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ANL/ESD-4

An Economic Assessment of the Impact of Two Crude Oil Price Scenarios on Households

Energy Systems Division
Argonne National Laboratory

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NTIS price codes:
Printed copy A04
Microfiche A01

Distribution
Category
UC-400

ANL/ESD--4

DE90 007896

ANL/ESD-4

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by D.A. Poyer, A.P.S. Teotia, R.C. Hemphill,* L.G. Hill,* J.L. Marinelli,* K.J. Rose,* and D.J. Santini

Technology Evaluation Group, Energy Systems Division,
Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439

March 1989 (published February 1990)

Work sponsored by United States Department of Energy,
Office of Minority Economic Impact, Research and Education Division

*Hemphill, Hill, Marinelli, and Rose are affiliated with Argonne's Environmental Assessment and Information Sciences Division.

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ACKNOWLEDGMENTS

We would like to thank a number of people for their help, without which this report could not have been completed. We thank Georgia Johnson of the Office of Minority Economic Impact in the U.S. Department of Energy for her technical and managerial support. Thanks also to Chuck Malefyt for invaluable editorial assistance that significantly improved the readability of this report. We also thank Cora Marrett of the University of Wisconsin and Les Baxter of the California Energy Commission for their insightful critiques of an earlier version of this report. Finally, our thanks go to the wonderful people in our word processing center who transformed a barely legible manuscript into the final version of this report.

Views expressed throughout this report are those of the authors and not necessarily those of the U.S. Department of Energy, Argonne National Laboratory, or the reviewers of this report.

AN ECONOMIC ASSESSMENT OF THE IMPACT OF TWO CRUDE OIL PRICE SCENARIOS ON HOUSEHOLDS

by

D.A. Poyer, A.P.S. Teotia, R.C. Hemphill, L.G. Hill, J.L. Marinelli, K.J. Rose, and D.J. Santini

ABSTRACT

The impact of two possible future crude oil price scenarios -- high and low price cases -- is assessed for three population groups: majority (non-Hispanic and nonblack), black, and Hispanic. The two price scenarios were taken from the "energy security" report published by the U.S. Department of Energy in 1987. Effects of the two crude oil price scenarios for the 1986-95 period are measured for energy demand and composition and for share of income spent on energy by the three population groups at both the national and census-region levels. The effects on blacks are marginally more adverse than on majority householders, while effects on Hispanics are about the same as those on the majority. Little change is seen in percentage of income spent on energy over the forecast period. Both Hispanic and black households would spend a larger share of their incomes on energy than would majority households. The relatively adverse effects in the higher price scenario shift from the South and West Census regions to the Northeast and Midwest.

SUMMARY

This study determined the potential impact of two likely crude oil price scenarios on U.S. minorities -- black and Hispanic households -- relative to all other U.S. households. The two scenarios are based on the lower and higher price cases described in *Energy Security: A Report to the President of the United States*, published by the U.S. Department of Energy in 1987. Each scenario delineates an energy future considered reasonable for the 1986-95 forecast period.

A number of perspectives -- primarily between and within the three population groups and between scenarios -- are used in this analysis. The focus is on the relative impact of the scenarios on energy consumption and expenditures, energy expenditure share of income, patterns of energy demand, and economic well-being.

Impacts of the two scenarios varied across census regions through effects on prices of various forms of energy, prices of nonenergy goods and services, growth of disposable income, and composition of housing stock, all of which are crucial in determining energy demand and its composition. Key findings are described below.

- Nationally and regionally, total energy consumption per household declines, with two exceptions. In the South census region, total energy demand for majority and Hispanic households increases slightly in the low price scenario. The greatest declines occur in black households in the Northeast census region: 17.8% in the low price scenario and 21.7% in the high.

- Energy expenditures for each population group increase nationally and regionally in both scenarios. Expenditure changes are rather uniform across regions for each population group. The greatest expenditure increases occur for black and majority households in the West census region: 54.2% in the low price scenario and 56.1% in the high, and 52.4% in the low and 55.2% in the high for black and majority households, respectively.

- Electricity consumption increases for each population group in both scenarios nationally and regionally. The greatest increases occur in the Northeast and Midwest census regions. Peak increases are in black households, as shown by rises of 24.3% in the Midwest and 30.2% in the Northeast in the high and low price scenarios, respectively.

- Nonelectric energy consumption declines for all population groups in both scenarios. Once again, black households experience the greatest percentage change, specifically in the South census region (29.7% in the low scenario and 30.1% in the high). Hispanic and majority households exhibit the greatest declines in the Northeast and Midwest.

- Electricity as a share of total energy demand is projected in both scenarios to become much more important. Nationally in 1986, electricity was estimated to be about 35%, 26%, and 27% of total energy consumption by majority, black, and Hispanic households, respectively. Those numbers are projected to increase in 1995 to 43%, 35%, and 32% in the low price scenario and to 42%, 35%, and 31% in the high.

- The economic well-being of black households is dramatically affected by rising energy prices in both scenarios, nationally and regionally. At the regional level, the most striking effects are seen in the South census region, where the cost of energy in black households increases by 92% in the low price scenario and 100% in the high. Comparable numbers for majority and Hispanic households are 81% and 80% in the low price scenario and 89% and 87% in the high.

- In both scenarios, share of income spent on energy is projected to slightly fall for each population group. Regionally, the energy expenditure share of income is projected to fall the most in the Northeast census region. The expenditure share gap between majority and Hispanic and black households is projected to remain about the same over the forecast period.

1 INTRODUCTION

This study analyzed the relative impact of two crude oil price scenarios on three population groups -- majority, black, and Hispanic households. The majority group consists of all households that are neither black or Hispanic. Because black and Hispanic households are not mutually exclusive, however, the analysis is confined to pairwise comparisons between the majority group and each of the two minority groups.

The study used the minority energy assessment model (MEAM) developed by Argonne for the Department of Energy's Office of Minority Economic Impact. MEAM is a two-stage budgeting model in which household energy demand is determined at the first level and the composition of energy demand between electric and nonelectric energy is determined at the second level (Deaton and Muellbauer 1980). Figure 1 is a conceptual illustration of the model; an explanation of MEAM is provided in App. A.

Input data to drive MEAM were generated by the Data Resources, Inc. (DRI), Energy and Macroeconomic models. The two specific scenarios created by DRI were, in turn, based on the low and high crude oil price cases given in the 1987 energy security report produced by the U.S. Department of Energy (1987) (see App. B).

The study assessed the relative impact of the two scenarios on energy consumption, patterns of energy demand, energy expenditures, and cost of energy to households (economic well-being). Several perspectives -- primarily between and within groups and between scenarios -- were used. Impacts varied among census regions in terms of their effects on prices of various forms of energy, prices of nonenergy goods

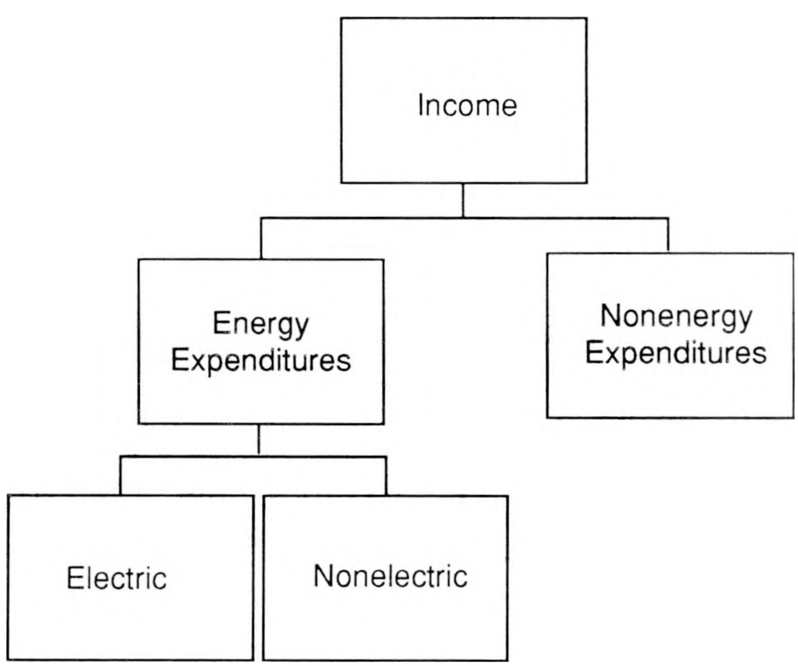

FIGURE 1 Conceptual Illustration of a Two-Stage Budgeting Model

and services, growth of disposable income, and composition of housing stock, all of which are crucial inputs to MEAM.

The marginal expenditure share (MES), i.e., the amount spent on a good from an additional dollar of income or expenditure, is the critical parameter in a linear expenditure system (LES) such as that used in MEAM. The MES value was allowed to vary by population group when the demand equations used in MEAM were estimated. Estimated values of MES for the population groups are shown in Table 1. Values for total energy and for electricity demand are significantly different for black and majority households, but only the MES value for total energy demand is significantly different for Hispanic and majority households.* The importance of the relative magnitudes of these parameters cannot be overemphasized. Subsequent analysis of the changing level and compositions of energy demand is closely tied to the values given in Table 1. The applied assumption that these values are stable over the forecast period is critical, because shifts in demand structure of the population groups could lead to substantially different variations in demand.

TABLE 1 Marginal Expenditure Share Parameters

	Marginal Expenditure Share	
Population Group	Total Energy Demand[a]	Electricity Demand[b]
Majority	0.0063 (0.0002)[c]	0.7462 (0.0045)
Black	0.0081 (0.0003)	0.6150 (0.0110)
Hispanic	0.0057 (0.0003)	0.7441 (0.0169)

[a]Marginal expenditure share for total energy demand is the fraction of an additional dollar of total expenditure spent on residential energy.

[b]Marginal expenditure share for electricity demand is the fraction of an additional dollar of *energy* expenditure spent on electricity.

[c]Standard deviation shown in parentheses.

Price and income elasticities (the percentage change in the demand for a good, given a 1% change in price or income) are very important in projecting changes in energy demand and expenditures. The relative movement in prices and income will ultimately determine the relative change in energy demand and expenditures and the composition of energy demanded. More specifically, price and income elasticities affiliated with the LES model are variable, depending partially on share of income spent on energy and partially on the MES parameter. Typically, own-price and income elasticities (see Sec. 1.1) will increase as share of income falls and MES increases.

*Subsequent analysis strongly indicates that the model estimated for Hispanic households may be biased. Income distribution for Hispanic households surveyed in the Residential Energy Consumption Survey (RECS) data file (U.S. Dept. of Energy 1985) was very different than the distribution shown in the Annual Housing Survey (AHS) data file. Estimated mean income using RECS data was much higher.

Given the assumed uniformity in the rate of change in prices and income faced by all three groups, the relative magnitudes of the price and income elasticities are of crucial importance in determining the relative rates of change in energy demand and expenditures, as well as the energy mix.

1.1 ENERGY DEMAND ELASTICITIES

1.1.1 Own-Price Elasticity

Own-price elasticity measures the percentage change in energy demanded, given a 1% change in the energy price. The relative magnitudes for each combination of population group and census region are very important in determining changes in energy demand, energy expenditure, and composition of energy demanded.

Variations in own-price elasticity will in large part explain how quantity demanded varies among population groups within and among regions for each group over the forecast period. In all cases, increased (decreased) energy price will generate a decrease (increase) in quantity of energy demanded.

Our empirical results suggest that nationally, quantity of energy demanded is most sensitive to energy price changes in black households, followed by majority and Hispanic households. For each census region, the same pattern is observed, i.e., quantity demand by black households is more sensitive to price changes than it is by majority or Hispanic households.* For each region, demand is least elastic in Hispanic households. For each group, energy demand is most elastic in the West and least elastic in the Northeast. For majority households, own-price elasticities of energy demand are equal in the Midwest and South; for Hispanics, demand is slightly more elastic in the South than in the Midwest. For blacks, the sensitivity of electricity demand to changes in its price is moderately higher in the South than in the Midwest. Black households in the West have the highest own-price elasticity of demand for energy, whereas Hispanics in the Northeast have the lowest.

1.1.2 Income Elasticity

Elasticity of income measures percentage change in energy demand, given a 1% change in household income. Once again, the relative magnitudes of these variables will influence change in household energy demand, expenditures, and composition of energy demand over the forecast period.

Our empirical results suggest that nationally, a change in income would most strongly affect energy demand in majority households but would have the least effect on

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*Comparison between black and Hispanic households is not technically appropriate because the two groups overlap. However, in the sample on which our estimates were determined, more than 90% of the Hispanic households are white.

Hispanic households. For each region, majority households will generally have the highest income elasticity. For any given population group, income elasticity in the West will generally be the highest, followed by that in the South. For majority households, income elasticities are approximately equal in the South and Midwest. Both majority and Hispanic households will have energy demand that is slightly more income-elastic in the Midwest than in the Northeast. In contrast, income elasticity for black households is slightly higher in the Northeast. Our empirical estimates of income elasticity for majority households are highest in the West and lowest for Hispanics in the Northeast.

1.1.3 Cross-Price Elasticity

Percentage change in energy demand, given a 1% change in the price of nonenergy goods and services, is known as cross-price elasticity. Our empirical estimates indicate that level of energy demand and price of nonenergy goods are directly related. Nationally, cross-price elasticity is highest in black households, followed by Hispanic and then majority households. Cross-price elasticity for black households is the highest in each region. Except in the West, Hispanics and majority households are about equal in each census region; in the West, the estimate is slightly higher for majority households.

Among regions, estimated elasticity is highest in the West for each of the households and lowest in the Northeast. Black households are higher in the South than in the Midwest, whereas Hispanic and majority households are equal in both regions. Black households in the West and Hispanic and majority households in the Northeast have the highest and lowest cross-price elasticity of energy demand, respectively.

In summary, our comparative analysis of total residential energy demand for the three population groups reveals that:

- Price elasticity of energy demand is highest for black households and lowest for Hispanics.

- Income elasticity is highest for black households and lowest for Hispanics.

- Cross-price elasticity is highest for black households and lower and about equal for minority and Hispanic households.

1.2 ELECTRICITY DEMAND ELASTICITIES

1.2.1 Own-Price Elasticity

At the national level, own-price elasticity of electricity demand is highest in Hispanic households, while those for black and majority households are lower and about equal. In both the South and the West, the estimated elasticity value for black households is the highest. However, in the Midwest and Northeast the value is highest for Hispanics. In the Northeast, own-price elasticities for black and majority households are equal, while in the Midwest, the value is higher for blacks than for majority households. Hispanics show a higher elasticity in the South, but lower in the West, compared to majority households. Regionally, own-price elasticity is highest in the Northeast for Hispanic and majority households. It is highest in the Midwest for black households. Of all census region/population group combinations, Hispanic households in the Northeast have the highest own-price elasticity of electricity demand. Hispanic households in the South have the lowest elasticity.

1.2.2 Expenditure Elasticity

As mentioned earlier, MEAM is a two-stage budgeting model. At the first level, income is allocated between energy and nonenergy expenditures, whereas at the second level, energy expenditures are allocated between electric and nonelectric energy consumption. It is therefore appropriate to discuss how electricity demand responds to changes in energy expenditures. Nationally, expenditure elasticity is highest for Hispanics, followed by black and then majority households. This pattern holds for each census region as well. For each population group, the estimated expenditure elasticity of electricity demand is highest in the Northeast, followed by the Midwest, the West, and the South. Hispanics in the Northeast and majority households in the South have the highest and lowest values, respectively.

1.2.3 Cross-Price Elasticity

In all cases considered here, cross-price elasticity is negative. Therefore, as the price of nonelectric energy increases, the demand for electricity will fall. For the entire U.S., electricity demand in Hispanic households is the most sensitive to nonelectric energy price changes. The value for black households is higher than that for majority households. This pattern also holds for each census region. In each population group, the highest cross-price elasticity is in the Northeast and the smallest is in the South. Hispanics in the Northeast and majority households in the South have the highest and lowest cross-price elasticity estimates for all group/region combinations.

Elasticities for electricity in the three population groups can be summarized as follows:

- The relative size of the own-price elasticity of electricity demand in the three population groups varies by region.
- Expenditure elasticity of electricity demand is highest for Hispanics and lowest for majority households.
- Cross-price elasticities indicate that electricity and nonelectric energy are gross complements. The values are highest for Hispanics and lowest for majority households.

2 OVERVIEW OF DOE ENERGY SECURITY REPORT

The U.S. Department of Energy (DOE) prepared the energy security report at the request of President Reagan in response to his concern over declining domestic oil production and rising oil imports (U.S. Dept. of Energy 1987). The document reviews and projects the nature and scope of energy security concerns, and it also examines the international aspects of key energy markets and evaluates all principal domestic energy resources. In addition, it weighs the costs and benefits of various oil import fees and a gasoline tax. Secretary of Energy Herrington stated that it "provides a solid, technical data base and options for further action by the Administration and Congress to preserve energy security." This chapter gives a brief overview of (1) various price cases considered in the energy security report, (2) potential effects of certain government policy options, and (3) the two scenarios selected for this study.

2.1 CRUDE OIL PRICE CASES

Figure 2 shows the average monthly cost of crude oil imported by U.S. refiners. By 1985, a buyer's market had emerged because prices had dropped substantially from their 1981 highs. Oil consumption in the industrialized countries was falling even while their economies expanded. Then the Organization of Petroleum Exporting Countries (OPEC) decided to defend its market share through price cuts, thus directly challenging

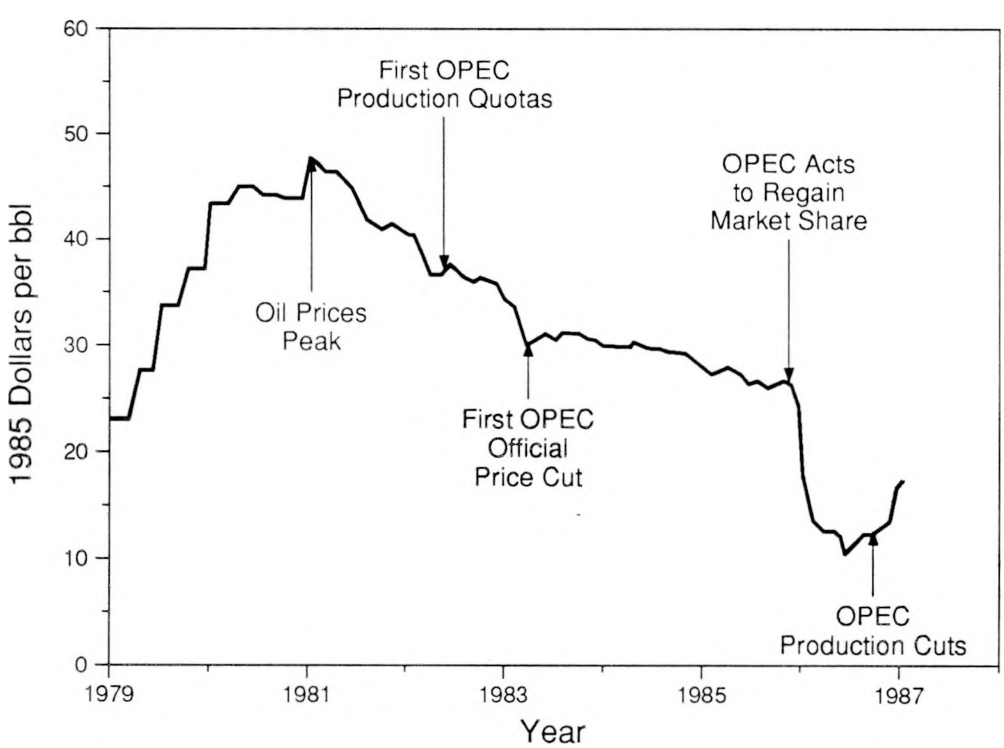

FIGURE 2 Average Monthly Cost of Crude Oil Imported by U.S. Refiners

non-OPEC producers. World crude oil prices collapsed from about $25/barrel (bbl) in January 1986 to about $10/bbl in July 1986. To recover its lost revenues, OPEC subsequently adopted a series of tentative agreements to cut its production by several million barrels per day. This led to a partial price recovery to about $17/bbl in early 1987. Since then, the per-barrel price has continued to hover generally in the $15-20 range.

In conjunction with a number of other federal agencies, DOE developed several alternative energy market cases through 1995. The consensus view was that free-world oil demand will increase from about 46 million bbl/day in 1985 to 49-53 million bbl/day by 1995. On the supply side, non-OPEC oil production was believed to be rather uncertain: a range of 22 to 26 million bbl/day was estimated for 1995. The price outlook consistent with these projections consists of relatively low oil prices over the next several years and then an increase to $20-$30/bbl by 1995. Highlights of these two cases are discussed in Secs. 2.1.1 and 2.1.2. Two variations of the lower price scenarios, the "price ratchet case" and the "price collapse case," are also considered. Highlights of these less likely cases are provided in Secs. 2.1.3 and 2.1.4.

2.1.1 Lower Oil Price Case

The "lower oil price case" in the energy security report assumes that real world oil prices (in constant 1985 dollars) of about $15/bbl will continue until 1990. Subsequently, the price would increase gradually to about $22/bbl in 1995 (Table 2). This corresponds to an average annual price increase of 4.7% between 1986 and 1995. Real U.S. gross national product (GNP) is assumed to grow at an average annual rate of 2.7% between 1985 and 1995. The degree of energy efficiency, as well as non-OPEC reserves, is assumed to be lower than in the higher oil price case. All of these assumptions would tend to increase U.S. oil imports to an estimated 10 million bbl/day by 1995.

2.1.2 Higher Oil Price Case

The "higher oil price case" assumes that the real world oil price will rise to about $23/bbl in 1990 and to about $28 in 1995 (Table 2). This corresponds to a 7.6% average annual price increase between 1985 and 1995. GNP growth, compared to that in the lower oil price case, is lower (about 2.5% yearly between 1985 and 1995) and both the degree of energy efficiency in the U.S. economy and non-OPEC oil reserves are assumed to be higher. Under these conditions, oil imports would tend to be lower; the estimate is about 8 million bbl/day in 1995.

2.1.3 Price Ratchet Case

The "price ratchet case" is the first variation of the lower oil price case; it assumes that prices will remain at about $15/bbl until 1990 (Table 2). However, during the 1990s the price would increase rapidly as major producing countries exert their renewed market power in an environment of increasing world oil demand and declining

TABLE 2 Projections of Imported Crude Oil Prices Described in the Energy Security Report, 1985-95

Year	Higher Oil Price Case	Lower Oil Price Case	Price Ratchet Case	Price Collapse Case
Price (1985 $/bbl)				
1972	7.90	7.90	7.90	7.90
1985	27.03	27.03	27.03	27.03
1986	14.23	14.23	14.23	14.23
1987	17.00	14.36	14.36	12.00
1988	18.51	14.49	14.49	10.00
1989	20.51	15.00	15.00	12.90
1990	22.51	15.49	15.49	15.22
1995	27.51	21.51	30.00	22.91
Annual Change (%)				
1972-85	9.9	9.9	9.9	9.9
1986-90	12.2	2.1	2.1	1.7
1990-95	6.0	6.8	14.1	8.5

non-OPEC production. The price rises to about $30/bbl by 1993 and remains there until 1995. This corresponds to an 8.6% average annual price increase between 1986 and 1995.

2.1.4 Price Collapse Case

This is the second variation of the lower oil price case. It assumes that OPEC influence is further diminished over the near term, sending real oil prices back to about $10/bbl by 1988. However, in the environment of a slow but steady increase in world oil demand and a substantial decline in non-OPEC oil production, prices recover slowly to $15/bbl by 1990. Subsequently, the price trajectory is similar to that in the lower oil price case, increasing to about $23 by 1995.

2.2 CRUDE OIL PRICE CASES UNDER VARIOUS NEW POLICY OPTIONS

One of the conclusions in the energy security report is that the domestic oil and gas drilling industry is in a state of crisis and faces serious future problems because of lower oil prices. According to Secretary of Energy Herrington, "[a]s a nation, we must recognize the warning signs and take thoughtful and prudent action that meets our responsibility to customers, industry, and the nation alike." Among other important options, the DOE report analyzed the cost-effectiveness of two of the more publicly discussed proposals: an oil import fee and a gasoline tax. A brief discussion of the cost-effectiveness analysis for these two proposals is provided below.

2.2.1 Oil Import Fee

To aid the ailing domestic oil and gas drilling industry and to reduce dependence on foreign oil, various import fee schemes have been suggested by industry proponents. However, higher oil prices have a social cost in terms of lower GNP growth in the short to intermediate period. Cost-effectiveness was analyzed for five scenarios with an oil import fee. A $5/bbl fee, a $10/bbl fee, and a $22/bbl floor were analyzed on the assumption that the nation will face lower imported oil prices, as outlined in Sec. 2.1.1. A $5/bbl fee and a $10/bbl fee were also analyzed on the assumption that the nation will face higher import prices, as outlined in Sec. 2.1.2. The major conclusion was that an import fee would not be cost-effective. In the $10/bbl fee case, for example, total economic benefits of about $46 billion were estimated for 1988-95. GNP growth would be reduced simultaneously, resulting in an economic loss of almost four times that amount. Unfavorable results were also estimated for the other import fee cases. Because of the unfavorable evaluation, the oil import fee option was rejected in the energy security report.

2.2.2 Gasoline Tax

A gasoline tax could be expected to have key benefits in terms of decreased gasoline demand (leading to reduced oil imports) and increased treasury revenue and reduced federal deficit. However, the tax would reduce consumer disposable income, increase inflation, and reduce the rate of GNP growth. Two gasoline tax cases were considered: 10¢ and 25¢/gallon; the conclusion was that neither is a cost-effective option. For example, in the first year of enactment (1988), the 10¢/gallon tax is expected to reduce GNP by $10 billion and the 25¢ tax would reduce GNP by $23 billion (both stated in 1985 dollars). For 1988-95, cumulative real GNP loss would be approximately $67 billion under the 10¢ tax and $155 billion under the 25¢ tax. Because of this unfavorable evaluation, the gasoline tax was rejected as a viable policy option.

2.3 SELECTED CRUDE OIL PRICE SCENARIOS

On the basis of the energy security study, we selected the two most likely scenarios for our analysis, which we named the high and low price scenarios. Associated with these scenarios is a set of assumptions pertaining to economic growth, the oil resource base, OPEC production and pricing policies, consumer reactions to oil price changes, interfuel competition, and other factors. Other scenarios that have more extreme swings in oil prices are considered to be less likely. Specifically excluded from our analysis are the "price ratchet case," with its sharp price jump in the 1990s, and the "price collapse case," with its sharp plunge in mid-1987. Also excluded were cases that included oil import fees or a gasoline tax because such cases were determined not to be cost-effective in the energy security report.

3 ECONOMIC ASSESSMENT OF EFFECTS OF ENERGY PRICE SCENARIOS ON MINORITY HOUSEHOLDS

Future effects of the two energy price scenarios on each population group were projected using MEAM. Projections were made for majority, black, and Hispanic households from 1986 through 1995; they included estimated residential energy demand, total energy demand, electricity demand, and nonelectric demand, as well as residential energy expenditures and energy expenditure share of income.

To aid in understanding national and regional demands and expenditures, regional population distributions are displayed in Table 3. Population distributions for the three groups are quite different, with the majority relatively more concentrated in the Northeast and Midwest than are blacks and Hispanics. As a result, analysis at the national level can be somewhat misleading because climate and socioeconomic factors that influence energy demand may also be highly correlated with regional energy demand. It will be seen that the comparative impact of changing energy prices on energy demand and expenditure varies from region to region.

Table 4 shows the projected percentage changes in key economic variables, based on an analysis by Data Resources, Inc. (1987). Because a preponderant share of household income is spent on nonenergy goods and services, changes in their prices are approximated by the consumer price index, which is given for each scenario in the last two columns of the table. It should be noted at the outset that the relative rise in income outpaces the rise in the price of nonenergy goods; this implies that real income increases over the forecast period, leaving all households better off at the end of the period.

Several prominent issues become evident when reviewing the values in Table 4. First, the relative increase in prices of nonelectric energy is higher than it is for electricity, as might be expected. This relative difference holds for both price scenarios and for all regions, with the gap narrowing in the low price scenario. Second, in both the low and high scenarios, the South census region is affected the most: household income there is expected to grow more slowly and the price of nonelectric energy is expected to grow more rapidly than in the other three regions. Electricity price is expected to grow the fastest in the West. Third, income growth is anticipated to be highest in the West, while the Northeast is a close second.

TABLE 3 Population Distribution by Region, 1982 (%)

Census Region	Majority[a]	Black[a]	Hispanic[b]
Northeast	21.7	20.2	19.0
Midwest	27.2	19.9	8.0
South	31.4	50.4	32.4
West	19.7	9.5	40.5

[a]Source: U.S. Dept. of Energy (1985).

[b]Source: U.S. Dept. of Commerce (1983).

TABLE 4 Percentage Change in Household Income and Prices in the Two Scenarios, 1986-95

Region, Period	Household Income		Price: Electricity		Price: Nonelectric Energy		Consumer Price Index	
	Low	High	Low	High	Low	High	Low	High
U.S.								
1986-90	4.8	5.0	1.1	2.3	0.6	5.4	4.1	4.9
1990-95	6.3	6.5	2.8	2.7	13.3	11.2	5.4	5.2
Northeast								
1986-90	5.8	6.0	-0.1	1.3	1.0	6.8	4.1	4.9
1990-95	6.5	6.7	1.8	1.7	12.0	9.9	5.4	5.2
Midwest								
1986-90	4.1	4.3	1.2	1.9	0.6	4.8	4.1	4.9
1990-95	6.3	6.5	2.4	2.4	12.2	10.4	5.4	5.2
South								
1986-90	4.0	4.2	1.0	2.3	-1.2	6.0	4.1	4.9
1990-95	6.1	6.4	3.6	3.4	17.2	14.5	5.4	5.2
West								
1986-90	5.7	5.9	3.0	3.9	-1.2	3.2	4.1	4.9
1990-95	6.6	6.8	2.6	2.5	13.7	11.4	5.4	5.2

Source: Data Resources, Inc. (1987).

The relative impacts among scenarios and across regions are also different. First, income shifts slightly from the Northeast and Midwest to the South and West as we move from the low to the high scenario. Second, the relative impact on nonelectric energy prices of moving from the low to the high scenario is greatest in the Northeast. Finally, the relative impact on electricity prices in both scenarios is greatest in the South, with the Northeast a close second.

In general, the primary factors driving energy demand and composition are relative prices and income. Impacts of these factors on energy demand by the three population categories will vary because of differing preference structures and demographic and household characteristics. The following discussion describes the net effect of relative prices and income on energy demand and the patterns of energy use, energy expenditures, and share of income spent on energy.

3.1 ENERGY DEMAND

Comparative projections of energy demand by majority, black, and Hispanic households are shown in Tables 5-10. Projections describing changes in composition of energy demand in 1986 and in the two scenarios in 1995 are shown in Figs. 3-7. Nationally, total energy demand is projected to fall for each of the population groups. In addition, the composition of residential energy demand is projected to change dramatically: for each population group, the electricity fraction of total demand increases substantially. Consequently, the total amount of primary fuel consumed nationally is not expected to be affected dramatically. The extent to which primary

TABLE 5 Residential Energy Demand per Household, U.S.

Population Group, Scenario, Energy Category	Demand (10^6 Btu/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High					
Elec.	33.3	36.1	36.4	2.0	0.2
Nonelec.	61.8	55.3	50.0	-2.7	-2.0
Total	95.1	91.4	86.4	-1.0	-1.1
Low					
Elec.	33.3	37.9	38.0	3.3	0.1
Nonelec.	61.8	58.6	50.8	-1.3	-2.8
Total	95.1	96.5	88.8	0.4	-1.6
Black					
High					
Elec.	27.4	31.3	32.8	3.4	0.9
Nonelec.	79.8	71.8	60.5	-2.6	-3.4
Total	107.2	103.1	93.3	-1.0	-2.0
Low					
Elec.	37.4	33.0	34.4	4.8	0.8
Nonelec.	79.8	78.8	62.4	-0.3	-4.6
Total	107.2	111.8	96.8	4.3	-2.8
Hispanic					
High					
Elec.	25.8	27.6	26.1	1.7	-1.1
Nonelec.	69.0	64.1	59.0	-1.8	-1.6
Total	94.8	91.7	87.1	-0.8	-1.0
Low					
Elec.	25.8	29.2	27.5	3.1	-1.2
Nonelec.	69.0	66.9	59.6	-0.8	-2.3
Total	94.8	96.1	87.1	0.3	-1.9

TABLE 6 Residential Energy Demand per Household, Northeast

Population Group, Scenario, Energy Category	Demand (10^6 Btu/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High					
Elec.	21.6	22.8	24.2	1.4	1.2
Nonelec.	96.9	83.7	71.5	-3.6	-3.1
Total	118.5	106.5	95.7	-2.6	-2.1
Low					
Elec.	21.6	24.3	25.7	3.0	1.1
Nonelec.	96.9	92.5	74.4	-1.2	-4.3
Total	118.5	116.8	100.1	-0.4	-3.0
Black					
High					
Elec.	17.9	20.0	21.7	2.8	1.6
Nonelec.	111.0	95.0	79.0	-3.8	-3.6
Total	128.9	115.0	100.7	-2.8	-2.6
Low					
Elec.	17.9	21.5	23.3	4.7	1.6
Nonelec.	111.0	107.0	83.0	-0.9	-5.0
Total	128.9	128.5	106.3	-0.1	-3.7
Hispanic					
High					
Elec.	11.6	12.0	12.3	0.9	0.5
Nonelec.	122.0	107.0	88.0	-3.2	-3.8
Total	133.6	119.0	100.3	-2.9	-3.4
Low					
Elec.	11.6	12.8	13.3	2.5	0.8
Nonelec.	122.0	119.0	92.0	-0.6	-5.0
Total	133.6	131.8	105.3	-0.3	-4.4

fuels are affected will depend on the extent to which they are used to generate electricity and on power-generating efficiency.

As expected, the overall projected rate of change in energy demand over the forecast period is higher in the high price scenario for each group. The pattern of change over the period is different for the two scenarios. In the high price scenario, the impact on demand is more immediate, whereas in the low scenario the change in demand is projected to be more rapid over the last five years of the forecast period. In the low scenario, total residential demand is projected to increase slightly between 1986 and 1990 for each population group.

TABLE 7 Residential Energy Demand per Household, Midwest

Population Group, Scenario, Energy Category	Demand (10^6 Btu/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High					
Elec.	28.9	31.5	33.8	2.2	1.4
Nonelec.	87.9	83.8	73.7	-1.2	-2.5
Total	116.8	115.3	107.5	-0.3	-1.4
Low					
Elec.	28.9	32.4	34.6	2.9	1.3
Nonelec.	87.9	89.7	75.5	0.5	-3.4
Total	116.8	122.1	110.1	1.1	-2.0
Black					
High					
Elec.	21.4	24.2	26.6	3.1	1.9
Nonelec.	119.0	113.0	95.0	-1.3	-3.4
Total	140.4	137.2	121.6	-0.6	-2.4
Low					
Elec.	21.4	24.9	27.3	3.9	1.9
Nonelec.	119.0	124.0	98.0	1.0	-4.6
Total	140.4	148.9	125.3	1.5	-3.4
Hispanic					
High					
Elec.	17.8	19.5	21.3	2.3	1.8
Nonelec.	107.0	101.0	86.0	-1.4	-3.2
Total	124.8	120.5	107.3	-0.9	-2.3
Low					
Elec.	17.8	19.8	21.8	2.7	1.9
Nonelec.	107.0	109.0	88.0	0.5	-4.2
Total	124.8	128.8	109.8	0.8	-3.1

Over the forecast period, energy demand converges for black and majority households. Total residential demand for Hispanic and majority households is about the same in 1986 and remains about the same over the forecast period, while demand in majority households falls slightly. However, demand composition in the two minority groups is quite different than that in majority households. In black and majority households, demand composition becomes more similar as black household demand for electricity increases and that for nonelectric energy decreases at a faster rate. In Hispanic and majority households, demand composition diverges.

TABLE 8 Residential Energy Demand per Household, South

Population Group, Scenario, Energy Category	Demand (10^6 Btu/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High					
Elec.	45.6	50.7	49.0	2.7	-0.7
Nonelec.	28.3	21.8	25.1	-6.3	2.8
Total	73.9	72.5	74.1	-0.5	0.4
Low					
Elec.	45.6	53.1	50.5	3.8	-1.0
Nonelec.	28.3	20.5	24.7	-7.7	3.8
Total	73.9	73.6	75.2	-0.1	0.4
Black					
High					
Elec.	32.8	37.8	37.2	3.6	-0.3
Nonelec.	50.1	40.6	35.0	-5.1	-2.9
Total	82.9	78.4	72.2	-1.4	-1.6
Low					
Elec.	32.8	39.7	38.8	4.9	-0.5
Nonelec.	50.1	43.1	35.2	-3.7	-4.0
Total	82.9	82.8	74.0	-0.0	-2.2
Hispanic					
High					
Elec.	39.3	42.9	39.7	2.2	-1.5
Nonelec.	29.3	25.0	29.0	-3.9	3.0
Total	68.6	67.9	68.7	-0.3	0.2
Low					
Elec.	39.3	45.2	41.0	3.5	-1.9
Nonelec.	29.3	23.6	28.5	-5.3	3.8
Total	68.6	68.8	69.5	0.1	0.2

Regionally, the greatest changes in energy demand are in the Northeast, primarily because of the rather large projected decline in nonelectric energy demand. This decline is partially offset by increased electricity demand. Energy demand is projected to change more in the high price scenario across all four regions for each population category. In the South and West, however, the projected change in total energy demand between the two price scenarios is significantly less than that in the Midwest and Northeast. Total energy demand in the South actually increases slightly in Hispanic and majority households in both scenarios, due primarily to the relative decrease in electricity price and the sizable expenditure share for electricity in those

TABLE 9 Residential Energy Demand per Household, West

Population Group, Scenario, Energy Category	Demand (10^6 Btu/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High					
Elec.	27.9	30.3	31.1	2.1	0.5
Nonelec.	45.5	40.9	41.2	-2.6	0.2
Total	73.4	71.2	72.3	-0.8	0.3
Low					
Elec.	27.9	31.9	32.2	3.4	0.2
Nonelec.	45.5	42.0	41.3	-2.0	-0.3
Total	73.4	73.9	73.5	0.2	-0.1
Black					
High					
Elec.	19.8	22.4	22.9	3.1	0.4
Nonelec.	66.4	62.7	54.5	-1.4	-2.8
Total	86.2	85.1	77.4	-0.3	-1.9
Low					
Elec.	19.8	24.1	24.1	5.0	0.0
Nonelec.	66.4	68.9	55.6	0.0	-4.2
Total	86.2	93.0	79.7	1.9	-3.0
Hispanic					
High					
Elec.	22.1	23.4	22.6	1.4	-0.7
Nonelec.	53.8	50.6	47.8	-1.5	-1.1
Total	75.9	74.0	70.4	-0.6	-1.0
Low					
Elec.	22.1	24.8	23.6	2.9	-1.0
Nonelec.	53.8	52.5	48.1	-0.6	-1.7
Total	75.9	77.3	71.7	0.5	-1.5

households. In black households, the effect of these two factors is insufficient to overcome the decline in nonelectric demand.

Once again, we see a general convergence regionally in the pattern of energy demand by black and majority households, with electricity demand rising and nonelectric energy demand falling faster in black households. For Hispanics, the regional changes in energy demand relative to that by the majority population are mixed. In the Northeast, the total level of residential energy demand for these two groups converges. However, the relative composition of demand diverges slightly for the two groups, with electricity

TABLE 10 Residential Energy Demand per Household, High Price Scenario

Region, Population Group	Demand (10^6 Btu/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
U.S.					
Majority	95.1	91.4	86.4	-1.0	-1.1
Black	107.2	103.1	93.3	-1.0	-2.0
Hispanic	94.8	91.7	87.1	-0.8	-1.0
Northeast					
Majority	118.5	106.5	95.7	-2.6	-2.1
Black	128.9	115.0	100.7	-2.8	-2.6
Hispanic	133.6	119.0	100.3	-2.9	-3.4
Midwest					
Majority	116.8	115.3	107.5	-0.3	-1.4
Black	140.4	137.2	121.6	-0.6	-2.4
Hispanic	124.8	120.5	107.3	-0.9	-2.3
South					
Majority	73.9	72.5	74.1	-0.5	0.4
Black	82.9	78.4	72.2	-1.4	-1.6
Hispanic	68.6	67.9	68.7	-0.3	0.2
West					
Majority	73.4	71.2	72.3	-0.8	0.3
Black	86.2	85.1	77.4	-0.3	-1.9
Hispanic	75.9	74.0	70.4	-0.6	-1.0

becoming relatively more important in majority households. A similar pattern emerges in the Midwest and West, where total energy demand converges and demand composition diverges. Again, electricity is projected to become relatively more important in majority households. In the South, virtually no change is projected in the relative relationship in demand between Hispanic and majority householders. As in the other three regions, however, the relative composition of demand does change, with electricity becoming more important for the majority.

3.2 ENERGY EXPENDITURES

Total residential energy expenditures are projected to increase over the forecast period in all cases (Tables 11-16). Nationally, black household expenditures are projected to increase more rapidly than those in majority households in both price scenarios.

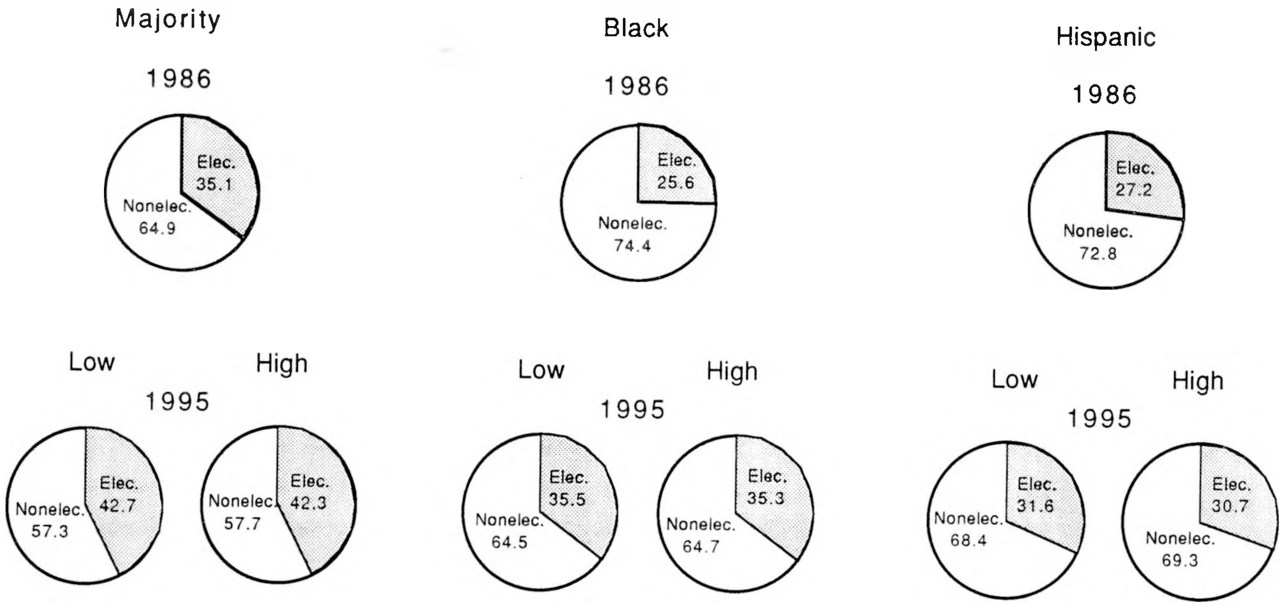

FIGURE 3 Composition of Energy Demand in U.S., 1986, and in the Two Scenarios, 1995 (percent)

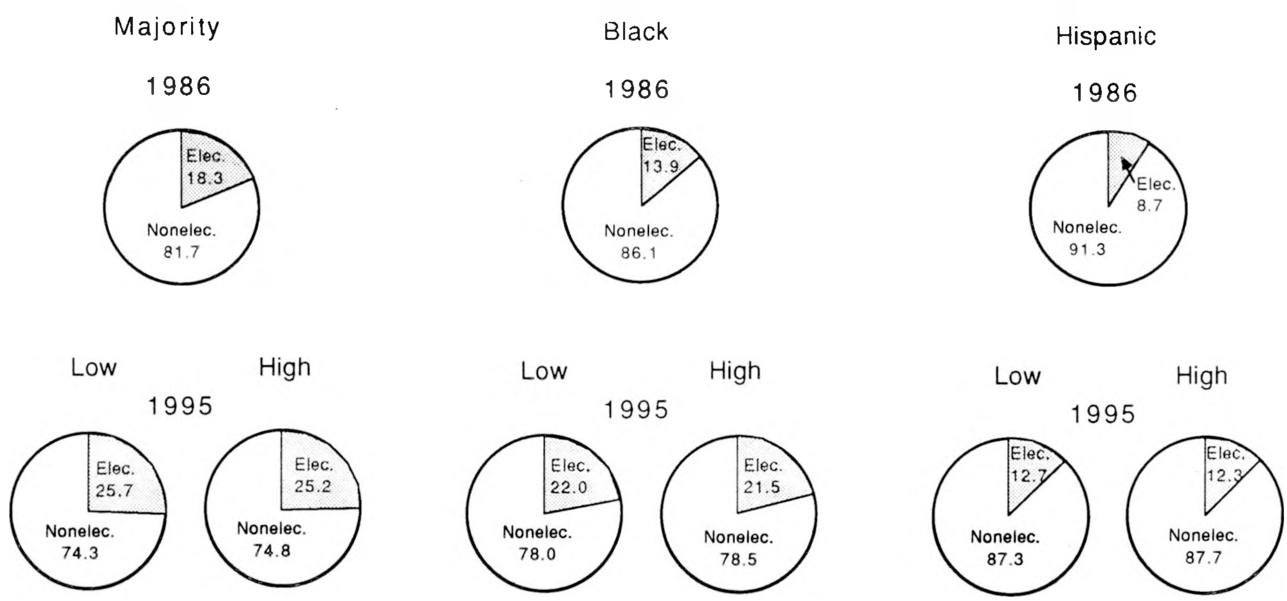

FIGURE 4 Composition of Energy Demand in Northeast, 1986, and in the Two Scenarios, 1995 (percent)

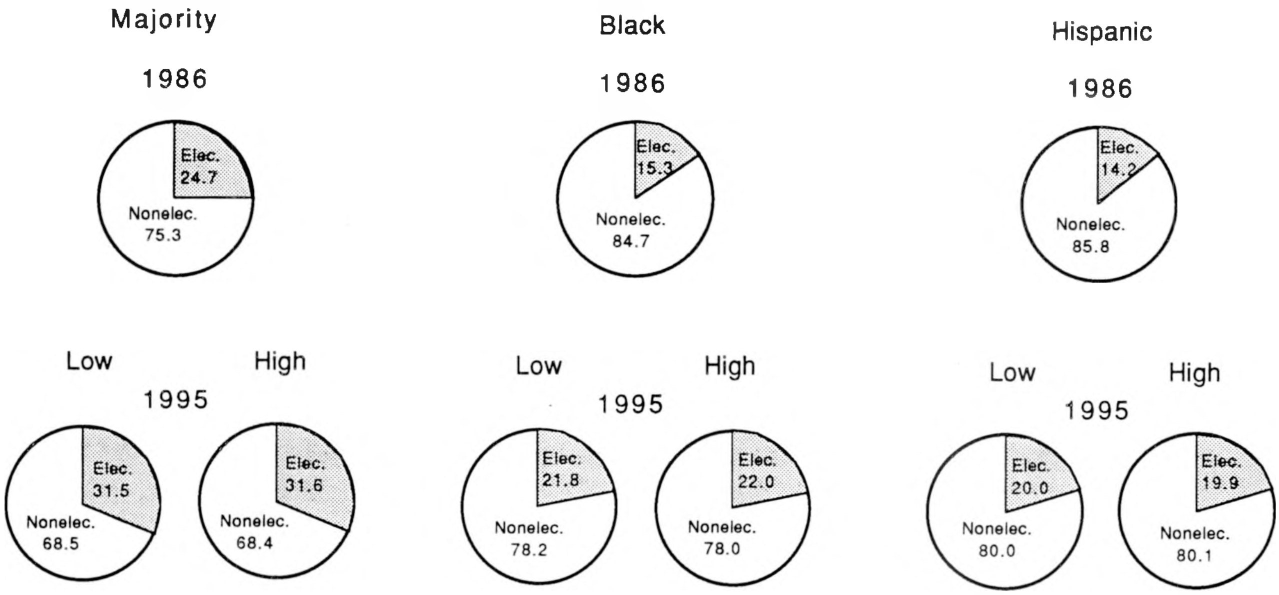

FIGURE 5 Composition of Energy Demand in Midwest, 1986, and in the Two Scenarios, 1995 (percent)

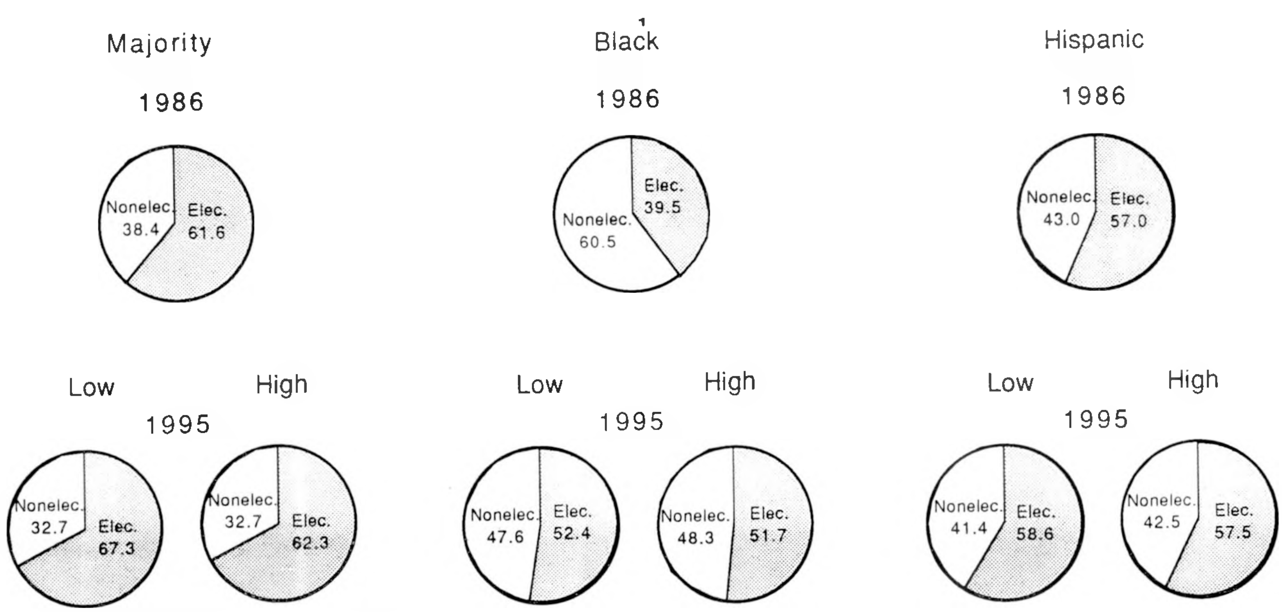

FIGURE 6 Composition of Energy Demand in South, 1986, and in the Two Scenarios, 1995 (percent)

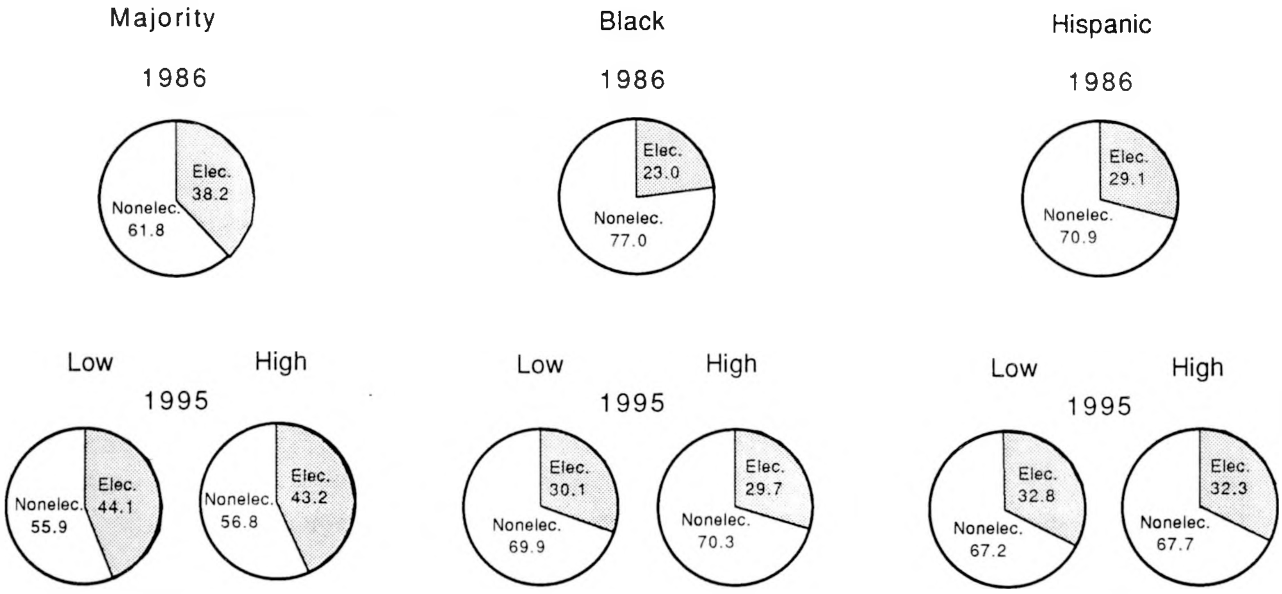

FIGURE 7 Composition of Energy Demand in West, 1986, and in the Two Scenarios, 1995 (percent)

TABLE 11 Residential Energy Expenditures, U.S.

Population Group, Scenario	Expenditures ($/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	1050	1219	1541	3.8	4.8
Low	1050	1179	1505	2.9	5.0
Black					
High	1017	1211	1559	4.5	5.2
Low	1017	1176	1527	3.7	5.4
Hispanic					
High	932	1083	1378	3.8	4.9
Low	932	1039	1339	2.8	5.2

TABLE 12 Residential Energy Expenditures, Northeast

Population Group, Scenario	Expenditures ($/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	1136	1270	1593	2.8	4.6
Low	1136	1207	1535	1.5	4.9
Black					
High	1109	1268	1600	3.4	4.7
Low	1109	1213	1549	2.2	5.0
Hispanic					
High	996	1118	1400	2.9	4.6
Low	996	1036	1330	1.0	5.1

TABLE 13 Residential Energy Expenditures, Midwest

Population Group, Scenario	Expenditures ($/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	1096	1276	1660	3.8	5.4
Low	1096	1224	1616	2.8	5.7
Black					
High	1083	1280	1673	4.3	5.5
Low	1083	1230	1630	3.2	5.8
Hispanic					
High	943	1091	1437	3.7	5.7
Low	943	1034	1389	2.3	6.1

TABLE 14 Residential Energy Expenditures, South

Population Group, Scenario	Expenditures ($/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	1081	1276	1628	4.2	5.0
Low	1081	1238	1584	3.4	5.1
Black					
High	941	1119	1454	4.4	5.4
Low	941	1086	1422	3.6	5.5
Hispanic					
High	958	1126	1436	4.1	5.0
Low	958	1088	1394	3.2	5.1

TABLE 15 Residential Energy Expenditures, West

Population Group, Scenario	Expenditures ($/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	777	927	1206	4.5	5.4
Low	777	907	1184	3.9	5.4
Black					
High	719	867	1122	4.8	5.3
Low	719	861	1109	4.6	5.2
Hispanic					
High	703	823	1050	4.0	5.0
Low	703	800	1028	3.3	5.1

TABLE 16 Residential Energy Expenditures, High Price Scenario

Region, Population Group	Expenditures ($/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
U.S.					
Majority	1050	1219	1541	3.8	4.8
Black	1017	1211	1559	4.5	5.2
Hispanic	932	1083	1378	3.8	4.9
Northeast					
Majority	1136	1270	1593	2.8	4.6
Black	1109	1268	1600	3.4	4.7
Hispanic	996	1118	1400	2.9	4.6
Midwest					
Majority	1096	1276	1660	3.8	5.4
Black	1083	1280	1673	4.3	5.5
Hispanic	943	1091	1437	3.7	5.7
South					
Majority	1081	1276	1628	4.2	5.0
Black	941	1119	1454	4.4	5.4
Hispanic	958	1126	1436	4.1	5.0
West					
Majority	777	927	1206	4.5	5.4
Black	719	867	1122	4.8	5.3
Hispanic	703	823	1050	4.0	5.0

rate of change in Hispanic energy expenditures is projected to be about the same as that for majority households.

The overall expenditure increase is greater in the high scenario for each population group, but the pattern of change over the forecast period is not uniform. In both scenarios and in all groups, the rate of expenditure change is higher in the second half of the forecast period. Between the scenarios in the second half, however, the annual rate of change remains nearly steady, whereas in the first half the difference in the rate between the two scenarios is more substantial. This is not surprising: in the second half of the forecast period, energy prices are projected to grow at a substantially higher rate than in the first half in both scenarios, with the projected second-half rate of increase slightly higher in the low scenario. However, in the first half, energy prices are projected to grow at a considerably faster rate in the high scenario.

Regionally, the same relative trends in energy expenditures are seen. The relative rate of expenditure change is not projected to vary widely between groups or regions. In all cases, the rate of change in energy expenditures for black households exceeds that for majority households. Hispanic and majority households are projected to have rates similar to one another. Rates of energy expenditure change are projected to be slightly higher in the South and West; this is due largely to the already high level of electricity demand in those regions, which implies that the saturation of electric heating and air conditioning is higher in those regions. As a result, there is not as much switching from the relatively more expensive nonelectric energy to electricity.

3.3 ENERGY EXPENDITURE SHARE OF INCOME

Projected energy expenditure shares are shown in Tables 17-22. For both price scenarios and for each population group in all four regions, the shares are projected to fall somewhat. The biggest drop in expenditure share is in the

TABLE 17 Energy Expenditure Share of Household Income, U.S. (%)

Population Group, Scenario	1986	1990	1995
Majority			
High	3.5	3.4	3.1
Low	3.5	3.3	3.1
Black			
High	5.5	5.4	5.1
Low	5.5	5.3	5.1
Hispanic			
High	4.4	4.2	3.9
Low	4.4	4.1	3.9

TABLE 18 Energy Expenditure Share of Household Income, Northeast (%)

Population Group, Scenario	1986	1990	1995
Majority			
High	3.5	3.1	2.8
Low	3.5	3.0	2.8
Black			
High	5.5	5.0	4.6
Low	5.5	4.8	4.5
Hispanic			
High	5.6	5.0	4.5
Low	5.6	4.7	4.4

TABLE 19 Energy Expenditure Share of Household Income, Midwest (%)

Population Group, Scenario	1986	1990	1995
Majority			
High	3.8	3.7	3.6
Low	3.8	3.6	3.5
Black			
High	6.4	6.4	6.2
Low	6.4	6.2	6.1
Hispanic			
High	4.7	4.6	4.5
Low	4.7	4.4	4.4

TABLE 20 Energy Expenditure Share of Household Income, South (%)

Population Group, Scenario	1986	1990	1995
Majority			
High	3.9	3.9	3.7
Low	3.9	3.8	3.6
Black			
High	5.3	5.4	5.1
Low	5.3	5.2	5.1
Hispanic			
High	4.5	4.5	4.2
Low	4.5	4.4	4.2

TABLE 21 Energy Expenditure Share of Household Income, West (%)

Population Group, Scenario	1986	1990	1995
Majority			
High	2.5	2.4	2.2
Low	2.5	2.3	2.2
Black			
High	3.6	3.5	3.2
Low	3.6	3.5	3.2
Hispanic			
High	3.1	2.8	2.6
Low	3.1	2.8	2.6

TABLE 22 Energy Expenditure Share of Household Income, High Price Scenario (%)

Region, Population Group	1986	1990	1995
U.S.			
Majority	3.5	3.4	3.1
Black	5.5	5.4	5.1
Hispanic	4.4	4.2	3.9
Northeast			
Majority	3.5	3.1	2.8
Black	5.5	5.0	4.6
Hispanic	5.6	5.0	4.5
Midwest			
Majority	3.8	3.7	3.6
Black	6.4	6.4	6.2
Hispanic	4.7	4.6	4.5
South			
Majority	3.9	3.9	3.7
Black	5.3	5.4	5.1
Hispanic	4.5	4.5	4.2
West			
Majority	2.5	2.4	2.2
Black	3.6	3.5	3.2
Hispanic	3.1	2.8	2.6

Northeast; a relatively high increase in income and a shift to electricity contribute to this outcome. The expenditure share gap between majority and minority households is projected to remain about the same over the forecast period, with black and Hispanic households spending a larger share of their income on energy.

It must be stressed that we assumed the same rate of change in income for each group. It is likely, however, that income changes in the three groups may vary, given different macroeconomic scenarios. To the extent that they do vary, a bias is implied in our expenditure and income estimates. These biases, however, will have opposite effects on estimated expenditure shares. With varying changes in income, depending on the associated size of the income and expenditure biases, the share estimate could be biased either upward or downward.

4 CONCLUSIONS

Over the 1986-95 forecast period, energy demand and its composition by black and majority households converge in both price scenarios. Except in the South, energy demand by black households remains higher than that by majority households over the entire period, but does converge. Total residential energy consumption by black households in the South is projected to fall slightly below that by majority households by 1995. In all cases, electricity demand by majority households will stay higher than that by black households. However, the rate of change in electricity consumption by black households will be higher. As a result, electricity consumption for the two population groups will converge in the forecast period.

Comparing Hispanic and majority households, the relative nature of changes in energy demand and its composition is more mixed. Nationally, total energy demand is about the same in both groups and remains so during the forecast period. Regionally, however, the picture is an amalgam: in the Northeast and Midwest, energy demand by Hispanic and majority households converges, with that by Hispanics declining. In the South, the projected rate of change in total energy consumption is almost identical and in the West it is higher for Hispanic households than for majority households.

Nationally, the composition of energy consumption in Hispanic and majority households is expected to diverge. Electricity consumption by Hispanics is projected to grow more slowly than in majority households, so that the projected difference in electricity consumption for Hispanic and majority households increases. Regionally, the same relative movement in electricity consumption is projected, except in the Midwest.

In energy expenditures, black households have the most growth in both price scenarios nationally and in each region. For both Hispanics and the majority, expenditures are similar at the national and regional levels. Projected energy expenditure shares in both price scenarios and for each population group are projected to fall somewhat in each of the four Census regions (Tables 18-21). The biggest drop is projected to occur in the Northeast; a relatively higher increase in income and a shift to electricity contribute to this outcome. The expenditure share gap between majority and minority households will remain about the same over the forecast period, with black and Hispanic households spending a larger share of their income on energy than will majority households.

Although we assumed the same rate of change in income for each population group, it is likely that income changes in the three groups may differ between macroeconomic scenarios. To the extent that they do vary, a bias is implied in our expenditure and income estimates; these biases will have opposite effects on expenditure share estimates. With varying changes in income and depending on the associated size of the income and expenditure biases, the share estimate could have an upward or downward bias.

The key findings in this study are:

- Total energy demand per household in both scenarios declines nationally and regionally, with two exceptions. In the South, total energy demand in majority and Hispanic households increases slightly in the low price scenario. The greatest declines are in black households in the Northeast: 17.8% in the low scenario and 21.7% in the high.

- Energy expenditures at both the national and regional levels increase for each population group in both scenarios. Changes in expenditures are rather uniform across regions for each of the population groups. The highest percentage increase in expenditures is for black and majority households in the West: 54.2% and 52.4% in the low price scenario and 56.1% and 55.2% in the high scenario for black and majority households, respectively.

- Electricity consumption increases for each population group in both scenarios nationally and regionally. The highest percentage increases occur in the Northeast and Midwest; black households exhibit the greatest increase of the three population groups. In the low scenario, electricity consumption by blacks increases by 24.3% in the Midwest; in the high scenario, it rises by 30.2% in the Northeast.

- Nonelectric energy consumption declines in each population group in both price scenarios. Once again, black households experience the highest percentage changes, notably in the South where the decline is 29.7% in the low price scenario and 30.1% in the high. Nonelectric energy consumption by Hispanic and majority households shows the greatest declines in the Northeast and Midwest.

- Electricity as a share of total energy demand is projected in both scenarios to become much more important than earlier. At the national level in 1986, electricity was estimated to account for about 35%, 26%, and 27% of total energy consumption by majority, black, and Hispanic households, respectively. In 1995, those shares are projected to increase to 43%, 35%, and 38% in the low price scenario and to 42%, 35%, and 31% in the high.

- Share of income spent on energy is projected to slightly fall for each population group in both scenarios. Regionally, energy expenditure share of income declines the most in the Northeast. The expenditure share gap between majority and minority households is projected to remain about the same over the forecast period.

APPENDIX A:

MINORITY ENERGY ASSESSMENT MODEL

The methodology underlying Argonne's Minority Energy Assessment Model (MEAM) is derived from economic theory. It is related to the linear expenditure system (LES) that is used extensively in applied economics. The theoretical underpinnings of this system were developed by Klein and Rubin (1947-48), Samuelson (1947-48), Geary (1950-51), and Stone (1954). For a detailed discussion of the LES model, see Deaton and Muellbauer (1980), pp. 61-67. An LES model is a complete demand system in which a number of conditions required by consumer demand theory are satisfied. The primary reason for embracing this analytical method is its logical consistency: it provides a clear interpretation of the effects of changing prices and income on patterns of consumption and the cost of living (the level of economic well-being). The system is particularly useful in assessing comparative impacts on different population groups.

In MEAM, the basic LES model has been modified to capture dynamic variations in demand. Through a quality index, the model incorporates the effects of demographic and household characteristics. The rather severe a priori restrictions imposed by the model are largely offset by the intuitively appealing interpretation of its cost and indirect utility functions. Furthermore, the model can easily be extended to accommodate additional commodity categories. The simplicity of the system is both its greatest strength and greatest weakness.

The primary purpose of our research is the systematic determination of variations in, and evaluation of, the impact of policy on the patterns of energy demand in various socioeconomic groups. To clearly discern the influence of policy and the effect of factors that influence energy demand, our analysis is conducted within a complete demand system. Energy is viewed as one commodity group in which choices of fuel type and level of utilization are made. A two-stage budgeting model, MEAM is a special case of the S-branch utility tree model of Brown and Heien (1972).

The MEAM model is a complex one in which a number of ideas put forth by various researchers have been combined; its structure can be divided into three elements. First, the "basic" model is the LES of Klein and Rubin (1947-48), Samuelson (1947-48), Geary (1950-51), and Stone (1954). The characterizing parameters of this element are known as structural parameters. The second element is the dynamic component. Dynamics are incorporated into the model by allowing certain structural parameters to change over time. The French economist Phlips (1972, 1983) has conducted extensive research in this area. We refer to the parameters that characterize this element as dynamic parameters. Finally, the third element is the quality component, within which we introduce the effect of the type of appliance stock on energy use. As in Muellbauer's "hedonic approach" to quality-adjusted prices, energy demand reflects the influence of space heating and other household and demographic factors through their effects on a "quality" index (Muellbauer 1975). The parameters that characterize this component are called quality parameters.

Several theoretical and modeling problems arise because energy is used in conjunction with energy-consuming appliances that are, in turn, used in the home having specific thermal attributes. Our approach in analyzing the relationship between stock and utilization decisions is somewhat different than the traditional approach. Typically, fuel utilization is determined by specific end use. Total residential fuel is then determined by multiplying the utilization rate by the fuel's share in that end use and then summing over all end uses. In MEAM, total residential demand is determined directly, and the influence on that demand of climate, demography, household category, and type of end use is measured through the quality index.

A.1 BASIC MODEL

The basic model, which determines actual total energy demand at the household level, is derived from the Stone-Geary utility function. The i^{th} good's cost equation* for the basic model is

$$p_i q_i = p_i \tau_i + \beta_i \left(E - \sum_{i=1}^{n} p_k \tau_k\right) \tag{A.1}$$

where:

p_i = price of i^{th} good,

q_i = quantity of i^{th} good demanded,

τ_i = "nondiscretionary" demand for i^{th} good,

β_i = marginal expenditure share on i^{th} good,

E = total expenditures for commodity group to which i^{th} good belongs, and

$\sum_{i=1}^{n} p_k \tau_k$ = total "nondiscretionary" expenditures for goods in total commodity group to which i^{th} good belongs.

This model is purely static and does not account for effects of household, demographic, or climatic factors on energy demand. In the next section, we briefly describe how a dynamic element is introduced into the model.

**Cost* refers to the product of unit price and quantity demanded. This equation should not be confused with the expenditure equation, which is the solution to the dual of the expenditure-constrained utility maximization problem.

A.2 DYNAMIC MODEL

Dynamics are introduced into the demand system through the "nondiscretionary" term in Eq. A.1. Phlips (1972, 1983) discusses the mechanics of incorporating dynamics into the LES model. The dynamic version of the model is

$$p_i q_i = p_i \left(\tau_i + \alpha_i s_i\right) + \beta\left[E - \sum_{i=1}^{n} p_k \left(\tau_k + \alpha_k s_k\right)\right] \qquad \text{(A.2)}$$

where:

α_i = dynamic adjustment of "nondiscretionary" demand for the i^{th} good, and

s_i = a state variable that embodies effect of past consumption of the i^{th} good on its current consumption.

The α_i parameter may be positive or negative. If positive, "nondiscretionary" demand increases over time and the i^{th} commodity is therefore referred to as habit-forming. Conversely, if α_i is negative, "nondiscretionary" demand declines over time. In the case of energy demand, this may signify the presence of energy conservation or an efficiency improvement in energy-using appliances.

A.3 EXTENDED DYNAMIC MODEL

Finally, we will show how energy demand is affected by energy use. If a particular fuel, e.g., natural gas or electricity, is used for space heating, it will affect the level of demand. Several ways have been suggested to systematically incorporate demand-influencing factors into the demand system. The two most prominent suggestions were made by Muellbauer (1975) and Pollak and Wales (1978). The latter suggests that the "nondiscretionary" parameter be specified as a linear function of various demographic and household factors. We chose Muellbauer's approach, in which variations in the quality of a good are systematically introduced into the demand system through their influence on the consumer's level of satisfaction.

The Muellbauer approach allows construction of a quality index that can be used to derive a quality-adjusted price index. In our model, the quality index is an exponential function of a linear combination of household, demographic, and climatic factors. Separate quality indices are specified at each level of our two-stage budgeting model. At the lower level of the budgeting hierarchy, determination of how a specified fuel is used becomes important.

The quality index that enters the fuel-specific demand equation is

$$\phi_e = \exp\left(\sum_{i=1}^{n} \nu_j b_j\right) \tag{A.3}$$

where:

ϕ_e = quality index associated with electricity demand,

ν_j = coefficient associated with j^{th} attribute, and

b_j = j^{th} attribute.

The quality index in Eq. A.3 is then incorporated into the demand model as

$$p_e q_e = p_e(\tau + \alpha_e s_e)\phi_e + \beta_e\left[E - p_e(\tau_e + \phi_e s_e)\phi_e - \sum_{i=1}^{n} p_k \tau_k\right] \tag{A.4}$$

where:

p_e = price of fuel,

q_e = quantity of fuel demanded,

τ_e = "nondiscretionary" demand for fuel,

α_e = dynamic adjustment of "nondiscretionary" demand for fuel,

s_e = state variable associated with fuel consumption,

ϕ_e = quality index associated with fuel demand,

β_e = marginal expenditure share for fuel,

E = total energy expenditures, and

$\sum_{i=1}^{n} p_k \tau_k$ = total expenditures on "nondiscretionary" alternative forms of energy.

Because the marginal expenditure share (β_e) is less than one, the level of fuel expenditure is directly related to the size of the quality index. For example, as the share of electricity heating increases -- holding all other things constant -- electricity demand will rise.

As mentioned earlier, our model is somewhat different than other residential energy demand models. Typically, individual utilization equations are used for each specific end-use category, i.e., there will be a specific equation for space heating, for water heating, etc. We decided, however, to estimate total fuel demand and demand by fuel type over all end-use categories and to capture the effect of using a fuel type in an end-use category in the quality index. This approach has an advantage in that the effect on the amount demanded by simultaneous use of a fuel type over more than the one end-use category is systematically resolved.

Our model has two types of time horizons. This point is raised because dynamics are incorporated in both the utilization equation (Eq. A.4) and the space heating share equation (Eq. A.5). The first time horizon may be characterized as a "conditional" short- and long-run period; within the context of this period we consider the adjustment period associated with energy demand while holding the composition of appliance stocks constant. The second time horizon can be characterized as an "unconditional" short- and long-run period, which is associated with the time horizon required to adjust the composition of appliance stocks to a new equilibrium.

A.4 SPACE HEATING SHARE MODEL

Space heating shares are estimated with a multinomial logit model (MNL). Specifically, the model is used to estimate space heating shares for natural gas, electricity, fuel oil, and residual fuel. Actual specification of the model was determined more from intuition than from theory: we believe that this area is ripe for much more research in both the theoretical and applied areas. The MNL equation for the j^{th} fuel for a household with z_i characteristics is

$$P_{ij} = \frac{\exp(\phi'_j z_i)}{\sum_{i=1}^{n} \exp(\phi'_k z_k)} \tag{A.5}$$

where:

P_{ij} = estimated space heating share for the j^{th} fuel for the i^{th} household,

ϕ_j = (n x 1) vector of coefficients associated with the j^{th} fuel, and

z_i = (n x 1) vector of household characteristics associated with i^{th} household.

As discussed earlier, our research is concerned with determining the comparative impact of energy policy among population groups. The MNL models were estimated for black and nonblack households. To estimate the model given in Eq. A.5, a normalization rule must be adopted; we set the vector of coefficients associated with the residual fuel category equal to the null set. Maximum-likelihood estimates were then obtained using the Newton-Raphson method. (For details on estimation of MNL models, see Maddala [1983], pp. 73-76.)

In Tables A.1 and A.2, variable definitions and parameter estimates, respectively, are shown for the space-heating share model. The model was estimated with data provided by the Energy Information Administration (U.S. Dept. of Energy 1980, 1981, 1982, 1983, 1984, 1985). For both nonblack and black households, the price variables are highly significant. Electricity share is most sensitive to price changes, followed by fuel oil and then natural gas. For the interactive variables, where heating and cooling degree-days interacted with housing stock vintage, the coefficients associated with older homes (built before 1940) are most significant. The relationship is typically positive for natural gas and fuel oil shares (the older the home, the more likely natural gas or fuel oil is used for space heating) and negative for electricity share for nonblacks and positive for blacks as heating load increases. For older homes, increased cooling loads cause the share of each fuel to fall, with the relative decline greatest for electricity, followed by fuel oil and then natural gas.

TABLE A.1 Variable Definitions for Space Heating Share Model

Variable	Definition
Log(PFUELi)	Natural log of price of i^{th} fuel
HDD x Khous1	Interactive variable between heating degree-days (65°F base and dummy variable for home built before 1940)
HDD x Khous2	Interactive variable between heating degree-days (65°F base and dummy variable for home built between 1940 and 1974)
HDD x Khous3	Interactive variable between heating degree-days (65°F base and dummy variable for home built after 1974)
CDD x Khous1	Interactive variable between cooling degree-days (65°F base and dummy variable for home built before 1940)
CDD x Khous2	Interactive variable between cooling degree-days (65°F base and dummy variable for home built between 1940 and 1974)
CDD x Khous3	Interactive variable between cooling degree-days (65°F base and dummy variable for home built after 1974)

TABLE A.2 Parameter Estimates for Space Heating Share Model

	Nonblack			Black		
Characteristic	Electricity	Natural Gas	Fuel Oil	Electricity	Natural Gas	Fuel Oil
Constant	6.49 (0.66)[a]	3.43 (0.37)	2.95 (0.45)	10.03 (1.20)	6.48 (0.59)	4.90 (0.65)
Log(PFUELi)	-1.61 (0.20)	-0.76 (0.10)	-1.13 (0.18)	-2.89 (0.35)	-2.29 (0.16)	-2.12 (0.23)
HDD x Khous1	-1.0×10^{-4} (7×10^{-5})	1.1×10^{-4} (5×10^{-5})	2.8×10^{-4} (5×10^{-5})	1.6×10^{-4} (1×10^{-4})	3.5×10^{-4} (1×10^{-4})	5.0×10^{-4} (1×10^{-4})
HDD x Khous2	-1.0×10^{-4} (7×10^{-5})	1.2×10^{-4} (5×10^{-5})	1.9×10^{-4} (5×10^{-5})	-5.8×10^{-5} (1×10^{-4})	6.8×10^{-5} (1×10^{-4})	1.7×10^{-4} (1×10^{-4})
HDD x Khous3	-1.7×10^{-5} (6×10^{-5})	5.0×10^{-6} (5×10^{-5})	0.0	2.0×10^{-4} (1×10^{-4})	1.2×10^{-4} (1×10^{-4})	0.0
CDD x Khous1	-1.2×10^{-3} (3×10^{-4})	-2.8×10^{-4} (2×10^{-4})	-8.7×10^{-4} (2×10^{-4})	-1.1×10^{-3} (3×10^{-4})	-5.3×10^{-4} (2×10^{-4})	-6.0×10^{-4} (2×10^{-4})
CDD x Khous2	-2.3×10^{-4} (1×10^{-4})	-3.8×10^{-4} (1×10^{-4})	-5.0×10^{-4} (1×10^{-4})	1.3×10^{-4} (1×10^{-4})	-6.0×10^{-5} (2×10^{-4})	4.9×10^{-5} (2×10^{-4})
CDD x Khous3	2.2×10^{-4} (2×10^{-4})	-3.7×10^{-4} (2×10^{-4})	0.0	1.2×10^{-5} (3×10^{-4})	-5.5×10^{-4} (3×10^{-4})	0.0

[a]Asymptotic standard errors are given in parentheses.

APPENDIX B:

CRUDE OIL PRICE EFFECTS ON THE MACROECONOMY AND THE ENERGY SECTOR

Macroeconomic and energy-sector consequences of the two oil price scenarios were estimated by using the DRI Annual Macromodel and U.S. Energy Model. Simulations were produced for both scenarios (high oil price and low oil price). Effects of the scenarios on the economy and energy sector are discussed below.

B.1 MACROECONOMY

The U.S. economy has grown relatively slowly since 1985 and seems likely to do so for some time in the DRI base case (based on TRENDLONG1087 described in Data Resources, Inc. 1987). Much of the expected near-term growth results from depreciation of the dollar that has already occurred. Real GNP growth, after falling from a robust 6.8% (the best performance since 1951) in 1984 to 3.4% in 1985 and 2.9% in 1986, averages 2.1% in 1987-90. This moderate growth over such a long period, together with small wage gains, implies that near-term inflation will remain low. Over the long run, supply-side factors begin to dominate the growth. The declining growth in labor force limits potential GNP growth over the long run. Real GNP is forecast to average a modest 2.8% in 1990-95. For the 1986-95 analysis period, this accounts for an average growth rate of 2.6%, almost the same as the historical growth rate of real GNP over the nine-year period of 1977-86 (Table B.1). Wide fluctuations, however, occurred in the growth rate as the economy experienced two back-to-back recessions in 1980 and 1981-82.

A new macroeconomy forecast for each of the oil price scenarios was obtained by solving the DRI Annual Macromodel after introducing crude oil price changes. Macroeconomic growth under the two alternative oil price scenarios is summarized in the next two sections.

B.1.1 Low Oil Price Scenario

The greatest effects of the low scenario occur in the short run. Crude oil falls from about $17/bbl in 1987 (constant 1985 dollars) to $14/bbl in 1988. After hitting bottom in 1988, prices recover slowly to about $15/bbl by 1990. Because lower oil prices foster economic growth, real GNP grows at an improved rate of 2.7% in 1987-90, compared with 2.1% in the DRI base case. As oil prices begin to rise from about $15/bbl in 1990 to $22/bbl by 1995, however, real GNP growth slows to 2.3% in 1990-95, compared to 2.8% in the DRI base case.

Compared to the historical growth rate of 2.6% in 1977-86, the economy grows at 2.5% in 1986-95. However, the economic environment will be substantially different: for example, aided by lower oil prices, the inflation rate, unemployment rate, and interest rate over the 1986-95 forecast period will be lower than corresponding rates in the previous (1977-86) period; trade and federal deficits will be higher.

TABLE B.1 Comparison of Past and Future Macroeconomic Indicators

Indicator	Actual, 1977-86	1986-95 Values: DRI Base Case	Low Scenario	High Scenario
Average Annual Growth (%)				
Real GNP	2.6	2.6	2.5	2.5
Inflation (GNP deflator)	6.0	4.4	4.4	4.5
Industrial production	2.5	2.9	2.7	2.8
Real disposable income	2.8	2.1	2.1	2.0
Average Level				
Unemployment rate (%)	7.5	6.4	6.2	6.5
Housing starts (10^6 units)	1.6	1.7	1.7	1.6
10-yr Treasury bond rate (%)	10.5	8.2	8.1	8.3
Merchandise trade balance ($\$10^9$)	-61.4	-123.4	-126.6	-120.5
Federal budget surplus ($\$10^9$)	-110.9	-163.7	-150.8	-173.9

B.1.2 High Oil Price Scenario

Crude oil in the high scenario continues on the upward trend from its 1986 low of $14/bbl. It rises to $17/bbl in 1988, $19 in 1989, and $23 in 1990. Because higher oil prices retard economic growth, the economy grows at an average rate of 2.0% in 1987-90, compared with 2.1% in the DRI base case. After 1990, oil continues to move higher, but at a slower rate, reaching $28/bbl by 1995. In this environment, the economy grows at a modest annual rate of 2.7%, compared with 2.8% in the DRI base case.

The key macroeconomic indicators forecast in the high oil price scenario are also shown in Table B.1. The economy, compared to that in the low scenario, is not as strong. For 1986-95, inflation, interest rates, unemployment, and the federal budget deficit are all higher, while income, housing starts, and the trade deficit are lower. A more detailed economic comparison between the two scenarios is provided in the next section.

B.1.3 Comparison of the Two Scenarios

This analysis addresses the macroeconomic effects on the economy of the two scenarios in terms of inflation, real GNP, interest rates, personal income, industrial production, unemployment, housing starts, trade, and the federal budget. Table B.2

TABLE B.2 Macroeconomic Effects of High Oil Price Scenario Relative to Low Oil Price Scenario

Variable	1988	1989	1990	1991	1992	1993	1994	1995
	Change Relative to Low Price Scenario							
Average real GNP (%)	-0.8	-1.7	-2.2	-2.2	-1.8	-1.1	-0.5	-0.2
Inflation index, CPI (%)	1.4	2.2	3.0	3.1	3.0	2.5	2.1	2.0
Inflation index, GNP deflator (%)	0.5	1.0	1.2	1.2	1.0	0.6	0.4	0.2
Industrial production index (%)	-1.6	-3.2	-4.1	-3.9	-2.8	-1.1	0.0	0.6
Real disposable income (%)	-0.7	-1.5	-2.1	-2.1	-2.0	-1.5	-1.0	-0.8
Average real GNP (10^9 1982 $)	-32	-66	-90	-93	-76	-47	-24	-7
Unemployment rate (%)	0.3	0.5	0.7	0.6	0.4	0.2	-0.1	-0.2
Housing starts (10^6 units)	-0.13	-0.23	-0.27	-0.24	-0.19	-0.14	-0.10	-0.08
10-yr Treasury bond rate (%)	0.26	0.32	0.40	0.33	0.26	0.20	0.17	0.17
Merchandise trade balance ($\$10^9$)	0.0	5.6	8.3	10.0	9.8	8.7	9.3	9.2
Federal budget surplus ($\$10^9$)	-13	-30	-44	-47	-40	-28	-18	-11

presents the macroeconomic effects of the high scenario relative to those in the low scenario. Highlights of this comparison are discussed below.

Price Levels. The effects on price levels are shown in terms of the GNP deflator and the consumer price index (CPI). The CPI measures the change in prices of all goods and services purchased by households; higher prices of imported oil directly affect the prices of gasoline and heating oil in the index. The GNP deflator is an index of prices for goods and services produced in the U.S. As such, it does not count the direct impact of higher prices of imported crude oil. Peak effects are estimated to occur in 1991, when the CPI in the high scenario is about 3.1% higher than in the low scenario. In comparison, the GNP deflator is higher by 1.2%. After 1991, the combination of lagged effects and a narrowing of the oil price differential offset each other so that the gap between the two scenarios is reduced to 0.2% by 1995.

Real GNP. Higher energy prices and resulting higher inflation rates are expected to reduce real income and aggregate demand, at least early in the forecast period. This effect will be reduced as the economy has time to assimilate changes in crude oil prices. The real GNP gap (i.e., GNP in the high scenario minus GNP in the low) reaches its widest point at 2.2% in 1991; this is equivalent to $93 billion (1982 dollars). This gap quickly narrows as the economy adjusts to the higher crude oil prices, shrinking to 0.2% in 1995. However, the high scenario incurs a cumulative loss in real GNP of $435 million more than in the low scenario.

Although the GNP effects are small, major differences in the composition of GNP are associated with the two scenarios. Real consumption in the high scenario declines steadily, relative to the lower price case. This loss in consumer expenditure causes reduced imports of various goods and services. However, exports rise because of increased demand from oil-exporting countries. Real investment is adversely affected, at least in early years of the forecast period, by higher interest rates due to higher oil prices. In the later years, investment effects are not clear because an expected increase in energy-sector investment, e.g., for oil drilling rigs and energy-saving appliances, may at least partly offset the investment decline in nonenergy sectors.

Personal Income. Higher energy prices and a higher inflation level are expected to reduce real personal income. Table B.2 shows that rising crude oil prices and the 1988-90 inflation rate causes real disposable income to decline. By 1990, real disposable income in the high scenario is 2.1% lower than in the low scenario. Subsequently, with the narrowing of the oil price and inflation gaps, the real disposable income gap is reduced to 0.8% by 1995.

Interest Rates. Higher inflation generally causes higher nominal interest rates. In our analysis, the interest rate on 10-year Treasury bond yield is reviewed (Table B.2); compared to the low scenario, yield in the high scenario is higher by 0.26% in 1988, 0.32% in 1989, and 0.40% in 1990. With the inflation gap narrowing in subsequent years, this interest rate gap also narrows: by 1995, the rate in the high scenario is only 0.17% higher than in the low scenario.

Housing Starts. Housing starts usually follow interest rate movements, because higher interest rates reduce new-home affordability. As shown in Table B.2, in the environment of rising interest rates in the high scenario, housing starts fall relative to the low scenario. Starts are lower by 130,000 units in 1988, 230,000 in 1989, and 270,000 in 1990. With the interest rate gap narrowing in later years, housing starts recover to a loss of only 80,000 units by 1995.

Unemployment Rate. Unemployment is closely tied to real GNP: the real GNP losses observed in the high-oil price scenario translate into higher unemployment rates (Table B.2). Relative to the low scenario, unemployment in the high scenario is higher by 0.3% in 1988, 0.5% in 1989, and 0.7% in 1990. With the real GNP gap narrowing in subsequent years, the unemployment rate gap between the two scenarios narrows to 0.2% by 1995.

Merchandise Trade Balance. Higher oil prices are expected to result in (1) lower imports and consumption of various goods and services and (2) higher exports. Higher prices for imported crude oil represent a transfer of wealth to foreign countries, which can then buy more goods and services from the United States, increasing U.S. exports. Also, the higher price of imported crude oil and the subsequent higher inflation level reduce household consumption of various goods and services, leading to lower imports. The overall benefits of higher oil prices are positive in terms of trade balance (Table B.2), which improves by $10 billion (nominal dollars) by 1991; that improvement is maintained throughout the forecast period.

Federal Budget Deficit. The higher unemployment rate in the high scenario is expected to result in (1) lower tax revenues to the federal government and (2) higher transfer payments by the federal government. Moreover, the higher interest rates would result in larger interest payments on the federal government debt. These effects are expected to result in a reduced federal budget deficit. Table B.2 shows the differential budget effects in the two scenarios. Compared to that in the low scenario, the federal budget deficit will be higher by $13 billion in 1988, $30 billion in 1989, $44 billion in 1990, and $47 billion in 1991. As the GNP and unemployment rate gaps narrow, the deficit will be higher by only $11 billion in 1995.

B.2 ENERGY SECTOR

Primarily because of energy conservation measures taken after the mid-1970s, total energy consumption (based on total primary consumption of all energy forms) continues to grow relatively slower than the growth in real GNP. For 1983-86, total energy consumption increased at an average annual rate of 1.7%, compared to real GNP growth of 4.2%. This trend is likely to continue, at a slower rate, under the DRI Energy base case (@Eng/ECONTROL0887, described in Data Resources, Inc. 1987). Growth in total energy consumption averages slightly more than 1% annually in 1988-90, compared to a growth of 2.5% in real GNP for the same period. Energy consumption growth slips gradually over the next five years, even when real GNP rates rises slightly. Specifically, consumption grows at an average annual rate of 0.9% in 1990-95, compared to 2.8% for real GNP.

The DRI base case forecast calls for a rebound in the imported crude oil price to $17.59/bbl in 1987 (1985 dollars). Near-term fluctuations are expected because of anticipated OPEC problems in managing the market. In an environment of modest increases in worldwide energy demand, crude oil prices are expected to continue their recovery to $18.34 in 1988, $19.47 in 1989, and $20.37 in 1990. Surpluses gradually diminish, non-OPEC supply growth declines, and world oil demand continues to rise. This makes OPEC's job easier over time. In this environment, oil prices rise in real terms at an average annual rate of about 2% in 1990-95. This leads to a price of $22.32/bbl by 1995. A new energy-sector forecast for each of the two oil price scenarios was obtained by iteratively solving the DRI Energy and Annual macromodels. The forecast for the two scenarios is summarized below.

B.2.1 Low Oil Price Scenario

National energy price projections are summarized in Table B.3. The following subsections discuss the effects of the low oil price scenario on regional price projections for electricity and natural gas, the two principal household fuels and those that exhibit the greatest regional price variations.

TABLE B.3 National Energy Prices in the Low Oil Price Scenario (constant 1985 $)

Variable	1988	1989	1990	1991	1992	1993	1994	1995
Oil ($/bbl)								
Imported crude	14.49	15.00	15.49	16.69	17.90	19.10	20.31	21.51
Crude (refiner acquisition)	14.47	14.92	15.31	16.49	17.71	18.91	20.11	21.30
Residual fuel	14.04	14.41	14.72	15.74	16.82	17.91	19.00	20.11
Distillate fuel	19.17	19.60	19.96	21.27	22.65	24.04	25.42	26.82
Natural Gas ($\$/10^6$ Btu)								
Average residential	4.56	4.57	4.80	5.20	5.67	6.14	6.64	7.02
Average industrial	2.17	2.27	2.33	2.49	2.64	2.81	2.95	2.99
Coal Prices ($\$/10^6$ Btu)								
Average electric utility	1.38	1.33	1.30	1.28	1.27	1.28	1.30	1.33
Electricity (¢/kWh)								
Residential	6.98	6.79	6.60	6.42	6.27	6.11	5.99	5.88

Petroleum Products. Prices of petroleum products are directly affected by changes in crude oil prices. While the prices of petroleum products in the low scenario are expected to fall slowly relative to crude oil as real crude feedstock costs advance faster than real refining costs, the varying rates of increase result in differing product response rates. In the low price scenario, 22% higher imported crude oil prices in 1987-95 result in a 19% higher residual fuel prices, 16% higher distillate fuel prices and jet fuel/kerosene prices, and 13% higher retail gasoline prices.

Natural Gas. More than 50% of natural gas sales are to the price-sensitive industrial and electric utility markets. For gas sales to remain in balance with available domestic and imported supplies, gas prices must respond to prices of the alternative crude oil. In the low scenario, the average price (1985 dollars) of natural gas to industry is $2.43 per million Btu in 1987 and $2.99 in 1995. The average industrial residual fuel price is $2.68 per million Btu in 1987 and $3.20 in 1995, leading to a gas-to-oil price ratio of 0.90:1 in 1987 and 0.93:1 in 1995. Relative stability in these price ratios reflects the competitive nature of oil and natural gas.

The average price to residential customers dipped 5% in 1986. This trend continues in the near term when residential natural gas prices decline by an additional 9% each in 1987 and 1988. With the 1988 turnaround in oil prices, gas prices recover by 1% in 1989 and 5% in 1990. As oil prices strengthen, natural gas also continues to rise in 1990-95 (Table B.3). The average annual increase of about 7% in imported oil prices is accompanied by an 8% annual increase in residential natural gas prices.

Historically, natural gas supply/demand factors have created wide price variations across the United States. Natural gas is the dominant space heating fuel, accounting for the largest end-use share of total residential energy consumption. Its demand is directly affected by local climate; in addition, customers in some parts of the country (particularly the Northeast) have had less access to natural gas. Furthermore, distribution costs vary by region. Most natural gas is produced in energy-rich states such as Louisiana, Oklahoma, and Texas. To further complicate matters, state-to-state differences in natural gas price regulations have also contributed to substantial regional price variations.

The relatively high 1986 price in the Northeast was due primarily to transportation costs from the distant gas fields in the South and Southwest. The ratio of highest to lowest price in the four census regions was about 1.38:1 in 1986. Table B.4 shows regional natural gas price projections in the low price scenario. After the 1988 oil price turnaround, natural gas prices begin to rise. By 1995, nominal prices reach $12.20/million Btu in the Northeast, $9.43/million Btu in the Midwest, $13.49/million Btu in the South, and $9.07/million Btu in the West. The high:low ratio in the four census regions is projected to be 1.49:1 for 1995. This increase in ratio since 1986 indicates that natural gas prices will have even greater regional price variations.

TABLE B.4 Regional Natural Gas and Electricity Prices in the Low Oil Price Scenario (current $\$/10^6$ Btu)

Region	1988	1989	1990	1991	1992	1993	1994	1995
Natural Gas								
U.S.	4.99	5.18	5.66	6.42	7.35	8.38	9.56	10.69
Northeast	6.15	6.34	6.89	7.72	8.71	9.83	11.03	12.20
Midwest	4.73	4.88	5.30	5.96	6.74	7.60	8.54	9.43
South	4.99	5.28	5.98	7.04	8.37	9.83	11.64	13.49
West	4.27	4.45	4.76	5.34	6.15	7.05	8.12	9.07
Electricity								
U.S.	22.37	22.58	22.83	23.22	23.80	24.46	25.29	26.23
Northeast	27.75	27.88	27.90	28.11	28.57	29.05	29.79	30.56
Midwest	23.46	23.44	23.56	23.92	24.45	25.04	25.77	26.54
South	20.48	20.73	21.09	21.62	22.28	23.09	24.03	25.13
West	21.29	21.76	22.18	22.42	23.01	23.57	24.36	25.23

Coal. Coal is used primarily by electric utilities and is only slowly moving into the industrial sector. There is virtually no substantial use in the residential sector. Unlike natural gas prices, coal prices are fairly unresponsive to oil price changes. The only effect is through the impact of oil prices on the general price level. In the low scenario, the average price (1985 dollars) of coal to electric utilities is $1.47 per million Btu in 1987 and $1.33 in 1995. As a result, the coal-to-oil-price ratio falls from 0.49:1 in 1987 to 0.36:1 in 1995; this dramatic change illustrates the insensitivity of coal prices to changes in oil prices.

Electricity. In 1987, electric utility shares were 54% for coal, 18% for nuclear power, 12% for hydropower, 10% for gas, 5% for oil, and 1% for other. As such, electricity prices are not expected to move proportionately with oil or gas prices, and electric utilities are partially buffered from the pressure of higher oil prices. In the low scenario, the inflation-adjusted average annual oil price increase of 2.4% in 1985-95 contrasts with a 2.3% decline in electricity prices. This is extremely favorable to consumers, especially those with high dependency on electricity for heating and/or cooling.

Historically, electricity prices have differed substantially across regions. The generally state-regulated electricity prices vary to reflect cost of generation and the allowable rate of return on investment. Fuel mix, which varies substantially across regions, is a key factor in the cost of electricity. Capital and operating costs vary by type of generating plant. Moreover, the regulatory climate can vary substantially between regions.

As with natural gas, the highest price in 1986 was in the Northeast, primarily because of local electric utility dependence on oil and gas. Approximately 26% of all electricity in the Northeast in 1986 was produced with expensive oil and gas, in contrast to only 1% in the Midwest. The 1986 ratio of highest to lowest price in the four census regions was 1.42:1. Table B.4 shows projected electricity prices in the low scenario. As discussed above, real electricity prices continue to decline because of such favorable factors as reduced need for new generating plants and modestly declining real coal prices in 1987-95. However, the nominal price of electricity will rise at a modest rate. By 1995, the ratio of highest to lowest price in the four regions is projected to be 1.22:1. This lower ratio indicates a narrowing in the relative difference in regional electricity prices.

B.2.2 High Oil Price Scenario

Petroleum Products. In the high scenario, the price of imported crude oil in 1987-95 is about 56% higher than in the low price scenario. As a result, residual fuel oil increases by 52%, distillate fuel oil by 48%, and retail gasoline by 32%.

Natural Gas. As noted in Sec. B.2.1, natural gas prices are greatly influenced by residual fuel oil prices in the price-sensitive industrial and electric utility end-use markets, which account for more than 50% of all natural gas sales. In the high scenario, the average price (1985 dollars) of natural gas to industry is $2.43 per million Btu in 1987 and $3.26 in 1995 (Table B.5). Average residual fuel oil price is $2.68 per million in 1987 and $4.07 in 1995, leading to a gas-to-oil price ratio of 0.90:1 in 1987 and 0.80:1 in 1995.

The average real price of natural gas to residential customers dipped by 5% in 1986 and an additional 9% in 1987. With the 1987 turnaround in oil prices, gas prices recover by 1% in 1988, 2% in 1989, and 8% in 1990; the trend continues through 1995. The average annual price increase of about 4% for imported oil is linked to a 6% annual price increase for residential natural gas.

As mentioned earlier, natural gas supply/demand factors historically have created wide price variations across the United States. In 1986, natural gas price (in nominal dollars) ranged from $6.93 per million Btu in the Northeast to $5.03 per million Btu in the West. Table B.6 shows prices in the high scenario. Following the 1987 oil price turnaround, natural gas prices began to rise. The nominal price reaches a peak of $14.26 per million Btu in the South. The ratio of highest to lowest price in the four

TABLE B.5 National Energy Prices in the High Oil Price Scenario (constant 1985 $)

Variable	1988	1989	1990	1991	1992	1993	1994	1995
Oil ($/bbl)								
Imported crude	18.51	20.51	22.51	23.51	24.51	25.51	26.51	27.51
Crude (refiner acquisition)	18.49	20.40	22.23	23.19	24.22	25.22	26.21	27.20
Residual fuel	17.94	19.70	21.37	22.14	23.00	23.89	24.77	25.69
Distillate fuel	24.49	26.80	28.98	29.92	30.97	32.06	33.13	34.25
Natural Gas ($\$/10^6$ Btu)								
Average residential	5.00	5.10	5.50	5.87	6.25	6.62	7.02	7.47
Average industrial	2.54	2.67	2.83	2.92	3.02	3.12	3.18	3.26
Coal Prices ($\$/10^6$ Btu)								
Average electric utility	1.39	1.36	1.37	1.37	1.37	1.38	1.40	1.42
Electricity (¢/kWh)								
Residential	7.08	6.94	6.81	6.65	6.50	6.34	6.21	6.10

TABLE B.6 Regional Natural Gas and Electricity Prices in the High Oil Price Scenario (current $\$/10^6$ Btu)

Region	1988	1989	1990	1991	1992	1993	1994	1995
Natural Gas								
U.S.	5.50	5.84	6.57	7.32	8.17	9.09	10.14	11.39
Northeast	6.69	7.06	7.91	8.74	9.65	10.63	11.69	13.00
Midwest	5.19	5.46	6.11	6.75	7.48	8.24	9.07	10.07
South	5.56	6.03	7.03	8.13	9.30	10.61	12.29	14.26
West	4.77	5.09	5.60	6.15	6.89	7.66	8.62	9.68
Electricity								
U.S.	22.81	23.28	23.85	24.34	24.92	25.52	26.29	27.25
Northeast	28.45	28.98	29.41	29.72	30.18	30.55	31.24	32.01
Midwest	23.69	23.89	24.27	24.77	25.32	25.88	26.57	27.35
South	20.96	21.48	22.18	22.80	23.46	24.20	25.08	26.22
West	21.66	22.32	22.98	23.28	23.85	24.34	25.05	25.95

census regions is 1.47:1 for 1995, compared to 1.38:1 in 1986, thereby indicating that natural gas will have even greater regional price variations.

Coal. As noted in Sec. B.2.1, coal prices are fairly unresponsive to changes in oil price. In the high scenario, the average price (1985 dollars) of coal to electric utilities is $1.47 per million Btu in 1987 and $1.42 in 1995, leading to a coal-to-oil price ratio of 0.49:1 in 1987 and 0.30:1 in 1995 (compared to 0.31:1 in the low scenario for 1995). This dramatic ratio change illustrates the insensitivity of coal prices to changes in oil prices.

Electricity. In Sec. B.2.1, it was mentioned that electricity prices were not expected to move proportionately with oil or gas prices. In the high scenario, the inflation-adjusted average annual increase in oil price of 5.9% in 1987-95 is contrasted with an annual decline of 1.7% in electricity price. This is extremely favorable to consumers, especially those with a high dependency on electricity for heating and/or cooling.

Historically, electricity prices have varied substantially across regions, usually because of regional factors such as generating-fuel mix and regulatory climate. In 1986, electricity ranged in price from $27.96 per million Btu in the Northeast to $19.72 per million Btu in the West (in nominal dollars). Real electricity prices continue to decline because of favorable factors such as reduced need for new generating plants and mostly stable real coal prices in 1987-95. As a result, the nominal price of electricity will rise only modestly, reaching $32.01 per million Btu in the Northeast, $27.35 in the Midwest, $26.22 in the South, and $25.95 in the West. The 1995 ratio of highest to lowest price in the four census regions is 1.23:1 (compared to 1.22:1 in the low scenario). This again is lower than the 1986 ratio of 1.42:1, indicating that regional electricity prices will narrow.

APPENDIX C:

COMPARATIVE EFFECTS ON ECONOMIC WELL-BEING

This appendix explains how changing energy prices without compensation affect the economic well-being of the three population groups. To do this, household utility is held constant at some arbitrary level, and changes in economic well-being are consequently measured in terms of the dollar value required to maintain that level of utility.

The expenditure function associated with the linear expenditure system is

$$c_e(U_0, p_{et}) = (p_{elt}\phi_{el})\tau_{el} + p_{nelt}\tau_{nel} + u_0(p_{elt}\phi_{el})^{\beta_{el}} (p_{nelt})^{(1-\beta_{el})} \qquad (C.1)$$

where:

c_e = residential energy expenditures required to maintain a given level of utility,

U_0 = level of utility in base period,

p_{et} = vector of energy prices in period t,

p_{elt} = price of electricity in period t,

ϕ_{el} = index measuring the influence of climatic and demographic factors on energy demand,

τ_{el} = "nondiscretionary" demand for electricity,

p_{nelt} = price of nonelectric energy in period t,

τ_{nel} = "nondiscretionary" demand for nonelectric energy, and

β_{el} = marginal expenditure share on electricity.

The ratio of the expenditure value in period t and the base period is a measure of the change in energy cost. The value is a relative indication of how changing energy prices affect the standard of living (Muellbauer 1975). In Tables C.1-C.5, these indices are reported for each population group by region.

TABLE C.1 Energy Cost Index, U.S.

Population Group, Scenario	Energy Cost Index			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	1.00	1.25	1.70	5.7	6.3
Low	1.00	1.14	1.62	3.3	7.3
Black					
High	1.00	1.26	1.80	5.9	7.4
Low	1.00	1.14	1.71	3.3	8.4
Hispanic					
High	1.00	1.24	1.72	5.5	6.8
Low	1.00	1.13	1.63	3.1	7.6

TABLE C.2 Energy Cost Index, Northeast

Population Group, Scenario	Energy Cost Index			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	1.00	1.23	1.65	5.3	6.1
Low	1.00	1.09	1.53	2.2	7.0
Black					
High	1.00	1.26	1.76	5.9	6.9
Low	1.00	1.10	1.62	2.4	8.0
Hispanic					
High	1.00	1.23	1.70	5.3	6.7
Low	1.00	1.06	1.56	1.5	8.0

TABLE C.3 Energy Cost Index, Midwest

Population Group, Scenario	Energy Cost Index			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	1.00	1.17	1.58	4.0	6.2
Low	1.00	1.08	1.51	1.9	6.9
Black					
High	1.00	1.19	1.68	4.4	7.1
Low	1.00	1.07	1.59	1.7	8.2
Hispanic					
High	1.00	1.18	1.65	4.2	6.9
Low	1.00	1.06	1.56	1.4	8.0

TABLE C.4 Energy Cost Index, South

Population Group, Scenario	Energy Cost Index			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	1.00	1.31	1.89	7.0	7.6
Low	1.00	1.22	1.81	5.1	8.2
Black					
High	1.00	1.31	2.01	7.0	8.9
Low	1.00	1.20	1.93	4.7	10.0
Hispanic					
High	1.00	1.30	1.87	6.8	7.5
Low	1.00	1.21	1.80	4.9	8.3

TABLE C.5 Energy Cost Index, West

Population Group, Scenario	Energy Cost Index			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	1.00	1.26	1.71	5.9	6.3
Low	1.00	1.18	1.65	4.2	6.9
Black					
High	1.00	1.25	1.79	5.7	7.4
Low	1.00	1.15	1.72	3.6	8.4
Hispanic					
High	1.00	1.25	1.70	5.7	6.3
Low	1.00	1.15	1.64	3.6	7.4

The most salient feature is the relatively rapid increase in energy cost for black households in each region over the forecast period. Nationally, the relative change in energy cost is projected to be approximately the same for Hispanic and majority households. Regionally, however, the relative movement in energy costs between Hispanics and majority households is mixed. In the Northeast and Midwest, relative energy cost is projected to increase slightly faster for Hispanics. On the other hand, in the South and West, energy cost is projected to increase somewhat faster for majority households.

The underlying reason for these variations is the relative difference in dependence on nonelectric energy. Prevailing housing patterns, income levels, and regional distribution contribute to existing patterns of energy use. Both nationally and regionally, black households consume relatively more nonelectric energy. At the national level in 1982, approximately 17% of all majority households used electricity for space heating and 30% had electric central air conditioning. For Hispanics, the values were 17% and 20%; for blacks, 9% and 17% (U.S. Dept. of Energy 1985).

Regionally, the relative change in energy cost is dependent on the underlying energy price forecast. Prices of both electric and nonelectric energy are projected to grow much faster in the South than elsewhere; consequently, the overall change in energy cost is projected to be higher there. Black households, in particular, will be affected severely by the projected rise in energy.

To this point, our analysis of the impact of changing energy prices on economic well-being has dealt primarily with the rate of change in the value of economic well-being, i.e., the energy cost index. In the following sections, the impact of changing energy prices on changes in economic well-being is assessed. Comparisons are made between regions and between population groups.

Figures C.1 and C.2 show the change in economic well-being in 1986-95 for each population group, by region. The values in these figures are estimated net increases in energy expenditures due to increase in income. Intuitively, the values in the figures measure the effect of changing energy prices on real income. From a slightly different viewpoint, they measure the additional energy expenditure that a household must make to maintain the same standard of living, after taking into account the change in energy expenditure due to an increase in household income.

Figures C.3 and C.4 show the percentage of 1986 household income accounted for by the change in economic well-being. These values are intended to show the relative deterioration in the standard of living due to changing energy prices over the forecast period.

C.1 REGIONAL IMPACTS

In both scenarios, the effect of changing energy prices on the standard of living in each population group is greatest in the South (Figs. C.1 and C.2). The relative deterioration in standard of living due to changing energy prices is also most severe in the South for each population group in both scenarios (Figs. C.3 and C.4).

For each population group, the relatively largest decrease in standard of living between the two price scenarios is projected to occur in the Northeast. This strongly indicates that the standard of living in the Northeast is relatively more sensitive to changing crude oil prices; the percentage values in Figs. C.3 and C.4 tend to bear this out. The percentage differences for the two price cases in the Northeast range from 0.4 percentage points for majority households to 0.5 percentage points for black and Hispanics, whereas the differences in the other three regions are no more than 0.3 percentage points.

C.2 POPULATION GROUP COMPARISONS

As mentioned in the previous section, households in the South are affected the most by changing energy prices. Majority households are affected most severely, in absolute dollar terms. A particular geographic pattern in the change in economic well-being emerges in a comparison of black and majority households. In the colder areas of the country -- the Northeast and Midwest -- the dollar change in the standard of living is greatest for black households. However, in the warmer areas of the country -- the South and West -- it is larger for majority households. This is explained partially by the extent to which the two groups are projected to substitute between electricity and nonelectric energy. In the colder areas, there is more switching by majority households from the relatively more expensive nonelectric energy to the relatively less expensive electricity.

For Hispanics, the dollar value impact of changing energy prices on the standard of living is projected to be smaller than for majority households in every case. However, once again a particular pattern is seen in the relative impact of changing energy prices on economic well-being of the two groups. The difference in the dollar value of the change in the standard of living is greater for majority households in the South and West regions and smaller in the Northeast and Midwest.

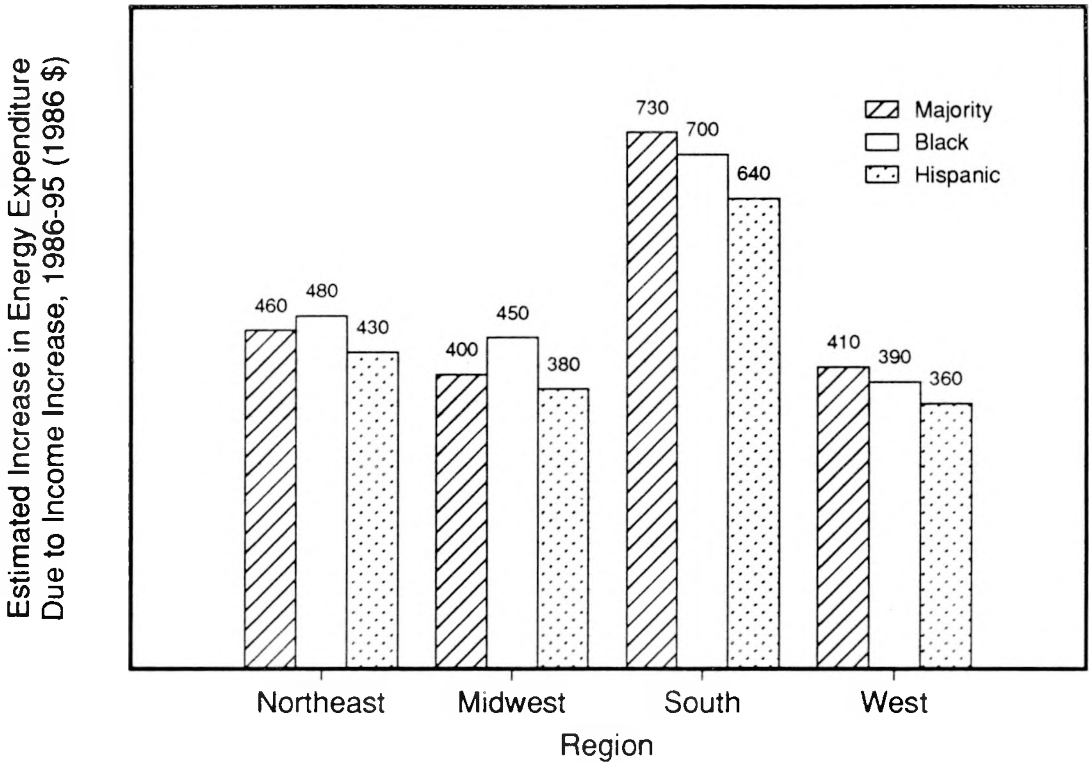

FIGURE C.1 Change in Economic Well-Being, Low Scenario

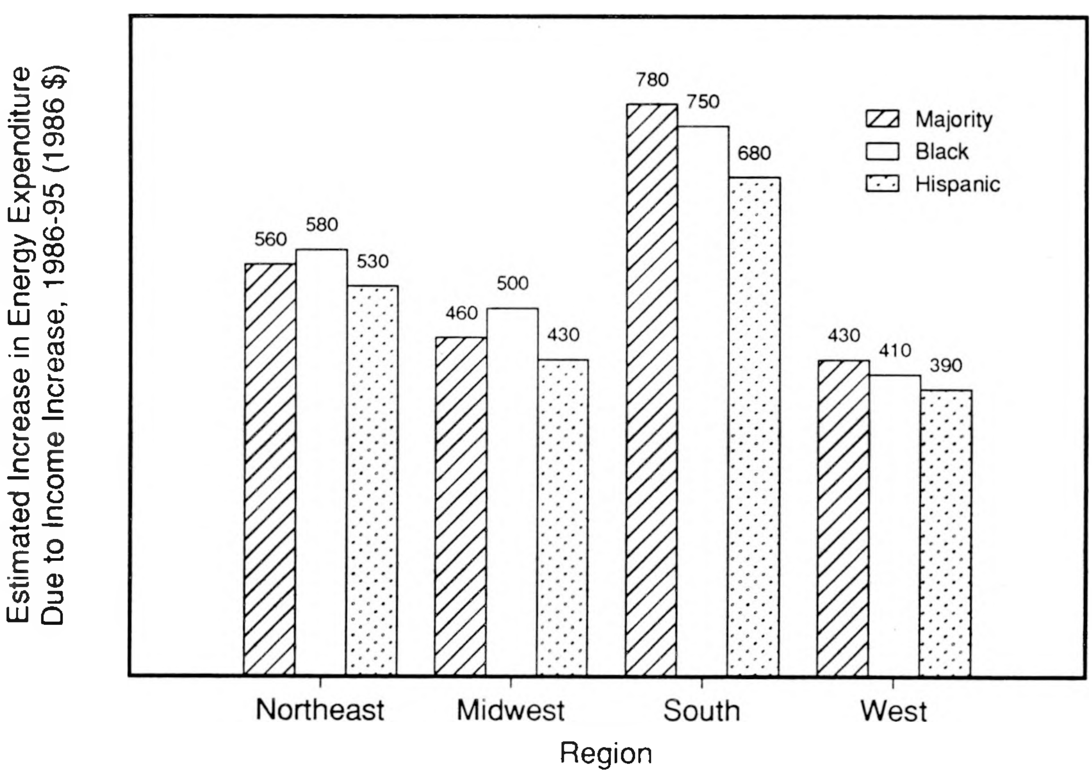

FIGURE C.2 Change in Economic Well-Being, High Scenario

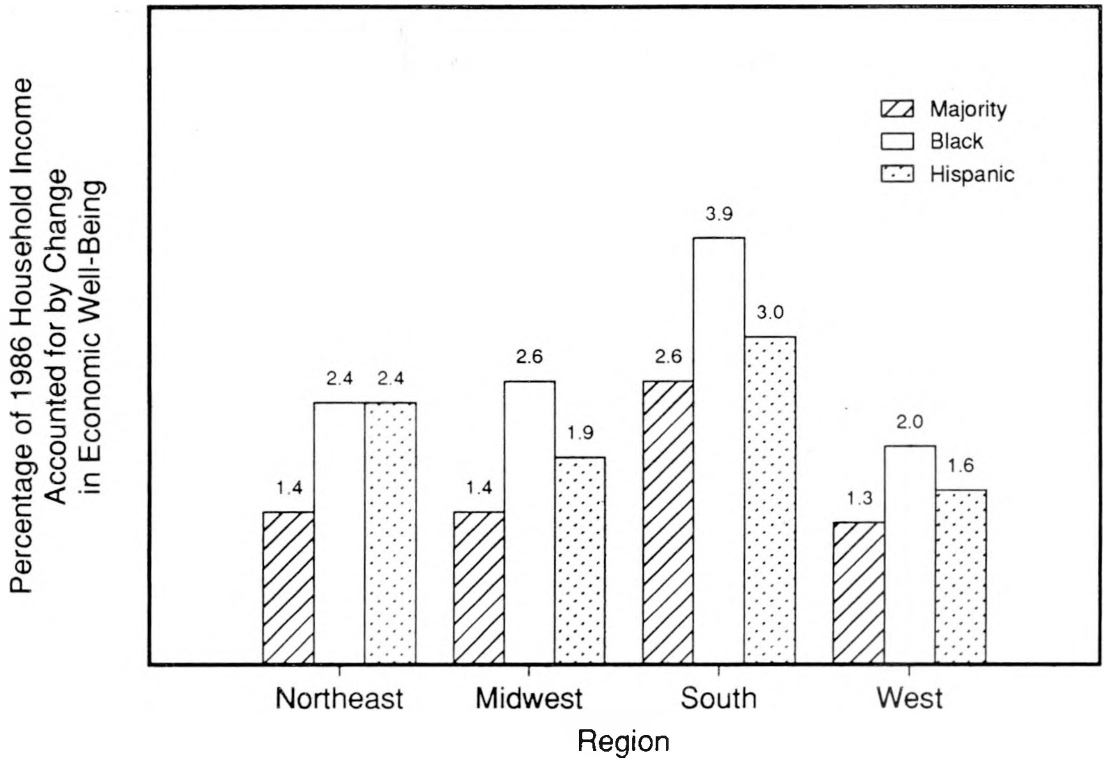

FIGURE C.3 Change in Economic Well-Being as a Percentage of 1986 Household Income, Low Scenario

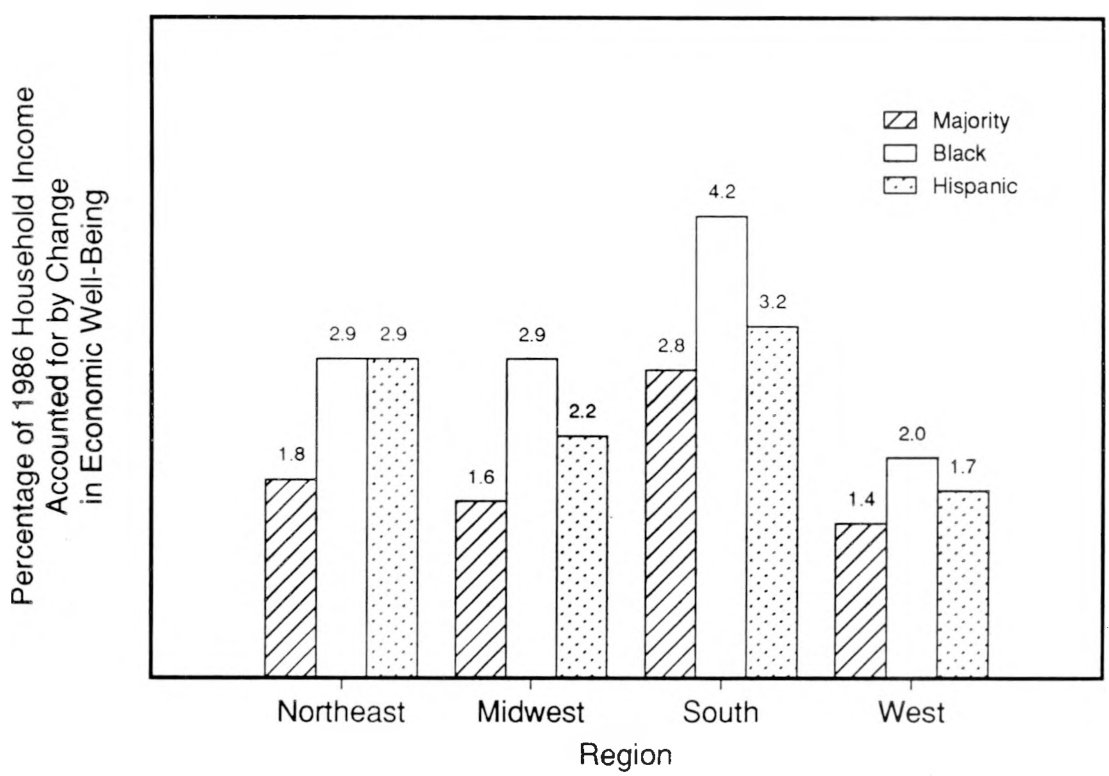

FIGURE C.4 Change in Economic Well-Being as a Percentage of 1986 Household Income, High Scenario

As a percentage of 1986 income, the projected change in the standard of living as a result of changing energy prices, for both black and Hispanic households, is higher than it is for majority households within regions and between the two scenarios. Once again, the relative size of the percentage point differences is influenced by regional location. The greatest percentage point differences between minority and majority households are in the Northeast and Midwest. The largest difference arises in the Midwest for black and majority households and in the Northeast for Hispanic and majority households.

APPENDIX D:

INCOME PROJECTIONS

The rate of change in combined family income is assumed to be the same for each population group (for the definition of family income, see U.S. Dept. of Energy 1984, p. 214). Rates were derived from projections made by Data Resources, Inc., of personal income and new homes. These projections were driven by the crude oil price projections reported in the DOE energy security report under the lower and higher price cases (U.S. Dept. of Energy 1987).

Income escalation rates were applied to the estimated family incomes for 1982. For black and majority households, these values were derived from the 1982-83 Residential Energy Consumption Survey (U.S. Dept. of Energy 1985) and for Hispanics from the 1981 and 1983 Annual Housing Survey (U.S. Dept. of Commerce 1983, 1984).

The only significant variation in these data is that among regions (Tables D.1-D.5). Little variation is seen in income change between the low and high price scenarios; income is projected to increase at a slightly faster rate in the high scenario. Regionally, income increases somewhat more in the Northeast and West, especially in the latter half of the forecast period. Rate of increase will be higher than that in consumer prices and the weighted price of energy, in both price scenarios. As result, households will be generally better off at the end of the forecast period.

TABLE D.1 Projected Income per Household, U.S.

Population Group, Scenario	Projected Income ($/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	29,600	36,000	49,400	5.0	6.5
Low	29,600	35,700	48,500	5.0	6.5
Black					
High	18,400	22,400	30,700	5.0	6.5
Low	18,400	22,200	30,200	5.0	6.5
Hispanic					
High	21,200	25,700	35,300	5.0	6.5
Low	21,200	25,500	34,500	5.0	6.5

TABLE D.2 Projected Income per Household, Northeast

Population Group, Scenario	Projected Income ($/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	32,100	40,500	56,000	6.0	6.7
Low	32,100	40,300	55,100	5.9	6.5
Black					
High	20,200	25,400	35,100	5.9	6.7
Low	20,200	25,300	34,600	5.8	6.5
Hispanic					
High	17,700	22,300	30,800	5.9	6.7
Low	17,700	22,200	30,400	5.8	6.5

TABLE D.3 Projected Income per Household, Midwest

Population Group, Scenario	Projected Income ($/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	28,800	34,100	46,700	4.3	6.5
Low	28,800	33,900	46,000	4.2	6.3
Black					
High	16,800	19,900	27,200	4.3	6.4
Low	16,800	19,700	26,800	4.1	6.3
Hispanic					
High	19,900	23,500	32,200	4.2	6.5
Low	19,900	23,400	31,700	4.1	6.3

TABLE D.4 Projected Income per Household, South

Population Group, Scenario	Projected Income ($/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	27,600	32,500	44,300	4.2	6.4
Low	27,600	32,200	43,400	3.9	6.2
Black					
High	17,700	20,900	28,500	4.2	6.4
Low	17,700	20,700	27,900	4.0	6.2
Hispanic					
High	21,100	24,900	33,900	4.2	6.4
Kiw	21,100	24,700	33,200	4.0	6.1

TABLE D.5 Projected Income per Household, West

Population Group, Scenario	Projected Income ($/household)			Annual Rate of Change (%)	
	1986	1990	1995	1986-90	1990-95
Majority					
High	31,200	39,300	54,600	5.9	6.8
Low	31,200	38,900	53,500	5.7	6.6
Black					
High	20,000	25,100	34,900	5.8	6.8
Low	20,000	24,900	34,200	5.6	6.6
Hispanic					
High	23,000	28,900	40,200	5.9	6.8
Low	23,000	28,700	39,400	5.7	6.5

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