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Residential Demand for Electricity and Distillate Fuel Oil

Colleen G. Rizy
David P. Vogt

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RESIDENTIAL DEMAND FOR ELECTRICITY AND DISTILLATE FUEL OIL

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ABSTRACT

This report documents the development of a forecasting model of the demand for electricity and distillate fuel oil in the residential sector. The model, developed by Oak Ridge National Laboratory (ORNL), is designed to address two needs of the Department of Energy (DOE) Office of Environmental Analyses (OEA): (1) the need for a general framework to conduct analyses of historical trends of energy consumption patterns; and (2) the need for a base for projecting alternative assumptions of national and regional energy consumption and fuel prices.

The model is data driven, using fuel consumption data from the Energy Information Administration (EIA) State Energy Data System (SEDS), price data from EIA's State Energy Price System (STEPS) data base and economic and demographic variables, such as population and income, from a previously existing ORNL data base of residential sector-specific variables. The framework uses the data management and statistical analyses capabilities of the Statistical Analysis System (SAS) to perform the data preparation, regression analyses and forecasting. The general framework, in addition to the use of SAS, provides the user with great flexibility in terms of employing alternative forecasting scenarios or extending the model to other sectors (i.e., commercial or industrial).

1. INTRODUCTION

The objectives of this project are: (1) to provide the Department of Energy (DOE) Office of Environmental Analyses (OEA) with a general framework to conduct analyses of historical trends of energy consumption patterns, and (2) to provide econometrically estimated regional energy consumption equations for selected sectors and fuels. It is neither our intent nor our purpose to propose a definitive model in this paper. Rather, our goal is to provide a methodology that is a first step in building a tool amenable to exploring the large number of alternative structures and policy issues in which an analyst may be interested.

Accomplishing the first subtask will enable OEA to efficiently conduct descriptive analyses on past energy consumption patterns, while accomplishing the second subtask will provide a base for projecting alternative assumptions of national and regional energy consumption and fuel prices. The Energy Information Administration's (EIA) State Energy Data System (SEDS) and the State Energy Price System (STEPS) data bases and the Statistical Analysis System (SAS) package are used to accomplish these two goals.[1]

The period of interest in this study is those years covered by the SEDS and STEPS data bases: 1970 through 1981. This is a time that has seen rapid growth in the real prices of electricity and other fuels (i.e., oil, natural gas, coal, etc.), reversing the previous historical trend of decreasing real prices of energy. As a result of this new trend in fuel prices, electricity is the only energy source that has enjoyed consistently positive per capita growth across the country.

The residential sector was chosen as the focus of this study because of an extensive residential data base of economic and demographic variables that already exists at Oak Ridge National Laboratory (ORNL). Electricity and distillate fuel were chosen as the subject fuels for the following reasons: (1) electricity has been modeled extensively and does not have the problems inherent with natural gas (i.e., curtailment, availability, etc.) and (2) distillate fuel consumption is greater than consumption of any other residential fuel, with the exception of natural gas.

This study encompasses the 48 contiguous states. The states are grouped into the ten Federal regions whose definitions are found in Appendix A.

Section 2 of this report presents an historical perspective of energy consumption patterns during the 1970-1981 period. In Section 3, the theoretical framework for the econometric models is presented. The regression results are found in Section 4, followed by the forecasting results in Section 5. Finally, Section 6 contains some concluding remarks.

2. HISTORICAL TRENDS

Over the 1970 to 1981 period, total fuel consumption declined in every region. The greatest annual decrease was over 2.7% in New England, with the smallest decrease of 1.2% in the Mid Atlantic. Of the six fuels in the residential sector, electricity (ES) is the only one for which every region has a positive growth rate in per capita consumption for the 1970-81 period. The greatest rate of growth occurs in the North Central region--over 4.0% annually. Per capita consumption of distillate fuel (DF) declined in every region, with the greatest decline in the West (14.2% annually). Only in the Northwest did per capita consumption of kerosene (KS) increase over the period. Per capita use of liquified petroleum gas (LG) fell in every region, with a decline of over 11% annually in the Southwest. Per capita consumption of natural gas (NG) increased only in New England, with all other regions declining--the most significant reduction occurring in the Northwest (3.65% annually). The regional pattern of growth in coal (SC) consumption varied the most of all fuels. The New England, Southwest, and Central regions all experienced growth in per capita coal use; whereas, the remaining regions showed an annual decline varying from over 5% in the Mid Atlantic to over 24% in the West.

Table 2.1 shows the compounded annual growth rates (1970-1981) of per capita consumption of the six residential fuels, by fuel and region, as well as per capita consumption of total energy by region. Appendix A is a listing of fuel and FIPS code definitions. Appendix B contains the per capita fuel consumption information at the state level.

Table 2.1. Compounded annual growth rate (1970-1981) in per capita fuel consumption by region and fuel[a]

Region	DF	ES	KS	LG	NG	SC	TOTAL
1	-5.14	2.42	-13.88	-1.90	0.80	4.88	-2.80
2	-4.04	2.13	-11.14	-0.20	0.01	-6.42	-1.56
3	-3.33	3.54	-8.97	-0.89	-1.02	-5.63	-1.22
4	-5.14	2.60	-13.96	-6.12	-2.63	-7.16	-1.63
5	-6.71	2.46	-13.20	-6.32	-0.60	-12.56	-1.42
6	-5.99	3.34	-2.08	-11.25	-3.39	4.70	-2.09
7	-0.40	3.55	-8.59	-7.64	-2.60	1.17	-1.95
8	-3.25	4.35	-11.69	-7.29	-3.19	-0.30	-2.21
9	-14.21	2.07	-8.93	-4.18	-3.13	-25.32	-2.05
10	-7.57	2.76	9.51	-7.20	-3.65	-3.48	-1.24

[a] Region definitions are: 1=New England; 2=New York/New Jersey; 3=Mid Atlantic; 4=South Atlantic; 5=Midwest; 6=Southwest; 7=Central; 8=North Central; 9=West (excluding Hawaii); and 10=Northwest (excluding Alaska).

The fuel definitions, which are also found in Appendix A, are: DF=distillate fuel; ES=electricity; KS=kerosene; LG=liquified petroleum gas; NG=natural gas; SC=coal; and TOTAL=all fuels combined.

Figures 2.1-2.10 are regional time trend plots of the consumption of electricity (ES) and distillate fuel (DF) in the residential sector for the 1970-81 period. In the New England and New York/New Jersey regions, the consumption of distillate fuel exceeds that of electricity throughout the period; the same consumption trend exists in the Mid Atlantic prior to 1981. As can be seen in Figure 2.1, the consumption of DF in New England, where distillate is used extensively for heating, is as much as six times greater than that of ES in some years. Similarly, Figures 2.2 and 2.3 show DF consumption to be as much as three times greater than ES in the New York/New Jersey and the Mid Atlantic regions, where, again, oil (and natural gas) is used widely for heating. The Midwest region shows a somewhat erratic pattern of DF consumption. There are peaks in 1972 and 1978, a trough in 1975 and a drastic decline from 1979 through 1981. Furthermore, although consumption of DF in the Midwest is greater than that of ES from 1970 to 1978, the drastic decline in DF after 1978 causes ES consumption to far surpass it in 1979 through 1981.

The South Atlantic, Southwest, Central, North Central, West, and Northwest regions all have greater consumption of ES than of DF throughout the period. This pattern can be explained by regional air conditioning needs, the fact that natural gas is widely used in several of these regions, and the inexpensiveness of electricity in the Northwest. Another noteworthy observation is that for almost every region, DF consumption declines significantly after 1978 (a possible explanation being the skyrocketing oil prices that followed the Iranian crisis of 1979). However, electricity consumption rises throughout the entire

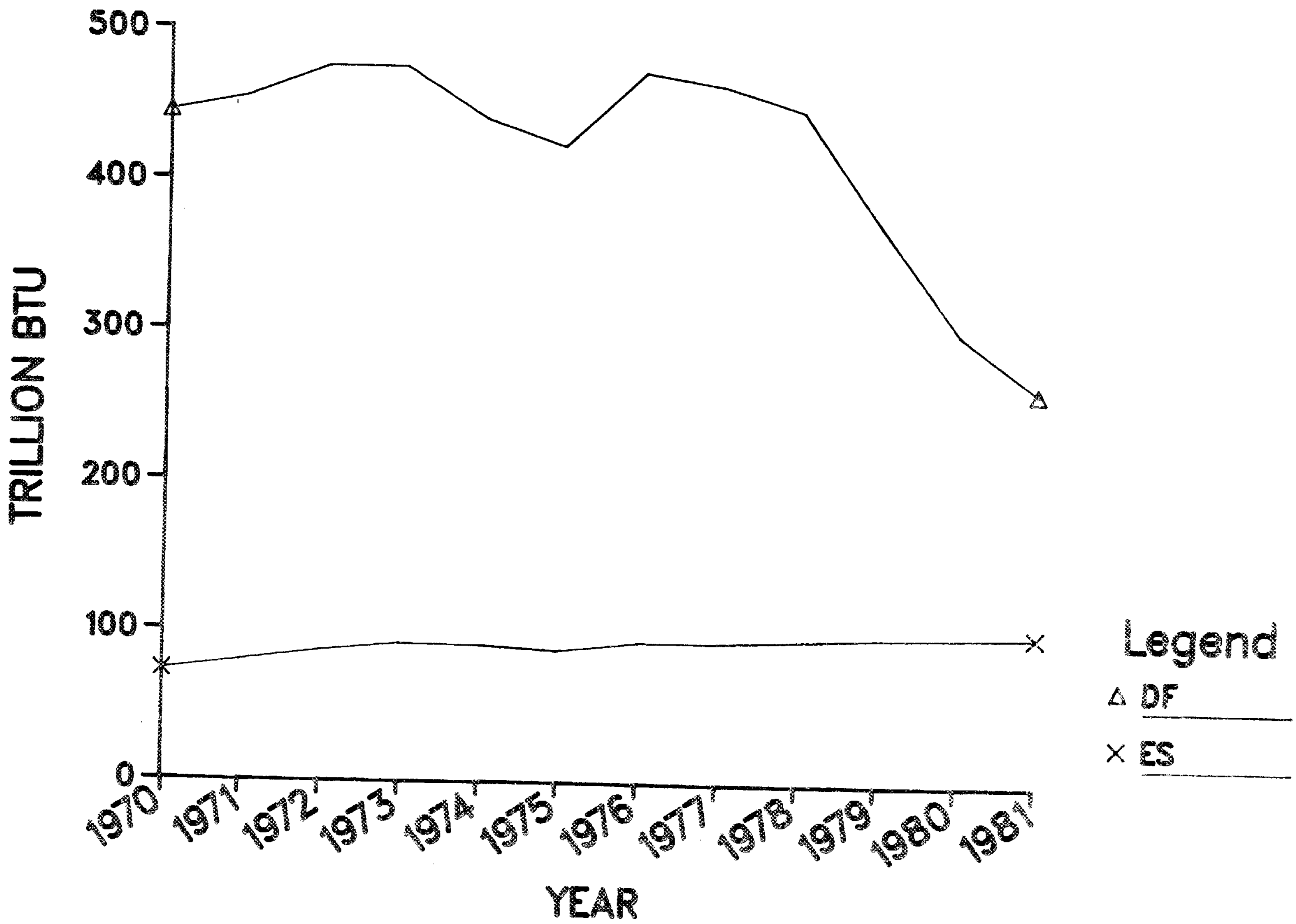

Fig. 2.1. Time trend plot of electricity and distillate fuel consumption for the New England region

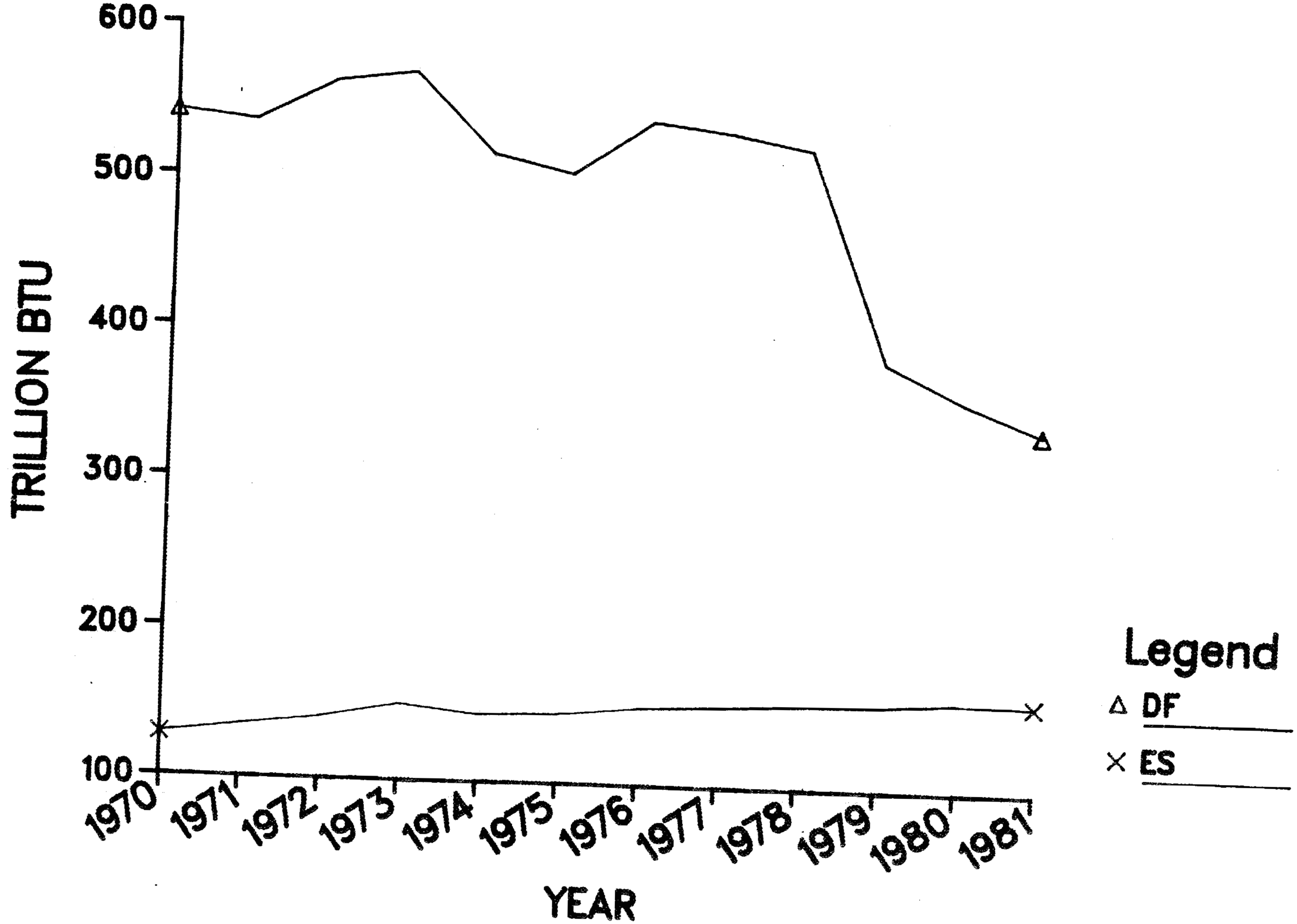

Fig. 2.2. Time trend plot of electricity and distillate fuel consumption for New York/New Jersey

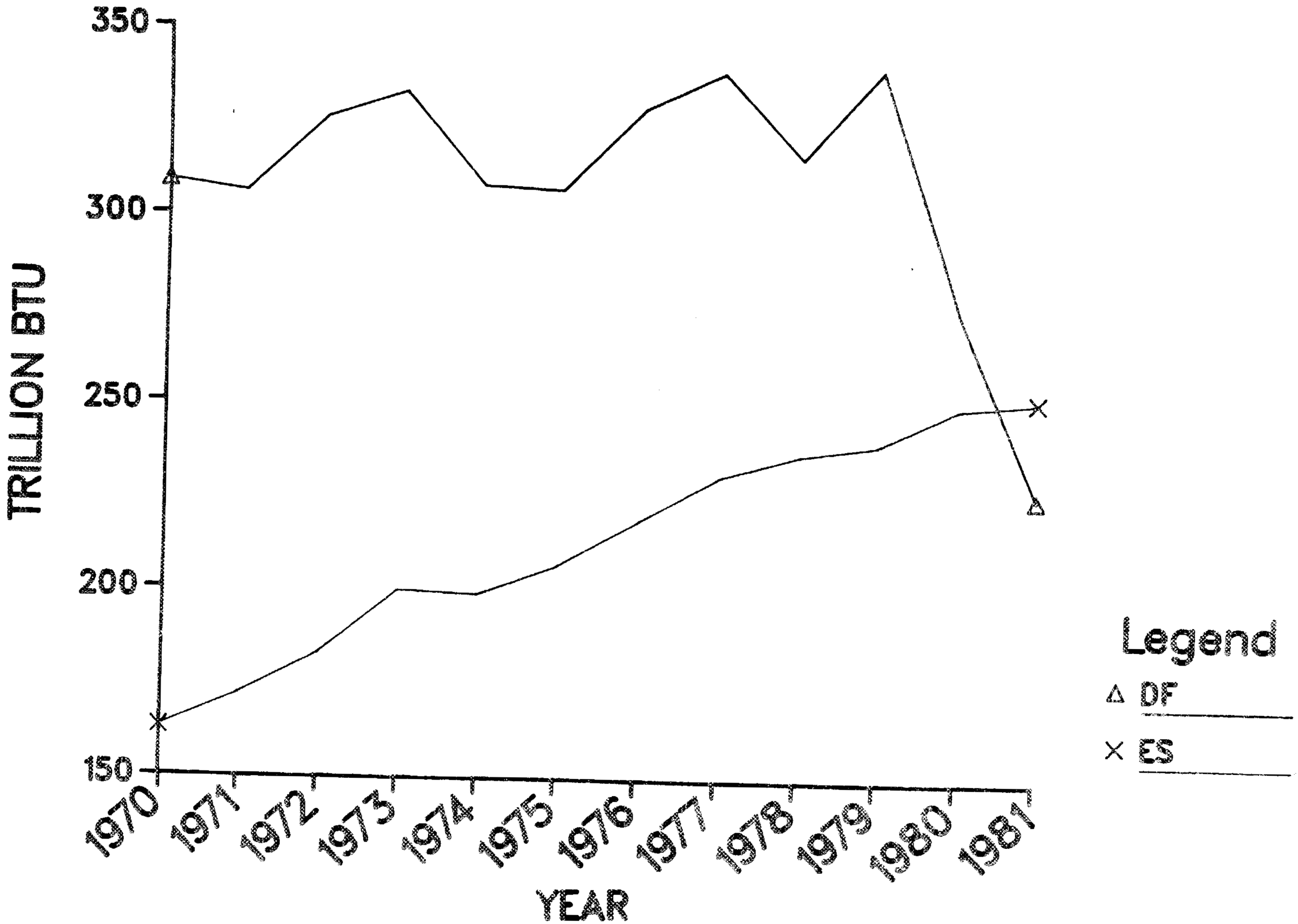

Fig. 2.3. Time trend plot of electricity and distillate fuel consumption for the Mid Atlantic region

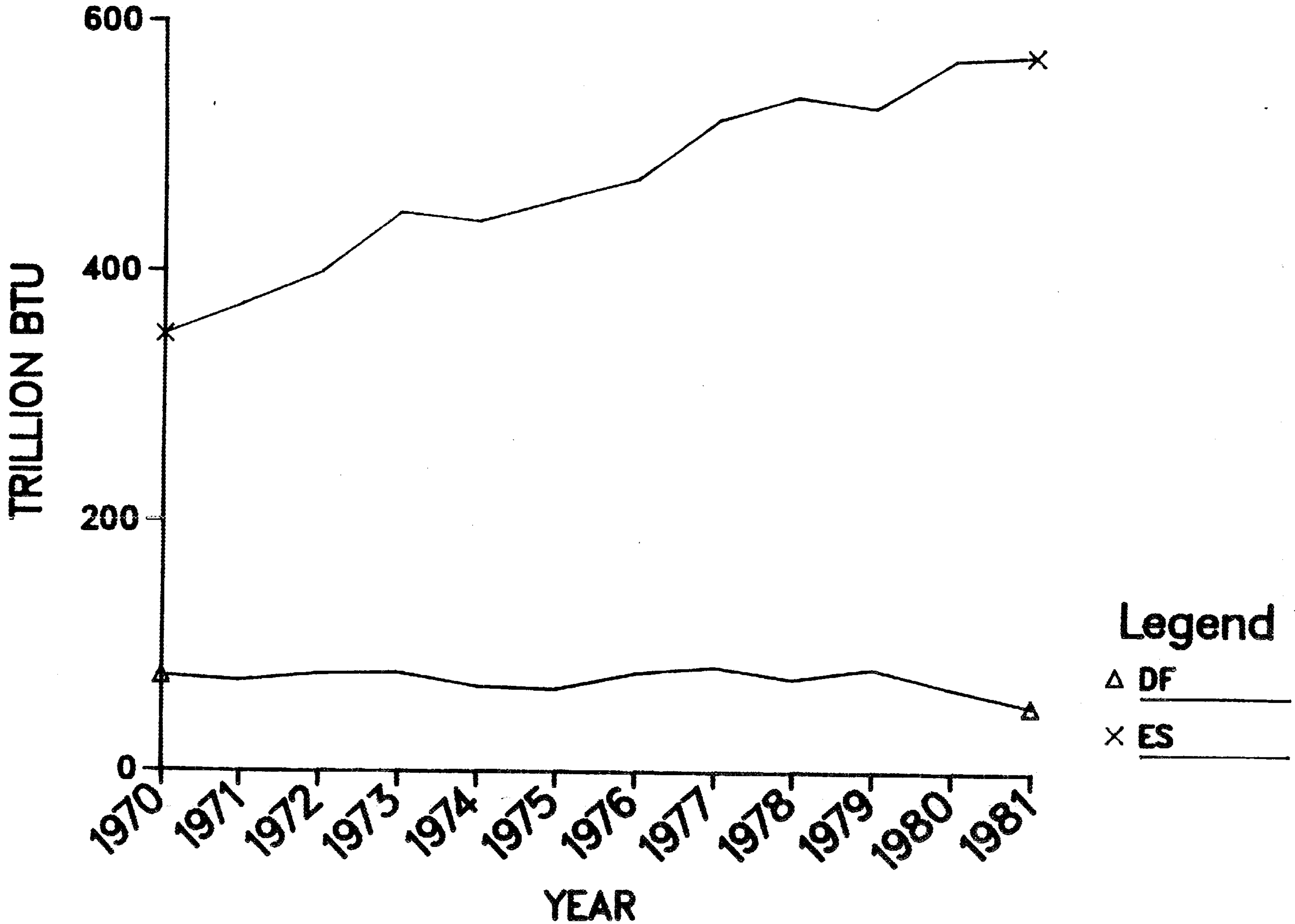

Fig. 2.4. Time trend plot of electricity and distillate fuel consumption for the South Atlantic region

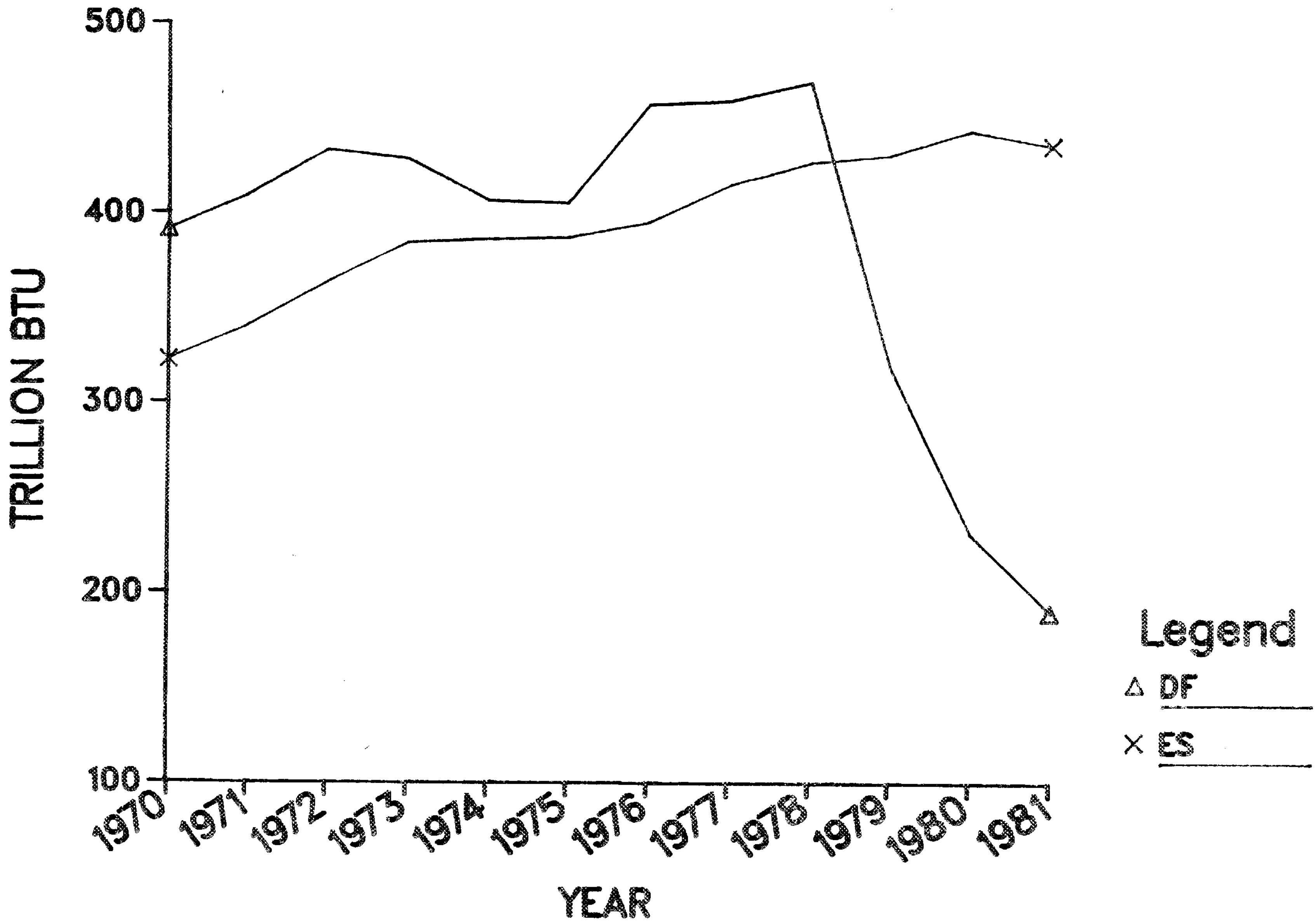

Fig. 2.5. Time trend plot of electricity and distillate fuel consumption for the Midwest region

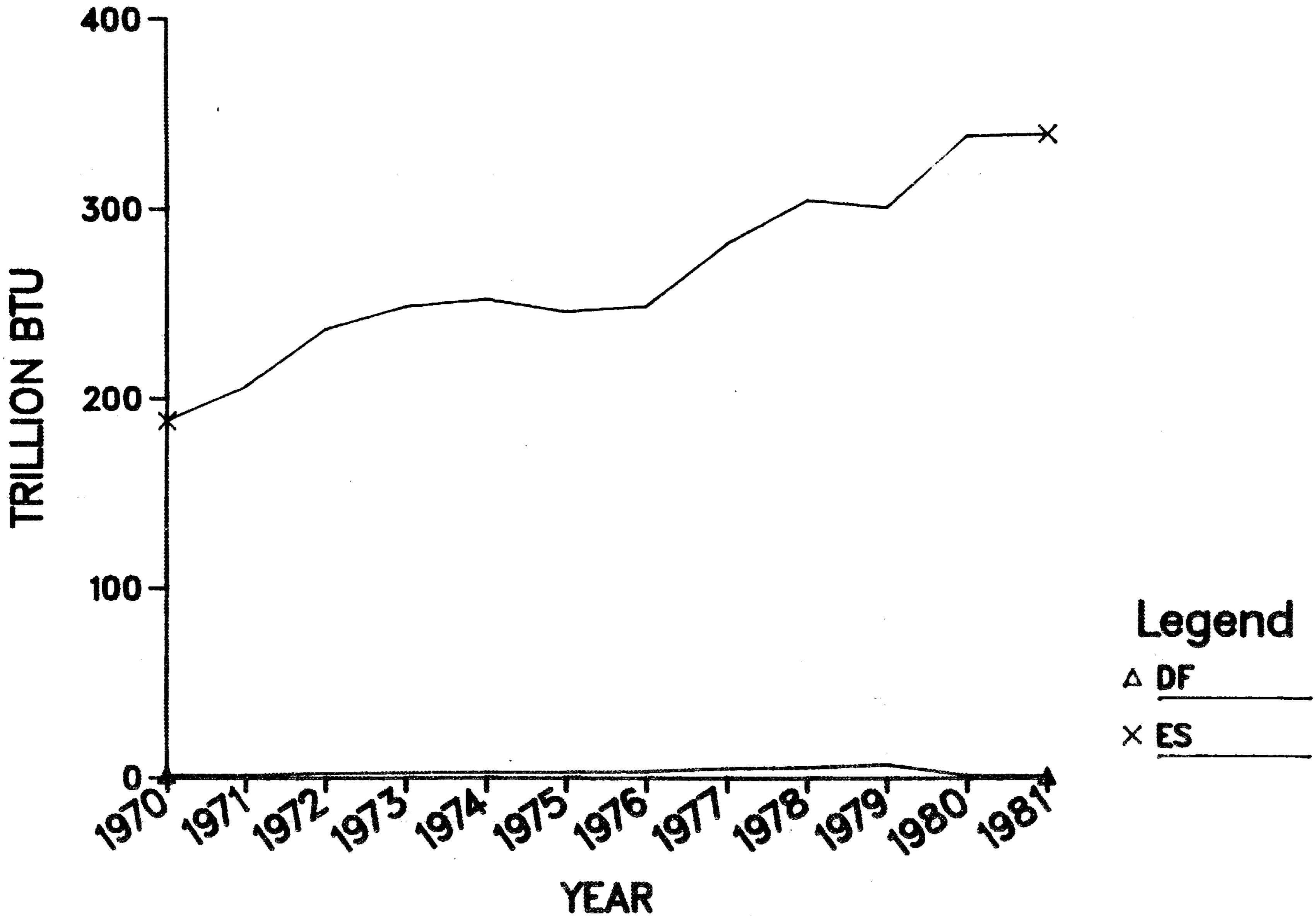

Fig. 2.6. Time trend plot of electricity and distillate fuel consumption for the Southwest region

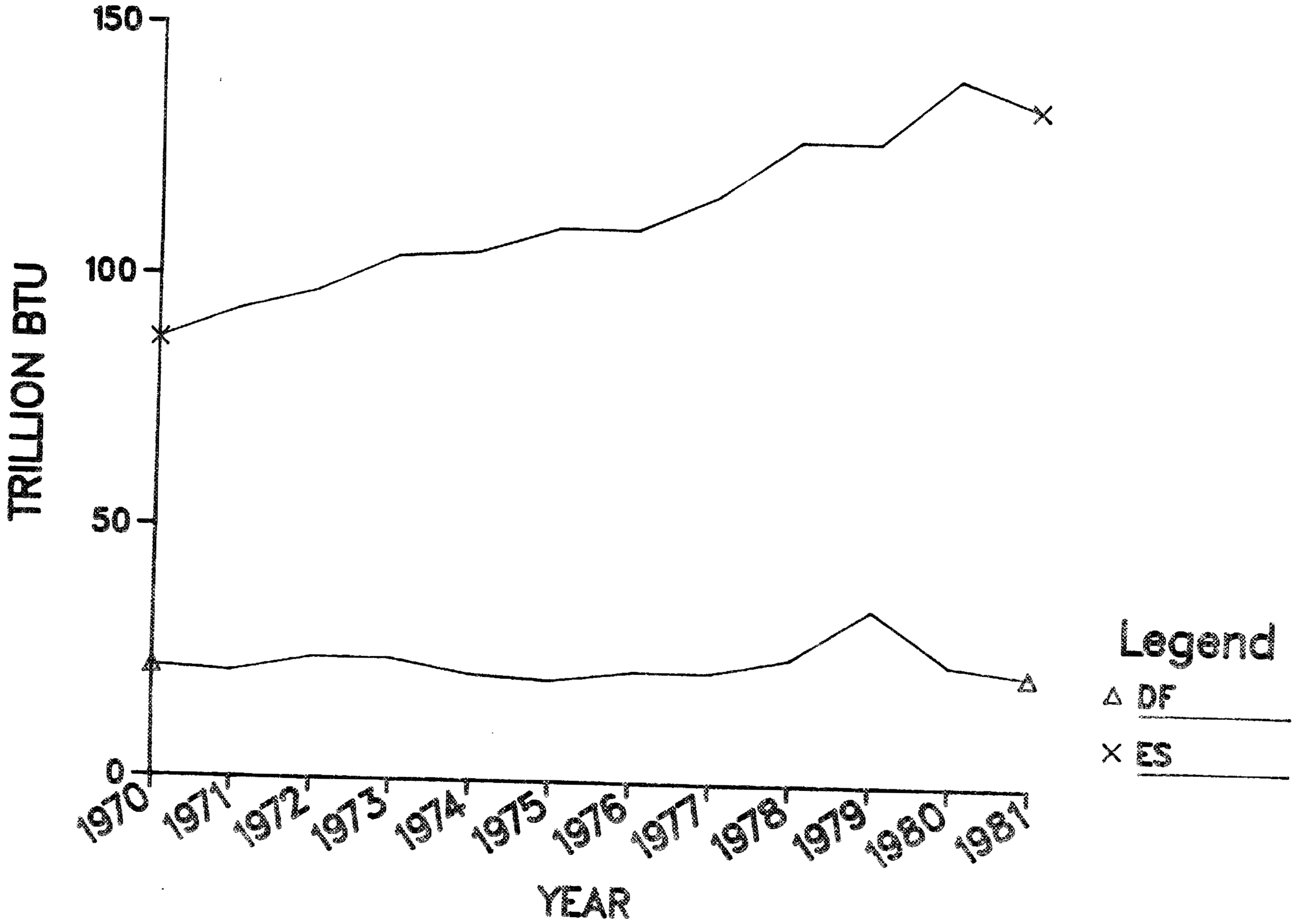

Fig. 2.7. Time trend plot of electricity and distillate fuel consumption for the Central region

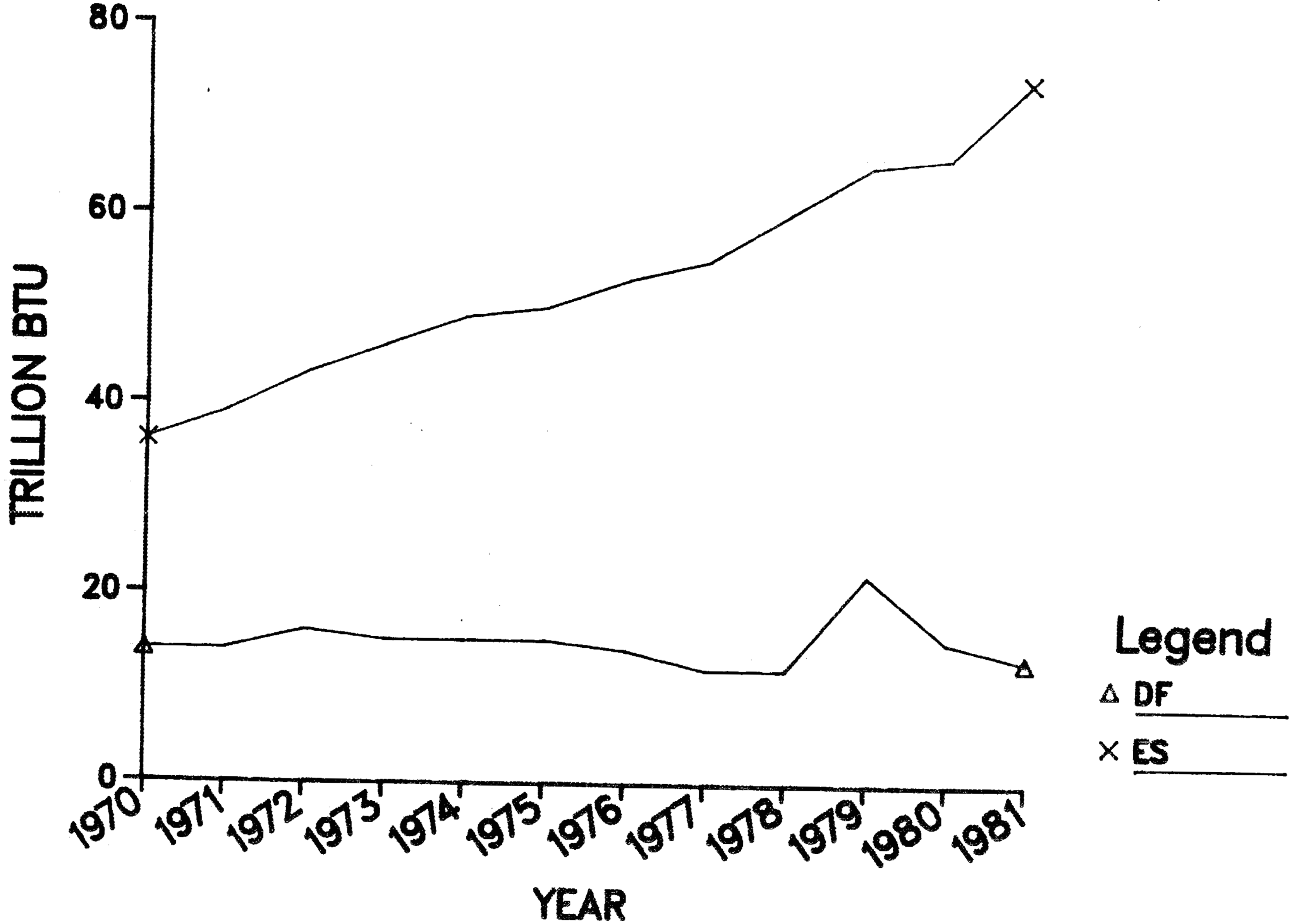

Fig. 2.8. Time trend plot of electricity and distillate fuel consumption for the North Central region

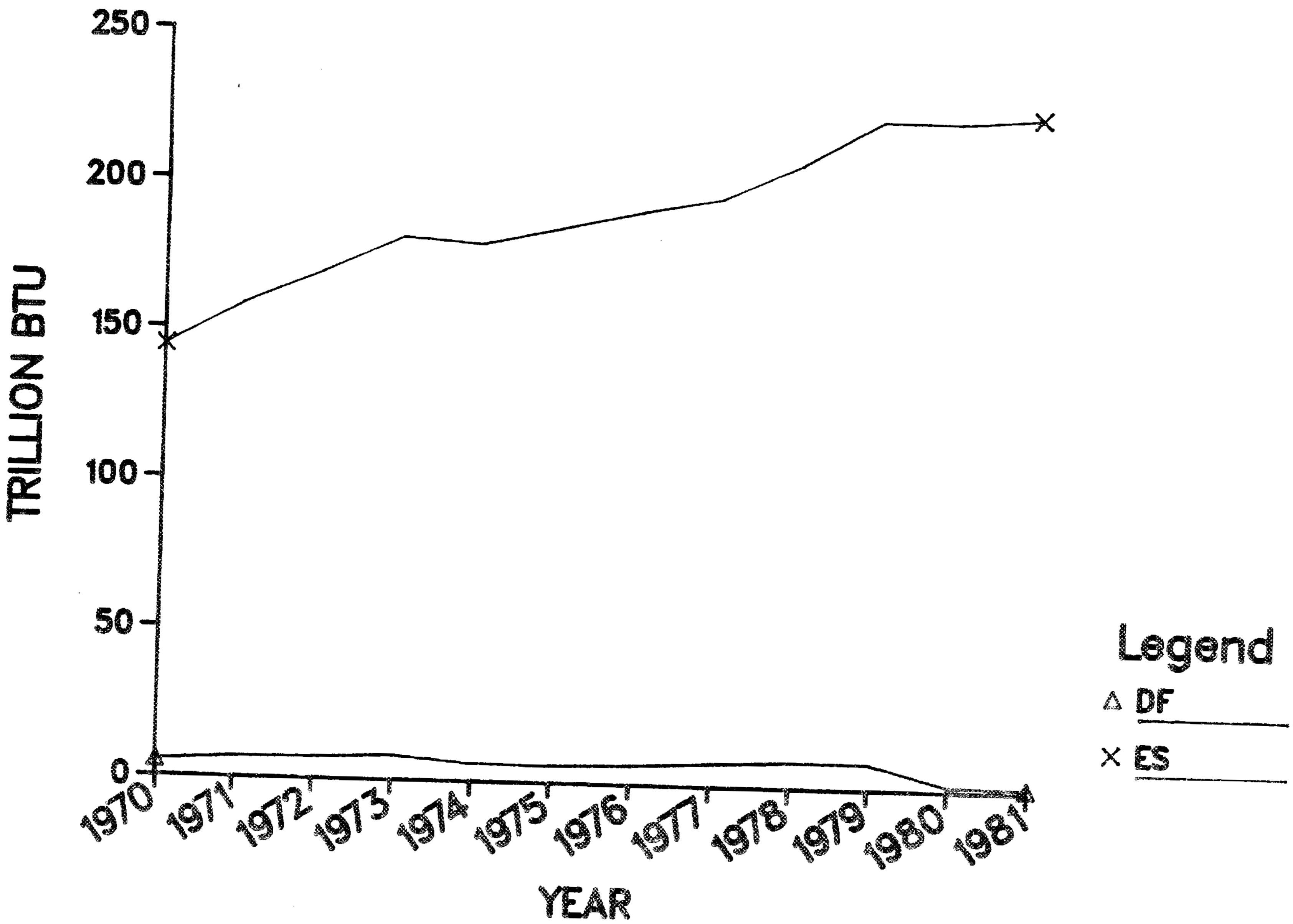

Fig. 2.9. Time trend plot of electricity and distillate fuel consumption for the West region

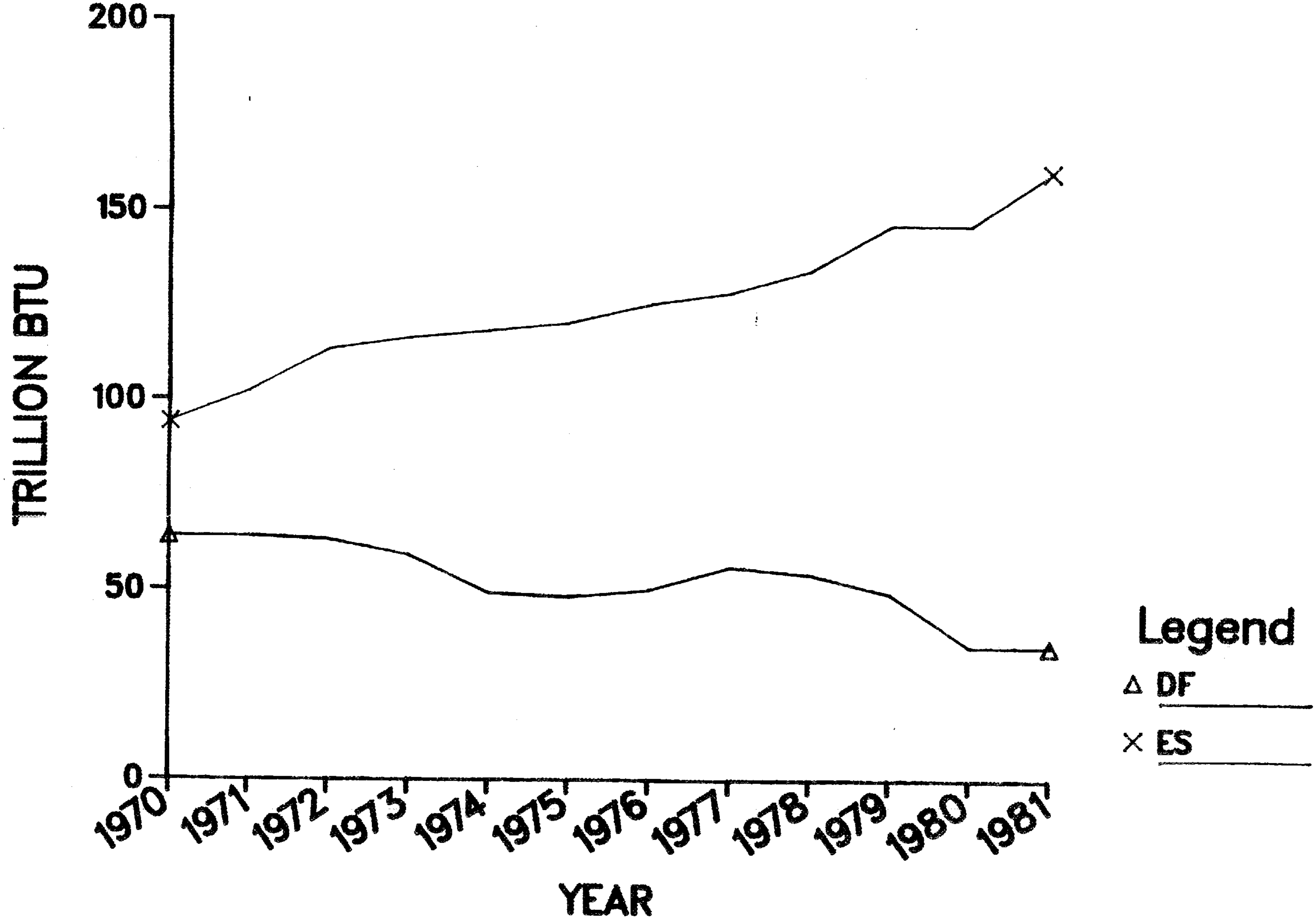

Fig. 2.10. Time trend plot of electricity and distillate fuel consumption for the Northwest region

period with the exception of a trough occurring in most regions around 1974 or 1975, reflecting the effects of the oil embargo.

Figures 2.11-2.30 are regional pie charts of the proportion of the consumption of each fuel to the total fuel consumption (TF) for 1970 and 1981. (Fuels which comprise less than 2% of the total are relegated to an "OTHER" category.) The same information, in tabular form, may be found in Table 2.2. The proportion of DF to TF falls from 1970 to 1981 in every region. As seen in Figures 2.11 and 2.12, DF is the major fuel in New England, comprising over 60% of the total in 1970 and almost 50% in 1981. In the New York/New Jersey region, DF comprises the largest proportion of total with 44% in 1970, but loses to natural gas in 1981. Consumption of DF is negligible in the Southwest and West regions.

ES's share of TF increases in every region from 1970 to 1981. In the Northwest, it has the greatest proportion in both years, growing from 40% of the total in 1970 to over 60% in 1981. In the South Atlantic region, ES grows from 33% of the total in 1970, surpassed only by natural gas, to become the major fuel in 1981 with over 50% of the total. The 1970 proportions vary from 10% of total in the New York/New Jersey region to approximately 40% in the Northwest. In 1981, ES's share of the total ranges from 10% in New York/New Jersey to over 60% in the Northwest.

Tables 2.3 and 2.4 show the growth of economic and demographic factors, as well as the growth of the consumption of electricity and distillate fuel, respectively, by region for the 1970-1981 period. These growth rates, along with the 1970 levels of heating and cooling

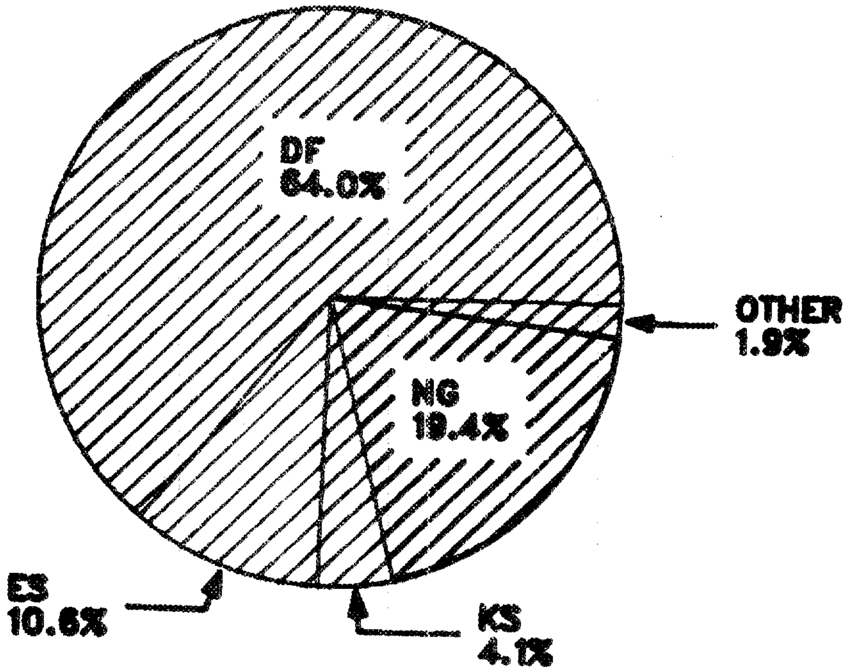

Fig. 2.11. Fuel shares in 1970, New England

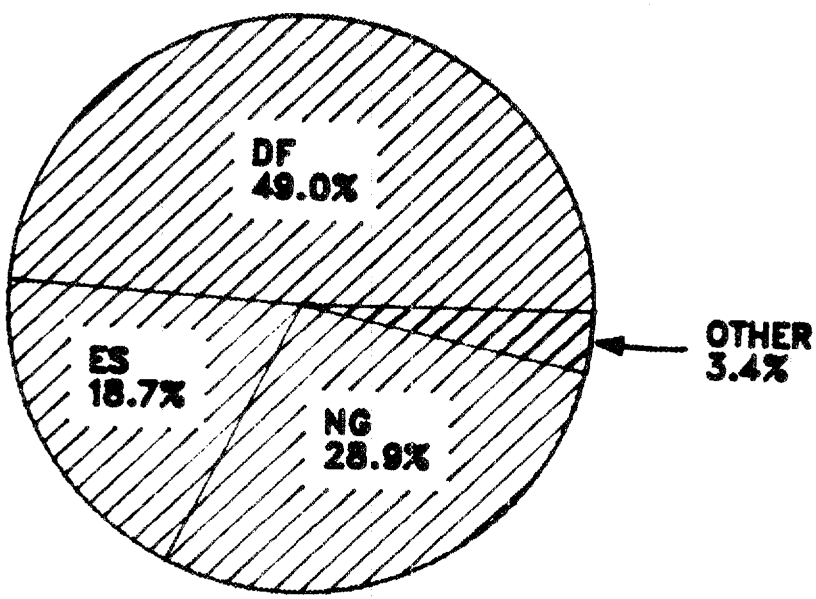

Fig. 2.12. Fuel shares in 1981, New England

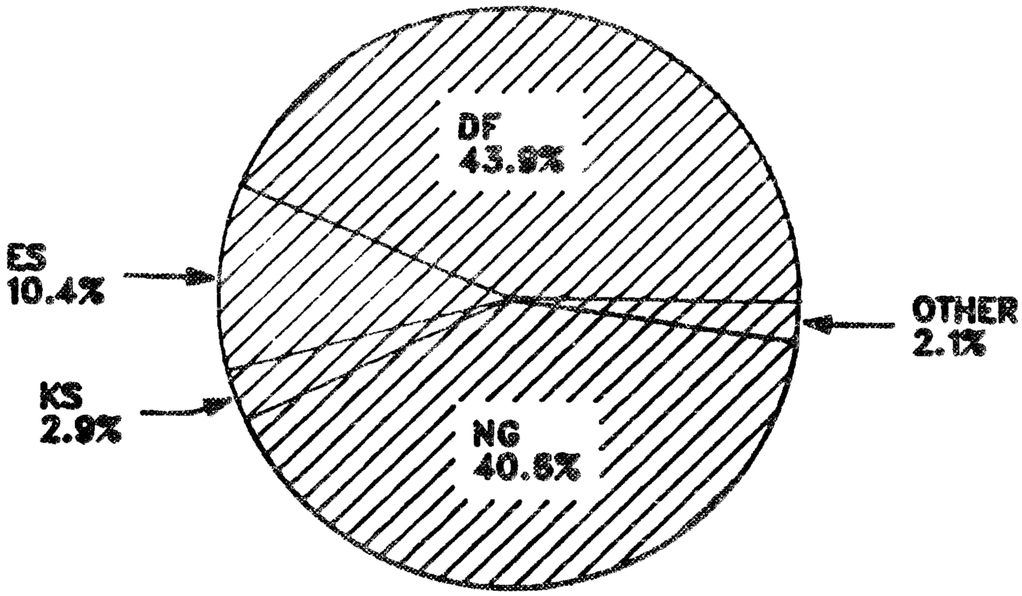

Fig. 2.13. Fuel shares in 1970, New York/New Jersey

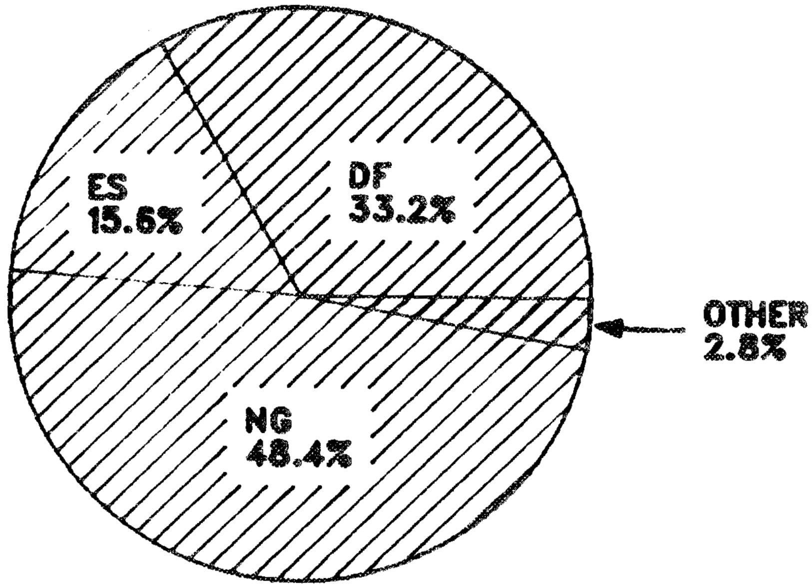

Fig. 2.14. Fuel shares in 1981, New York/New Jersey

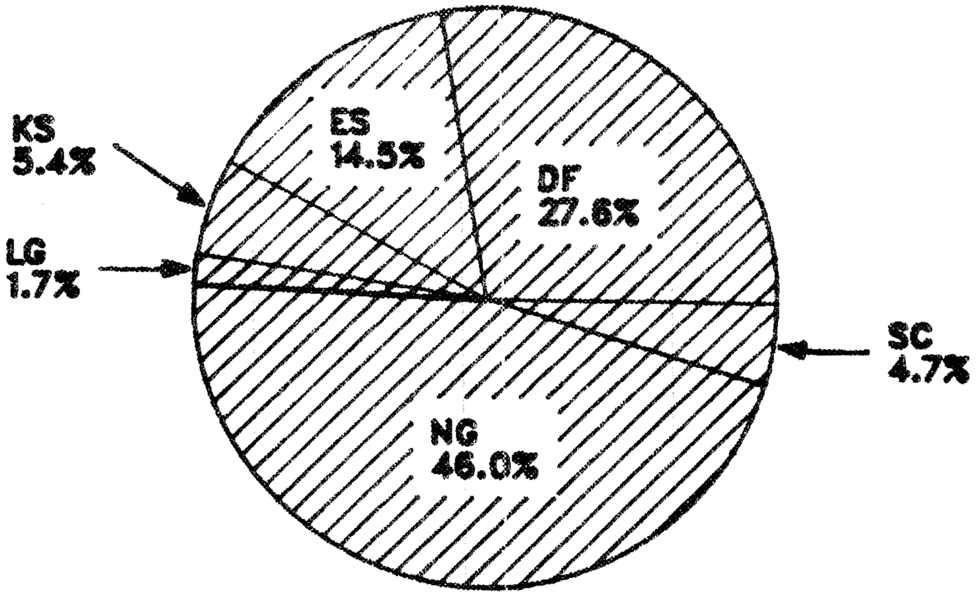

Fig. 2.15. Fuel shares in 1970, Mid Atlantic

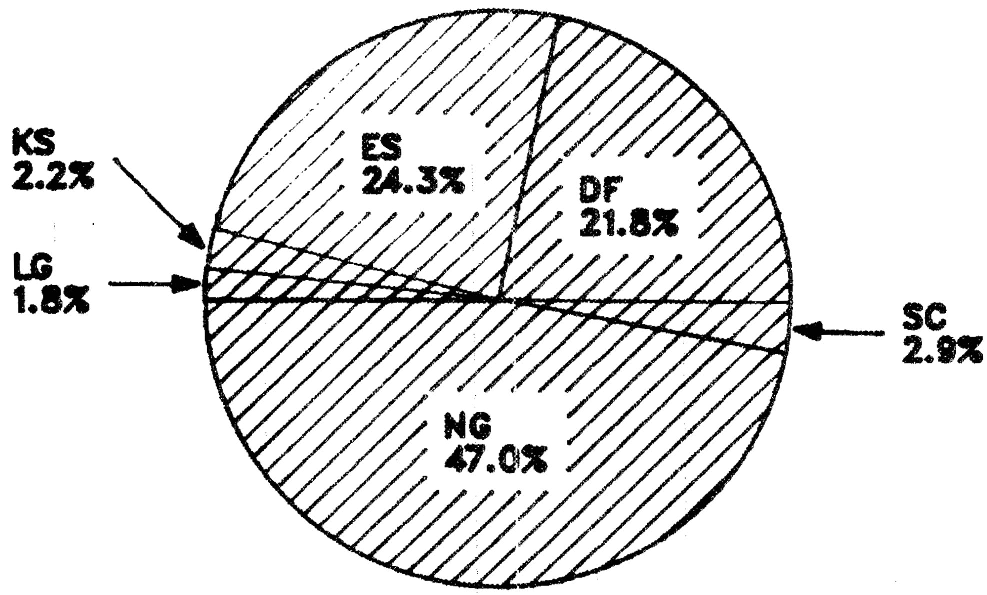

Fig. 2.16. Fuel shares in 1981, Mid Atlantic

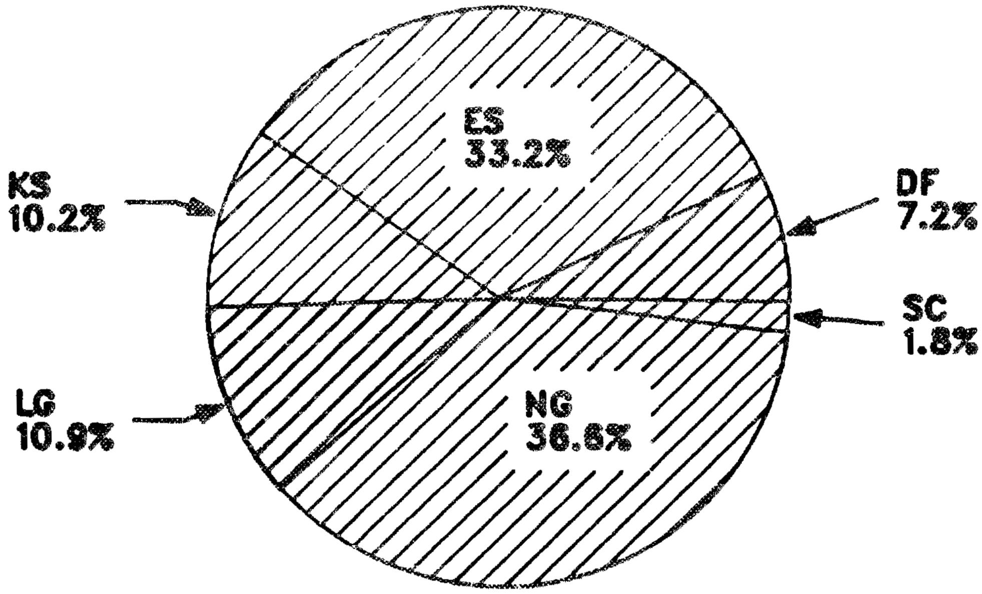

Fig. 2.17. Fuel shares in 1970, South Atlantic

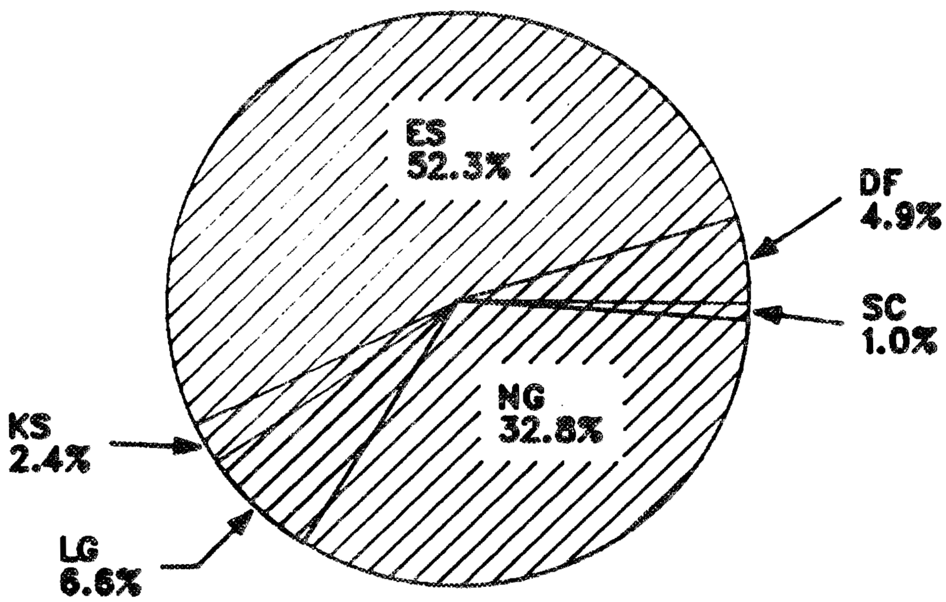

Fig. 2.18. Fuel shares in 1981, South Atlantic

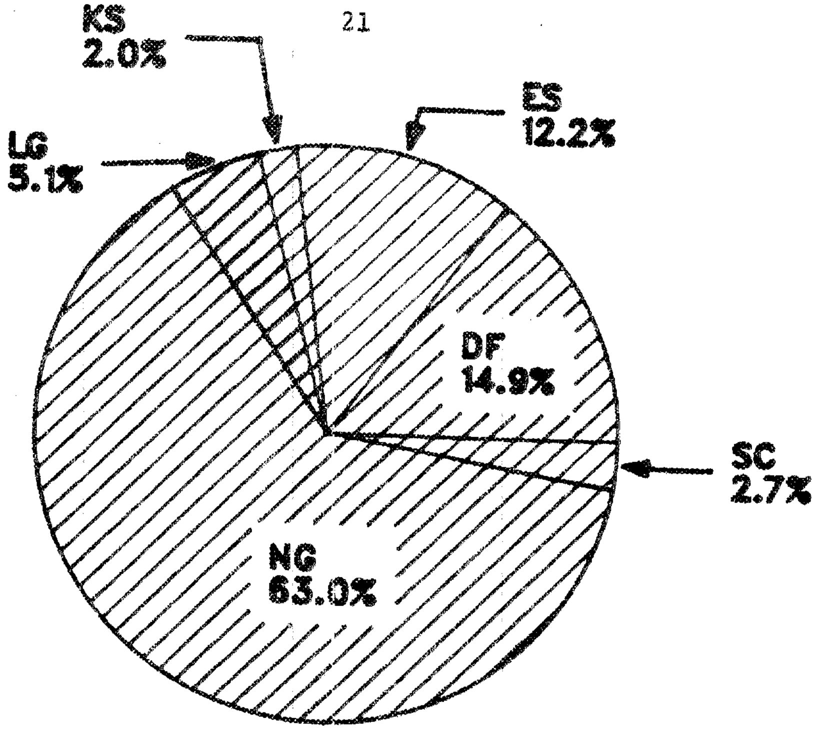

Fig. 2.19. Fuel shares in 1970, Midwest

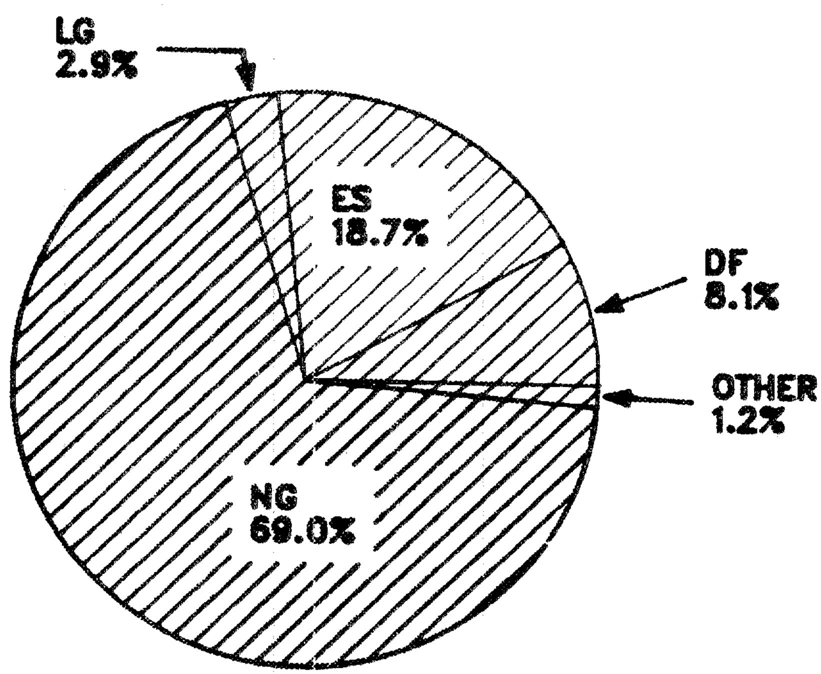

Fig. 2.20. Fuel shares in 1981, Midwest

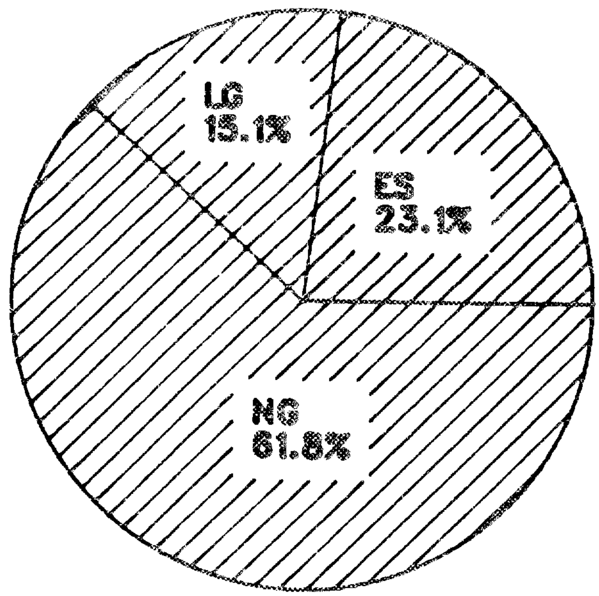

Fig. 2.21. Fuel shares in 1970, Southwest

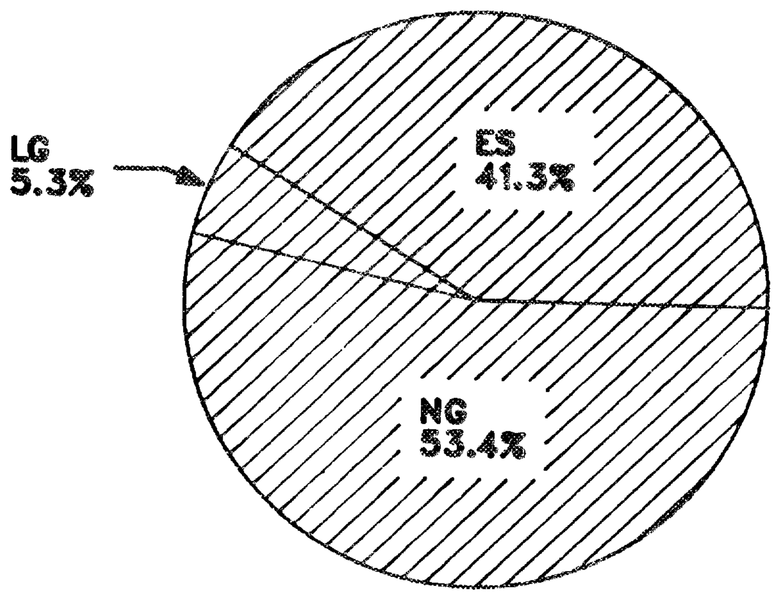

Fig. 2.22. Fuel shares in 1981, Southwest

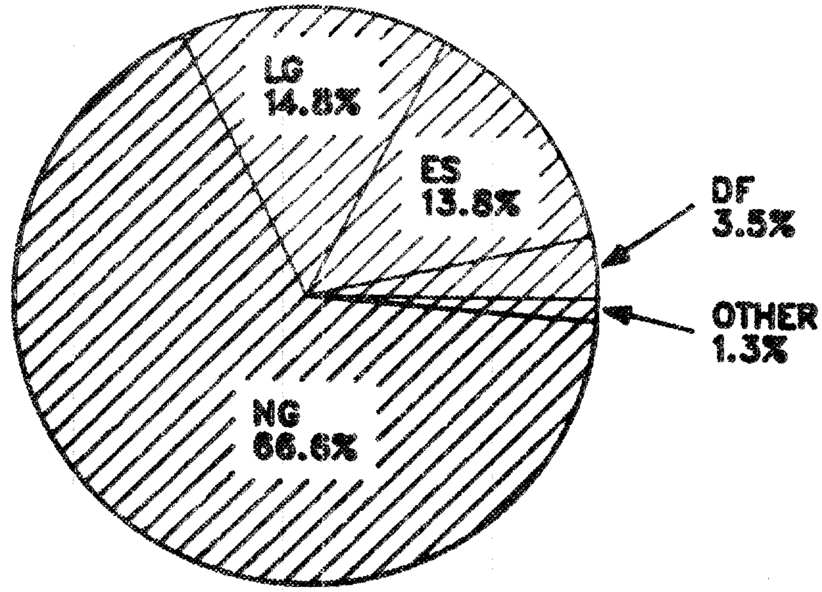

Fig. 2.23. Fuel shares in 1970, Central

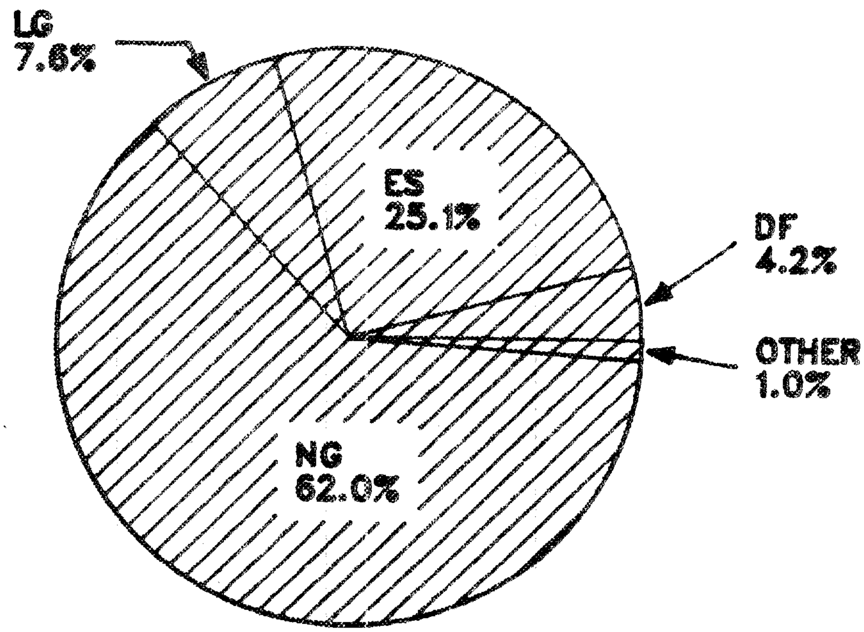

Fig. 2.24. Fuel shares in 1981, Central

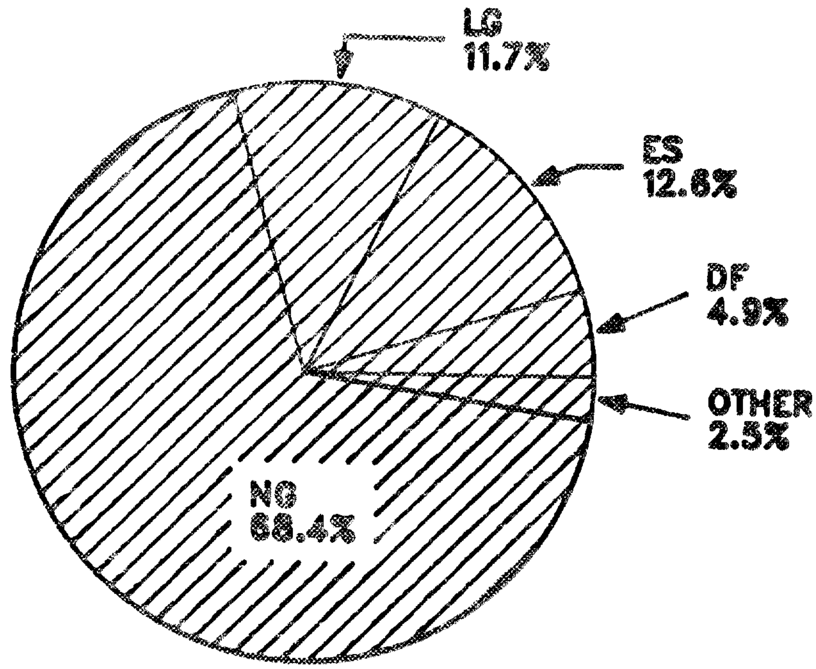

Fig. 2.25. Fuel shares in 1970, North Central

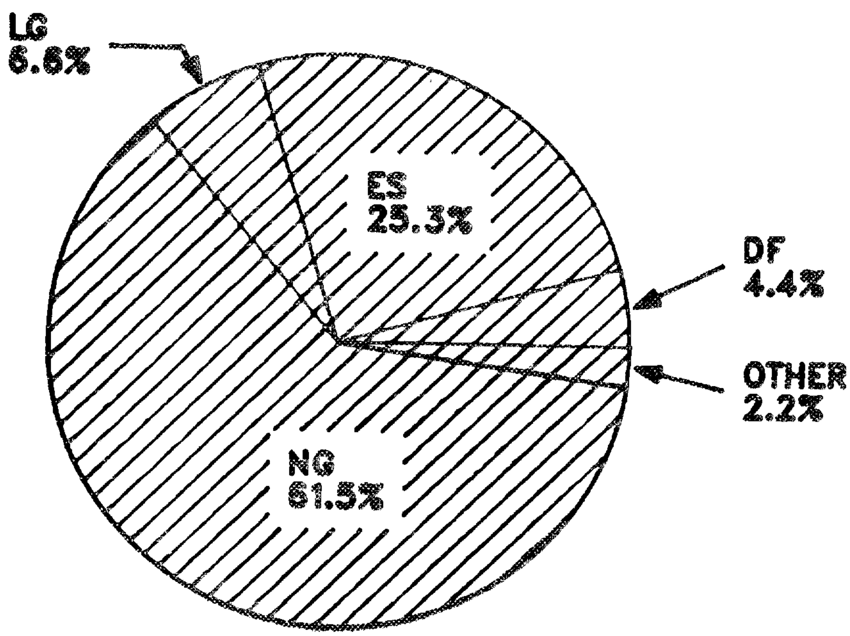

Fig. 2.26. Fuel shares in 1981, North Central

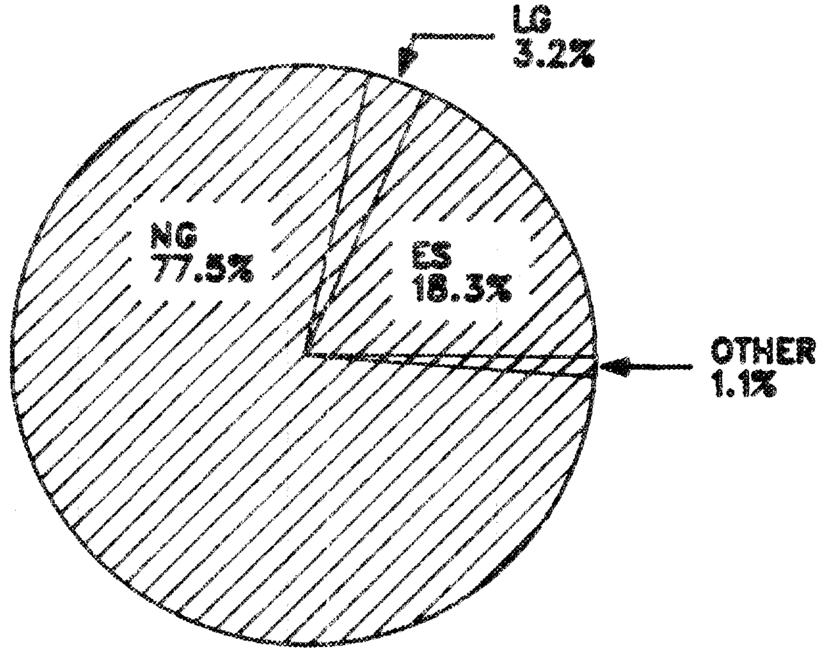

Fig. 2.27. Fuel shares in 1970, West

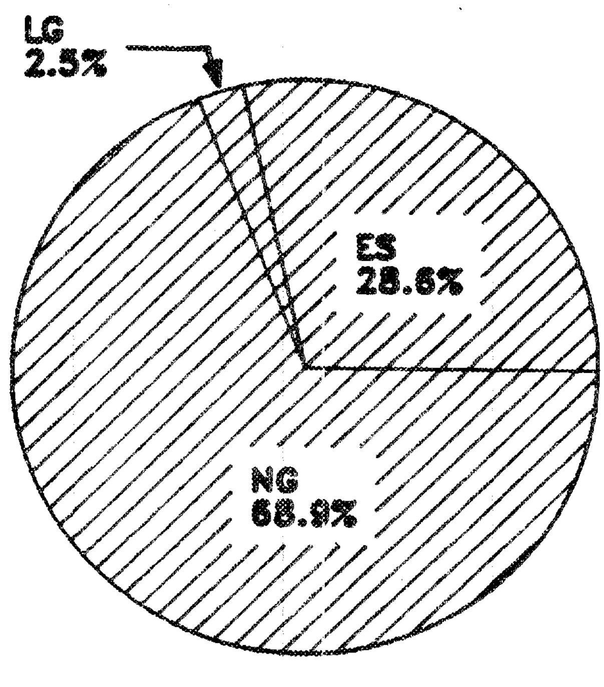

Fig. 2.28. Fuel shares in 1981, West

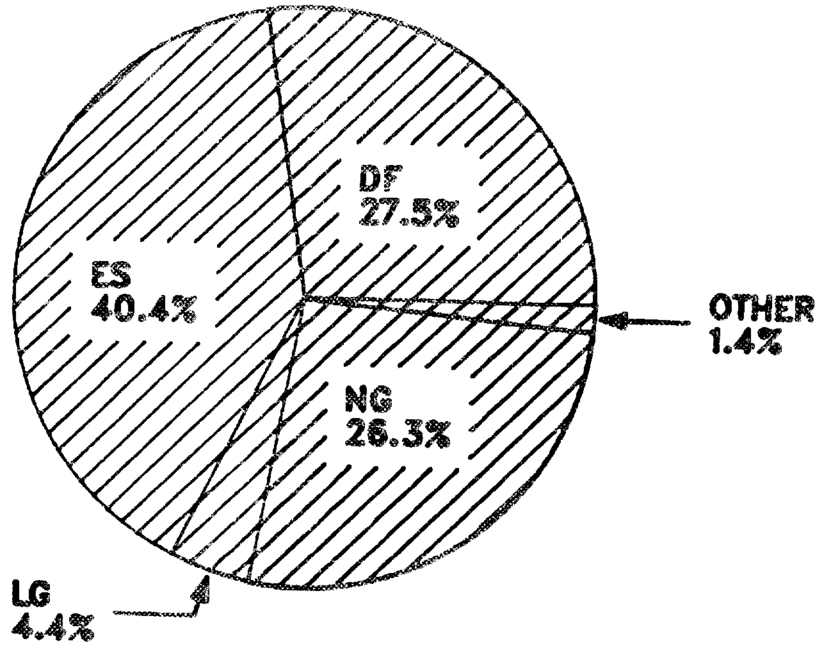

Fig. 2.29. Fuel shares in 1970, Northwest

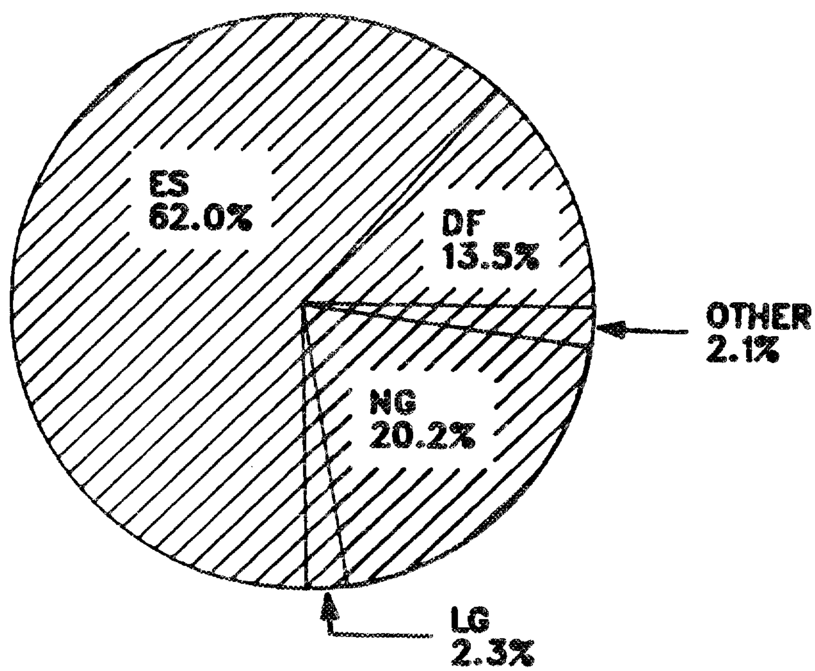

Fig. 2.30. Fuel shares in 1981, Northwest

Table 2.2. Fuel shares (%) for 1970 and 1981, by region[a]

Region	DF	ES	KS	LG	NG	SC	OTHER
New England							
1970	64.00	10.57	4.15	b	19.43	b	1.86
1981	48.98	18.74	b	b	28.92	b	3.36
New York/ New Jersey							
1970	43.91	10.40	2.92	b	40.65	b	2.13
1981	33.17	15.60	b	b	48.41	b	2.82
Mid Atlantic							
1970	27.64	14.54	5.44	1.69	45.98	4.70	0.00
1981	21.81	24.34	2.22	1.75	47.02	2.85	0.00
South Atlantic							
1970	7.21	33.22	10.24	10.91	36.64	1.77	0.00
1981	4.87	52.33	2.42	6.60	32.83	0.95	0.00
Midwest							
1970	14.88	12.25	2.05	5.08	63.01	2.74	0.00
1981	8.14	18.69	b	2.91	69.03	b	1.24
Southwest							
1970	b	23.04	b	15.06	61.54	b	0.36
1981	b	41.18	b	5.24	53.26	b	0.32
Central							
1970	3.50	13.85	b	14.86	66.73	b	1.27
1981	4.16	25.15	b	7.62	62.03	b	1.04
North Central							
1970	4.91	12.57	b	11.69	68.35	b	2.48
1981	4.37	25.28	b	6.59	61.34	b	2.18
West							
1970	b	18.30	b	3.19	77.45	b	1.06
1981	b	28.53	b	2.52	68.70	b	0.25
Northwest							
1970	27.46	40.39	b	4.42	26.30	b	1.44
1981	13.47	61.98	b	2.27	20.18	b	2.11

[a] Shares may not add to 100% due to rounding error.
[b] Share is less than 2% and has been relegated to the OTHER category.

Table 2.3. Regional factors in the growth of electricity consumption, 1970-1981

Region	Compounded Annual Growth Rate, 1970-1981: Consumption Level	Consumption Per Capita	Population	Real Per Capita Income	Real Price	1970: Average HDD	Average CDD	Per Capita Consumption[a]	% of Total Fuel Use
1	2.85	2.42	0.43	0.93	2.50	6787	479	6.20	10.57
2	1.99	2.13	-0.14	0.64	3.37	5984	806	5.06	10.40
3	4.05	3.54	0.51	1.06	1.63	5367	956	6.95	14.54
4	4.61	2.60	2.01	1.44	2.68	2878	2037	10.96	33.22
5	2.82	2.46	0.36	0.99	0.69	6677	808	7.30	12.25
6	5.52	3.34	2.18	2.25	0.11	2575	2281	9.23	23.04
7	4.02	3.55	0.47	1.52	-0.25	5763	1275	7.78	13.85
8	6.63	4.35	2.28	2.15	-1.05	7795	483	6.53	12.57
9	8.06	2.07	2.08	1.06	2.16	2611	904	6.47	18.30
10	4.93	2.76	2.17	1.28	-0.28	5773	230	15.13	40.39

[a] Per Capita Consumption is measured in 10^6 Btu/person.

Table 2.4. Regional factors in the growth of distillate fuel consumption, 1970-1981

Region	Compounded Annual Growth Rate, 1970-1981					1970			
	Consumption								
	Level	Per Capita	Population	Real Per Capita Income	Real Price	Average HDD	Average CDD	Per Capita Consumption[a]	% of Total Fuel Use
1	-4.71	-5.14	0.43	0.93	9.22	6787	479	37.56	64.00
2	-4.18	-4.04	-0.14	0.64	9.69	5984	806	21.38	43.91
3	-2.83	-3.33	0.51	1.06	9.82	5367	956	13.22	27.64
4	-3.13	-5.14	2.01	1.44	10.80	2878	2037	2.38	7.21
5	-6.35	-6.71	0.36	0.99	10.59	6677	808	8.87	14.88
6	-3.81	-5.99	2.18	2.25	10.80	2575	2281	0.06	b
7	0.07	-0.40	0.47	1.52	10.64	5763	1275	1.97	3.50
8	-0.97	-3.25	2.28	2.15	10.22	7795	483	2.55	4.91
9	0.05	-14.21	2.08	1.06	9.99	2611	904	0.24	b
10	-5.40	-7.57	2.17	1.28	9.28	5773	230	10.29	27.46

[a] Per Capita Consumption is measured in 10^6 Btu/person.

[b] Less than 2%.

degree days (HDD and CDD, respectively),[1] per capita consumption (of electricity or distillate fuel) and the individual fuel consumption share of total fuel consumption, are shown to help illuminate the potentially important factors affecting electricity and distillate fuel demand. Intuitively, one would expect own-price to play a major role in the demand for electricity and distillate fuel. At the same time, the importance of certain other factors in the determination of demand may be judged, in a limited way, by the relative growth of those factors.

Table 2.3 shows that the historical growth in real electricity price ranges from -1.05% annually (in the North Central) to 3.37% (in New York/New Jersey); population varies from -0.14% to 2.28%; and the real per capita income range is 0.64% to 2.25%. The ranges of growth for the economic and demographic variables are similar to each other. For the discussion at hand, the important issue is the relative growth of these factors within a region. In five regions, the growth in real electricity price is exceeded by the growth in population and/or income, which may indicate that population and/or income are also important determinants of electricity demand--more so than in the regions where electricity price growth clearly surpasses the growth in population and/or income.

On the other hand, it can be seen in Table 2.4 that the growth of the real price of distillate fuel far surpasses that of the other variables. One may surmise from this fact that price is likely to be the major driving force of the distillate fuel consumption pattern, although certainly there are other factors involved.

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[1]A heating (cooling) degree day is defined as one degree below (above) 65 degrees Fahrenheit. The degree days are weighted by population.

3. THEORETICAL FOUNDATIONS

This chapter presents the theoretical foundation for the electricity and distillate fuel models used to estimate the historical consumption patterns. A literature review of recent residential energy demand studies produced variations of two basic approaches to modeling demand: what Bohi refers to as structural demand models and reduced-form models.[2] These approaches are discussed below. A list of the articles reviewed for this study can be found in Appendix C.

The quantity of energy consumed by an individual or a firm is derived from a two-stage process. First, the decision to buy a particular energy-using durable must be made. This decision includes a consideration of all of the equipment's characteristics, including its energy efficiency and the type of fuel used. Once the stock of appliances or capital equipment is in place, the decision must be made as to the intensity of use.

One way to characterize the demand process econometrically is to estimate a set of equations for each consuming sector. One equation would focus on the durable choice, and the other would estimate electricity usage given the level of energy-consuming stock in place. This is what is often referred to as a structural model. Although this strategy is the most direct and embodies the greatest amount of theoretical cognizance, it suffers from the need for detailed data on changing levels of the capital stock. The rate of retirement of existing appliances, new equipment additions, and the utilization rate of the different vintages of equipment must be specified in such a dynamic, capital-stock adjustment model, as well as equipment prices. Data on the percentage of households with each major appliance is available for census years, and surveys have been conducted to collect appliance utilization and vintage information for some year or region. However, we are not aware of a reliable historical series of annual, state-level data, making the development of the capital-stock adjustment model difficult.

End-use modeling basically involves estimating energy demand for individual appliance types and aggregating the individual demands to obtain a total demand over all uses of the fuel under consideration. This approach generally requires an extensive data base on appliance holdings.

Recognizing the limitations imposed by data availability, it is still possible to examine both the short-run and long-run demand for a particular energy source, be it electricity or a fuel such as oil or gas, using a dynamic, partial-adjustment model. This model is constructed to account for a possible short-run disequilibrium in the markets for electricity or electricity-using durables. The model is derived from the following pair of structural equations:

$$E_t^* = f(P_t, X_t) \qquad (3.1)$$

$$(E_t \div E_{t-1}) = (E_t^* \div E_{t-1})^{\delta} \qquad (3.2)$$

where

E_t = actual quantity of a specific energy source consumed in time t,

E_t^* = desired quantity of energy source in time t,

P_t = own-price of energy source,

X_t = economic, weather, and demographic variables that are expected to influence the demand for energy source, and

δ = adjustment factor, $0 < \delta < 1$ (reflects the speed with which actual demand adjusts to desired demand).

Equation 3.1 is the familiar characterization of a demand function from classical economic theory. For residential consumers, it represents the solution to the problem of utility maximization subject to the budget constraint. For commercial and industrial customers, this factor-demand equation can be derived from the firms' efforts to minimize costs for a given level of sales or production.

Equation 3.2 represents the adjustment process, which characterizes the movement from the actual to the desired quantity of the given source of energy. Assuming that the first equation can be represented in a log-linear form, the reduced-form equation combining Equations 3.1 and 3.2 can be expressed as a logarithmic Koyck model:

$$\ln E_t = \delta\alpha_0 + (1-\delta) \cdot \ln E_{t-1} + \delta\alpha_1 \cdot \ln P_t + \delta\alpha_2 \cdot \ln X_t + \delta\mu_t \qquad (3.3)$$

where

α_0 = a scalar parameter,

α_1 = long-run own-price elasticity, $\alpha_1 < 0$, ($\delta\alpha_1$=short-run),

α_2 = a vector of additional coefficients, and

μ_t = error term.

Taylor et al. have compared the performance of several versions of the partial adjustment model.[3] Their examination included the linear, semi-logarithmic, and logarithmic Koyck models, in addition to the Houthakker-Taylor flow-adjustment approach.[4] The logarithmic Koyck model was judged to be best in producing reasonable results. This approach was also used successfully in Chern et al. and Maddigan et al. [5,6,7]

When modeling electricity demand, there is a special problem that arises with the characterization of the price of electricity. Most investor-owned utilities use a declining-block rate schedule. This pricing strategy allows for the allocation of a fixed-cost customer charge over the initial kilowatt hours of demand. The declining-block structure makes it difficult to select a single price variable for econometric analysis. As Taylor points out, the changing marginal price derived from the declining step function can result in discontinuous demand curves and non-unique tangencies of the indifference curves with the derived budget constraint.[8]

If consumers attempt to equate the marginal cost of a kilowatt hour of electricity with the marginal benefit, it can be argued that the most appropriate price for demand analysis would be the marginal price. Taylor et al. argue that both marginal price and intramarginal expenditure, which is measured as the product of the difference between average and marginal price and the quantity of electricity demanded, should be included in the specification.[9] Some of the articles covered in our literature review incorporate both average and marginal price. Blattenberger et al. use both a "fixed charge" (calculated as 1 - the ratio of actual fixed charge to income) in their dynamic models of electricity and natural gas.[10] These price variables "have been calculated from actual rate schedules." In his static model of electricity demand, T.P. Roth uses both average and marginal price variables.[11] The wrong sign on the average price variable is due, he claims, to the high degree of correlation between average and marginal price. However, both the McFadden et al. model and the Garbacz model of electricity demand obtain correct signs on each price variable when they are used together in the respective models. [12,13]

The use of average price rather than marginal price has several advantages. First, data on average price are readily available. Second, consumers as a rule do not make decisions on the basis of the marginal price they pay since there is no way to pinpoint the movement from one block to the next from a monthly electric bill. It is reasonable to hypothesize that consumers tend to make decisions about usage on the basis of the expected cost of electricity, which is best reflected by the average price.

A third advantage to the average price model is its greater amenability in a forecasting framework. Average price can be compared directly with average utility-system costs, making forecasting more straightforward.

There is a difficulty with the use of average price as an independent variable in the estimation of the reduced-form demand equation. Because of the declining-block rate schedule, the quantity purchased by the consumer determines the average price. At the same time, the expected price of electricity affects how much electricity the consumer wants to buy. This simultaneous nature of the determination of price and quantity causes an identification problem.[2]

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[2]Beierlein et al. argue that average price, i.e., "annual dollars sales to a sector are divided by the number of units sold to that sector over the period," is a supply price, and as such is not simultaneously determined with demand which means that "demand can be modeled separately."[14]

A method for obtaining an unbiased estimate of the price coefficient, is to consider average price endogenous in a simultaneous equation system.[3] However, this method is precluded from our use by its data requirements.

Our literature review produced fewer studies of residential fuel oil demand than studies of residential electricity demand. There are several end-use studies of fuel oil demand. However, the Blattenberger et al. paper is the only paper we reviewed that models fuel oil in the reduced-form framework (dynamic or static).[16] The authors present a single equation model of residential fuel oil using average price; as in their electricity and natural gas models, the fuel oil model is a logarithmic Koyck version of the flow-adjustment model of Houthakker and Taylor.[17]

Therefore, equation 3.3 represents the general form of the electricity and fuel oil submodels for the residential sector. The data set is

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[3]Employing the approach used by Chern et al., the price function is linear with a quadratic term:

$$P_t - K_t = \beta_0 + \beta_1 \cdot (E/N)_t + \beta_2 \cdot E/N)_t^2 + \beta_3 \cdot N_t + \mu_t \qquad (3.4)$$

where

K_t = average total cost of generation, transmission, and distribution in time t,
N_t = number of customers in time t, and
μ_t = disturbance term.

As shown in Chern et al., this particular constrained formulation of the price function ensures that the sectoral prices are bounded by the utility system's average cost, and thus, it produces more plausible price forecasts than the unconstrained logarithmic specification used by Halvorsen.[15]

pooled cross-section, time-series: annual, state-level data for 1970-1981. The seemingly unrelated regression (SUR) estimation technique is used to jointly estimate the two equations in each region. SUR is employed in an effort to account for the possibility of correlation among the error terms of the individual electricity and fuel oil equations.[4] The details of the variables used to estimate the structural coefficients in the residential sector are presented in the following section.

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[4]Beierlein et al. argue for the use of the error components (EC) technique in conjunction with SUR in order to capture the time-series and cross-section components of the disturbance terms.[18]

4. REGRESSION RESULTS

The seemingly unrelated regression results for the electricity and distillate fuel oil equations, by region, are found in Table 4.1, with the asymptotic t-ratios in parentheses. The variable definitions follow. Appendix D contains both SUR and Ordinary Least Squares (OLS) results for the sake of comparison.

Table 4.1. Seemingly unrelated regression results

New England

$$\begin{array}{llllll} \mathrm{LQTES} = & -2.077 & -\ 0.199\cdot\mathrm{LPRES} & +\ 0.774\cdot\mathrm{LES} & +\ 0.355\cdot\mathrm{LRPCI} & +\ 0.177\cdot\mathrm{LHDD}\ + \\ & (-2.11) & (-5.10) & (17.54) & (2.89) & (2.45) \end{array}$$

$$\begin{array}{lllll} 0.070\cdot\mathrm{D1} & +\ 0.026\cdot\mathrm{D2} & -\ 0.079\cdot\mathrm{D3} & +\ 0.377\cdot\mathrm{D4} & +\ 0.248\cdot\mathrm{D5} \\ (1.41) & (0.92) & (-2.53) & (4.76) & (4.32) \end{array}$$

$$\begin{array}{llllll} \mathrm{LQTDF} = & -4.358 & -\ 0.418\cdot\mathrm{LPRDF} & +\ 0.699\cdot\mathrm{LDF} & +\ 0.920\cdot\mathrm{LRPCI} & +\ 0.318\cdot\mathrm{D1}\ + \\ & (-1.13) & (-5.74) & (6.52) & (1.91) & (2.77) \end{array}$$

$$\begin{array}{llll} 0.089\cdot\mathrm{D2} & +\ 0.012\cdot\mathrm{D3} & +\ 0.512\cdot\mathrm{D4} & +\ 0.182\cdot\mathrm{D5} \\ (1.67) & (0.13) & (2.54) & (1.44) \end{array}$$

New York/New Jersey

$$\begin{array}{llllll} \mathrm{LQTES} = & -1.439 & -\ 0.148\cdot\mathrm{LPRES} & +\ 0.960\cdot\mathrm{LES} & +\ 0.140\cdot\mathrm{LCDD} & +\ 0.153\cdot\mathrm{LHDD}\ + \\ & (-0.92) & (-1.88) & (7.96) & (2.51) & (1.36) \end{array}$$

$$\begin{array}{l} 0.044\cdot\mathrm{D1} \\ (0.55) \end{array}$$

$$\begin{array}{llllll} \mathrm{LQTDF} = & -18.584 & -\ 0.229\cdot\mathrm{LPRDF} & +\ 0.613\cdot\mathrm{LDF} & +\ 2.288\cdot\mathrm{LPOP} & +\ 0.353\cdot\mathrm{LHDD}\ - \\ & (-0.93) & (-2.04) & (2.88) & (1.13) & (0.81) \end{array}$$

$$\begin{array}{l} -1.853\cdot\mathrm{D1} \\ (-1.00) \end{array}$$

Mid Atlantic

$$\begin{array}{llllll} \mathrm{LQTES} = & -2.127 & -\ 0.096\cdot\mathrm{LPRES} & +\ 0.800\cdot\mathrm{LES} & +\ 0.399\cdot\mathrm{LRPCI} & +\ 0.141\cdot\mathrm{LCDD}\ + \\ & (-1.56) & (-1.12) & (12.66) & (2.51) & (2.84) \end{array}$$

$$\begin{array}{lllll} 0.025\cdot\mathrm{LHDD} & +\ 0.157\cdot\mathrm{D1} & -\ 0.133\cdot\mathrm{D2} & -\ 0.520\cdot\mathrm{D3} & -\ 0.118\cdot\mathrm{D4} \\ (0.16) & (3.27) & (-2.59) & (-3.04) & (-1.30) \end{array}$$

Table 4.1. con't.

$$LQTDF = \underset{(-1.78)}{-15.179} - \underset{(-3.79)}{0.337 \cdot LPRDF} + \underset{(6.11)}{0.628 \cdot LDF} + \underset{(2.21)}{1.148 \cdot LRPCI} + \underset{(1.60)}{1.147 \cdot LPOP} -$$

$$\underset{(-0.88)}{0.517 \cdot D1} - \underset{(-0.76)}{0.075 \cdot D2} + \underset{(1.16)}{1.715 \cdot D3} + \underset{(0.71)}{0.508 \cdot D4}$$

South Atlantic

$$LQTES = \underset{(-3.35)}{-3.094} - \underset{(-1.64)}{0.103 \cdot LPRES} + \underset{(15.99)}{0.762 \cdot LES} + \underset{(2.31)}{0.296 \cdot LRPCI} + \underset{(5.94)}{0.262 \cdot LCDD} +$$

$$\underset{(3.30)}{0.173 \cdot LHDD} + \underset{(1.04)}{0.051 \cdot D1} + \underset{(2.96)}{0.190 \cdot D2} + \underset{(5.19)}{0.226 \cdot D3} + \underset{(2.56)}{0.059 \cdot D4} +$$

$$\underset{(3.74)}{0.137 \cdot D5} + \underset{(3.62)}{0.381 \cdot D6} + \underset{(3.05)}{0.095 \cdot D7}$$

$$LQTDF = \underset{(-1.03)}{-9.808} - \underset{(-3.73)}{0.671 \cdot LPRDF} + \underset{(8.79)}{0.965 \cdot LDF} + \underset{(0.68)}{0.829 \cdot LRPCI} + \underset{(0.83)}{0.441 \cdot LHDD} -$$

$$\underset{(0.12)}{0.043 \cdot D1} + \underset{(0.41)}{0.131 \cdot D2} + \underset{(0.41)}{0.197 \cdot D3} + \underset{(0.86)}{0.301 \cdot D4} + \underset{(0.59)}{0.178 \cdot D5} +$$

$$\underset{(0.84)}{0.748 \cdot D6} + \underset{(0.41)}{0.109 \cdot D7}$$

Midwest

$$LQTES = \underset{(-2.73)}{-6.026} - \underset{(-0.21)}{0.013 \cdot LPRES} + \underset{(12.42)}{0.664 \cdot LES} + \underset{(2.66)}{0.741 \cdot LPOP} + \underset{(2.45)}{0.197 \cdot LRPCI} +$$

$$\underset{(3.36)}{0.072 \cdot LCDD} + \underset{(2.77)}{0.149 \cdot LHDD} - \underset{(-1.36)}{0.370 \cdot D1} - \underset{(-0.55)}{0.044 \cdot D2} - \underset{(-1.68)}{0.480 \cdot D3} -$$

$$\underset{(-1.67)}{0.385 \cdot D4} - \underset{(-1.03)}{0.044 \cdot D5}$$

$$LQTDF = \underset{(0.07)}{0.213} - \underset{(-5.43)}{0.370 \cdot LPRDF} + \underset{(9.15)}{0.914 \cdot LDF} + \underset{(0.29)}{0.104 \cdot LHDD} + \underset{(0.31)}{0.050 \cdot D1} +$$

$$\underset{(0.17)}{0.027 \cdot D2} - \underset{(-0.22)}{0.034 \cdot D3} + \underset{(0.34)}{0.052 \cdot D4} + \underset{(0.45)}{0.044 \cdot D5}$$

Southwest

$$LQTES = \underset{(-2.93)}{-2.899} - \underset{(-1.35)}{0.104 \cdot LPRES} + \underset{(9.68)}{0.657 \cdot LES} + \underset{(1.67)}{0.298 \cdot LRPCI} + \underset{(4.86)}{0.352 \cdot LCDD} +$$

$$\underset{(1.72)}{0.160 \cdot LHDD} + \underset{(2.17)}{0.250 \cdot D1} + \underset{(2.35)}{0.392 \cdot D2} + \underset{(2.16)}{0.260 \cdot D3} + \underset{(3.46)}{0.754 \cdot D4}$$

Table 4.1. con't.

$$\begin{array}{llllll}
LQTDF = & 1.114 & -\ 0.294 \cdot LPRDF & +\ 0.808 \cdot LDF & -\ 0.012 \cdot LHDD & +\ 0.370 \cdot D1\ - \\
 & (0.08) & (-0.87) & (3.61) & (-0.01) & (0.31)
\end{array}$$

$$\begin{array}{lll}
0.395 \cdot D2 & +\ 0.258 \cdot D3 & +\ 0.259 \cdot D4 \\
(-0.24) & (0.39) & (0.14)
\end{array}$$

Central

$$\begin{array}{llllll}
LQTES = & -9.439 & -\ 0.225 \cdot LPRES & +\ 0.726 \cdot LES & +\ 1.200 \cdot LPOP & +\ 0.278 \cdot LCDD\ + \\
 & (-1.94) & (-1.37) & (9.80) & (1.59) & (4.22)
\end{array}$$

$$\begin{array}{llll}
0.205 \cdot LHDD & -\ 0.499 \cdot D1 & -\ 1.030 \cdot D2 & -\ 0.423 \cdot D3 \\
(1.94) & (-1.15) & (-1.31) & (-1.54)
\end{array}$$

$$\begin{array}{llllll}
LQTDF = & -21.010 & -\ 0.140 \cdot LPRDF & +\ 0.574 \cdot LDF & +\ 2.775 \cdot LHDD & +\ 0.564 \cdot D1\ + \\
 & (-3.08) & (-0.76) & (2.96) & (3.60) & (1.23)
\end{array}$$

$$\begin{array}{ll}
1.219 \cdot D2 & +\ 0.124 \cdot D3 \\
(2.96) & (0.48)
\end{array}$$

North Central

$$\begin{array}{llllll}
LQTES = & -3.701 & -\ 0.060 \cdot LPRES & +\ 0.836 \cdot LES & +\ 0.462 \cdot LPOP & +\ 0.210 \cdot LHDD\ + \\
 & (-2.92) & (-0.85) & (13.98) & (3.36) & (2.12)
\end{array}$$

$$\begin{array}{lllll}
0.407 \cdot D1 & +\ 0.419 \cdot D2 & +\ 0.369 \cdot D3 & +\ 0.565 \cdot D4 & +\ 0.219 \cdot D5 \\
(2.78) & (2.95) & (2.89) & (3.12) & (3.02)
\end{array}$$

$$\begin{array}{llllll}
LQTDF = & -20.219 & -\ 0.125 \cdot LPRDF & +\ 0.815 \cdot LDF & +\ 2.424 \cdot LHDD & -\ 0.305 \cdot D1\ + \\
 & (-3.21) & (-0.97) & (7.77) & (3.49) & (-1.14)
\end{array}$$

$$\begin{array}{llll}
0.129 \cdot D2 & -\ 0.020 \cdot D3 & -\ 0.504 \cdot D4 & +\ 0.265 \cdot D5 \\
(0.76) & (-0.11) & (-1.76) & (1.83)
\end{array}$$

West

$$\begin{array}{llllll}
LQTES = & -6.653 & -\ 0.118 \cdot LPRES & +\ 0.672 \cdot LES & +\ 0.821 \cdot LRPCI & +\ 0.241 \cdot LPOP\ + \\
 & (-5.32) & (-2.28) & (10.60) & (7.47) & (2.61)
\end{array}$$

$$\begin{array}{lll}
0.177 \cdot LHDD & +\ 0.156 \cdot D1 & -\ 0.169 \cdot D2 \\
(2.86) & (1.09) & (-0.82)
\end{array}$$

$$\begin{array}{llllll}
LQTDF = & -72.766 & -\ 1.407 \cdot LPRDF & +\ 0.665 \cdot LDF & +\ 5.654 \cdot LRPCI & +\ 3.536 \cdot LHDD\ + \\
 & (-1.76) & (-2.44) & (3.63) & (1.56) & (1.43)
\end{array}$$

$$\begin{array}{ll}
0.789 \cdot D1 & -\ 0.075 \cdot D2 \\
(0.92) & (-1.43)
\end{array}$$

Table 4.1. con't.

Northwest

$$LQTES = \underset{(-1.58)}{-3.779} - \underset{(-2.50)}{0.266 \cdot LPRES} + \underset{(6.23)}{0.644 \cdot LES} + \underset{(3.25)}{0.692 \cdot LPOP} + \underset{(1.90)}{0.066 \cdot LCDD} +$$

$$\underset{(1.40)}{0.287 \cdot LHDD} - \underset{(-2.25)}{0.426 \cdot D1} - \underset{(-1.82)}{0.216 \cdot D2}$$

$$LQTDF = \underset{(-2.37)}{-19.548} - \underset{(-3.93)}{0.456 \cdot LPRDF} + \underset{(1.87)}{0.315 \cdot LDF} + \underset{(2.89)}{1.334 \cdot LRPCI} + \underset{(2.09)}{1.650 \cdot LHDD} +$$

$$\underset{(3.53)}{1.303 \cdot D1} + \underset{(3.45)}{1.153 \cdot D2}$$

---

where,

QTES = sales of electricity (10^9 Btu),
LQTES = natural log of QTES,
QTDF = consumption of distillate fuel (10^9 Btu),
LQTDF = natural log of QTDF,
PRES = price of electricity ($\$/10^6$ Btu),
CPI = consumer price index (1972=1.0),
LPRES = natural log of PRES÷CPI,
PRDF = price of distillate fuel ($\$/10^6$ Btu),
LPRDF = natural log of PRDF÷CPI,
LES = one year lag of LQTES,
LDF = one year lag of LQTDF,
PCI = per capita personal income ($'s),
RPCI = real per capita personal income (PCI÷CPI),
LRPCI = natural log of RPCI,
POP = population (10^3),
LPOP = natural log of POP,
HDD = heating degree days,
LHDD = natural log of HDD,
CDD = cooling degree days.
LCDD = natural log of CDD, and

the state dummy variables, D1-D7, are defined in Table 4.2. The dummy variables are used to capture variations in demand across states that may not be reflected in the effects of the other independent variables. A list of data sources for the dependent and independent variables is contained in Appendix E.

As can be seen in Table 4.1, own-price appears in the estimation of both equations for every region with the negative sign one expects *a priori*. The own-price coefficient of distillate fuel is statistically significant for 7 of the 10 regions (the exceptions are the Southwest, Central, and North Central), whereas the coefficient of real electricity price (LPRES) is statistically significant in only 3 regions: New England, the West, and the Northwest. The short-run (SR) and long-run (LR) own-price elasticities for both electricity and distillate fuel are found in Table 4.3.

Table 4.2. Definition of state dummies
(D= 1.0 for designated state and 0 otherwise)

	Region				
	New England[a]	New York/ New Jersey[b]	Mid Atlantic[c]	South Atlantic[d]	Midwest[e]
D1	Connecticut	New Jersey	Delaware	Alabama	Illinois
D2	Maine		Maryland & DC	Florida	Indiana
D3	Massachusetts		Pennsylvania	Georgia	Michigan
D4	New Hampshire		Virginia	Kentucky	Minnesota
D5	Rhode Island			Mississippi	Ohio
D6				North Carolina	
D7				South Carolina	

[a] Vermont is reflected in the general constant term.
[b] New York is reflected in the general constant term.
[c] West Virginia is reflected in the general constant term.
[d] Tennessee is reflected in the general constant term.
[e] Wisconsin is reflected in the general constant term.

Table 4.2. con't.

	Region				
	South-west[a]	Central[b]	North Central[c]	West[d]	North-west[e]
D1	Arkansas	Iowa	Colorado	Arizona	Idaho
D2	Louisiana	Kansas	Montana	California	Oregon
D3	New Mex-ico	Missouri	North Dakota		
D4	Oklahoma		South Dakota		
D5			Utah		
D6					
D7					

[a] Texas is reflected in the general constant term.
[b] Nebraska is reflected in the general constant term.
[c] Wyoming is reflected in the general constant term.
[d] Nevada is reflected in the general constant term; Hawaii has been omitted from this analysis.
[e] Washington is reflected in the general constant term; Alaska has been omitted from this analysis.

Table 4.3. Short-run (SR) and long-run (LR) own-price elasticities for electricity (ES) and distillate fuel (DF), by region

	ES		DF	
	SR	LR	SR	LR
New England	-0.199	-0.881	-0.418	-1.389
NY/NJ	-0.148	-3.700	-0.229	-0.592
Mid Atlantic	-0.096	-0.480	-0.337	-0.906
South Atlantic	-0.103	-0.433	-0.671	-19.17
Midwest	-0.013	-0.039	-0.370	-4.302
Southwest	-0.104	-0.303	-0.294	-1.531
Central	-0.225	-0.821	-0.140	-0.329
North Central	-0.060	-0.366	-0.125	-0.676
West	-0.118	-0.360	-1.407	-4.200
Northwest	-0.266	-0.747	-0.456	-0.666

The lagged dependent variable is statistically significant in the electricity demand equation in every region. Similarly, LDF is statistically significant in all regions except the Northwest. Generally, the asymptotic t-ratios are greater for LES than for LDF. LES has the greatest value in the New York/New Jersey region (0.960), which implies that this region has the smallest coefficient of adjustment (1 - 0.960 =0.04). This, in turn, implies that in this region actual demand for electricity adjusts to desired demand more slowly than in any other region. The same results are implied for DF in the South Atlantic region.

The number of cooling degree days, LCDD, does not appear as an explanatory factor of DF demand in any region---as one would expect since DF is not used for air conditioning. However, LCDD is a statistically significant determinant of electricity demand in 6 regions: New York/New Jersey, Mid Atlantic, South Atlantic, Midwest, Southwest, and Central.

The other weather variable, heating degree days (LHDD), is an explanatory variable of ES demand in every region; furthermore, it is statistically significant in 5 regions. LHDD is a statistically significant variable in the DF equation in the Central, North Central, and Northwest regions. Additionally, LHDD is included in the DF equations in 5 other regions. It appears with a negative sign in the estimation for the Southwest, but it is not statistically significant.

The estimation results indicate that population, LPOP, is more often a determinant of electricity demand than of distillate fuel use. The same is true of real per capita income, LRPCI. A possible explanation for this pattern is discussed above in Chapter 2. That is, the relative growth of the economic and demographic variables during the historical period suggest that own-price is a dominant driving force of distillate fuel consumption since its growth so clearly surpasses that of other variables, such as population and income. On the other hand, the growth of electricity price is similar to that of income and population and a particular dominating factor is not suggested. Tables 4.4 and 4.5 show the elasticities for population and income, respectively.

Table 4.4. Short-run (SR) and long-run (LR) population elasticities for electricity (ES) and distillate fuel (DF), by region

	ES		DF	
	SR	LR	SR	LR
New England	---	---	---	---
NY/NJ	---	---	2.288	5.912
Mid Atlantic	---	---	1.147	3.083
South Atlantic	---	---	---	---
Midwest	0.741	2.205	---	---
Southwest	---	---	---	---
Central	1.200	4.380	---	---
North Central	0.462	2.817	---	---
West	0.241	0.735	---	---
Northwest	0.692	1.944	---	---

Table 4.5. Short-run (SR) and long-run (LR) income elasticities for electricity (ES) and distillate fuel (DF), by region

	ES		DF	
	SR	LR	SR	LR
New England	0.355	1.571	0.920	3.056
NY/NJ	---	---	---	---
Mid Atlantic	0.399	1.995	1.148	3.086
South Atlantic	0.296	1.244	0.829	23.686
Midwest	0.197	0.586	---	---
Southwest	0.298	0.869	---	---
Central	---	---	---	---
North Central	---	---	---	---
West	0.821	2.503	5.654	16.878
Northwest	---	---	1.334	1.947

As noted above, the t-statistic is an indicator of whether or not an independent variable is statistically significant in a multiple regression model. A <u>beta coefficient</u> indicates an independent variable's relative importance in the regression equation with respect to the other independent variables. The beta coefficient is calculated as follows:

$$\tilde{\beta}_i^* = \tilde{\beta}_i \cdot (s_{X_i}/s_Y) \qquad (4.1)$$

where, $\tilde{\beta}_i^*$ = beta coefficient for independent variable X_i,

X = vector of independent variables of which there are $i=1, 2, \ldots, n$,

$\tilde{\beta}_i$ = regression coefficient of X_i,

s = standard deviation, and

Y = dependent variable.

The beta coefficient measures the change in the standard deviation of Y induced by a change in the standard deviation of X_i. Since all independent variables have been standardized, the beta coefficient reflects the historical importance of the variations in the independent variables in dependent variable changes. Tables 4.6-4.15 display the beta coefficients of both the electricity and distillate fuel consumption equations for each region.

To illustrate the implications of the beta coefficients, consider the electricity demand equation, in Table 4.12, of the Central region. It can be seen that, based on the beta coefficients, population is the most important independent variable relative to the other variables because its beta coefficient is the largest in absolute value (1.2). That is, historically, a change of 1 in the standard deviation of population induces a change of 1.2 in the standard deviation of electricity consumption. On the other hand, the t-statistic for the regression coefficient of population (Table 4.1) indicates that population is not a statistically significant determinant of electricity demand. In other words, one cannot reject the null hypothesis that the coefficient of population is equal to zero because the t value of 1.59 is less than the rule-of-thumb value of 2.0 used to reject the null hypothesis at the 5% level of significance. Thus, the beta coefficient supports the inclusion

Table 4.6. Beta coefficients for the New England region

	Dependent Variable	
	LQTES	LQTDF
LPRES	-0.038	
LPRDF		-0.163
LES	0.776	
LDF		0.687
LRPCI	0.061	0.153
LPOP		
LHDD	0.031	
LCDD		
D1	0.034	0.148
D2	0.013	0.041
D3	-0.038	0.006
D4	0.182	0.238
D5	0.120	0.085

Table 4.7. Beta coefficients for the New York/New Jersey region

	Dependent Variable	
	LQTES	LQTDF
LPRES	-0.055	
LPRDF		-0.213
LES	0.965	
LDF		0.605
LRPCI		
LPOP		2.901
LHDD	0.027	0.060
LCDD	0.062	
D1	0.063	-2.616

Table 4.8. Beta coefficients for the Mid Atlantic region

	Dependent Variable	
	LQTES	LQTDF
LPRES	-0.014	
LPRDF		-0.080
LES	0.795	
LDF		0.633
LRPCI	0.053	0.111
LPOP		0.844
LHDD	0.003	
LCDD	0.031	
D1	0.061	-0.148
D2	-0.052	-0.021
D3	-0.203	0.490
D4	-0.046	0.145

Table 4.9. Beta coefficients for the South Atlantic region

	Dependent Variable	
	LQTES	LQTDF
LPRES	-0.038	
LPRDF		-0.148
LES	0.760	
LDF		1.000
LRPCI	0.065	0.053
LPOP		
LHDD	0.193	0.144
LCDD	0.176	
D1	0.035	-0.009
D2	0.130	0.026
D3	0.155	0.040
D4	0.040	0.060
D5	0.094	0.036
D6	0.261	0.150
D7	0.065	0.022

Table 4.10. Beta coefficients for the Midwest region

	Dependent Variable	
	LQTES	LQTDF
LPRES	-0.003	
LPRDF		-0.328
LES	0.666	
LDF		0.785
LRPCI	0.041	
LPOP	0.798	
LHDD	0.058	0.038
LCDD	0.053	
D1	-0.354	0.046
D2	-0.042	0.025
D3	-0.459	-0.031
D4	-0.368	0.047
D5	-0.042	0.040

Table 4.11. Beta coefficients for the Southwest region

	Dependent Variable	
	LQTES	LQTDF
LPRES	-0.014	
LPRDF		-0.075
LES	0.654	
LDF		0.776
LRPCI	0.034	
LPOP		
LHDD	0.058	-0.002
LCDD	0.139	
D1	0.098	0.083
D2	0.154	-0.089
D3	0.102	0.058
D4	0.297	0.058

Table 4.12. Beta coefficients for the Central region

	Dependent Variable	
	LQTES	LQTDF
LPRES	-0.052	
LPRDF		-0.039
LES	0.721	
LDF		0.549
LRPCI		
LPOP	1.200	
LHDD	0.074	0.307
LCDD	0.154	
D1	-0.528	0.184
D2	-1.090	0.397
D3	-0.448	0.040

Table 4.13. Beta coefficients for the North Central region

	Dependent Variable	
	LQTES	LQTDF
LPRES	-0.017	
LPRDF		-0.034
LES	0.829	
LDF		0.805
LRPCI		
LPOP	0.496	
LHDD	0.047	0.238
LCDD		
D1	0.272	-0.089
D2	0.280	0.038
D3	0.246	-0.006
D4	0.377	-0.147
D5	0.146	0.077

Table 4.14. Beta coefficients for the West region

	Dependent Variable	
	LQTES	LQTDF
LPRES	-0.021	
LPRDF		-0.369
LES	0.674	
LDF		1.272
LRPCI	0.078	0.430
LPOP	0.306	
LHDD	0.043	0.726
LCDD		
D1	0.063	0.268
D2	-0.069	-0.025

Table 4.15. Beta coefficients for the Northwest region

	Dependent Variable	
	LQTES	LQTDF
LPRES	-0.068	
LPRDF		-0.184
LES	0.644	
LDF		0.308
LRPCI		0.179
LPOP	0.593	
LHDD	0.048	0.253
LCDD	0.034	
D1	-0.274	0.765
D2	-0.139	0.677

of a variable in a regression equation that may not be statistically significant.

One measure of the goodness of fit of an estimated equation is the mean absolute percentage error (MAPE). Actual values of the independent variables during the historical period and the coefficients of the estimated equation are used to "predict" historical values of the dependent variable. A comparison of the predicted and actual values of the dependent variable is then made to determine the sample period performance of the estimated equation. The MAPE is calculated as follows:

$$MAPE = 1/T \sum_{t=1}^{T} (y_t - \hat{y}_t) / y_t \qquad (4.2)$$

where, t = time period (i.e., years) in the historical period, $t=1, 2, \ldots, T$,

$\hat{y}$ = estimated value of dependent variable in time t, and

y = actual value of dependent variable in time t.

Because the MAPE statistic is a percentage error, it avoids bias in accuracy measures that can be introduced by differing units of measurement.

Table 4.16 contains the MAPE statistics for the electricity (ES) and distillate fuel (DF) equations by state and region. The MAPEs are based on data for 1971 through 1981; 1970 cannot be included because the values of the lags for that year are unknown. At the state-level, the ES MAPE for Delaware (FIPS=1000) is the highest, with a value of 1%, and the MAPE for Wisconsin (FIPS=55000) is the lowest--0.09%. The regional MAPEs all fall within a range of 0.06% to 0.18%.

At the regional level, the Southwest has the highest MAPE for the DF equations, with a value of 8.03%, while the Northwest has the best measure of goodness of fit (0.48%). Pennsylvania (FIPS=42000) has the smallest state-level MAPE (0.04%), while Arizona (FIPS=4000) has the poorest measure of goodness of fit, with a MAPE of 27.04%. Four of 48 states have MAPEs greater than 20%. A possible explanation of this lies in the 1970-1981 growth rates of distillate fuel consumption. The 47 state average of the compounded annual growth rate is -3.76%. Louisiana, FIPS=22000, is not included in this calculation because there is no

Table 4.16. MAPE statistics for 1971-1981, by state and region

FIPS	State Abbreviations	MAPE (%) Electricity	MAPE (%) Distillate Fuel
9000	CT	0.19	1.29
23000	ME	0.19	0.90
25000	MA	0.25	0.87
33000	NH	0.15	1.17
44000	RI	0.17	0.96
50000	VT	0.39	0.75
R1		0.10	0.66
34000	NJ	0.12	0.51
36000	NY	0.12	2.99
R2		0.11	1.52
10000	DE	1.00	0.83
24000	MD	0.17	0.58
42000	PA	0.11	0.40
51000	VA	0.25	1.29
54000	WV	0.18	2.32
R3		0.18	0.62
1000	AL	0.36	8.33
12000	FL	0.12	2.47
13000	GA	0.29	2.57
21000	KY	0.61	5.21
28000	MS	0.46	21.31
37000	NC	0.15	3.15
45000	SC	0.19	3.16
47000	TN	0.54	7.58
R4		0.13	2.15
17000	IL	0.15	2.70
18000	IN	0.11	1.01
26000	MI	0.13	0.76
27000	MN	0.22	1.02
39000	OH	0.19	1.49
55000	WI	0.09	1.38
R5		0.06	1.09
5000	AR	0.90	10.47
22000	LA	0.23	25.81
35000	NM	0.33	15.34
40000	OK	0.43	16.31
48000	TX	0.32	21.57
R6		0.11	8.03

Table 4.16. con't.

FIPS	State Abbreviation	MAPE (%) Electricity	Distillate Fuel
19000	IA	0.27	1.11
20000	KS	0.62	7.88
29000	MO	0.42	1.83
31000	NE	0.19	2.16
R7		0.09	1.28
8000	CO	0.79	6.34
30000	MT	0.36	2.53
38000	ND	0.55	4.81
46000	SD	0.39	4.00
49000	UT	0.52	4.76
56000	WY	0.19	5.06
R8		0.15	1.13
4000	AZ	0.24	27.04
6000	CA	0.16	7.02
32000	NV	0.21	6.93
R9		0.08	7.44
16000	ID	0.18	1.45
41000	OR	0.18	0.95
53000	WA	0.36	0.54
R10		0.09	0.48

distillate fuel consumption in this state in 1980 or in 1981.) Mississippi (FIPS=28000), Texas (FIPS=48000) and Arizona (FIPS=4000) show growth rates 7.8, 6.3 and 9.1 times greater, respectively, than the 47 state average for the same period. (Appendix F contains the growth rates for 1970-1981, as well as the projected 1982-2000 growth rates discussed in the next section.) Thus, with respect to the norm, these three states have a somewhat atypical pattern of growth. As for Louisiana, the fact that there is no consumption after 1979 contributes to the large MAPE statistic.

The model specification presented above is only one of many alternatives that can be easily accomodated within the framework of this system. This specification is the first phase of building a modeling tool amenable to the alternatives. Two alternatives suggested by a reviewer of an earlier draft of this paper are a model that includes cross prices and one that takes into account the distinct subsets of the sample period with respect to fuel prices (i.e., from 1970 to 1973, prices were relatively low and stable; whereas, from 1974 through 1981, prices rose dramatically due both to the Arab oil embargo of 1973 and the Iranian crisis in 1979).

For the sake of comparison, Appendix G contains the regression results for both the model presented above and that same model with the addition of cross prices ("without" and "with", respectively): distillate fuel price in the electricity demand equation and electricity price in the distillate fuel demand equation. As can be seen in Tables G.1-G.10, the regression results indicate that distillate fuel is not a substitute for electricity in any region (no statistically significant coefficients of LPRDF in the LQTES equations). However, electricity price is a statistically significant variable in the distillate fuel demand equations of the New England and Southwest regions. The cross price elasticity has the positive sign one expects *a priori* in New England, indicating a switch from distillate fuel to electricity when electricity price declines, *ceteris paribus*. On the other hand, the sign of the cross price elasticity in the Southwest is negative. As pointed out earlier, there are some inconsistencies in the data series of distillate fuel prices and consumption in this region. This is further evidenced by some correlation coefficients calculated for this region: electricity price and distillate fuel consumption have a correlation coefficient of -0.27152, while the coefficient of correlation between distillate fuel consumption and own price is 0.07024; the signs of these coefficients are the opposite of what one would intuitively expect.

Appendix H contains another alternative specification of the model, which is the inclusion of a dummy variable for time (DPR). Specifically, the cross product of own-price and a dummy variable, having a value of one for 1974-1981 and zero otherwise, is included. This cross-product term is included to account for the possible change in own-price elasticity during a period of rapidly increasing energy prices. This is not a statistical test for structural change.

The alternative specifications in Appendices G and H display the structural versatility of this system's framework. The model is amenable to the exploration of a number of issues in which an analyst may be interested.

5. FORECASTING RESULTS

As the main objective of this project is to demonstrate the feasibility of a simple, yet reliable, system to estimate and update forecasts of energy patterns, rather than generating a specific forecast, we do not seek documented sources for the forecasts of the independent variables. Rather, each independent variable, with the exceptions of HDD and CDD, is assumed to grow at its compounded annual 1976-1981 growth rate throughout the 1982-2000 forecasting period. A listing of these growth rates can be found in Appendix I. HDD and CDD are assumed to remain at their respective 1981 levels for the forecasting period.

The compounded annual growth rates of all the exogenous variables vary across states. Over the 1976-1981 period, the growth in the real price of electricity (PRES) varies from a high of 5.03% in Louisiana to a low of -9.21% in Oklahoma; interestingly, these two states are both in the Southwest region. The growth in the real distillate fuel prices (PRDF) over the same period is as much as 13 to 14 times greater, in some states, than the growth in PRES. PRDF growth rates vary from 7.66% annually in California to 14.59% in Arkansas. With the exception of the states in the West region, the growth is over 10% annually in each state. The growth rate of real per capita income (RPCI) is over 3% in only two states--Oklahoma and North Dakota. In 14 of the 48 states under consideration in this study, RPCI declined from 1976 to 1981. The growth in population (POP) varies from a high of 6.71% in Nevada to a low of -0.59% in New York. (Massachusetts is the only other state with a negative growth rate for the five year period.)

Table 5.1 contains the regional, annual forecasts of ES and DF for the 1982-2000 forecasting period. These forecasts were obtained using the SIMLIN procedure in SAS. (Appendix J is an example for the New England region of the SAS program that was written to estimate and forecast the consumption patterns.) The reader should bear in mind that these particular forecasts are not intended to be predictions of "the" levels of electricity and distillate oil demand in the future; it should also be stressed that forecasts made with econometric models are only probabilistic and contingent on the validity of the assumptions used. This methodology is presented as a tool for analyzing the effects of various economic and demographic factors on the level of energy demand. It is useful for policy analysts to determine the effects of various pricing policies and scenarios.

The model forecasts state-level consumption figures that are then aggregated to the regional level. Table 5.2 contains the compounded annual growth rates (1982-2000) in per capita consumption of electricity (ES) and distillate fuel (DF) by region and in the levels of consumption. Appendix F presents the state-level compounded annual growth rates both in the levels of electricity and distillate fuel consumption and in the per capita consumption of the two energy sources for the historical period (1970-1981) and the forecast period (1982-2000).

Obviously, the growth rates of the exogenous variables are an important driving force of the projections of electricity and distillate fuel consumption. Consider for example, the negative growth in the level of distillate fuel consumption in every state over the forecast

Table 5.1. Projected consumption of electricity (ES) and distillate fuel (DF), trillion Btu

YEAR	New England ES	New England DF	New York/ New Jersey ES	New York/ New Jersey DF	Mid Atlantic ES	Mid Atlantic DF
1982	99.208	227.219	159.026	311.657	252.073	206.181
1983	98.590	198.053	158.398	285.830	252.221	188.795
1984	98.186	173.015	157.561	261.848	252.396	173.065
1985	97.952	151.356	156.528	239.772	252.609	158.713
1986	97.853	132.537	155.310	219.550	252.871	145.585
1987	97.865	116.144	153.920	201.079	253.189	133.567
1988	97.967	101.839	152.370	184.231	253.568	122.569
1989	98.146	89.341	150.671	168.873	254.013	112.505
1990	98.388	78.411	148.837	154.877	254.527	103.299
1991	98.685	68.847	146.879	142.120	255.111	94.879
1992	99.030	60.472	144.807	130.488	255.765	87.177
1993	99.417	53.134	142.635	119.880	256.489	80.132
1994	99.842	46.702	140.372	110.199	257.284	73.686
1995	100.301	41.062	138.029	101.360	258.147	67.788
1996	100.793	36.114	135.617	93.285	259.079	62.389
1997	101.315	31.771	133.144	85.904	260.077	57.447
1998	101.865	27.958	130.620	79.154	261.142	52.920
1999	102.442	24.610	128.054	72.977	262.271	48.772
2000	103.045	21.668	125.453	67.321	263.463	44.971

YEAR	South Atlantic ES	South Atlantic DF	Midwest ES	Midwest DF	Southwest ES	Southwest DF
1982	578.454	34.534	433.841	143.996	334.070	0.637
1983	582.038	20.958	433.555	106.646	332.591	0.513
1984	584.825	11.976	434.781	77.338	333.361	0.423
1985	586.980	6.462	437.026	55.020	335.646	0.353
1986	588.640	3.302	439.966	38.464	338.986	0.296
1987	589.920	1.602	443.390	26.465	343.090	0.249
1988	590.909	0.740	447.160	17.948	347.774	0.209
1989	591.679	0.327	451.181	12.013	352.922	0.174
1990	592.288	0.138	455.394	7.945	358.462	0.145
1991	592.778	0.056	459.758	5.198	364.351	0.121
1992	593.186	0.022	464.245	3.367	370.566	0.100
1993	593.536	0.008	468.838	2.162	377.096	0.083
1994	593.850	0.003	473.526	1.377	383.940	0.069
1995	594.143	0.001	478.301	0.870	391.102	0.057
1996	594.428	a	483.160	0.546	398.593	0.047
1997	594.714	a	488.100	0.341	406.424	0.038
1998	595.008	a	493.119	0.212	414.610	0.031
1999	595.315	a	498.217	0.131	423.169	0.026
2000	595.640	a	503.395	0.080	432.120	0.021

[a]Consumption is less than one billion Btu.

Table 5.1. con't.

YEAR	Central ES	Central DF	North Central ES	North Central DF	West ES	West DF
1982	132.768	16.329	76.513	8.594	228.423	0.569
1983	132.444	13.491	79.807	6.173	234.442	0.322
1984	133.303	11.909	83.683	4.666	242.108	0.214
1985	135.041	10.910	88.156	3.672	251.070	0.156
1986	137.451	10.207	93.255	2.983	261.100	0.121
1987	140.391	9.664	99.017	2.486	272.052	0.097
1988	143.764	9.212	105.488	2.113	283.837	0.080
1989	147.500	8.817	112.722	1.826	296.401	0.067
1990	151.552	8.457	120.786	1.597	309.717	0.057
1991	155.886	8.122	129.753	1.412	323.777	0.049
1992	160.482	7.806	139.709	1.259	338.584	0.042
1993	165.324	7.505	150.749	1.129	354.155	0.036
1994	170.405	7.218	162.983	1.019	370.510	0.031
1995	175.722	6.943	176.533	0.923	387.678	0.027
1996	181.274	6.679	191.536	0.839	405.691	0.024
1997	187.063	6.425	208.145	0.765	424.587	0.021
1998	193.095	6.181	226.533	0.699	444.406	0.018
1999	199.375	5.947	246.892	0.640	465.191	0.017
2000	205.910	5.721	269.436	0.587	486.990	0.014

YEAR	Northwest ES	Northwest DF
1982	165.021	28.823
1983	171.657	26.083
1984	179.320	24.179
1985	187.841	22.577
1986	197.124	21.129
1987	207.116	19.789
1988	217.793	18.538
1989	229.151	17.367
1990	241.199	16.271
1991	253.958	15.245
1992	267.454	14.283
1993	281.720	13.382
1994	296.793	12.539
1995	312.716	11.748
1996	329.534	11.008
1997	347.295	10.314
1998	366.054	9.664
1999	385.866	9.056
2000	406.792	8.485

Table 5.2. Compounded annual growth rate, 1982-2000, in consumption of electricity (ES) and distillate Fuel (DF)

	ES		DF	
	Per Capita	Level	Per Capita	Level
New England	-0.20	0.21	-12.60	-12.24
New York/New Jersey	-0.97	-1.31	-7.84	-17.43
Mid Atlantic	-1.05	0.25	-9.30	-8.11
South Atlantic	-2.22	0.16	-60.44	-59.48
Midwest	0.42	0.83	-34.33	-34.06
Southwest	-1.43	1.44	-19.41	-17.27
Central	1.91	2.47	-6.17	-5.66
North Central	4.24	7.24	-16.27	-13.85
West	1.45	4.30	-20.83	-18.60
Northwest	2.03	5.14	-9.34	-6.57

period. (See Appendix F.) This may be largely attributed to the high growth rates of PRDF assumed for the forecast period.

Specifically, in the South Atlantic region, state-level growth rates in the level of distillate fuel consumption vary from -55.01% to -68.97%. At the same time, this region has the largest (in absolute value) regression coefficient for distillate fuel price of all regions, with the exception of the West; furthermore, the assumed growth rates of PRDF, for the forecast period, are quite high, varying from 11.33% to 14.12%.

Contrary to the implications for distillate fuel consumption, growth of electricity consumption over the 1982-2000 period appears to be driven more by population and income than by own price. Consider the North Central, West and Northwest regions, which are three of the four region with growth in the level of consumption greater than 4% annually. Each of these three regions seems to be driven primarily by population (POP). POP is a statistically significant variable in each region, with beta coefficients also indicating importance. Furthermore, the growth rates of POP for the states in those regions are among the highest of all states.

Table 5.3 further illustrates the importance of independent variable growth rate assumptions with respect to the projections of electricity and distillate fuel consumption, as well as the ease with which alternate assumptions can be implemented within the model's framework. The consumption growth rates in Table 5.3 are driven by the same independent variable assumptions as those driving the growth rates in Table 5.2, with the exception of fuel prices. As mentioned above, the own-prices pertinent to Table 5.2 are assumed to grow at the 1976-1981 annualized rate throughout the 1982-2000 forecast period. Whereas, the real electricity and distillate fuel prices relevant to Table 5.3 are assumed to remain at their 1981 level throughout the forecast period; that is, zero growth in real fuel prices is assumed.

The zero real growth assumed for distillate fuel prices is lower (much lower in some cases) for every state than the 1976-1981 growth rates. The same is true for electricity prices, with the exception of 13 states that experienced negative real growth over the 1976-1981 period. The differences between the consumption growth rates in Tables 5.2 and 5.3 are greater for distillate fuel than for electricity

Table 5.3. Compounded annual growth rate, 1982-2000, in consumption of electricity (ES) and distillate Fuel (DF) with zero growth in real fuel prices

	ES		DF	
	Per Capita	Level	Per Capita	Level
New England	1.10	1.52	1.88	2.30
New York/New Jersey	0.28	-0.07	-1.14	-1.48
Mid Atlantic	-1.39	-0.10	1.01	2.34
South Atlantic	-1.65	0.75	-17.32	-15.48
Midwest	0.43	0.84	-10.67	-10.32
Southwest	-1.36	1.52	-5.92	-2.42
Central	1.32	1.87	-2.67	-2.10
North Central	4.67	7.69	-10.55	-8.10
West	1.74	4.59	6.29	8.72
Northwest	2.69	5.83	-2.82	0.14

primarily because distillate fuel prices were increasing much more rapidly than electricity prices during the 1976-1981 period, and therefore, the change from 1976-1981 growth rates to zero real growth is greater for distillate fuel than for electricity.

Table 5.3 serves to illuminate the important role played by the independent variables in the determination of consumption projections. Furthermore, the model's amenability to alternative forecasting assumptions is evidenced.

6. CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

This report presents the econometric estimation of a model of electricity and distillate fuel oil demand for the residential sector, as well as forecasts of those demands for the 1982-2000 period. The SUR estimation technique is used, employing pooled cross-sectional, time-series data for 1970 through 1981. The estimated coefficients, along with projected values of the independent variables, are used to forecast state-level demand, which is then aggregated to the regional level. SAS and the system framework provide a method for analyzing the effects of alternative price and policy scenarios.

Results of the model estimation show a variation across regions and between the two energy sources as to the important determinants of demand. For both electricity and distillate fuel oil, own-price is an important factor in the determination of demand. Price seems to be the major driving force behind distillate fuel oil demand. However, electricity demand appears to be influenced more by population and income, depending upon the region, for the reasons discussed above in Chapters 2 and 4.

Forecasting results display the importance of the projected values of the independent variables with respect to the forecasts of demand. The framework of this system, along with SAS, enable the user to easily exploit the model's sensitivity to alternative assumptions concerning the independent variables.

Several areas could be pursued in future research. Other sectors, such as the commercial and/or industrial, could be modeled in a framework similar to the one presented here for the residential sector. Additionally, as mentioned in the theoretical section of this report, incorporating a price equation and then estimating demand and price in a simultaneous-equations framework would eliminate the concern of simultaneity introduced by the mutual dependence of demand and price; furthermore, it would provide an unbiased estimate of price. The inclusion of cross prices in the model would make the system more amenable to analyzing alternative price and policy scenarios. Finally, a possible extension of the framework in this study would be to model total fuel demand, disaggregating to constituent demands with the use of system constraints.

REFERENCES

1. SAS User's Guide: Statistics, SAS Institute Inc., Cary, North Carolina, 1982 edition.

2. Douglas R. Bohi and Mary Beth Zimmerman, "An Update on Econometric Studies of Energy Demand Behavior," Annual Review of Energy, 1984, pp. 105-154.

3. L.D. Taylor, G.R. Blattenberger, and P.K. Verleger, Jr., The Residential Demand for Energy, EPRI EA-235, Electric Power Research Institute, Palo Alto, CA, January 1977.

4. H.S. Houthakker and L.D. Taylor, Consumer Demand in the United States, Cambridge: Harvard University Press, 1970.

5. W.S. Chern, R.E. Just, B.D. Holcomb, and H.D. Nguyen, Regional Econometric Model for Forecasting Electricity Demand by Sector and by State, ORNL/NUREG-49, Oak Ridge National Laboratory, Oak Ridge, TN, October 1978.

6. W.S. Chern, J.W. Dick, C.A. Gallagher, B.D. Holcomb, R.E. Just, and H.D. Nguyen, The ORNL State-Level Electricity Demand Forecasting Model, ORNL/NUREG-63, Oak Ridge National Laboratory, Oak Ridge, TN, July 1980.

7. Ruth J. Maddigan, Wen S. Chern, Colleen A. Gallagher, Brady D. Holcomb, and James C. Cobbs, The ORNL Rural Electric Energy Demand Forecasting Model, ORNL/TM-7863, Oak Ridge National Laboratory, Oak Ridge, TN, September 1981.

8. L.D. Taylor, "The Demand for Electricity: A Survey," Bell Journal of Economics and Management Science, Vol. 6, Spring 1975, pp. 74-110.

9. Ref. 3.

10. Gail R. Blattenberger, Lester D. Taylor, and Robert K. Rennhack, "Natural Gas Availability and the Residential Demand for Energy," The Energy Journal, Vol. 4, No. 1, January 1983, pp.23-45.

11. Timothy P. Roth, "Average and Marginal Price Changes and the Demand for Electricity: An Econometric Study," Applied Economics, Vol. 13, No. 3, September 1981, pp. 377-388.

12. D. McFadden, C. Puig, and D. Kirshner, "Determinants of the Long-Run Demand for Electricity," American Statistical Association, 1977 Proceedings of the Business and Economics Section, Part 2, pp. 109-117, 1977.

13. Christopher Garbacz, "Electricity Demand and the Elasticity of Intra-Marginal Price," Applied Economics, Vol. 15, No. 5, pp. 699-701, October 1983.

14. James G. Beierlein, James W. Dunn and James C. McConnon, Jr., "The Demand for Electricity and Natural Gas in the Northeastern United States," The Review of Economics and Statistics, Vol. LXIII, No. 3, August 1981, pp. 403-408.

15. Ref. 5.

16. Ref. 10.

17. Ref. 4.

18. Ref. 14.

APPENDIX A

Fuel and FIPS Code Definitions

Table A.1. Fuel code definitions

SECTOR	FUEL	DEFINITION
RESIDENTIAL	DF	Distillate Fuel
	ES	Electricity Sales
	KS	Kerosene
	LG	Liquified Petroleum Gases
	NG	Natural Gas
	SC	Total Coal (Anthracite + Bituminous and Lignite)
COMMERCIAL	DF	Distillate Fuel
	ES	Electricity Sales
	KS	Kerosene
	LG	Liquified Petroleum Gases
	MG	Motor Gasoline
	NG	Natural Gas
	RF	Residual Fuel
	SC	Total Coal (Anthracite + Bituminous and Lignite)
INDUSTRIAL	AS	Asphalt
	CC	Coal Coke
	DF	Distillate Fuel
	ES	Electricity Sales
	KS	Kerosene
	LG	Liquified Petroleum Gases
	LU	Lubricants
	MG	Motor Gasoline
	NG	Natural Gas
	PM	Other Petroleum
	RD	Road Oil
	RF	Residual Fuel
	SC	Total Coal (Anthracite + Bituminous and Lignite)
TRANSPORTATION	AV	Aviation Gasoline
	DL	Diesel
	ES	Electricity Sales
	JF	Jet Fuel, total
	LG	Liquified Petroleum Gases
	LU	Lubricants
	MG	Motor Gasoline
	RF	Residual Fuel
	SC	Coal

Table A.1. con't.

SECTOR	FUEL	DEFINITION
UTILITIES	DF	Distillate Fuel
	NG	Natural Gas
	NU	Nuclear
	PC	Petroleum Coke
	RF	Residual Fuel
	SC	Total Coal (Anthracite + Bituminous and Lignite)
	WW	Wood & Waste

Table A.2. FIPS code definitions

FEDERAL REGION	STATE	FIPS
1	Connecticut	9000
1	Maine	23000
1	Massachusetts	25000
1	New Hampshire	33000
1	Rhode Island	44000
1	Vermont	50000
2	New Jersey	34000
2	New York	36000
3	Delaware	10000
3	Maryland & DC	24000
3	Pennsylvania	42000
3	Virginia	51000
3	West Virginia	54000
4	Alabama	1000
4	Florida	12000
4	Georgia	13000
4	Kentucky	21000
4	Mississippi	28000
4	North Carolina	37000
4	South Carolina	45000
4	Tennessee	47000
5	Illinois	17000
5	Indiana	18000
5	Michigan	26000
5	Minnesota	27000
5	Ohio	39000
5	Wisconsin	55000
6	Arkansas	5000
6	Lousiana	22000
6	New Mexico	35000
6	Oklahoma	40000
6	Texas	48000
7	Iowa	19000
7	Kansas	20000
7	Missouri	29000
7	Nebraska	31000

Table A.2. con't.

FEDERAL REGION	STATE	FIPS
8	Colorado	8000
8	Montana	30000
8	North Dakota	38000
8	South Dakota	46000
8	Utah	49000
8	Wyoming	56000
9	Arizona	4000
9	California	6000
9	Hawaii	15000
9	Nevada	32000
10	Alaska	2000
10	Idaho	16000
10	Oregon	41000
10	Washington	53000

APPENDIX B

State-Level Per Capita Fuel Consumption,
Compounded Annual Growth,
1970-1981

Table B.1. Compounded growth rates of per capita consumption, by fuel and state for New England 1970-1981

FIPS	STATE	DF	ES	KS	LG	NG	SC	TOTAL
9000	CT	-1.13	2.47	-8.87	-3.32	0.28	9.35	-0.46
23000	ME	-4.81	4.03	-17.29	-2.44	-0.45	3.77	-3.61
25000	MA	-6.46	1.95	-17.24	-2.85	1.27	5.76	-3.43
33000	NH	-6.94	2.58	-12.50	-0.56	-0.45	-3.65	-3.17
44000	RI	-7.21	2.45	-16.37	-2.71	1.66	9.96	-3.79
50000	VT	-7.05	1.75	-9.11	-1.06	0.48	-0.23	-3.93
Total		-5.14	2.42	-13.88	-1.90	0.80	4.88	-2.80

Table B.2. Compounded growth rates of per capita consumption, by fuel and state for New York/New Jersey 1970-1981

FIPS	STATE	DF	ES	KS	LG	NG	SC	TOTAL
34000	NJ	-3.44	2.26	-12.07	0.51	0.01	-12.57	-0.96
36000	NY	-4.48	2.03	-10.92	-0.39	0.01	-4.53	-1.85
Total		-4.04	2.13	-11.14	-0.20	0.01	-6.42	-1.56

Table B.3. Compounded growth rates of per capita consumption, by fuel and state for Mid Atlantic 1970-1981

FIPS	STATE	DF	ES	KS	LG	NG	SC	TOTAL
10000	DE	-6.74	1.16	-3.92	-0.30	-2.08	-16.88	-2.99
24000	MD	-3.36	3.78	-11.23	-1.62	-0.73	-3.06	-1.12
42000	PA	-2.36	2.89	-4.72	-0.70	-0.47	-5.16	-1.28
51000	VA	-6.29	3.90	-14.75	-1.96	-1.21	-11.48	-1.34
54000	WV	11.06	5.08	-0.80	2.21	-2.96	-0.97	-0.07
Total		-3.33	3.54	-8.97	-0.89	-1.02	-5.63	-1.22

Table B.4. Compounded growth rates of per capita consumption, by fuel and state for South Atlantic 1970-1981

FIPS	STATE	DF	ES	KS	LG	NG	SC	TOTAL
1000	AL	-7.67	1.75	-3.34	-6.69	-2.18	-4.13	-2.01
12000	FL	-3.86	2.05	-15.42	-5.57	-2.73	a	1.26
13000	GA	-4.46	2.66	-12.47	-4.00	-1.34	-12.81	-0.59
21000	KY	1.99	5.04	-13.62	-6.62	-3.06	-0.72	-2.45
28000	MS	-30.07	1.79	-9.46	-9.30	-3.59	a	-3.37
37000	NC	-5.37	3.46	-15.10	-2.41	0.25	-10.79	-3.27
45000	SC	-6.36	3.43	-12.71	-3.32	-1.87	-7.52	-1.60
47000	TN	8.10	1.39	-8.49	-11.20	-2.50	-11.14	-1.73
Total		-5.14	2.60	-13.96	-6.12	-2.63	-7.16	-1.63

[a] Consumption is zero throughout the 1970-1981 period.

Table B.5. Compounded growth rates of per capita consumption, by fuel and state for Midwest 1970-1981

FIPS	STATE	DF	ES	KS	LG	NG	SC	TOTAL
17000	IL	-13.16	1.83	-18.31	-6.84	0.23	-17.46	-1.08
18000	IN	-6.40	2.70	-11.03	-6.52	-0.54	-7.35	-1.23
26000	MI	-7.91	1.77	-8.78	-4.36	0.17	-13.13	-1.10
27000	MN	-4.26	2.11	-19.74	-8.59	-1.28	-12.99	-1.92
39000	OH	-4.50	3.47	-9.43	-3.46	-1.96	-7.02	-1.81
55000	WI	-4.59	2.44	-25.07	-7.31	-0.16	-26.83	-1.80
Total		-6.71	2.46	-13.20	-6.32	-0.60	-12.56	-1.42

Table B.6. Compounded growth rates of per capita consumption, by fuel and state for Southwest 1970-1981

FIPS	STATE	DF	ES	KS	LG	NG	SC	TOTAL
5000	AR	-12.17	4.54	-12.18	-13.08	-4.61	b	-4.38
22000	LA	a	4.35	1.59	-9.21	-2.05	b	-1.05
35000	NM	14.64	1.80	7.49	-10.35	-4.44	15.25	-3.78
40000	OK	35.65	3.82	-12.19	-11.56	-2.71	-2.73	-2.30
48000	TX	-25.46	2.72	9.08	-10.45	-3.44	10.97	-1.60
Total		-5.99	3.34	-2.08	-11.25	-3.39	4.70	-2.09

a Consumption is zero after 1979.

b Consumption is zero throughout the 1970-1981 period.

Table B.7. Compounded growth rates of per capita consumption, by fuel and state for Central 1970-1981

FIPS	STATE	DF	ES	KS	LG	NG	SC	TOTAL
19000	IA	-1.23	3.58	-3.18	-6.24	-2.34	2.67	-1.80
20000	KS	-9.45	2.69	-20.39	-10.15	-2.95	-10.51	-2.60
29000	MO	0.14	4.42	0.40	-6.53	-2.31	1.38	-1.37
31000	NE	5.70	2.26	-21.30	-10.24	-3.17	-7.26	-2.77
Total		-0.40	3.55	-8.59	-7.64	-2.60	1.17	-1.95

Table B.8. Compounded growth rates of per capita consumption, by fuel and state for North Central 1970-1981

FIPS	STATE	DF	ES	KS	LG	NG	SC	TOTAL
8000	CO	-12.25	4.54	-8.10	-6.38	-3.60	-9.74	-2.13
30000	MT	-0.41	4.67	a	-6.51	-4.50	-5.36	-3.46
38000	ND	-0.92	5.33	-21.59	-6.84	0.15	1.54	-1.69
46000	SD	-1.13	3.88	-0.35	-7.43	-3.48	5.78	-3.86
49000	UT	-9.03	3.20	9.93	-8.63	-1.49	2.61	-0.05
56000	WY	3.13	5.61	-16.47	-6.70	-9.55	12.93	-4.77
Total		-3.25	4.35	-11.69	-7.29	-3.19	-0.30	-2.21

[a] Consumption is zero throughout the 1970-1981 period.

Table B.9. Compounded growth rates of per capita consumption, by fuel and state for West (excluding Hawaii) 1970-1981

FIPS	STATE	DF	ES	KS	LG	NG	SC	TOTAL
4000	AZ	-36.81	3.04	a	-6.83	-5.19	b	-0.05
6000	LA	-17.64	1.79	-9.04	-3.48	-2.89	-31.29	-2.27
32000	NV	-11.34	0.17	b	-8.80	0.36	-21.82	1.41
Total		-14.21	2.07	-8.93	-4.18	-3.13	-25.32	-2.05

[a] Consumption is zero after 1979.

[b] Consumption is zero throughout the 1970-1981 period.

Table B.10. Compounded growth rates of per capita consumption, by fuel and state for Northwest (excluding Alaska) 1970-1981

FIPS	STATE	DF	ES	KS	LG	NG	SC	TOTAL
16000	AK	-8.56	4.47	a	-10.52	-3.98	-9.00	-0.95
41000	ID	-3.97	0.43	-1.34	-5.33	-3.48	b	-1.66
53000	WA	-9.26	3.71	12.73	-6.81	-3.54	10.33	-1.02
Total		-7.57	2.76	9.51	-7.20	-3.65	-3.48	-1.24

[a] Consumption is zero after 1979.

[b] Consumption is zero in 1981.

APPENDIX C

Literature Review Bibliography

BIBLIOGRAPHY

Barnes, Roberta, Robert Gillingham and Robert Hagemann, "The Short-Run Residential Demand for Electricity," The Review of Economics and Statistics, Vol. LXIII, No. 4, November 1981, pp. 541-552.

Baltagi, Badi H. and James M. Griffin, "U.S. Gasoline Demand: What Next?," The Energy Journal, Vol. 5, No. 1, January 1984, pp. 129-140.

Beierlein, James G., James W. Dunn and James C. McConnon, Jr., "The Demand for Electricity and Natural Gas in the Northeastern United States," The Review of Economics and Statistics, Vol. LXIII, No. 3, August 1981, pp. 403-408.

Blattenberger, Gail R., Lester D. Taylor and Robert K. Rennhack, "Natural Gas Availability and the Residential Demand for Energy," The Energy Journal, Vol. 4, No. 1, January 1983, pp. 23-45.

Bloch, Farrell E., "Residential Demand for Natural Gas," Journal of Urban Economics, Vol. 7, No. 3, May 1980, pp. 371-383.

Brown, Scott B., "An Aggregate Petroleum Consumption Model," Energy Economics, Vol. 5, No. 1, January 1983, pp. 27-30.

Dahl, Carol A., "An Analysis of the Short-Run Consumer Demand for Gasoline Using Household Survey Data: A Comment," The Review of Economics ansd Statistics, Vol. LXV, No. 3, August 1983, pp. 532-534.

Drollas, Leonidas P., "The Demand for Gasoline, Further Evidence," Energy Economics, Vol. 6, No. 1, January 1984, pp. 71-82.

Dubin, Jeffrey A. and Daniel L. McFadden, "An Econometric Analysis of Residential Electric Appliance Holdings and Consumption," Econometrica, Vol. 52, No. 2, March 1984, pp. 345-362.

Garbacz, Christopher, "Electricity Demand and the Elasticity of Intra-Marginal Price," Applied Economics, Vol. 15, No. 5, October 1983, pp. 699-701.

Garbacz, Christopher, "A Model of Residential Demand for Electricity Using a National Household Sample," Energy Economics, Vol. 5, No. 2, April 1983, pp. 124-128.

Garbacz, Christopher, "Residential Electricity Demand: A Suggested Appliance Stock Equation," The Energy Journal, Vol. 5, No. 2, April 1984, pp. 151-154.

Gillingham, Robert and Robert P. Hagemann, "Household Demand for Fuel Oil," Applied Economics, Vol. 16, No. 4, August 1984, pp. 475-482.

Green, David Jay, "A Small Scale Partial Equilibrium Model of Natural Gas Markets: Responses to Alternative Deregulation Scenarios and Oil Price Changes," Southern Economic Journal, Vol. 50. No. 4, April 1984, pp. 1112-1130.

Hartman, Raymond S. and Alix Werth, "Short-Run Residential Demand for Fuels: A Disaggregated Approach," Land Economics, Vol. 57, No. 2, May 1981, pp. 197-212.

Ironmonger, Duncan, Ian Manning and Tran Van Hoa, "Longitudinal Working Models, Estimates of Household Energy Consumption in Australia," Energy Economics, Vol. 6, No. 1, January 1984, pp. 41-46.

Lakshmanan, T.R., "A Multiregional Model of the Economy, Environment, and Energy Demand in the United States," Economic Geography, July 1983, pp. 296-320.

Maddigan R.J. and C.G. Rizy, "Modeling Deamnd and Supply Interactions to Forecast Load Growth for Electricity Distribution Systems," Energy, Vol. 9, No. 2, February 1984, pp. 149-162.

Maddigan, Ruth J., Wen S. Chern and Colleen Gallagher Rizy, "The Irrigation Demand for Electricity," American Journal of Agricultural Economics, Vol. 64, No. 4, November 1982, pp. 673-680.

Maddigan, Ruth J., Wen S. Chern and Colleen Gallagher Rizy, "Rural Residential Denmand for Electricity," Land Economics, Vol. 59, No. 2, May 1983, pp. 150-162.

Reister, David B., "Energy Conservation--The Post-Embargo Record," Energy, Vol. 7, No. 5, 1982, pp. 403-411.

Roth, Timothy P., "Average and Marginal Price Changes and the Demand for Electricity: An Econometric Study," Applied Economics, Vol. 13, No. 3, September 1981, pp. 377-388.

Roth, T.P., "Electricity Demand Estimation Using Proxy Variables: Some Reservations," Applied Economics, Vol. 15, No. 5, October 1983, pp. 703-704.

Uri, Noel D., "The Regional Demand for Energy by the Residential Sector in the United States," Applied Energy, Vol. 13, No. 1, January 1983, pp. 23-44.

Wilkinson, Jack W., "The Supply, Demand, and Average Price of Natural Gas under Free-Market Conditions," The Energy Journal, Vol. 4, No. 1, January 1983, pp. 99-123.

APPENDIX D

SUR and OLS Estimation Results

Table D.1. Comparison of SUR and OLS results for New England[a]

Independent Variable	LQTES SUR	LQTES OLS	LQTDF SUR	LQTDF OLS
Intercept	-2.077 (-2.11)	-2.130 (-2.14)	-4.538 (-1.13)	-4.001 (-1.03)
LPRES	-0.199 (-5.10)	-0.185 (-4.65)		
LPRDF			-0.418 (-5.74)	-0.418 (-5.67)
LES	0.774 (17.54)	0.772 (17.19)		
LDF			0.699 (6.52)	0.679 (6.21)
LRPCI	0.355 (2.89)	0.344 (2.77)	0.920 (1.91)	0.902 (1.86)
LPOP				
LCDD				
LHDD	0.177 (2.45)	0.193 (2.60)		
D1	0.070 (1.41)	0.067 (1.33)	0.318 (2.77)	0.323 (2.79)
D2	0.026 (0.92)	0.023 (0.81)	0.089 (1.67)	0.089 (1.68)
D3	-0.079 (-2.53)	-0.082 (-2.56)	0.012 (0.13)	-0.0003 (-0.004)
D4	0.377 (4.76)	0.380 (4.71)	0.512 (2.54)	0.552 (2.69)
D5	0.248 (4.32)	0.254 (4.34)	0.182 (1.44)	0.206 (1.60)

[a] The figures in parentheses are asymptotic t-ratios.

Table D.2. Comparison of SUR and OLS results for New York/New Jersey[a]

Independent Variable	Dependent Variable: LQTES SUR	LQTES OLS	LQTDF SUR	LQTDF OLS
Intercept	-1.439 (-0.92)	-1.330 (-0.85)	-18.584 (-0.93)	-17.136 (-0.85)
LPRES	-0.148 (-1.88)	-0.124 (-1.56)		
LPRDF			-0.229 (-2.04)	-0.245 (-2.17)
LES	0.960 (7.96)	0.929 (7.63)		
LDF			0.613 (2.88)	0.587 (2.74)
LRPCI				
LPOP			2.288 (1.13)	2.167 (1.06)
LCDD	0.140 (2.51)	0.150 (2.66)		
LHDD	0.153 (1.36)	0.165 (1.46)	0.353 (0.81)	0.348 (0.80)
D1	0.044 (0.55)	0.066 (0.81)	-1.853 (-1.00)	-1.728 (-0.92)

[a] The figures in parentheses are asymptotic t-ratios.

Table D.3. Comparison of SUR and OLS Results for Mid Atlantic[a]

Independent Variable	Dependent Variable			
	LQTES		LQTDF	
	SUR	OLS	SUR	OLS
Intercept	-2.127 (-1.56)	-1.991 (-1.46)	-15.179 (-1.78)	-17.036 (-1.98)
LPRES	-0.096 (-1.12)	-0.106 (-1.23)		
LPRDF			-0.337 (-3.79)	-0.355 (-3.96)
LES	0.800 (12.66)	0.807 (12.73)		
LDF			0.628 (6.11)	0.634 (6.13)
LRPCI	0.399 (2.51)	0.398 (2.51)	1.148 (2.21)	1.190 (2.29)
LPOP			1.147 (1.60)	1.316 (1.82)
LCDD	0.141 (2.84)	0.126 (2.53)		
LHDD	0.025 (0.16)	0.015 (0.09)		
D1	0.157 (3.27)	0.152 (3.13)	-0.517 (-0.88)	-0.671 (-1.13)
D2	-0.133 (-2.59)	-0.129 (-2.51)	-0.075 (-0.76)	-0.069 (-0.70)
D3	-0.520 (-3.04)	-0.501 (-2.92)	1.715 (1.16)	2.087 (1.40)
D4	-0.118 (-1.30)	-0.114 (-1.25)	0.508 (0.71)	0.704 (0.98)

[a] The figures in parentheses are asymptotic t-ratios.

Table D.4. Comparison of SUR and OLS Results for South Atlantic[a]

Independent Variable	Dependent Variable LQTES SUR	OLS	LQTDF SUR	OLS
Intercept	-3.094 (-3.35)	-3.001 (-3.25)	-9.808 (-1.03)	-9.539 (-1.07)
LPRES	-0.103 (-1.64)	-0.102 (-1.62)		
LPRDF			-0.671 (-3.73)	-0.662 (-3.67)
LES	0.762 (15.99)	0.768 (16.07)		
LDF			0.965 (8.79)	0.965 (8.77)
LRPCI	0.296 (2.31)	0.288 (2.24)	0.829 (0.68)	0.805 (0.66)
LPOP				
LCDD	0.262 (5.94)	0.254 (5.74)		
LHDD	0.173 (3.30)	0.170 (3.23)	0.441 (0.83)	0.430 (0.81)
D1	0.051 (1.04)	0.049 (1.00)	0.043 (0.12)	0.052 (0.14)
D2	0.190 (2.96)	0.184 (2.85)	0.131 (0.41)	0.140 (0.43)
D3	0.226 (5.19)	0.220 (5.05)	0.197 (0.41)	0.202 (0.42)
D4	0.059 (2.56)	0.058 (2.52)	0.301 (0.86)	0.302 (0.86)
D5	0.137 (3.73)	0.134 (3.64)	0.178 (0.59)	0.183 (0.61)
D6	0.381 (3.62)	0.375 (3.56)	0.748 (0.84)	0.740 (0.83)
D7	0.095 (3.05)	0.092 (2.96)	0.109 (0.41)	0.113 (0.43)

[a] The figures in parentheses are asymptotic t-ratios.

Table D.5. Comparison of SUR and OLS Results for Midwest[a]

Independent Variable	Dependent Variable			
	LQTES		LQTDF	
	SUR	OLS	SUR	OLS
Intercept	-6.026 (-2.73)	-6.017 (-2.72)	0.213 (0.07)	0.211 (0.07)
LPRES	-0.013 (-0.21)	-0.013 (-0.21)		
LPRDF			-0.370 (-5.43)	-0.370 (-5.43)
LES	0.664 (12.42)	0.664 (12.42)		
LDF			0.914 (9.15)	0.915 (9.16)
LRPCI	0.197 (2.66)	0.197 (0.45)		
LPOP	0.741 (2.45)	0.739 (2.67)		
LCDD	0.072 (3.36)	0.072 (3.36)		
LHDD	0.149 (2.77)	0.149 (2.77)	0.104 (0.29)	0.104 (0.29)
D1	-0.370 (-1.36)	-0.369 (-1.36)	0.050 (0.31)	0.049 (0.31)
D2	-0.044 (-0.55)	-0.043 (-0.54)	0.027 (0.17)	0.027 (0.17)
D3	-0.480 (-1.68)	-0.479 (-1.68)	-0.034 (-0.22)	-0.034 (-0.23)
D4	-0.385 (-1.67)	-0.384 (-1.67)	0.052 (0.34)	0.051 (0.34)
D5	-0.044 (-1.03)	-0.044 (-1.02)	0.044 (0.45)	0.044 (0.45)

[a] The figures in parentheses are asymptotic t-ratios.

Table D.6. Comparison of SUR and OLS Results for Southwest[a]

Independent Variable	LQTES SUR	LQTES OLS	LQTDF SUR	LQTDF OLS
Intercept	-2.899 (-2.93)	-2.896 (-2.91)	1.114 (0.08)	1.270 (0.10)
LPRES	-0.104 (-1.35)	-0.079 (-1.03)		
LPRDF			-0.294 (-0.87)	-0.285 (-0.84)
LES	0.657 (9.68)	0.664 (9.73)		
LDF			0.808 (3.61)	0.812 (3.60)
LRPCI	0.298 (1.67)	0.287 (1.60)		
LPOP				
LCDD	0.352 (4.86)	0.351 (4.82)		
LHDD	0.160 (1.72)	0.156 (1.68)	-0.012 (-0.01)	-0.033 (-0.02)
D1	0.250 (2.17)	0.244 (2.10)	0.370 (0.31)	0.353 (0.30)
D2	0.392 (2.35)	0.383 (2.29)	-0.395 (-0.24)	-0.415 (-0.25)
D3	0.260 (2.16)	0.255 (2.11)	0.258 (0.39)	0.251 (0.38)
D4	0.754 (3.46)	0.736 (3.36)	0.259 (0.14)	0.231 (0.12)

[a] The figures in parentheses are asymptotic t-ratios.

Table D.7. Comparison of SUR and OLS Results for Central[a]

Independent Variable	LQTES SUR	LQTES OLS	LQTDF SUR	LQTDF OLS
Intercept	-9.439 (-1.94)	-9.994 (-1.94)	-21.010 (-3.08)	-21.227 (-3.11)
LPRES	-0.225 (-1.37)	-0.178 (-1.00)		
LPRDF			-0.140 (-0.76)	-0.169 (-0.90)
LES	0.726 (9.80)	0.726 (9.38)		
LDF			0.574 (2.96)	0.609 (3.02)
LRPCI				
LPOP	1.200 (1.59)	1.258 (1.57)		
LCDD	0.278 (4.22)	0.297 (4.19)		
LHDD	0.205 (1.94)	0.194 (1.82)	2.775 (3.60)	2.773 (3.60)
D1	-0.499 (-1.15)	-0.540 (-1.18)	0.564 (1.23)	0.486 (1.02)
D2	-1.030 (-1.31)	-1.110 (-1.33)	1.219 (2.96)	1.155 (2.72)
D3	-0.423 (-1.54)	-0.461 (-1.59)	0.124 (0.48)	0.150 (0.57)

Dependent Variable: LQTES, LQTDF.

[a] The figures in parentheses are asymptotic t-ratios.

Table D.8. Comparison of SUR and OLS Results for North Central[a]

Independent Variable	Dependent Variable LQTES SUR	LQTES OLS	LQTDF SUR	LQTDF OLS
Intercept	-3.701 (-2.92)	-3.482 (-2.74)	-20.219 (-3.21)	-19.720 (-3.13)
LPRES	-0.060 (-0.85)	-0.060 (-0.86)		
LPRDF			-0.125 (-0.97)	-0.117 (-0.91)
LES	0.836 (13.98)	0.849 (14.11)		
LDF			0.815 (7.77)	0.769 (7.28)
LRPCI				
LPOP	0.462 (3.36)	0.421 (3.04)		
LCDD				
LHDD	0.210 (2.12)	0.207 (2.09)	2.424 (3.49)	2.405 (3.46)
D1	0.407 (2.78)	0.364 (2.46)	-0.305 (-1.14)	-0.240 (-0.90)
D2	0.419 (2.95)	0.377 (2.63)	0.129 (0.76)	0.172 (1.02)
D3	0.369 (2.89)	0.330 (2.56)	-0.020 (-0.11)	0.019 (0.11)
D4	0.565 (3.12)	0.511 (2.80)	-0.504 (-1.76)	-0.612 (-2.13)
D5	0.219 (3.02)	0.199 (2.73)	0.265 (1.83)	0.268 (1.85)

[a] The figures in parentheses are asymptotic t-ratios.

Table D.9. Comparison of SUR and OLS Results for West[a]

Independent Variable	Dependent Variable: LQTES SUR	LQTES OLS	LQTDF SUR	LQTDF OLS
Intercept	-6.653 (-5.32)	-6.901 (-5.46)	-72.766 (-1.76)	-74.896 (-1.79)
LPRES	-0.118 (-2.28)	-0.149 (-2.71)		
LPRDF			-1.407 (-2.44)	-1.246 (-2.13)
LES	0.672 (10.60)	0.679 (10.17)		
LDF			0.665 (3.63)	0.650 (3.35)
LRPCI	0.821 (7.47)	0.831 (7.54)	5.654 (1.43)	5.496 (1.51)
LPOP	0.241 (2.61)	0.255 (2.61)		
LCDD				
LHDD	0.177 (2.86)	0.178 (2.85)	3.536 (1.43)	3.981 (1.58)
D1	0.156 (1.09)	0.204 (1.35)	0.789 (0.92)	0.794 (0.93)
D2	-0.169 (-0.82)	-0.111 (-0.51)	-1.930 (-1.43)	-2.158 (-1.57)

[a] The figures in parentheses are asymptotic t-ratios.

Table D.10. Comparison of SUR and OLS Results for Northwest[a]

Independent Variable	Dependent Variable LQTES SUR	LQTES OLS	LQTDF SUR	LQTDF OLS
Intercept	-3.779 (-1.58)	-3.728 (-1.57)	-19.548 (-2.37)	-19.570 (-2.39)
LPRES	-0.266 (-2.50)	-0.268 (-2.52)		
LPRDF			-0.456 (-3.93)	-0.453 (-3.90)
LES	0.644 (6.23)	0.643 (6.22)		
LDF			0.315 (1.87)	0.316 (1.88)
LRPCI			1.344 (2.89)	1.327 (2.87)
LPOP	0.692 (3.25)	0.693 (3.25)		
LCDD	0.066 (1.90)	0.064 (1.84)		
LHDD	0.287 (1.40)	0.284 (1.39)	1.650 (2.09)	1.658 (2.10)
D1	-0.426 (-2.25)	-0.428 (-2.26)	1.303 (3.53)	1.303 (3.53)
D2	-0.216 (-1.82)	-0.217 (-1.83)	1.153 (3.45)	1.155 (3.45)

[a] The figures in parentheses are asymptotic t-ratios.

APPENDIX E

Data Sources

VARIABLE	DEFINITION	UNIT	SOURCE
QTES	electricity consumption	10^9 Btu	Energy Price and Expenditure Data Report, 1970-1981 (State and U.S. Total), DOE/EIA-0376.
QTDF	distillate fuel consumption	10^9 Btu	Energy Price and Expenditure Data Report, 1970-1981 (State and U.S. Total), DOE/EIA-0376.
PRES	electricity price	$\$/10^6$ Btu	Energy Price and Expenditure Data Report, 1970-1981 (State and U.S. Total), DOE/EIA-0376.
PRDF	distillate fuel price	$\$/10^6$ Btu	Energy Price and Expenditure Data Report, 1970-1981 (State and U.S. Total), DOE/EIA-0376.
INC	personal income	10^6 $	U.S. Bureau of the Census, Statistical Abstract of the United States, U.S. Government Printing Office, Washington, DC, selected issues.
POP	population	10^3	U.S. Bureau of the Census, Current Population Reports, U.S. Government Printing Office, Washington, DC, selected years.
HDD	heating degree days	state CDD and HDD data are weighted averages over divisions using population as the weighting factors	U.S. Department of Commerce, State, Regional and National Monthly and Seasonal Heating Degree Days Weighted by Population, National Oceanic and Atmospheric Administration, Asheville, NC, selected issues.
CDD	cooling degree days		U.S. Department of Commerce, State, Regional and National Monthly and Seasonal Cooling Degree Days Weighted by Population, National Oceanic and Atmospheric Administration, Asheville, NC, selected issues.

VARIABLE	DEFINITION	UNIT	SOURCE
CPI	consumer price index	=1.0 in 1972	U.S. Bureau of the Census, _Statistical Abstract of the United States_, U.S. Government Printing Office, Washington, DC, selected issues.
RPCI	real per capita income	10^3 $	INC÷(POP·CPI)

APPENDIX F

Compounded Annual Growth Rates (1970-1981 and 1982-2000)
of Electricity and Distillate Fuel Consumption,
by State

Table F.1. Compounded annual growth rates for New England

	Distillate Fuel				Electricity			
	Level		Per Capita		Level		Per Capita	
	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000
9000	-0.86	-11.55	-1.13	-11.58	2.74	0.62	2.47	0.57
23000	-3.67	-15.80	-4.81	-16.76	5.28	-3.30	4.03	-4.40
25000	-6.36	-11.60	-6.46	-11.44	2.06	0.76	1.95	0.94
33000	-4.90	-12.34	-6.94	-14.61	4.83	-1.54	2.58	-4.09
44000	-7.19	-14.97	-7.21	-15.42	2.47	-2.02	2.45	-2.54
50000	-5.80	-14.63	-7.05	-16.00	3.13	2.35	1.75	0.71

Table F.2. Compounded annual growth rates for New York/New Jersey

	Distillate Fuel				Electricity			
	Level		Per Capita		Level		Per Capita	
	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000
34000	-3.15	-5.98	-3.44	-6.16	2.56	-1.04	2.26	-1.23
36000	-4.79	-10.43	-4.48	-9.89	1.70	-1.46	2.03	-0.87

Table F.3. Compounded annual growth rates for the Mid Atlantic

	Distillate Fuel				Electricity			
	Level		Per Capita		Level		Per Capita	
	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000
10000	-6.02	-9.91	-6.74	-10.34	1.94	-0.99	1.16	-1.46
24000	-2.97	-8.56	-3.36	-11.54	4.20	-3.22	3.78	-6.37
42000	-2.29	-9.66	-2.36	-9.68	2.96	0.98	2.89	0.95
51000	-4.95	-4.13	-6.29	-5.60	5.39	0.86	3.90	-0.68
54000	12.25	-10.44	11.06	-11.75	6.20	-0.10	5.08	-1.56

Table F.4. Compounded annual growth rates for the South Atlantic

	Distillate Fuel				Electricity			
	Level		Per Capita		Level		Per Capita	
	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000
1000	-6.56	-64.42	-7.67	-64.91	2.97	-0.75	1.75	-2.11
12000	-0.25	-55.01	-3.86	-56.69	5.88	1.23	2.05	-2.55
13000	-2.76	-61.47	-4.46	-62.34	4.48	0.56	2.66	-1.71
21000	3.23	-64.74	1.99	-65.23	6.31	-1.74	5.04	-3.10
28000	-29.18	-68.97	-30.07	-69.46	3.09	-0.31	1.79	-1.88
37000	-4.02	-62.62	-5.37	-63.26	4.94	0.16	3.47	-1.54
45000	-4.61	-58.87	-6.36	-59.78	5.37	0.22	3.43	-2.00
47000	9.73	-63.78	8.10	-64.46	2.92	-0.98	1.39	-2.83

Table F.5. Compounded annual growth rates for the Midwest

	Distillate Fuel				Electricity			
	Level		Per Capita		Level		Per Capita	
	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000
17000	-12.91	-35.11	-13.16	-35.38	2.12	0.68	1.83	0.26
18000	-5.92	-34.17	-6.40	-34.63	3.22	1.13	2.70	0.43
26000	-7.60	-36.33	-7.91	-36.48	2.11	0.31	1.77	0.08
27000	-3.58	-32.88	-4.26	-33.37	2.83	2.12	2.11	1.38
39000	-4.38	-34.72	-4.50	-34.86	3.60	0.23	3.47	0.03
55000	-3.99	-32.60	-4.59	-32.96	3.09	1.51	2.44	0.96

Table F.6. Compounded annual growth rates for the Southwest

	Distillate Fuel				Electricity			
	Level		Per Capita		Level		Per Capita	
	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000
5000	-10.73	-13.90	12.17	-15.38	6.26	0.09	4.54	-1.64
22000	a	a	a	a	5.94	0.46	4.35	-1.78
35000	17.51	-17.05	14.64	-19.23	4.35	-0.41	1.80	-3.02
40000	38.05	-21.15	35.65	-22.94	5.65	5.61	3.82	3.21
48000	-23.57	-11.88	-25.46	-14.75	5.32	0.38	2.72	-2.89

[a] Consumption is zero after 1979.

Table F.7. Compounded annual growth rates for the Central

	Distillate Fuel				Electricity			
	Level		Per Capita		Level		Per Capita	
	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000
19000	-0.94	-6.05	-1.23	-6.35	3.88	0.36	3.58	0.04
20000	-8.96	-1.42	-9.45	-2.06	3.25	0.98	2.69	0.32
29000	0.64	-5.13	0.14	-5.75	4.94	4.08	4.42	3.39
31000	6.32	-6.80	5.70	-7.15	2.86	1.62	2.26	1.23

Table F.8. Compounded annual growth rates for the North Central

	Distillate Fuel				Electricity			
	Level		Per Capita		Level		Per Capita	
	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000
8000	-9.82	-10.52	-12.25	-13.06	7.44	7.09	4.54	4.05
30000	0.84	-10.34	-0.41	-11.33	5.98	3.26	4.67	2.12
38000	-0.32	-15.44	-0.92	-15.90	5.98	0.90	5.33	0.35
46000	-0.78	-15.80	-1.13	-15.95	4.24	-0.46	3.88	-0.63
49000	-5.97	-10.15	-9.03	-13.95	6.68	10.94	3.20	6.25
56000	6.91	-12.72	3.13	-16.72	9.47	12.04	5.61	6.91

Table F.9. Compounded annual growth rates for the West

	Distillate Fuel				Electricity			
	Level		Per Capita		Level		Per Capita	
	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000
4000	-34.12	-13.40	-36.81	-17.00	7.44	5.50	3.04	1.11
6000	-16.17	-15.55	-17.64	-17.52	3.60	3.89	1.79	1.46
32000	-6.83	-26.27	-11.34	-30.90	5.27	6.28	0.18	-0.40

Table F.10. Compounded annual growth rates for the Northwest

	Distillate Fuel				Electricity			
	Level		Per Capita		Level		Per Capita	
	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000	1970-81	1982-2000
16000	-6.02	-7.28	-8.56	-9.99	7.37	6.06	4.47	2.96
41000	-1.82	-6.96	-3.97	-9.46	2.68	3.60	0.43	0.82
53000	-7.46	-6.22	-9.26	-9.16	5.78	5.58	3.71	2.27

APPENDIX G

Regression Results with Cross Prices

Table G.1. Comparison of SUR results, with and without cross prices, for New England[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-2.077 (-2.11)	-1.581 (-1.40)	-4.538 (-1.13)	-5.501 (-1.45)
LPRES	-0.199 (-5.10)	-0.199 (-4.34)		0.425 (2.29)
LPRDF		0.014 (0.73)	-0.418 (-5.74)	-0.516 (-6.13)
LES	0.774 (17.54)	0.750 (15.17)		
LDF			0.699 (6.52)	0.692 (6.74)
LRPCI	0.355 (2.89)	0.335 (2.66)	0.920 (1.91)	0.952 (2.04)
LPOP				
LCDD				
LHDD	0.177 (2.45)	0.162 (2.21)		
D1	0.070 (1.41)	0.080 (1.61)	0.318 (2.77)	0.432 (3.52)
D2	0.026 (0.92)	0.034 (1.18)	0.089 (1.67)	0.131 (2.39)
D3	-0.079 (-2.53)	-0.081 (-2.45)	0.012 (0.13)	0.138 (1.34)
D4	0.377 (4.76)	0.423 (4.66)	0.512 (2.54)	0.529 (2.73)
D5	0.248 (4.32)	0.287 (4.22)	0.182 (1.44)	0.229 (1.85)

[a]The figures in parentheses are asymptotic t-ratios.

Table G.2. Comparison of SUR results, with and without cross prices, for New York/ New Jersey[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-1.439 (-0.92)	-2.890 (-1.40)	-18.584 (-0.93)	-8.315 (-0.42)
LPRES	-0.148 (-1.88)	-0.101 (-1.23)		0.558 (1.79)
LPRDF		-0.034 (-1.15)	-0.229 (-2.04)	-0.474 (-2.83)
LES	0.960 (7.96)	1.032 (6.95)		
LDF			0.613 (2.88)	0.415 (1.85)
LRPCI				
LPOP			2.288 (1.13)	1.378 (0.70)
LCDD	0.140 (2.51)	0.170 (2.88)		
LHDD	0.153 (1.36)	0.197 (1.70)	0.353 (0.81)	0.245 (0.59)
D1	0.044 (0.55)	-0.004 (-0.04)	-1.853 (-1.00)	-0.929 (-0.51)

[a]The figures in parentheses are asymptotic t-ratios.

Table G.3. Comparison of SUR results, with and without cross prices, for Mid Atlantic[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-2.127 (-1.56)	-2.464 (-1.72)	-15.179 (-1.78)	-16.773 (-1.90)
LPRES	-0.096 (-1.12)	-0.097 (-1.12)		-0.166 (-0.55)
LPRDF		-0.038 (-0.78)	-0.337 (-3.79)	-0.332 (-3.57)
LES	0.800 (12.66)	0.882 (7.28)		
LDF			0.628 (6.11)	0.603 (5.28)
LRPCI	0.399 (2.51)	0.348 (2.01)	1.148 (2.21)	1.296 (2.26)
LPOP			1.147 (1.60)	1.259 (1.71)
LCDD	0.141 (2.84)	0.140 (2.83)		
LHDD	0.025 (0.16)	0.014 (0.09)		
D1	0.157 (3.27)	0.114 (1.57)	-0.157 (-0.88)	-0.561 (-0.94)
D2	-0.133 (-2.59)	-0.092 (-1.29)	-0.075 (-0.76)	-0.068 (-0.68)
D3	-0.520 (-3.04)	-0.323 (-1.07)	1.715 (1.16)	1.944 (1.29)
D4	-0.118 (-1.30)	-0.031 (-0.22)	0.508 (0.71)	0.566 (0.78)

[a]The figures in parentheses are asymptotic t-ratios.

Table G.4. Comparison of SUR results, with and without cross prices, for South Atlantic[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-3.094 (-3.35)	-2.771 (-2.88)	-9.808 (-1.03)	-6.733 (-0.68)
LPRES	-0.103 (-1.64)	-0.138 (-1.89)		0.789 (1.04)
LPRDF		0.036 (1.13)	-0.671 (-3.73)	-0.803 (-3.56)
LES	0.762 (15.99)	0.699 (9.97)		
LDF			0.965 (8.79)	0.965 (8.82)
LRPCI	0.296 (2.31)	0.347 (2.55)	0.829 (0.68)	0.427 (0.33)
LPOP				
LCDD	0.262 (5.94)	0.255 (5.67)		
LHDD	0.173 (3.30)	0.175 (3.33)	0.441 (0.83)	0.285 (0.52)
D1	0.051 (1.04)	0.040 (0.79)	0.043 (0.12)	0.276 (0.65)
D2	0.190 (2.96)	0.226 (3.27)	0.131 (0.41)	0.519 (1.06)
D3	0.226 (5.19)	0.263 (5.02)	0.197 (0.41)	0.292 (0.61)
D4	0.059 (2.56)	0.061 (2.64)	0.301 (0.86)	0.321 (0.92)
D5	0.137 (3.73)	0.162 (3.90)	0.178 (0.59)	0.289 (0.91)
D6	0.381 (3.62)	0.463 (3.68)	0.748 (0.84)	0.560 (0.61)
D7	0.095 (3.05)	0.117 (3.30)	0.109 (0.41)	0.222 (0.79)

[a]The figures in parentheses are asymptotic t-ratios.

Table G.5. Comparison of SUR results, with and without cross prices, for Midwest[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-6.026 (-2.73)	-7.663 (-2.58)	0.213 (0.07)	0.867 (0.28)
LPRES	-0.013 (-0.21)	-0.017 (-0.27)		0.741 (1.70)
LPRDF		-0.021 (-0.82)	-0.370 (-5.43)	-0.417 (-5.75)
LES	0.664 (12.42)	0.737 (7.08)		
LDF			0.914 (9.15)	0.901 (9.14)
LRPCI	0.197 (2.66)	0.151 (1.62)		
LPOP	0.741 (2.45)	0.896 (2.52)		
LCDD	0.072 (3.36)	0.071 (3.25)		
LHDD	0.149 (2.77)	0.150 (2.78)	0.104 (0.29)	-0.114 (-0.30)
D1	-0.370 (-1.36)	-0.596 (-1.54)	0.050 (0.31)	-0.071 (-0.41)
D2	-0.044 (-0.55)	-0.125 (-0.98)	0.027 (0.17)	0.008 (0.05)
D3	-0.480 (-1.68)	-0.704 (-1.78)	-0.034 (-0.22)	-0.215 (-1.18)
D4	-0.385 (-1.67)	-0.560 (-1.78)	0.052 (0.34)	-0.056 (-0.35)
D5	-0.044 (-1.03)	-0.079 (-1.31)	0.044 (0.45)	0.023 (0.24)

Dependent Variable: LQTES, LQTDF.

[a]The figures in parentheses are asymptotic t-ratios.

Table G.6. Comparison of SUR results, with and without cross prices, for Southwest[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-2.899	-3.236	1.114	3.441
	(-2.93)	(-2.76)	(0.08)	(0.29)
LPRES	-0.104	-0.087		-4.245
	(-1.35)	(-1.09)		(-3.25)
LPRDF		-0.015	-0.294	-0.178
		(-0.48)	(-0.87)	(-0.57)
LES	0.657	0.679		
	(9.68)	(8.18)		
LDF			0.808	0.629
			(3.61)	(2.97)
LRPCI	0.298	0.324		
	(1.67)	(1.73)		
LPOP				
LCDD	0.352	0.354		
	(4.86)	(4.85)		
LHDD	0.160	0.147	-0.012	0.863
	(1.72)	(1.51)	(-0.01)	(0.58)
D1	0.250	0.220	0.370	0.640
	(2.17)	(1.63)	(0.31)	(0.59)
D2	0.392	0.338	-0.395	-0.613
	(2.35)	(1.61)	(-0.24)	(-0.41)
D3	0.260	0.221	0.258	-0.510
	(2.16)	(1.43)	(0.39)	(-0.79)
D4	0.754	0.672	0.259	0.793
	(3.46)	(2.36)	(0.14)	(0.47)

[a]The figures in parentheses are asymptotic t-ratios.

Table G.7. Comparison of SUR results, with and without cross prices, for Central[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-9.439 (-1.94)	-7.870 (-1.29)	-21.010 (-3.08)	-21.080 (-3.11)
LPRES	-0.225 (-1.37)	-0.165 (-0.92)		-1.383 (-1.08)
LPRDF		0.017 (0.36)	-0.140 (-0.76)	-0.171 (-0.92)
LES	0.726 (9.80)	0.701 (6.36)		
LDF			0.574 (2.96)	0.631 (3.13)
LRPCI				
LPOP	1.200 (1.59)	1.005 (1.15)		
LCDD	0.278 (4.22)	0.272 (4.04)		
LHDD	0.205 (1.94)	0.207 (1.80)	2.774 (3.60)	3.038 (3.78)
D1	-0.499 (-1.15)	-0.378 (-0.71)	0.564 (1.23)	0.707 (1.49)
D2	-1.030 (-1.31)	-0.793 (-0.81)	1.219 (2.96)	1.410 (3.18)
D3	-0.423 (-1.54)	-0.344 (-1.00)	0.124 (0.48)	0.401 (1.10)

[a]The figures in parentheses are asymptotic t-ratios.

Table G.8. Comparison of SUR results, with and without cross prices, for North Central[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
	Dependent Variable			
Intercept	-3.701	-3.608	-20.219	-15.379
	(-2.92)	(-2.77)	(-3.21)	(-2.16)
LPRES	-0.060	-0.065		-0.632
	(-0.85)	(-0.91)		(-1.35)
LPRDF		-0.007	-0.125	-0.223
		(-0.14)	(-0.97)	(-1.52)
LES	0.836	0.849		
	(13.98)	(8.73)		
LDF			0.815	0.736
			(7.77)	(6.45)
LRPCI				
LPOP	0.462	0.445		
	(3.36)	(3.18)		
LCDD				
LHDD	0.210	0.201	2.424	2.097
	(2.12)	(1.86)	(3.49)	(2.88)
D1	0.407	0.399	-0.305	-0.151
	(2.78)	(2.45)	(-1.14)	(-0.53)
D2	0.419	0.409	0.129	0.189
	(2.95)	(2.67)	(0.76)	(1.10)
D3	0.369	0.359	-0.020	-0.122
	(2.89)	(2.54)	(-0.11)	(-0.63)
D4	0.565	0.557	-0.504	-0.801
	(3.12)	(2.60)	(-1.76)	(-2.34)
D5	0.219	0.216	0.265	0.228
	(3.02)	(2.55)	(1.83)	(1.56)

[a]The figures in parentheses are asymptotic t-ratios.

Table G.9. Comparison of SUR results, with and without cross prices, for West[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-6.653 (-5.32)	-6.953 (-5.62)	-72.766 (-1.76)	-65.144 (-1.60)
LPRES	-0.118 (-2.28)	-0.121 (-2.15)		2.829 (1.53)
LPRDF		-0.040 (-1.24)	-1.407 (-2.44)	-2.019 (-2.65)
LES	0.672 (10.60)	0.742 (9.68)		
LDF			0.665 (3.63)	0.637 (3.60)
LRPCI	0.821 (7.47)	0.805 (7.26)	5.654 (1.43)	3.879 (1.05)
LPOP	0.241 (2.61)	0.226 (2.52)		
LCDD				
LHDD	0.177 (2.86)	0.151 (2.36)	3.536 (1.43)	3.839 (1.59)
D1	0.156 (1.09)	0.245 (1.62)	0.789 (0.92)	0.264 (0.29)
D2	-0.169 (-0.82)	-0.018 (-0.08)	-1.930 (-1.43)	-1.219 (-0.85)

[a]The figures in parentheses are asymptotic t-ratios.

Table G.10. Comparison of SUR results, with and without cross prices, for Northwest[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-3.779 (-1.58)	-4.543 (-1.88)	-19.548 (-2.37)	-20.492 (-2.42)
LPRES	-0.266 (-2.50)	-0.272 (-2.60)		0.200 (0.64)
LPRDF		-0.082 (-1.42)	-0.456 (-3.93)	-0.446 (-3.78)
LES	0.644 (6.23)	0.637 (6.28)		
LDF			0.315 (1.87)	0.327 (1.91)
LRPCI			1.344 (2.89)	1.360 (2.89)
LPOP	0.692 (3.25)	0.968 (3.39)		
LCDD	0.066 (1.90)	0.054 (1.53)		
LHDD	0.287 (1.40)	0.188 (0.88)	1.650 (2.09)	1.686 (2.11)
D1	-0.426 (-2.25)	-0.854 (-2.41)	1.303 (3.53)	1.358 (3.55)
D2	-0.216 (-1.82)	-0.530 (-2.12)	1.153 (3.45)	1.149 (3.39)

[a]The figures in parentheses are asymptotic t-ratios.

APPENDIX H

Regression Results with Dummy Variable for Time

Table H.1. Comparison of SUR results, with and without time dummy, for New England[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
	Dependent Variable			
Intercept	-2.077 (-2.11)	-2.539 (-2.33)	-4.538 (-1.13)	-3.354 (-0.94)
LPRES	-0.199 (-5.10)	-0.150 (-2.68)		
LPRDF			-0.418 (-5.74)	-1.010 (-5.65)
LES	0.774 (17.54)	0.798 (16.03)		
LDF			0.699 (6.52)	0.548 (5.20)
LRPCI	0.355 (2.89)	0.339 (2.77)	0.920 (1.91)	1.015 (2.30)
LPOP				
LCDD				
LHDD	0.177 (2.45)	0.210 (2.80)		
D1	0.070 (1.41)	0.058 (1.18)	0.318 (2.77)	0.392 (3.68)
D2	0.026 (0.92)	0.016 (0.55)	0.089 (1.67)	0.102 (2.08)
D3	-0.079 (-2.53)	-0.076 (-2.38)	0.012 (0.13)	-0.046 (-0.56)
D4	0.377 (4.76)	0.331 (3.64)	0.512 (2.54)	0.790 (3.99)
D5	0.248 (4.32)	0.218 (3.33)	0.182 (1.44)	0.308 (2.55)
DPR		-0.006 (-0.95)		0.356 (3.51)

[a]The figures in parentheses are asymptotic t-ratios.

Table H.2. Comparison of SUR results, with and without time dummy, for New York/New Jersey[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
	Dependent Variable			
Intercept	-1.439 (-0.92)	-1.481 (-0.91)	-18.584 (-0.93)	-13.570 (-0.64)
LPRES	-0.148 (-1.88)	-0.030 (-0.15)		
LPRDF			-0.229 (-2.04)	-0.525 (-1.37)
LES	0.960 (7.96)	0.933 (7.52)		
LDF			0.613 (2.88)	0.469 (1.74)
LRPCI				
LPOP			2.288 (1.13)	2.073 (1.00)
LCDD	0.140 (2.51)	0.134 (2.20)		
LHDD	0.153 (1.36)	0.164 (1.43)	0.353 (0.81)	0.210 (0.44)
D1	0.044 (0.55)	0.056 (0.68)	-1.853 (-1.00)	-1.561 (-0.81)
DPR		-0.010 (-0.56)		0.169 (0.78)

[a]The figures in parentheses are asymptotic t-ratios.

Table H.3. Comparison of SUR results, with and without time dummy, for Mid Atlantic[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-2.127	-1.630	-15.179	-14.507
	(-1.56)	(-1.12)	(-1.78)	(-1.71)
LPRES	-0.096	-0.172		
	(-1.12)	(-1.36)		
LPRDF			-0.337	-0.770
			(-3.79)	(-2.64)
LES	0.800	0.751		
	(12.66)	(8.48)		
LDF			0.628	0.636
			(6.11)	(6.26)
LRPCI	0.399	0.387	1.148	0.918
	(2.51)	(2.42)	(2.21)	(1.72)
LPOP			1.147	1.301
			(1.60)	(1.82)
LCDD	0.141	0.147		
	(2.84)	(2.79)		
LHDD	0.025	0.053		
	(0.16)	(0.32)		
D1	0.157	0.191	-0.157	-0.654
	(3.27)	(2.91)	(-0.88)	(-1.12)
D2	-0.133	-0.143	-0.075	-0.026
	(-2.59)	(-2.69)	(-0.76)	(-0.26)
D3	-0.520	-0.617	1.715	2.090
	(-3.04)	(-2.92)	(1.16)	(1.42)
D4	-0.118	-0.186	0.508	0.643
	(-1.30)	(-1.52)	(0.71)	(0.91)
DPR		0.014		0.310
		(0.84)		(1.54)

[a]The figures in parentheses are asymptotic t-ratios.

Table H.4. Comparison of SUR results, with and without time dummy, for South Atlantic[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-3.094 (-3.35)	-2.958 (-3.15)	-9.808 (-1.03)	-6.764 (-0.72)
LPRES	-0.103 (-1.64)	-0.139 (-1.59)		
LPRDF			-0.671 (-3.73)	-2.099 (-2.98)
LES	0.762 (15.99)	0.740 (12.90)		
LDF			0.965 (8.79)	0.929 (8.54)
LRPCI	0.296 (2.31)	0.299 (2.31)	0.829 (0.68)	0.519 (0.43)
LPOP				
LCDD	0.262 (5.94)	0.269 (5.84)		
LHDD	0.173 (3.30)	0.182 (3.31)	0.441 (0.83)	0.442 (0.85)
D1	0.051 (1.04)	0.049 (0.98)	0.043 (0.12)	0.142 (0.39)
D2	0.190 (2.96)	0.200 (3.05)	0.131 (0.41)	0.207 (0.65)
D3	0.226 (5.19)	0.244 (4.76)	0.197 (0.41)	0.435 (0.91)
D4	0.059 (2.56)	0.064 (2.63)	0.301 (0.86)	0.473 (1.34)
D5	0.137 (3.73)	0.151 (3.63)	0.178 (0.59)	0.334 (1.10)
D6	0.381 (3.62)	0.424 (3.43)	0.748 (0.84)	0.982 (1.11)
D7	0.095 (3.05)	0.103 (3.11)	0.109 (0.41)	0.121 (0.47)
DPR		0.008 (0.66)		1.120 (2.10)

[a]The figures in parentheses are asymptotic t-ratios.

Table H.5. Comparison of SUR results, with and without time dummy, for Midwest[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-6.026 (-2.73)	-6.762 (-3.19)	0.213 (0.07)	5.216 (1.66)
LPRES	-0.013 (-0.21)	0.021 (0.34)		
LPRDF			-0.370 (-5.43)	-1.535 (-4.87)
LES	0.664 (12.42)	0.741 (11.99)		
LDF			0.914 (9.15)	0.759 (7.85)
LRPCI	0.197 (2.66)	0.173 (2.44)		
LPOP	0.741 (2.45)	0.742 (2.57)		
LCDD	0.072 (3.36)	0.069 (3.34)		
LHDD	0.149 (2.77)	0.158 (3.05)	0.104 (0.29)	-0.232 (-0.68)
D1	-0.370 (-1.36)	-0.445 (-1.71)	0.050 (0.31)	-0.043 (-0.29)
D2	-0.044 (-0.55)	-0.073 (-0.96)	0.027 (0.17)	-0.081 (-0.56)
D3	-0.480 (-1.68)	-0.551 (-2.02)	-0.034 (-0.22)	-0.084 (-0.61)
D4	-0.385 (-1.67)	-0.437 (-1.98)	0.052 (0.34)	0.091 (0.67)
D5	-0.044 (-1.03)	-0.054 (-1.32)	0.044 (0.45)	0.067 (0.76)
DPR		-0.101 (-2.26)		0.881 (3.74)

[a]The figures in parentheses are asymptotic t-ratios.

Table H.6. Comparison of SUR results, with and without time dummy, for Southwest[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-2.899 (-2.93)	-3.128 (-2.70)	1.114 (0.08)	0.752 (0.06)
LPRES	-0.104 (-1.35)	-0.094 (-1.19)		
LPRDF			-0.294 (-0.87)	0.588 (0.19)
LES	0.657 (9.68)	0.670 (8.97)		
LDF			0.808 (3.61)	0.801 (3.49)
LRPCI	0.298 (1.67)	0.321 (1.68)		
LPOP				
LCDD	0.352 (4.86)	0.345 (4.62)		
LHDD	0.160 (1.72)	0.154 (1.62)	-0.012 (-0.01)	0.033 (0.02)
D1	0.250 (2.17)	0.239 (2.00)	0.370 (0.31)	0.404 (0.33)
D2	0.392 (2.35)	0.369 (2.09)	-0.395 (-0.24)	-0.355 (-0.21)
D3	0.260 (2.16)	0.241 (1.87)	0.258 (0.39)	0.298 (0.44)
D4	0.754 (3.46)	0.714 (2.97)	0.259 (0.14)	0.314 (0.17)
DPR		-0.005 (-0.40)		-0.876 (-0.29)

[a]The figures in parentheses are asymptotic t-ratios.

Table H.7. Comparison of SUR results, with and without time dummy, for Central[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
	Dependent Variable			
Intercept	-9.439 (-1.94)	-9.469 (-1.89)	-21.010 (-3.08)	-20.318 (-2.80)
LPRES	-0.225 (-1.37)	-0.241 (-1.42)		
LPRDF			-0.140 (-0.76)	-0.484 (-0.44)
LES	0.726 (9.80)	0.711 (7.94)		
LDF			0.574 (2.96)	0.593 (2.89)
LRPCI				
LPOP	1.200 (1.59)	1.231 (1.60)		
LCDD	0.278 (4.22)	0.275 (4.11)		
LHDD	0.205 (1.94)	0.204 (1.90)	2.774 (3.60)	2.689 (3.24)
D1	-0.499 (-1.15)	-0.507 (-1.15)	0.564 (1.23)	0.533 (1.12)
D2	-1.030 (-1.31)	-1.046 (-1.30)	1.219 (2.96)	1.169 (2.62)
D3	-0.423 (-1.54)	-0.429 (-1.53)	0.124 (0.48)	0.120 (0.45)
DPR		0.003 (0.30)		0.262 (0.31)

[a]The figures in parentheses are asymptotic t-ratios.

Table H.8. Comparison of SUR results, with and without time dummy, for North Central[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-3.701 (-2.92)	-3.699 (-2.85)	-20.219 (-3.21)	-18.624 (-2.79)
LPRES	-0.060 (-0.85)	-0.061 (-0.86)		
LPRDF			-0.125 (-0.97)	-0.583 (-0.91)
LES	0.836 (13.98)	0.841 (12.29)		
LDF			0.815 (7.77)	0.803 (7.57)
LRPCI				
LPOP	0.462 (3.36)	0.458 (3.29)		
LCDD				
LHDD	0.210 (2.12)	0.209 (2.09)	2.424 (3.49)	2.269 (3.12)
D1	0.407 (2.78)	0.406 (2.72)	-0.305 (-1.14)	-0.249 (-0.90)
D2	0.419 (2.95)	0.418 (2.89)	0.129 (0.76)	0.148 (0.86)
D3	0.369 (2.89)	0.367 (2.83)	-0.020 (-0.11)	0.009 (0.05)
D4	0.565 (3.12)	0.565 (3.03)	-0.504 (-1.76)	-0.519 (-1.80)
D5	0.219 (3.02)	0.220 (2.92)	0.265 (1.83)	0.244 (1.65)
DPR		-0.001 (-0.12)		0.337 (0.73)

[a]The figures in parentheses are asymptotic t-ratios.

Table H.9. Comparison of SUR results, with and without time dummy, for West[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-6.653 (-5.32)	-6.948 (-5.52)	-72.766 (-1.76)	-73.480 (-1.87)
LPRES	-0.118 (-2.28)	-0.095 (-1.37)		
LPRDF			-1.407 (-2.44)	-6.890 (-2.80)
LES	0.672 (10.60)	0.722 (8.85)		
LDF			0.665 (3.63)	0.611 (3.54)
LRPCI	0.821 (7.47)	0.823 (7.49)	5.654 (1.43)	6.112 (1.77)
LPOP	0.241 (2.61)	0.202 (1.85)		
LCDD				
LHDD	0.177 (2.86)	0.182 (2.94)	3.536 (1.43)	3.327 (1.41)
D1	0.156 (1.09)	0.160 (1.07)	0.789 (0.92)	0.772 (0.95)
D2	-0.169 (-0.82)	-0.168 (-0.79)	-1.930 (-1.43)	-1.869 (-1.46)
DPR		-0.009 (-0.88)		4.306 (2.29)

[a]The figures in parentheses are asymptotic t-ratios.

Table H.10. Comparison of SUR results, with and without time dummy, for Northwest[a]

Independent Variable	LQTES without	LQTES with	LQTDF without	LQTDF with
Intercept	-3.779 (-1.58)	-4.421 (-1.74)	-19.548 (-2.37)	-13.699 (-1.25)
LPRES	-0.266 (-2.50)	-0.255 (-2.35)		
LPRDF			-0.456 (-3.93)	-0.783 (-1.88)
LES	0.644 (6.23)	0.677 (6.09)		
LDF			0.315 (1.87)	0.331 (1.95)
LRPCI			1.344 (2.89)	1.219 (1.27)
LPOP	0.692 (3.25)	0.709 (3.30)		
LCDD	0.066 (1.90)	0.065 (1.85)		
LHDD	0.287 (1.40)	0.314 (1.50)	1.650 (2.09)	1.085 (1.97)
D1	-0.426 (-2.25)	-0.501 (-2.41)	1.303 (3.53)	1.240 (3.27)
D2	-0.216 (-1.82)	-0.264 (-2.01)	1.153 (3.45)	1.045 (2.89)
DPR		-0.013 (-0.86)		0.225 (0.82)

[a]The figures in parentheses are asymptotic t-ratios.

APPENDIX I

Exogenous Variables Assumptions for the Forecast Period

Table I.1. State-level compounded annual growth rates (1976-1981) of real electricity (PRES) and distillate fuel (PRDF) prices, real per capita income (RPCI) and population (POP)

Region & FIPS	PRES	PRDF	RPCI	POP
New England				
9000	2.24	12.98	1.88	0.04
23000	3.50	12.54	-0.22	1.15
25000	1.42	12.96	1.40	-0.18
33000	3.24	12.37	0.92	2.65
44000	2.64	13.13	0.10	0.53
50000	-2.09	13.21	0.50	1.63
New York/New Jersey				
34000	0.73	13.17	0.77	0.19
36000	1.16	13.71	0.51	-0.59
Mid Atlantic				
10000	1.65	13.08	-0.33	0.48
24000	-1.18	14.40	-2.17	3.37
42000	-1.34	12.74	0.26	0.03
51000	0.60	13.87	0.59	1.56
54000	-4.35	13.41	-1.03	1.48
South Atlantic				
1000	3.25	14.05	0.28	1.39
12000	2.79	13.72	1.58	3.87
13000	0.03	13.33	0.31	2.32
21000	2.46	14.12	-0.17	1.40
28000	2.20	14.12	0.40	1.60
37000	-0.62	13.01	-0.06	1.73
45000	-1.26	11.33	-0.33	2.27
47000	1.97	14.12	-0.15	1.90
Midwest				
17000	0.96	13.81	-0.25	0.42
18000	0.14	13.63	-0.40	0.70
26000	-1.05	14.60	-0.30	0.23
27000	1.17	12.83	1.59	0.73
39000	0.52	13.97	0.05	0.20
55000	-0.25	12.63	0.94	0.54

Table I.1. con't.

Region & FIPS	PRES	PRDF	RPCI	POP
Southwest				
5000	1.06	14.59	0.65	1.75
22000	5.03	a	2.50	2.28
35000	3.13	10.66	0.46	2.69
40000	-9.21	14.03	3.08	2.32
48000	3.12	14.52	2.02	3.37
Central				
19000	0.19	12.87	1.49	0.33
20000	1.55	12.22	1.68	0.66
29000	-1.89	12.22	0.50	0.67
31000	-0.67	12.22	1.15	0.38
North Central				
8000	0.64	12.08	2.01	2.92
30000	-1.09	11.95	0.34	1.12
38000	0.09	13.18	3.12	0.55
46000	1.24	13.18	2.41	0.17
49000	2.73	11.81	-0.26	4.41
56000	2.36	11.91	2.73	4.80
West				
4000	0.28	8.36	1.16	4.34
6000	1.04	7.66	1.09	2.39
32000	0.42	8.22	0.70	6.71
Northwest				
16000	-0.19	10.98	-0.41	3.01
41000	2.52	10.24	-0.01	2.76
53000	0.56	11.54	0.47	3.23

[a] Consumption and price are zero after 1979.

Table I.2. Forecast period values of HDD and CDD, by state

FIPS	HDD	CDD
9000	6113	594
23000	7670	212
25000	6464	442
33000	7370	291
44000	6092	471
50000	7869	260
34000	5652	766
36000	6046	659
10000	4893	1008
24000	4939	951
42000	6167	595
51000	4682	1028
54000	5703	700
1000	3046	1890
12000	973	3302
13000	3084	1769
21000	4764	1133
28000	2603	2197
37000	3877	1335
45000	3078	1796
47000	4191	1322
17000	6154	778
18000	5982	841
26000	6931	511
27000	8011	418
39000	6156	671
55000	7411	443
5000	3293	1794
22000	1883	2680
35000	4187	993
40000	3302	2007
48000	1891	2648
19000	2917	799
20000	2387	1471
29000	4939	1207
31000	1583	1031

Table I.2. con't.

FIPS	HDD	CDD
8000	6395	369
30000	7312	271
38000	8333	440
46000	6700	788
49000	5891	781
56000	7119	323
4000	1832	2939
6000	2224	1052
32000	3681	1848
16000	6386	427
41000	4913	222
53000	5204	199

APPENDIX J

Sample SAS Program for the New England Region

These first 6 statements are Job Control Language (JCL) specific to the ORNL computer system. With these statements, SAS, as well as the correct input data set for the region under consideration, is accessed.

```
01 //CAGRES1 JOB (xxxxx,I02),'RIZY BIN R'
02 /*ROUTE XEQ MSS
03 // EXEC SAS
04 //INPUT DD UNIT=3330V,VOL=SER=VCOLLE,
05 //       DSN=CAG.SAS.WORKFILE,DISP=(OLD,KEEP)
06 //SYSIN DD *
```

Statements 1-36 transform the raw data in the SAS data set (RESDNTL1). That is, all variables are logged and the price and income variables are deflated by the Consumer Price Index (CPI). Additionally, the lags of the dependent variables are created.

```
1 DATA RESDNTL1;
2 SET INPUT.RESDNTL1;
3 PRDF=PRDF/CPI;
4 PRES=PRES/CPI;
5 PRKS=PRKS/CPI;
6 PRLG=PRLG/CPI;
7 PRNG=PRNG/CPI;
8 PRSC=PRSC/CPI;
9 LQTDF=LOG(QTDF);
10 LQTES=LOG(QTES);
11 LQTKS=LOG(QTKS);
12 LQTLG=LOG(QTLG);
13 LQTNG=LOG(QTNG);
14 LQTSC=LOG(QTSC);
15 LPRDF=LOG(PRDF);
16 LPRES=LOG(PRES);
17 LPRKS=LOG(PRKS);
18 LPRLG=LOG(PRLG);
19 LPRNG=LOG(PRNG);
20 LPRSC=LOG(PRSC);
21 LCDD=LOG(CDD);
22 LHDD=LOG(HDD);
23 LRPCI=LOG(RPCI);
24 LPOP=LOG(POP);
25 LDF=LAG1(LQTDF);
26 IF FIPS>9000 AND YEAR=1970 THEN LDF=.;
27 LES=LAG1(LQTES);
28 IF FIPS>9000 AND YEAR=1970 THEN LES=.;
29 LKS=LAG1(LQTKS);
30 IF FIPS>9000 AND YEAR=1970 THE LKS=.;
31 LLG=LAG1(LQTLG);
32 IF FIPS>9000 AND YEAR=1970 THE LLG=.;
33 LNG=LAG1(LQTNG);
```

```
34 IF FIPS>9000 AND YEAR=1970 THEN LNG=.;
35 LSC=LAG1(LQTSC);
36 IF FIPS>9000 AND YEAR=1970 THEN LSC=.;
```

Statements 37-64 estimate the electricity and distillate fuel consumption equations in a Seemingly Unrelated Regression (SUR) equation framework. An output data set, CEST, is created which contains the parameter estimates--both the Ordinary Least Squares (OLS) and 3 Stage Least Squares (3SLS) estimates.

```
37 PROC SYSREG OUTEST=CEST DATA=RESDNTL1;
38 EQ1:MODEL LQTES=
39 LPRES
40 LES
41 LRPCI
42 LHDD
43 D1-D5
44 ;
45 EQ2:MODEL LQTDF=
46 LPRDF
47 LDF
48 LRPCI
49 D1-D5
50 ;
51 SYSTEM EQ1 EQ2;
52 LABEL LQTES=LOG OF ELECTRICITY CONSUMPTION
53       LPRES=LOG OF REAL ELECTRICITY PRICE
54         LES=ONE YEAR LAG OF LQTES
55       LRPCI=LOG OF REAL PER CAPITA INCOME
56        LPOP=LOG OF POPULATION
57        LCDD=LOG OF COOLING DEGREE DAYS
58        LHDD=LOG OF HEATING DEGREE DAYS
59       LQTDF=LOG OF DISTILLATE FUEL CONSUMPTION
60       LPRDF=LOG OF REAL DISTILLATE FUEL PRICE
61         LDF=ONE YEAR LAG OF LQTDF;
62 TITLE1 SEEMINGLY UNRELATED REGRESSION EQUATIONS FOR;
63 TITLE2 CONSUMPTION OF ELECTRICITY AND DISTILLATE FUEL;
64 TITLE3 IN THE NEW ENGLAND REGION;
```

Statements 65-83 comprise the first step in creating the data set of projected values of the exogenous variables. A data set (GROWTH) containing the annual compounded growth rate, for 1976-1981, for each state and variable is created. These growth rates will be used to calculate the projected values of the exogenous variables.

```
65 ***CALCULATE GROWTH RATES FOR EXOGENOUS VARIABLES
```

```
66 *
67 *;
68 DATA R76; SET RESDNTL1;
69 IF YEAR=1976;
70 RENAME PRES=PRES76 PRDF=PRDF76 RPCI=RPCI76 POP=POP76;
71 PROC SORT; BY FIPS;
72 DATA R81; SET RESDNTL1;
73 IF YEAR=1981;
74 RENAME PRES=PRES81 PRDF=PRDF81 RPCI=RPCI81 POP=POP81;
75 PROC SORT; BY FIPS;
76 DATA GROWTH; MERGE R76 R81; BY FIPS;
77 GPRES=EXP((LOG(PRES81/PRES76))/5);
78 GPRDF=EXP((LOG(PRDF81/PRDF76))/5);
79 GRPCI=EXP((LOG(RPCI81/RPCI76))/5);
80 GPOP=EXP((LOG(POP81/POP76))/5);
81 DATA GROWTH; SET GROWTH; IF YEAR=1981;
82 KEEP FIPS GPRES GPRDF GRPCI GPOP;
83 PROC SORT; BY FIPS;
```

Statements 84-89 are the second step in creating the data set of projected exogenous variables. Here, a data set is created which contains only 1981 values for all variables. This data set is BASE.

```
84 *** SET UP 1981 BASE YEAR DATA SET FOR PROJECTIONS
85 *
86 *;
87 DATA BASE; SET RESDNTL1;
88 IF YEAR=1981;
89 PROC SORT DATA=BASE; BY FIPS YEAR;
```

Statements 90-107 apply the 1976-1981 growth rates to their respective variables to create a data set, PROJECT, of projected values of the exogenous variables for 1982-2000.

```
90 ***CREATE PROJECTED EXOGENOUS VARIABLE DATA SET
91 *
92 *;
93 DATA PROJECT; MERGE BASE GROWTH; BY FIPS;
94 DO WHILE (YEAR<2000);
95 YEAR=YEAR+1;
96 PRES=PRES*GPRES;
97 PRDF=PRDF*GPRDF;
98 RPCI=RPCI*GRPCI;
99 POP=POP*GPOP;
100 LPRES=LOG(PRES);
101 LPRDF=LOG(PRDF);
```

```
102 LRPCI=LOG(RPCI);
103 OUTPUT;
104 END;
105 PROC SORT DATA=PROJECT; BY FIPS YEAR;
106 DATA PROJECT; SET PROJECT;
107 KEEP FIPS YEAR LPRES LPRDF LRPCI LHDD D1-D5;
```

In statements 108-122, a data set is created for each state, according to the FIPS number, which contains only two varibles: FIPS and YEAR (=1982-2000). These data sets are called YEARi.

```
108 ***COMPUTE PROJECTIONS
109 *
110 *;
111 DATA YEAR1; SET PROJECT; KEEP FIPS YEAR; IF FIPS=9000;
112 PROC SORT; BY FIPS;
113 DATA YEAR2; SET PROJECT; KEEP FIPS YEAR; IF FIPS=23000;
114 PROC SORT; BY FIPS;
115 DATA YEAR3; SET PROJECT; KEEP FIPS YEAR; IF FIPS=25000;
116 PROC SORT; BY FIPS;
117 DATA YEAR4; SET PROJECT; KEEP FIPS YEAR; IF FIPS=33000;
118 PROC SORT; BY FIPS;
119 DATA YEAR5; SET PROJECT; KEEP FIPS YEAR; IF FIPS=44000;
120 PROC SORT; BY FIPS;
121 DATA YEAR6; SET PROJECT; KEEP FIPS YEAR; IF FIPS=50000;
122 PROC SORT; BY FIPS;
```

Statements 123-138 create a data set for each state, PROJECTi, which contains the FIPS code, YEAR and projected values of the exogenous variables, including the lags.

```
123 DATA BASE1; SET RESDNTL1; IF YEAR=1981;
124 KEEP FIPS YEAR LQTES LQTDF;
125 YEAR=YEAR+1;
126 PROC SORT; BY FIPS;
127 DATA BASE2; SET BASE1;
128 RENAME LQTES=LES LQTDF=LDF;
129 PROC SORT; BY FIPS YEAR;
130 DATA BASE3; MERGE BASE1 BASE2; BY FIPS YEAR;
131 DATA PROJECT; MERGE BASE3 PROJECT;
132 BY FIPS YEAR;
133 DATA PROJECT1; SET PROJECT; IF FIPS=9000;
134 DATA PROJECT2; SET PROJECT; IF FIPS=23000;
135 DATA PROJECT3; SET PROJECT; IF FIPS=25000;
136 DATA PROJECT4; SET PROJECT; IF FIPS=33000;
137 DATA PROJECT5; SET PROJECT; IF FIPS=44000;
138 DATA PROJECT6; SET PROJECT; IF FIPS=50000;
```

Statements 139-148 use the 3SLS parameter estimates and the projected exogenous variables to project electricity and distillate fuel consumption, QTES and QTDF, respectively, for the first state in the region.

```
139 PROC SIMLIN EST=CEST DATA=PROJECT1 TYPE='3SLS';
140 ENDOGENOUS LQTES LQTDF;
141 EXOGENOUS LPRES LPRDF LRPCI LHDD D1-D5;
142 LAGGED LES LQTES 1 LDF LQTDF 1;
143 OUTPUT OUT=PROJECT1 P=PES PDF;
144 PROC PRINT;
145 DATA PROJECT1; MERGE YEAR1 PROJECT1;
146 QTES=EXP(PES); QTDF=EXP(PDF);
147 PROC SORT; BY FIPS YEAR;
148 PROC PRINT; VAR FIPS YEAR QTES QTDF;
```

Statements 149-198 do the same thing as 139-148 for the remaining states in the region.

```
149 PROC SIMLIN EST=CEST DATA=PROJECT2 TYPE='3SLS';
150 ENDOGENOUS LQTES LQTDF;
151 EXOGENOUS LPRES LPRDF LRPCI LHDD D1-D5;
152 LAGGED LES LQTES 1 LDF LQTDF 1;
153 OUTPUT OUT=PROJECT2 P=PES PDF;
154 PROC PRINT;
155 DATA PROJECT2; MERGE YEAR2 PROJECT2;
156 QTES=EXP(PES); QTDF=EXP(PDF);
157 PROC SORT; BY FIPS YEAR;
158 PROC PRINT; VAR FIPS YEAR QTES QTDF;
159 PROC SIMLIN EST=CEST DATA=PROJECT3 TYPE='3SLS';
160 ENDOGENOUS LQTES LQTDF;
161 EXOGENOUS LPRES LPRDF LRPCI LHDD D1-D5;
162 LAGGED LES LQTES 1 LDF LQTDF 1;
163 OUTPUT OUT=PROJECT3 P=PES PDF;
164 PROC PRINT;
165 DATA PROJECT3; MERGE YEAR3 PROJECT3;
166 QTES=EXP(PES); QTDF=EXP(PDF);
167 PROC SORT; BY FIPS YEAR;
168 PROC PRINT; VAR FIPS YEAR QTES QTDF;
169 PROC SIMLIN EST=CEST DATA=PROJECT4 TYPE='3SLS';
170 ENDOGENOUS LQTES LQTDF;
171 EXOGENOUS LPRES LPRDF LRPCI LHDD D1-D5;
172 LAGGED LES LQTES 1 LDF LQTDF 1;
173 OUTPUT OUT=PROJECT4 P=PES PDF;
174 PROC PRINT;
175 DATA PROJECT4; MERGE YEAR4 PROJECT4;
176 QTES=EXP(PES); QTDF=EXP(PDF);
177 PROC SORT; BY FIPS YEAR;
178 PROC PRINT; VAR FIPS YEAR QTES QTDF;
179 PROC SIMLIN EST=CEST DATA=PROJECT5 TYPE='3SLS';
```

```
180 ENDOGENOUS LQTES LQTDF;
181 EXOGENOUS LPRES LPRDF LRPCI LHDD D1-D5;
182 LAGGED LES LQTES 1 LDF LQTDF 1;
183 OUTPUT OUT=PROJECT5 P=PES PDF;
184 PROC PRINT;
185 DATA PROJECT5; MERGE YEAR5 PROJECT5;
186 QTES=EXP(PES); QTDF=EXP(PDF);
187 PROC SORT; BY FIPS YEAR;
188 PROC PRINT; VAR FIPS YEAR QTES QTDF;
189 PROC SIMLIN EST=CEST DATA=PROJECT6 TYPE='3SLS';
190 ENDOGENOUS LQTES LQTDF;
191 EXOGENOUS LPRES LPRDF LRPCI LHDD D1-D5;
192 LAGGED LES LQTES 1 LDF LQTDF 1;
193 OUTPUT OUT=PROJECT6 P=PES PDF;
194 PROC PRINT;
195 DATA PROJECT6; MERGE YEAR6 PROJECT6;
196 QTES=EXP(PES); QTDF=EXP(PDF);
197 PROC SORT; BY FIPS YEAR;
198 PROC PRINT; VAR FIPS YEAR QTES QTDF;
```

In statements 199-206, the individual state data sets of projected QTES and QTDF are merged into one data set, REGION, and the regional totals of QTES and QTDF are calculated.

```
199 DATA FORECAST; MERGE PROJECT1 PROJECT2 PROJECT3 PROJECT4
200 PROJECT5 PROJECT6; BY FIPS YEAR;
201 PROC PRINT;
202 DATA REGION; SET FORECAST;
203 PROC SORT DATA=REGION; BY YEAR;
204 PROC MEANS DATA=REGION SUM; VAR QTES QTDF; BY YEAR;
205 OUTPUT OUT=REGION SUM=QTES QTDF;
206 PROC PRINT DATA=REGION; VAR YEAR QTES QTDF;
```

These last two card images are JCL which end the job.

```
/*
//
```

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