

Introduction to the Technical Notes

Purpose

All of the estimates contained in the state energy consumption data tables are developed using the State Energy Data System (SEDS), which is maintained and operated by the U.S. Energy Information Administration (EIA). The goal in maintaining SEDS is to create historical time series of energy production, consumption, prices, and expenditures by state that are defined as consistently as possible over time and across sectors. SEDS exists for two principal reasons: (1) to provide state energy production, consumption, price and expenditure estimates to Members of Congress, federal and state agencies, and the general public, and (2) to provide the historical series necessary for EIA's energy models.

Efforts are made to ensure that the sums of the state estimates equal the national totals as closely as possible for each energy type and end-use sector as published in other EIA publications. SEDS energy consumption estimates are generally comparable to the national statistics in EIA's *Monthly Energy Review* consumption tables.

The report

The SEDS consumption tables, available on the EIA website at <http://www.eia.gov/state/seds/seds-data-complete.php>, provide annual time series estimates of state-level energy use by broad energy-consuming sectors. Companion tables containing state-level price and expenditure estimates can be found at the same website. State-level energy production estimates, a recent addition to SEDS, are also available at <http://www.eia.gov/state/seds/seds-data-complete.php>. In addition, tables showing state-level consumption, price, and expenditure estimates by energy source as they are updated for the most current year can be found at <http://www.eia.gov/state/seds/seds-data-fuel.php>.

The following technical notes are provided to assist users in understanding and interpreting the SEDS consumption estimates. Each section describes how the estimates were derived for each individual energy source and lists the sources of all data series. Additional information is contained in the appendices.

Technical notes for state-level prices and expenditures, as well as production, are also available at [http://www.eia.gov/state/seds/seds-technical-notes-](http://www.eia.gov/state/seds/seds-technical-notes-complete.php)

[complete.php](http://www.eia.gov/state/seds/seds-technical-notes-complete.php).

Due to page-size constraints, most of the time-series tables displayed as Portable Document Format (PDF) files show estimates for only selected years from 1960 through 2000; thereafter, data are shown consecutively. However, estimates for all years from 1960 forward are maintained in SEDS and are included in the HTML versions of the tables and in the CSV data files available via EIA's website. All years are covered by the documentation in this report.

All estimates with revisions since the last edition of SEDS that are large enough to be seen in the published tables' level of rounding are preceded with an "R" in the PDF data tables on the website.

Estimates

Estimation methodologies. Using SEDS, EIA develops estimates of energy consumption by principal energy sources and broad energy-consuming sectors, by state, from 1960 forward. Energy consumption is estimated by using data from existing surveys of energy suppliers that report consumption, sales, or distribution of energy at the state level. Most of the SEDS estimates rely directly on collected state-level consumption data (See "Collected data and estimated values in SEDS" on page 5, which summarizes the status of current data sources used). Some consumption estimates in SEDS are based on a variety of surrogate measures. The measures are selected principally on the basis of applicability as an indicator of consumption, availability, continuity over time, and consistency. For instance, for petroleum, "product supplied" is a surrogate for consumption and is derived by summing field and refinery production, plus imports, minus exports, plus or minus changes in stocks. State-level sales survey data are used to disaggregate the national petroleum product supplied totals to the states. The measures of consumption and estimation methodologies are explained in detail under each energy source in the Technical Notes.

Methods are also applied to estimate state electrical system energy losses that are not available from any survey. See "Energy consumption measures—total and site" on page 6 for a discussion about losses and how they are reflected in the SEDS tables. U.S. electrical system energy losses are defined as the differences between the heat content of all energy consumed by the electric power sector and the heat content of electricity retail sales. State-level

losses are estimated using two methodologies, depending on whether data on net interstate flow of electricity are available. See Section 6, “Electricity,” for details.

Data sources. The original source documents cited in the Technical Notes include descriptions of the data collection methodologies, universes, imputation or adjustment techniques (if any), and errors associated with the processes. Due to the many collection forms and procedures associated with those reports, it is not possible to develop a meaningful numerical estimate of the errors of the integrated data published here.

Reliable, consistent series for long periods of time—especially in the earlier years—are difficult to develop, and estimates and assumptions must be applied to fill data gaps and to maintain definitional consistency. Although SEDS incorporates the most consistent series and procedures possible, users of this report should recognize the limitations of the data that are due to changing and inadequate data sources.

For example, in reports prepared by the Bureau of Mines in the late 1960s and early 1970s, petroleum consumption was equated to demand. Later, consumption was equated to apparent demand and, more recently, to product supplied. Changes in surveys and reduction of data collections, especially after 1978, disturbed the continuity of some petroleum consumption series, most notably for distillate fuel oil, residual fuel oil, and kerosene. These and other data inconsistencies are explained in detail for each energy source in the Technical Notes.

Comparison with other energy consumption reports

EIA conducts many energy-related surveys. In general, the surveys can be divided into two broad groups. One group of surveys, called supply surveys, is directed to the suppliers and marketers of specific energy sources. Those surveys measure the quantities of specific fuels supplied to the market. The results of supply surveys are combined and published in a number of EIA data products, including the *Monthly Energy Review* and SEDS. The second group of surveys, called energy consumption surveys, gather information directly from end users of energy. Although there are some elements in common, the supply survey data and the consumption survey data have substantially different approaches, capabilities, and objectives. Thus, care must be taken in analyzing SEDS consumption estimates in conjunction with consumption survey data for the following reasons:

- SEDS data are designed to be a broad accounting of energy consumption, covering all energy use and splitting it into major sectors as clearly as possible. The energy consumption surveys are designed

to be comprehensive and representative within individual sectors. However, the sectors are restricted for purposes of creating relatively homogeneous, well-defined populations and for aiding in sampling and data collection. For example, the Commercial Buildings Energy Consumption Survey covers only energy consumption in commercial buildings, while SEDS includes other commercial consumption, such as street lighting and public services; and the Manufacturing Energy Consumption Survey covers only manufacturing establishments, while SEDS includes other industrial energy consumption (i.e., mining, construction, agriculture, fisheries, and forestry). Further, the consumption surveys do not cover all energy-using sectors. Therefore, energy consumption surveys cannot be summed together to account for all energy use.

- Energy consumption surveys provide user characteristics that allow for both macro-level (for major sectoral sub-populations) and micro-level (at the unit of data collection) interpretive analysis. The surveys of energy consumption by residential households from the Residential Energy Consumption Survey (Form EIA-457) and by commercial buildings from the Commercial Buildings Energy Consumption Survey (Form EIA-871) provide detailed information about the energy end users, their size, their stock of energy-consuming equipment and appliances, and their total energy consumption and expenditures. The Manufacturing Energy Consumption Survey (Form EIA-846) collects consumption by type of use and fuel switching capability from manufacturing establishments grouped by manufacturing classification. SEDS, on the other hand, provides limited characterization of the end users of energy but greater geographic and energy product detail, as well as annual historical time series.
- Sectoral classification in SEDS is generally based on supplier classifications of customer accounts, by whatever means suppliers choose to use. (See discussion in next section.) Sectoral classification for the energy consumption surveys is based upon a categorization, verified by end user, of the primary economic activity of the data collection unit (household, building, or establishment).
- The energy consumption surveys provide data at national and Census region and/or Census division levels, whereas the estimates in SEDS are on national and state levels.
- The reference periods are also different in that SEDS covers calendar years from 1960 forward, while the consumption surveys are for

selected years, and the residential end-use surveys taken before 1987 cover a heating season year (i.e., April through March). Beginning with

the 1987 residential end-use survey, the reference period is a calendar year.

Collected data and estimated values in SEDS

Coal. U.S. total coal consumption data by sector are taken directly from EIA's *Annual Coal Report (ACR)* and predecessor publications. Total coal consumption by state and for most sectors is from the ACR, except where values are withheld and must be estimated. The state-level disaggregation of the ACR's combined residential and commercial sector consumption, available through 2007, are estimates. For 2008 forward, only commercial sector consumption is available in ACR, and residential sector consumption is assumed to be zero. Data on coal consumption in the electric power sector (utility-scale facilities with capacity of 1 megawatt and greater) by state and coal type are from Form EIA-923, "Power Plant Operations Report," and predecessor forms.

Natural gas. Natural gas consumption by state and sector is taken directly from EIA's *Natural Gas Annual (NGA)*. Natural gas consumed as lease fuel and plant fuel and natural gas delivered to industrial consumers in the NGA are combined in SEDS as industrial sector consumption. Natural gas consumed as vehicle fuel and pipeline fuel are combined in SEDS as transportation sector consumption. Data on natural gas consumption in the electric power sector are from Form EIA-923, "Power Plant Operations Report," and predecessor forms.

Petroleum. U.S. total consumption for each petroleum product is equal to the "product supplied" data from EIA's *Petroleum Supply Annual (PSA)*. State values for distillate fuel oil, residual fuel oil, and petroleum coke consumption by the electric power industry are unpublished data from Form EIA-923, "Power Plant Operations Report," and predecessor forms. All other state and sector values for consumption of petroleum products are estimates based on sales data from several sources.

Renewable energy. Renewable energy (**hydroelectric power, geothermal, solar, wind, wood, and waste**) used by the electric power industry (electric power sector and utility-scale commercial and industrial combined heat and power and electricity-only plants)

is collected on Form EIA-923, "Power Plant Operations Report," and predecessor forms. In addition, data on small-scale photovoltaic electricity generation for the residential, commercial, and industrial sectors are from EIA's *Electric Power Annual* for 2014 forward. Data for earlier years are estimated in SEDS. Solar thermal energy consumed as heat, produced by non-electric applications, is also estimated. Geothermal energy direct use and by heat pumps in the residential, commercial, and industrial sectors are estimates based on a survey from the Oregon Institute of Technology Geo-Heat Center (through 2009). U.S. wood consumption in the residential, other commercial, and other industrial sectors are estimated by EIA based on data collected on Form EIA-457, "Residential Energy Consumption Survey," Form EIA-871, "Commercial Buildings Energy Consumption Survey," and Form EIA-846, "Manufacturing Energy Consumption Survey" and are published in the *Monthly Energy Review (MER)*. The estimates are allocated to the states in SEDS. U.S. **fuel ethanol and biodiesel** consumption is estimated by EIA based on data collected from various survey forms and reported in PSA and MER. State-level consumption by sector is estimated in SEDS.

Nuclear electric power. Nuclear electricity generation by state is collected on Form EIA-923, "Power Plant Operations Report," and predecessor forms.

Electricity. Electricity consumption is equal to retail sales data by sector and state from the *Electric Power Annual (EPA)* with one exception. The exception is that the EPA "Other" category, available from 1960 through 2002, is allocated to the transportation and commercial sectors in each state.

Net interstate flow of electricity. Net interstate electricity flows in kilowatthours from 1990 forward are taken from EIA's State Electricity Profiles. The heat content of these series in British thermal units are estimated in SEDS from 1960 forward.

Electrical system energy losses. These series are estimated in SEDS.

For a more detailed description of the differences between SEDS and the energy consumption surveys, see the EIA analysis report *Energy Consumption by End-Use Sector: A Comparison of Measures by Consumption and Supply Surveys*, DOE/EIA-0533, April 1990.

Energy-consuming sectors

The consumption estimates in SEDS are based on data collected by various surveys that do not necessarily define the consuming sectors exactly the same way. The Technical Notes of this report describe in detail for each energy source how the collected data series are combined and assigned to SEDS consuming sectors. To the degree possible, energy consumption in this report has been assigned to the five sectors according to the following general definitions:

- **Residential sector:** An energy-consuming sector that consists of living quarters for private households. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a variety of other appliances. The residential sector excludes institutional living quarters.
- **Commercial sector:** An energy-consuming sector that consists of service-providing facilities and equipment of: businesses; federal, state, and local governments; and other private and public organizations, such as religious, social, or fraternal groups. The commercial sector includes institutional living quarters. It also includes sewage treatment facilities. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a wide variety of other

Energy consumption measures—total and site

Sources of energy can be categorized as primary and secondary. Primary sources of energy, such as coal, petroleum, and natural gas are consumed directly. Electricity is a secondary form of energy that is created from primary energy sources. The amount of electricity actually consumed by the end user (site consumption) does not include the energy lost in the generation and delivery of the electricity to the point of use.

Primary sources of energy are measured in applicable physical units. Coal is measured by the short ton (equal to 2,000 pounds); petroleum, by the barrel (equal to 42 gallons); and natural gas, by the cubic foot. Energy sources are also measured by their heat content, generally expressed in British thermal units (Btu). The heat content per unit of physical unit (i.e., thermal conversion factors) represents the gross (or higher or upper) energy content of the fuel. For example, in 2018, the average short ton of coal consumed by the electric power sector contained 18.915 million Btu (Appendix B, Table B13), the average barrel of distillate fuel oil contained 5.759 million Btu (Appendix B, Table B1), and the average cubic foot of natural gas consumed by the electric power sector contained 1,033 Btu (Appendix B, Table B3).

Electricity, a secondary form of energy, can also be measured in physical units, commonly kilowatthours, and by heat content. The

conventional thermal conversion factor for electricity consumed by the end user (site consumption) is 3,412 Btu per kilowatthour.

In 2018 the electric power sector consumed 38.2 quadrillion Btu of primary energy to provide 13.2 quadrillion Btu of electricity for sale. These data indicate that 65% of the primary (embodied) energy in the fuels consumed to generate the electricity was used (or “lost”) in converting the primary energy to electricity and transmitting and distributing the electricity to the consumers, and 35% was used as site (point-of-use) electricity by consumers.

In evaluating these energy consumption tables, the tables titled “Total Energy Consumption” include all primary energy sources, including those used to generate electricity; the electricity generated is not included. Tables showing “End-Use Sector Consumption” include columns for the primary sources and electricity that are consumed by the sector, as well as a column for the estimated energy lost in the electrical system processes. The “Total” column in those tables includes all energy consumed by the sector and the associated energy lost in the generation and transmission of electricity. The column titled “Net” is site energy consumption—that is, the sum of the primary sources and electricity, excluding the electrical system energy losses. See Section 7 “Total Energy” for details.

equipment. *Note:* This sector includes generators that produce electricity and/or useful thermal output primarily to support the activities of the above-mentioned commercial establishments.

- **Industrial sector:** An energy-consuming sector that consists of all facilities and equipment used for producing, processing, or assembling goods. The industrial sector encompasses the following types of activity: manufacturing (NAICS codes 31-33); agriculture, forestry, fishing, and hunting (NAICS code 11); mining, including oil and gas extraction (NAICS code 21); and construction (NAICS code 23). Overall energy use in this sector is largely for process heat and cooling and powering machinery, with lesser amounts used for facility heating, air conditioning, and lighting. Fossil fuels are also used as raw material inputs to manufactured products. *Note:* This sector includes generators that produce electricity and/or useful thermal output primarily to support the above-mentioned industrial activities.
- **Transportation sector:** An energy-consuming sector that consists of all vehicles whose primary purpose is transporting people and/or goods from one physical location to another. Included are automobiles; trucks; buses; motorcycles; trains, subways, and other rail vehicles; aircraft; and ships, barges, and other waterborne vehicles. Vehicles whose primary purpose is not transportation (e.g., construction cranes and bulldozers, farming vehicles, and warehouse tractors and forklifts) are classified in the sector of their primary use. In this report, natural gas used in the operation of natural gas pipelines is included in the transportation sector.
- **Electric power sector:** An energy-consuming sector that consists of electricity-only and combined-heat-and-power plants within the NAICS (North American Industry Classification System) 22 category whose primary business is to sell electricity, or electricity and heat, to the public. *Note:* This sector includes electric utilities and independent power producers.

The first four energy-consuming sectors—residential, commercial, industrial, and transportation sectors—are also called end-use sectors.

Sector definition discrepancies

Although the end-use allocations are made according to these aggregations as closely as possible, some data are collected by using different classifications. For example, electric utilities may classify commercial and industrial users

by the quantity of electricity purchased rather than by the business activity of the purchaser. Natural gas used in agriculture, forestry, and fisheries was collected and reported in the commercial sector through 1995. Beginning with 1996 data, deliveries of natural gas for agriculture, forestry, and fisheries are reported in the industrial sector instead. Another example is master-metered condominiums and apartments and buildings with a combination of residential and commercial units. In many cases, the metering and billing practices cause residential energy usage of electricity, natural gas, or fuel oil to be included in the commercial sector. No adjustments for these discrepancies were made.

SEDS does not provide further disaggregated end-use consumption estimates. For example, the industrial sector cannot be broken down into the chemical or rubber industries, all manufacturing, or agriculture. The input series for the system are provided in broad end-use categories from the data collection forms and are not available by the individual components. Additional disaggregated regional information, such as counties or cities, are also not available in SEDS.