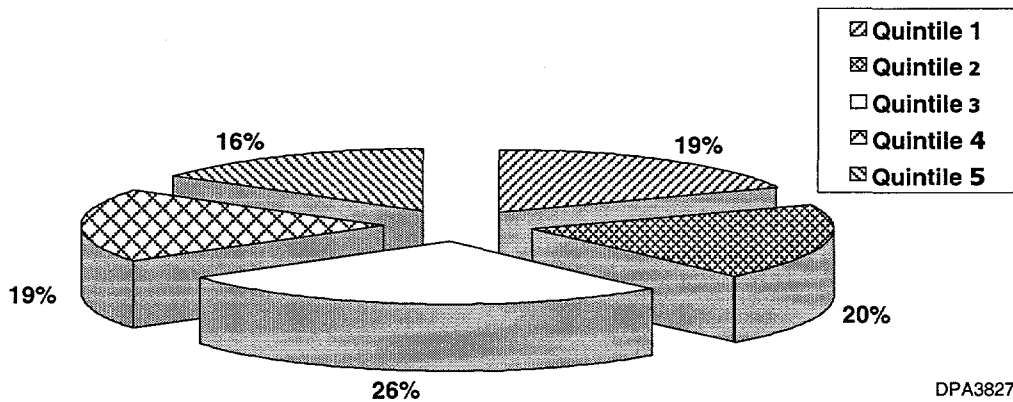


FIGURE 27 Aggregate LPG Consumption Shares by Income Quintile for 1993

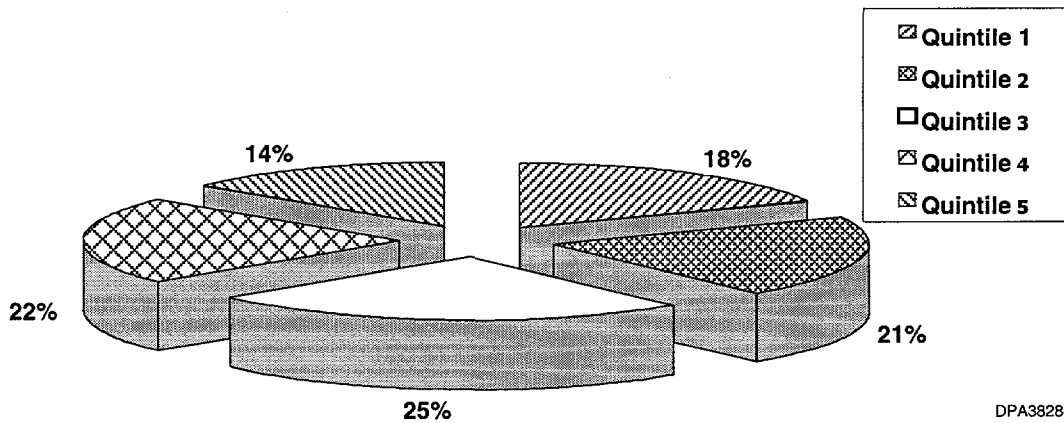


FIGURE 28 Aggregate LPG Consumption Shares by Income Quintile for 2015

3.5.2 LPG Expenditures

Projected LPG expenditures are shown in Figure 29. Overall, changes in LPG expenditures are expected to be minimal between 1993 and 2015. However, the changes are expected to differ in the near and the long term of that period. The changes generally cancel each other out, and the overall change in LPG expenditures is expected to be minimal. The average annual rate of change in household LPG expenditures, for all households, is projected to decrease by 0.15%.

Near-term forecasts project LPG expenditures to increase at an average annual rate of 0.62% between 1993 and 2000. Long-term forecasts project a decline of 0.5% per year.

The rate of change in LPG expenditures varies significantly across income groups. Projections for average household LPG expenditures between 1993 and 2015 anticipate an increase for the second and fourth income quintiles and a decrease for the other three groups. Expenditures for the fourth income quintile are projected to rise at a substantial 1.67% per year and then fall to 0.1% in the forecast period.

Average household LPG expenditures are projected to decline at annual rates of 0.55% and 0.68% for the middle and highest income quintiles, respectively. Expenditures are also projected to decline for the middle income quintile — falling at an annual rate of 0.07% between 1993 and 2000 and 0.77% between 2000 and 2015. Between the near- and long-term periods, the projected change in the annual rate of expenditures is largest for the highest income group. From

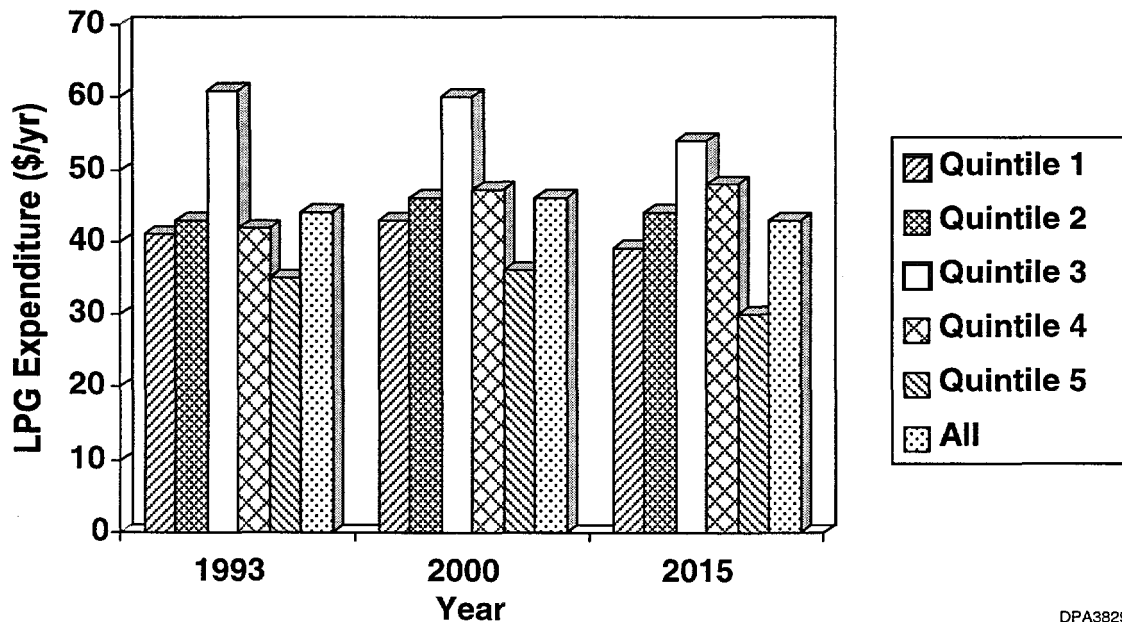


FIGURE 29 LPG Expenditures by Income Quintile for 1993, 2000, and 2015

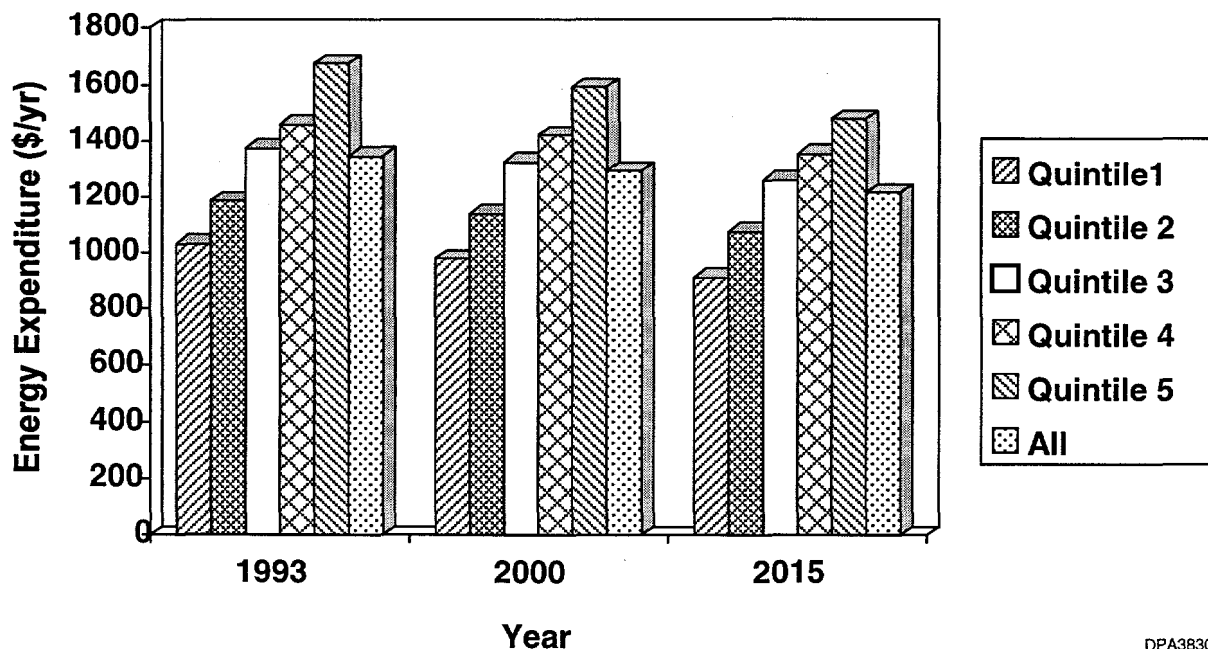
1993 to 2000, the annual rate of change in LPG expenditures is projected to be 0.46%, whereas from 2000 to 2015, the annual rate of change is projected to plummet to -1.2%.

3.6 HOUSEHOLD ENERGY EXPENDITURES AND INCOME SHARE

3.6.1 Energy Expenditures

Primarily as a result of the projected fall in the cost of natural gas and electricity, household energy expenditures are estimated to decline slightly, but steadily, over the entire forecast period (Figure 30). Expenditures are projected to decline at an average of 0.59% per year between 1993 and 2000 and 0.4% between 2000 and 2015.

The absolute difference in the projected change in household energy expenditures among the income quintiles is not large. The most significant projected fall in expenditures occurs with the lowest and highest income quintiles. Expenditures are projected to decline 0.56% and 0.57% per year for the lowest- and highest-income quintiles, respectively. The smallest projected decline in expenditures occurs for the middle and fourth income quintiles; declines are 0.39% and 0.34% per year, respectively.



DPA3830

FIGURE 30 Energy Expenditures by Income Quintile for 1993, 2000, and 2015

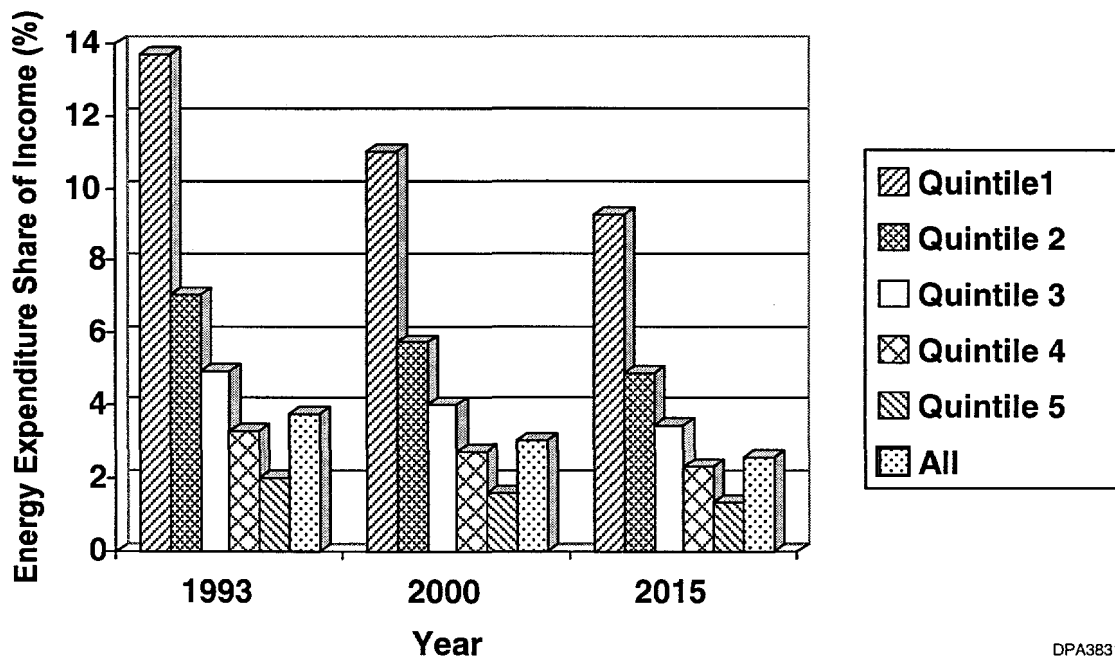
3.6.2 Energy Expenditure Income Share

As expected, the energy expenditure share of income varies inversely with income, falling as income increases. The lowest income quintile is estimated to spend close to 14% of household income on residential energy in 1993, whereas the highest income quintile spends only 2%. These shares are projected to improve over the time period examined under the 1997 AEO scenario.

The energy expenditure income share declines throughout the time period under the 1997 AEO energy price and income forecast scenario. Under this scenario, little difference occurs in the relative change in the energy expenditure share of income across income quintiles, as shown in Figure 31. The energy expenditure share is projected to decline by approximately 30% for each income group, ranging from a 29% decline for the fourth income quintile to a 32% decline for the lowest and highest income quintiles.

3.6.3 Energy Expenditure Composition

The residential fuel and electricity shares of energy expenditures for 1993 and 2015 are shown in Figures 32 and 33, respectively. The figures illustrate the relative importance of electricity in a household's energy budget. As income and energy expenditures rise, expenditures



DPA3831

FIGURE 31 Energy Expenditure Share of Income by Income Quintile for 1993, 2000, and 2015

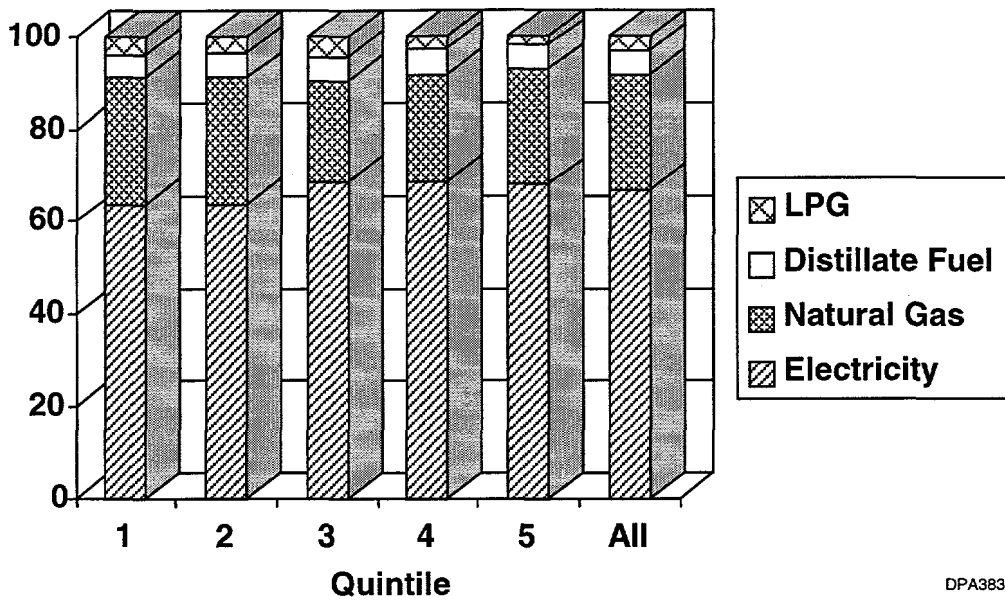


FIGURE 32 Fuel and Electricity Shares of Energy Expenditures by Income Quintile for 1993

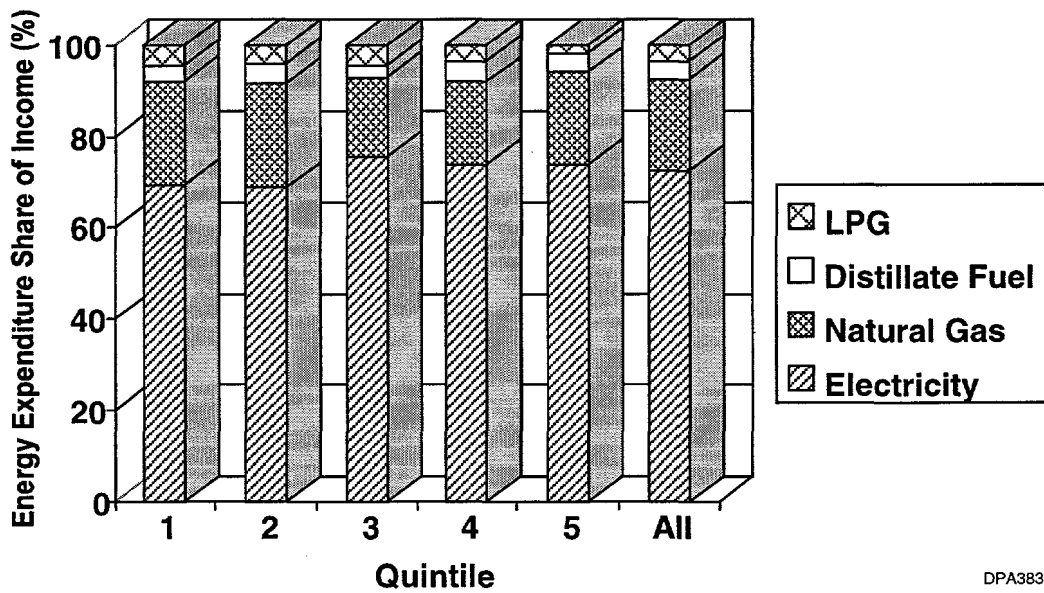


FIGURE 33 Fuel and Electricity Shares of Energy Expenditures by Income Quintile for 2015

on electricity grow at a disproportionately faster rate, and, as a consequence, electricity's share of total energy expenditures increases. This disproportionate increase occurred in 1993 and is projected to continue until 2015 (the end of the forecast period). In 1993, electricity accounted for approximately 64% of total residential expenditures for the first and second income quintiles and about 68% for the third, fourth, and fifth income quintiles.

The electricity share of total residential expenditures grows for each income quintile group. Overall, the share is projected to grow from 67% to 73% between 1993 and 2015. The largest growth is projected for middle income households, increasing from 69% in 1993 to 75% in 2015.

The percentage of total energy expenditures for natural gas falls from 25% to 20% between 1993 and 2015. This decline is projected to be particularly large early in the forecast period when natural gas prices are projected to decline rapidly. Without exception, the natural gas energy expenditure share also falls for each income group. The biggest decline occurs for the fourth income quintile.

The most significant declines in energy costs occur for distillate fuel. The share of energy expenditures spent on distillate fuel is projected to fall by more than 25%. The projected decline is particularly significant for those in the middle income quintile; the decline is from 5.2% in 1993 to 2.9% in 2015. Surprisingly, at the other extreme is the fourth income quintile, for which the projected decline is substantially less: from 5.4% in 1993 to 4.7% in 2015.

Overall, projections indicate that the LPG energy share will increase slightly between 1993 and 2015. The largest increase is projected to occur in the fourth income quintile, where increases will range from 2.9% in 1993 to 3.5% in 2015. The two lowest income quintiles also show a projected increase in LPG shares, whereas the middle and highest income quintiles are expected to show slight declines in this area.

3 CONCLUSIONS

The composition of household energy consumption is projected to change dramatically under the 1997 AEO forecast scenario. Electricity is projected to become a significantly important component of household energy use over time. With regard to consumption, electricity is the only one of the four major residential energy sources for which consumption is projected to increase for each of the five income groups. Natural gas and distillate fuel consumption are projected to fall for each of the income categories, and overall consumption of LPG per household is projected to decline. Electricity consumption is projected to increase by 14% between 1993 and 2015, from 35 to 40 million Btu/yr per household. The largest growth in electricity consumption is projected to occur within the third and fourth income groups, by more than 15% in the third income quintile and 14% in the fourth income quintile.

Natural gas consumption is projected to decrease slowly during the same period. On the basis of all households, natural gas consumption is projected to decline from 53 to 47 million Btu/yr per household between 1993 and 2015. The average household consumption of this fuel is projected to decline slightly faster for the highest income quintile, from 66 to 57 million Btu/yr per household from 1993 to 2015.

Distillate fuel consumption is projected to fall dramatically for all households over the forecast period, that is, from 10 to 7 million Btu/yr per household from 1993 to 2015, or by almost 40%. Distillate fuel consumption is expected to fall for each income quintile, with the most dramatic decline occurring for the middle income quintile. This group is expected to consume 50% less distillate fuel, with consumption decreasing from 10 to 5 million Btu/yr per household from 1993 to 2015.

The projected change in LPG consumption varies for the five income quintiles. Overall, LPG consumption is projected to decline from 4.1 to 3.7 million Btu/yr per household from 1993 to 2015, but it is expected to increase slightly for the fourth income quintile, from 3.9 to 4.1 million Btu/yr per household from 1993 to 2015.

As a result of the declining costs of electricity and natural gas and the more efficient use of energy, real household energy expenditures are projected to decline for each income quintile at an average annual rate of 0.5%. While only slight differences occur in the projected change in energy expenditures among the income quintiles, the composition of total energy expenditures is projected to change dramatically. The major outcome is that electricity will continue to increase in importance. For all households, the electricity share of total energy expenditures is projected to grow from 67% in 1993 to 73% in 2015. The relative change in electricity expenditures is approximately the same across the five income groups.

The growth in the electricity share of energy expenditures comes at the expense of natural gas and distillate fuel. The natural gas expenditure share is projected to fall from 25% in 1993 to

20% in 2015; the share is projected to fall the most for the fourth income quintile: from 23% in 1993 to 18% in 2015. The distillate fuel expenditure share is projected to fall precipitously, by more than 25% (from 5% to 4% between 1993 and 2015). This fall is even more dramatic for the middle income quintile: down from 5% in 1993 to 3% in 2015.

It is projected that the overall energy expenditure share of income will drop from 3.7% in 1993 to 2.6% in 2015. Under the 1997 AEO scenario, the energy expenditure share of household income is projected to fall from 13.7% to 9.3% for the lowest income quintile.

4 REFERENCES

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