APPENDIX TO CHAPTER B

REPORT OF THE PANEL ON ENERGY DEMAND AND CONSERVATION OF THE COMMITTEE ON NUCLEAR AND ALTERNATIVE ENERGY SYSTEMS IN THE NATIONAL ACADEMY OF SCIENCE - NATIONAL RESEARCH COUNCIL

ENERGY DEMAND: CONSERVATION, TAXATION, AND GROWTH

by

Tim Mount and Tim Tyrrell

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Summary

The main purpose of this study is to estimate an econometric model of the demand for energy in the U.S., and to use it to derive forecasts of future demand between now and 1990 under a variety of alternative assumptions about how the economy will develop. The data used to estimate this model are annual observations from 1964 to 1974 for individual states, broken down into different classes of customers as well as into the major types of fuel. With a set of data of this type, the basic analysis is conducted at a more disaggregated level than in most other studies.

After the oil embargo in 1973, many economic factors relating to energy have shown substantial deviations from earlier trends. An attempt is made in the analysis to determine whether or not the estimated econometric model can explain these recent changes in the pattern of use of energy. It is found that an additional factor must be added to the model. This factor, which is called the Non-Market Conservation Effect, corresponds to the reduction in the use of energy in 1974 which cannot be attributed to purely market forces. There is some evidence that this non-market effect is still present in 1975, when most of the policies for the direct rationing of energy had been withdrawn. This may be considered as a demonstration of the potential for conserving energy through increased public awareness.

The different forecasted levels of use of energy in 1990 range from an increase of almost 80 percent from the 1974 level to a decline of over 10 percent. The magnitude of this range illustrates the importance of whether the future price of energy decreases or increases, and of whether or not successful efforts are made to keep Non-Market Conservation in effect. An additional part of the analysis is to demonstrate that the eventual price of energy need not be determined solely by the cost of producing energy. A tax on the use of energy can be an effective way of reducing the quantity of energy demanded. A corollary to this is that direct or indirect subsidies to producers would increase the quantity demanded, and return growth rates to previous high levels.

1. MODELING THE DEMAND FOR ENERGY

1.1 Introduction

In any attempt to forecast the consumption of energy, it is possible to extrapolate future levels from past observations of consumption, and a variety of relatively sophisticated models of this type can be estimated using time-series analysis.[1/] Linear or log-linear extrapolation are just two simple examples of this approach. With the oil embargo in 1973, an economic recession, and dramatic increases of the real prices of energy, it is inevitable that the form of such a model will have altered significantly during the last three years. Unfortunately, it is in just such a situation when these models break down that some explanation of how future consumption levels will be affected is really needed. This is where the advantage of econometric modeling is potentially most valuable.[2/]

In an econometric model, important measured characteristics of the market for energy are linked together in a mathematical relationship. The usual approach is to try to relate consumption levels to factors such as the size of the population, real income per capita, and the prices of different sources of energy and of other competing or complementary products. Forecasts can only be obtained if the levels of these explanatory factors are specified, and in this respect, econometric models are more demanding than time-series models because the factors themselves must be forecasted. This can either be done in another segment of the model or independently of the model. Nevertheless, a well-specified econometric model is still useful because there is a greater chance that its form will remain stable during a period such as the "energy crisis" than there is with a purely time-series model. In addition, it is possible to calculate forecasts using the same econometric model under a wide variety of different assumptions about how the economy will develop, including specifications which are purely hypothetical.

This discussion does not imply that the structure of an econometric model is always stable or that the corresponding forecasts are correct. It is fairly safe to assume that forecasts of the consumption of oil for 1974 and 1975 which were made before the oil embargo in 1973 would have been considerably higher than actual levels, regardless of the type of model used. However, this error need not indicate that the structure of an econometric model has altered, because the levels of some explanatory factors, such as the price of imported oil, were probably incorrectly specified when the forecasts were made. Using the actual levels of these factors in 1974 and 1975 may still provide accurate predictions of consumption for these years. Although, from a strictly forecasting point of view, this is just being wise after the event is over, an econometric model still provides an explanation of why observed changes of consumption patterns occurred by indicating, for example, the relative importance of the recession to that of price increases.

The conclusion that should be drawn is that econometric models play a dual role. Forecasting the most likely range of future levels of consumption is one objective, but the second, and in many ways the most important, is to provide a way of investigating a variety of alternative policies about the future use of energy. It is this latter property which makes econometric models attractive for studies such as the one being conducted by the Panel on Demand and Conservation. An additional conclusion is that given the substantial changes that have occurred since the oil embargo, some attempt should be made to determine whether the estimated structure of a forecasting model still provides an accurate explanation of consumption patterns in 1974 and 1975.

1.2 Specification of the Demand Model

The main statistical objective of this analysis is to estimate the relative effects of population, real income and the prices of different sources of energy on the consumption of a specific category of energy. For each category, the quantity demanded is regressed directly on these explanatory factors, and consequently, it is assumed that purchases by individuals do not influence any of the prices charged, and furthermore, that there are no supply restrictions. In other words, all customers can buy as much as they want at the specified prices. With this approach, there is no guarantee that the forecasted levels of consumption for a given set of prices will be exactly the same as the quantities supplied at those prices. It is, however, always possible to equate demand and supply by taxing consumption whenever the demand price is higher than the corresponding supply price, or by subsidizing production if the demand price is lower than the supply price. Both types of adjustment are discussed again in a later section of the paper.

Given the basic approach of determining the quantity of energy demanded in terms of measured characteristics of the market, it is now possible to discuss the nature of the data used in this analysis. All of the models are estimated from annual data for the years 1964 to 1974, using the state or some combination of states as the basic unit. In addition to the regional disaggregation, two major classes of customer are identified. These are (1) Residential and Commercial (these two categories are combined because data on the consumption of oil are not sufficiently disaggregated), and (2) Industrial. For Residential and Commercial customers, three competing fuels are considered; namely, electricity, natural gas and oil.[3/] The demand for gasoline is determined in an independent model with no other competing fuels. For Industrial customers, the choice of fuel is from electricity, natural gas, oil and coal. In the initial stages of this analysis, a model for predicting the fuels used for generating electricity was also considered. However, this model performed very unreliably in comparison to the models for the other two classes of customer, and consequently, no results are presented for Electric Utilities.[4/]

With this particular scheme of disaggregating the demand for energy, there are 8 separate categories of demand identified for estimation, which together account for roughly 80 percent of all energy used in the U.S. This is reasonably consistent with one of our initial objectives, which was to obtain as complete a coverage of all forms of energy as practical. The major omitted categories of customers are associated with rail, sea and air transporation, and with the military. In terms of energy, the omitted categories are comprised mainly of petroleum products, such as aviation fuel. It should be noted, however, that the estimated model for oil in the Residential and Commercial sector proves to be unsatisfactory, and even though this model is estimated, it is not used to derive forecasts.

The decision to use data for individual states rather than national data as the basis for estimation is primarily to benefit from the considerable amount of variation in key market characteristics, such as prices and incomes, which exists among states. By using data of this type, however, the number and variety of variables for which sources are readily available are limited, and some analyses which can be conducted at the national level can not be attempted with state data.

The next step is to specify the exact form of the demand relationship for each class of customers and each type of fuel. Since the primary objective of this analysis is to forecast the demand for all energy in the U.S., the basic approach is to treat the demand for any fuel by a given class of customers in a similar way, and to avoid selecting a method of analysis for one fuel which can not be executed for other fuels. Consequently, the actual method chosen is relatively straightforward.

For Residential and Commercial customers, the model relates the quantity of each fuel demanded to population, income per capita, the price of the fuel, the prices of substitute fuels and the price of appliances. The last variable was, in fact, dropped from the analysis since it performed unreliably and had little affect on the explanatory power of the model. In each equation the prices of substitute fuels are lagged by one period. The rationale for this is that there is a definite delay before stocks of appliances and equipment can be changed. Raising the price of electricity, for example, may reduce the intensity of use of electric appliances and equipment immediately, but the associated increase of demand for oil will only materialize if new oil burning equipment is installed. In addition, an index of urbanization is used as a proxy for the relative importance of such factors as the percentage number of families living in apartments.

The model for gasoline is similar to the model described for the other fuels used by Residential and Commercial customers. However, there are no substitute fuels in this case, and the price of appliances is replaced by the price of automobiles.

Nearly all published models incorporate some form of distributed lag mechanism to represent the gradual adjustment of consumption levels over time to changes of the market characteristics. This adjustment reflects the fact that the demand for energy at any point of time depends on the existing stocks of appliances, equipment and vehicles, and that generally these stocks can not be modified immediately in response to market forces. We have followed the widely used practice of specifying a linear regression model with a partial adjustment mechanism by including the quantity demanded in the previous time-period as an explanatory variable.[5/] Since all of the major variables are measured in logarithmic units, the coefficient of a variable such as income corresponds to the short-run elasticity.[6/] For any specified fuel, the basic objective is to estimate elasticities for population, real income per capita, the price of that fuel, and the prices of substitute fuels. Some analysts favor excluding population from the model, and measuring the quantity of each fuel demanded in per capita units.[7/] This is equivalent to assuming that demand adjusts immediately to population changes, and gradually to changes of the other factors. Such an assumption seems reasonable if the annual changes of population are solely from migration of families from one state to another, rather than from changes in the composition of existing families within each state. The latter situation is more in line with our approach. However, since our estimated long-run elasticities for population are close to one, there is little substantive difference between the two specifications.

The choice of how to measure the prices of different fuels is not a simple task because, for nearly all fuels, customers pay lower prices when purchasing larger quantities. The most widely discussed situation in which this occurs is with the familiar declining-block tariff for electricity. Until recently, concern was mainly centered on whether to use the average price paid or the marginal price paid in the model.[8/] The average price is relatively easy to calculate from available sources of data, and we have used average prices in our earlier studies as well as in this one. Although it is also easy to determine the marginal price for an individual customer during a particular billing period, the representative marginal price for all customers in a state over a one year period is not easy to determine, and consequently, various simplifying assumptions must be employed. Existing evidence in the literature relates exclusively to the residential demand for electricity, and it suggests the resulting estimated models have similar characteristics, regardless of which measurement of price is used.[9/]

Additional contributions to this issue of measuring price were recently made by Taylor,[10/] who has used the fact that any multi-block tariff is equivalent to a two-part tariff, and consequently, can be directly related to the earlier analysis by Houthakker of the rates for electricity in England.[11/] This work by Taylor has resulted in the most thorough investigation of how to measure the residential price for electricity to date. The implications of Taylor's approach is that two measures of the rate schedule should be included in the model. One measure is the marginal price, and the other is the sum of expenditures made above this marginal price for initial quantities of electricity. This latter term will be referred to as the "fixed charge". It is interesting to note that we adopted a similar approach in an earlier study of the demand for electricity although the two measures chosen by us were different from Taylor's.[12/] We concluded in that study that the level of the rate schedule, measured by the average price in our case, was all that really mattered from the point of view of forecasting the demand for electricity.

In an empirical analysis of the residential demand for electricity using Taylor's approach to measuring price, the resulting long-run elasticity for price is found to be "not as large [in absolute terms] as previous studies have indicated"[13/], and a value of -0.8 is considered more realistic. The corresponding value in our analysis is -1.02 (see Table 2). However, the apparent disparity between these two figures does not accurately reflect the true difference between the models. An increase of the average price, the measure used in our analysis, implies that both the marginal price and the fixed charge increase. Since the elasticity reported by Taylor et al refers only to an increase of the marginal price, its absolute magnitude is smaller than it would be when the fixed charge increases as well. With this modification, the long-run price elasticities for the two preferred models are -0.99 and -0.95[14/], which are very similar to our value. It is possible that by measuring price differently from Taylor, the estimates of other elasticities are biased, but this does not appear to be the case here. For income, our elasticity is slightly larger than the value estimated by Taylor et al. The elasticity for the price of gas is very small in both analyses.[15/] We do find a relatively large elasticity for the price of distillate oil, but this variable is not used by Taylor et al. Hence, we conclude that overall there is little substantive difference between the two approaches, although there may be a tendency towards higher forecasts of demand with our model whenever the price of oil increases, due to substitution between electricity and oil.

Having concluded that the distinction between average and marginal prices is not important for forecasting purposes, it should be noted that the distinction does have considerable significance for developing government policies towards energy. In particular, the design of rate schedules will influence the way in which demand develops. For Residential and Commercial customers, the main competition among different fuels is for space and water heating, which together account for about half of the direct purchases of energy (excluding gasoline) for homes. If lower prices are charged when large quantities are purchased, the competitive position of a fuel is obviously enhanced in the important heating segment of the market. This type of price discrimination is only practical if resales can be prevented, and consequently, it is easier to discriminate with electricity and natural gas than with distillate oil. Since declining-block tariffs are so widely used for electricity, it is possible to make electric heating as inexpensive to customers as direct heating by natural gas or oil. In terms of energy use, however, electric resistance heating uses about twice as much energy in total, unless hydro power is used, due to losses during the generation and distribution process. There is one situation in which the use of electric heating may be valid, and it is when the source of energy for generation is not suitable for direct use. Hydro and nuclear power are obvious examples, but with most fossil fuels, and particularly with natural gas, this justification need not exist.

The implication of the previous discussion is that the main value derived from representing rate schedules accurately is that it makes it possible to conduct a formal analysis of an issue such as the role of electric heating. A similar argument could be made for investigating the common practice of charging much higher prices for electricity and natural gas to residential customers than to industrial customers. From a strictly economic point of view, the use of declining block rates is efficient if economies of scale exist, implying that expanding the use of a fuel leads to lower average costs. This situation probably did exist for the generation of electricity during the fifties and sixties, but clearly it is not the case now. New generating facilities are considerably more expensive to build, particularly if nuclear reactors are used, the prices paid by electric utilities for fossil fuels have increased substantially, and sites for new dams are very limited. Hence, the desirability of continuing to use declining block rates for electricity is in doubt. With natural gas, the case against this practice is even more obvious, since an increasing proportion of supplies now come from relatively inaccessible fields.

An obvious question which now arises is that if the design of rate schedules is so important, why is this not more apparent in the estimated models of demand which include design characteristics. We were, in fact, disappointed by the absence of significant results in our earlier investigation of rate schedules and the demand for electricity. The only plausible explanation is that the competition among fuels for heating is obscured by aggregation, particularly when the number of households with electric heating is as small as it is. Interestingly enough, existing studies of the demand for space and water heating tend to find relatively high elasticities with respect to price. In the analysis by Lin et al, the earlier results of Wilson, of Anderson, and of Baughman and Joskow are also presented.[16/] In all four cases, the smallest long-run elasticity in absolute terms is -1.77 for water heating, and -2.04 for space heating. The more recent study by Taylor et al does, however, find substantially smaller values for these elasticities.[17/] Hence, all studies except the one by Taylor et al support our contention that the design of rate schedules is an important factor for determining the competitive position of different fuels for heating in the residential and commercial market. A similar argument is expected to hold for many industrial processes.

Turning now to the model for Industrial customers, the quantity of each fuel demanded is specified to depend on the prices of the fuel, of alternative fuels, of other competitive inputs, and of equipment and machinery, and also on the level of industrial output. The assumption underlying this specification is that producers attempt to minimize costs for any given level of output. Since changing the relative importance of different fuels often involves changing existing stocks of equipment and machinery, demand is expected to adjust gradually to market forces. As a result, a distributed lag mechanism is included in the model. The same procedure adopted for Residential and Commercial customers is used, implying that the quantity demanded in the previous period is present as a regressor.

The main difficulty encountered with the model for Industrial customers is the lack of suitable data. With regard to the prices of the four fuels, only the prices of the regulated fuels, electricity and natural gas, are readily available at the state level. For residual oil and coal, the prices paid by electric utilities are used as proxy variables for the actual prices since the latter are not published. In each model, the prices of substitute fuels are lagged by one period to allow for the delay involved with changing existing equipment and machinery. The prices of other relevant inputs, such as labor, capital, equipment and machinery, are even more difficult to obtain. During the initial stages of the analysis, price indices for labor and equipment were included, but in the end, only the Wholesale Price Index is used as a proxy for the prices of non-fuel inputs. The problems encountered with this part of the analysis probably relate to the fact that the prices of non-fuel inputs could only be obtained at the national level, and consequently, regional differences are not identified.

The most difficult factor to measure is industrial output. One obvious procedure is to use the value added by manufacturing, which is reported for individual states in the Annual Survey of Manufactures.[18/] However, the appropriate data for 1974 are still unavailable. Since the oil embargo intitated by the Organization of Petroleum Exporting Countries occurred in 1973, any assessment of the consequences of this embargo makes the use of data for 1974 essential. Consequently, we resorted to a more indirect way of measuring industrial output. States with larger populations and higher levels of income are assumed to have greater production from industry than in other states. An additional variable is an index of urbanization which acts as a proxy for the type of industrial production in each state. The Gross National Product is also included to reflect national aspects of demand which are not reflected by these state measures. Consequently, determining the elasticity for income implies that both the coefficients for the Gross National Product and for income within the state must be considered. In other words, the overall effect of income is evaluated as though it grows at the same rate throughout the economy.

1.3 Estimation of the Residential and Commercial, and the Industrial Demand Model

For both classes of customer, the form of the demand model is very similar. The logarithm of the quantity of each of the following fuels; electricity, natural gas, oil and coal (only for Industrial customers) is regressed separately on the logarithms of population, income per capita, the prices of the four (three for the Residential and Commercial customers) competing fuels, the lagged dependent variable and other variables discussed in the previous section. All variables measured in terms of nominal dollars are converted to real dollars through deflation by the Consumer Price Index.

Although the models for both classes of customer are estimated from pooled cross-section and time-series data, the degree of regional disaggregation varies between classes. For Residential and Commercial customers, there are 47 cross-section units representing the 48 contiguous states in the U.S. (North and South Carolina are combined, and so are Washington, D.C. and Maryland), but for Industrial customers, only 33 cross-section units are identified, and the exact combinations of states are listed in the Appendix.

Whenever a lagged dependent variable is present as a regressor in a linear regression model, the ordinary least squares estimator is inconsistent if the unexplained residuals in the model are interdependent through time. With pooled cross-section and time-series data of the type used for this analysis, the residuals are related through time if systematic differences exist among states which are not captured by the other regressors. Since it is almost certain that differences of this type do exist, it is appropriate to use an alternative estimator which is consistent. We have chosen to use a generalized least squares estimator under the assumption that random effects exist among states. Although it is also possible to specify that the effects are fixed, in which case the model can be estimated consistently by ordinary least squares, the generalized least squares estimator under our specification may be much more efficient if there are large differences in the levels of regressors among states.[19/] Since our type of disaggregated data was chosen specifically to benefit from the large regional variation, the generalized least squares estimator seems appropriate. This reasoning probably explains why the model with random effects is so widely used in studies of the demand for energy based on pooled data.

Computing the generalized least squares estimator requires that two components of the variance of the residual term are known. Since this is not the case, these variances must be estimated. Once again the lagged dependent variable creates statistical problems because many standard estimates of the variances are no longer appropriate. Unbiasedness, which is the most commonly used small-sample property of estimators of the variances, can not, in general, be established with our model. Consequently, we rely on the standard Analysis of Variance estimator for a balanced one-way layout using realized values of the residuals.[20/] The consistency of this procedure depends on using a consistent estimator of the coefficients of the regressors to compute the residuals, and the ordinary least squares estimator of a model which includes a fixed effect for each state is chosen for this purpose.

Even though the differences among states are specified as random for estimation, realized values of these effects are needed for forecasting. This implies that the forecast for any state is conditional on knowing which state is being considered. It should be noted that the standard procedures for obtaining values of the state effects are not identical when the effects are random as opposed to fixed. The appropriate procedure in our case is described in detail by Searle.[21/]

2. THE EMPIRICAL RESULTS

2.1 The Oil Embargo: Market and Non-Market Effects

Using the specification of the demand model discussed in the previous section, the first step of the analysis is to determine whether the structure of this model was affected by the public's response to the oil embargo in 1973. If the structure has changed during the last two and a half years, it is unlikely that reliable estimates of the current structure can be obtained from our sample, since it only covers the years 1964 to 1974. Hence, it is sensible to determine whether consumption levels in 1974, the first year after the oil embargo, are in some way inconsistent with the estimated structure before making any forecasts. One way of doing this is to compare the estimated models for two different sample periods; one covering 1964 to 1973, and the other covering 1964 to 1974. In this way, it is possible to determine whether the addition of data for 1974 changes the estimated models substantially.

The results of this preliminary analysis are reported in Table 1. For each category of demand, I Corresponds to the fitted model for 1964 to 1973, and II to the fitted model for 1964 to 1974. A comparison of the two sets of estimated coefficients for each equation shows that there are some dramatic changes.[22/] In the Residential and Commercial sector, the coefficients for the price of oil in the equations for electricity and for natural gas change sign in spite of the fact that the corresponding t ratios are relatively large. In addition, there are substantial changes in the coefficients for the prices of gasoline and of automobiles in the equation for gasoline. In the Industrial sector, the most obvious changes are in the coefficients for the Wholesale Price Index, and in the relative importance of income per capita within the state compared to the Gross National Product.

This evidence suggests that the structure of the model was not the same in 1974 as it had been in the earlier years. Consequently, the model is slightly modified in order to find a stable structure. If a dummy variable for the year 1974 is introduced, most of the changes of the estimated coefficients in the Residential and Commercial sector and some in the Industrial sector are reduced substantially, indicating that

Table 1. STRUCTURAL STABILITY OF THE CONVENTIONAL DEMAND MODEL 1/

Residential and Commercial

Explanatory Variable	Electricity			Natural Gas			Oil			Gasoline		
	I	II	III	I	II	III	I	II	III	I	II	III
1. Population	.22	.20	.20	.29	.27	.23	.31	.21	.21	.39	.38	.31
2. Income per capita	.22	.17	.22	-.05	-.13	-.08	.91	.88	.90	.17	.23	.13
3. Price of electricity	-.23	-.19	-.20	-.08	-.02	-.04	-.01	-.04	-.02	-	-	-
4. Price of natural gas	-.01	-.01	-.01	-.28	-.30	-.26	.29	.37	.38	-	-	
5. Price of oil	.06	-.14	.06	.32	-.12	.18	-.27	-.23	-.28	-	-	
6. Price of gasoline	-	-	-	-	-	-	-	-	-	-.15	-.33	-.14
7. Price of automobiles	-	-	-	-	-	-	-	-	-	-.23	-.12	-.27
8. Urbanization	-.13	-.11	-.14	.16	.14	.17	-.64	-.58	-.59	-.06	-.19	-.07
9. Conservation effect	-	-	-.06	-	-	-.09	-	-	.02	-	-	-.07
10. Lagged dependent	.79	.80	.80	.74	.74	.78	.70	.78	.78	.62	.60	.67

Industrial

Explanatory Variable	Electricity			Natural Gas			Oil			Coal		
	I	II	III	I	II	III	I	II	III	I	II	III
1. Population	.21	.24	.22	.41	.44	.45	.29	.30	.31	.18	.14	.13
2. Income per capita	.03	.14	.12	.32	-.10	-.10	.87	.72	.80	.31	.12	.13
3. Price of electricity	-.12	-.16	-.14	-.06	.09	.12	-.38	-.18	-.32	.18	.01	-.04
4. Price of natural gas	.03	.06	.04	-.86	-.66	-.67	-.06	.02	-.06	.02	.01	-.02
5. Price of oil	.00	.01	.01	.04	.04	.04	.05	.02	.68	.03	.02	.03
6. Price of coal	.04	.03	.03	.04	-.03	-.04	-.02	-.10	-.08	-.31	-.18	-.14
7. Wholesale Price Index	.19	-.21	.18	.08	-.13	-.28	.93	-.07	.86	1.95	1.39	2.04
8. Gross National Product	.22	.13	.15	-.19	.34	.34	-.53	-.47	-.46	-.09	-.13	-.05
9. Conservation effect	-	-	-.04	-	-	-.03	-	-	-.21	-	-	-.13
10. Lagged dependent	.79	.74	.78	.60	.60	.58	.70	.72	.72	.87	.87	.88

1/ For each category of demand, the three models are estimated from data for:

I. 1964 to 1973

II. 1964 to 1974

III. 1964 to 1974, with a dummy variable for 1974 included.

the structure is now reasonably stable for these two sectors. These results are summarized in Table 1 under Model III.

Inclusion of the dummy variable for 1974 is equivalent to allowing for a change of the "tastes" of residential customers or of the management practices followed by commercial and industrial customers in 1974. This change is measured by a shift of the intercept of each equation. In other words, the demand model for 1964 to 1973 is effectively replaced by another model in 1974 which has the same elasticities for all factors as before, but has a different intercept. It is, of course, possible to consider more general situations in which more than one parameter changes. However, since most of the substantive differences between Models I and II disappear when a dummy variable for 1974 is included, this modification seems sufficient.[23]

The estimated coefficients of the dummy variable for 1974 are relatively large and also have sizeable t ratios in both the Residential and Commercial sector and the Industrial sector, which indicates that there were some important non-market influences on consumption in 1974. An obvious example of such an effect is the restriction which was imposed on the sale of gasoline. Private motorists could only make purchases on alternate days. In addition there were many appeals made to the public and to industry to encourage people to reduce the use of all sources of energy. Consequently, we have labeled this variable as the effect of Non-Market Conservation to indicate that it is an effect which can not be accounted for by the response of the market to increased prices and the recession. Inspection of the corresponding estimated coefficients in Table 1 shows that all but one of the coefficients are negative, implying, as one would suspect, an additional constraint on consumption. The exception is a small increase of the use of oil (Number 2 distillate oil) by Residential and Commercial customers.

2.2 The Estimated Model

Even when the dummy variable for 1974 is included, some of the estimated coefficients in Table 1 have signs that are not consistent with standard economic logic. While there may be a legitimate explanation for these apparently illogical signs, such as the forced curtailment of gas sales to certain customers or the existence of long-term delivery contracts, these inconsistencies may lead to misleading forecasts, since they tend to reflect mainly short-run phenomena. Consequently, an attempt is made in this section to constrain the signs of the coefficients to conform with economic logic. In almost all cases, this makes little difference to the performance of the model, since the coefficients with "incorrect" signs are not well determined in a statistical sense. The resulting estimated long-run elasticities for all 8 categories of demand are summarized in Table 2. Table A3 in the appendix shows the actual estimated form of the models, together with the associated summary statistics such as t ratios.

Residential and Commercial

The direct price elasticities for the three competing fuels (electricity, natural gas and oil) are all relatively large (absolutely greater than one in the long-run), but there is a high degree of substitution between natural gas and oil,[24/] probably reflecting competition for space and water heating. Substitution between electricity and either of the other two fuels is relatively small, and only one of the four possible substitution elasticities in the three equations is non-zero. The direct price elasticity for gasoline is relatively small compared to the other fuels, and is only about half as big as the elasticity for the price of new cars.

The long-run income elasticities vary tremendously among fuels. Oil has by far the largest value, followed by electricity, gasoline and finally natural gas, which has a value of zero. The two values for oil and natural gas are both surprising, and there is no obvious reason why such extreme results arise from the data. One explanation might be that a great deal of substitution of oil for natural gas occurred during the sample period due, for example, to forced curtailments of supplies of natural gas rather than to price considerations. Although this may be the case in some states, the overall effect for the U.S. was, in fact, that the use of natural gas by Residential and Commercial customers increased almost three times as fast as the use of oil. The long-run elasticity for population is close to unity in all cases. If prices remained constant, these

Table 2. SUMMARY OF THE ESTIMATED MODEL.

Estimated Long-run elasticity 1/	Residential and Commercial			
	Electricity	Natural Gas	Oil	Gasoline
1. Price of electricity	-1.02	.00	.00	-
2. Price of natural gas	.00	-1.22	1.60	-
3. Price of oil	.31	1.10	-1.22	-
4. Price of gasoline	-	-	-	-.42
5. Price of automobiles	-	-	-	-.81
6. Income per capita	1.13	.00	4.05	.39
7. Population	1.04	1.03	.96	.93
Percentage adjustment during first year 2/	19	21	23	33
Conservation effect for 1974 in percent 3/	-6	-10	+3	-7

Estimated Long-run elasticity 1/	Industrial			
	Electricity	Natural Gas	Oil	Coal
1. Price of electricity	-.64	.09	.00	.24
2. Price of natural gas	.16	-1.71	.00	.00
3. Price of oil	.04	.10	.00	.27
4. Price of coal	.14	.00	.00	-1.16
5. Wholesale Price Index	.83	.00	1.73	17.23
6. Income per capita	.53	.00	1.90	.80
7. Gross National Product	.67	.52	.00	.00
8. Population	.97	1.07	1.32	1.09
Percentage adjustment in first year 2/	22	41	27	12
Conservation effect in percent 3/	-4	+0	-13	-13

1/ Defined in statement No. 6 of the references and notes section.

2/ With a partial adjustment model, this is $(1 - \hat{\lambda})\ 100$, where $\hat{\lambda}$ is the estimated coefficient for the lagged dependent variable. The short-run elasticity equals $(1 - \hat{\lambda}) \times$ long-run elasticity for each explanatory factor.

3/ Since the model is linear in logarithms, this is $(e^{\hat{\phi}} - 1)\ 100$, where $\hat{\phi}$ is the estimated coefficient of the dummy variable for 1974.

results suggest that the use of oil, and to a much lesser extent the use of electricity, would grow faster than the Gross National Product, while the use of gasoline would grow more slowly, and the use of natural gas would just keep pace with population.

With regard to Non-Market Conservation in 1974, relatively large reductions in consumption were found for all fuels except oil. The effect for this latter fuel was slightly positive, which may reflect a switch by Commercial customers from residual oil, which is largely imported, to distillate oil, which is produced mainly from domestic sources (note that only Number 2 Distillate oil is included in this category of demand). This suggests that it might be sensible to combine residual and distillate oil for Residential and Commercial customers if the model were reestimated.

Industrial

The direct price elasticities for the four competing fuels (electricity, natural gas, oil and coal) vary much more than they do in the Residential and Commercial sector. Natural gas has the highest value in absolute terms, followed by coal, electricity and oil, which has a value of zero. Substitution elasticities are generally quite small in all equations. In fact, all of the price elasticities for the four fuels in the oil equation have incorrect signs in all versions of the model, and consequently, are constrained to zero.[25/] This may reflect our use of the price of oil paid by Electric Utilities in this equation, since no price data are readily available at this level of disaggregation for Industrial customers. The same problem also exists for the price of coal, and these limitations of the data may account for the difficulties experienced in obtaining reliable estimates of the price elasticities for this sector.

Both income per capita within the state and the Gross National Product are present in each equation, and the sum of the two corresponding elasticities is equivalent to the income effect. Oil has the highest income effect, followed by electricity, coal and natural gas. This is the same ordering, with the addition of coal, as the Residential and Commercial sector. Once again all of the long-run elasticities for population are close to one. In the absence of price changes, increasing both income variables would make the use of oil and of electricity expand faster than income, and the use of coal and of natural gas grow slower than income.

In 1974, substantial reductions in the quantities of oil and coal below the levels predicted by standard market forces were experienced since the effects of Non-Market Conservation are large and negative for these two fuels. The corresponding value for electricity is much smaller, and for natural gas, it is slightly positive.

2.3 The Predictive Performance of the Estimated Model

All of the models fit the data reasonably well. If predictions are made for each category of demand for all states year by year, almost all of the resulting correlation coefficients between the predicted and true levels of consumption computed across states are greater than 0.98.[26/] The lowest value occurs with the demand for oil by Industrial customers, but the form of this equation is basically deficient because all four of the price coefficients are zero in the estimated model (see Table 2). Although the correlation coefficient is a widely used measure of goodness-of-fit, Theil's U statistic is in many ways more appropriate. If O_t and P_t represent the observed and predicted levels of demand for observation t, then the correlation coefficient measures whether O_t and P_t are linearly related. In other words, it measures how well the equation $O_t = \alpha + \beta P_t$, where α and β are two parameters, represents the sample. As long as β is positive, a perfect positive correlation may exist for any values of α and β. However, a perfect fit only corresponds to the situation in which $\alpha = 0$ and $\beta = 1$, and consequently, the correlation coefficient can be large even when the model does not fit well. With Theil's U statistic, the following standardized version of the root mean square error is used:

$$U = \frac{\sqrt{\frac{1}{T}\sum_t \left(O_t - P_t\right)^2}}{\sqrt{\frac{1}{T}\sum_t O_t^2} + \sqrt{\frac{1}{T}\sum_t P_t^2}}$$

U varies from zero (perfect fit; $\alpha = 0$ and $\beta = 1$) to one (an exact inverse relationship; $\alpha = 0$ and $\beta = -1$). The computed values for each category of demand for each year are summarized in Table 3.[27/] Only four of the 80 values are greater than 0.1, which illustrates the generally high level of performance of the estimated model. However, another, and more important, reason for presenting the information in Table 3 is to determine whether the fit of the model has deteriorated during the sample period. In particular, it is important to determine whether the fit in the later years is noticeably worse than it is in the earlier years. There is no indication of such a change for any of the four fuels used by the Residential and Commercial sector, and for the Industrial sector, it is only with natural gas that the largest annual value of the U statistic occurs in 1974. A possible reason for the relatively poor fit of this equation in 1974 is that forced curtailments of supplies were important in some states but not in others.

With a regional model such as the one under discussion, there is no guarantee that predictions at the national level will be as accurate as those at the state level. A similar problem can also arise when converting log-linear models to physical units, even though the models fit well in the linear form. For this reason, a summary of the predicted and observed levels of consumption in the U.S. is given in Table 4 for all 8 categories of demand. The corresponding correlation coefficient and Theil's U statistic are presented for each category. These results also indicate a high level of prediction performance for all fuels used by Residential and Commercial customers, and to a slightly lesser extent by Industrial customers.

Although regional data have not yet been collected for 1975, values of all of the important variables in the model have been published for the whole U.S. Hence, it is possible to determine the growth of each variable from 1974 to 1975 and to apply these rates to the regional data in 1974 to derive rough forecasts of the levels of consumption in 1975. If these forecasts are then aggregated across states, they can then be compared with the true values at the national level. The results are summarized in Table 5. In almost all cases, the forecasted levels are greater than the true values. This suggests that the effect of Non-Market Conservation identified in 1974 may still be present in 1975. For this reason,

Table 3. COMPUTED VALUES OF THEIL'S U STATISTIC

	Year									
	65	66	67	68	69	70	71	72	73	74
Residential and Commercial										
1. Electricity	.012	.020	.009	.007	.010	.007	.008	.006	.015	.007
2. Natural Gas	.015	.011	.008	.020	.013	.017	.024	.019	.031	.028
3. Oil	.054	.028	.027	.017	.016	.013	.016	.023	.019	.020
4. Gasoline	.008	.011	.008	.013	.015	.031	.022	.016	.007	.010
Industrial										
1. Electricity	.016	.014	.012	.013	.014	.015	.012	.017	.018	.013
2. Natural Gas	.022	.018	.014	.012	.020	.023	.039	.063	.032	.121
3. Oil	.085	.077	.121	.040	.057	.059	.125	.106	.056	.068
4. Coal	.022	.026	.015	.017	.027	.061	.036	.075	.052	.040

able 4. PREDICTED LEVELS OF CONSUMPTION IN THE U.S. FOR 1965 TO 1974[a/]

esidential and ommercial	Units	65	66	67	68	69	70	71	72	73	74	Correlation Coefficient	Theil's U Statistic
l. Electricity	10^9 kwh	482 (481)	527 (530)	579 (572)	629 (630)	692 (692)	756 (758)	817 (810)	869 (870)	937 (947)	943 (944)	.999	.003
2. Natural Gas	10^{13}btu	543 (534)	563 (564)	592 (594)	625 (625)	656 (669)	697 (692)	717 (719)	734 (741)	750 (727)	700 (715)	.989	.008
3. Oil	10^6 barrels	365 (396)	391 (395)	398 (416)	426 (429)	440 (433)	436 (441)	444 (439)	464 (452)	458 (445)	432 (426)	.958	.016
4. Gasoline	10^{12}gallons	73 (73)	76 (77)	80 (79)	83 (84)	88 (88)	92 (89)	94 (96)	101 (101)	106 (106)	101 (101)	.993	.007
ndustrial													
.. Electricity	10^9 kwh	433 (432)	463 (464)	492 (485)	517 (517)	549 (556)	580 (571)	594 (591)	625 (637)	681 (685)	685 (687)	.998	.005
2. Natural Gas	10^{13}btu	624 (617)	661 (668)	712 (701)	761 (759)	826 (813)	867 (843)	830 (814)	839 (886)	869 (836)	730 (810)	.920	.021
3. Oil	10^6 barrels	177 (182)	175 (187)	180 (176)	175 (180)	180 (171)	174 (181)	182 (185)	192 (201)	216 (218)	204 (206)	.912	.018
.. Coal	10^6 tons	211 (211)	219 (210)	207 (206)	199 (198)	187 (193)	172 (191)	165 (160)	145 (163)	168 (160)	159 (155)	.918	.026

a/ The observed values are given in parentheses

Table 5. FORECASTS OF FUEL CONSUMPTION IN 1975

Explanatory Factor	Specified Growth Rates from 1974 to 1975 (Percent)[a/] Residential and Commercial	Industrial	Electric Utilities
1. Population	.8	.8	-
2. Income per Capita	-1.9	-1.9	-
3. Gross National Product	-	-2.0	-
4. Price of Electricity	2.3	8.2	-
5. Price of Natural Gas	11.5	34.8	37.9
6. Price of Oil	-.7	1.0	1.0
7. Price of Coal	-	10.0	10.0
8. Price of Gasoline	2.8	-	-
9. Price of Automobiles	-.5	-	-
10. Wholesale Price Index	-	.1	-

Consumption in 1975[b/]

Fuel[c/]	Residential and Commercial $O^{a/}$	F_1	F_2	Industrial $O^{a/}$	F_1	F_2
1. Electricity	1000	1004 (+.4)	946 (-5.4)	659	720 (+9.2)	691 (+4.9)
2. Natural Gas	701	783 (+11.7)	706 (+.7)	688	599 (-12.9)	599 (-12.9)
3. Oil	428	404 (-5.6)	415 (-3.0)	175	224 (+28.0)	194 (+10.9)
4. Coal	-	-	-	151	179 (+18.5)	156 (+3.3)
5. Gasoline	103	106 (+2.9)	99 (-3.9)	-	-	-

a/ Preliminary values derived by Duane Chapman from various sources

b/ 0 Observed level of consumption

F_1 Forecasted level with no Conservation Effect

F_2 Forecasted level with Conservation Effect

The percentage error is given in parentheses

c/ Units are the same as in Table 5.

another set of forecasts is made with Non-Market Conservation included. In all 8 cases, inclusion of this effect moves the forecast towards the observed value, but in two cases, the resulting error is larger than before although the sign is now reversed, implying that the effect of Non-Market Conservation is somewhat smaller than it was in 1974. Since the forecasts for 1975 are generally improved by including Non-Market Conservation, forecasts from 1975 to 1990 are made in the following section both with and without this factor.

Since each forecast for 1975 is derived using the same growth rate in all states for any particular explanatory factor, no account of regional differences in price increases, for example, is made. Consequently, the resulting forecast must not be considered as equivalent to a prediction in the sample period. Regional patterns of the explanatory factors are known to have changed in 1975. Therefore, it is not really surprising that the errors of the forecasts are relatively large compared to the errors in the sample period, and these large errors do not necessarily imply that the model has undergone any structural change.

2.4 Alternative Scenarios for 1990

Five basic scenarios have been suggested by the Panel on Demand and Conservation which relate to different assumptions about energy prices and income levels in the year 2010. These scenarios, which are labeled A, B, B', C and D, can be characterized by increasing energy prices in A, B and B', constant prices in C and modest price declines in D. The price of natural gas, however, increases in every scenario. For all scenarios except B', the appropriate assumptions about energy prices are combined with the same set of specified growth rates for the other explanatory factors such as population, Gross National Product and income per capita. Scenario B' is identical to Scenario B except that a higher rate of growth for income is specified. Different rates of growth of income and population are specified for each state, and are based on projections made by the Bureau of Economic Analysis, (BEA) of the U.S. Department of Commerce.[28] The BEA projections correspond to an increase in the Gross National Product which is somewhat larger than the increase selected by the Panel, and consequently, increases of incomes in each state have been multiplied by a common scalar to bring the average rate down to the Panel's level. In this way, the relative differences in the rates of growth of income among states are maintained. It whould be noted that the BEA has already made an appraisal of their earlier projections for the years 1973-1975. Projected income levels in the northeastern states were generally higher than the actual levels, while the projections were too low in the rest of the country. The published projections of population were also found to differ from the actual levels in 1975, and the errors had a similar pattern to those found for income, but they were generally smaller. Unfortunately, no adjusted projections have been published for income or population, and therefore, we have had to rely on the existing ones for our forecasts.

Although the specified growth rates for income and population differ between states, no such differences are made for prices. Different growth rates are specified for the prices of electricity, natural gas, coal, and of petroleum products, and consequently, it is assumed that the prices of gasoline, distillate oil and residual oil all grow at the same rate in a particular scenario. In addition, the rate of growth of the price of any fuel is assumed to be the same for all classes of customers. This latter assumption has some important implications for policy since it implies that existing differentials in the prices charged to industrial and residential customers, for example, will be maintained in the future. The current practice of charging relatively high prices to residential customers has been frequently criticized, particularly with regard to electricity and natural gas prices. The effect of removing such differentials has obvious relevance to the rate at which stocks of fuels are depleted, and the fact that this topic is not investigated further here does not imply that it is unimportant.

The percentage change from 1974 to 1990 for each of the explanatory factors is presented in Table 6 for all five scenarios. The levels of other explanatory factors which are not listed in Table 6 are held at their 1974 values, and therefore, in the cases of the price of automobiles and the Wholesale Price Index are assumed to increase at the same rate as the

Consumer Price Index. In every case, non-zero growth rates are converted to the corresponding annual rates by assuming that each factor grows linearly rather than at an exponential rate.

Table 6. SPECIFIED CHANGES OF THE EXPLANATORY FACTORS FOR EACH SCENARIO

Explanatory Factor	Percentage change from 1974 to 1990 in real terms[a/] SCENARIO A	B	B'	C	D
1. Population	16.1	16.1	16.1	16.1	16.1
2. Income per capita	30.6	30.6	70.4	30.6	30.6
3. Gross National Product	47.1	47.1	87.3	47.1	47.1
4. Price of Electricity	114.1	47.1	47.1	0.0	-15.4
5. Price of Natural Gas	553.8	266.7	266.7	150.0	97.0
6. Price of Oil	194.9	66.7	66.7	0.0	-18.1
7. Price of Coal	150.0	47.1	47.1	0.0	-13.6

a/ If X_t measures the level of the factor in year t, then the tabulated value is:

$$100 \left[\frac{X_{1990} - X_{1974}}{X_{1974}}\right]$$

2.5 The Forecasting Results

After some preliminary investigations, the model of the demand for oil in the Residential and Commercial sector was found to be unsatisfactory. It has already been noted that both the income elasticity and the substitution elasticity with respect to natural gas are extremely large in this equation. Since the specified growth rates in the five scenarios for both of these factors, particularly the latter, are also large, forecasts of the use of oil by Residential and Commercial customers are often unrealistically high, and in some cases, this category of fuel accounts for over 40 percent of all energy, compared to about

4 percent now. In order to make it possible to compare the forecasts for different scenarios on the same basis, this equation is dropped, and consequently, the demand for oil by Residential and Commercial customers is now assumed to be part of the category "Other Primary Energy".

It is convenient at this stage to convert each fuel to a common unit (btu, British Thermal Units) so that the total quantity of energy of all types can be measured.[29/] The seven categories used for forecasting account for over 70 percent of the energy from all sources used in the U.S. We assume that the same proportional relationship will hold in the future, and the subtotal for the seven categories of fuel is multiplied by 1.37 to give the total amount of energy from all sources. The implication of this procedure is that omitted categories of demand, which include the distillate oil used by Residential and Commercial customers, oil for feedstocks, and fuels used for air and rail transportation, are influenced by population, income and the prices of fuels. The magnitude of these effects correspond to some weighted average of the values in the seven equations used for forecasting.

A similar procedure to the one used for Other Primary Energy is followed for converting the total amount of electricity purchased by the Residential and Commercial sector and the Industrial sector to the total amount generated. The difference between forecasted sales and generation is accounted for by some additional classes of customers, such as railways, and more importantly, by losses during the distribution process, and the difference corresponds to roughly 12 percent of generation. The forecasted level of sales for each census region is converted to the level of generation by multiplying it by a scalar corresponding to the ratio that existed between generation and sales in 1974.

For each scenario, two versions of the estimated model are used to derive forecasts. In the first version of the model, Non-Market Conservation (N-MC) is omitted, and as a result, it is assumed that demand returns to its pre-1974 structure in 1975 and remains unchanged in subsequent years. In the second version, the estimate of N-MC is included, implying that the structure of demand in 1974 is maintained throughout the forecast period. The reason for considering this latter assumption is that forecasts for 1975 derived in the previous section were generally more accurate with N-MC present, suggesting that the shift of demand in 1974 was not just a temporary phenomenon. These two proceudres for deriving forecasts may be interpreted as defining two extreme situations. With N-MC omitted, the assumption is that non-market effects are no longer present after 1974. However, since efforts to maintain lower speed limits on highways, for example, are still being continued, there is no reason to believe that omitting the N-MC is correct. On the other hand, the appropriate level for the N-MC can not be determined from existing data since it depends to a large extent on whether or not policies for ensuring that energy is used more efficiently are actively encouraged by the government. Hence, the forecasts with N-MC present are meant to illustrate the potential for reducing the need for more energy through increased public awareness and legislative means.

The 10 forecasts of the levels of energy used in 1990 are summarized in Table 7 for each of the seven categories of fuel as well as for various aggregates. In addition, the corresponding observed levels for 1974 are shown. In the following discussion, the percentage increase from 1974 to 1990 is used as a bench mark for making comparisons. We have chosen not to adopt the common practice of using annual growth rates because such a measure often leads to the mistaken conclusion that the use of energy will necessarily grow exponentially in the future as it has in the past.

With Scenario A, in which the prices of all fuels increase substantially, the total quantity of energy is forecasted to increase by 22 percent between 1974 and 1990 if there is no continuation of Non-Market Conservation after 1974, or to decline by 15 percent if this effect continues throughout the forecast period. The use of natural gas drops dramatically in both cases, especially for Industrial customers, and to a lesser extent, so does the use of gasoline. However, the total use of electricity and the use of oil and coal by Industrial customers increase in both cases, and in the case with no N-MC, these increases are sufficient to offset the decreases of other fuels. With Scenario B, in which more modest increases in the prices of fuels are specified, the forecasted levels in 1990 are as large or larger than the corresponding forecasts with Scenario A. Although

Table 7. ALTERNATIVE FORECASTS OF ENERGY USE IN 1990 (QUADRILLION BTU)

Type of Fuel a/		Observed Level In 1974	SCENARIO b/ A: No N-MC	A: Continued N-MC	B: No N-MC	B: Continued N-MC	B': No N-MC	B': Continued N-MC	C: No N-MC	C: Continued N-MC	D: No N-MC	D: Continued N-MC
1. Electricity	R/C	9.9	13.9	10.3	16.5	12.2	21.0	15.5	20.0	14.8	21.8	16.1
	IND	7.2	14.4	12.0	15.0	12.5	19.3	16.1	16.5	13.7	17.0	14.2
2. Natural Gas	R/C	7.1	5.0	3.1	5.7	3.5	5.7	3.5	5.6	3.4	6.2	3.8
	IND	8.1	.5	.5	1.2	1.2	1.3	1.3	2.1	2.1	3.0	3.0
3. Oil	IND	1.3	3.3	1.9	3.3	1.9	5.1	3.0	3.3	1.9	3.3	1.9
4. Coal	IND	4.4	11.9	4.4	15.4	5.7	17.6	6.5	17.7	6.6	18.6	6.9
5. Gasoline	R/C	12.7	12.0	9.8	15.0	12.2	16.5	13.5	18.2	14.8	19.6	16.0
6. Total Generation of Electricity c/		19.4	32.0	25.2	35.7	28.0	45.7	35.9	41.3	32.3	43.9	34.3
7. Forecasted Primary Energy d/		33.6	32.7	19.7	40.5	24.6	46.2	27.8	46.9	28.9	50.7	31.6
8. Other Primary Energy e/		19.9	24.3	16.9	28.7	19.8	34.6	24.0	33.2	23.0	35.6	24.8
9. Grand Total		72.9	89.0	61.8	104.9	72.4	126.5	87.7	121.4	84.2	130.1	90.7

a/ R/C refers to Residential and Commercial customers
IND refers to Industrial customers

b/ No N-MC refers to the forecast with no Non-Market Conservation after 1974.
Continued N-MC refers to the forecast with continued Non-Market Conservation after 1974.

c/ Equal to the sum of the quantities of electricity demanded by Residential and Commercial and by Industrial customers multiplied by a factor for each census region to account for other customers and distribution losses.

d/ Equal to the sum of categories 2 to 5.

e/ Equal to a fixed proportion (37.03 percent) of the sum of categories 6 and 7.

once again the use of natural gas is forecasted to decline both with and without N-MC, the use of gasoline declines only if N-MC continues. The combined effect on the total quantity of energy in 1990 is an increase of 44 percent from 1974 without N-MC and a decline of one percent with N-MC.

The price of natural gas increases in Scenario C and D, but the prices of other fuels remain at their 1974 levels in C and decline in D. In all cases the forecasted levels of all fuels except natural gas in 1990 are higher than in 1974. Without N-MC, the largest increases are for the coal used by Industrial customers, followed by oil for Industrial customers, total generation of electricity and gasoline. With continued N-MC, the first three of these categories have similar percentage increases, and once again, the increase of gasoline is relatively small. The combined effect is that without N-MC the total use of energy increases by 67 and 78 percent from 1974 to 1990 for Scenarios C and D, respectively, and the corresponding increases with N-MC are 16 and 24 percent.

Scenarios B' and B are identical except that income is specified to grow faster in Scenario B'. The forecasted quantities of fuels used in 1990 with Scenario B' are very similar to those with Scenario D. The quantities of natural gas are, in fact, lower with Scenario B', but the corresponding quantites of oil and gasoline are higher. This demonstrates that in terms of the overall use of energy, additional growth of the economy has a similar effect to reducing the price of energy. With both scenarios B' and D, relatively high rates of growth of energy are forecated, corresponding to annual growth rates of about 3.5 percent without N-MC, and less than 1.5 percent with N-MC. Since the corresponding observed rate of growth during the sample period (1964-1974) is roughly 3.5 percent, it suggests that historical rates of growth will not be attained in the future if the real price of energy declines, unless the rate of growth of real GNP is relatively high. With Scenarios A and B, even lower rates of growth of energy are forecasted.

2.6 Implemenation of Alternative Policies for Conserving Energy.

In the previous section, the importance of the relationship between the price of energy and the quantity of energy demanded was demonstrated.

Higher prices for energy in the future, together with somewhat lower rates of growth of income and population than in the past, can lead to substantially lower rates of growth of the use of energy than the rate observed over the last 25 years. In some cases, a decline in the use of energy is forecasted when Non-Market Conservation is present throughout the forecast period. However, there has been no discussion up to this point about whether or not higher prices for energy are likely to occur in the future. In a market economy, such a discussion inevitably involves consideration of the costs of producing energy. Since this topic falls outside the responsibilities of the Panel on Demand and Conservation, no detailed analysis of costs is undertaken here. The purpose of this section is to emphasize that the price of energy should be viewed as a matter of government policy and not as something that is determined exclusively by market forces. Indeed, present pricing procedures cannot be described as being influenced solely by costs.

The assumption underlying our model of the demand for energy is that customers take the prices of fuels as given at any point of time, and that they can buy any desired quantity of each fuel at those prices. In other words, the supply relationship for each fuel is assumed to be infinitely elastic with respect to price for a range of quantities around the amount purchased. If, however, a specified price in a competitive market is substantially higher than the corresponding average cost of production, producers would eventually reduce the price and so increase the quantity demanded until the price charged is equal to the cost. If, on the other hand, the price charged is lower than the average cost of production, the quantity produced would not be sufficient to cover demand.

There is no reason in practice why forecasts should be limited to situations in which price and cost are equal. If some form of excise or sales tax is imposed by the government on a fuel, then the price charged to customers is higher than the price received by producers. Similarly, if some costs of production are subsidized by the government, or directly by the public in the case of external costs such as industrial pollution, then producers can charge prices which are less than the social cost of production. This implies that the appropriate choice of taxes and subsidies can make any set of prices compatible with any set of production costs.[30/] Consequently, each one of the scenarios discussed in the previous section as well as any other specified set of prices for energy may be considered as a possible choice for the future. The main limitation on the range of possibilities is the ability of the government to establish and enforce a chosen policy without causing an unacceptable disruption of the economic system.

In the following analysis, the objective is to illustrate the main implications of the five scenarios, defined in Table 6, in terms of the government measures needed to implement them. We assume, for simplicity, that the costs of producing each fuel are the same for all scenarios. Any divergence from this assumption would require some knowledge of the costs of producing the different forecasted quantities of each fuel, and the appropriate information can not be readily obtained without undertaking a thorough analysis of production. This, as stated above, is not within the scope of this Panel's study. The prices chosen to represent the market equilibrium are those specified for Scenarios B (and B'), in which the prices of all fuels rise modestly in real terms. It should be noted that Scenario C is closer to the "base case" selected by the Modeling Resources Group. In Scenario C, production costs in real terms are assumed to remain constant for electricity, oil and coal, and to increase sufficiently for natural gas to make this price similar to the prices of other fossil fuels on a btu basis by the year 2010. However, these assumptions appear to represent a distinctly optimistic view of future developments of production technology when the current economic and environmental problems associated with nuclear power, Alaskan oil and western coal are considered. To these domestic problems must be added the increasing cost of importing fuels such as oil. For these various reasons, we consider that Scenario B provides a more realistic representation of future production costs.

If the price of a fuel in Scenario B is assumed to represent the price needed by producers to cover their costs, then the difference between the price in any other scenario and the price in Scenario B measures the extent of the intervention required from the government to implement the alternative scenario. The taxes or subsidies for electricity, natural gas, oil and coal implied by Scenario A, C and D are summarized in Table 8 for the years 1975 to 1990. Since the forecasting procedure uses different prices

Table 8. ILLUSTRATION OF THE TAX OR SUBSIDIES FOR EACH MAJOR FUEL (1975-1990)[a/]

	Electricity (¢/kwh)[b/]			Natural Gas ($/$10^6$btu)[b/]			Oil ($/barrel)[b/]			Coal ($/ton)[b/]		
Scenario A	P_1	P_2	(P_1-P_2)[c/]	P_1	P_2	(P_1-P_2)[c/]	P_1	P_2	(P_1-P_2)[c/]	P_1	P_2	(P_1-P_2)[c/]
1975	2.89	2.78	0.11	1.60	1.39	0.21	13.91	12.92	0.99	19.25	18.12	1.13
1980	3.86	3.18	0.68	3.66	2.38	1.28	21.46	15.50	5.96	27.50	20.71	6.79
1985	4.82	3.57	1.25	5.71	3.37	2.34	29.02	18.09	10.93	35.75	23.30	12.45
1990	5.78	3.97	1.81	7.77	4.36	3.41	36.57	20.67	15.90	44.00	25.89	18.11
Scenario C												
1975	2.70	2.78	(0.08)	1.30	1.39	(0.09)	12.40	12.92	(0.52)	17.60	18.12	(0.52)
1980	2.70	3.18	(0.48)	1.86	2.38	(0.52)	12.40	15.50	(3.10)	17.60	20.71	(3.11)
1985	2.70	3.57	(0.87)	2.41	3.37	(0.96)	12.40	18.09	(5.69)	17.60	23.30	(5.70)
1990	2.70	3.97	(1.27)	2.97	4.36	(1.39)	12.40	20.67	(8.27)	17.60	25.89	(8.29)
Scenario D												
1975	2.67	2.78	(0.11)	1.26	1.39	(0.13)	12.26	12.92	(0.66)	17.45	18.12	(0.67)
1980	2.54	3.18	(0.64)	1.62	2.38	(0.76)	11.56	15.50	(3.94)	16.70	20.71	(4.01)
1985	2.41	3.57	(1.16)	1.98	3.37	(1.39)	10.86	18.09	(7.23)	15.95	23.30	(7.35)
1990	2.28	3.97	(1.69)	2.34	4.36	(2.02)	10.16	20.67	(10.51)	15.21	25.89	(10.68)

a/ In Scenarios B and B', all taxes and subsidies are zero so that the prices charged to customers equal the prices received by producers. These latter prices are the same in all scenarios.

b/ P_1 is the price charged to customers

P_2 is the price received by producers

(P_1-P_2) is the tax or subsidy

c/ Values in parentheses correspond to subsidies for each fuel in different states and for different classes of customers, the prices shown in Table 8 represent typical values.

In all cases, the tax or subsidy for each fuel increases over time as a proportion of the price charged to customers. With Scenario A, in which price increases are the largest, the implied taxes correspond to between one third and one half of the price charged in 1990. Their are no taxes or subsidies with Scenarios B and B' since each price equals the cost of production under our assumption. With Scenarios C and D, subsidies must be paid to producers to maintain the increases in the use of energy implied by the corresponding forecasts. By 1990, the subsidies in Scenario C for electricity, natural gas and coal correspond to about half of the price paid by consumers, and the subsidy for oil is even higher in relative terms. In Scenario D, all subsidies are higher than in Scenario C, and by 1990 are almost equal to the demand price for oil and natural gas, and are somewhat lower in relative terms for electricity and coal. It should be noted that under our assumption all fuels are either taxed or subsidized in each scenario. However, there is no analytical reason for not considering taxes on some fuels and subsidies on others.

The revenues generated by the taxes on fuels or the costs of subsidies paid to producers are summarized in Table 9 for 1990. In addition, the total tax or subsidy for the years 1975 to 1990 for each scenario are summarized in Table 10. The categories of fuel shown in Table 9 correspond to the seven demand equations used for forecasting, and to the aggregates identified in that table.

The specific method used to define the rate of taxation or subsidy for this analysis implies that a known proportion of the total revenue from sales for each type of fuel and for each year accrues to or is paid out by the government. With regard to the fuels included in "Other Primary Energy", it is assumed that the overall average tax or subsidy per btu for the seven estimated demand models applies to these excluded fuels.

If government expenditures are assumed to increase at the same rate as the values specified for GNP in the alternative scenarios, then by 1990, these expenditures will be approximately $485 billion for Scenarios A, B, C and D, and $618 billion for Scenario B'. The corresponding revenues from taxes in Scenario A range from roughly 30 percent to 40 percent of all

Table 9. REVENUE FROM TAXES OR COST OF SUBSIDIES IN 1990 (BILLION 1975 DOLLARS)

Type of Fuel[a/]		SCENARIO[b/] A No N-MC	A Continued N-MC	C[c/] No N-MC	C[c/] Continued N-MC	D[c/] No N-MC	D[c/] Continued N-MC
Electricity	R/C	25.20	18.62	(26.28)	(19.42)	(38.40)	(28.37)
	IND	14.35	11.98	(11.93)	(9.96)	(16.53)	(13.80)
Natural Gas	R/C	17.39	10.67	(8.06)	(4.94)	(12.96)	(7.95)
	IND	0.88	0.88	(1.53)	(1.53)	(3.20)	(3.20)
Oil	IND	7.68	4.55	(4.16)	(2.46)	(5.36)	(3.18)
Coal	IND	8.17	3.04	(5.78)	(2.15)	(7.91)	(2.94)
Gasoline	R/C	64.43	52.53	(52.94)	(43.16)	(73.40)	(59.84)
Total Generation of Electricity d/		44.82	34.68	(43.30)	(33.29)	(62.25)	(47.80)
Total Forecasted Primary Energy d/		98.56	71.67	(72.46)	(54.24)	(102.82)	(77.10)
Other Primary Energy d/		53.94	40.01	(43.55)	(32.93)	(62.10)	(46.98)
Grand Total		197.32	146.35	(159.30)	(120.45)	(227.17)	(171.88)

a/ R/C refers to Residential and Commercial customers.

IND refers to Industrial customers.

b/ No N-MC refers to the forecast with no Non-Market Conservation after 1974.

Continued N-MC refers to the forecast with continued Non-Market Conservation after 1974.

Scenarios B and B' are used as the base case, and consequently, no revenues or costs accrue.

c/ Figures in parentheses correspond to a subsidy.

d/ Equal to the sum of categories 2 to 5.
For electricity, it is assumed that the tax or subsidy is applied to the total quantity generated and not just to the quantity sold.

Table 10. TOTAL REVENUE FROM TAXES OR TOTAL COST OF SUBSIDIES (1975-1990) (BILLION 1975 DOLLARS)

	Revenue from Taxes		Cost of Subsidies	
	No[a/] N-MC	Continued[a/] N-MC	No N-MC	Continued N-MC
Scenario A[b/]				
1975	11.48	10.70	0	0
1980	72.36	57.16	0	0
1985	133.49	100.65	0	0
1990	197.32	146.35	0	0
Scenario C				
1975	0	0	6.95	6.49
1980	0	0	49.16	39.27
1985	0	0	99.71	76.43
1990	0	0	159.30	120.45
Scenario D				
1975	0	0	9.35	8.74
1980	0	0	54.73	53.94
1985	0	0	124.03	106.93
1990	0	0	227.17	171.88

a/ No N-MC refers to the forecast with no Non-Market Conservation after 1974.

Continued N-MC refers to the forecast with continued Non-Market Conservation after 1974.

b/ In Scenarios B and B', prices and costs are equal for all fuels, and consequently, no revenues or subsidies accrue.

government expenditures. This implies that substantial reductions of other sources of taxation would be possible in this situation.

With regard to the cost of subsidies in Scenarios C and D, the forecasted values in 1990 range from about 25 percent to 47 percent of government expenditures. However, with subsidies it is not necessarily the government that pays. If certain external costs, such as the medical expenses related to pollution from power plants, damages from oil-spills, etc., are born by the public, then producers are effectively subsidized even though no formal mechanism for payment of subsidies is instituted by the government. External costs of this type are transferred to the public whenever environmental quality is allowed to decline. This is not the case with the taxation of fuels, however, since then some form of government action is always required. It is also possible for the government to pay subsidies indirectly to producers. Much of the federal expenditure on research into energy production can be viewed in this way, and in addition, certain tax adjustments such as the investment tax credit are more valuable to producers of energy because of the capital-intensive nature of their industry than to labor-intensive industries such as construction.

3. CONCLUSIONS

In this analysis, we have attempted to estimate demand models for the major types of fuel and classes of customer in the U.S. The estimated models are then used to derive forecasts of the quantities of these fuels and of the total amount of energy demanded in the U.S. by the year 1990 for five alternative scenarios. Each scenario represents a different set of specifications about the future prices of fuels and the future levels of income and population chosen by the Panel on Demand and Conservation.

Each demand relationship can be specified as a linear regression model which is then estimated by generalized least squares from a set of pooled annual data for individual states. Satisfactory equations are obtained for the quantities of gasoline, electricity, and natural gas demanded by Residential and Commercial customers, but the corresponding equation for oil has to be rejected for forecasting purposes. For Industrial customers, all four of the equations for electricity, natural gas, oil and coal are retained, although the equation for oil is not entirely satisfactory since all of the price effects are found to be zero. This problem is attributed in part to the inadequate nature of available data on oil prices at this level of disaggregation.

In addition to the effects of population, income and the prices of fuels on the quantities of fuels demanded, certain non-market forces are present in 1974 immediately after the oil embargo, and their effect on demand is estimated. Among the seven categories used for forecasting, estimates of "Non-Market Conservation" during 1974 range from a 13 percent reduction in the quantities of oil and coal demanded by Industrial customers to a slightly positive effect on the demand for natural gas by Industrial customers. In general, Non-Market Conservation can be explained by short-term policies, such as the restrictions placed on the sales of gasoline, as well as by longer term considerations, such as the public's willingness to turn down thermostats in the winter, form car pools and to adopt other practices for using energy more efficiently. These latter changes probably result from an increasing awareness by the public and by industry of how to avoid wasting energy. Some evidence for these longer term effects is provided in the form of forecasts for 1975. Generally, these forecasts are improved if the estimated effect of Non-Market Conservation in 1974 is still present in the model. Furthermore, government policies instituted by federal agencies in 1976 are expected to lead to additional reductions of demand in the future that will be independent of market forces. Consequently, forecasts for 1990 are derived under two alternative assumptions. The first is that Non-Market Conservation is only present in 1974, and the second is that the estimated shift in the structure of demand in 1974 represents a permanent change of attitudes towards the use of energy. Given the continued efforts of the government to encourage the efficient use of energy through increasing public awareness and through legislation, the first assumption is probably unrealistic. However, it is not possible to determine exactly how effective Non-Market Conservation will be in the future, and consequently, use of the estimated value for 1974 is primarily to illustrate the potential importance of such efforts.

The different specifications for the future levels of the prices of fuels, together with the potential effect of Non-Market Conservation, provide a wide range of forecasts for 1990. The highest forecast corresponds to an increase of 78 percent above the level in 1974, while the lowest is equivalent to a decrease of 15 percent when the effect of Non-Market Conservation is continued until 1990. These results support a major contention of the Panel which is that a wide variety of future paths for energy are possible. These paths range from exponential growth to a flattening of the quantity of energy used at roughly the current level. We conclude that there is nothing predetermined about the path that energy demand will follow, and deciding which path is chosen is an appropriate matter for public deliberation and decision.

We also demonstrate that a selected path can be implemented by instituting either a tax on the sale of energy or a subsidy for the producers of energy. Since a tax increases the price paid by customers above the cost of production, the quantity of a fuel demanded will be reduced, but on the other hand, a subsidy will increase the quantity demanded. One additional point is that subsidies can be paid in a number of indirect ways, such as ignoring the environmental costs associated with production. To this extent, taxation is more difficult to implement because it does require government action, while subsidies can exist through government inaction

Notes and References

1. See, for example, Time Series Analysis by G. E. P. Box and G. M. Jenkins, Holden Day, revised edition 1976.

2. In practice, the distinction between time-series and econometric analyses is not clear cut. Control variables can be included in time-series models, for example.

3. Number 2 Distillate oil is the source of oil for Residential and Commercial customers, while residual oil is the dominant source for Industrial customers.

4. These results are available in an earlier version of this paper: "The Future Demand for Energy in the U.S.: Growth or Decline?" Dept. of Agric. Econ., Cornell University, September 1976.

5. An additional analysis involving estimation of polynomial lags has been conducted, but none of these results are reported here.

6. A short-run elasticity is approximately the proportional change of the quantity demanded associated with a one percent increase of the factor, holding all other factors constant, which occurs in the first time period. The long-run elasticity is defined in the same way except that the proportional change of demand is measured after all of the adjustment process has been completed.

7. "Long-Range Forecasting Properties of State-of-the-Art Models of Demand for Electric Energy" prepared by Charles River Associates, EPRI EA-221 Project 333, Electric Power Research Institute, Stanford, Calif, Dec. 1976.

8. The marginal price is the cost of purchasing one additional unit of the fuel, and for any individual customer, this is generally lower than the average price. However, when aggregating marginal prices for all customers in the state, the difference between the resulting average and marginal prices may be less obvious.

9. Examples of studies using marginal prices are:
   a) H. S. Houthakker, P. K. Verleger and D. P. Sheehan "Dynamic Analyses for Gasoline and Residential Electricity", American Journal of Agricultural Economics, 56, 1974.
   b) R. Halvorsen "Residential Demand for Electric Energy", Review of Economics and Statistics, 57, 1975.

10. L. D. Taylor "Decreasing - Block Pricing and the Residential Demand for Electricity", in Energy Demand, ed. W. D. Nordhaus, International Institute of Applied Systems Analysis, Laxenburg, Austria, 1976.

11. H. S. Houthakker, "Electricity Tarrifs in Theory and Practice", Economic Journal, 61, 1951.

12. T. D. Mount and L. D. Chapman, "Effects of Increasing the Use of Electricity on Environmental Quality in the U.S.: A Model of Power Generation and the Policy Issues Raised by its Application", in Energy Demand, ed. W. D. Nordhaus, International Institute of Applied Systems Analysis, Laxenburg, Austria, 1976.

13. L. D. Taylor, G. R. Blattenberger, and P. K. Verleger, "The Residential Demand for Energy", draft of a report to the Electric Power Research Institute, EPRI contract 431, p. 10-1, 1976.

14. See Table 1, p. 5-4 of the reference in footnote 13.

15. This may reflect the fact that the price of gas, on a btu basis, has been kept low through institutional means. Hence, small changes of this price do not alter the competitive position of gas to any extent.

16. W. Lin, E. Hirst and S. Cohn, "Fuel Choices in the Household Sector", ORNL/CON-3, Oak Ridge National Laboratory, Tenn., Table 5 p.17, 1976.

17. See Table 5 p. 6-12 of the reference in footnote 13.

18. Annual Survey of Manufactures, Bureau of the Census, Dept. of Commerce, Washington, D.C.

19. This issue is discussed in detail by G. S. Maddala, "The Use of Variance Components Models in Pooling Cross Section and Time Series Data", Econometrica, 39, 1971.

20. S. R. Searle, Linear Models, Wiley, New York, Section 8 in Chapter 9, 1971.

21. See Section 8 in Chapter 10 of the reference in footnote 20.

22. Since each equation is estimated using a Generalized Least Squares estimator, the standard F statistic for testing whether a structural change has occurred is not appropriate, and no attempt has been made to test the hypothesis formally.

23. We have attempted to estimate more general changes in the structure of the demand for electricity in an earlier analysis, but the results were not very conclusive. See the reference in footnote 12.

24. In the equation for oil, the substitution elasticity is larger than the absolute magnitude of the direct elasticity, and consequently, is not consistent with economic logic.

25. Estimated models in which some, but not all, prices are omitted also give inconsistent signs.

26. All of the calculations in this section are in real rather than logarithmic units.

27. The predictions are computed with a program which, for reasons of space, does not use the data for 1964, and consequently, no results for 1964 are presented in this section.

28. U.S. Department of Commerce, Regional Economic Analysis Division, Bureau of Economic Analysis, "State Projections of Income, Employment, and Population to 1990", Survey of Current Business, 54 No. 4, April 1974.

29. The following conversion rates are used:

Electricity (Input btu/kwh generated)	10.5×10^3 btu/kwh
Natural Gas	measured in btu
Oil (R/C)	5.825×10^6 btu/barrel
Oil (IND)	6.145×10^6 btu/barrel
Coal (IND)	28.250×10^6 btu/ton
Gasoline	124.950×10^3 btu/gallon

30. Restrictions on trade would also be necessary if domestic prices are sufficiently different from world prices.

Table A 1 SOURCES OF DATA

Name of variable	Price Units	Price Source[a]	Quantity Units	Quantity Source[a]
Residential and Commercial				
1. Electricity	mills/kwh	6	10^6kwh	6
2. Natural Gas	$/$10^9$ btu	3	10^{12}btu	3
3. Oil	cents/gallon	5	10^3barrels	4[c]
4. Gasoline	cents/gallon	4[b]	10^3gallon	4[a]
Industrial				
1. Electricity	mills/kwh	6	10^6kwh	6
2. Natural Gas	$/$10^9$btu	3	10^{12}btu	3
3. Oil	cents/10^6btu	6[d]	10^3barrels	4[c]
4. Coal	cents/10^6btu	6[d]	10^3tons	1, 2

General	Units	Source[a]
1. Population	10^3	8
2. Income per capita	10^3dollars	9
3. Gross National Product	Index	10
4. Generation	10^6kwh	6
5. Urbanization	Index	11
6. Price of Automobiles	Index	9
7. Wholesale Price Index	Index	10
8. Consumer Price Index (used to deflate variables measured in dollars)	Index	10

a/ Listed on the following page

APPENDIX

Table A 1 cont.

1 U.S. Dept. of Interior, Minerals Yearbook.

2 U.S. Dept. of Interior, Bureau of Mines, Washington, D. C., Mineral Industry Surveys, "Bituminous Coal and Liguite Distribution," Prepared in Division of Fossil Fuels, 1971, 1972, 1973.

3 American Gas Association, Dept. of Statistics, Gas Facts.

4 American Petroleum Institute, Petroleum Facts and Figures.

a/ Information for Gasoline Sales was taken from data published by the API for the years 1970-73.

b/ Gasoline Prices were taken from National Petroleum News Fact Book for the years 1970-73.

c/ Information after 1969 was taken from Bureau of Mines, Mineral Industry Surveys, "Shipments of Fuel Oil and Kerosine."

5 U.S. Bureau of Labor Statistics, Retail Prices and Indexes of Fuels and Utilities.

6 Edison Electric Institute, Statistical Year Book of Electric Utility Industry.

a/ Coal includes bituminous and anthracite coal and relative small amounts of coke, lignite and wood.

b/ Oil includes fuel oil, crude oil, and small amounts of tar and gasoline.

c/ Gas includes natural and manufactured gas and waste gas.

d/ Because these figures are unavailable we are assuming that it is the same price as that paid by utilities, therefore we have used the same figures as those used for utilities.

7 U.S. Dept. of Interior, Bureau of Mines, Washington, D. C., Mineral Industry Surveys, "Natural Gas Production and Consumption: 1973," Prepared in Division of Fossil Fuels, 1974.

8 U.S. Dept. of Commerce, Statisitical Abstract of the U.S.

9 U.S. Dept. of Commerce, Survey of Current Business

10 Council of Economic Advisers, Economic Report of the President

11 U.S. Dept. of Commerce, Census of Population

Table A 2. THE GROUPINGS OF STATES FOR INDUSTRIAL CUSTOMERS

1. Maine, New Hampshire, Vermont, Rhode Island
2. North Dakota, South Dakota
3. Nebraska, Kansas
4. Georgia, Florida
5. Alabama, Mississippi
6. Arkansas, Louisiana, Texas, Oklahoma
7. Montana, Idaho
8. Arizona, Nevada
9. Washington, Oregon
10. Maryland, Delaware, Washington D.C.
11. North Carolina, South Carolina

12 - 33 The remaining 22 individual states.

Table A 3. THE ESTIMATED MODEL

Explanatory factor	Residential and Commercial: Elect.	Nat.Gas	Oil	Gasoline	Industrial: Elect.	Nat.Gas	Oil	Coal
1. Population	.200 (10.3)	.215 (7.0)	.222 (2.9)	.311 (8.9)	.217 (6.3)	.434 (5.2)	.359 (1.9)	.127 (1.6)
2. Income per capita	.218 (7.5)	.000	.938 (5.4)	.131 (3.6)	.118 (1.9)	.000	.518 (3.2)	.093 (0.6)
3. Gross National Product	-	-	-	-	.151 (2.2)	.211 (1.7)	.000	.000
4. Generation	-	-	-	-	-	-	-	-
5. Price of electricity	-.197 (11.8)	.000	.000	-	-.145 (5.6)	.038 (0.4)	.000	.028 (0.2)
6. Price of natural gas	.000	-.254 (8.1)	.370 (3.3)	-	.036 (1.3)	-.694 (7.0)	.000	.000
7. Price of oil	.059 (1.3)	.230 (3.2)	-.282 (1.8)	-	.009 (0.9)	.041 (1.1)	.000	.032 (0.5)
8. Price of coal	-	-	-	-	.031 (2.0)	.000	.000	-.136 (1.8)
9. Price of gasoline	-	-	-	-.141 (4.4)	-	-	-	-
10. Price of automobiles	-	-	-	-.271 (5.5)	-	-	-	-
11. Wholesale Price Index	-	-	-	-	.185 (2.1)	.000	.471 (1.0)	2.014 (3.9)
12. Urbanization Index	-.143 (3.0)	.128 (1.7)	-.633 (2.0)	-.067 (1.3)	-	-	-	-
13. Conservation Effect	-.060 (4.9)	-.104 (5.4)	.028 (0.4)	-.068 (7.6)	-.041 (3.5)	.000 (0.0)	-.144 (2.0)	-.134 (1.7)
14. Lagged Dependent	.807 (61.1)	.792 (38.4)	.769 (25.0)	.666 (19.9)	.776 (34.9)	.594 (11.8)	.728 (17.7)	.883 (33.8)
Typical Error (Percent)[a/]	2.4	5.0	26.2	2.6	3.5	15.3	25.9	25.4

a/ If $\hat{\sigma}_\epsilon$ is the estimated standard error of the regression, this value is equal to $[\exp(\hat{\sigma}_\epsilon) - 1]100$. Note that these errors apply at the level of individual states and not at the national level.