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MODEL DOCUMENTATION REPORT: SHORT-TERM INTEGRATED FORECASTING SYSTEM DEMAND MODEL 1985

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DISCLAIMER

PREFACE

This report documents the demand models used by the Short-Term Integrated Forecasting System (STIFS) to produce the energy demand forecasts published in the Short-Term Energy Outlook (Outlook). Following an introductory section, Chapter 2 presents an overview of the models, and Chapter 3 gives a general description of the modeling procedure. Chapter 4 presents the variables, estimated coefficients, and mathematical specifications for the energy demand models. Chapter 5 presents documentation of the model estimates used to generate the forecasts published in the April 1985 Outlook, Volume 1. This technical presentation is intended for those readers interested in the details of the methods behind the demand and price forecasts published in Volume 1 of the Outlook. This documentation corresponds to the models used to produce the April 1985 Outlook and archived on computer tape. This tape may be purchased from the National Energy Information Center, EI-20, Energy Information Administration, Room 1F-028, Forrestal Building, Washington, D.C., 20585, (202) 252-8800.

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1. INTRODUCTION

The Short-Term Integrated Forecasting System (STIFS) Demand Model consists of a set of energy demand and price models that are used to forecast monthly demand and prices of various energy products up to eight quarters in the future. The STIFS demand model is based on monthly data (unless otherwise noted), but the forecast is published on a quarterly basis. All of the forecasts are presented at the national level, and no regional detail is available.

The model discussed in this report is the April 1985 version of the STIFS demand model. The relationships described by this model include:

- The specification of retail energy prices as a function of input prices (for example, the world oil price where appropriate), seasonal factors, and other significant variables.

- The specification of energy demand by product as a function of price, a measure of economic activity, and other appropriate variables.

Earlier analyses of this type are documented in Energy Information Administration (Washington, D.C.): the Short-Term Energy Outlook (Outlook), Volume 2: Methodology, published February 1980, August 1980, May 1981, November 1981, May 1982, November 1982, May 1983, and May 1984; and Energy Information Administration, Model Documentation: Short-Term Integrated Forecasting System Demand Model, March 1983 and May 1984.

This model is updated every quarter to produce new demand forecasts for the Outlook. The updating process ranges from reestimating the equations with additional data to completely restructuring the model. The data used in this analysis come from a variety of sources which are detailed in this report. The most common data sources are listed below. (See "References" for complete citations.)

- Bureau of Economic Analysis, U.S. Department of Commerce, National Income and Product Accounts of the United States

- Bureau of Labor Statistics, U.S. Department of Labor, Employment and Earnings

- Bureau of Economic Analysis, U.S. Department of Commerce, Survey of Current Business

- Board of Governors, U.S. Federal Reserve System, Industrial Production

- U.S. Department of Energy, Energy Information Administration, Monthly Energy Review

- U.S. Department of Energy, Energy Information Administration, Petroleum Supply Monthly

- U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Monthly State, Regional, and National Heating Degree Days Weighted by Population.

Generally, the published monthly data are used directly. However, a few data conversions such as deseasonalization or interpolation are performed where necessary. These conversions are described in this report.

The STIFS demand model is actually a collection of 18 individual models representing the demand for each type of fuel. The individual fuel models are listed below:

(1) Motor Gasoline
(2) Nonutility Distillate Fuel Oil
    (a) Diesel
    (b) Nondiesel
(3) Nonutility Residual Fuel Oil
(4) Jet Fuel, Kerosene-Type and Naphtha-Type
(5) Liquefied Petroleum Gases
(6) Petrochemical Feedstocks and Ethane
(7) Kerosene
(8) Road Oil and Asphalt
(9) Still Gas
(10) Petroleum Coke
(11) Miscellaneous Products
(12) Coal
    (a) Coking
    (b) Electric Utility
    (c) Retail and General Industry
(13) Electricity Generation
(14) Nonutility Natural Gas
(15) Utility Petroleum

In addition, forecasts for many energy prices are used as inputs to the above models to forecast energy demand. The energy prices forecast in STIFS are:

(1) Gasoline
    (a) Wholesale
    (b) Retail
(2) Heating Oil, Wholesale and Residential

(3) Residual Fuel Oil
(4) Propane
(5) Natural Gas, Residential and Utility
(6) Utility Coal
(7) Residential Electricity

The demand estimates produced by these models are used in the STIFS integrating model to produce a full energy balance of energy supply, demand, and stock change. These forecasts are published quarterly in the Outlook. Details of the major changes in the forecasting methodology and an evaluation of previous forecast errors are presented once a year in Volume 2 of the Outlook, the Methodology publication.

2. MODEL OVERVIEW

The STIFS demand model is a set of individual energy product demand models which produces projections of demand for total energy and individual energy products. The geographical area of consideration is the United States, defined as the 50 States excluding the territories and islands. The model forecasts on a monthly basis but quarterly values are published. All forecasts extend up to eight quarters into the future. The structure of the individual models is summarized below, beginning with the energy prices used in the demand models. Most of these models are econometric, estimated by ordinary least squares or the Cochrane-Orcutt procedure which corrects for autocorrelation. The exceptions to these procedures are noted in the report. Since all of the models are deterministic, no iterative solution algorithm is used. Instead, a solution is obtained by simulating first the energy price equations, and then simulating the demand models using the resultant price forecasts.

Energy Prices

Imported Crude Oil Prices. The price of imported crude oil to refiners is based on the Oil Market Simulation (OMS) model of the International and Contingency Information Division. Forecasts from the model are generally benchmarked to the latest available data.

Domestic Crude Oil Prices. The price of domestic crude oil is assumed to be the projected imported crude oil price, plus the average of the differences over the last 6 months between domestic and imported crude oil prices.

Refiner Acquisition Cost of Crude Oil. This price is projected as a weighted average of imported and domestic crude oil prices, with the weights being crude oil imports and domestic production, respectively. The weights are based on the most recent 6-month averages and are held constant throughout the forecast period.

Retail Motor Gasoline Prices. The price of retail gasoline is the sum of the refiner acquisition cost of crude oil, refiners' margins, and retailers' margins. Refiners' margins are assumed to increase with inflation, while the retail margin (including taxes) is assumed to remain constant.

Retail Distillate Prices. The price of retail distillate fuel oil is the sum of projected crude oil costs and projected distributor margins.

Retail Residual Fuel Prices. This price is estimated as a function of the price of crude oil, a 1-month lagged dependent variable, and two dummy variables.

Kerosene Jet-Fuel Prices. The price of kerosene jet-fuel is estimated as a function of time, the price of crude oil, a dummy variable, and a 1-month lagged dependent variable.

Natural Gas Wellhead Prices. The annual price of natural gas at the wellhead is taken from the most recent Annual Energy Outlook (AEO), benchmarked to the most recent data. Monthly projections are based on projected inflation rates.

Propane Prices. The price of consumer grade propane is estimated as a function of the retail price of heating oil.

Natural Gas Price to Electric Utilities. This price is estimated as a function of the wellhead price of natural gas.

Residential Natural Gas Prices. The price of residential natural gas is estimated as a function of the wellhead price and a 1-month lagged dependent variable.

Residential Electricity Prices. The price of residential electricity is estimated as a function of the price of natural gas, a 1-month lagged dependent variable, and the interest rate on AA-rated utility bonds.

Energy Demand

The energy demand equations are generally estimated over the 1975 through 1984 time period using monthly data. Most of the demand equations are econometrically estimated, with a few exceptions.

Motor Gasoline Demand. The demand for motor gasoline is modeled using two econometrically estimated equations. The first equation estimates a mile-per-gallon (MPG) proxy variable as a function of current real gasoline prices and a time trend. In the second equation, gasoline demand is estimated as a function of real gasoline prices, disposable personal income, an index of industrial output (a proxy for commercial and industrial activity related to gasoline use), and MPG.

Nonutility Distillate Fuel. The demand for nonutility distillate fuel is modeled as two separate equations, representing diesel fuel demand and heating oil demand. Both equations are estimated as a function of price and industrial production, with heating oil also assumed to be a function of population-weighted heating degree days. Both equations include dummy variables, and the diesel equation includes a 1-month lagged dependent variable.

Nonutility Residual Fuel. The demand for nonutility residual fuel is estimated as a function of the price of residual fuel, the index of industrial production, heating degree days, a 1-month lagged dependent variable, and several dummy variables.

Other Petroleum Products. The demand for other petroleum products is defined as the sum of the demands for eight individual petroleum product categories including liquefied petroleum gases (LPG), jet fuel, petrochemical feedstocks, kerosene, road oil and asphalt, still gas, petroleum coke, and miscellaneous products. The principal variables affecting the demand for these products are economic activity, as represented by real disposable personal income or an appropriate industrial production index, and price, for which the ratio of the producer price index of petroleum products to the overall producer price index is used as a general indicator. Several equations also include dummy variables to reflect structural changes or other atypical market conditions. In addition, a lagged value of the dependent variable is specified in several of the "other" product equations to help improve explanatory power and forecasting capability.

Electricity Generation. Total electricity generation is estimated as a function of real disposable personal income, the real average price of electricity, and population-weighted heating and cooling degree days. The equation includes variables which allow for differential heating-degree day response in both January and February.

Electricity Generation by Source. Petroleum generation at electric utilities is based on an analysis of recent trends in those States (mainly New England and the Middle Atlantic) which make up the largest share of oil-fired generating capacity. Nuclear and hydroelectric generation forecasts are provided by the Office of Coal, Nuclear, Electric, and Alternate Fuels, and are based primarily on projected changes in capacity (for nuclear) and recent and projected levels of precipitation and water storage (for hydroelectricity). Coal-fired generation is discussed below. Generation from gas-fired plants is a balancing item after the above forecasts have been independently constructed.

Coal Demand. The total demand for coal is the sum of coal consumption by electric utilities, coke plants, and retail and general industry, minus stock withdrawals, plus coal exports minus coal imports. The electric utility use of coal is determined by the level and percentage utilization of generating capacity. Total coal generating capacity is determined from EIA data sources on existing capacity and new capacity expected to begin operating during the forecast period. The utilization rate is determined by recent trends. Coke plant coal demand is estimated as a function of raw steel production. Other industrial coal demand is estimated as a function of an industrial production index and monthly dummy variables. Retail and commercial coal demand is estimated as a function of 11 dummy variables (to capture seasonal variation) and a time trend.

These models use a variety of data that are described in this report. A small number of conversions made to these data are also described. The basic data series are noted throughout Chapter 4. Full citations for the data sources discussed in this report are noted in "References." General references for model development are listed below.

Model Development References

Anderson, K. P. October 1973. "Residential Energy Use: An Econometric Analysis." The Rand Corporation.

Archibald, R., and Gillingham, R. 1981. "An Analysis of the Short-Run Consumer Demand for Gasoline Using Household Survey Data," The Review of Economics and Statistics.

Balestra, P., and Nerlove, M. July 1966. "Pooling Cross-Section and Time-Series Data in the Estimation of a Dynamic Model: The Demand for Natural Gas." Econometrica.

Baltagi, Badi H., and Griffin, J. M. "U.S. Gasoline Demand: What Next?" The Energy Journal, Volume 5, No. 1.

Barnes, R., Gillingham R., and Hagemann, R. March 1980. Bureau of Labor Statistics. "The Short-Run Residential Demand for Natural Gas." Washington, D.C.

Bopp, A., and Sitzer, S. 1984. "Some Empirical Consequences of Estimating Asymmetric Consumption Relations Using Symmetric Functional Forms." American Statistical Association 1984 Proceedings of the Business and Economic Statistical Section.

Cato, D., Sweeney, J., and Rodekohr, M. 1976. "The Capital Stock Adjustment Process and the Demand for Gasoline: A Market Share Approach" in A. B. Askin and J. Kraft (eds.), Econometric Dimensions of Energy Supply and Demand, Lexington Books.

Drollas, Leonidas P. January 1984. "The Demand for Gasoline: Further Evidence." Energy Economics.

Halvorsen, R. February 1975. "Residential Demand for Electric Energy." The Review of Economics and Statistics.

Houthakker, H. S., and Taylor, L. D. 1966. Consumer Demand in the United States. Harvard University Press.

Sitzer, S., Paxson, D., and Gamson, N. Winter 1982. "Price Forecasting in DOE's Short-Term Integrated Forecasting System." Energy Economics, Policy, and Management.

Taylor, L. Spring 1975. "The Demand for Electricity: A Survey." The Bell Journal of Economics.

3. GENERAL PROCESS FLOW

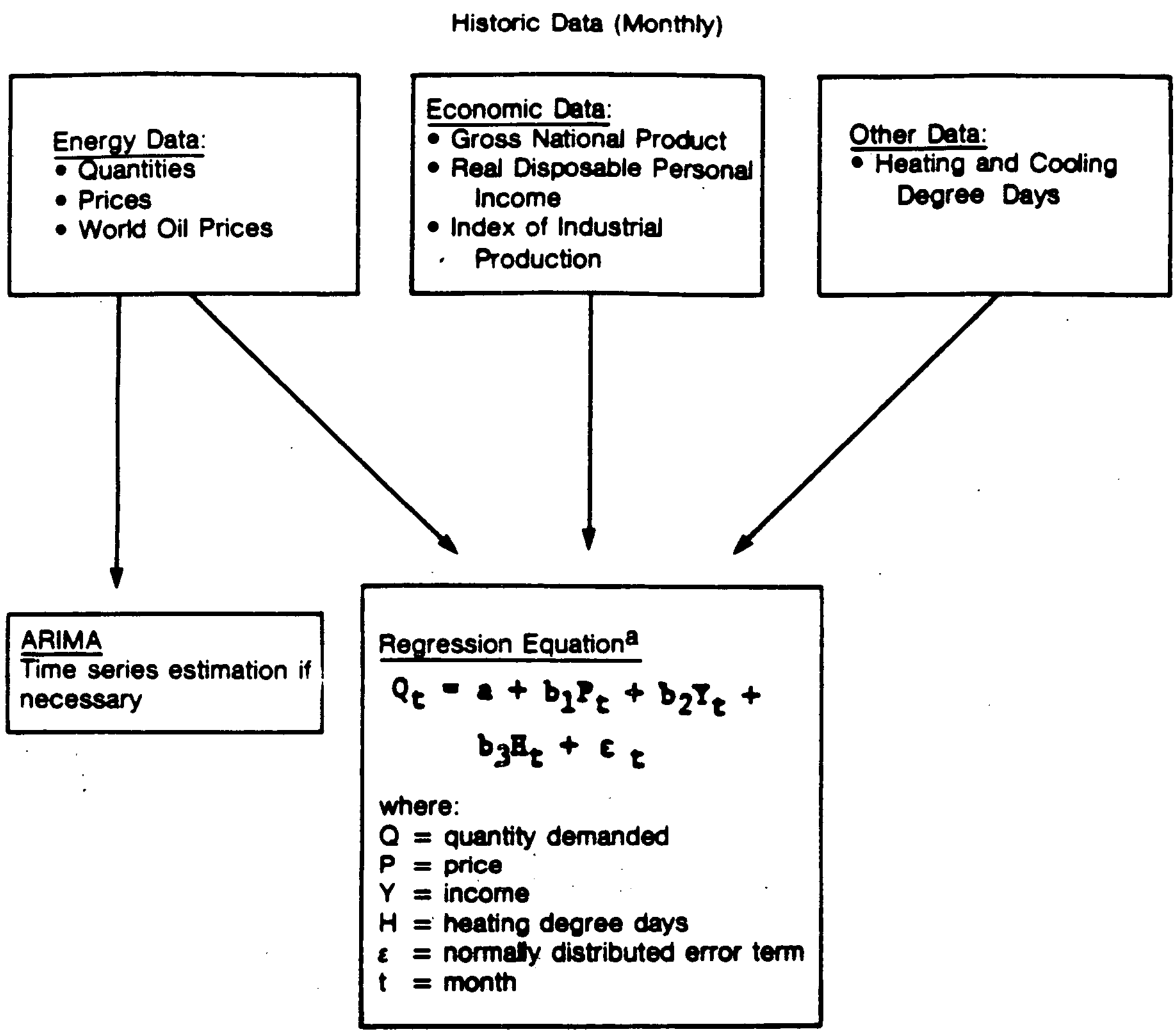
The estimation and forecasts of the Short-Term Integrated Forecasting System (STIFS) Demand Model consist of a multiphase process. This process is described below. No fuel-specific discussion is presented because the process differs very little across fuels. The specific determinants of demand for each fuel do vary and will be discussed in the following sections.

Phase 1 of the process for determining fuel demand is shown in Figure 1. This phase consists of combining historical monthly economic data, energy data, and other data into a regression equation where the relevant parameters are estimated. Occasionally, monthly economic data are estimated from quarterly data where no monthly values are published. (These instances are noted in the following sections.) Generally, the economic data consist of either real Gross National Product (GNP), Real Disposable Personal Income, or the Index of Industrial Production. The energy data consist either of the dependent variables being forecast, namely, the quantity demanded of various energy products, or the prices of these commodities.

Other relevant data consist of items such as population-weighted heating and cooling degree days, the world oil price, and energy product prices. Unless otherwise noted, all data are monthly, total U.S. values (the 50 States, excluding islands and territories), nonseasonally adjusted. Any differences are explicitly noted in the data description tables.

A general demand function is shown at the bottom of Figure 1: the quantity of energy demanded is expressed as a function of its price, a measure of economic activity, and other factors such as heating and cooling degree days. In most cases, the estimation technique used is ordinary least squares. On some occasions, the Cochrane-Orcutt procedure or generalized least squares is used to estimate the parameters. After the estimation of econometric equations, the residuals for recent history are examined for potential bias. If some bias is noted, "combining" techniques may be used to join the econometric forecast with that of a time series approach, such as an Autoregressive Integrated Moving Average (ARIMA) model, to produce the final forecast. For the April 1985 Outlook, such a technique was used to produce the nonutility residual fuel oil projection. The near-term model error of the nonutility residual fuel demand model was found to be relatively large (i.e., overforecasting demand) and therefore a combining technique was used. This technique is illustrated by Granger in C. W. J. Granger and P. Newbold, Forecasting Economic Time Series, Academic Press, New York, New York, 1977, pp. 269-273.

Figure 1. General Procedure for Regression Estimation



[a] Generalization provided for illustration only.

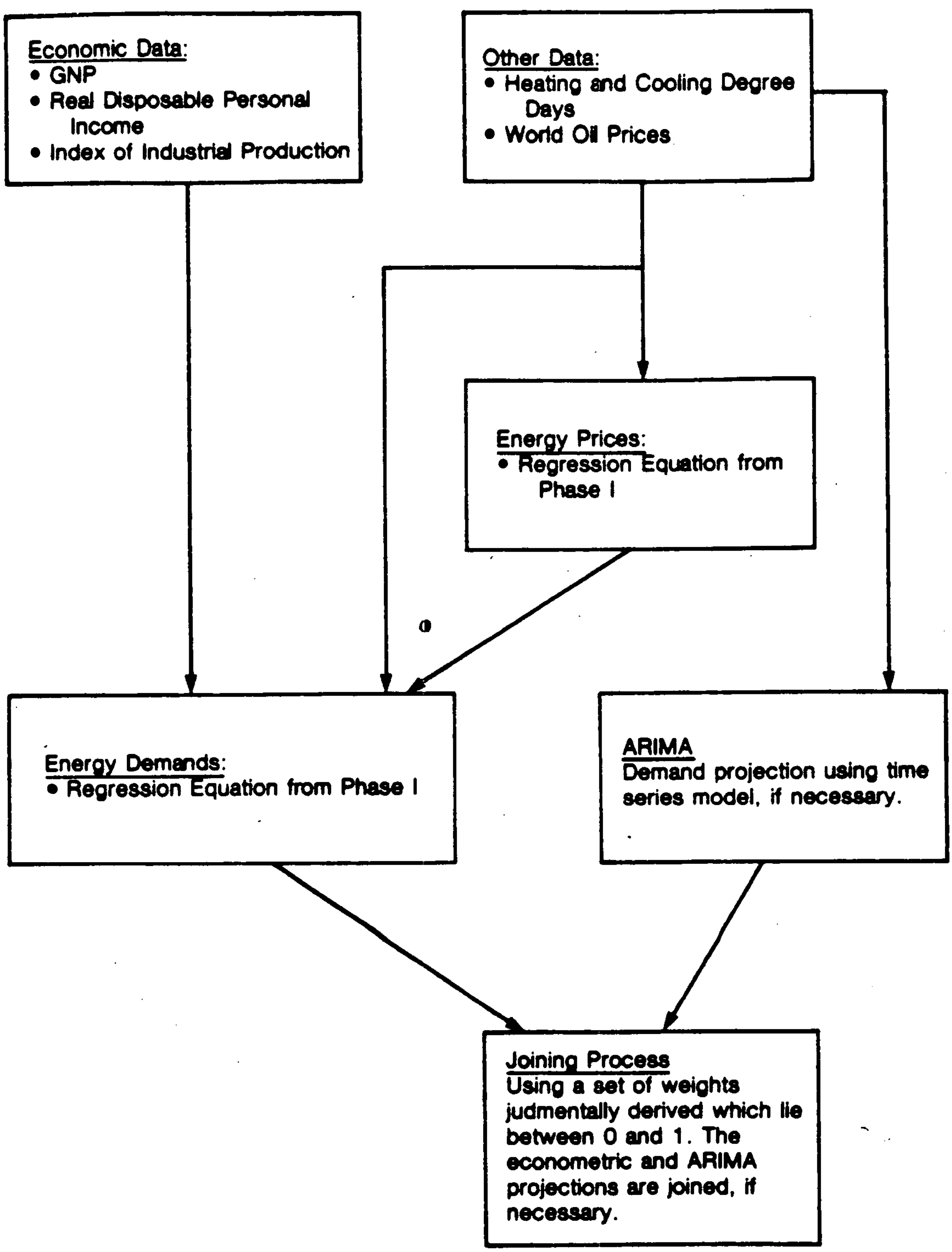
The joining of the two forecasts (econometric and ARIMA) consists of developing a set of weights between zero and one which are used to weight the econometric forecast and ARIMA projections to produce a final forecast. Typically, the weights are relatively high with respect to the ARIMA forecast in early months and are phased out over several months so that the econometric forecast prevails in the longer run. In practice, the ARIMA projections often are more accurate in the near term, but the econometric projections may be more accurate in the long run because they presumably capture the underlying economic influences on energy demand. While it is possible to estimate a set of optimal weights, judgment is used to determine the weights because of the complicated process necessary to determine optimal weights. For the April 1985 Outlook, this combining technique was used only for the forecast of nonutility residual fuel oil demand, as discussed in Chapter 4.

In Phase II, shown in Figure 2, forecasts of the exogenous variables are developed and used in the regression equations to forecast energy demands and prices. The forecasts of the economic variables are generally taken from the Data Resources, Incorporated (DRI) macroeconomic model. Forecasts of world oil prices are developed internally in EIA,[1] and other variables such as heating and cooling degree days are assumed to behave normally (30-year averages are used). For the April 1985 Outlook, the Data Resources, Incorporated, (DRI) CONTROL0485 forecast of April 1985 was used, modified to reflect the projected base case price of world oil. The quarterly values of the macroeconomic variables are listed in Table 2 of the April 1985 Outlook. The actual monthly values of these exogenous variables may be found in the archived tape noted in Appendix B of this report. As this type of model is deterministic, no iterative solution techniques are used to forecast prices or demand.

[1]World oil price forecasts are produced by the International and Contingency Information Division, Energy Information Administration.

Figure 2. General Forecasting Procedure

Forecasted Exogenous Variables (Monthly)



4. VARIABLES, ESTIMATED COEFFICIENTS, AND REPORT OF MATHEMATICAL SPECIFICATION

This section presents the model variables and estimated coefficients with their definitions, sources, and units of measurement. To illustrate the interrelationship between these factors and the demand models, the specific model equation will first be presented. Definitions and data sources are provided for each variable in the accompanying tables. In all equations, the estimated parameters are denoted by B_j, $j = 0,1,2,\ldots n$. Unless otherwise noted, all equations are estimated using ordinary least squares.

Gasoline

The demand for gasoline is modeled econometrically in two steps: first, a proxy for MPG is estimated; secondly, gasoline demand is estimated as a function of several economic variables and MPG.

Total Motor Gasoline Demand. Motor gasoline demand is expressed as an identity:

$$G \equiv (GVMT/GMPG)^{1} \qquad (1)$$

[1] The actual gasoline data series used for G is motor gasoline product supplied, as reported in Energy Information Administration, Monthly Energy Review, DOE/EIA-0035. Although the model being described here is applicable to highway vehicle travel, some off-highway and nonvehicle use of gasoline is included in the EIA series. Although no explicit correction is made in the data for this fact, it is assumed that the percent relationship of off-highway and nonvehicle motor gasoline use to total motor gasoline use is relatively small, constant, and/or does not vary widely enough to significantly affect the results. According to the Department of Transportation, nonhighway use of motor gasoline (excluding aviation gasoline) was 2.2 percent and 2.0 percent of total gasoline use (excluding aviation gasoline) in 1982 and 1983, respectively. See Federal Highway Administration, Highway Statistics (Annual 1982, 1983, Tables MF-24 and MF-26).

where:

G = total motor gasoline demand (million gallons)
GVMT = monthly gasoline-powered vehicle travel (million miles)
GMPG = monthly gasoline-powered vehicle-miles per gallon (weighted fleet average).

Neither GVMT nor GMPG is measured on a monthly basis, except insofar as they appear in certain compilations of panel data or vehicle travel surveys.[2] The following relationships for these variables are posited, however:

$$(GVMT/Days) = Exp[b_0 + b_1 ln\left(\frac{PRMG}{GMPG}\right) + b_2 ln(YD72) + b_3 ln(JQINDM)] \qquad (2)$$

Equation (2) is expressed in daily rates, to correct for varying lengths of months.

$$GMPG = Exp[b_4 + b_5 ln(PRMG) + b_6 ln(MGTIME)] \qquad (3)$$

and, substituting (2) into (1),

$$[(G/Days)*42] = Exp[b_0 + b_1 ln(PRMG) + b_2 ln(YD72) \qquad (4)$$

$$+ b_3 ln(JQINDM) - (b_1 + 1) ln(GMPG)]/42$$

Equation (4) is expressed in million barrels per day to conform with typical reporting formats where:

PRMG = average real retail motor gasoline price, all grades
YD72 = real personal disposable income, $1972
JQINDM = industrial production index, all manufacturing
MGTIME = integer valued variable representing time periods away from December 1974
$\frac{PRMG}{GMPG}$ = real fuel costs per mile of gasoline-powered travel
Days = days in the month.

Note that in equation (4), the coefficient on GMPG is linearly related to the coefficient on PRMG, which follows from the substitution. This restriction is satisfied in the estimation method used.

The proxy used for GMPG is PGMPG = (VMT/G), where VMT equals total highway vehicle travel (million miles) reported monthly by the Federal Highway

[2]The Department of Transportation publishes travel and fuel consumption data for several classes of motor vehicle (see Highway Statistics, Table VM-1), but does not distinguish between gasoline-powered vehicles and diesel-powered vehicles in providing this information.

Administration. It is assumed that, in general, PGMPG = k*GMPG, where k equals the proportionality factor. The estimating equations in the motor gasoline model are:

$$GMPG*k = Exp[B_4 + B_5 \ln(PRMG) + B_6 \ln(MGTIME) + B_{00} DPRE + B_{01} DPRE*\ln(MGTIME)] \quad (3')$$

$$[G/(Days*42)] = \exp[b_0' + b_1 \ln(PRMG) + b_2 \ln(YD72) + b_3 \ln(JQINDM) + (b_1 - 1)\ln(PGMPG) + b_{10} D75 + b_{11} D76 + b_{12} D77 + b_{13} D78 + b_{14} D79]/42 \quad (4')$$

where:

$b_0' = b_0 + (b_1 - 1)\ln k$

DPRE = dummy variable for period 1975-1979, used to correct for apparent shift in rate of change in MPG due to medium run price effects after the Iranian revolution

D75, ..., D79 = dummary variables used to allow for shifts in constant term in equation (4'), presumably due in part to a non-constant k.

Data descriptions, sources, and units for variables appearing in the motor gasoline equations are provided in Table 1.

Deseasonalization. All variables in the motor gasoline model, including price, total motor gasoline demand, and MPG are deseasonalized for estimation purposes using the Census Bureau X-11 program. The seasonal factors used to forecast motor gasoline demand for the April 1985 Short-Term Energy Outlook are provided in Table 2.

Nonutility Distillate Fuel Oil

Nonutility distillate fuel oil is modeled as two separate equations, one each for diesel fuel and heating oil. The diesel fuel equation is a linear formulation in which deseasonalized monthly diesel fuel demand (DIESADJ) is assumed to be a function of real diesel fuel prices (PDRLADJ), the index of industrial production (JQINDM), a dummy variable for the 1975 through 1978 period (DUM7578, set to zero in the forecast), and a lagged dependent variable. As estimated, the equation also includes an outlier dummy variable (MAR83) which is not used in the projections. The equation is:

$$DIESADJ_t = B_0 + B_1 DIESADJ_{t-1} + B_2 PDRLADJ + B_3 JQINDM + B_4 DUM7578 + B_5 MAR83 \quad (5)$$

Table 1. Data Definitions and Sources for Motor Gasoline Equations

Variable	Description	Source	Units
G	Total Motor Gasoline Product Supplied (equated to demand)	Monthly Energy Review and some estimates for 1980 and 1981 documented in the Short-Term Integrated Forecasting System historical data base for the variable XDMG.	Million gallons
PRMG	Price of Gasoline (all grades)/Consumer Price Index	Prices: Bureau of Labor Statistics [ ]. - Note: for estimation, gasoline prices were adjusted for BLS weight change after August 1981. CPI: Data Resources Incorporated, U.S. Central Data Base (CPIU), originally from Bureau of Labor Statistics, Consumer Price Index--Detailed Report [ ].	1967 cents per gallon
YD72	Disposable personal income in constant 1972 dollars	DRI U.S. Central data base (YD72),[a] originally from U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts of the United States, Table 2.2 [6].	Billion 1972 dollars
JQINDM	Industrial Production Index, all manufacturing	U.S. Federal Reserve Board [13].	Index 1967 = 1.0
MGTIME	Integer valued time variable = 1 for January 1975; = 2 for February 1975, etc.		
VMT	Monthly total vehicle travel in the United States	Federal Highway Administration (FHWA), Traffic Volume Trends (monthly) [ ].	Million miles
PGMPG	VMT/G	Calculated.	Miles/gallon
DPRE	Dummy variable for Pre-Iranian period = 1 for 7501-7912; 0 otherwise	--	--
D75, ..., D79	Dummy variables = 1 during respective years; 0 otherwise	--	--

[a]DRI variable name.

Table 2. Seasonal Factors[a] for Motor Gasoline Demand, MPG Proxy, and Gasoline Prices

Month	Motor Gasoline Demand	MPG Proxy	Gasoline Prices
January	0.933	0.916	0.985
February	0.934	0.951	0.992
March	0.975	0.984	0.974
April	0.995	1.007	0.985
May	1.016	1.018	1.001
June	1.059	1.025	1.013
July	1.032	1.078	1.019
August	1.039	1.080	1.015
September	1.004	1.024	1.013
October	0.994	1.022	1.007
November	1.004	0.969	1.002
December	1.009	0.924	0.992

[a]These seasonal factors are the 1-year ahead seasonal factors produced by running a monthly multiplicative version of the Census Bureau's X-11 procedure, using the Statistical Analysis System (SAS) procedure "PROC X-11." The estimation interval for the seasonal factors was January 1975 through December 1984.

The heating oil equation is a linear formulation in which demand for heating oil (HTGOIL) is expressed as a function of the real price of heating oil (PDISR), the index of industrial production, population-weighted monthly heating degree days (HDD), a winter trend variable (WINTREND), representing reductions in households using heating oil as a primary source of heat, and a dummy variable for the summer months (SUMDUM). The winter trend variable is multiplied by HDD, in order to weight the reduction in heating degree days during the forecast period. The equation is:

$$HTGOIL = B_0 + B_1 PDISR + B_2 JQINDM + B_3 HDD + B_4 WINTREND*HDD + B_5 SUMDUM \qquad (6)$$

Demand for nonutility distillate fuel oil (XDDS) is the sum of seasonalized diesel fuel consumption and heating oil consumption (HTGOIL) or:

$$XDDS = DIESADJ * DIESFAC + HTGOIL \qquad (7)$$

The data sources and units for the nonutility distillate demand model are summarized in Table 3. The seasonal factors for demand (DIESFAC) are summarized in Table 4.

Table 3. Data Definitions and Sources for the Nonutility Distillate and Residual Demand Models

Variable	Definition	Source	Units
XDDS	Nonutility distillate fuel oil product supplied.	Monthly Energy Review [11] and EIA, FPC Form 423 [26].	Million barrels per day
DIESADJ	No. 2 diesel fuel product supplied, deseasonalized	Petroleum Marketing Monthly, X11MULT procedure from SPEAKEASY.	Million barrels per day
HTGOIL	No. 2 heating oil product supplied	Monthly Energy Review, FPC Form 423, Petroleum Marketing Monthly (calculated).	Million barrels per day
HDD	Monthly heating degree days. National, 1980 population-weighted.	National Oceanic and Atmospheric Administration, U.S. Department of Commerce [12].	Cumulative mean daily degrees above 65 Fahrenheit
JQINDM	Industrial Production Index of all manufactured articles.	Board of Governors, Federal Reserve System [13].	Index, 1967=1.0
PDISR	Real retail price of No. 2 distillate fuel. (Nominal price/CPIU). CPIU is consumer price index--all urban. (Base: 1967 = 1.0)	Petroleum Marketing Monthly. CPIU from Bureau of Labor Statistics [5].	(1967) cents per gallon
PDRLADJ	Real deseasonalized price of No. 2 diesel fuel. (Nominal price/CPIU/ $PDIESFAC_t$)	Petroleum Marketing Monthly, Bureau of Labor Statistics, SPEAKEASY.	(1967) cents per gallon
XDRS	Nonutility residual fuel oil product supplied	Monthly Energy Review [11] and EIA, FPC Form 423 [26].	Million barrels per day
PRS	Real wholesale price of residual fuel in cents per gallon, all sulfur contents.	U.S. Department of Energy, FEA Form P302-M-1, "Petroleum Monthly Report for Product Prices" [15].	1967 cents per gallon
WPI	WPI is producer price index--all commodities, not seasonally adjusted. (Base: 1967 = 1.0)	Bureau of Labor Statistics, U.S. Department of Labor [16].	1967=1.0
D1	Equals 1.0 for 1979:04, 1981:05, 1982:12, 1983:10	NA	NA
D2	Equals 1.0 for 1982:04,09, 1983:03, 06,08	NA	NA
D3	Equals 1.0 for 1983:04-010	NA	NA

Table 4. Seasonal Factors Used in Diesel Demand Equation

Month	Demand Factor (DIESFAC)	Month	Demand Factor (DIESFAC)
January	0.952	July	0.978
February	0.934	August	0.996
March	0.949	September	1.030
April	1.042	October	1.087
May	2.002	November	1.012
June	1.046	December	1.965

Nonutility Residual Fuel Oil

Nonutility residual fuel oil is modeled as a linear function of the index of industrial production (JQINDM), the real price of residual fuel (PRS deflated by the Wholesale Price Index), heating degree days (HDD), a 1-month lagged dependent variable, and several dummy variables. These dummy variables include: decontrol dummy (DEC), a winter dummy (DUMWIN), defined as one for October through March and zero elsewhere, and a 1983 dummy (DUM83), or:

$$XDRS_t = B_0 + B_1(PRS/WPI) + B_2JPIN + B_3HDD + B_4D7677 + B_5DEC + B_6XDRS_{t-1} + B_7DUMWIN + B_8DUM \quad (8)$$

See Table 3 for data definitions and sources.

An ARIMA equation (ARIMA (1, 1, 1); first order autoregressive, first differences, first order moving average) was used in joining the econometric results. The equation is defined as:

$$x_t = X_t - X_{t-1} = \text{first differences} \quad (9)$$

$$x_t = 0.00287x_{t-1} + 0.558e_{t-1} + e_t$$

where:

0.00287 = autoregressive coefficient
0.558 = moving average coefficient
e = error term
X = nonutility residual fuel demand (XDRS)
t = month.

The X11ARIMA package in SPEAKEZ IBM[3] was used to forecast 18 months ahead. Since an ARIMA forecast is most reliable in the very short term (6 months out or less), weights were assigned to the econometric and ARIMA results as follows:

	Weights	
Forecast Period	ARIMA	Econometric
First 3 months	80 percent	20 percent
2nd 3 months	60 percent	40 percent
3rd 3 months	40 percent	60 percent
4th 3 months	20 percent	80 percent
5th 3 months	20 percent	80 percent
6th 3 months	20 percent	80 percent

Other Petroleum Products

The demand for other petroleum products is modeled as the summation of the demands for 8 individual petroleum product categories, including liquefied petroleum gases (LPG), jet fuel, petrochemical feedstocks, kerosene, road oil and asphalt, still gas, petroleum coke, and miscellaneous products. The specification of each equation is discussed below. Variable definitions, sources, and units are provided in Table 5.

The regression equations for each of the other product supplied categories, with the exception of petrochemical feedstocks and petroleum coke, are estimated using deseasonalized data. To obtain nonseasonally adjusted projections, the monthly forecasts developed using these equations are adjusted with the seasonal factors presented in Appendix A. This procedure is used because the desired end result is a forecast which retains the seasonal pattern; and because, empirically, the forecast results have been superior to those using a regression based on raw data. Petrochemical feedstocks and petroleum coke are estimated and forecast using the unadjusted data because no stable seasonal patterns were evident in these series.

Ordinary least squares regressions of several of the other product equations indicated relatively high levels of serial correlation, which in the presence of a lagged dependent variable may result in biased coefficient estimates. In these instances, the equations were estimated employing the Cochrane-Orcutt correction for serially correlated error terms.

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[3]See Energy Information Administration, EIA's User Guide to the EIA Computer Facility, DOE/EIA-0350 (Washington, D.C., 1982), p. IV-59.

Table 5. Data Definitions and Sources for Other Petroleum Products

Variable	Definition	Source	Units
DLPG	Liquefied petroleum gases product supplied, excluding ethane, seasonally adjusted	Petroleum Supply Monthly (PSM), Table 4 [10] and Appendix Table A.2.[a]	Thousand barrels per day
DKJF	Kerosene-type jet fuel product supplied, seasonally adjusted	PSM [10] and Appendix Table A.2.[a]	Thousand barrels per day
DPFET	Petrochemical feedstocks and ethane product supplied	PSM [10].	Thousand barrels per day
DK	Kerosene product supplied, seasonally adjusted	PSM [10] and Appendix Table A.2.[a]	Thousand barrels per day
DRDAS	Road oil and asphalt product supplied, seasonally adjusted	PSM [10] and Appendix Table A.2.[a]	Thousand barrels per day
DSG	Still gas product supplied, seasonally adjusted	PSM [10] and Appendix Table A.2.[a]	Thousand barrels per day
DCOKE	Petroleum coke product supplied	PSM [10].	Thousand barrels per day
DMISC	Miscellaneous products supplied, seasonally adjusted[b]	PSM [10] and Appendix Table A.2.[a]	Thousand barrels per day
RPETP	Producer price index for petroleum products deflated by the producer price index for all items	Bureau of Labor Statistics [11].	Index, 1967 = 1.0
YD72	Real disposable personal income	Bureau of Economic Analysis [12].	Billion 1972 dollars, annual rate
DEVHDD	Deviation from normal heating degree days, population-weighted	National Oceanic and Atmospheric Administration [13].	Number of degree days per month
DPATCO	Dummy variable for the Professional Air Traffic Controllers' Strike (=1, August 1981-August 1982; 0, otherwise)	--	--
DL6	Dummy variable for last 6 months (= 1, July 1984-December 1984; 0, otherwise)	--	--
JQINDM	Index of manufacturing, total	U.S. Federal Reserve Board [4].	Index, 1967 = 1.0
JQIND28	Index of chemical production	U.S. Federal Reserve Board [4].	Index, 1967 = 1.0

[a]Raw data for these series are published in the PSM [10]. These data are seasonally adjusted with Bureau of the Census seasonal adjustment factor (X11MULT).
[b]DMISC includes lubricants, waxes, aviation gasoline, and special naphthas, as well as the miscellaneous product supplied category in the PSM [10].
-- = Not applicable.

In addition to the eight categories which are modeled explicitly in the STIFS Demand Model, total other product supplied includes three additional categories: crude oil consumed without processing, pentanes and heavier components extracted from natural gas, and unfinished oils and blending components. Projections for these components are developed exogenously and added to the other projected volumes to obtain total other petroleum product supplied.

Liquefied Petroleum Gases (LPG). Demand for liquefied petroleum gases (DLPG) is modeled as a linear function of the petroleum product price index (RPETP), weather (DEVHDD), and a 1-month lagged variable. The dependent variable is seasonally adjusted to account for normal peaks in demand during the winter months, while the weather variable is specified to represent deviations from normal heating degree day patterns. The specification for the LPG equation, which is estimated using the Cochrane-Orcutt procedure to correct for first-order serial correlation in the error term, is:

$$DLPG_t = B_0 (1 - \rho) + B_1(RPETP_t - \rho*RPETP_{t-1}) + B_2(DEVHDD_t - \rho*DEVHDD_{t-1}) + B_3(DLPG_{t-1} - \rho*DLPG_{t-2}) + \rho*DLPG_{t-1} \quad (10)$$

Alternative specifications which included an income variable were examined, but the coefficient on income was consistently found to be not significantly different from zero.

Jet Fuel. Demand for jet fuel is modeled as the summation of the demand for kerosene-type jet fuel (DKJF) and naphtha-type jet fuel. A single equation for kerosene-type jet fuel is estimated as a function of the producer price index of petroleum products, real disposable income (YD72), and a dummy variable to reflect the negative impact on flight activity of the Professional Air Traffic Controllers' strike (DPATCO). The specification of the kerosene-type jet fuel model is:

$$DKJF_t = B_0 + B_1YD72 + B_2RPETP + B_3DPATCO + B_4DKJF_{t-1} \quad (11)$$

Naphtha-type jet fuel use, which can be attributed almost exclusively to the military, is held constant throughout the forecast period at its 1981-1984 annual average of 208,000 barrels per day.

Petrochemical Feedstocks and Ethane. The demand for feedstocks (DPFET) is directly related to the level of activity in the chemical industry (JQIND28). Other factors used in the feedstocks equation are the producer price index of petroleum products, a dummy variable for the most recent 6 months, and a 1-month lagged dependent variable, or:

$$DPFET_t = B_1JQIND28 + B_2RPETP + B_3DL6 + B_4DPFET_{t-1} \quad (12)$$

The dummy variable reflects unusually low demands for petrochemical feedstocks during the second half of 1984, which is the most recent 6 months of data for the April 1985 Outlook. This dummy is set to one throughout the projection period, reflecting expectations that demands will not recover rapidly. These expectations are based in part on the fact that markets for petrochemicals produced in the United States will be subject to increasing levels of competition as the new Saudi complexes are brought into operation.

Kerosene. Demand for kerosene (DK), which is used for residential and commercial purposes as well as by industry, is specified as a function of real disposable income, the ratio of the petroleum product price index to the overall price index, and weather. The original data series for the dependent variable is seasonally adjusted to account for the wide swings in demand from summer to winter months. The variable representing deviations from normal heating degree days further helps to improve the equation's historical fit by accounting for those changes in demand which are related to unusual weather patterns. The specification for the kerosene equation is:

$$DK_t = B_0 + B_1 YD72 + B_2 RPETP + B_3 DEVHDD + B_4 DK_{t-1} \tag{13}$$

The coefficient on income in this equation is negative, supporting the results of other studies[4] which indicate that kerosene is an inferior good, that is, has a negative income elasticity.

Road Oil and Asphalt. The equation for road oil and asphalt demand (DRDAS) includes the producer price index and the 1-month lag on the dependent variable. The level of economic activity is not a significant determinant, based on standard statistical tests, and has been excluded from the final specification. Data for the dependent variable were seasonally adjusted, and the Cochrane-Orcutt method was used to estimate the equation:

$$DRDAS_t = B_0 + B_1 RPETP + B_2 DRDAS_{t-1} \tag{14}$$

While this simple equation fits the data well, it should be recognized that exogenous factors such as the availability of Federal highway funds have significantly affected asphalt demands in the past and are likely to do so in the future.

Still Gas. Still gas is supplied as a feedstock to petrochemical producers and as a fuel to refineries. The equation for still gas product supplied (DS6) includes the industrial manufacturing index and a 6-month dummy variable (DL6), or:

$$DSG = B_0 + B_1 JQINDM + B_2 DL6 \tag{15}$$

Petroleum Coke. The petroleum coke (DCOKE) equation is specified with the index of manufacturing activity, the petroleum price index, and the lagged dependent variable, or:

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[4] Bopp, A. E., "The Demand for Kerosene: A Modern Giffen Good," Applied Economics, Volume 15, No. 4, August 1983, pp. 459-468.

$$DCOKE_t = B_0 + B_1 JQINDM + B_2 RPETP + B_3 DCOKE_{t-1} \quad (16)$$

This equation was selected as the best of several alternatives, but fails to fit the historical data very closely. The problem in estimating petroleum coke product supplied, based on demand determinants, may be attributable to the fact that petroleum coke is produced solely as a byproduct of other refinery operations.

Miscellaneous Products. The miscellaneous products category in the STIFS Demand Model is defined to include aviation gasoline, special naphthas, lubricants, and waxes as well as those products specifically defined as miscellaneous (such as petroleum rocket fuels and synthetic natural gas feedstocks) in the Petroleum Supply Monthly. The specification of the equation for miscellaneous products (DMISC) is:

$$DMISC = B_1 JQINDM + B_2 RPETP + B_3 DL6 + B_4 DMISC_{-1} \quad (17)$$

Electricity Generation and Sales

Total electricity generation (EG) is modeled as a linear function of real disposable personal income (YD72), the real average price of electricity (RP), heating (HDD) and cooling (CDD) degree days, and monthly dummies for January (JAN) and February (FEB). The dummies are each multiplied by HDD for the months to allow for differing responses to heating degree days. The equation is:

$$EG = B_0 + B_1 YD72 + B_2 RP + B_3 HDD + B_4 CDD + B_5 JAN \cdot HDD + B_6 FEB \cdot HDD \quad (18)$$

Data definitions and sources are shown in Table 6.

The total electricity generation equation for the April 1985 forecast was estimated using monthly values from January 1977 through December 1984. The Cochrane-Orcutt iterative procedure, which corrects for serial correlation in the error term, was used based on the Durbin-Watson test statistic that resulted from the ordinary least squares method of estimation. No attempt to deseasonalize generation is made; rather, the impacts of seasonal forces are incorporated directly in the equation. In both the estimation and forecast periods, the heating and cooling degree day variables are assumed to be zero in the months where they are relatively insignificant: Heating degree days are used from October through April, and cooling degree days are used from May through September. This technique increases the significance of the weather variables and results in a more accurate estimation of the coefficients.

Total electricity generation rather than electricity sales was selected as the variable to be forecast mainly because of the timeliness of the data. Power plants report information on generation each month on EIA Form 759, "Monthly Power Plant Report." Although the sales data also are reported

Table 6. Data Definitions, Units, and Sources for the Electricity Generation Model

Variable	Definition	Source
Electricity Generation	Monthly electricity generation (million kilowatt-hours).	Monthly Energy Review [11]
Price	Average total retail electricity price (cents per kilowatt-hour). Deflated by CPIU.	Monthly Energy Review [11]. CPIU from DRI [5].
CPIU	Consumer Price Index.	DRI, originally from Bureau of Labor Statistics, Consumer Price Index--Detailed Report [5].
YD72	Real disposable personal income (1972 dollars).	DRI, originally from Bureau of Economic Analysis [6].
HDD	Population-weighted heating degree days.	National Oceanic and Atmospheric Administration [12].
CDD	Population-weighted cooling degree days.	National Oceanic and Atmospheric Administration [12].
JAN	Dummy variable (= 1, all January; 0 otherwise).	--
FEB	Dummy variable (= 1, all February; 0 otherwise).	--

-- = Not applicable.

monthly (on the EIA Form 826, "Electric Utility Company Monthly Statement"), these sales data reports lag generation data reports by 1 month. (This problem is most evident in the month of February where total sales of electricity frequently exceed total generation for the month. Apparently in this case, and it is assumed for other months as well, sales in the previous month are not reported until the next month.) In addition to the timeliness issue, the sales data are estimated from a sample of utility reports based on utility billing cycles, while the generation reports (EI-759) are a monthly census of all generating plants providing electricity for public sale. Finally, the sales series is revised more frequently, requiring more changes to the data base and published numbers. In the Outlook, electricity sales are assumed to grow at the same rate as electricity generation in the forecast period. Although the actual growth rates between the two series usually differ, there is no consistent pattern to use in developing an independent forecast of sales.

Utility Petroleum

The demand for utility petroleum is assumed to be proportional to the amount of electricity (in billion kilowatthours) generated from petroleum. For the April 1985 Outlook, it was assumed that the 1984-1985 decline in petroleum-generated electricity would be equal, in percentage terms, to the 1983-1984 decline of 17 percent. This assumption was based on a recent analysis of trends in generation from States comprising the largest share of oil-fired generating plants, mainly New England, New York, and New Jersey. The final forecast was reduced slightly, based on an indication from preliminary first-quarter data that oil use was continuing to decline strongly.

For 1986, the assumption of falling real oil prices indicated a smaller rate of decline in electricity generation from petroleum, to about 10 percent. Consequently, 1986 petroleum-generated electricity was forecast to be 88 billion kilowatthours, 10 percent below the initial 1985 forecast of 98 billion kilowatthours. The annual forecasts were then distributed into monthly values by applying the following seasonal factors:

Month	Factor	Month	Factor
January	0.132	July	0.084
February	0.120	August	0.076
March	0.072	September	0.078
April	0.067	October	0.052
May	0.047	November	0.096
June	0.083	December	0.095

The monthly projections are further distributed into monthly demands for utility residual fuel oil, distillate fuel oil, and petroleum coke by factors of 0.945, 0.05, and 0.005, respectively. These weights are based on the approximate annual shares by each fuel of total utility petroleum consumption in 1982.

Net Electricity Imports

The level of net electricity imports (NM) is assumed to be a linear function of time (T) and is forecast using the ordinary least squares procedure. The time variable is a proxy for changes in the factors that determine import capacity (such as transmission facilities and historical patterns of import use) and for the pricing structure which favors imports. The equation is as follows:

$$NM = B_0 + B_1(T) \tag{19}$$

Table 7 provides a list of data definitions and sources.

This equation provides annual forecast values expressed in quadrillion Btu which are converted into billion kilowatthours using a factor of 0.01028 (derived by estimating an average factor difference between previous net import values published in quadrillion Btu in the Monthly Energy Review and in billion kilowatthours in the Outlook). These annual values are then added to the annual electricity exports projection of 3.5 billion kilowatthours (the annual historical trend in electricity exports has been relatively flat; hence, the forecast for exports has been set at the 1982 annual value) to determine gross imports of electricity. Annual gross imports and exports are then separately distributed into monthly values by multiplying the annual totals of each by the following weights:

	Weights	
Month	Gross Imports	Exports
January	0.075	0.054
February	0.077	0.065
March	0.080	0.110
April	0.082	0.148
May	0.072	0.176
June	0.078	0.115
July	0.085	0.074
August	0.088	0.040
September	0.096	0.042
October	0.096	0.061
November	0.085	0.054
December	0.086	0.061

These monthly weights are based on an examination of monthly electricity import and export data collected by the Department of Energy's Economic Regulatory Administration: The gross import weights are derived by dividing the 1983 annual total by the monthly values; likewise, the export weights are derived by dividing the 1983 annual total for exports by the monthly export values. Monthly net import values are thus derived by subtracting monthly exports from monthly gross imports.

Table 7. Data Definitions and Sources for Net Electricity Imports Equation

Variable	Definition	Source	Units
NM	Net imports of electricity, annual	Monthly Energy Review, DOE/EIA-0035(84/04)	Quadrillion Btu
T	Time variable (= 1-7 for 1977-1983)	--	--

-- = Not applicable.

Nonutility Natural Gas Demand

Nonutility natural gas demand, shown in the Outlook table as "all other uses" of natural gas, includes residential, commercial, transportation (pipeline fuel), and industrial uses (other than for refinery fuel) of natural gas, plus supplemental natural gas. In 1984, this aggregate category accounted for nearly 80 percent of total natural gas demand. Because the largest single segment of this demand is industrial use, the economic variable used in the estimations is the index of industrial production. The form of the equation is:

$$NG = B_0 + B_1 JQ + B_2 RPR + B_3 HDD + B_4 DUM \qquad (20)$$

where:

NG = all other natural gas demand
JQ = the index of industrial production
RPR = the real price of residential natural gas
HDD = the number of heating degree days
DUM = a dummy variable (= 0, 8101-8406; = 1, 8407-8412).

Data definitions and sources are given in Table 8.

Heating degree days were used because natural gas is an important fuel for space heating. Cooling degree days, however, were omitted from the equation because very little air conditioning is fueled by natural gas. A dummy variable was included for the last 6 months of 1984 to correct for a tendency to overforecast in those months. Apparently the recovery in natural gas demand was not as strong as expected based on the levels of economic activity and prices.

Table 8. Data Definitions, Units, and Sources for the Nonutility Natural Gas Equation

Variable	Definition	Source
Nonutility Natural Gas	Total natural gas consumption minus electric utility and refinery gas (trillion cubic feet)	Natural Gas Monthly [25].
HDD	Population-weighted heating degree days	National Oceanic and Atmospheric
Administration.		
RPR	National average residential price of natural gas (cents per thousand cubic feet)	Monthly Energy Review [9].
CPIU	Consumer Price Index	DRI, originally from Bureau of Labor Statistics, Consumer Price Index--Detailed Report [3].
JQ	Index of manufacturing	U.S. Federal Reserve Board [11].

Coal

Total demand for coal is the sum of coal consumption (by electric utilities, coke plants, and retail and general industry), minus stock with- drawals, plus coal exports, minus coal imports. The determinants of these components are discussed below.

Electric Utility Coal Demand. Electric utilities' demand for coal is derived from the overall demand for electricity, as discussed above. In the short run, utilities must decide how to meet current demand for electricity efficiently and reliably with a relatively fixed stock of generating plants. Correctly predicting the portion of electricity demand from coal-fired plants requires a representation of the way that short-run factors affect utilities' utilization rates for the existing stock of coal-fired plants. In addition, this representation should account for the possibility that increases in capacity may affect the fuel choice for electric generation even in the short run.

For the April 1985 Outlook, a highly aggregated single-equation model of coal-fired electricity generation was devised to project utility coal consumption. It was assumed that coal-fired generation (XGCLEL) is a function of total electricity generation (XGEL), nuclear-powered electricity generation in high coal-using areas (NUHCU) and nuclear generation in low coal-using areas (NULCU),[5] and hydroelectric generation (XGHYEL). The aggregate level of coal-fired generating capacity (CAP) was also considered explicitly as a determinant of coal-fired generation. In this case, capacity is measured in terms of potential output per month (kilowatthours of electricity) that would be generated if all coal-fired plants ran at 100 percent of nameplate capacity (in megawatts) for an entire month. The equation for coal-fired generation can be expressed as follows:

$$XGCLEL = A_0(M_i) + (A_1+A_2CAP)XGEL + A_{31}NUHCU + A_{32}NULCU + A_4XGHYEL + A_5DS1 + A_6DS2 + A_7O1 \qquad (21)$$

The term $A_0(M_i)$ is generated by including 11 monthly dummies in the ordinary least squares (OLS) regression. DS1 and DS2 represent the 1978 and 1981 coal strikes, respectively; O1 is a dummy variable for December 1978 and January 1979.

Equation (21) is not intrinsically linear because of the multiplicative term $(A_1+A_2CAP)XGEL$. However, the model is linear in parameters and can be estimated by OLS. This formulation was used to capture, in a single equation, the effect of the gradually increasing quantity of coal-based generating capacity. It should be noted that, since nuclear and hydroelectric generation appear on the right-hand side of the equation, it is assumed that these variables are determined independently of the coal share. Otherwise, simultaneous equations bias would be a potential problem in this formulation. In addition, it is assumed that coal-fired generation will displace other forms of generation (mostly from petroleum and natural gas) to the extent possible. The model assumes that, given the level of electricity supplied from nuclear and hydroelectric plants, the proportion to which incremental changes in electricity demand are met by coal-fired generation is not constant, but (aside from typical seasonal influences) is limited only by the amount of available coal-fired generating capacity.

If the average efficiency of coal-fired electric plants and the thermal content of coal consumed are constant, then the amount of coal (in tons) needed to generate one unit of electricity (Kilowatthour) should remain constant. However, increased plant efficiency and the introduction of lower quality coal could change the tons of coal/kilowatthour ratio. Although

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[5] Appendix C discusses the rationale for using the specification with nuclear generation from high and low coal-using areas for the coal-fired generation equation.

these influences tend to work in opposite directions (increased efficiency vs. lower coal quality), on balance, the recent trend in the coal/kilowatt-hour ratio has been upward (i.e., more coal per kilowatthour). Part of this trend may be explained by the installation of pollution abatement equipment at coal-fired generating plants. Scrubbers and other equipment designed to reduce the emission of sulfur compounds and other pollutants tend to increase[6] generating plant energy requirements and thus lower net electricity output.

For the April 1985 Outlook, a simple equation was devised, which does not assume strict proportionality between coal input and electricity output, but measures changes in coal consumption due to changes in electricity requirements. This equation allowed for a trend in the coal/electricity technical coefficient and for some seasonality in the coefficient as well. Seasonality in this instance could arise from normal geographic shifts, from month to month, of electricity requirements from areas with newer, more efficient plants (or with access to higher quality coal) to areas with older, less efficient plants (or with access to lower quality fuel). In addition, ambient atmospheric conditions (temperature extremes) may affect conversion loss rates, and these conditions can change significantly over the course of a year. Thus, consumption of coal at electric utilities (XFCLEL) is expressed as a function of generation (XGCLEL), time, a monthly intercept term (B_0M_i), and two dummy variables for strikes, or:

$$XFCLEL = B_0(M_i) + B_1 XGCLEL + B_2 time + B_3 DS1 + B_4 DS2 \qquad (22)$$

Equation (22) was estimated using generalized least squares, with the assumption of first-order serial correlation of the error term.

The definitions, sources, and units of the data used in the electric utility coal consumption equations are presented in Table 9.

Coking Coal Demand

Coking coal is coal used in the manufacture of coke, which fuels blast furnaces that produce molten iron for steelmaking. Thus, coking coal demand is derived from the demand for steel. Coke is only used in steel plants that employ basic oxygen furnaces or open hearth furnaces.

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[6] During historical periods of coal supply shortages (i.e., during strikes), the coal/kilowatthour ratio rose sharply, indicating the substitution of low-Btu coal for higher Btu coal in the generation of electricity. In determining the trend of the coal/kilowatthour ratio, strike periods were excluded. Coal burned per thousand kilowatthours was 0.495 tons in 1984, or 2 percent higher than in 1977, and 8 percent higher than in 1973. See Energy Information Administration, Monthly Energy Review, DOE/EIA-0035-(85/3).

Table 9. Data Definitions, Units, and Sources for the Electric Utility Coal Demand Model

Variable	Definition	Source	Units
XGCLEL	Monthly electricity generation from coal	Monthly Energy Review (MER) [11].	Billion kilowatthours
XFCLEL	Monthly coal consumption at electric utilities	MER [11].	Million short tons
XGEL	Monthly total electricity generation	MER [11].	Billion kilowatthours
XGHYEL	Monthly hydroelectric generation	MER [11].	Billion kilowatthours
NUHCU	Monthly nuclear-based electricity generation in high coal-using regions	Electric Power Monthly [ ].	Billion kilowatthours
NULCU	Monthly nuclear-based electricity generation in low coal-using regions	Electric Power Monthly [ ].	Billion kilowatthours
CAP	Monthly total coal-fired electricity generating capacity in place (nameplate capacity)	DOE, Generating Units Reference File [18].	Billion kilowatthours
M_i	Dummy variable = 1 for month i, 0 otherwise; i=2,...,12	--	--
DS1	Dummy variable for coal strike, = 1 for 7712-7803, = 0 otherwise	--	--
DS2	Dummy variable for coal strike = 1 for 8104-8106, = 0 otherwise	--	--
O1	Dummy variable, = 1 for 7812-7901; = 0 otherwise	--	--
Time	= 1 for 7701; = 2 for 7702; = 96 for 8412, etc.	--	--
XKCLEL	End-of-month coal stocks held at electric utilities	MER [11].	Million short tons

Determining the domestic demand for coking coal (XFCLCK) in the short run requires estimates of how much of new coke demand (XDCK) will be satisifed from coke production (XFCKPD), coke stocks (XKCK), and net coke imports (XMCK). Given changes in coke stocks, net coke imports, and estimates for new coke demand, domestic coke production is determined by the following identity:

$$XFCKPD = XDCK - (XKCK_{-1} - XKCK) - XMCK \tag{23}$$

where -1 indicates a one period lag.

It was assumed that XDCK would be proportional to total steel output from basic oxygen furnaces (BOF) and open-hearth furnaces (OHF):

$$XDCK = k*s*RSP \tag{24}$$

where:

RSP = total steel output, including output from electric-arc furnaces (estimated by procedure described below)
s = share of total RSP from BOF and OHF
k = average ratio of coke input to steel output for BOF and OHF.

For 1984, s was 0.668 and k was 0.485, according to figures from the American Iron and Steel Institute. These parameters were held at their 1984 average values for the forecast period in the April 1985 Outlook.

For RSP, the following equation was estimated:

$$RSP = D_0(M_i) + D_1 JQI\&S + D_2 TIME + D_3 TIME*JQI\&S \tag{25}$$

and finally, for coking coal consumption

$$XFCLCK = E_0 + E_1 XFCKPD + E_2 time \tag{26}$$

where:

JQI&S = index of industrial production in iron and steel
XFCLCK = coking coal consumption
$D_0(M_i)$, = intercept term varying from month to month
M_i = index for month = 1,...,12.

The trend term in (26) is designed to capture any tendency toward more efficient use of coal (reduced waste, etc.) that may have occurred in coke production processes.

Net coke imports (XMCK), which are generally negative (imports, on a quarterly basis, exceeded exports only once since the last quarter of 1977), were assumed to be 1.5 percent of total consumption (in absolute value), which was the 1984 average.

The remaining problem for determining coking coal demand is the determination of coke stocks. A days' supply number for coke stocks (DSCK) was assumed for each month in the forecast period, where

$$DSCK = (XKCK / \sum_{i=0}^{2} XDCK(i+1)) * \sum_{i=0}^{2} Days(i+1) \quad (27)$$

XDCK(i+1) = coke demand i+1 periods into the future
Days(i+1) = number of days in the month i+1 months in the future.

The schedule of DSCK assumed for the April 1985 Outlook was as shown in Table 10. The definitions, sources, and units of the data used in the coke and coking coal equations are presented in Table 11.

Table 10. Days Supply of Coal and Coke Assumed for the April 1985 Outlook (End-of-Quarter)

Year	Quarter	Coke at Coke Plants	Coal at Coke Plants	Coal at Utilities	Coal for Retail & General Industry
1985	1	45	49	93	56
	2	44	55	90	62
	3	43	48	89	49
	4	42	46	86	49
1986	1	42	46	89	53
	2	42	52	88	58

Retail and General Industry

For the April 1985 Outlook, two separate equations were used to forecast coal consumption by the industrial sector (excluding use at coke plants and synfuels plants) and the retail/commercial sector. Coal used in the manufacture of synfuels was also separately estimated. Combined retail, commercial, other (noncoke plant) industrial, and synfuels consumption of coal is labeled "Retail and General Industry" coal consumption.

Other Industry Coal Consumption (exclusive of synfuels)

Other industry coal consumption net of synfuels-related consumption (XFCLIT) is assumed to be a function of the level of industrial production (JQINDM) and seasonal factors.

$$XFCLIT = G_0(M_i) + G_1 JQINDM + G_2 DS1 \quad (28)$$

Table 11. Data Definitions, Units, and Sources for Coke, Coking Coal, and Other Components of Coal Demand and Coal Stocks

Variable	Definition	Source	Units
RSP	Monthly raw steel production	Annual Statistical Report, 1980, Ameircan Iron and Steel Institute [19] and monthly Raw Steel and Pig Iron Production Reports (ALS-7) [20].	Million tons
JQI&S	Monthly index for basic iron and steel production	Data Resources, Incorporated (DRI), Model of the U.S. Economy (JQIND331&2), monthly.	--
XDCK	Monthly coke consumption[a]	December 1977 through December 1980: U.S. Department of Energy, Coke and Coal Chemicals [21]; January 1980 through December 1981, Coke Plant Report [22]; January 1981 through December 1984, Quarterly Coal Report [23].	Million tons
XKCK	End-of-month coke stocks[a]	U.S. Department of Energy [21, 22, 23].	Million tons
XFCKPD	Monthly coke production[a]	U.S. Department of Energy [21, 22, 23].	Million tons
XMCK	Monthly coke net imports	U.S. Department of Commerce, Report FT-410, Commodity by Country [24] and Report FT-546, Commodity by Country [25].	Million tons
XFCLCK	Monthly coking coal consumption[a] (i.e., coal carbonized at coke plants)	MER [11].	Million tons
XICL	Monthly coal imports	Monthly Energy Review (MER) [11].	Million tons
XECL	Monthly coal exports	U.S. Department of Commerce [24, 25].	Million tons
XKCLCK	End-of-months coal stocks[a] at coke plants	MER [11].	Million tons
Time	= 1 for 7701, ..., = 96 for 8412, etc.		

[a]Data for coking coal consumption, coke consumption, coke production, coke stocks, and coking coal stocks are no longer published on a monthly basis by DOE. Consequently, monthly values for XDCK, XFCKPD, XKCK, XFCLCK, and XKCLCK are estimated from their reported quarterly data, based on reported monthly raw steel production data from the American Iron and Steel Institute, and other relevant information.

-- = Not applicable.

The variable DS1 is the strike dummy defined for equations (21) and (22). The term $G_0(M_i)$ is identical to $A_0(M_i)$ in equation (21).

Synfuels Related Coal Consumption. For all of 1984, consumption of the coal in the manufacture of synfuels (XCSYN--all coal gasification) was 1.7 million tons. For the first quarter of 1985, XCSYN was assumed to have been 1.0 million tons. For the forecast, synfuels related coal use was assumed to be 1.1 and 1.2 million tons for the second and third quarters of 1985 and 1.3 million tons in every quarter thereafter.

Retail and Commercial Coal Consumption

Retail and commercial coal consumption (XFCLRC) is a small and relatively stable portion of total retail and general industry coal consumption. For the April 1985 Outlook, XFCLRC was simply assumed to be a function of time, seasonal dummies, and strike dummies as follows:

$$XFCLRC = H_0(M_i) + H_1 time + H_2 * Ftime \qquad (29)$$

where:

$H_0(M_i)$ is identical to $A_0(M_i)$ in equation (21)
Ftime is a slope dummy for time for the period 1983 to 1984.

Total retail and general industry coal consumption (XDCLCI) is defined as follows:

$$XDCLCI = XFCLIT + XFCLRC + XCSYN \qquad (30)$$

The definition, sources, and units of the data used in the retail and general industry coal demand equations are presented in Table 12.

Coal Stocks

Initial coal stock forecasts were derived by assuming a days' supply of coal for each consuming sector, reflecting what appeared to be normal levels by the end of the forecast period. The days' supply schedules for coal stocks are reported in Table 10. For sector i, days' supply in the current period was defined as follows:

$$DS(i) = \left(K(i) / \sum_{j=0}^{2} C(i)(j+1)\right) \sum_{j=0}^{2} Days(j+1) \qquad (31)$$

where:

DS(i) = days supply sector i
K(i) = stock level sector i

Table 12. Data Definitions, Units, and Sources for the Retail and General Industry Coal Demand Model

Variable	Definition	Source	Units
XFCLIT	Monthly coal consumption by industrial users, other than coke plants and synfuels plants.	*Monthly Energy Review* [11], and internal EIA documents needed to back out synfuels related use.	Million short tons
XFCLRC	Monthly coal consumption by retail and commercial customers.	MER [11].	Million short tons
JQINDM	Industrial production index, all manufacturing	U.S. Federal Reserve Board [13].	Index, 1967 = 1.0
Time	= 1 for 7701; 84 for 8312, etc.	--	--
DS1	Dummy variable for coal strike, = 1 for 7801-7803, = 0 otherwise	--	--
XCSYN	Synfuels related consumption of coal	Internal EIA documents on individual plant use of coal.	Million short tons
XKCLCI	End-of-month coal stocks[a] held by other industrial coal users.	MER [11].	Million short tons

[a]Data for retail and general industry coal consumption and for other industrial coal stocks are no longer available on a monthly basis. Consequently, monthly values for XFCLIT, XFCLRC, and XKCLCI are estimated, based on monthly values for JQINDM and by interpolation.

Note: Forecasts of macroeconomic variables are derived from Data Resources, Inc., macroeconomic forecast CONTROL0485.

C(i)(j+1) = consumption in sector i for period j+1
Days(j+1) = number days in the month j+1 periods in the future.

Then, given assumed values for DS(i), forecast stock levels are:

$$K(i)(forecast) = DS(i) \frac{\sum_{j=0}^{2} C(i)(j+1)(forecast)}{\sum_{j=0}^{2} Days(j+1)} \qquad (32)$$

It should be noted that the discussion surrounding (31) and (32) pertain only to secondary or consumer stocks. Producer and distributor stocks of coal were assumed to remain at the level of the last historical observation throughout the forecast period for the April 1985 *Outlook*. Given independently derived estimates of coal production and total domestic demand for coal (including net exports), consumer coal stocks were then adjusted to balance domestic supply and demand. The definitions, sources, and units for the coal stock variables are presented in Tables 9, 11, and 12.

For the April 1985 *Outlook* forecast, coal imports were assumed to be 500,000 tons per quarter, or 2 million tons per year, which largely reflects the expectation of increased penetration of the U.S. coal market by Colombia and other competitive suppliers. Coal exports were assumed to be essentially unchanged in the forecast period from those published in the January 1985 *Outlook*. In that *Outlook*, exports were derived by applying export price elasticities developed for the August 1984 *Outlook*. Appendix D reproduces a portion of an internal memorandum documenting the development of these elasticities. The forecasts, disaggregated to metallurgical coal and steam coal categories, are given in Table 13.

Table 13. Coal Export Projections for the April 1985 *Outlook*
(Million Short Tons)

Year	Quarter	Metallurgical Coal Exports	Steam Coal Exports	Total Exports
1985	1	14	2	16
	2	14	4	18
	3	15	5	20
	4	14	4	18
1986	1	14	1	15
	2	15	3	18

Coal Production

The forecast of domestic coal production in the April 1985 Outlook was provided by the Energy Information Administration's Office of Coal, Nuclear, Electric and Alternate Fuels, Coal Division, Data Analysis and Forecasting Branch. The forecast was generated by the Short-Term Coal Analysis System (SCOAL).

Energy Prices

This section discusses the methodology for forecasting the various energy prices published in the Outlook. These prices are important in their own right as they are widely used for budget planning and other purposes by local government and corporate planners. These prices are also used to make the projections of energy demand discussed in the previous section. All of the variable sources, units, and definitions for the energy price models are summarized in Table 14.

Imported Crude Oil Prices. The price of imported crude oil (PIMP) is based on the Oil Market Simulation (OMS) model of the International and Contingency Information Division. Forecasts from the model are benchmarked to the most recent available data.

Domestic Crude Oil Prices. The price of domestic crude oil (PDOM) is assumed to be the projected imported crude oil prices, plus the average of the differences over the last 6 months of history between domestic and imported crude oil prices, or:

$$PDOM_t = PIMP_t + \frac{\sum_{i=b-5}^{b} (PDOM_i - PIMP_i)}{6} \tag{33}$$

b represents the most recent month of data, which was January 1985 for the April 1985 Outlook.

Refiner Acquisition Cost of Crude Oil. The composite refiner acquisition cost of crude oil (PCRUDE) is projected as a weighted average of imported and domestic crude oil prices, with the weights being crude oil imports (IMP) and domestic production (DPROD), respectively. The weights are based on the most recent 6-month averages and are held constant throughout the forecast period. The weight for imports (WIMP) is calculated as:

$$WIMP_t = \frac{\sum_{i=b-5}^{b} IMP_i}{\sum_{i=b-5}^{b} (IMP_i + DPROD_i)} \tag{34}$$

Table 14. Data Definitions, Units, and Sources for the Energy Price Models

Variable	Definition	Source	Units
XDRS	Demand for nonutility residual fuel Number 6. Total residual-less shipments of fuel to electric utilities.	MER, FERC Form 423, Cost and Quality of Fuels for Electric Utility Plants [23].	Million barrels/
INDM	Industrial production index for all manufacturing	Board of Governors, Federal Reserve System, Industrial Production Index [13].	1967 = 1.00
HDD	Heating degree days, 1980 population-weighted	National Oceanic and Atmospheric Administration, U.S. Department of Commerce [12].	Number of degree days
PDIS	Retail price of distillate fuel oil	Monthly Energy Review (MER) [11].	Cents/gallon
PRS	Retail price of residual fuel oil average all sulfur contents	MER [11].	Dollars/barrel
PEL	Residential price of electricity	MER [11] and EIA, EIA Form 826 "Electric Utility Company Monthly Statement" [24].	Cents/kwhr
PCOAL	Price of coal to electric utilities	MER [11] and EIA, FERC Form 423, "Monthly Reporting of Cost and Quality of Fuels for Electric Plants" [23].	Cents/million Btu
PNGE	Price of natural gas to electric utilities	MER [11] and FERC Form 423 [23].	Cents/million Btu
PNGR	Price of natural gas to residences	MER [11].	Cents/million Btu
PNGWH	Price of natural gas at the wellhead	MER [11].	Cents/thousand cubic feet
PROP	Retail price of consumer-grade propane	MER [11].	Cents/gallon
WPI	Wholesale price index, all commodities	Bureau of Labor Statistics, Department of Labor [16].	1967 = 1.0
PCRUDE	Composite refiners' acquisition cost of crude oil	MER [11].	Dollars/barrel
PRMG	Retail price of motor gasoline average, all grades and services	MER, WPSR, BLS, Consumer Price Index.	Cents/gallon
PWMG	Wholesale price of motor gasoline average, all grades	"Producer Price Index," various issues (monthly report), Bureau of Labor Statistics [16].	Cents/gallon
PIMP	Price of imported crude oil	MER [11].	Dollars/barrel
PDOM	Price of domestic crude oil	MER [11].	Dollars/barrel
BOND	Average yield on new issues of AA-rated corporate utility bonds, per cent per annum, rated AA by Moody's investor service.	Raw data from Wall Street Journal. Compiled by Data Resources, Incorporated (DRI), U.S. Central Database [3].	
NUKE	Maximum dependable capacity of operable nuclear reactors.	MER [11].	Billion net kilowatts

The weight for domestic production (WDOM) is then (1 - WIMP). Thus the composite price of crude oil is:

$$PCRUD = WIMP*PCRUD + WDOM*PDOM \quad (35)$$

Retail Motor Gasoline Price. The retail price of motor gasoline (PRMG) was assumed to be a function of the wholesale price of motor gasoline (PWMG) and retail margins (RTMAR). PWMG was assumed to be a function of the refiners' acquisition cost of crude oil (PCRUDE) and refiners margins (RFMAR). For the April 1985 *Outlook*, retail margins (including taxes) were assumed to be flat in nominal terms for the forecast. RFMAR was assumed to be flat in real terms. The refiners' margins were multiplied by seasonal factors ZWHM determined by the Census Bureau X11 seasonal adjustment rountine. (The seasonal factors are shown on Table 15.) Thus:

$$PRMG = PWMG + RTMAR \quad (36)$$

where: $PWMG = PCRUDE + (RFMAR * ZWHM)$

Table 15. Motor Gasoline Refiners Margin Seasonal Factors

Month	Factor	Month	Factor
January	0.861	July	1.148
February	0.852	August	1.349
March	0.868	September	1.073
April	0.992	October	1.019
May	1.049	November	0.983
June	1.099	December	0.908

Retail Distillate Price. Retail distillate prices (PDIS) are assumed to be a function of the sum of the margin (DMARG) between PDIS and PCRUDE. DMARG is assumed to increase at the rate of inflation. The PDIS variable is then multiplied by the seasonal factors ZPDIS determined by the X11 routine. The seasonal factors are shown on Table 16. Therefore:

$$PDIS = (DMARG + PCRUDE)*ZPDIS \quad (37)$$

Propane Price. The price of consumer-grad propane (PROP) is estimated as a function of the retail price of distillate fuel oil (PDIS), or:

$$PROP = B_0 + B_1 PDIS \quad (38)$$

Retail Residual Fuel Price. Retail residual fuel prices (PRS) are estimated as a function of the price of crude oil (PCRUDE), a 1-month lagged dependent variable, and dummy variables representing the outbreak of the Iran/Iraq War (DUMII, November-December 1980), an outlier for July 1978 (DUMINC), and the British coal strike (DUMBRIT), or:

$$PRS_t = B_0 + B_1PRS_{t-1} + B_2PCRUDE_t + B_3DumII + B_4DUMINC + B_5DUMBRIT \quad (39)$$

The coefficients for B_3, B_4, and B_5 are not used in the forecast.

Table 16. Retail Heating Oil Seasonal Factors

Month	Factor	Month	Factor
January	1.029	July	0.983
February	1.035	August	0.980
March	1.003	September	0.988
April	0.984	October	1.003
May	0.989	November	1.008
June	0.990	December	1.011

Natural Gas Price to Electric Utilities

The natural gas price to electric utilities (PNGE) is estimated as a function of the wellhead price (PNGWH) and a PNGE lagged 1 month, or:

$$PNGE_t = B_0 + B_1PNGWH_t + B_2PNGE_{t-1} \quad (40)$$

Residential Natural Gas Prices

The price of natural gas to residential consumers (PNGR) is estimated as a function of the wellhead price (PNGWH) and PNGR lagged 1 month, or:

$$PNGR_t = B_0 + B_1PNGWH + B_2PNGR_{t-1} \quad (41)$$

Residential Electricity Price

The residential electricity price (PEL) is estimated as a function of the price of gas (PNGE) to utilities, a 1-month lagged dependent variable, nuclear capacity lagged 12 months (NUKE), and the bond rate (BOND):

$$\ln(PEL_t) = B_0 + B_1\ln(NUKE_{t-12}) + B_2\ln(PNGE) + B_3BOND + B_4\ln(PEL_{t-1}) \quad (42)$$

where:

PEL = residential price of electricity/WPI, in cents per kilowatthour
PCOAL = price of coal to electric utilities/WPI, in cents per million Btu

PNGE = price of natural gas to electric utilities/WPI, in cents per million Btu

BOND = cost of capital, average yield on new issues of AA-rated corporate utility bonds, percent per year.

Coal Price

The price of coal (PCOAL) is assumed to be a function of the assumed rate of inflation and two dummy variables:

$$PCOAL = B_0 + B_1WPI + B_2DUM84 + B_3Strike \qquad (43)$$

where:

PCOAL = price of coal in time t, in cents per million Btu

WPI = measure of inflation, 1972=1.00

DUM84 = dummy variable, 1 for 1984; 0 otherwise

Strike = dummy variable for periods of United Mine Workers of America (UMWA) strike, 1 for 7801-7804; 0 otherwise.

Since there is no coal strike anticipated within the next 2 years, the coefficient for B_3 is not used in the forecast.

5. DOCUMENTATION OF MODEL ESTIMATES

Tables 17 through 45 summarize the model estimates of the econometric equations used in the Short-Term Integrated Forecasting System demand model. The equations are referred to by number as they appear in Chapter 4.

Table 17. Gasoline-Powered Vehicle MPG Proxy: Equation (3')

Variable	Coefficient Estimate	t-Statistic
Constant (B4)	0.214	0.96
Price (B5)	0.221	6.35
Trend (B6)	0.379	16.09
DPRE (B00)	1.523	13.33
DPRE*Trend (B01)	-0.357	-14.60

R-Squared = 0.94
Durbin-Watson Statistic = 1.68
Standard Error = 0.86
Estimation Interval = January 1975-December 1984, monthly
Estimation Technique = Ordinary least squares

Table 18 Total Gasoline Demand: Equation (4')

Variable	Coefficient Estimate	t-Statistic
Constant (B0')	3.619	4.79
Price (B1)	-0.211	-8.58
YD72 (B2)	0.169	1.58
JQINDM (B3)	0.164	3.49
D75 (B10)	-0.119	-7.04
D76 (B11)	-0.093	-5.72
D77 (B12)	-0.074	-5.08
D78 (B13)	-0.046	-3.68
D79 (B14)	-0.039	-4.45
Restriction[a]	0.013	3.30

R-Squared = 0.89
Durbin-Watson Statistic = 1.39
Standard Error = 0.79
Estimation Interval = January 1975-December 1984
Estimation Technique = Restricted least squares

[a]The restriction coefficient is the estimated Lagrangian multiplier derived from the restricted least squares estimation procedure. The significance of this coefficient indicates that unrestricted parameter estimates are significantly different from those above, and that applying the restriction does not significantly increase the error sum of squares.

Table 19. No. 2 Diesel Fuel Oil: Equation (5)

Variable	Coefficient Estimate	t-Statistic
Constant (B0)	0.640442	4.01572
$DIESADJ_{t-1}$ (B1)	0.531591	7.02928
PDRLADJ (B2)	-0.007329	-3.36737
JQINDM (B3)	0.190631	2.39156
DUM7578 (B4)	-0.118360	-3.47247
MAR83 (B5)	0.189381	2.86389

R-Squared (corrected) = 0.6799
Durbin-H Statistic = -0.4611
Estimation Interval: August 1975 through December 1984
Estimation Technique: Ordinary least squares

Table 20. No. 2 Heating Oil: Equation (6)

Variable	Coefficient Estimate	t-Statistic
Constant (B0)	0.255657	0.904467
PDISR (B1)	-0.008247	-3.47036
JQUINDM (B2)	0.666370	4.03511
HDD (B3)	0.002304	35.3355
WINTREND·HDD (B4)	-0.000229	-17.4784
SUMDUM (B5)	-0.200924	-3.64715

R-Squared (corrected) = 0.9587
Durbin-Watson Statistic = 1.9402
Estimation Interval: January 1978 through December 1984
Estimation Technique: Ordinary least squares

Table 21. Nonutility Residual Fuel Oil: Equation (8)

Variable	Coefficient Estimate	t-Statistic
Constant (B0)	0.727	4.36
PRS (B1)	-0.016	-5.00
INDM (B2)	0.341	2.67
HDD (B3)	0.001	11.83
DUM7677 (B4)	0.128	2.30
DUMDec (B5)	-0.116	-2.75
$XDRS_{t-1}$ (B6)	0.229	4.01
DUMWIN (B7)	-0.143	-3.74
DUM (B8)	-0.267	-5.22

R-Squared (corrected) = 0.919
Durbin-H Statistic = -0.66
Estimation Interval: July 1975 through December 1984, monthly
Estimation Technique: Ordinary least squares

Table 22. Liquefied Petroleum Gases: Equation (10)

Variable	Coefficient Symbols	Coefficient Estimate	t-Statistic
Constant	B_0	537.82	7.00
RPETP	B_1	-23.69	-2.37
DEVHDD	B_2	0.37	4.06
$DLPG_{-1}$	B_3	0.52	7.77
Autocorrelation Coefficient ..	p	-0.21	-2.52

R-Squared (corrected) = 0.30
Correlation Coefficient--Squared (original data; seasonalized backcast) = 0.91
Estimation Interval = January 1973-December 1984
Estimation Technique = Cochrane-Orcutt procedure
Standard Error of Regression = 72.69

Table 23. Kerosene-Type Jet Fuel: Equation (11)

Variable	Coefficient Symbols	Coefficient Estimate	t-Statistic
Constant	B_0	218.14	3.77
YD72	B_1	0.44	5.62
RPETP	B_2	-42.94	-3.87
DPATCO	B_3	-22.15	-1.74
$DKJF_{-1}$	B_4	0.32	3.60

R-Squared (corrected) = 0.58
Correlation Coefficient--Squared (original data; seasonalized backcast) = 0.66
Durbin-H Statistic = -2.50
Estimation Interval = January 1976-December 1984
Estimation Technique = Ordinary least squares
Standard Error of Regression = 37.06

Table 24. Petrochemical Feedstocks and Ethane: Equation (12)

Variable	Coefficient Symbol	Coefficient Estimate	t-Statistic
JQIND28	B_1	157.23	2.15
RPETP	B_2	-29.39	-1.53
DL6	B_3	-81.85	-2.29
$DPFET_{-1}$	B_4	0.75	10.89

R-Squared (corrected) = 0.66
Durbin-H Statistic = -1.13
Estimation Interval = January 1978-December 1984
Estimation Technique = Ordinary least squares
Standard Error of Regression = 69.21

Table 25. Kerosene: Equation (13)

Variable	Coefficient Symbol	Coefficient Estimate	t-Statistic
Constant	B_0	504.52	11.71
YD72	B_1	-0.28	-6.85
RPETP	B_2	-27.59	-4.49
DEVHDD	B_3	0.12	2.86

R-Squared (corrected) = 0.56
Correlation Coefficient--Squared (original data; seasonalized backcast) = 0.90
Durbin-Watson Statistic = 1.41
Estimation Interval = January 1978-December 1984
Estimation Technique = Ordinary least squares
Standard Error of Regression = 21.70

Table 26. Road Oil and Asphalt: Equation (14)

Variable	Coefficient Symbol	Coefficient Estimate	t-Statistic
Constant	B_0	155.50	4.38
RPETP	B_1	-30.73	-3.90
$DRDAS_{-1}$	B_2	0.78	14.63
Autocorrelation Coefficient ..	p	-0.38	-3.72

R-Squared (corrected) = 0.76
Correlation Coefficient--Squared (original data; seasonalized backcast) = 0.99
Estimation Interval = January 1978-December 1984
Estimation Technique = Cochrane-Orcutt
Standard Error of Regression = 30.38

Table 27. Still Gas: Equation (15)

Variable	Coefficient Symbol	Coefficient Estimate	t-Statistic
Constant	B_0	365.76	6.53
JQINDM	B_1	127.33	3.38
DL6	B_2	-33.12	-2.89
Autocorrelation Coefficient ..	p	0.39	3.88

R-Squared (corrected) = 0.36
Correlation Coefficient--Squared (original data; seasonalized backcast) = 0.68
Estimation Interval = January 1978-December 1984
Estimation Technique = Cochrane-Orcutt
Standard Error of Regression = 15.86

Table 28. Petroleum Coke: Equation (16)

Variable	Coefficient Symbol	Coefficient Estimate	t-Statistic
Constant	B_0	57.55	4.09
JQINDM	B_1	26.02	2.24
RPETP	B_2	-3.39	-1.11
$DCOKE_{-1}$	B_3	0.64	11.40
Autocorrelation Coefficient ..	p	-0.52	-8.50

R-Squared (corrected) = 0.22
Estimation Interval = January 1969-December 1984
Estimation Technique = Cochrane-Orcutt procedure
Standard Error of Regression = 25.64

Table 29. Miscellaneous Products: Equation (17)

Variable	Coefficient Symbol	Coefficient Estimate	t-Statistic
JQINDM	B_1	118.80	3.87
RPETP	B_2	-22.59	-2.50
DL6	B_3	-46.48	-2.85
$DMISC_{-1}$	B_4	0.68	8.58

R-Squared = 0.69
Correlation Coefficient--Squared (original data; seasonalized backcast) = 0.71
Durbin-H Statistic = -5.08
Estimation Interval = January 1978-December 1984
Estimation Technique = Ordinary least squares
Standard Error of Regression = 31.17

Table 30. Electricity Generation: Equation (18)

Variable	Coefficient Estimate	t-Statistic
Constant (B0)	70,084	10.4
Price (B1)	-24,228	-5.1
YD72 (B2)	134	16.3
HDD (B3)	32	14.2
CDD (B4)	164	30.5
JAN (B5)	9	4.1
FEB (B6)	-11	-4.7
Rho	-0.18	-1.8

R-Squared (corrected) = 0.93
Durbin-Watson Statistic = 1.88
Estimation Interval = January 1977 through December 1984
Estimation Technique = Cochrane-Orcutt iterative procedure
Standard Error of Regression = 4,155

Table 31. Net Electricity Imports: Equation (19)

Variable	Coefficient Estimate	t-Statistic
Constant (B_0)	0.138	4.871
T (B_1)	0.031	4.876

R-Squared (corrected) = 0.792
Durbin-Watson Statistic = 2.544
Estimation Interval = Annual, 1977 through 1983
Estimation Technique = Ordinary least squares
Standard Error of Regression = 0.033

Table 32. Nonutility Natural Gas Demand: Equation (20)

Variable	Coefficient Estimate	t-Statistic
Constant	1.026	6.9
HDD	0.00114	54.9
Price	-0.00315	-7.8
JQ	0.190	2.1
Dummy	-0.056	2.0
Rho	0.255	1.87

R-Squared (corrected) = 0.99
Durbin-Watson Statistic = 1.70
Estimation Interval = 8010-8412
Number of observations = 51

Table 33. Electric Utility Coal-Fired Generation: Equation (21)

Variable	Coefficient Estimate	t-Statistic
Intercept[a]		
a_0(M1)	assumed 0	
a_0(M2)-a_0(M1)	6.491	9.30
a_0(M3)-a_0(M1)	assumed 0	
a_0(M4)-a_0(M1)	assumed 0	
a_0(M5)-a_0(M1)	-2.234	-3.02
a_0(M6)-a_0(M1)	-1.502	-2.09
a_0(M7)-a_0(M1)	-6.108	-8.00
a_0(M8)-a_0(M1)	-6.300	-7.78
a_0(M9)-a_0(M1)	-2.674	-3.55
a_0(M10)-a_0(M1)	-3.027	-4.14
a_0(M11)-a_0(M1)	assumed 0	
a_0(M12)-a_0(M1)	assumed 0	
XGEL (a_1)	0.234	17.80
XGEL*CAP (a_2)	0.0023	31.75
NUHCU (a_{31})	-0.619	-4.56
NULCU (a_{32})	-0.490	-3.01
XGHYEL	-0.594	-8.55
DS1 (a_5)	-9.603	-8.92
DS2 (a_6)	-4.648	-4.22
01 (a_7)	-5.411	-4.23

R-Squared (corrected) = 0.983
Durbin-Watson Statistic = 1.72
Standard Error = 1.77
Estimation Interval: January 1977 through December 1984
Estimation Technique: Ordinary least squares

[a]The first intercept term represents the intercept for January. Subsequent terms are estimated as differences from the January intercept. Thus, the first term plus the second term yields the intercept for February, and so on.

Table 34. Electric Utility Coal Consumption: Equation (22)

Variable	Coefficient Estimate	t-Statistic
Intercept[a]		
$b_0(M1)$	0.844	1.44
$b_0(M2)-b_0(M1)$	assumed 0	
$b_0(M3)-b_0(M1)$	-0.448	-3.40
$b_0(M4)-b_0(M1)$	-0.582	-3.36
$b_0(M5)-b_0(M1)$	-0.489	-2.95
$b_0(M6)-b_0(M1)$	-0.414	-3.03
$b_0(M7)-b_0(M1)$	assumed 0	
$b_0(M8)-b_0(M1)$	0.241	1.85
$b_0(M9)-b_0(M1)$	assumed 0	
$b_0(M10)-b_0(M1)$	-0.359	-2.69
$b_0(M11)-b_0(M1)$	-0.358	-2.63
$b_0(M12)-b_0(M1)$	assumed 0	
XGCLEL (b_1)	0.476	69.03
time (b_2)	0.019	6.36
DS1 (b_3)	1.161	4.50
DS2 (b_4)	0.770	3.10
Rho[b]	0.300	3.07

R-Squared (corrected) = 0.996
Standard Error = 0.6
Estimation Interval: January 1977 through December 1984
Estimation Technique: Generalized least squares[c]

[a]See footnote a on Table 32.
[b]Rho is the first-order serial correlation coefficient.
[c]The estimation package was the Statistical Analysis System (SAS) Autoreg procedure, performed without iteration.

Table 35. Coking Coal Consumption: Equation (23)

Variable	Coefficient Estimate	t-Statistic
Intercept (e_0)	0.246	2.91
XFCKPD (e_1)	1.406	82.53
Time (e_2)	-0.002	-3.599

R-Squared (corrected) = 0.996
Durbin-Watson Statistic = 1.92
Standard Error = 1.75
Estimation Interval: January 1977 through December 1984
Estimation Technique: Ordinary least squares

Table 36. Raw Steel Production: Equation (25)

Variable	Coefficient Estimate	t-Statistic
Intercept[a]		
d_0(M1)	1.077	1.94
d_0(M2)-d_0(M1)	-0.274	-2.55
d_0(M3)-d_0(M1)	1.101	10.37
d_0(M4)-d_0(M1)	0.939	8.89
d_0(M5)-d_0(M1)	1.185	11.24
d_0(M6)-d_0(M1)	0.537	5.09
d_0(M7)-d_0(M1)	assumed 0	
d_0(M8)-d_0(M1)	assumed 0	
d_0(M9)-d_0(M1)	-0.308	-2.92
d_0(M10)-d_0(M1)	assumed 0	
d_0(M11)-d_0(M1)	-0.384	-3.64
d_0(M12)-d_0(M1)	assumed 0	
JQI&S (D1)	8.852	16.60
Time (D2)	-0.021	-2.41
JQI&S*Time (D3)	0.018	1.87

R-Squared (corrected) = 0.984
Durbin-Watson Statistic = 1.75
Standard Error = 2.99
Estimation Interval: January 1977 through December 1983
Estimation Technique: Ordinary least squares

[a]See footnote a on Table 32.

Table 37. Other Industry Coal Consumption (exclusive of synfuels related consumption): Equation (28)

Variable	Coefficient Estimate	t-Statistic
Intercept[a]		
g_0(M1)	2.724	3.01
g_0(M2)-g_0(M1)	-0.505	-5.61
g_0(M3)-g_0(M1)	-0.648	-5.68
g_0(M4)-g_0(M1)	-0.864	-6.74
g_0(M5)-g_0(M1)	-1.091	-8.11
g_0(M6)-g_0(M1)	-1.361	-9.89
g_0(M7)-g_0(M1)	-1.398	-10.06
g_0(M8)-g_0(M1)	-1.320	-9.54
g_0(M9)-g_0(M1)	-1.409	-10.38
g_0(M10)-g_0(M1)	-0.901	-6.94
g_0(M11)-g_0(M1)	-0.650	-5.47
g_0(M12)-g_0(M1)	-0.241	-2.46
JQINDM (g_1)	2.418	3.96
DS1 (g_2)	-1.004	-5.26
Rho[b]	0.611	7.56

R-Squared (corrected) = 0.692
Standard Error = 4.0
Estimation Interval: January 1977 through December 1984
Estimation Technique: Generalized least squares[c]

[a]See footnote a on Table 32.
[b]Rho is the first-order serial correlation coefficient.
[c]The estimation package was the Statistical Analysis System (SAS) Autoreg procedure, performed without iteration.

Table 38. Retail and Commercial Coal Consumption: Equation (29)

Variable	Coefficient Estimate	t-Statistic
Intercept[a]		
$h_0(M1)$	1.081	20.23
$h_0(M2)-h_0(M1)$	-0.211	-5.09
$h_0(M3)-h_0(M1)$	-0.356	-7.07
$h_0(M4)-h_0(M1)$	-0.352	-6.53
$h_0(M5)-h_0(M1)$	-0.484	-8.72
$h_0(M6)-h_0(M1)$	-0.534	-9.50
$h_0(M7)-h_0(M1)$	-0.465	-8.22
$h_0(M8)-h_0(M1)$	-0.436	-7.72
$h_0(M9)-h_0(M1)$	-0.391	-6.99
$h_0(M10)-h_0(M1)$	-0.270	-4.93
$h_0(M11)-h_0(M1)$	-0.137	2.52
$h_0(M12)-h_0(M1)$	-0.009	0.09
Time (h_1)	-0.003	-2.45
FTime (h_2)	0.002	2.26
Rho[b]	0.466	5.16

R-Squared (corrected) = 0.644
Standard Error = 14.0
Estimation Interval: January 1977 through December 1984
Estimation Technique: Generalized least squares[c]

[a] See footnote a on Table 32.
[b] Rho is the first-order serial correlation coefficient.
[c] The estimation package was the Statistical Analysis System (SAS) Autoreg procedure, performed without iteration.

Table 39. Retail Motor Gasoline Price: Equation (33)

Variable	Coefficient Estimate	t-Statistic
Constant (B0)	1.143	13.05
$\ln(PRMG)_{t-1}$ (B1)	0.162	3.81
Percent Self (B2)	-0.294	-5.18
DumIran (B3)	0.013	2.71
Ln(PWMG) (B4)	0.646	19.63
Rho	0.843	15.50

R-Squared (corrected) = 0.998
Durbin-H Statistic = 0.70
Estimation Interval: August 1975 through October 1983, monthly
Estimation Technique: Cochrane-Orcutt procedure

Table 40. Propane Price: Equation (34)

Variable	Coefficient Estimate	t-Statistic
Constant (B0)	13.82	2.60
$PDIS_t$ (B1)	0.53	10.14
Rho	0.738	9.95

R-Squared (corrected) = 0.952
Durbin-Watson Statistic = 2.18
Estimation Interval: January 1978 through December 1984, monthly
Estimation Technique: Cochrane-Orcutt procedure

The consumer grade propane price data were deseasonalized using the X11MULT package on SPEAKEZ, IBM. The seasonal factors are:

January = 1.006	July = 0.987
February = 0.99	August = 1.012
March = 0.988	September = 1.042
April = 0.992	October = 0.981
May = 1.004	November = 1.003
June = 0.981	December = 1.013

Table 41. Retail Residual Fuel Oil Price: Equation (35)

Variable	Coefficient Estimate	t-Statistic
Constant (B0)	3.630	3.44
PRS_{t-1} (B1)	0.151	1.88
PCRUDE (B2)	0.642	8.56
DUMII (B3)	1.593	4.42
DumInc (B4)	-1.195	-3.33
Dumbrit (B5)	1.569	3.72
Rho	0.831	14.79

R-Squared (corrected) = 0.99
Durbin-H Statistic = 1.30
Estimation Interval: July 1975 through December 1984, monthly
Estimation Technique: Cochrane-Orcutt procedure

The electricity price data were deseasonalized using the X11MULT package on SPEAKEZ, IBM. The seasonal factors are:

January = 1.005	July = 0.989
February = 1.034	August = 0.980
March = 1.991	September = 0.986
April = 0.972	October = 1.013
May = 0.987	November = 1.012
June = 1.000	December = 1.021

Table 42. Natural Gas to Electric Utilities Price: Equation (37)

Variable	Coefficient Estimate	t-Statistic
Constant (B0)	5.043	4.89
$PWNGWH_{-t}$ (B1)	0.768	4.03
$PNGR_{t-1}$ (B2)	0.263	13.87

R-Squared (corrected) = 0.995
Durbin-H Statistic = 0.455
Estimation Interval = August 1975 through November 1984, monthly
Estimation Technique = Ordinary least squares
Standard Error of Regression = 1.68

The electric utility natural gas price data were deseasonalized using the X11MULT package on SPEAKEZ, IBM. The seasonal factors are:

January = 0.978	July = 1.038
February = 0.988	August = 1.030
March = 0.980	September = 1.026
April = 0.975	October = 1.013
May = 1.007	November = 0.988
June = 1.012	December = 0.964

Table 43. Residential Natural Gas Price: Equation (38)

Variable	Coefficient Estimate	t-Statistic
Constant (B0)	2.71	0.94
$PNGWH_t$ (B1)	0.41	4.58
$PNGR_{t-1}$ (B2)	0.81	20.51

R-Squared (corrected) = 0.988
Durbin-H Statistic = 2.04
Estimation Interval: January 1978 through November 1984, monthly
Estimation Technique: Ordinary least squares

The residential natural gas price data were deseasonalized using the X11MULT package on SPEAKEZ, IBM. The seasonal factors are:

January = 0.992	July = 1.004
February = 0.993	August = 0.989
March = 0.990	September = 1.006
April = 0.991	October = 1.014
May = 1.021	November = 0.995
June = 1.010	December = 0.992

Table 44. Residential Electricity Price: Equation (40)

Variable	Coefficient Estimate	t-Statistic
Constant (B0)	0.111	-1.40
$LnNUKE_{t12}$ (B1)	0.0447	1.87
$LnPGAS_t$ (B2)	0.035	1.99
$BOND_t$ (B3)	0.0009	4.41
$LnPEL_{t-1}$ (B4)	0.724	10.82

R-Squared (corrected) = 0.98
Durbin-H Statistic = 0.46
Estimation Interval = January 1978 through November 1984, monthly
Estimation Technique = Ordinary least squares
Standard Error of Regression = 0.0067

The electricity price data were deseasonalized using the X11MULT package on SPEAKEZ, IBM. The seasonal factors are:

January = 0.936	July = 1.045
February = 0.945	August = 1.044
March = 0.972	September = 1.040
April = 0.986	October = 1.029
May = 1.016	November = 0.99
June = 1.038	December = 0.956

Table 45. Coal Prices to Electric Utilities: Equation (41)

Variable	Coefficient Estimate	t-Statistic
Constant (B0)	-16.86	-1.68
PPI (B1)	59.00	14.87
DUMN (B2)	-2.45	-1.12
Strike (B3)	4.28	2.67
Rho	0.89	20.01

R-Squared (corrected) = 0.995
Durbin-Watson Statistic = 1.902
Estimation Interval = January 1976 through November 1984
Estimation Technique = Cochrane-Orcutt procedure
Standard Error of Regression = 2.16

APPENDIX A. MODEL ABSTRACT

Model Name: Short-Term Integrated Forecasting System Demand Model

Acronym: STIFS Demand Model

Status: Active, used to produce the demand forecasts for the Short-Term Energy Outlook

Purpose: To provide monthly and quarterly energy demand forecasts by fuel, petroleum products, coal, and electricity for up to eight quarters in the future on a quarterly basis for the United States; also provided are forecasts of energy prices for gasoline, heating oil, residual oil, residential electricity, and residential natural gas.

Energy System: Gasoline, distillate, nonutility distillate, nonutility residual, other petroleum products, coal, electricity

Coverage: United States, monthly, aggregate fuel demands not disaggregated by sector.

Special Features: None

Model Structure and Modeling Techniques: Econometric and some time series techniques used to estimate coefficients. Deterministic forecasting approach.

Model Interfaces: (1) Short-Term Coal Analysis System (SCOAL), Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, Model Documentation, February 1982; (2) Short-Term Nuclear Annual Power Production, Oak Ridge National Laboratory, CET-001/SNAPPS, August 1981.

Input Data: Most of the models assume that fuel demand can be expressed as a function of the price of the fuel, some measure of economic activity (such as Gross National Product or Real Disposable Personal Income) and, if appropriate, a measure of weather (heating and cooling degree days). In the case of gasoline demand and utility demand for coal stocks, measures such as auto stocks and utility capacity are used.

Data Sources:

- Bureau of Economic Analysis, U.S. Department of Commerce, National Income and Product Accounts of the United States

- Bureau of Labor Statistics, U.S. Department of Labor, Employment and Earnings

- Bureau of Economic Analysis, U.S. Department of Commerce, Survey of Current Business

- Board of Governors, U.S. Federal Reserve System, Industrial Production

- Energy Information Administration, U.S. Department of Energy, Monthly Energy Review

- Energy Information Administration, U.S. Department of Energy, Petroleum Supply Monthly

- National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Monthly State, Regional, and National Heating Degree Days Weighted by Population.

Output Data: See above.

Computing Environment: IBM 3033, FORTRAN.

Cost to Run: 18 CPU seconds for demands; 17 CPU seconds for prices

Official Model Representative: Mark Rodekohr (252-5209)

Status of Evaluation Efforts: None underway at this time.

Archive Tape Identification: CSTDSS. See Energy Information Administration, Short-Term Integrated Forecasting System Demand Model Installation Manual, Washington, D.C., July 1985.

Data Model Last Update: 3/1/85. The model is updated once a quarter.

APPENDIX B. OTHER PETROLEUM PRODUCT DATA DEVELOPMENT

Seasonal Factors for Other Petroleum Products

The dependent variable in each of the other petroleum production equations, with the exception of petrochemical feedstocks and petroleum coke, is deseasonalized prior to estimation. Seasonality is introduced into the forecast using the seasonal factors shown in Table B.1. These factors were estimated using the Bureau of Census--X11 multiplicative procedure in SPEAKEZ. The factors corresponding to the most recent 12 months of observations are used for forecasting based on the assumption that the seasonal patterns remain the same over the forecast period.

Table B.1. Seasonal Factors for Forecasting Demand for "Other Products," April 1985 Outlook

	Seasonal Factors					
Month	LPG	Jet Fuel	Kerosene	Road Oil and Asphalt	Still Gas	Miscellaneous
January	1.41	1.09	1.55	0.36	0.96	0.95
February	1.18	1.02	1.26	0.41	0.95	1.04
March	1.01	0.98	0.95	0.54	0.94	1.01
April	0.84	0.99	0.89	0.72	0.97	1.01
May	0.81	0.94	0.77	1.05	1.00	0.92
June	0.79	0.99	0.67	1.45	1.07	1.01
July	0.83	1.01	0.72	1.52	1.06	0.96
August	0.83	1.00	0.67	1.70	1.05	1.01
September	0.98	1.02	0.86	1.52	1.05	1.08
October	1.04	0.95	0.98	1.34	0.97	1.04
November	1.12	0.95	1.18	0.86	1.00	1.03
December	1.15	1.06	1.51	0.52	0.99	0.95

APPENDIX C. NUCLEAR POWERED GENERATION GROWTH BY REGION AND EFFECTS ON FORECASTS OF COAL

This appendix describes some analysis performed in order to detect regional implications of nuclear generation growth on coal-fired generation and non-nuclear electricity fuel shares in general. The following tables indicate the (estimated) regional decomposition of nuclear-powered generation based on a preliminary nuclear forecast for the January 1985 Short-Term Energy Outlook (Outlook). An update of the analysis in this section using the April 1985 Outlook forecast for nuclear generation was not performed because the forecasts were very similar.

Table C.1. shows that, for the forecast period, increases in nuclear power generation will be concentrated somewhat less in major coal-burning regions, compared to the growth observed between 1980 and 1984.

Table C.1. Selected Characteristics of Major Utility Coal-Burning Regions (Over 53 Percent Coal Share) Compared to Other Regions

	Distribution of Nuclear-Powered Generation Growth		Percent of U.S. Total Coal-Fired Generation	
	1984-1986	1980-1984	1984	1980
Major Coal-Burning Regions	41.4	67.2	78.9	82.2
Other Regions	58.6	32.8	21.1	17.8
Total	100.0	100.0	100.0	100.0

Major Coal-Burning Regions: North Central, South Atlantic, East South Central, Mountain.

Note: 1984 data estimated.

However, from Tables C.2. and C.3., this result is seen to be largely brought about by the sharp dropoff in nuclear growth in the southeast, particularly in the South Atlantic region. In the forecast period, the North Central region and the West South Central regions will experience an acceleration in nuclear growth that will likely affect the coal share in those regions.

In STIFS, the forecast of oil- and gas-fired electricity generation combined is a residual after coal, nuclear, and hydroelectric generation are determined. Since nuclear and hydroelectricity are then predetermined, the starting place for improving the electricity fuel shares would be a modification of the coal model. Assuming that the substitution pattern for hydroelectricity will remain the same as in the past, it seems reasonable to concentrate on the way nuclear generation enters the coal-fired generation model. Previously, coal-fired generation was modeled as:

$$XGCLEL = a(M_i) + b*XGEL + c*XGEL*CAP + d*XGNUEL + e*XGHYEL + u \qquad (C.1)$$

where:

XGCLEL = coal-fired generation, in billion kilowatthours (BkWh)
XGEL = total generation (BkWh)
XGNUEL = nuclear generation (BkWh)
XGHYEL = hydroelectric generation (BkWh)
Cap = coal-fired capacity (BkWh)
M_i = index for month, i=1, ..., 12
a,b,c,d,e are parameters; u is a random disturbance.

Equation (C.1) is estimated on a national aggregate basis, so that regional distinctions are not made. However, it is possible to construct new variables that will allow the derivatives of XGCLEL, with respect to XGNUEL, to vary when nuclear growth is in low coal-using areas as opposed to high coal-using areas. High coal regions were defined as those regions in which coal-based generation as a percent of total generation was more than 53 percent on average for 1980 and 1984, which was the average percent for the entire United States for 1980 and 1984. (See Table C.4.)

The new coal equation is:

$$XGCLEL = a'(M_i) + b'*XGEL + c'*XGEL*Cap + d_1'*XGNUEL*LNSHR + d_2'*XGNUEL*HNSHR + e'*XGHYEL \qquad (C.2)$$

where:

LNSHR = share of total nuclear generation in low coal-using areas
HNSHR = share of total nuclear generation in high coal-using areas. (High coal-using areas are defined as the East North Central, West North Central, South Atlantic, East South Central, and Mountain regions.)

The multiplicative nuclear terms in (C.2) are equal to the levels of nuclear generation in low and high coal-using areas, but are written out in the way shown to illustrate that the effect of the two nuclear variables is to allow for a variable XGNUEL slope as the geographical distribution of nuclear generation changes. The expectation is that both d_1' and d_2' in (C.2) will have negative signs, and that d_2' will be greater in absolute value than d_1'.

Table C.2. Nuclear Generation by Census Region

	Projections				History					
	1986		1985		1984e		1983		1980	
	BkWh	%	BkWh	%	BkWh	%	BkWh	%	BkWh	%
New England	24,645	5.8	22,279	6.0	22,802	6.9	26,251	8.9	22,450	8.9
Mid Atlantic	69,259	16.4	62,944	16.9	50,571	15.4	37,422	12.7	38,944	15.5
East North Central	77,498	18.3	68,380	18.4	60,174	18.3	58,607	20.0	55,663	22.2
West North Central	26,681	6.3	23,976	6.4	18,315	5.6	20,143	6.9	18,373	7.3
South Atlantic	113,427	26.8	105,190	28.3	105,278	32.0	90,872	30.9	70,765	28.2
East South Central	41,847	9.9	38,287	10.3	37,940	11.5	39,195	13.3	24,016	9.6
West South Central	19,874	4.7	12,032	3.2	11,853	3.6	7,646	2.6	7,883	3.1
Mountain	1,006	0.2	1,001	0.3	85	0.0	748	0.3	667	0.3
Pacific Contiguous	48,254	11.4	38,082	10.2	22,023	6.7	12,792	4.4	12,356	4.9
Pacific Noncontiguous	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	422,491	100.0	372,171	100.0	329,041	100.0	293,677	100.0	251,116*	

e = estimated.
BkWh = Billion kilowatthours.
*Note: This column does not add.
Source: History - Electric Power Monthly; Projection - Energy Information Administration.

Table C.3. Distribution of Nuclear-Powered Generation Growth by Census Region
(Percent Change over Period)

Region	1984-1986	1980-1984
New England	2.0	0.5
Mid Atlantic	20.0	14.9
East North Central	18.5	5.8
West North Central	9.0	0.0
South Atlantic	8.7	44.3
East South Central	4.2	17.9
West South Central	8.6	5.1
Mountain	1.0	-0.7
Pacific Contiguous	28.1	12.4
Pacific Noncontiguous	0.0	0.0
Total (percent)	100.0	100.0

Note: 1984 data estimated.
Source: History - Electric Power Monthly; Projections - Energy Information Administration.

Table C.4. Coal Share of Electricity Generation by Census Region, 1984 and 1980

Region	Percent of U.S. Total Coal-Fired Generation		Coal Share of Total Regional Generation	
	1984	1980	1984	1980
New England	1.0	0.4	17.2	5.8
Mid Atlantic	9.1	10.3	45.3	45.9
East North Central	24.9	27.4	82.9	80.3
West North Central	11.0	10.8	81.1	74.4
South Atlantic	21.4	21.5	62.4	59.7
East South Central	11.4	13.5	68.5	73.2
West South Central	10.5	6.4	40.9	23.9
Mountain	10.2	9.0	69.9	65.8
Pacific Contiguous	0.4	0.7	2.2	2.9
Pacific Noncontiguous	0.0	0.0	3.2	3.1
Total (percent)	100.0	100.0	55.0	50.8

Note: 1984 data estimated.
Source: History - Electric Power Monthly; Projections - Energy Information Administration.

Model Tests

Test runs using the old coal model (equation (C.1)) and the new model (equation (C.2)) were performed, and the separate simulation results are reported in Table C.5. Regression results for the two models are presented in Table C.6.

Table C.5. Test Coal Forecasts With and Without Regional Decomposition of Nuclear Generation

	Total Generation	Hydro (Billion kWh)	Nuclear Generation HCU	Nuclear Generation LCU	Coal-Fired Generation With Regional	Coal-Fired Generation Without Regional
1984	2,429	325	220	108	1,348	1,347
1985	2,487	311	243	129	1,412	1,401
1986	2,537	298	267	155	1,453	1,436

[a]High coal-using areas.

[b]Low coal-using areas.

Table C.5. presents comparative forecasts for coal-fired generation for the period 1984-1986 using the two equations discussed above. Also shown are the values for total generation, hydroelectric generation, and nuclear generation by region that are assumed for the forecast.

Given that the statistical model used to incorporate regional nuclear effects is quite adequate compared to the old model (see Tables C.6.) and that the signs and relative magnitudes of the new coefficients are as expected, it seems evident from Table C.6. that the old model would have understated coal-fired generation for 1985 and 1986.

Table C.6. Alternative Coal-Fired Generation Model Specifications Involving Regional Nuclear Generation Data

	Model 1		Model 2	
RHS Variable	Parameter Estimate	t-Statistic	Parameter Estimate	t-Statistic
Intercept[a]	15.2165	--	-1.263	--
XGEL	0.1247	4.10	0.2326	16.17
CAP*XGEL	0.0024	28.83	0.0023	30.05
XGHYEL	-0.6252	-8.33	-0.5897	-8.16
XGNUEL	-0.6565	-7.19	--	--
NUHCU	--	--	-0.6053	-4.35
NULCU	--	--	-0.4828	-2.62
DS1	-8.7673	-8.60	-9.6218	-8.82
DS2	-4.5889	-4.60	-4.6261	-4.13
01	-3.7859	-2.98	-5.4191	-4.16
Durbin-Watson	1.69		1.72	
Adjusted R-Square	0.99		0.98	
Standard Error	1.62		1.79	

[a]Average value for 12 months.

Notes: XGEL = total generation; CAP = coal-based generating capacity; XGHYEL = hydroelectric generation; XGNUEL = nuclear generation; NUHCU = XGNUEL for high coal-using areas; NULCU = XGNUEL for low coal-using areas; DS1, DS2 = strike dummies; 01 = dummy for outlier.

Model 1 = October 1984 Short-Term Energy Outlook model; Model 2 = Equation (C.2) model.

APPENDIX D. COAL EXPORT ELASTICITIES (EXCERPTED FROM MEMORANDUM TO THE RECORD FOR EI-621 DATED SEPTEMBER 24, 1984)

For the August 1984 Outlook, some use was made of cross-section time-series data on U.S. coal exports (drawn from the commodity exports file maintained under account # CN6524 and from IMF data on exchange rates and growth rates) to get estimated price elasticities for coal exports by rank and region. The estimation period (using quarterly data) was from 1980 through 1983. The unique pattern of quarterly coal exports to Canada (very sharp dropoff in the first quarter) led to the separate estimation of the Canadian numbers from the other countries (five in all) considered in the analysis.

The coal export analysis centered on bituminous steam coal exports and bituminous met coal exports, which, combined, make up virtually all exports of coal. The estimated price elasticities were combined with some reasonable, if not overly conservative, assumptions concerning growth in foreign steel demand and changes in world oil prices.

For the Canadian regressions, no significant price elasticities were obtained, generally because of the fact that seasonal changes tend to dominate the observed variance. The other five countries reviewed (West Germany, France, Italy, United Kingdom, and Japan) were pooled for the remaining regressions. The results of these regressions are reported in Table D.1.

Table D.1. Coal Export Regressions
(Interval: 80Q1-83Q4 Quarterly)

	Steam Coal				Met Coal			
	Canada		Other		Canada		Other	
RHS Variables	Est.	't'	Est.	't'	Est.	't'	Est.	't'
Intercept	-3.531	-1.03	-0.525	-1.42	0.272	0.26	0.414	1.39
DQ2	3.796	2.67	0.161	1.74	2.111	3.38	-0.117	-0.53
DQ3	3.731	6.33	-0.025	-0.27	1.880	4.39	0.027	0.12
DQ4	3.880	6.93	0.066	0.69	1.791	4.22	0.154	0.70
HPR	0.704	0,82	-0.080	-1.51	-0.154	-0.48	-0.109	-1.10
OPR	0.066	0.91	0.022	2.03	--		--	
Lag	0.120	0.37	0.476	4.65	--		0.513	4.98
DWG	--		-0.092	-0.76	--		-0.102	-0.41
DIT	--		0.300	2.35	--		0.380	1.40
DFR	--		0.246	2.12	--		0.671	2.38
DJP	--		0.224	1.71	--		2.196	4.00
Adjusted R-Squared	0.834		0.509		0.735		0.878	
Standard Error	0.731		0.293		0.460		0.682	
Dep. Var.	Not used		0.393		Not used		1.266	
HPR	"		1.801		"		2.192	
OPR	"		34.926		"		--	
Estimated Elasticities								
HPR	Not used		-0.700		Not used		-0.388	
OPR	"		3.731		"		--	

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