Short-Term Energy Outlook Retail Electricity Sales Module

eia Concepts, Data Sources, and Techniques
Handbook of Energy Modeling Methods

www.eia.gov
U.S. Department of Energy
Washington, DC 20585
Last updated: January 2023

The U.S. Energy Information Administration (EIA), the statistical and analytical agency within the U.S. Department of Energy (DOE), prepared this report. By law, our data, analyses, and forecasts are independent of approval by any other officer or employee of the U.S. Government. The views in this report do not represent those of DOE or any other federal agencies.

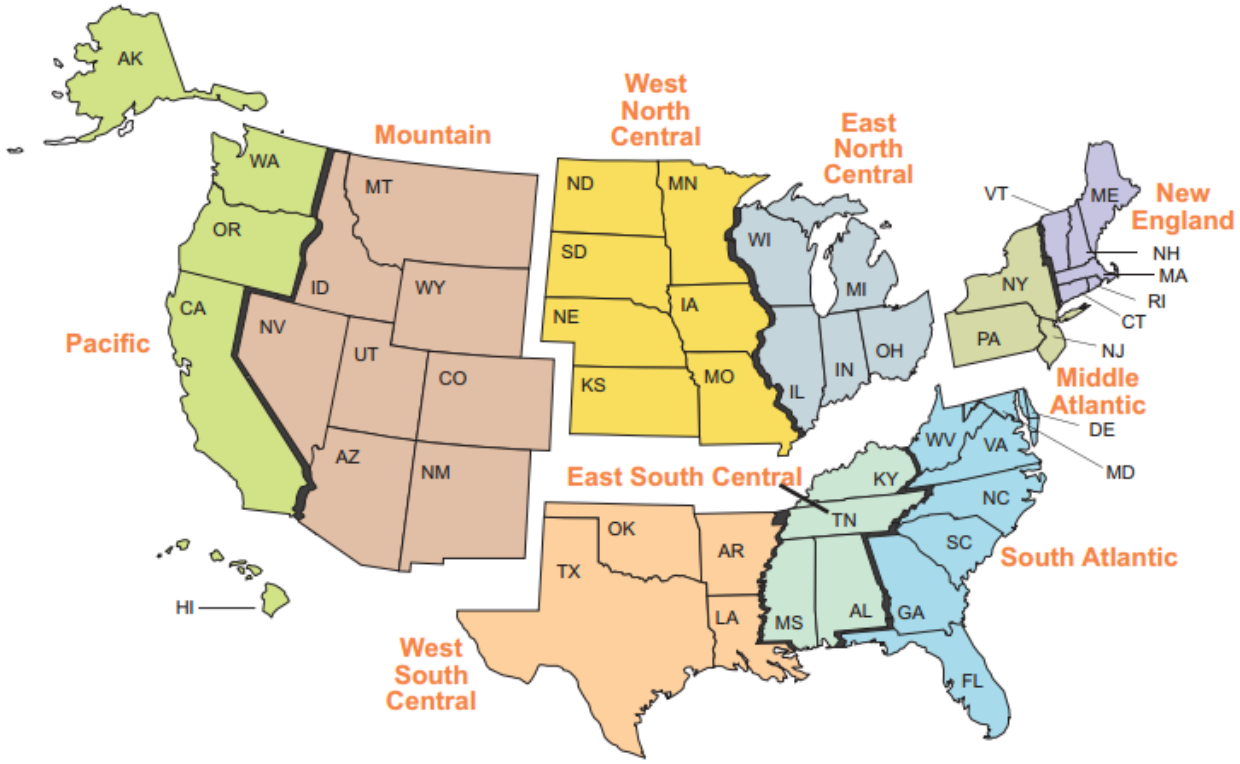
Table of Contents

Table of Figures

Introduction

The Retail Electricity Sales Module is a component of the U.S. Short-Term Energy Model (USSTEM) within EIA's Short-Term Integrated Forecasting System (STIFS). The module is designed to provide forecasts of retail electricity sales to customers for their own use (end-use customers) and not for resale to others. The module forecasts the amount of electricity sold to four end-use sectors (residential, commercial, industrial, and transportation) for the entire United States and for the nine U.S. census divisions (Figure 1). The Retail Electricity Sales Module is closely linked to the USSTEM Electricity Supply Module, where total retail sales act as an input for determining total U.S. electricity load and generation. Some industrial and commercial establishments consume electricity they produce onsite. This type of electricity consumption is modeled in the Electricity Supply Module.

Figure 1. U.S. census divisions



Data source: U.S. Census Bureau

Data Sources

The data input for the Retail Electricity Sales Module are by month. In most cases, retail sales data are converted to average per-day units for each month, so that the data can be integrated into other USSTEM modules. The primary EIA data sources for the Retail Electricity Sales Module are our:

- *Electric Power Monthly*
- *Electricity Monthly Update*
- *Electric Power Annual*

Retail electricity data in each of these publications are derived from three EIA surveys. The *Annual Electric Power Industry Report* (Form EIA-861) collects operational data and characteristics annually from a sample of electric utilities and energy service providers. Schedule 4 of this survey collects information from respondents about the amount of electricity sold to the retail customers in the four end-use sectors and the corresponding amount of revenue received during the past year.

Most investor-owned utilities and competitive retail electric suppliers (about 500 respondents) are required to file the *Monthly Electric Power Industry Report* (Form EIA-861M) each month. This survey collects retail revenues and sales to each end-use sector, and this observed data provide the basis for imputing the monthly sales of respondents who file annual, rather than monthly, reports (Forms EIA-861/861S).

We send the short form of the *Annual Electric Power Industry Report* (Form EIA-861S) to approximately 1,100 smaller utilities. This survey collects data on total retail revenue and sales of electricity during the year, but it does not request a breakdown of how much is sold to each end-use sector. Once every five years, the respondents of this survey fill out the full *Annual Electric Power Industry Report* (Form EIA-861) in lieu of the abbreviated form.

In addition to the data published in the EIA sources listed above, the Retail Electricity Sales Module also uses data from outside sources. The Edison Electric Institute (EEI) compiles a *Weekly Electric Output* report with data for nine regions of the United States. Although EEI's regional mapping does not correspond exactly with census divisions, strong correlations exist between the EEI output data and EIA total retail sales. The Retail Electricity Sales Module incorporates information from weekly output to estimate electricity sales for the most recent months for which EIA monthly data are not yet available.

We obtain historical data and forecasts for cooling degree days and heating degree days from the National Oceanic and Atmospheric Administration (NOAA).[1] Degree-day data are collected for individual states. We calculate weighted averages for each census division (and for the entire United States) using the states' populations during each month, estimated by the U.S. Census Bureau. This averaging method differs from NOAA's method, which uses a constant population weight for each state (currently based

[1] Cooling degree days (CDD) are a measure of how warm a location is over a period of time compared with a base temperature, usually 65°F. The measure for CDD for a particular day is calculated as the positive deviation of the day's average temperature from (usually) 65°F; if the average falls below 65°F, the value for CDD = 0. Heating degree days (HDD), a measure of the relative coldness of a location, are calculated as the deviation of daily average temperature below 65°F; HDD = 0 if the daily average temperature exceeds 65°F.

on the 2010 census). We use the dynamic population weighting methodology for USSTEM to capture geographic shifts in population that affect energy consumption patterns.

Macroeconomic data such as population, GDP, income, employment, and industrial production are incorporated as explanatory variables in many USSTEM modules. The macroeconomic forecasts are generated by models IHS Market developed. IHS Markit updates its national macroeconomic forecasts monthly using its model of the U.S. economy. We re-run the IHS Markit model to produce macroeconomic forecasts that are consistent with our *Short-Term Energy Outlook* energy price forecasts.

Electricity Retail Sales Module Inputs and Regression Models

The Electricity Retail Sales Module forecasts regional retail electricity sales for five end-use sectors:

- The residential sector
- The commercial sector
- The industrial sector
- The transportation sector
- All end-use sectors combined

Census division regions for retail electricity are:

- East North Central
- East South Central
- Middle Atlantic
- Mountain
- New England
- Pacific Contiguous
- Pacific Noncontiguous
- South Atlantic
- West North Central
- West South Central

The Retail Electricity Sales Module differentiates between the contiguous states (California, Oregon, and Washington) and the noncontiguous states (Alaska and Hawaii) in the Pacific Census Division. Because of this differentiation, the census division definitions differ slightly from the standard ones that are shown in Figure 1.

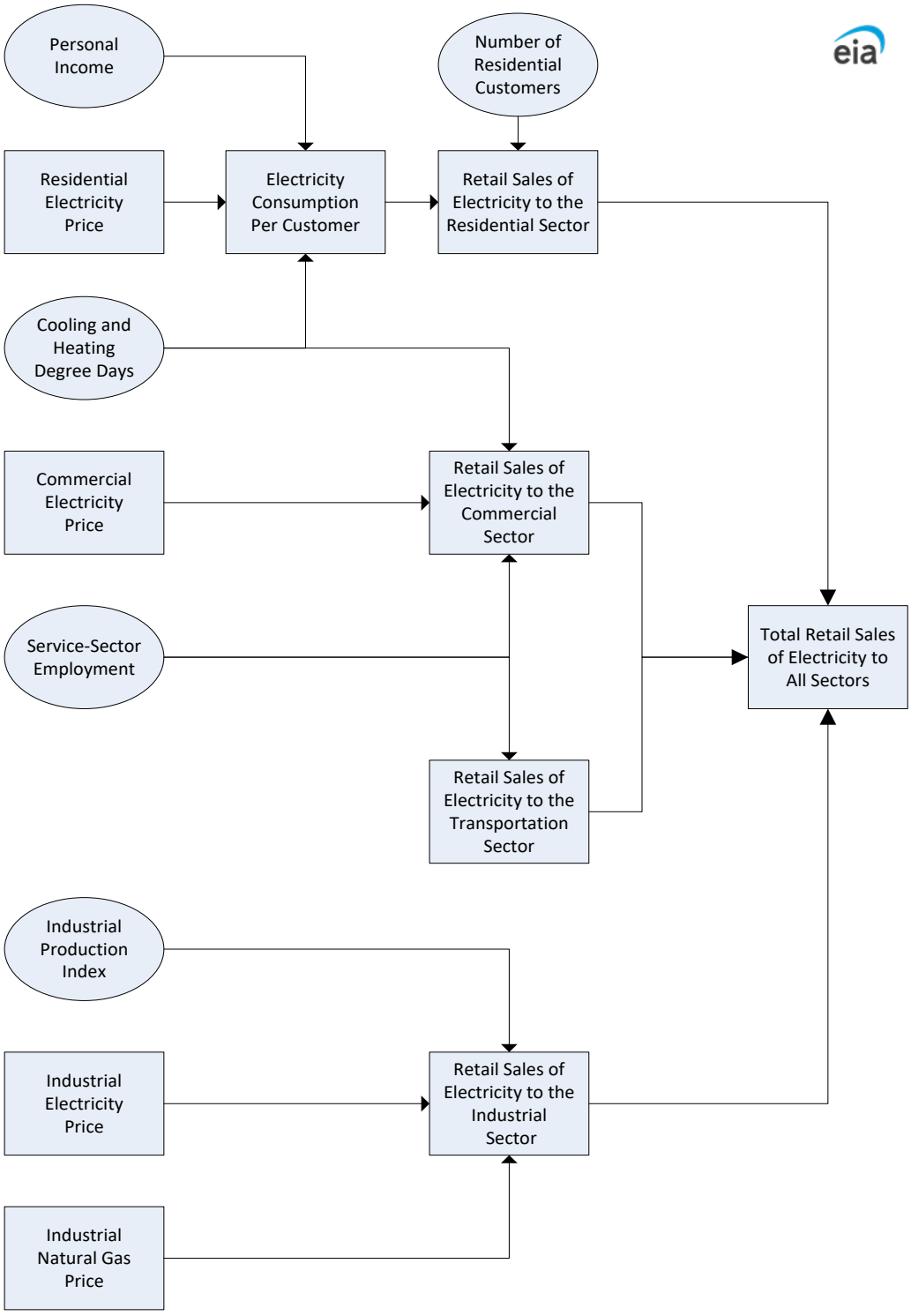
Regional Retail Electricity Sales Model Structure

We designed the USSTEM Retail Electricity Sales Module to forecast sales to each end-use sector within the nine census division areas (Figure 2).[2] Direct use of electricity by power generators is modeled separately in the USSTEM Electricity Supply Module because that electricity is produced and consumed onsite. We estimate retail sales in each regional area individually and then aggregate them into U.S. totals for each end-use sector and a U.S. retail sales total across all end-use sectors.

The Retail Electricity Sales Module uses linear regression models to estimate coefficients that represent relationships between important variables, for example, supply, demand, number of customers, and prices. Some regression models include monthly dummy variables to capture the normal seasonality in the data series and to account for specific historical months for which the data reflect infrequent and unpredictable events such as hurricanes, fuel disruptions, or other factors. Most models also include a lagged dependent variable term to account for any autocorrelation in the estimation.

[2] The Retail Electricity Sales Module divides the Pacific Census Division into two separate areas: California, Oregon, and Washington and Hawaii and Alaska.

Figure 2. Structure of the *Short-Term Energy Outlook*'s Retail Electricity Sales Module



Data Source: U.S. Energy Information Administration

*Oval shapes include independent variables whereas rectangle shapes include dependent variables.

Residential sector retail sale estimations

The Retail Electricity Sales Module models residential electricity consumption on a per-customer basis to analyze changes in the average monthly electricity bill. Disaggregating the data in this way also allows better modeling of the effects of changes in energy efficiency on retail electricity sales.

Average residential consumption per customer for each census division is defined as the total monthly retail sales of electricity to the residential sector in the region divided by the total number of residential customers. A residential customer corresponds to an individual electric meter. In some cases, more than one household may share a meter. Some electricity customers represent seasonal residences.

We collect annual data on the total retail sales and number of customers in the *Annual Electric Power Industry Report* (Form EIA-861). Historical estimates of growth in the number of customers for the most recent year are calculated using responses from our *Monthly Electric Power Industry Report* (EIA-861M), which collects retail sales and customer data from a sample of annual EIA-861 respondents. We calculate the forecast annual growth in the number of residential customers using the growth rate of the forecast number of households as projected by IHS Markit.

For each census division, the Retail Electricity Sales Module estimates average consumption per residential customer as a function of five independent variables:

- Retail residential electricity price in the census division, cents per kilowatthour
- Consumer price index in the census division
- Personal disposable income in the census division, nominal dollars
- Cooling degree days in the census division
- Heating degree days in the census division

Increases in the real residential electricity price should place downward pressure on customers' electricity consumption. In many cases, however, the responsiveness of consumption to changes in prices is relatively insignificant. The most important factor affecting retail sales of electricity to the residential sector is weather. The numbers of cooling and heating degree days are significantly correlated with residential consumption. The electricity sales data we collected in some cases reflect billing cycles that do not correspond with calendar months. Therefore, one-month lagged observations for heating and cooling degree days are included as explanatory variables.

Commercial sector retail sale estimations

As in the residential sector, consumption of electricity in the commercial sector is also highly sensitive to fluctuations in weather conditions. Space cooling, space heating, ventilation, and lighting are the primary uses of electricity in the commercial sector. Electricity used for cooking and refrigeration in food-service establishments and for computers and other equipment in office buildings account for the rest.

The Retail Electricity Sales Module estimates aggregate retail commercial sales of electricity for each census division. The number of customers is not included in the commercial sector regression models, like in the residential sales regression models. Electric utilities responding to EIA surveys will sometimes reclassify customers as commercial or industrial depending on their electricity consumption, not

necessarily on the type of business they conduct. So, the number of commercial sector customers can sometimes fluctuate widely from year to year.

Total retail electricity sales to the commercial sector in each census division (billion kilowatthours per day) are modeled as a function of regional private sector employment, weather (as measured by degree days), and commercial electricity prices. The regression model for each census division includes six explanatory variables:

- Retail commercial electricity price in the census division, cents per kilowatthour
- Consumer price index in the census division
- Personal disposable income in the census division, nominal dollars
- Cooling degree days in the census division
- Heating degree days in the census division
- Private sector employment in the census division

Theoretically, the coefficient on the commercial electricity price variable should be negative, but for most of the regional models, the effect of price changes is not significant. All of the regression models contain significant coefficients for the degree day variables, but the lagged series are not as robust such that does not have as good performance for data drawn from a wide range of probability distributions. Growth in private sector employment is a significant explanatory variable in most of the commercial electricity sales models.

Industrial sector retail sale estimations

Macroeconomic conditions primarily determine electricity use in the industrial sector. Space heating and cooling needs are minimal for industrial facilities, in contrast to the residential and commercial sectors. Most of the electricity consumed in the industrial sector is used to facilitate manufacturing processes. The chemical, primary metals, and food industries purchase nearly half the electricity sold to the industrial sector. Many manufacturing facilities can generate their own electric power, which they can use to supplement or substitute for retail electricity purchases if the cost of self-generation is low compared with the retail price of electricity.

The most important driver of retail sales to the industrial sector is the overall level of economic activity, but, different industries will expand at different rates. To reflect average economic activity, USSTEM uses an electricity-weighted industrial production index, which averages the industrial production indexes of various industries with weights based on the relative amounts of electricity they purchase. Another significant explanatory variable is the regional retail price of purchased electricity for the industrial sector. The regional industrial price of natural gas also is included in the model equations because this fuel could be considered a substitute for purchased electricity for those manufacturers that can produce their own electricity, often with generating units fueled by natural gas. At the census division level, the module estimates retail sales of electricity to the industrial sector as a function of three explanatory variables:

- Retail industrial electricity price in the census division, cents per kilowatthour
- Consumer price index in the census division
- U.S. electricity-weighted industrial production index (previously described)

The coefficient on the retail electricity price should be negative, and for most of the regions, the estimated coefficients are of the correct sign and are statistically different from zero. The coefficient on the natural gas price variables is positive for most regions and significant in about half of the regions. The electricity-weighted industrial production index is also significant and positive for most regions. We include dummy variables for certain years to account for when one or more large customers are reclassified to different end-use sectors. This effect is most evident in the New England Census Division.

Transportation sector retail sale estimations

Retail sales of electricity to the transportation sector consist primarily of sales to public transit operators such as subway, light-rail, and streetcar systems. The overall transportation-sector electricity sales are very small compared with the amount sold to other end-use sectors, but the number of customers is also much smaller. Transportation sales can be quite volatile, so forecasting transportation sales can be difficult. However, transportation electricity use follows some seasonal patterns, with especially large spikes in January and February. Electricity sales to the transportation sector are also assumed to be positively related to overall commercial employment.

For each census division, the Retail Electricity Sales Module estimates total retail sales of electricity to the transportation sector as a function of two explanatory variables:

- Private sector employment in the census division, millions
- Monthly dummy variables (the January and February peak is captured in the constant term)

Total retail sales of electricity estimates

The total retail electricity sold in each region is simply equal to the sum of the electricity sold to all of the four end-use sectors.

Model adjustment factors

Most regression models in USSTEM have associated *add factors*, which allow manual adjustments to the modeled output. The add factors allow additive adjustments to the forecasts of the model's dependent variable to reflect analyst judgment about issues that might not be adequately portrayed in the model, such as extended power outages, extreme weather events, etc.