

Introduction to the technical notes

Purpose

The U.S. Energy Information Administration (EIA) develops, maintains, and operates the State Energy Data System (SEDS). The goal of SEDS is to provide historical time series of energy production, consumption, prices, expenditures, and indicators, by state that are defined as consistently as possible over time and across sectors. SEDS maintains these estimates for Members of Congress, federal and state agencies, the general public, and as inputs for EIA's energy models.

SEDS ensures 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*.

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 are also available at <http://www.eia.gov/state/seds/seds-data-complete.php>. In addition, SEDS publishes the most recent year of data tables for state-level consumption, price, expenditure, and indicator estimates by energy source as they are updated at <http://www.eia.gov/state/seds/seds-data-fuel.php>.

SEDS provides the following technical notes to assist users in understanding and interpreting the SEDS consumption estimates. Each section describes how SEDS derives the estimates for each individual energy source and lists the sources of all data series.

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-complete.php>.

Due to page-size constraints, most of the PDF time-series tables show estimates for only selected years. However, SEDS maintains consumption estimates for all years from 1960 forward and includes them in the HTML

tables and CSV, XLSX, and ZIP data files available on EIA's website. The documentation in this report covers all years. In the published SEDS tables, all estimates with revisions since the last SEDS report that are large enough to be seen are preceded with an "R."

Estimates

Estimation methodologies. Using SEDS, EIA develops estimates of energy consumption by energy sources, broad energy-consuming sectors, and by state for 1960 forward. SEDS estimates energy consumption using data from 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 3, which summarizes the status of current data sources used). SEDS uses a variety of surrogate measures to estimate energy consumption. SEDS selects the measures mainly on the basis of applicability as an indicator of consumption, availability, continuity over time, and consistency. For instance, for petroleum, EIA uses "product supplied" as an approximation for consumption. EIA calculates "product supplied" as the sum of field and refinery production, plus imports, minus exports, plus or minus changes in stocks. SEDS uses state-level sales survey data and other proxies of consumption to allocate 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.

SEDS also estimates state electrical system energy losses that are not available from any survey. See "Energy consumption measures—total and end use" on page 4 for a discussion about losses and how SEDS displays them in the 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 sales to ultimate customers. SEDS estimates state-level losses using two methods, 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 methods, imputation or adjustment techniques, and errors associated with the processes. Due

to the many different collection forms and procedures associated with the source data and estimation methods, it is not possible to develop a meaningful numerical estimate of the errors of the integrated data published in SEDS.

It is difficult to develop reliable, consistent series for long periods of time—especially in the earlier years—and SEDS must make assumptions 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. The technical notes explain these and other data inconsistencies in detail for each energy source.

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, gather information from suppliers and marketers of specific energy sources. Those surveys measure the quantities of specific fuels supplied to the market. EIA combines the results of supply surveys and publishes them in various EIA 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 with consumption survey data for the following reasons:

- SEDS consumption is a broad accounting of energy consumption, covering all energy use allocated into major sectors as clearly as possible. The energy consumption surveys are comprehensive and representative within individual sectors. However, for sampling and data collection purposes, the sectors are restricted for purposes of creating relatively homogeneous, well-defined

populations. For example, the *Commercial Buildings Energy Consumption Survey* (CBECS) 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* (MECS) 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, and therefore 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* (RECS, Form EIA-457) and by commercial buildings from the CBECS (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 MECS (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 the next section). Energy consumption surveys base their sectoral classification on a categorization, verified by end user, of the data collection unit's (household, building, or establishment) primary economic activity.
- The energy consumption surveys provide data at national and Census levels, SEDS provides estimates at national and state levels.
- The reference periods are also different. SEDS covers calendar years for 1960 forward, while the consumption surveys are for selected years. Before 1987, the residential end-use surveys cover a heating season year (April through March). Beginning with the 1987 residential end-use survey, the reference period is a calendar year.

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.

Collected data and estimated values in SEDS

Coal. SEDS takes U.S. total coal consumption data by sector 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 SEDS estimates withheld values. The state-level allocation of the ACR's combined residential and commercial sector consumption, available through 2007, are estimates. For 2008 forward, ACR only provides commercial sector consumption and SEDS assumes residential sector consumption to be zero. Electric power sector coal consumption (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. SEDS takes natural gas consumption by state and sector directly from EIA's *Natural Gas Annual* (NGA). SEDS combines natural gas consumed as lease fuel and plant fuel and natural gas delivered to industrial consumers in the NGA for industrial sector consumption. SEDS combines natural gas consumed as vehicle fuel and pipeline fuel for transportation sector consumption. Electric power sector natural gas consumption is 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 from Form EIA-923, "Power Plant Operations Report," and predecessor forms. SEDS estimates all other state and sector values for consumption of petroleum products based on sales data and other surrogate measures from several sources.

Renewable energy. EIA collects 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) on Form EIA-923, "Power Plant Operations Report," and predecessor forms. In addition, for 2014 forward,

EIA's *Electric Power Annual* provides data on small-scale photovoltaic electricity generation for the residential, commercial, and industrial sectors. SEDS estimates data for earlier years. SEDS also estimates solar thermal energy consumed as heat, produced by non-electric applications. 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). EIA estimates U.S. wood consumption in the residential, other commercial, and other industrial sectors 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). SEDS allocates the estimates to the states. EIA estimates U.S. **biofuels** consumption based on data collected from various survey forms and reported in PSA and MER. SEDS estimates state-level consumption by sector for biodiesel, fuel ethanol, and renewable diesel. SEDS does not estimate state-level consumption for other biofuels.

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

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

Net interstate flow of electricity. For 1990 forward, EIA's *State Electricity Profiles* provide net interstate electricity flows in kilowatthours. For 1960 forward, SEDS estimates the heat content of these series in British thermal units (Btu).

Electrical system energy losses. SEDS estimates these series.

Energy-consuming sectors

SEDS bases its consumption estimates on data collected by various surveys that define the consuming sectors differently. The technical notes of this report describe how SEDS combines the collected data series for each energy source and assigns them to the consuming sectors. To the degree possible, SEDS assigns energy consumption 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 equipment. Note: This sector includes generators that produce electricity and/or useful thermal output primarily to support commercial activities.
- **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

Energy consumption measures—total and end use

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

Primary energy sources are measured in different physical units, for example coal in short tons, liquid fuels in barrels or gallons, and natural gas in cubic feet. Energy sources are also measured by their heat content, such as in British thermal units (Btu), to compare different types of energy to each other. The heat content per unit of physical unit (thermal conversion factors) represents the gross (or higher or upper) energy content of the fuel. For example, in 2022, the average short ton of coal consumed by the electric power sector contained 18.792 million Btu (Appendix B, Table B13), the average barrel of distillate fuel oil contained 5.765 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 is 3,412 Btu

per kilowatthour.

In 2022 the electric power sector consumed 33.1 quadrillion Btu of primary energy to provide 13.4 quadrillion Btu of electricity sales to ultimate customers in the residential, commercial, industrial and transportation sectors. These data show that 59% of the primary energy in the fuels consumed to generate the electricity was used (or “lost”) to convert the primary energy into electricity and distribute it to the end-use sectors. Only 41% of the primary energy was used as electricity by end users.

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 from primary energy is not double counted. Tables titled “End-use sector consumption” include columns for the primary sources and electricity 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 “End Use” is the sum of the primary sources and electricity, excluding the electrical system energy losses. See Section 7 “Total energy” for details.

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 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 SEDS makes the end-use allocations according to these aggregations as closely as possible, some data sources collect information 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. Before 1996, EIA collected and reported natural gas used in agriculture, forestry, and fisheries in the commercial sector. For 1996 forward, EIA collects and reports natural gas used for agriculture, forestry, and fisheries 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 use of electricity, natural gas, or fuel oil to be included in the commercial sector. SEDS makes no adjustments for these discrepancies.

SEDS does not provide further disaggregated end-use sector consumption estimates. For example, the industrial sector cannot be broken down into the chemical or rubber industries, all manufacturing, or agriculture. Additional disaggregated regional information, such as counties or cities, are also not available in SEDS.