FORECAST APPENDIX
NEW YORK STATE ENERGY PLAN - **JUNE 2002**

ALL FUELS DEMAND AND PRICE FORECAST METHODOLOGY

INTRODUCTION

Twenty-year forecasts of energy demand and prices for electricity, natural gas, petroleum, and coal were developed for the State Energy Plan. The base year for forecasting is 2000. Forecasts include: (1) an Outlook Case, (2) a High Economic Growth Case, and (3) a Low Economic Growth Case, for a total of three forecast scenarios.

The Energy Plan forecasts are consistent with and derived from forecasts published in the *Annual Energy Outlook (AEO) 2002* by the U.S. Department of Energy (DOE) Energy Information Administration (EIA). The Middle Atlantic *AEO 2002* forecast, which includes the states of New York, Pennsylvania, and New Jersey, serves as the basis for the Energy Plan forecasts. Electricity demand projections were derived in part from the *AEO 2002* electricity forecast developed specifically for the New York Control Area (NYCA). This forecast was adjusted to reflect energy efficiency and demand reductions in New York not factored into the AEO forecast. This adjusted forecast was input to the NYCA Market Assessment and Portfolio Strategies (MAPS) electricity market model, which then calculated the specific primary fossil fuel use required to meet electricity demand. Fossil fuel use projected from the MAPS model was added to the AEO 2002-based forecasts of other sector fossil fuel use to derive total statewide fossil fuel demand.

FORECAST METHODOLOGY

New York projections were derived from the EIA Middle Atlantic Region all fuels demand and price forecasts and the NYCA Electricity Market Module demand and price forecasts. EIA produces regional forecasts under various economic and price scenarios. EIA uses the National Energy Modeling System (NEMS)[1] energy market projections of the *AEO 2002*.

---

[1] NEMS is a computer-based, energy-economy modeling system for U.S. energy markets, using an integrated modular approach to represent macroeconomic activity, international energy supply availability, and end-use consumption sectors. For each fuel and consuming sector, the model balances energy supply and demand while accounting for competition among various energy fuels and sources. NEMS projects the production, importation, conversion, consumption, and consumer prices of energy based on macroeconomic and financial factors, world energy markets, resource availability and costs, market behavior, cost and performance of technologies, and demographic assumptions.

The Energy Plan forecasts represent a reasonable range of possible future energy demand and prices as a basis for assessing energy markets and future market needs. Macroeconomic variables, used by EIA for its Outlook, High, and Low Economic Growth Cases, affect forecasts of future capital investment, productivity gains, and technology and market development, among other modeling parameters. Growth rates for key economic variables determine energy demand growth in both the EIA national and New York's forecasts. The primary growth rates for determining economic activity are provided in Table 1.

Table 1

Annual Average U.S. EIA Growth Rates (2000-2020) of Economic Variables			
	High Case	Outlook Case	Low Case
Productivity	2.4%	2.2%	1.9%
Labor Force	1.0%	0.8%	0.6%
GDP	3.4%	3.0%	2.4%
World Oil Price	0.4%	-0.5%	-2.3%

These economic variables are measured by EIA at a national level, but interact differently with regional variables in the ten census division (NEMS) economic modules. The High Economic Growth Case incorporates population, labor force, and productivity growth rates that are higher than the Outlook Case. Productivity gains result in lower inflation and interest rates. The Low Economic Growth Case assumes lower population, labor force, and productivity gains than the Outlook Case, with higher interest and inflation rates.[2]

Method Overview

The New York forecasts were derived from EIA's Middle Atlantic fuel demand and price forecasts, by determining the historic relationships between fuel demand and prices in New York and those in the Middle Atlantic region. New York's energy use as a percentage of Middle Atlantic energy use has remained fairly stable over the last four decades. Thirty-nine years (1960-1999) of New York fuel use, expressed as a percentage of the Middle Atlantic region's fuel use, defines the historic relationship between the two, by end-use sector. Only twenty nine years of Middle Atlantic State prices were available. Twenty nine years (1970-

---

[2] EIA Assumptions to the Annual Energy Outlook 2002, pg 58

1999) of New York fuel prices, expressed as a percentage of Middle Atlantic prices, by sector, define the historic relationship used to modify the Middle Atlantic forecasts. These demand and price relationships were projected into the future using linear regression and a univariate time series forecast. The forecasted percentages were then applied to the EIA Middle Atlantic regional forecasts to obtain 20-year New York forecasts. The 2000 New York forecasted data were then replaced with actual 2000 data reported in New York State Energy Research and Devlopment Authority's (NYSERDA) *Patterns and Trends 2000.*

SYSTAT® 9.0 for Windows® was used to generate year-to-year New York forecasts. Regression analysis and univariate time-series metholodgies were used. The regression analysis model produces a more dynamic forecasted ratio of New York to Middle Atlantic, but in the cases where the historical trend flucuates and history is determined to not be an accurate predictor of the future, the time-series model is used. The time-series model is preferred in this case because it weighs recent years more heavily than years past.

To predict New York as a percentage of the Middle Atlantic using regression analysis, the SYSTAT® program fits an equation into to a set of data in order to best describe the relationship between the variables. In this case, the relationship established between the ratio of New York data to Middle Atlantic for a given fuel and over a specified period of time, was linear. The relationship between New York and Middle Atlantic was fairly stable for most fuel prices and demands by sector. Test statistics revealed the historical ratio was a positive predictor of the future, and therefore acceptable.

The SYSTAT® program ran a time-series projection using an Autoregressive Integrated Moving Average (ARIMA) model[3] to determine New York's growth trend in relation to that of the Middle Atlantic region. The historical data series used to generate New York demand and price forecasts for electricity, natural gas, petroleum, and coal satisfied standard statistical tests, and were deemed to capture the relationship sufficiently between all of the New York energy demand and prices and those of the Middle Atlantic region.[4]

---

[3] ARIMA models use either past values (the autoregressive model), past errors (the moving average model), or combinations of past values and past errors to create an accurate projection. A Box-Jenkins univariate time series model is the specific ARIMA model used. The Box-Jenkins ARIMA modeling process occurs in three stages: Identification, Estimation, and Diagnosis.

[4] The autoregressive (AR) model addresses serial correlation of errors. For example, a residual from the model reveals an autocorrelation statistic of .953. Correlation coefficients can be squared to reveal the proportion of variance, or in this case, the variation in error terms. This means that over 89% of the variation in error from predicting New York's percentage of Middle Atlantic in one year can be accounted

Petroleum Demand Forecasts

The petroleum demand forecasts for New York are based on the historical relationships between New York's petroleum use and the EIA Middle Atlantic regional petroleum use for distillate, residual, propane, kerosene and motor gasoline. The demand forecasts include the following petroleum products by sector:

- Residential use of distillate, propane, and kerosene.
- Commercial use of distillate, residual oil, propane, and kerosene.
- Industrial use of distillate, residual oil, and propane.
- Transportation use of diesel, jet fuel, residual oil, propane, and motor gasoline.
- Electric Generation use of distillate and residual oil.
- Total distillate, residual oil, propane, kerosene, motor gasoline, jet fuel, and Statewide total petroleum demand.

As shown in Figure 1, a strong correlation exists between variations in historical New York petroleum demand and variations in historical Middle Atlantic regional demand, indicating that the Middle Atlantic petroleum demand forecast could serve as a predictor for future New York petroleum use. These historical relationships were measured for each of the end-use sectors. Figure 2 compares the results of demand predicted using the statistical method with the actual petroleum consumed in New York from 1960 to 1999.

---

for by the error in predicting the previous year's percentage. Where serial correlation was found in plotted residuals, the appropriate number of AR parameters were added to eliminate their influence on the forecast.
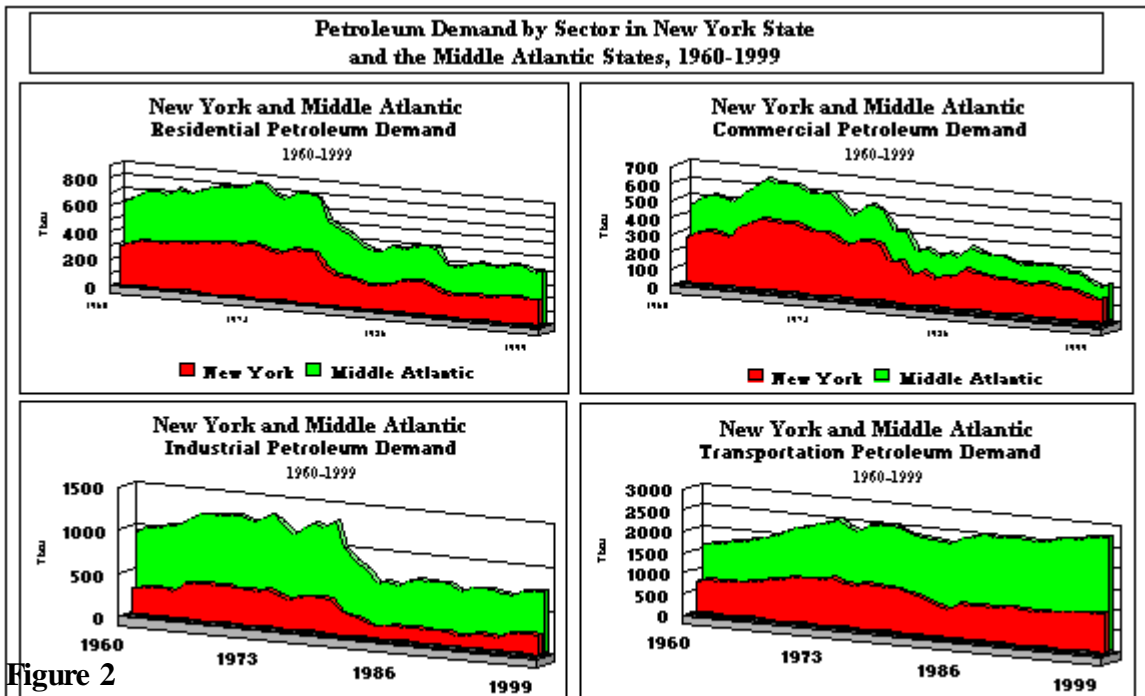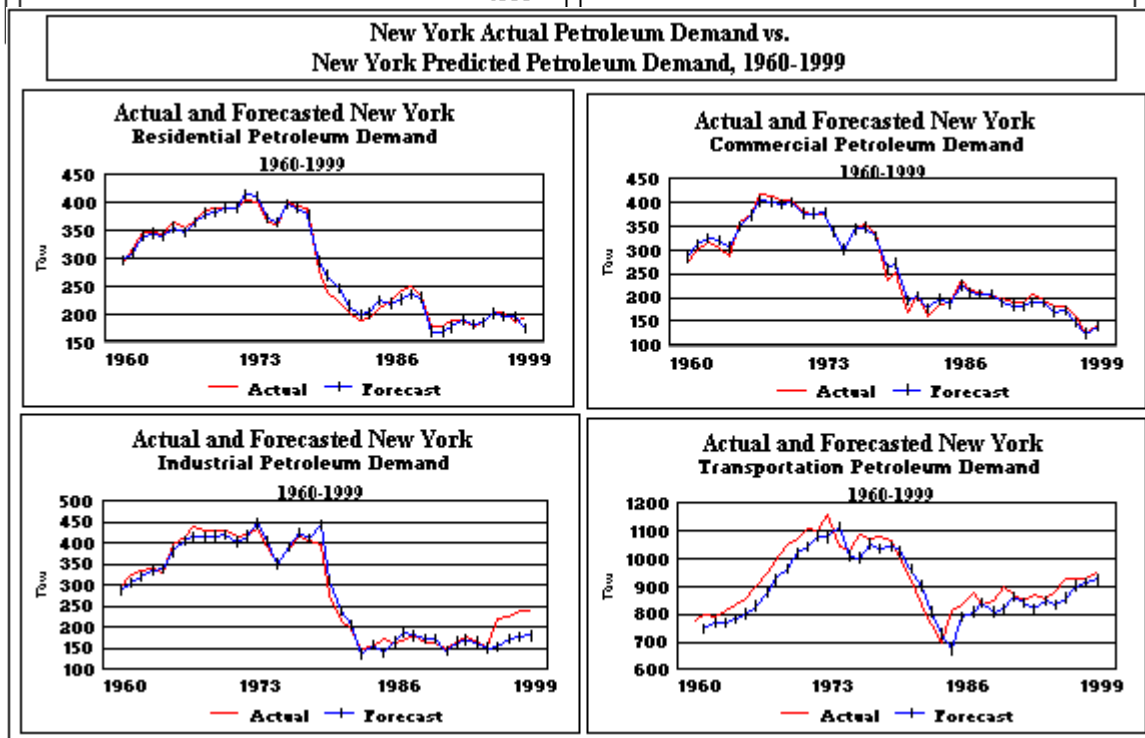
Figure 1

Petroleum Demand by Sector in New York State and the Middle Atlantic States, 1960-1999

Figure 2

New York Actual Petroleum Demand vs. New York Predicted Petroleum Demand, 1960-1999

Petroleum use in the electric generation sector came from the MAPS model, as did all fuel demand forecasts in the Electric Generation sector. Figure 3 presents the high, outlook, and low annual forecasted petroleum demand for New York. Tables for the high, outlook, and low forecasted annual petroleum demand and total growth rates are the presented at the end of this appendix.
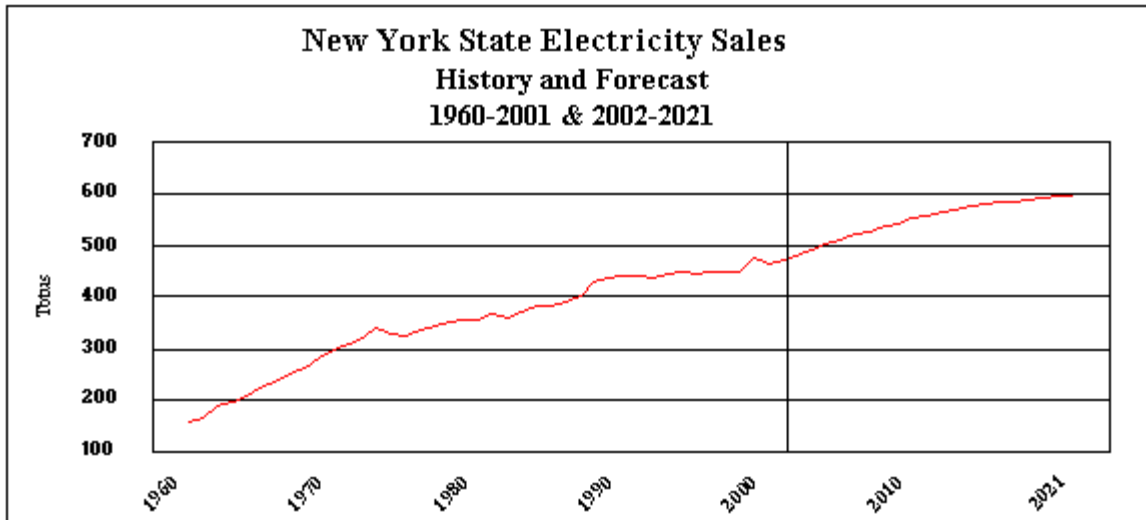
Figure 3
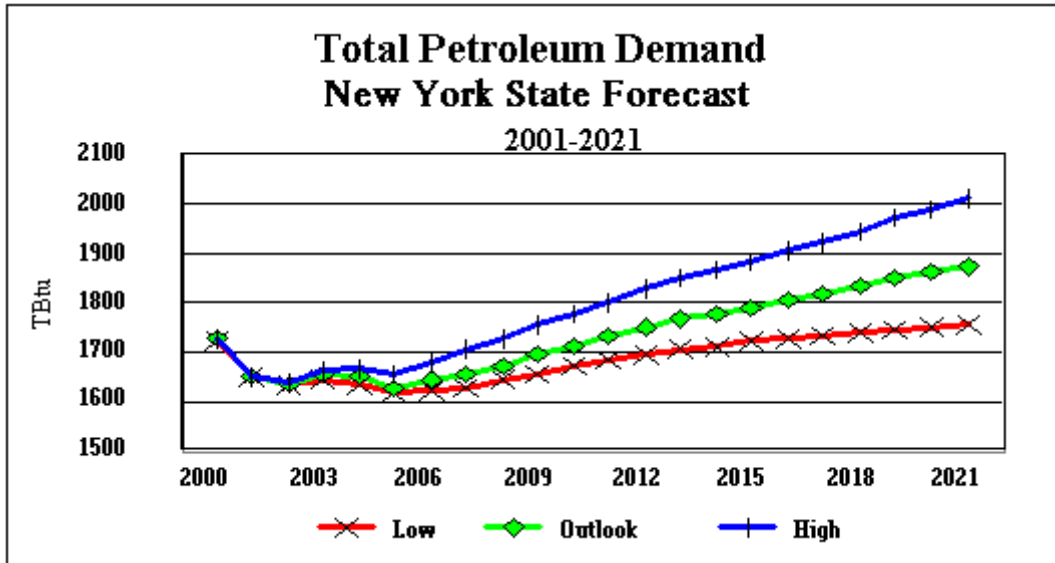
Electricity Demand Forecast

Electricity demand forecasts were derived from EIA's NEMS-based Electricity Market Module (EMM) forecast of the New York Control Area (NYCA), published in the *AEO 2002*. The Electricity Market Module comprises four sub-modules: electricity capacity planning; electricity fuel dispatching; load and demand-side management; and electricity finance and pricing. It includes non-utility capacity and generation, electricity transmission, and trade.[5] Year 2000 and 2001 weather-normalized, actual data supplant the quantity forecasted for those years, leaving future electricity forecasted quantities unaffected. It is estimated that demand side management and energy efficiency programs, firm and temporary, reduced electricity demand by as much as 1,583 MW in Summer 2001. The entire amount of load relief is not reported in this electricity forecast. Only permanent load reductions have been considered.

---

[5] The purpose of the electricity market module is to determine the lowest cost way to supply electricity, within environmental and operational constraints. New York is a self-contained supply region within the model. Twenty-nine capacity types are represented. Cost and performance characteristics of new electricity generating technologies change according to the assigned technological learning parameters. These parameters vary with economic growth. Distributed generation technology takes the form of peaking capacity and base-load capacity.

The electricity requirements and demand forecasts were developed with data taken from EIA's *State Energy Data Report 1999*, NYSERDA's *Patterns and Trends 2000*, and the New York Control Area forecast from Table 64 in the *AEO 2002*. Figure 4 shows historical electricity sales in New York, from 1960 through 2001, graphed with the electricity sales forecast for the years 2002-2021.

Figure 4

EIA's NYCA electricity sales forecasts were consistent with the historical data trend. Figure 5 shows both New York's electricity requirements and peak demand forecast, for the period 2000-2021. Sector-specific electricity forecast tables are presented at the end of this appendix.

Figure 5
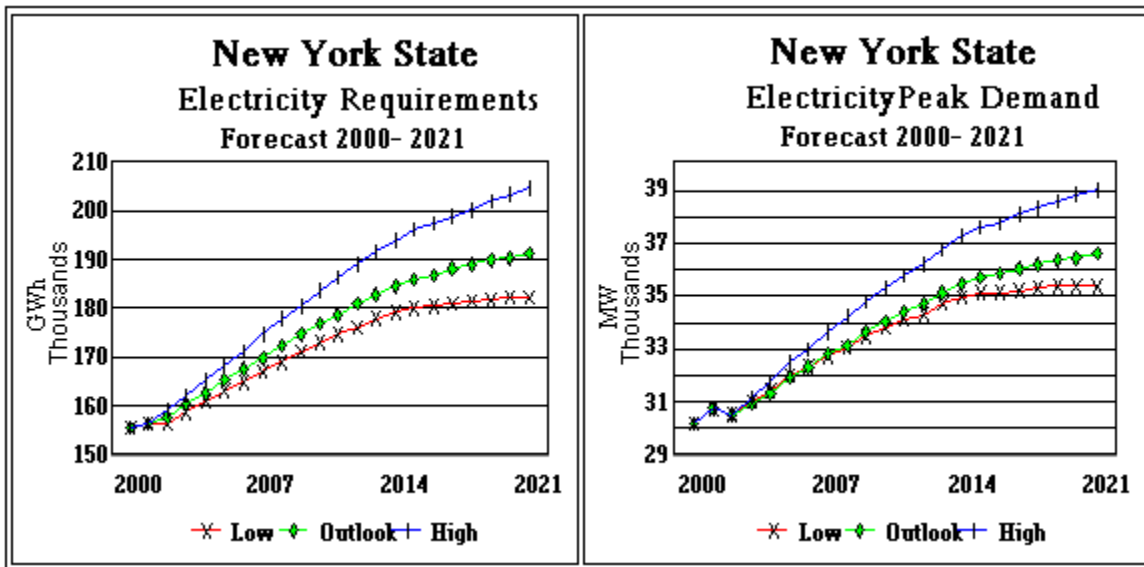
Natural Gas Demand Forecasts

The natural gas demand forecasts were developed in a manner similar to that used to develop the petroleum forecasts. Variations in historical natural gas demand remained consistent between New York and the Middle Atlantic regional fuel sectors. Therefore, statistically valid forecasts of New York natural gas demand could be constructed using EIA's NEMS-based Middle Atlantic region forecasts, published in the *AEO 2002*. Fuel demand in the Electric Generation sector was created using the MAPS program in conjunction with EIA-based electricity requirements and peak demand forecasts. New York and Middle Atlantic region natural gas use data from 1960 to 1999**,** EIA'S *State Energy Data Report 1999*, are shown in Figure 6 for the residential, commercial, and industrial sectors.

Figure 6
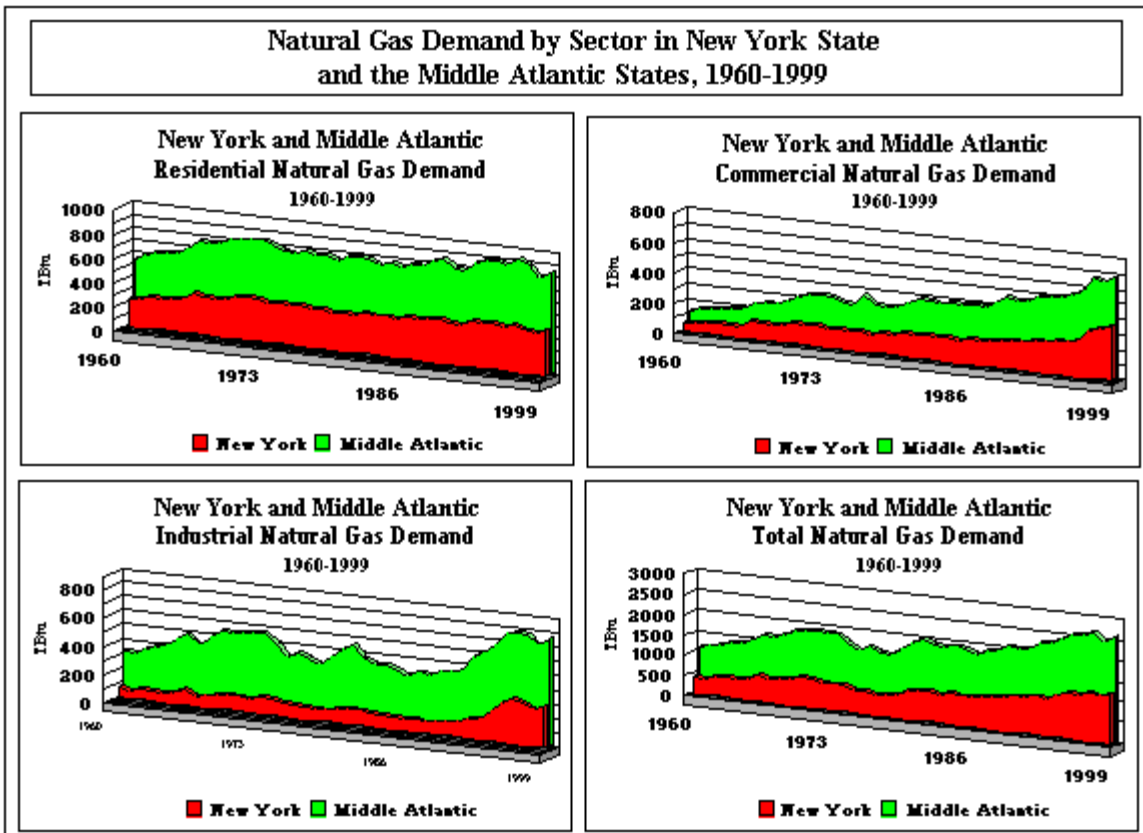
Regression analysis and time series models were developed to formulate the relationship of natural gas demand in New York to that of the Middle Atlantic region. New York natural gas forecasts were created by applying the resulting coefficients to corresponding EIA NEMS-based *AEO 2002* Middle Atlantic forecasts. This method was proven to be acceptable by statistical standards. Applying the forecast equation coefficients to the Middle

Atlantic historical aggregate yielded an approximation of New York historical data. Graphs of predicted and actual historical natural gas use in New York from 1960 to 1999 are shown in Figure 7.

Figure 7

New York Actual Natural Gas Demand vs. New York Predicted Natural Gas Demand, 1960-1999
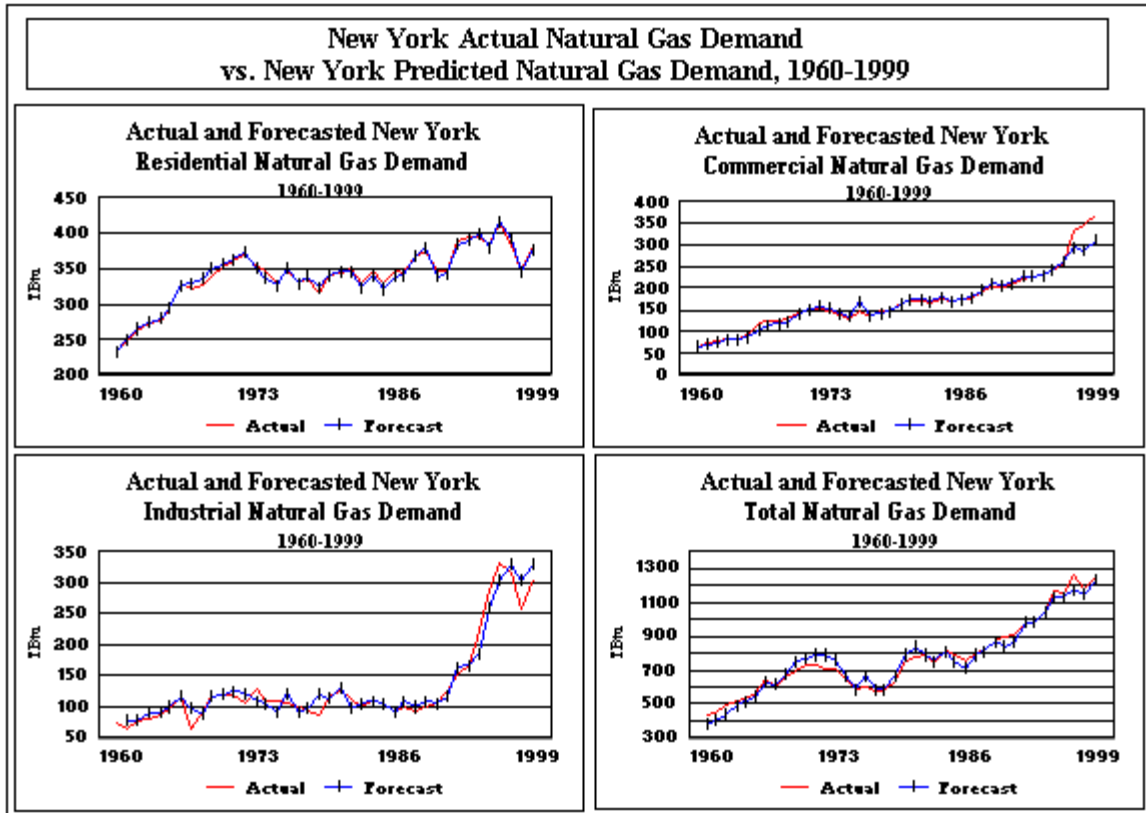
Figure 7 shows that, historically, variations in New York natural gas demand change consistently with variations in Middle Atlantic natural gas demand. The historical New York natural gas demand forecast maintained that consistency throughout the planning period. Statistical analysis yielded acceptable results as well. The sector coefficients were applied to EIA's NEMS-based Middle Atlantic regional natural gas demand forecasts, by sector. The New York natural gas demand forecasts are the result of this process. Figure 8 presents the high, outlook, and low annual forecasted natural gas demand for New York. Sector-specific natural gas forecast tables are presented at the end of this appendix.

Figure 8

Total Natural Gas Demand
New York State Forecast
2001-2021

Legend: —✕— Low   —◆— Outlook   —+— High
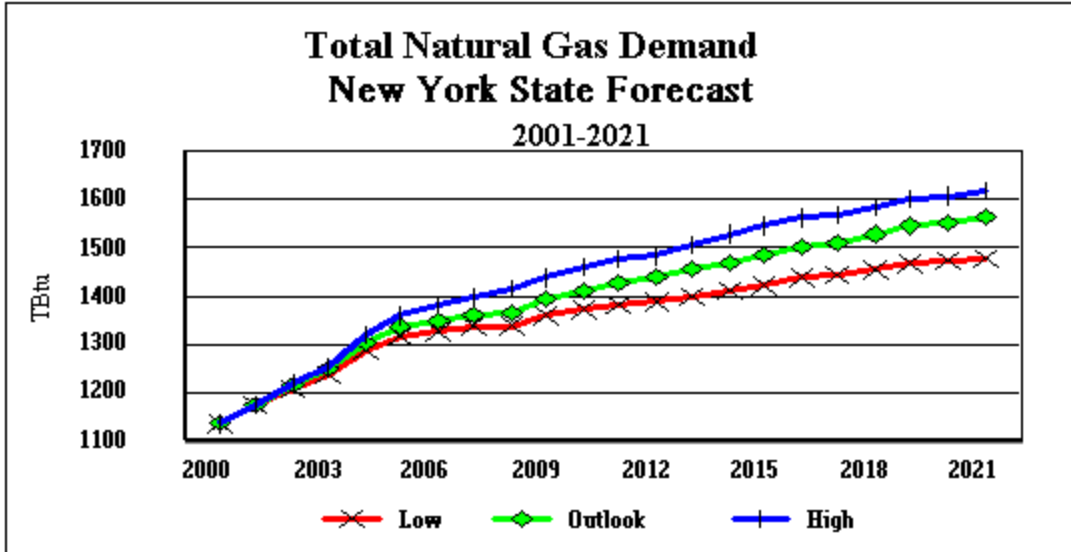
Coal Demand Forecast

The coal demand forecasts were developed in the same way as the petroleum and natural gas demand forecasts. The process began with an analysis of historical data. The historical Middle Atlantic regional coal demand sector aggregate from 1960 to 1999, was taken from EIA's *State Energy Data Report 1999*. That data is graphed with New York historical coal demand in Figure 9. Electric Generation demand is a result of the MAPS program and the *AEO 2002* modified NYCA electricity requirements and peak demand forecasts. New York's coal demand represents only a small portion of the total Middle Atlantic regional demand.

Variations in regional coal use for Middle Atlantic over the historical period, 1960 to 1999, were closely correlated with variations in New York coal use over the same period. It was determined that the relationship between historical New York and Middle Atlantic served as a good predictor of the future relationship between New York and Middle Atlantic regional demand. Therefore, statistically valid forecasts of New York coal demand could be constructed from EIA's Middle Atlantic regional forecasts. Time series and regression analysis models were used to model the relationship of New York to the Middle Atlantic region. Coefficients were developed for each sector and applied to the corresponding historical EIA Middle Atlantic coal demand aggregate. A historical New York coal demand forecast, high, outlook, and low was created and compared to actual historical coal use data. The 1960 to 1999 comparison is shown in Figure 10.
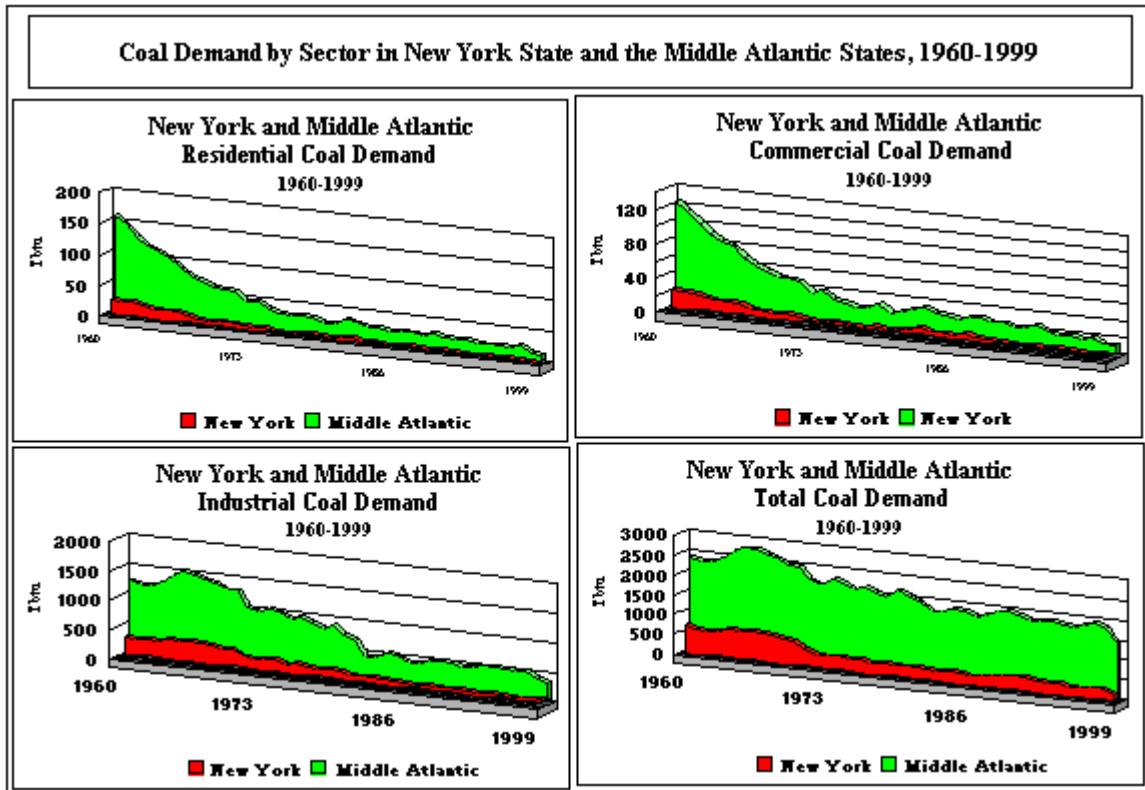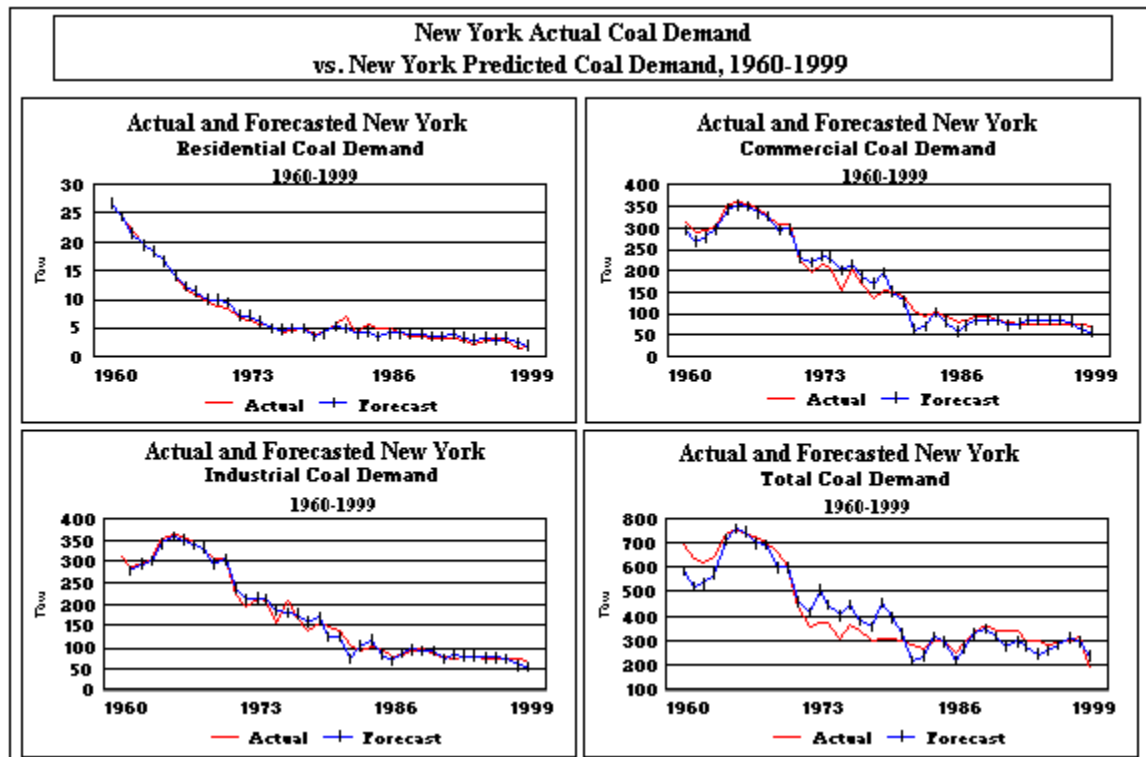
Figure 9

Coal Demand by Sector in New York State and the Middle Atlantic States, 1960-1999

Figure 10

New York Actual Coal Demand
vs. New York Predicted Coal Demand, 1960-1999

The high and low macroeconomic cases were also based on high, outlook, and low national economic forecasts developed by EIA and published in the *AEO 2002*. Coal forecasts include demand for anthracite and bituminous coal products. Figure 11 presents the high, outlook, and low annual forecasted coal demand in New York. The annual forecast is presented in the tables at the end of this appendix.

Figure 11
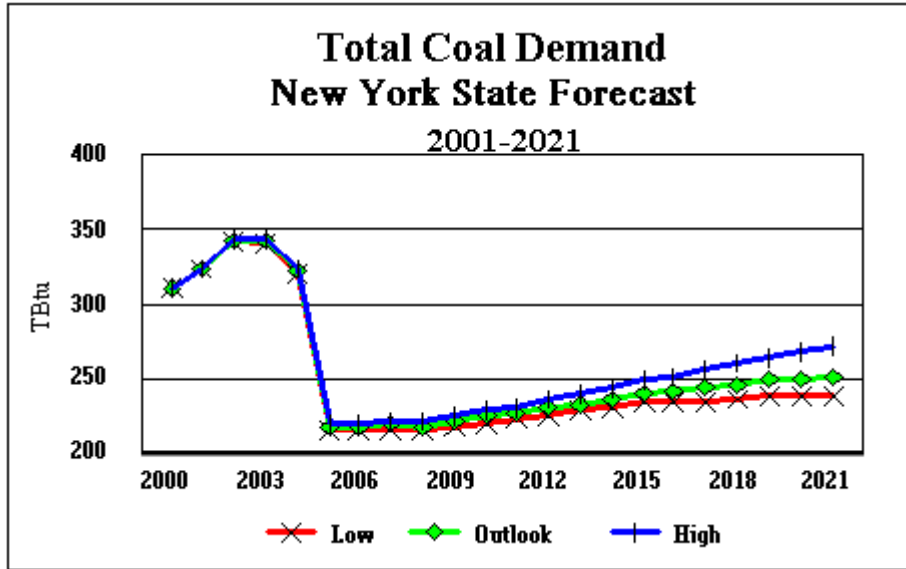
Price Forecast Method Overview

To determine the fuel price forecasts for New York, the historical relationships between New York prices and the Middle Atlantic region prices were analyzed. Regression analysis and time series forecasting methodologies were used. Historical New York price data for residential, commercial, industrial, and transportation fuels came from NYSERDA's *Patterns and Trends 2000*. The Middle Atlantic regional prices were taken from EIA'S *State Energy Price and Expenditure Report 1999*, which provides fuel price and expenditures by sector through 1999.

For each of the fuel prices forecasted, the sum of nominal fuel expenditures in New York, New Jersey, and Pennsylvania was divided by total fuel demand in the three states to obtain a regional fuel price in dollars per million Btu. Changes in nominal New York prices have closely matched changes in nominal Middle Atlantic regional prices over the 1970 to 1999 period.

The coefficients of the time series equations express the historical relationships between New York and Middle Atlantic prices. These coefficients were applied to EIA'S NEMS-

based forecasts of Middle Atlantic regional prices to obtain the New York price projections. Final forecasts were expressed in year 2000 dollars per million Btu. The high and low New York fuel price forecasts are based on high, outlook, and low economic growth scenarios taken directly from the *AEO 2002* national price forecast.

Petroleum Prices

Price forecasts were developed for the following petroleum products and sectors:

- Residential distillate, propane, and average petroleum products
- Commercial distillate, residual oil, and average petroleum products
- Industrial distillate, residual oil, propane, and average petroleum products
- Transportation gasoline, diesel jet fuel, residual oil, propane, and average petroleum products
- Electric generation distillate, residual oil, and average petroleum products
- Statewide distillate, residual oil, propane, and average petroleum products

Figure 12 demonstrates how closely-matched New York and Middle Atlantic prices have been over the 1970-1999 period. Clearly, forecasting New York prices as a percentage of Middle Atlantic prices, based on 20 years of data, results in a reasonable forecast, as shown in Figure 13. The specific ratios of historical New York price data to historical Middle Atlantic average prices by fuel and sector, were selected using linear regression and time series forecasting methodologies.
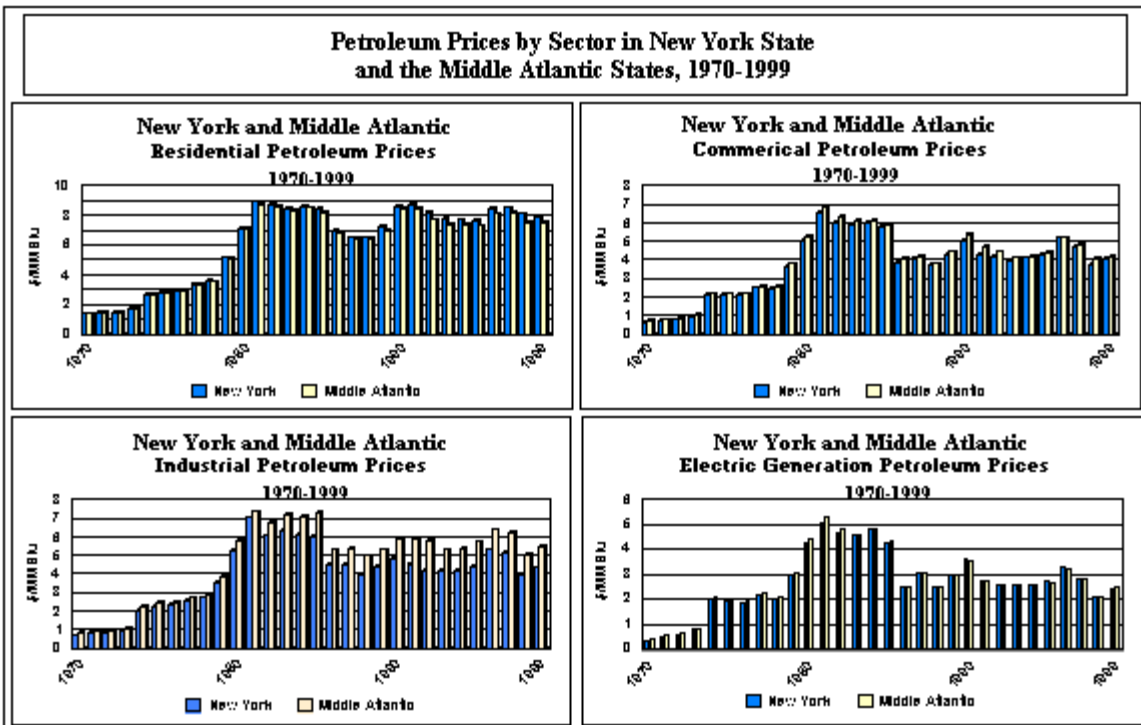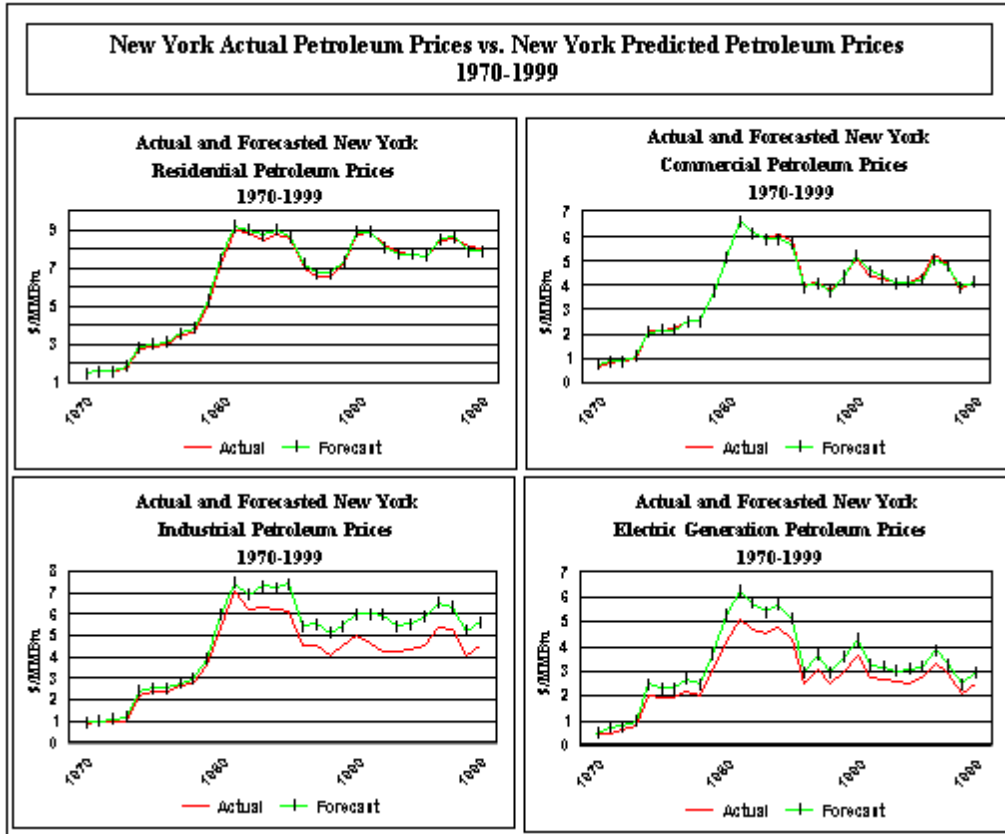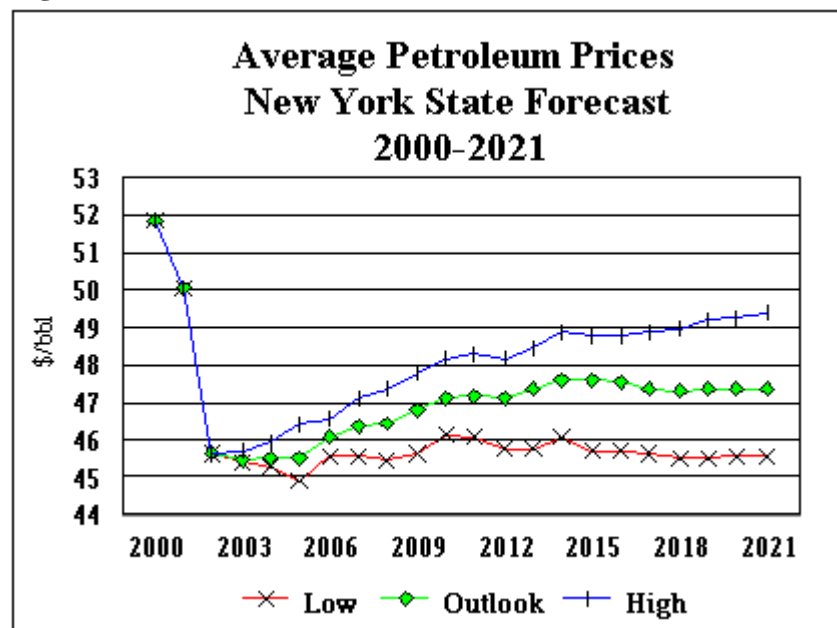
Figure 12

13

Figure 13

New York Actual Petroleum Prices vs. New York Predicted Petroleum Prices 1970-1999

Actual and Forecasted New York Residential Petroleum Prices 1970-1999
— Actual + Forecast

Actual and Forecasted New York Commercial Petroleum Prices 1970-1999
— Actual + Forecast

Actual and Forecasted New York Industrial Petroleum Prices 1970-1999
— Actual + Forecast

Actual and Forecasted New York Electric Generation Petroleum Prices 1970-1999
— Actual + Forecast

Time series forecasts weigh recent years more heavily than years of the distant past. Accuracy may be greater in the forecast than in a historical re-creation if the relationship between New York and Middle Atlantic prices, by fuel and sector, changed significantly over time. The high and low forecasts were created using EIA's NEMS-based high, outlook, and low national petroleum price forecasts. Figure 14 shows the resulting high, outlook, and low total petroleum price forecasts for New York. Forecasted petroleum

Figure 14

Average Petroleum Prices New York State Forecast 2000-2021
—✕— Low —◆— Outlook —+— High

14

retail prices are presented by sector in the forecast tables at the end of this appendix.

Electricity Prices

Retail electricity prices are a product of the NEMS Electricity Market Module (EMM). The EMM models a national electrical landscape, incorporating the effects of trading and borders on regional prices. New York sector electricity prices were taken directly from the NYCA forecast, published in Table 64 of the *AEO 2002*. These forecasts predict the long-term trend of average electricity prices. It is not a function of the EMM to predict price spikes. Price volatility is precipitated by resource scarcity, and artificial scarcity created by transmission constraints. Fuel supply, generation availability, and electricity transmission were analyzed in depth in other fuel assessments published in the 2002 State

Figure 15
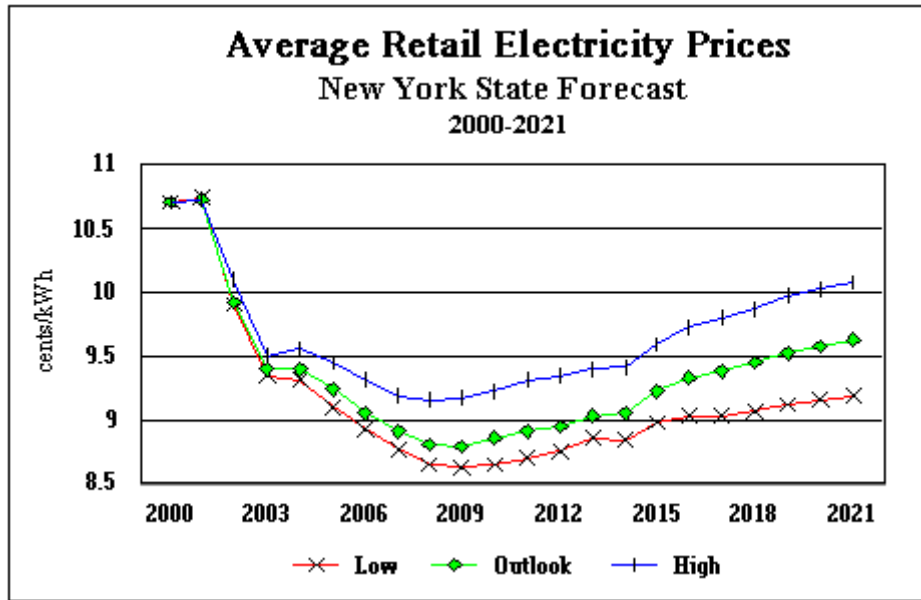
Energy Plan. Figure 15 shows a drop in prices over the long-term for all levels of economic growth. Forecasted electricity retail prices are listed by sector in the forecast tables at the end of this appendix.

Natural Gas Prices

Natural Gas price forecasts were derived from EIA *AEO 2002* Middle Atlantic forecasts. The same linear regression and time series forecasting techniques used to create petroleum price forecasts were utilized. Figure 16 demonstrates the similarity of New York and Middle Atlantic price variations.

Figure 16

Natural Gas Prices by Sector in New York State and the Middle Atlantic States, 1970-1999
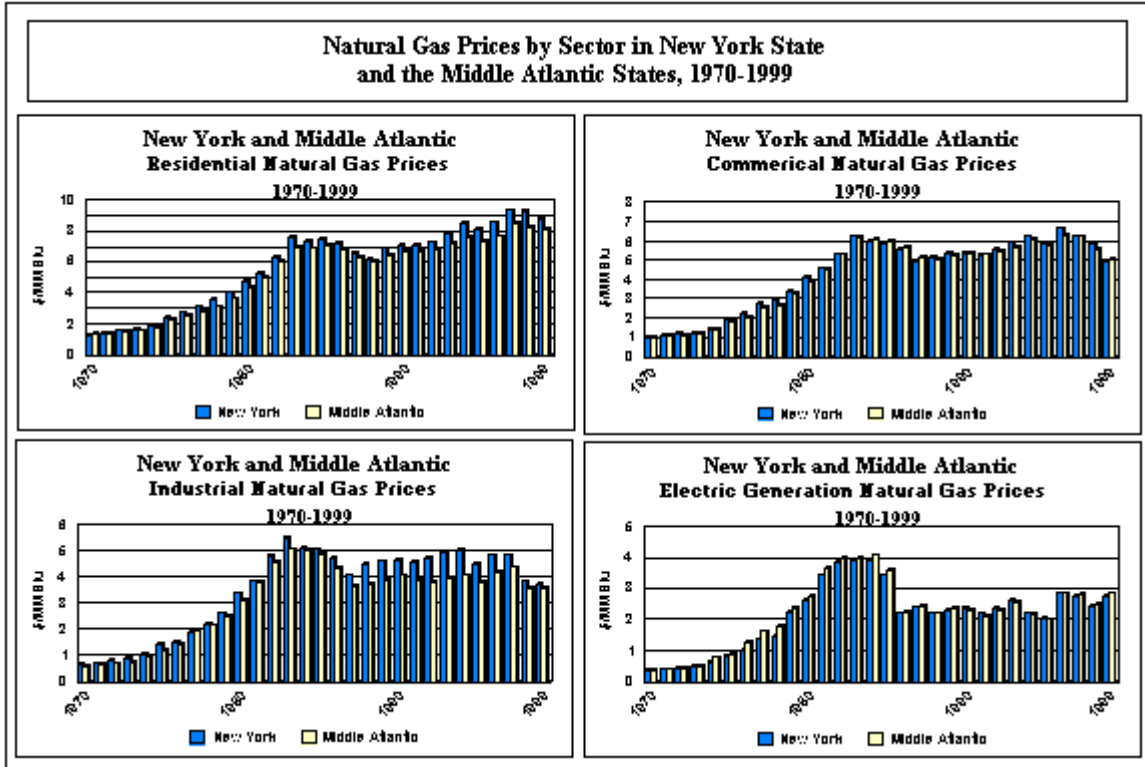
The coefficients derived from the statistical analysis were applied to historical Middle Atlantic average prices, compiled from the *State Energy Data Report 1999*. The historical New York price forecast is graphed with the actual data to illustrate the accuracy of the forecasting formula. The historical New York natural gas price forecast is presented by sector in Figure 17.

The formulas used to re-create historical New York prices from Middle Atlantic average prices were deemed acceptable by statistical standards. Consequently, they were applied to EIA's NEMS-based Middle Atlantic natural gas price forecasts published in *AEO 2002*. The high and low bandwidths were also derived using EIA's NEMS-based *AEO 2002* high, outlook, and low national natural gas price forecasts, by sector. The New York natural gas forecasts are graphed in Figure 18. Annual sector-specific price forecasts are presented in the tables at the end of this appendix.
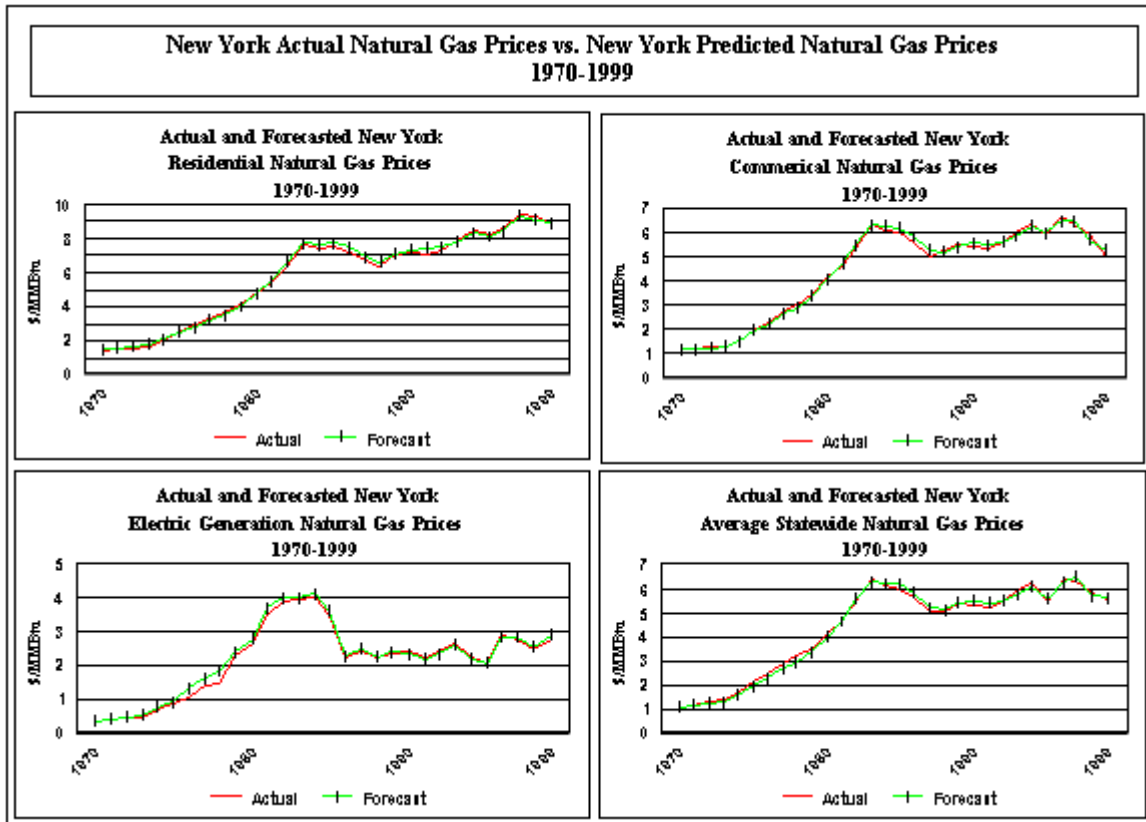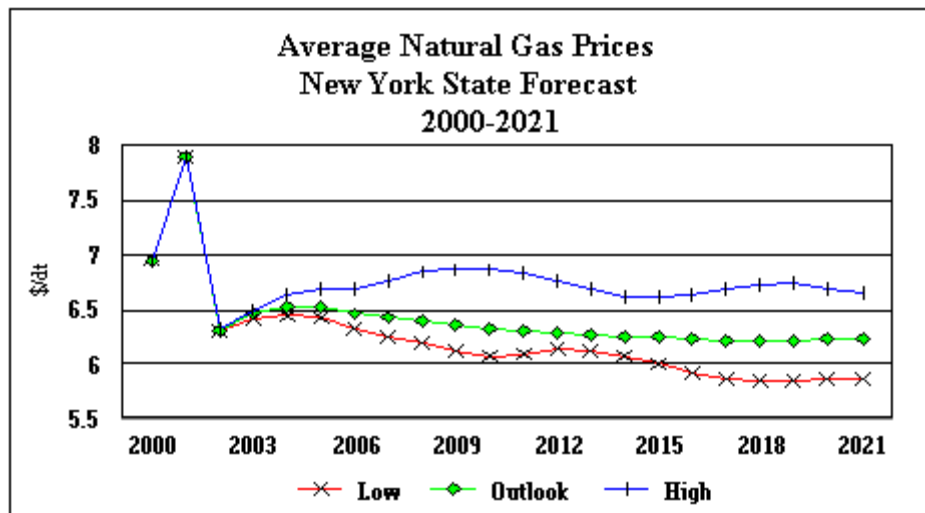
Figure 17

New York Actual Natural Gas Prices vs. New York Predicted Natural Gas Prices
1970-1999

Actual and Forecasted New York
Residential Natural Gas Prices
1970-1999

Actual and Forecasted New York
Commercial Natural Gas Prices
1970-1999

Actual and Forecasted New York
Electric Generation Natural Gas Prices
1970-1999

Actual and Forecasted New York
Average Statewide Natural Gas Prices
1970-1999

Figure 18

Average Natural Gas Prices
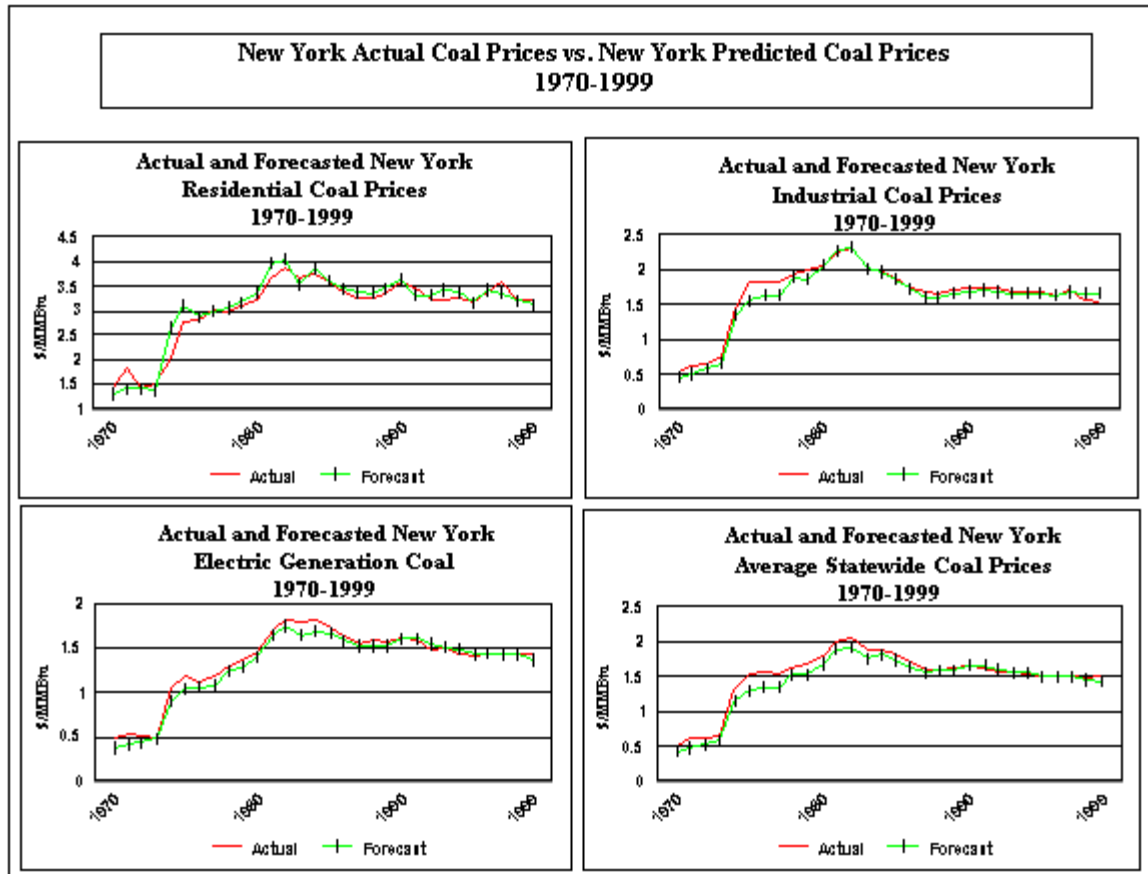New York State Forecast
2000-2021

Coal prices

Coal prices were derived from EIA's NEMS-based, *AEO 2002* Middle Atlantic forecasts in the same manner as petroleum and natural gas price forecasts. Historically, fluctuations in New York sector coal prices have tracked the changes in corresponding Middle Atlantic sector coal prices in both direction and magnitude. New York is a small portion of total Middle Atlantic coal use, and as a result, forecasted coal prices are higher in New York. Figure 19 illustrates the similarity between New York and Middle Atlantic coal prices by sector.

Figure 19
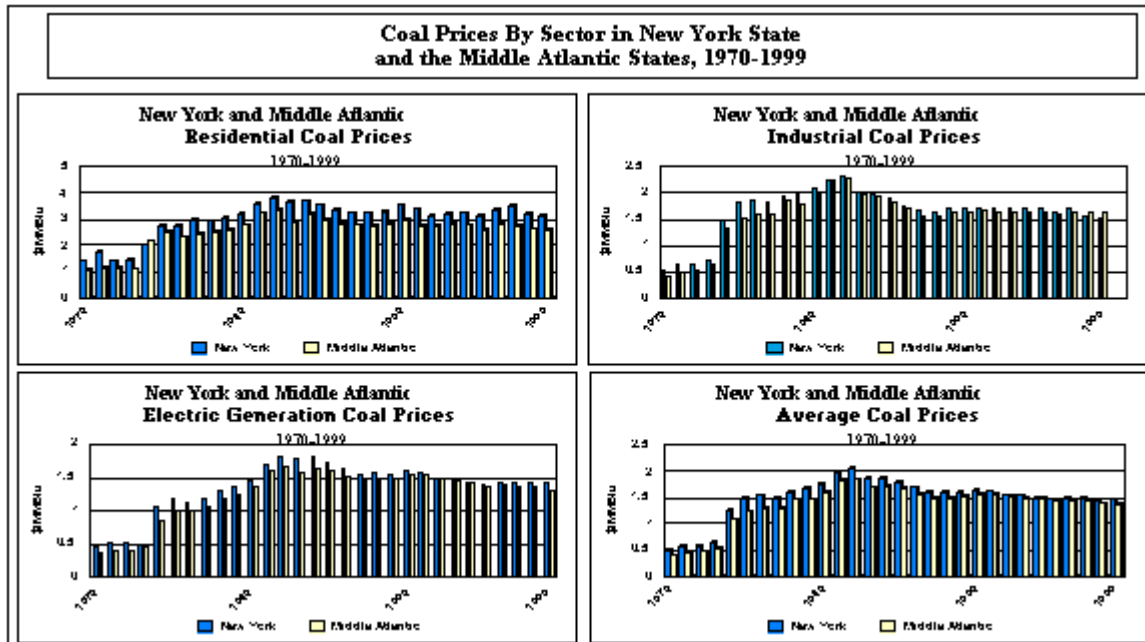
Because variations in New York coal prices have tracked changes in Middle Atlantic coal prices, formulas describing the relationship between New York and the Middle Atlantic could be developed. These formulas, a product of time series and regression analysis, were also used to compare historical New York coal prices with forecasted prices for those years. The coefficients of the formulas, derived for each sector, were applied to historical Middle Atlantic average coal prices, compiled from the *State Energy Data Report 1999*. Beyond satisfying statistical requirements, using the forecasting formulas in this way provides a visual approximation of their accuracy. The historical New York coal price forecast, from 1970 to 1999, is shown in Figure 20.

Figure 20

New York Actual Coal Prices vs. New York Predicted Coal Prices
1970-1999

Through statistical analysis and graphical demonstration, it was determined that New York can be accurately predicted as a percentage of Middle Atlantic. The forecasting coefficients were applied to EIA's NEMS-based Middle Atlantic coal forecasts, published in the *AEO 2002*. Long-term, average price annual forecasts were created by sector. High and low forecasts were derived from the high, outlook, and low national economic forecasts published in the EIA's *AEO 2002*. Figure 21 shows the New York average total coal price forecast, bounded by a high and low economic forecast.

Forecasted annual retail prices and total growth rates for coal are listed in the forecast tables at the end of this appendix .

Figure 21

Average Coal Prices
New York State Forecast
2000-2021

Low — Outlook — High