

Section 5. Renewable Energy

The renewable energy sources included in the State Energy Data System (SEDS) are biodiesel, fuel ethanol, wood, waste, hydroelectric, geothermal, solar, and wind energy.

Biodiesel

Biodiesel is a renewable fuel that can be made from vegetable oils, animal fats, and recycled grease. Biodiesel can be used with, or as a substitute for, petroleum-derived diesel or distillate fuel oil in vehicles or any equipment that operates with diesel fuel. While some smaller amounts of biodiesel are consumed in other sectors, SEDS assigns all biodiesel consumption to the transportation sector because of a lack of information to allocate to the other sectors. For 2001 forward, biodiesel estimates are compiled in SEDS and shown in the tables on primary energy consumption by source.

Physical units

The biodiesel consumption data series in physical units are identified in SEDS by the following names (“ZZ” in the variable name represents the two-letter state code that differs for each state):

- BDTCPUS = biodiesel total consumption in the United States, in thousand barrels
- BDTCPZZ = biodiesel total consumption by state, in thousand barrels

For 2001 forward, the U.S. total biodiesel consumption is developed by the U.S. Energy Information Administration (EIA) and published in EIA’s *Monthly Energy Review*. For 2011 forward, internal EIA estimates of biodiesel consumption by Petroleum Administration for Defense District (PADD) are calculated using PADD-level biodiesel production, net receipts to refineries, net imports, and stock change.

For 2001 through 2010, the state estimates are calculated using the 2011 state shares applied to the U.S. total biodiesel consumption from EIA’s *Monthly Energy Review* for each year.

For 2011 forward, the state estimates are calculated using EIA’s U.S. total biodiesel consumption, internal EIA PADD-level estimates, state-level

reported data, and state-level biodiesel blend ratio mandates.

Some states self-report annual biodiesel consumption in their state, and SEDS assumes those values for those states. State reported biodiesel consumption is available from California’s Air Resources Board, *Low Carbon Fuel Standard Reporting Tool Quarterly Summaries* (2011 forward), Hawaii’s Department of Business, Economic Development & Tourism Data Warehouse (2011 forward, for utility use), Iowa’s Department of Revenue, *Retailers Fuel Gallons Annual Report* and the Iowa Renewable Fuels Association (2011 forward), Montana’s Energy Office (2016 forward), New Mexico’s Department of Agriculture (2016 forward), and Oregon’s Data for the Clean Fuel Program (2016 forward).

Some states have mandates that require a minimum ratio of biodiesel to be blended with petroleum-derived diesel or distillate fuel oil. SEDS assumes that the mandates are the minimum ratio of biodiesel consumption to distillate fuel oil consumption in those states, and biodiesel consumption in these states can exceed the reported blend ratio mandate. States with mandates include Hawaii (5% of distillate fuel oil consumption in the transportation sector for 2016 forward), Illinois (8% for 2011 forward), Minnesota (5% from 2011 to 2013, 6.3% in 2014, 7.5% from 2015 to 2017, and 10% in 2018), New York (2% from 2011 to 2016, 2% of distillate fuel oil consumption in the transportation sector and 3.5% of all other sectors for 2017 and 2018), Oregon (2% to 4.2% from 2011 to 2015), Pennsylvania (2% for 2011 forward), and Washington (2% for 2011 forward).

For the rest of the states, biodiesel consumption is estimated using the following data and methodology:

- U.S. biodiesel consumption (BDTCPUS) reported in EIA’s Monthly Energy Review is allocated to the corresponding PADD using internal EIA estimates.
- Reported state biodiesel consumption and minimum biodiesel blend ratios from state mandates are removed from the PADD estimates.
- The remaining volume of biodiesel for each PADD is then allocated to all the states without reported data in proportion to the value of each state’s distillate fuel oil consumption.

SEDS assigns all biodiesel consumption to the transportation sector (BDACP):

$$\begin{aligned}
 \text{BDACPZZ} &= \text{BDTCPZZ} \\
 \text{BDACPUS} &= \sum \text{BDACPZZ}
 \end{aligned}$$

British thermal units (Btu)

Estimates for biodiesel consumption in Btu are developed by multiplying the estimated physical unit consumption by EIA’s heat content conversion factor for biodiesel (5.359 million Btu per barrel). Btu consumption by state and for the United States are:

$$\begin{aligned} \text{BDACBZZ} &= \text{BDACPZZ} * 5.359 \\ \text{BDACBUS} &= \text{BDACBZZ} \\ \text{BDTCBZZ} &= \text{BDACBZZ} \\ \text{BDTCBUS} &= \text{BDTCBZZ} \end{aligned}$$

Energy losses and co-products from biodiesel production

Beginning in 2001, energy losses and co-products from the production of biodiesel are incorporated into state and U.S. industrial sector energy consumption (TEICBZZ and TEICBUS). This concept is defined as the difference between the heat content of the biomass inputs to the production of biodiesel and the heat content of the biodiesel produced. Energy losses for the United States are allocated to the states according to the biodiesel production share for each state. Energy losses for each state and the United States are then added to state and U.S. industrial and total energy consumption.

$$\begin{aligned} \text{BDLCBUS} &= \text{energy losses and co-products from the production of} \\ &\quad \text{biodiesel for the United States, in billion Btu;} \\ \text{BDPRBUS} &= \text{production of biodiesel for the United States, in billion} \\ &\quad \text{Btu; and} \\ \text{BDPRBZZ} &= \text{production of biodiesel by state, in billion Btu.} \\ \text{BDLCBZZ} &= (\text{BDPRBZZ} / \text{BDPRBUS}) * \text{BDLCBUS} \end{aligned}$$

Additional note

Because of differences in data sources and estimation methods, the ratio of biodiesel consumption to distillate fuel oil consumption should not be interpreted as the average biodiesel blend ratio.

Data sources

BDTCPUS — Biodiesel total consumption in the United States.

- 1960 through 2000: No data available. Values are assumed to be zero.
- 2001 forward: EIA, *Monthly Energy Review*, Table 10.4.

Fuel Ethanol

Fuel ethanol is used as a gasoline octane enhancer and oxygenate. A small amount of fuel ethanol is used as an alternative fuel, such as E85. It is typically produced biologically from biomass feedstocks such as agricultural crops and cellulosic residues from agricultural crops or wood. It can also be produced chemically from ethylene. For 1981 forward, fuel ethanol estimates are compiled in SEDS and shown in the tables on primary energy consumption by source.

The U.S. total fuel ethanol consumption in SEDS is a series developed by the U.S. Energy Information Administration (EIA) from annual reports of field production of oxygenated gasoline (before 2005), finished motor gasoline and motor gasoline blending components adjustments (2005 forward), and refinery and blender net inputs of fuel ethanol and an adjustment item (all years). The fuel ethanol in physical units is denatured fuel ethanol, which includes a small amount of denaturant added to the fuel ethanol to make it unfit for human consumption.

Through 2004, the U.S. total is allocated to the states using data series on gasohol or fuel ethanol published by the U.S. Department of Transportation, Federal Highway Administration (FHWA).

For 2005 through 2009, the state estimates are calculated using the following EIA data series and assumptions:

- estimated use of fuel ethanol by Petroleum Administration for Defense (PAD) Refining District
- prime supplier sales of conventional (including oxygenated) gasoline and reformulated gasoline by state
- production of conventional and reformulated gasoline, total and blended with alcohol, by PAD Refining District
- a standard ethanol-to-motor gasoline ratio of 10% for all states except Alaska (0%), California (5.7%), and Minnesota (12%)

First, fuel ethanol consumption by refining district is estimated by adding fuel ethanol used as refinery and blender net inputs and an adjustment item derived from the supply and disposition of petroleum and other liquids. Next, the shares of both conventional and reformulated gasoline blended with fuel ethanol are calculated for each Refining District. Then, a set of preliminary state estimates for fuel ethanol blended into motor gasoline is calculated by multiplying the prime supplier sales for both conventional and reformulated gasoline with the corresponding share of gasoline blended with alcohol and the ethanol-to-gasoline ratio, and summing them together for each state. Finally, the preliminary state-level fuel ethanol estimates are scaled to the

fuel ethanol use for each Refining District.

For 2010 forward, the estimation method is refined. Data series and assumptions used in the calculation include

- U.S. fuel ethanol consumption
- motor gasoline consumption by state from SEDS
- prime supplier sales of conventional gasoline and reformulated gasoline by state
- production of conventional and reformulated gasoline, total and blended with fuel ethanol, by PAD Refining District
- inter-PADD movements of conventional gasoline
- net exports of conventional gasoline by PAD Refining District
- a standard ethanol-to-motor gasoline ratio of 10% for all states except Alaska (0%), Iowa (12%), and Minnesota (12%)

First, state-level motor gasoline consumption is allocated to conventional and reformulated gasoline consumption using the corresponding prime supplier sales ratios. Next, the shares of both conventional and reformulated gasoline blended with fuel ethanol are calculated for each Refining District. To better account for the amount of conventional gasoline in the denominator, the share is adjusted by inter-PADD movements and net exports. Then, a set of preliminary fuel ethanol consumption estimates is calculated by multiplying the state-level conventional and reformulated gasoline consumption estimates by the corresponding District-level shares of gasoline blended with fuel ethanol as well as by the ethanol-to-gasoline ratio. The preliminary conventional and reformulated ethanol uses are then summed together for each state. Finally, the preliminary estimates are adjusted to sum to the U.S. fuel ethanol total consumption.

The fuel ethanol data series are identified in SEDS by the following names ("ZZ" in the variable name represents the two-letter state code that differs for each state):

- ENTCPUS = fuel ethanol total consumption in the United States, in thousand barrels;
- ENTCBUS = fuel ethanol total consumption in the United States, in billion Btu; and
- ENTRPZZ = fuel ethanol blended into motor gasoline (1993 forward) or total gasohol sales (1981 through 1992) by states, in thousand gallons.

The U.S. total of the state series, ENTRPUS, is calculated as the sum of the state data, ENTRPZZ. The U.S. value, ENTCPUS, is allocated to the states in proportion to the state estimates, ENTRPZZ:

$$\begin{aligned} \text{ENTRPUS} &= \sum \text{ENTRPZZ} \\ \text{ENTCPZZ} &= (\text{ENTRPZZ} / \text{ENTRPUS}) * \text{ENTCPUS} \end{aligned}$$

Fuel ethanol total consumption by state, ENTCPZZ, is allocated to the commercial, industrial, and transportation sectors according to the motor gasoline consumption share for each sector:

$$\begin{aligned} \text{ENACPZZ} &= (\text{MGACPZZ} / \text{MGTCPZZ}) * \text{ENTCPZZ} \\ \text{ENCCPZZ} &= (\text{MGCCPZZ} / \text{MGTCPZZ}) * \text{ENTCPZZ} \\ \text{ENICPZZ} &= (\text{MGICPZZ} / \text{MGTCPZZ}) * \text{ENTCPZZ} \end{aligned}$$

The U.S. consumption estimates for the three sectors are calculated as the sum of the states' values.

Fuel ethanol total consumption by state in Btu, ENTCBZZ, is calculated by multiplying U.S. fuel ethanol total consumption in Btu with the state share of fuel ethanol consumption in physical unit:

$$\text{ENTCBZZ} = (\text{ENTCPZZ} / \text{ENTCPUS}) * \text{ENTCBUS}$$

Fuel ethanol total consumption by state in Btu is allocated to the commercial, industrial, and transportation sectors according to the motor gasoline consumption share for each sector:

$$\begin{aligned} \text{ENACBZZ} &= (\text{MGACPZZ} / \text{MGTCPZZ}) * \text{ENTCBZZ} \\ \text{ENCCBZZ} &= (\text{MGCCPZZ} / \text{MGTCPZZ}) * \text{ENTCBZZ} \\ \text{ENICBZZ} &= (\text{MGICPZZ} / \text{MGTCPZZ}) * \text{ENTCBZZ} \\ \text{ENACBUS} &= \sum \text{ENACBZZ} \\ \text{ENCCBUS} &= \sum \text{ENCCBZZ} \\ \text{ENICBUS} &= \sum \text{ENICBZZ} \end{aligned}$$

The U.S. fuel ethanol conversion factor is derived from the U.S. fuel ethanol total consumption in Btu and in physical unit:

$$\text{ENTCKUS} = \text{ENTCBUS} / \text{ENTCPUS}$$

Fuel ethanol excluding denaturant

Fuel ethanol contains a small amount of denaturant, which is added to make the finished product unsuitable for human consumption. Fuel ethanol denaturant is typically natural gasoline (pentanes plus) or conventional gasoline. These volumes are already accounted for under petroleum. Therefore, to avoid double-counting, and to separately identify the renewable content of fuel ethanol, EIA estimates the Btu content of fuel ethanol excluding denaturant consumed by the United States. This is then allocated to the states based on

the states shares of fuel ethanol consumption, as follows:

EMTCBUS = fuel ethanol, excluding denaturant, consumed in the United States, in billion Btu.

EMTCBZZ = $(ENTCBZZ / EMTCBUS) * EMTCBUS$

Similarly, fuel ethanol excluding denaturant is allocated to the commercial, industrial, and transportation sectors according to the motor gasoline consumption share for each sector:

EMACBZZ = $(MGACPZZ / MGTCPZZ) * EMTCBZZ$

EMCCBZZ = $(MGCCPZZ / MGTCPZZ) * EMTCBZZ$

EMICBZZ = $(MGICPZZ / MGTCPZZ) * EMTCBZZ$

EMACBUS = $\Sigma EMACBZZ$

EMCCBUS = $\Sigma EMCCBZZ$

EMICBUS = $\Sigma EMICBZZ$

Energy losses and co-products from fuel ethanol production

Beginning in 1981, energy losses and co-products from the production of fuel ethanol are incorporated into state and U.S. industrial sector energy consumption (TEICBZZ and TEICBUS). This concept is defined as the difference between the heat content of the biomass inputs to the production of fuel ethanol and the heat content of the fuel ethanol produced. Energy losses for the United States are allocated to the states according to the fuel ethanol production share for each state. Energy losses for each state and the United States are then added to state and U.S. industrial and total energy consumption.

EMLCBUS = energy losses and co-products from the production of fuel ethanol for the United States, in billion Btu;

EMPRBUS = production of fuel ethanol, excluding denaturant, for the United States, in billion Btu; and

EMPRBZZ = production of fuel ethanol, excluding denaturant, by state, in billion Btu.

EMLCBZZ = $(EMPRBZZ / EMPRBUS) * EMLCBUS$

Additional notes

1. Because of differences in data sources and estimation methods, the ratio of fuel ethanol consumption to motor gasoline consumption should not be interpreted as the average ethanol blend rate.

2. Fuel ethanol data blended into motor gasoline (ENTRPZZ) are published in FHWA *Highway Statistics* from 1993 through 2001, 2003, and 2004.

In 2002, fuel ethanol blended into motor gasoline is not available from *Highway Statistics*. The ratio of each state’s fuel ethanol in gasohol to total gasohol consumption is calculated for 2001 and 2003. The two ratios for each state are averaged and the average is applied to each state’s 2002 total gasohol consumption to derive the amount of fuel ethanol consumed in gasohol in 2002. Fuel ethanol and gasohol data for Florida, Massachusetts, and Rhode Island are available for only 2001 or 2003; in these instances, the ratio of only the available year is used.

Data sources

EMLCBUS — Energy losses and co-products from the production of fuel ethanol for the United States.

- 1960 through 1980: No data available. Values are assumed to be zero.
- 1981 forward: EIA, *Monthly Energy Review*, Table 10.3.

EMPRBUS — Production of fuel ethanol excluding denaturant for the United States.

- 1960 through 1980: No data available. Values are assumed to be zero.
- 1981 forward: EIA, *Monthly Energy Review*, Table 10.3.

EMPRBZZ — Production of fuel ethanol excluding denaturant by state.

- 1960 through 1980: No data available. Values are assumed to be zero.
- 1981 forward: EIA, State Energy Data System, production estimates.

EMTCBUS — Fuel ethanol excluding denaturant consumed in the United States in billion Btu.

- 1960 through 1980: No data available. Values are assumed to be zero.
- 1981 forward: EIA, *Monthly Energy Review*, Table 10.3.

ENTCBUS — Fuel ethanol including denaturant consumed in the United States in billion Btu.

- 1960 through 1980: No data available. Values are assumed to be zero.
- 1981 forward: EIA, *Monthly Energy Review*, Table 10.3.

ENTCPUS — Fuel ethanol, including denaturant, consumed in the United States.

- 1960 through 1980: No data available. Values are assumed to be zero.
- 1981 through 1992:
 - 1981, 1984, 1987, and 1989: EIA, *Estimates of U.S. Biofuels Consumption 1990*, Table 10.
 - 1982 and 1983: EIA, Office of Coal, Nuclear, Electric, and Alternate Fuels estimates.
 - 1985, 1986, 1988, and 1991: Values interpolated.
 - 1990 and 1992: EIA, *Estimates of U.S. Biomass Energy Consumption 1992*, Table D1.
- 1993 through 2004: EIA estimates based on data in the EIA *Petroleum Supply Annual*, (PSA) Tables 2 and 16. Ten percent of the “Field Production” of “Oxygenated Finished Motor Gasoline” from the PSA Table 2 is added to the “Refinery Input of Fuel Ethanol” from the PSA Table 16.
- 2005 through 2008: EIA estimates based on data in the EIA PSA, Tables 1 and 15. Motor gasoline blending components adjustments and finished motor gasoline adjustments from PSA, Table 1, are added to fuel ethanol refinery and blender net inputs from PSA, Table 15.
- 2009 forward: EIA estimates based on data in the EIA PSA, Table 1. Fuel Ethanol Stock Exchange and Fuel Ethanol Exports are subtracted from Fuel Ethanol Renewable Fuels and Oxygenate Plant Net Production and Fuel Ethanol Imports.

http://www.eia.gov/dnav/pet/pet_pnp_refp_a_epm0f_ypr_mbb1_a.htm, Refinery and Blender Net Production for the finished motor gasoline products—http://www.eia.gov/dnav/pet/pet_sum_snd_a_EPOOXE_mbb1_a_cur.htm. See explanation of estimation methodology on page 95.

- 2010 forward: EIA estimates based on Petroleum & Other Liquids data website, Prime Supplier Sales Volumes, Motor Gasoline http://www.eia.gov/dnav/pet/pet_cons_prim_a_epm0_p00_mgalpd_a.htm, Refinery and Blender Net Production for the finished motor gasoline products—http://www.eia.gov/dnav/pet/pet_pnp_refp_a_epm0f_ypr_mbb1_a.htm, movements of conventional gasoline between PAD Districts—http://www.eia.gov/dnav/pet/pet_move_ptb_a_EPMOC_TNR_mbb1_a.htm, and unpublished imports and exports of conventional gasoline by Refining District. See explanation of estimation methodology on page 95.

ENTRPZZ — Fuel ethanol blended into motor gasoline by state.

- 1960 through 1980: Values are set to be zero.
- 1981 through 1992: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics, Summary to 1995*, Table MF-233GLA.
- 1993 through 1995: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics, Summary to 1995*, Table MF-233E, column titled “Total Ethanol Used in Gasohol.”
- 1996 through 2001, 2003, and 2004: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Table MF-33E, column titled “Total Ethanol Used in Gasohol.”
- 2002: EIA estimates based on the 2001 and 2003 data from *Highway Statistics*. For an explanation of the estimation methodology, see the “Additional Notes” on page 96.
- 2005 through 2009: EIA estimates based on Petroleum & Other Liquids data website, Prime Supplier Sales Volumes, Motor Gasoline http://www.eia.gov/dnav/pet/pet_cons_prim_a_epm0_p00_

Geothermal Energy

Electricity generated from geothermal energy is included in the State Energy Data System (SEDS) for all years. Before 1989, it covered geothermal energy input at electric utilities only; for 1989 forward, it includes geothermal energy input for independent power producers in the electric power sector. For 2018 forward, it also covers input for utility-scale commercial CHP and electricity-only facilities. The data series are identified in SEDS by the following names (“ZZ” in the variable name represents the two-letter state code that differs for each state):

- GEEGPZZ = geothermal electricity net generation in the electric power sector by state, in million kilowatthours, and
- GEC5PZZ = geothermal electricity net generation at utility-scale commercial CHP and electricity-only facilities by state, in million kilowatthours.

Geothermal energy is also used as direct heat or from heat pumps in the residential, commercial (excluding CHP and electricity-only facilities), and industrial sectors. National estimates of geothermal energy consumption for these three end-use sectors for 1989 through 2011 were developed by the Oregon Institute of Technology Geo-Heat Center, which also provided state estimates for selected years (see additional notes on page 98). From 2012 forward, estimates are no longer available from the Geo-Heat Center. The U.S. consumption for these series, estimated by EIA and reported in the *Monthly Energy Review*, is allocated to the states using each state’s average share of U.S. geothermal energy consumption for 2009 through 2011.

These data series are identified in SEDS by the following names (“ZZ” in the variable name represents the two-letter state code that differs for each state). For the residential and industrial sectors, they represent all geothermal energy consumed:

- GEC4BZZ = geothermal energy consumed as direct heat or from heat pumps in the commercial sector by state, in billion British thermal units (Btu);
- GEICBZZ = geothermal energy consumed by the industrial sector by state, in billion Btu; and
- GERCBZZ = geothermal energy consumed by the residential sector by state, in billion Btu.

The U.S. totals for the state-level series are calculated by summing the state data:

- GEEGPUS = Σ GEEGPZZ
- GEC5PUS = Σ GEC5PZZ
- GEC4BUS = Σ GEC4BZZ
- GEICBUS = Σ GEICBZZ
- GERCBUS = Σ GERCBZZ

Geothermal electricity net generation in the electric power sector and the commercial CHP and electricity-only facilities is converted from kilowatthours to British thermal units (Btu) by using the U.S. average heat content of fossil fuels consumed at steam-electric power plants, FFETKUS, as a conversion factor. The annual values for this factor are shown in the Consumption Technical Notes, Appendix B, Table B1, <http://www.eia.gov/state/seds/seds-technical-notes-complete.php>.

- FFETKUS = factor for converting geothermal electricity net generation from kilowatthours to Btu.

The values for the electric power sector in each state are converted to Btu and the U.S. total is the sum of the state data:

- GEEGBZZ = GEEGPZZ * FFETKUS
- GEEGBUS = Σ GEEGBZZ

The values for geothermal energy consumed in the commercial CHP and electricity-only facilities in each state are converted to Btu:

- GEC5BZZ = GEC5PZZ * FFETKUS

Total commercial sector consumption is the sum of geothermal consumed as direct heat or from heat pumps and in CHP and electricity-only facilities. The U.S. total is the sum of the state data.

- GECCBZZ = GEC5BZZ + GEC4BZZ
- GECCBUS = Σ GECCBZZ

The state totals for geothermal energy are the sum of the residential, commercial, and industrial sectors’ use and the electric power sector’s geothermal-based generation. The U.S. total is the sum of the state data.

- GETCBZZ = GERCBZZ + GECCBZZ + GEICBZZ + GEEGBZZ
- GETCBUS = Σ GETCBZZ

Additional notes

Consumption estimates of geothermal energy in the residential, commercial,

and industrial sectors are from the Oregon Institute of Technology Geo-Heat Center. State data for 1989 and 1994 are based on surveys of geothermal equipment producers, distributors, and installers and state energy offices. State estimates from 1998 forward are developed by the Geo-Heat Center from discussions with industry sources.

The state data for 1989, 1994, and 1998 are used by the U.S. Energy Information Administration (EIA) to estimate the state values for intervening years. States with the same value in two survey years are assigned that value for each intervening year. For states with increases or decreases in the survey data, the difference is allocated evenly over the intervening years. If a state went from zero to a value or from a value to zero, it was given zero in the intervening years. The state data for each intervening year are summed and states with increasing or decreasing values are adjusted until the U.S. total equals the U.S. total estimated by the Oregon Institute of Technology Geo-Heat Center.

Data sources

FFETKUS — Fossil-fueled steam-electric power plant conversion factor.

- 1960 through 1988: Estimated by EIA as the weighted annual average heat rate for fossil-fueled steam-electric plants in the United States as published in the EIA, *Electric Plant Cost and Power Production Expenses 1991*, Table 9.
- 1989 through 2000: Calculated annually by EIA by using heat rate data reported on Form EIA-860, “Annual Electric Generator Report” (and predecessor forms); and net generation data reported on Form EIA-759, “Monthly Power Plant Report.” The computation includes data for all electric utility steam-electric plants using fossil fuels.
- 2001 forward: Calculated annually by EIA by using fuel consumption and net generation data reported on Form EIA-923, “Power Plant Operations Report,” and predecessor forms. The computation includes data for all electric utilities and electricity-only independent power producers using fossil fuels.

GEC4BUS — Geothermal energy as direct heat or from heat pumps in the commercial sector in the United States.

- 2012 forward: EIA, *Monthly Energy Review*, Table 10.2a and unpublished data.

GEC4BZZ — Geothermal energy consumed as direct heat or from heat pumps

in the commercial sector by state.

- 1960 through 1988: No data available. Values assumed to be zero.
- 1989: Oregon Institute of Technology Geo-Heat Center, unpublished tables (April 1999) based on a survey.
- 1990 through 1993: U.S. totals are estimates from the Oregon Institute of Technology Geo-Heat Center, unpublished tables. State data for 1989 and 1994 are used to estimate state values for the intervening years. For an explanation of the estimation methodology, see the “Additional Note” on page 98.
- 1994: Oregon Institute of Technology Geo-Heat Center, unpublished tables (April 1999) based on a survey.
- 1995 through 1997: U.S. totals are from the Oregon Institute of Technology Geo-Heat Center, unpublished tables. State data for 1994 and 1998 are used to estimate state values for the intervening years. For an explanation of the estimation methodology, see the “Additional Note” on page 98.
- 1998 through 2011: Oregon Institute of Technology Geo-Heat Center, unpublished tables based on informal surveys and estimations.
- 2012 forward: Estimated by EIA, based on Oregon Institute of Technology Geo-Heat Center data.

GEC5PZZ — Geothermal electricity net generation at utility-scale commercial CHP and electricity-only facilities by state.

- 1960 through 2017: Values are assumed to be zero.
- 2018 forward: EIA, Form EIA-923, “Power Plant Operations Report.”

GEEGPZZ — Geothermal electricity net generation in the electric power sector by state.

- 1960 forward: EIA, Form EIA-923, “Power Plant Operations Report,” and predecessor forms.

GEICBUS — Geothermal energy consumed by the industrial sector in the United States.

- 2012 forward: EIA, *Monthly Energy Review*, Table 10.2b.

GEICBZZ — Geothermal energy consumed by the industrial sector by state.

- 1960 through 1988: No data available. Values assumed to be zero.
- 1989: Oregon Institute of Technology Geo-Heat Center, unpublished

tables (April 1999) based on a survey.

- 1990 through 1993: U.S. totals are estimates from the Oregon Institute of Technology Geo-Heat Center, unpublished tables. State data for 1989 and 1994 are used to estimate state values for the intervening years. For an explanation of the estimation methodology, see the “Additional Note” on page 98.
- 1994: Oregon Institute of Technology Geo-Heat Center, unpublished tables, (April 1999) based on a survey.
- 1995 through 1997: U.S. totals are from the Oregon Institute of Technology Geo-Heat Center, unpublished tables. State data for 1994 and 1998 are used to estimate state values for the intervening years. For an explanation of the estimation methodology, see the “Additional Note” on page 98.
- 1998 through 2011: Oregon Institute of Technology Geo-Heat Center, unpublished tables based on informal surveys and estimations.
- 2012 forward: Estimated by EIA, based on Oregon Institute of Technology Geo-Heat Center data.

unpublished tables based on informal surveys and estimations.

- 2012 forward: Estimated by EIA, based on Oregon Institute of Technology Geo-Heat Center data.

GERCBUS — Geothermal energy consumed by the residential sector in the United States.

- 2012 forward: EIA, *Monthly Energy Review*, Table 10.2a.

GERCBZZ — Geothermal energy consumed by the residential sector by state.

- 1960 through 1988: No data available. Values assumed to be zero.
- 1989: Oregon Institute of Technology Geo-Heat Center, unpublished tables (April 1999) based on a survey.
- 1990 through 1993: U.S. totals are estimates from the Oregon Institute of Technology Geo-Heat Center, unpublished tables. State data for 1989 and 1994 are used to estimate state values for the intervening years. For an explanation of the estimation methodology, see the “Additional Note” on page 98.
- 1994: Oregon Institute of Technology Geo-Heat Center, unpublished tables (April 1999) based on a survey.
- 1995 through 1997: U.S. totals are from the Oregon Institute of Technology Geo-Heat Center, unpublished tables. State data for 1994 and 1998 are used to estimate state values for the intervening years. For an explanation of the estimation methodology, see the “Additional Note” on page 98.
- 1998 through 2011: Oregon Institute of Technology Geo-Heat Center,

Hydroelectric Power

Electricity generated from hydropower is included in the State Energy Data System (SEDS) in the industrial and electric power sectors for all years, 1960 forward, and in the commercial sector for 1989 forward. In the electric power sector, there are two types of hydroelectricity: conventional hydroelectricity and pumped-storage hydroelectricity. Conventional hydroelectricity uses falling water to drive turbines to produce electricity. Pumped-storage hydroelectricity is generated by releasing water that has been pumped into an elevated storage reservoir during off-peak periods to drive the turbines during times of peak demand. Electricity produced from pumped storage, when it can be identified separately, is not included in energy consumption estimates because the energy that was used to pump the water is already accounted for. Hydroelectricity data series included in SEDS are identified by the following names ("ZZ" in the name represents the two-letter state code that differs for each state):

- HVEGPZZ = conventional hydroelectricity net generation in the electric power sector by state, in million kilowatthours;
- HVC5PZZ = conventional hydroelectricity net generation at commercial CHP and electricity-only facilities by state, in million kilowatthours; and
- HVI5PZZ = conventional hydroelectricity net generation at industrial CHP and electricity-only facilities by state, in million kilowatthours.

The U.S. value for each of the series is the sum of the state data.

Total use of hydroelectricity in the commercial, industrial, and electric power sectors is assumed to be the electricity generated by conventional hydroelectricity. The U.S. total for each sector is the sum of the state values:

- HYCCPZZ = HVC5PZZ
- HYCCPUS = Σ HYCCPZZ
- HYICPZZ = HVI5PZZ
- HYICPUS = Σ HYICPZZ
- HYEGPZZ = HVEGPZZ
- HYEGPUS = Σ HYEGPZZ

Hydroelectricity net generation is converted from kilowatthours to British thermal units (Btu) by using the U.S. average heat content of fossil fuels consumed at steam-electric power plants, FFETKUS, as a conversion factor. The annual values for this factor are shown in the Consumption Technical

Notes, Appendix B, Table B1, <http://www.eia.gov/state/seds/seds-technical-notes-complete.php>.

- HYCCBZZ = HYCCPZZ * FFETKUS
- HYICBZZ = HYICPZZ * FFETKUS
- HYEGBZZ = HYEGPZZ * FFETKUS

The U.S. value for each of the series is the sum of the state data.

Total hydroelectricity consumption for each state is the sum of the commercial, industrial, and electric power sectors' generation.

- HYTCPZZ = HYCCPZZ + HYICPZZ + HYEGPZZ
- HYTCPUS = Σ HYTCPZZ
- HYTCBZZ = HYCCBZZ + HYICBZZ + HYEGBZZ
- HYTCBUS = Σ HYTCBZZ

Data sources

FFETKUS — Fossil-fueled steam-electric power plant conversion factor.

- 1960 through 1988: Estimated by EIA as the weighted annual average heat rate for fossil-fueled steam-electric plants in the United States as published in the EIA, *Electric Plant Cost and Power Production Expenses 1991*, Table 9.
- 1989 through 2000: Calculated annually by EIA by using heat rate data reported on Form EIA-860, "Annual Electric Generator Report" (and predecessor forms); and net generation data reported on Form EIA-759, "Monthly Power Plant Report." The computation includes data for all electric utility steam-electric plants using fossil fuels.
- 2001 forward: Calculated annually by EIA by using fuel consumption and net generation data reported on Form EIA-923, "Power Plant Operations Report," and predecessor forms. The computation includes data for all electric utilities and electricity-only independent power producers using fossil fuels.

HVC5PZZ — Conventional hydroelectricity net generation at commercial CHP and electricity-only facilities by state.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 forward: EIA, Form EIA-923, "Power Plant Operations Report," and predecessor forms.

HVI5PZZ — Conventional hydroelectricity net generation at industrial CHP

and electricity-only facilities by state.

- 1960 through 1978: Federal Power Commission, Form 4, "Monthly Power Plant Report."
- 1979 and 1980: EIA estimates based on previous years' data.
- 1981 through 1988: No data available. The 1980 data are repeated for each year.
- 1989 forward: EIA, Form EIA-923, "Power Plant Operations Report," and predecessor forms.

HVEGPZZ — Conventional hydroelectricity net generation in the electric power sector (includes pumped-storage hydroelectric power through 1989) by state.

- 1960 through 1977: Federal Power Commission, News Release, "Power Production, Fuel Consumption, and Installed Capacity Data."
- 1978 through 1980: EIA, *Energy Data Reports*, "Power Production, Fuel Consumption and Installed Capacity Data."
- 1981 through 1988: EIA, Form EIA-759, "Monthly Power Plant Report," and predecessor forms. The data rounded to gigawatthours are published in the following reports:
 - 1981 through 1985: EIA, *Electric Power Annual 1985*, Table 6.
 - 1986 and 1987: EIA, *Electric Power Annual 1987*, Table 18.
 - 1988: EIA, *Electric Power Annual 1989*, Table 14.
- 1989 forward: EIA, Form EIA-923, "Power Plant Operations Report," and predecessor forms.

Solar Energy

Solar energy consumption covers solar thermal and photovoltaic electricity generation and solar thermal energy consumed as heat. For electricity net generation in facilities with capacity of 1 megawatt or greater (utility-scale), data are collected by the U.S. Energy Information Administration (EIA) on Form EIA-923, "Power Plant Operations Report," and predecessor forms. Net generation in the electric power sector is available for 1984 forward and net generation at commercial and industrial utility-scale facilities are available for 2008 forward.

For photovoltaic electricity generation in facilities with a combined generator capacity less than 1 megawatt (small-scale), data for the residential, commercial, and industrial sectors for 2014 forward are estimated by EIA and reported in EIA's *Electric Power Annual*. State-level generation for 1989 through 2013 are calculated by allocating the national estimate, published in EIA's *Monthly Energy Review* (MER), to the states using cumulative capacity of photovoltaic installation.

For solar thermal energy consumed as heat, that is, produced by non-electric applications such as pool heating and hot water heating, the national series is estimated by EIA for 1989 forward and published in the MER. Although there are applications in the commercial and industrial sectors, they cannot be separately estimated, and all applications are included in the residential sector. The method of estimating state-level data is described on page 104.

Electric power sector

The electric power sector includes estimates of electricity produced from solar thermal and photovoltaic energy sources by electric utilities for 1984 forward, and by both electric utilities and independent power producers for 1989 forward. The data series is identified in SEDS by the following name ("ZZ" in the variable name represents the two-letter state code that differs for each state):

SOEGPZZ = solar thermal and photovoltaic electricity net generation in the electric power sector, for each state, in million kilowatthours.

The U.S. total for this series is calculated as the sum of the state data:

SOEGPUS = \sum SOEGPZZ

Solar thermal and photovoltaic electricity net generation in the electric

power sector is converted from kilowatthours to British thermal units (Btu) by using a conversion factor that is the U.S. average heat content of fossil fuels consumed at steam-electric power plants, FFETKUS. The annual values for this factor are shown in Appendix B, Table B1, <http://www.eia.gov/state/seds/seds-technical-notes-complete.php>.

FFETKUS = factor for converting solar thermal and photovoltaic electricity net generation from kilowatthours to Btu.

The values for the electric power sector in each state are converted to Btu and the U.S. total is the sum of the state data:

SOEGBZZ = SOEGPZZ * FFETKUS
SOEGBUS = ΣSOEGBZZ

Commercial sector

Solar energy consumed by the commercial sector covers solar electricity generation at utility-scale and small-scale facilities. Data for solar thermal and photovoltaic electricity net generation at commercial combined-heat-and-power (CHP) and electricity-only plants with combined generator capacity of 1 megawatt or greater (utility-scale) are available for 2008 forward. The SEDS data series is identified by the following name ("ZZ" in the name represents the two-letter state code that differs for each state):

SOC5PZZ = solar thermal and photovoltaic electricity net generation at utility-scale commercial CHP and electricity-only facilities by state, in million kilowatthours.

The U.S. value for each series is the sum of the state data.

SOC5PUS = ΣSOC5PZZ

Data for photovoltaic electricity generation at facilities with a combined generator capacity less than 1 megawatt (small-scale) in the commercial sector, not covered by EIA's power plant operations survey, are estimated by EIA for 2014 forward. The SEDS data series is identified by the following name ("ZZ" in the name represents the two-letter state code that differs for each state):

SOC7PZZ = photovoltaic electricity generation at small-scale commercial facilities by state, in million kilowatthours.

The U.S. value for the series is the sum of the state data:

SOC7PUS = ΣSOC7PZZ

Before 2014, U.S. small-scale photovoltaic electricity generation is estimated by EIA and published in the EIA *Monthly Energy Review*. For 2006 through 2013, state generation is estimated using historical growth rates of the state-level cumulative installed capacity estimated by EIA based on capacity of PV installations in the non-residential sector provided by the Interstate Renewable Energy Council (IREC) and aligned to the U.S. total. For 1989 through 2005, the U.S. total is allocated to the states using 2006 state cumulative installed capacity shares.

Consumption in Btu is calculated by using the conversion factor FFETKUS:

SOC5BZZ = SOC5PZZ * FFETKUS
SOC7BZZ = SOC7PZZ * FFETKUS

Total commercial sector solar energy consumption includes consumption of energy from both utility-scale and small-scale electricity generation:

SOCCPZZ = SOC5PZZ + SOC7PZZ
SOCCPUS = ΣSOCCPZZ
SOCCBZZ = SOC5BZZ + SOC7BZZ
SOCCBUS = ΣSOCCBZZ

Industrial sector

Solar energy consumed by the industrial sector covers solar energy generation at utility-scale and small-scale facilities. Data for solar thermal and photovoltaic electricity net generation at industrial combined-heat-and-power (CHP) and electricity-only plants with combined generator capacity of 1 megawatt or greater (utility-scale) are available for 2008 forward. The SEDS data series is identified by the following name ("ZZ" in the name represents the two-letter state code that differs for each state):

SOI5PZZ = solar thermal and photovoltaic electricity net generation at utility-scale industrial CHP and electricity-only facilities by state, in million kilowatthours.

The U.S. value for the series is the sum of the state data:

SOI5PUS = ΣSOI5PZZ

Data for photovoltaic electricity generation at facilities with a combined generator capacity less than 1 megawatt (small-scale) in the industrial sector,

not covered by EIA's power plant operations survey, are estimated by EIA for 2014 forward. The SEDS data series is identified by the following name ("ZZ" in the name represents the two-letter state code that differs for each state):

SOI7PZZ = photovoltaic electricity generation at small-scale industrial facilities by state, in million kilowatthours.

The U.S. value for the series is the sum of the state data:

SOI7PUS = Σ SOI7PZZ

Before 2014, U.S. small-scale photovoltaic electricity generation is estimated by EIA and published in the EIA *Monthly Energy Review*. For 2006 through 2013, state generation is estimated using historical growth rates of the state-level cumulative installed capacity estimated by EIA based on capacity of PV installations in the non-residential sector published by the Interstate Renewable Energy Council (IREC) and aligned to the U.S. total. For 1989 through 2005, the U.S. total is allocated to the states using 2006 state cumulative installed capacity shares.

Consumption in Btu is calculated by using the conversion factor FFETKUS:

SOI5BZZ = SOI5PZZ * FFETKUS
SOI7BZZ = SOI7PZZ * FFETKUS

Total industrial sector solar energy consumption includes consumption of energy from both utility-scale and small-scale electricity generation:

SOICPZZ = SOI5PZZ + SOI7PZZ
SOICPUS = Σ SOICPZZ
SOICBZZ = SOI5BZZ + SOI7BZZ
SOICBUS = Σ SOICBZZ

Residential sector

Solar energy consumed by the residential sector covers small-scale photovoltaic electricity generation and solar thermal energy consumed as heat. Data in British thermal units (Btu) for U.S. solar thermal energy consumed as heat are estimated by EIA and published in the EIA *Monthly Energy Review* for 1989 forward:

SOT8BUS = solar thermal energy consumed as heat in the United States, in billion Btu.

The commercial and industrial sectors also consume solar thermal energy

as heat, but those amounts cannot be separately estimated. All solar heat consumption is included in the residential sector.

A state-level series for allocating the U.S. total to the states is developed by EIA from accumulated data on shipments of solar thermal collectors to states, measured in square feet, as collected on Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey," and predecessor forms. The data were published in the EIA *Renewable Energy Annual*. The assumption is made that the retirement/replacement period for solar thermal collectors is 20 years. See "Additional Notes on Solar Energy" on page 105 for more details. The data series are identified in SEDS by the following names ("ZZ" in the variable name represents the two-letter state code that differs for each state):

SOTTPZZ = rolling 20-year accumulation of shipments of solar thermal energy collectors by state, in square feet.

The U.S. total of shipments of solar thermal energy collectors is calculated as the sum of the state data:

SOTTPUS = Σ SOTTPZZ

The survey EIA-63A was terminated in 2012 and data for 2010 forward are not available from EIA or other sources. The 2009 values for SOTTPZZ are used for 2010 forward.

The U.S. solar thermal energy consumed as heat is allocated to the states as follows:

SOT8BZZ = (SOTTPZZ / SOTTPUS) * SOT8BUS

Data for photovoltaic electricity generation by small-scale applications in the residential sector are estimated by EIA for 2014 forward. The SEDS data series is identified by the following name ("ZZ" in the name represents the two-letter state code that differs for each state):

SOR7PZZ = photovoltaic electricity generation by small-scale applications in the residential sector by state, in million kilowatthours.

The U.S. value for the series is the sum of the state data:

SOI7PUS = Σ SOI7PZZ

Before 2014, U.S. small-scale photovoltaic electricity generation is estimated by EIA and published in the EIA *Monthly Energy Review*. For 2006 through 2013, state generation is estimated using historical growth rates of the state-

level cumulative installed capacity estimated by EIA based on capacity of PV installations in the residential sector provided by the Interstate Renewable Energy Council (IREC) and aligned to the U.S. total. For 1989 through 2005, the U.S. total is allocated to the states using 2006 state cumulative installed capacity shares.

Consumption in Btu is calculated by using the conversion factor FFETKUS:

$$\text{SOR7BZZ} = \text{SOR7PZZ} * \text{FFETKUS}$$

Total residential sector solar energy consumption includes solar thermal energy consumed as heat and energy consumption from small-scale electricity generation:

$$\begin{aligned} \text{SORCBZZ} &= \text{SOT8BZZ} + \text{SOR7BZZ} \\ \text{SORCBUS} &= \sum \text{SORCBZZ} \end{aligned}$$

Total consumption

Each state's total solar energy consumption is the sum of the sectors' values, and the U.S. total is the sum of the states' totals:

$$\begin{aligned} \text{SOTCBZZ} &= \text{SOEGBZZ} + \text{SOCCBZZ} + \text{SOICBZZ} + \text{SORCBZZ} \\ \text{SOTCBUS} &= \sum \text{SOTCBZZ} \end{aligned}$$

Additional calculation

Total net generation from solar energy in both utility-scale and small-scale facilities and applications is calculated as follows:

$$\begin{aligned} \text{SOTGPZZ} &= \text{SOR7PZZ} + \text{SOCCPZZ} + \text{SOICPZZ} + \text{SOEGPZZ} \\ \text{SOTGPUS} &= \sum \text{SOTGPZZ} \end{aligned}$$

Additional notes

Shipments of solar thermal collectors in the United States, in thousand square feet, for 1974 through 2009 are collected on Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey," (and predecessor forms) and used to develop this series for 1989 forward. The data are accumulated year to year on the assumption that the replacement/retirement period for solar thermal collectors is 20 years. Data for 1974 through 1985 are available for the U.S. total only and are allocated to the states by using an allocating series that is the average of the 1986 and 1987 shipments (the first years state-level data were collected). The ratios of the average 1986 and 1987 state values to the average 1986 and 1987 U.S. value are applied to the national annual values for

each year, 1974 through 1985. Beginning in 1986, the U.S. data are adjusted to remove Puerto Rico and the Virgin Islands.

Shipments of solar thermal collectors include high-temperature parabolic dish or trough collectors used by the electric power sector. Data for California (1986 through 1996, 1998 through 2001, 2008, and 2009), Arizona (2005, 2009), and Nevada (2006) are reduced by the shipments of high-temperature parabolic dish or trough collectors to the electric power sector as shown in the EIA *Renewable Energy Annual*. See SOTTPZZ Data Sources on page 106 for source table details.

Data sources

FFETKUS — Fossil-fueled steam-electric power plant conversion factor.

- 1960 through 1988: Estimated by EIA as the weighted annual average heat rate for fossil-fueled steam-electric plants in the United States as published in the EIA, *Electric Plant Cost and Power Production Expenses 1991*, Table 9.
- 1989 through 2000: Calculated annually by EIA by using heat rate data reported on Form EIA-860, "Annual Electric Generator Report" (and predecessor forms); and net generation data reported on Form EIA-759, "Monthly Power Plant Report." The computation includes data for all electric utility steam-electric plants using fossil fuels.
- 2001 forward: Calculated annually by EIA by using fuel consumption and net generation data reported on Form EIA-923, "Power Plant Operations Report," and its predecessor forms. The computation includes data for all electric utilities and electricity-only independent power producers using fossil fuels.

SOC5PZZ — Solar thermal and photovoltaic electricity net generation at utility-scale commercial CHP and electricity-only facilities by state.

- 1960 through 2007: No data available. Values are assumed to be zero.
- 2008 forward: EIA, Form EIA-923, "Power Plant Operations Report."

SOC7PUS — Photovoltaic electricity generation at small-scale commercial facilities in the United States.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 through 2013: EIA, *Monthly Energy Review*, Table 10.6.
- 2014 forward: EIA, *Electric Power Annual*, Table 3.4.B.

SOC7PZZ — Photovoltaic electricity generation at small-scale commercial

facilities by state.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 through 2013: Estimated by EIA.
- 2014 forward: EIA, *Electric Power Annual*, Table 3.21.

SOEGPZZ — Solar thermal and photovoltaic electricity net generation in the electric power sector by state.

- 1960 through 1983: No data available. Values are assumed to be zero.
- 1984 forward: EIA, Form EIA-923, "Power Plant Operations Report," and predecessor forms.

SOI5PZZ — Solar thermal and photovoltaic electricity net generation at utility-scale industrial CHP and electricity-only facilities by state.

- 1960 through 2007: No data available. Values are assumed to be zero.
- 2008 forward: EIA, Form EIA-923, "Power Plant Operations Report."

SOI7PUS — Photovoltaic electricity generation at small-scale industrial facilities in the United States.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 through 2013: EIA, *Monthly Energy Review*, Table 10.6.
- 2014 forward: EIA, *Electric Power Annual*, Table 3.5.B.

SOI7PZZ — Photovoltaic electricity generation at small-scale industrial facilities by state.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 through 2013: Estimated by EIA.
- 2014 forward: EIA, *Electric Power Annual*, Table 3.21.

SOR7PUS — Photovoltaic electricity generation by small-scale applications in the residential sector in the United States.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 through 2013: EIA, *Monthly Energy Review*, Table 10.6.
- 2014 forward: EIA, *Electric Power Annual*, Table 3.6.

SOR7PZZ — Photovoltaic electricity generation by small-scale applications in the residential sector by state.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 through 2013: Estimated by EIA.

- 2014 forward: EIA, *Electric Power Annual*, Table 3.21.

SOT8BUS — Solar thermal energy consumed as heat in the United States.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 forward: EIA, *Monthly Energy Review*, Table 10.5.

SOTTPZZ — Rolling 20-year accumulation of shipments of solar thermal energy collectors by state.

- 1960 through 1988: Values are set to zero in SEDS for consistency with SORCBUS.
- 1989 through 2009: Shipments of solar thermal collectors in the United States, in thousand square feet, for 1974 forward are collected on Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey," (and predecessor forms) and used to develop this series for 1989 forward. The sources for these data series are
 - 1986 through 1993: EIA, *Solar Collector Manufacturing Activity* for each year. The specific table numbers are
 - 1986 through 1988, 1990: Table 5.
 - 1989: Table 4.
 - 1991 and 1992: Table 13.
 - 1993: Table 12.
 - 1994 through 2009: EIA, *Renewable Energy Annual*. Data are from the report of the following year (i.e., 1994 data are published in the *Renewable Energy Annual 1995*) for 1994 through 2000. Beginning in 2001, data are from the report of the same year. The specific tables are
 - 1994: Table 13.
 - 1995: Table F9.
 - 1996: Table 16.
 - 1997: Table 15.
 - 1998 and 1999: Table 12.
 - 2000: Unpublished data.
 - 2001 through 2003: Table 14.
 - 2004 and 2005: Table 34.
 - 2006 through 2009: Table 2.6.

Note: High-temperature parabolic dish or trough collectors shipped to the electric power sector are deducted from the solar thermal collector shipments. They are available in the following tables:

- 1986 through 1993: EIA, *Renewable Energy Annual 1995*, Table 13.
- 1994 through 2009: EIA, *Renewable Energy Annual*. Data are from

the report of the following year (i.e., 1994 data are published in the *Renewable Energy Annual 1995*) for 1994 through 2000. Beginning in 2001, data are from the report of the same year. The specific tables are

- 1994: Table H3.
- 1995: Table F10.
- 1996: Table 17.
- 1997: Table 19.
- 1998 and 1999: Table 16.
- 2000: Unpublished data.
- 2001 through 2003: Table 18.
- 2004 and 2005: Table 38.
- 2006: Table 2.10.
- 2007 through 2009: Table 2.13.

Wind Energy

Wind electricity net generation in the electric power sector is included in the State Energy Data System (SEDS) for 1983 forward. For 2009 forward, data for wind electricity net generation at utility-scale commercial and industrial combined-heat-and-power (CHP) and electricity-only plants are available from the U.S. Energy Information Administration (EIA) electric power plant survey. The data are identified in SEDS by the following name ("ZZ" in the variable name represents the two-letter state code that differs for each state):

- WYEGPZZ = wind electricity net generation in the electric power sector, by state, in million kilowatthours;
- WYC5PZZ = wind electricity net generation at utility-scale commercial CHP and electricity-only facilities by state, in million kilowatthours; and
- WYI5PZZ = wind electricity net generation at utility-scale industrial CHP and electricity-only facilities by state, in million kilowatthours.

Wind electricity net generation in the commercial and industrial sectors is represented by

- WYCCPZZ = WYC5PZZ
- WYICPZZ = WYI5PZZ

The U.S. total is calculated as the sum of the state data for each series.

Wind electricity net generation is converted from kilowatthours to British thermal units (Btu) by using a conversion factor that is the U.S. average heat content of fossil fuels consumed at steam-electric power plants, FFETKUS. The annual values for this factor are shown in Appendix B, Table B1, <http://www.eia.gov/state/seds/seds-technical-notes-complete.php>.

- FFETKUS = factor for converting wind electricity net generation from kilowatthours to Btu.
- WYEBBZZ = WYEGPZZ * FFETKUS
- WYC5BZZ = WYC5PZZ * FFETKUS
- WYI5BZZ = WYI5PZZ * FFETKUS
- WYCCBZZ = WYC5BZZ
- WYICBZZ = WYI5BZZ

The U.S. value for each of the series is the sum of the state data.

Each state's total consumption of wind electricity is the sum of the sectors'

values, and the U.S. total is the sum of the states' totals:

$$\begin{aligned} \text{WYTCPZZ} &= \text{WYEGPZZ} + \text{WYCCPZZ} + \text{WYICPZZ} \\ \text{WYTCPUS} &= \Sigma \text{WYTCPZZ} \\ \text{WYTCBZZ} &= \text{WYEBZZ} + \text{WYCCBZZ} + \text{WYICBZZ} \\ \text{WYTCBUS} &= \Sigma \text{WYTCBZZ} \end{aligned}$$

Data sources

FFETKUS — Fossil-fueled steam-electric power plant conversion factor.

- 1960 through 1988: Estimated by EIA as the weighted annual average heat rate for fossil-fueled steam-electric plants in the United States as published in the EIA, *Electric Plant Cost and Power Production Expenses 1991*, Table 9.
- 1989 through 2000: Calculated annually by EIA by using heat rate data reported on Form EIA-860, "Annual Electric Generator Report" (and predecessor forms); and net generation data reported on Form EIA-759, "Monthly Power Plant Report." The computation includes data for all electric utility steam-electric plants using fossil fuels.
- 2001 forward: Calculated annually by EIA by using fuel consumption and net generation data reported on Form EIA-923, "Power Plant Operations Report," and predecessor forms. The computation includes data for all electric utilities and electricity-only independent power producers using fossil fuels.

WYC5PZZ — Wind electricity net generation at utility-scale commercial CHP and electricity-only facilities by state.

- 1960 through 2008: No data available. Values are assumed to be zero.
- 2009 forward: EIA, Form EIA-923, "Power Plant Operations Report."

WYEGPZZ — Wind electricity net generation in the electric power sector by state.

- 1960 through 1982: No data available. Values are assumed to be zero.
- 1983 forward: EIA, Form EIA-923, "Power Plant Operations Report," and predecessor forms.

WY15PZZ — Wind electricity net generation at utility-scale industrial CHP and electricity-only facilities by state.

- 1960 through 2009: No data available. Values are assumed to be zero.
- 2010 forward: EIA, Form EIA-923, "Power Plant Operations Report."

Wood and Waste

Different forms of wood and waste are used by each consuming sector. The residential sector burns wood for space heating. The commercial sector uses wood for space heating, and it uses wood, municipal waste, and landfill gas for steam heat and electricity generation. The industrial sector uses combustible industrial byproducts and wood chips for electricity generation and process steam. The electric power sector uses wood, industrial wood waste and waste gas, and municipal waste as cofiring or primary fuels to produce electricity. Consumption of wood and waste in all sectors is included in the State Energy Data System (SEDS) for 1960 forward. Wood includes wood and wood-derived fuels. Waste is biomass waste which includes municipal solid waste from biogenic sources, landfill gas, sludge waste, agricultural byproducts, etc. Before 2001, waste also includes non-biomass waste (municipal solid waste from non-biogenic sources and tire-derived fuels).

Residential sector

Physical units

Before 2015, residential sector wood consumption is estimated in thousand cords and converted to British thermal units (Btu). For 2015 forward, residential wood consumption is estimated in Btu only.

Estimates of wood consumed in the residential sector by state for 1960 through 1979 are from the U.S. Energy Information Administration (EIA) *Estimates of U.S. Wood Energy Consumption from 1949 to 1981*. Data published in thousand short tons are converted to thousand cords using the factors of one short ton equals 17.2 million Btu (as published in the footnote of Table A4) and 20 million Btu equal one cord of wood, (as published in EIA, *Household Energy Consumption and Expenditures 1993*, page 314).

For 1980 through 2014, state estimates are developed using (1) U.S. total, Census division, and selected state data collected on the EIA triennial/quadrennial survey, Residential Energy Consumption Survey (RECS), (2) U.S. residential wood consumption estimates published in EIA's *Annual Energy Review* (AER) or *Monthly Energy Review* (MER), and (3) U.S. Department of Commerce, Census Bureau, annual estimates of number of housing units by state from the Population Census or Annual Housing Survey (prior to 2005) or the number of occupied housing units that use wood as primary heating fuel from the American Community Survey (2005 through 2014).

RECS data are available for 1981, 1984, 1987, 1990, 1993, 1997, 2001, 2005, and 2009. The 1981 RECS provides wood consumption data for the national

total and Census regions. For all other cycles, RECS provides data for the national total and Census divisions. From 1993 through 2005, data for the four largest consuming states—California, Florida, New York, and Texas are available. The regional totals for the rest of the states in each Census division are compiled. For 2009, data are available in the microdata file for 16 states (the top four states plus Arizona, Colorado, Georgia, Illinois, Massachusetts, Michigan, Missouri, New Jersey, Pennsylvania, Tennessee, Virginia, and Wisconsin) and 11 regions covering all the other states.

For the RECS data years prior to 2005, the regional values are allocated to the states within each region in proportion to the U.S. Census Bureau data on housing units by state, assuming that no wood is consumed in the residential sector in Hawaii. For 2005 and 2009, the number of occupied housing units that use wood as primary heating fuel from the American Community Survey (3-Year Estimates) is used to allocate the regional values to the states.

For the other (non-RECS) years, the U.S. totals published in AER or MER are converted from Btu to thousand cords using the factor of 20 million Btu per cord. They are then allocated to the states using the estimated state shares of the preceding available RECS year.

The state data derived above are identified in SEDS as WDRCBZZ, "ZZ" represents the two-letter state code that differs for each state.

WDRCBZZ = wood consumed by the residential sector of each state, in billion Btu.

The state-level data are summed to a U.S. total:

WDRCBUS = \sum WDRCBZZ

British thermal units (Btu)

For 1960 through 2014, the residential sector data in cords are converted to Btu by using the conversion factor of 20 million Btu per cord:

WDRCBZZ = WDRCPZZ * 20
WDRCBUS = \sum WDRCBZZ

For 2015 forward, residential wood consumption is estimated in billion Btu, using (1) data collected on the EIA Residential Energy Consumption Survey (RECS), (2) U.S. residential wood consumption estimates published in EIA's *Monthly Energy Review* (MER), (3) U.S. Department of Commerce, Census Bureau, annual estimates of number of occupied housing units that use wood as primary heating fuel from the American Community Survey (ACS), and (4) U.S. Department of Commerce, National Oceanic and Atmospheric

Administration (NOAA), state-level population-weighted heating degree-days (HDD). For Hawaii, an adjusted temperature-based HDD using EIA internal estimates is assigned.

RECS data are available for 2015. However, data by state are no longer available. A set of state shares is derived by using the product of heating degree-days and ACS housing units that use wood as primary heating fuel for each state for 2015.

For the other (non-RECS) years, state shares based on the product of heating degree-days and ACS housing units using wood as primary heating fuel for the year are applied to the U.S. total Btu consumption published in MER.

The state data derived above are identified in SEDS as WDRCBZZ, "ZZ" represents the two-letter state code that differs for each state.

WDRCBZZ = wood consumed by the residential sector of each state, in billion Btu.

The U.S. total for the state data series is calculated as the sum of the state values.

Data sources

WDRCBZZ — Wood energy consumed by the residential sector by state.

- 1960 through 1979: EIA, *Estimates of U.S. Wood Consumption from 1949 to 1981*, Table A4.
- 1980 through 2014: U.S. totals published in the EIA *Annual Energy Review* (AER) or *Monthly Energy Review* (MER), Table 10.2a.
 - 1980 through 1983: U.S. Census region wood consumption in thousand cords from Form EIA-457, "1981 Residential Energy Consumption Survey" is allocated to the states within each region in proportion to the U.S. Department of Commerce, Census Bureau, *American Housing Survey*, "Total Housing Units for States, July 1, 1981."
 - 1984 through 1986: U.S. Census division wood consumption in thousand cords from Form EIA-457, "1984 Residential Energy Consumption Survey" is allocated to the states within each division in proportion to the U.S. Department of Commerce, Census Bureau, *American Housing Survey*, "Total Housing Units for States, July 1, 1984."
 - 1987 through 1989: U.S. Census division wood consumption in thousand cords from Form EIA-457, "1987 Residential Energy Consumption Survey" is allocated to the states within each division in proportion to the U.S. Department of Commerce, Census Bureau,

- American Housing Survey, "Total Housing Units for States, July 1, 1987."*
- 1990 through 1992: U.S. Census division wood consumption in thousand cords is from Form EIA-457, "1990 Residential Energy Consumption Survey." State-level estimates are available for 1993 for California, Florida, New York, and Texas from the Form EIA-457, "1993 Residential Energy Consumption Survey." Those four states' percentages of their respective Census division totals in the 1993 survey are applied to the 1990 Census division data to derive their 1990 values. Wood consumption by the other states in each division is estimated by allocating the remaining division data to the states in proportion to the U.S. Department of Commerce, Census Bureau, Internet file (ST-98-51) "Estimates of Housing Units,...Annual Time Series,... (includes revised April 1, 1990 census housing...)" column titled "4/1/90 Census" at <http://www.census.gov/population/estimates/housing/sthuhh6.txt>.
 - 1993 through 1996: Residential wood consumption data for U.S. Census divisions and for California, Florida, New York, and Texas are from Form EIA-457, "1993 Residential Energy Consumption Survey." Data for the other states in each division are estimated by allocating the remaining division data to the states in proportion to the U.S. Department of Commerce, Census Bureau, Internet file (ST-98-51) "Estimates of Housing Units,...Annual Time Series, July 1, 1991 to July 1, 1998...," column titled "7/1/93" at <http://www.census.gov/population/estimates/housing/sthuhh6.txt>.
 - 1997 through 2000: Residential wood consumption data for U.S. Census divisions and for California, Florida, New York, and Texas are from Form EIA-457, "1997 Residential Energy Consumption Survey." Data for the other states in each division are estimated by allocating the remaining division data to the states in proportion to the U.S. Department of Commerce, Census Bureau, Internet file (ST-98-51) "Estimates of Housing Units,...Annual Time Series, July 1, 1991 to July 1, 1998...," column titled "7/1/97" at <http://www.census.gov/population/estimates/housing/sthuhh6.txt>.
 - 2001 through 2004: Residential wood consumption data for U.S. Census divisions and for California, Florida, New York, and Texas are from Form EIA-457, "2001 Residential Energy Consumption Survey." Data for the other states in each division are estimated by allocating the remaining division data to the states in proportion to the U.S. Department of Commerce, Census Bureau, Internet file "Table 1. Annual Estimates of Housing Units for the United States and States: April 1, 2000 to July 1, 2007," column titled "July 1, 2001" at <http://www.census.gov/programs-surveys/pepest.html>.

- 2005 through 2008: Residential wood consumption data for U.S. Census divisions and for California, Florida, New York, and Texas are from Form EIA-457, "2005 Residential Energy Consumption Survey." Data for the other states in each division are estimated by allocating the remaining division data to the states in proportion to the U.S. Department of Commerce, Census Bureau, 2005-2007 American Community Survey 3-Year Estimates, Series B25040, by state, Occupied Housing Units by House Heating Fuel," item titled "Wood," at <https://data.census.gov/cedsci/>.
- 2009 through 2014: Residential wood consumption data for 16 states and 11 regions are from Form EIA-457, "2009 Residential Energy Consumption Survey." Data for the states in each region are estimated by allocating the regional data to the states in proportion to the U.S. Department of Commerce, Census Bureau, 2008-2010 American Community Survey 3-Year Estimates, Series B25040, by state, Occupied Housing Units by House Heating Fuel," item titled "Wood," at <https://data.census.gov/cedsci/>.

WDRCBUS — Wood energy consumed by the residential sector in the United States.

- 2015 forward: EIA, *Monthly Energy Review*, Table 10.2a.

WDRCBZZ — Wood energy consumed by the residential sector by state.

- 2015 forward: Estimated by EIA using state allocators derived from U.S. Department of Commerce, Census Bureau, American Community Survey 1-Year Estimates, Series B25040, by state, Occupied Housing Units by House Heating Fuel," item titled "Wood," at <https://data.census.gov/cedsci/> and U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Centers for Environmental Information, historical state-level heating degree days data at <ftp://ftp.ncdc.noaa.gov/pub/data/cirs/climdiv/> and National Weather Service Climate Prediction Service, Degree Days Statistics at http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/degree_days/.

Commercial sector

Estimates of wood consumed in the commercial sector by state for 1960 through 1979 are from the EIA, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981*. The data published in thousand short tons are converted to billion Btu by using the conversion factor of one short ton equals 17.2 million

Btu. The assumption was made in that report that wood is consumed in the commercial sector in proportion to consumption in the residential sector each year. For 1980 through 1988, national-level commercial wood consumption estimates in trillion Btu are from the EIA, *Annual Energy Review* (AER). Using the same methodology as for previous years, the national data are allocated to the states in proportion to residential sector wood use each year.

For 1989 forward, state-level data on wood and waste consumption by commercial combined-heat-and-power (CHP) and electricity-only plants are available from Form EIA-923, "Power Plant Operations Report," and predecessor forms. The U.S. total wood consumption in the commercial sector is published in the AER or the *Monthly Energy Review* (MER). The U.S. total of the state commercial CHP and electricity-only plant wood consumption is subtracted from the AER/MER national commercial sector total, and the remainder is allocated to the states in proportion to each state's residential sector wood use each year from 1989 forward.

The data series described above, used to estimate SEDS wood and waste consumption in the commercial sector, are identified as follows ("ZZ" in the variable names represents the two-letter state code that differs for each state):

- WDCCBUS = wood consumed by the commercial sector in the United States, in billion Btu;
- WDC3BZZ = wood consumed by CHP and electricity-only facilities in the commercial sector of each state, in billion Btu; and
- WSC3BZZ = waste consumed by CHP and electricity-only facilities in the commercial sector of each state, in billion Btu.

The U.S. totals for the state-level series are calculated as the sum of the state data.

$$\begin{aligned} \text{WDC3BUS} &= \sum \text{WDC3BZZ} \\ \text{WSC3BUS} &= \sum \text{WSC3BZZ} \end{aligned}$$

The national total wood consumed by commercial entities other than CHP and electricity-only facilities are calculated as shown below, and those volumes are allocated to the states in proportion to the residential wood consumption series as follows:

$$\begin{aligned} \text{WDC4BUS} &= \text{WDCCBUS} - \text{WDC3BUS} \\ \text{WDC4BZZ} &= (\text{WDRCPZZ} / \text{WDRCPUS}) * \text{WDC4BUS} \end{aligned}$$

State totals of commercial wood consumption are calculated as the sum of consumption by CHP and electricity-only facilities and the remaining

commercial sector:

$$\text{WDCCBZZ} = \text{WDC3BZZ} + \text{WDC4BZZ}$$

Total commercial consumption of waste is set equal to the commercial consumption of waste by CHP and electricity-only facilities, which are the only commercial facilities with waste consumption, and the U.S. total is calculated as the sum of the state values:

$$\begin{aligned} \text{WSCCBZZ} &= \text{WSC3BZZ} \\ \text{WSCCBUS} &= \sum \text{WSCCBZZ} \end{aligned}$$

The total wood and waste consumption in the commercial sector is calculated as the sum of wood consumption and waste consumption, and the U.S. total is calculated as the sum of the state data:

$$\begin{aligned} \text{WWCCBZZ} &= \text{WDCCBZZ} + \text{WSCCBZZ} \\ \text{WWCCBUS} &= \sum \text{WWCCBZZ} \end{aligned}$$

Data sources

WDC3BZZ — Wood energy consumed by CHP and electricity-only facilities in the commercial sector of each state.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 forward: EIA, Form EIA-923, "Power Plant Operations Report," and predecessor forms, <http://www.eia.gov/electricity/data/eia923/>.

WDCCBUS — Wood consumed by the commercial sector in the United States.

- 1960 through 1979: EIA, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981*, Table A7.
- 1980 through 2010: EIA, *Annual Energy Review*, Table 10.2a.
- 2011 forward: EIA, *Monthly Energy Review*, Table 10.2a.

WSC3BZZ — Waste energy consumed by CHP and electricity-only facilities in the commercial sector of each state.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 forward: EIA, Form EIA-923, "Power Plant Operations Report," and predecessor forms, <http://www.eia.gov/electricity/data/eia923/>.

Industrial sector

**W
O
O
D

A
N
D

W
A
S
T
E**

For 1989 forward, state-level data on wood and waste consumption by industrial combined heat and power (CHP) and electricity-only facilities are available from Form EIA-923, "Power Plant Operations Report," and predecessor forms. These data are used with the manufacturing data to estimate total industrial sector wood and waste consumption for each state.

Industrial wood and waste consumption is expressed in Btu because its components are physically measured in a variety of units (e.g., tons, cubic feet, and kilowatthours). Wood and waste consumed by industrial CHP and electricity-only facilities are identified in SEDS by the following names ("ZZ" in the variable name represents the two-letter state code that differs for each state):

- WDI3BZZ = wood consumed by CHP and electricity-only facilities in the industrial sector in each state, in billion Btu; and
- WSI3BZZ = waste consumed by CHP and electricity-only facilities in the industrial sector of each state, in billion Btu.

Before 1989, wood and waste consumed by industrial CHP and electricity-only facilities are assumed to be zero.

The U.S. totals of the state series are calculated as the sum of the state data:

$$\begin{aligned} \text{WDI3BUS} &= \sum \text{WDI3BZZ} \\ \text{WSI3BUS} &= \sum \text{WSI3BZZ} \end{aligned}$$

Wood and waste consumed by all other industries (mainly the manufacturing sector) are identified in SEDS by the following names:

- WDI4BZZ = wood consumed for other uses in the industrial sector of each state, in billion Btu; and
- WSI4BZZ = waste consumed for other uses in the industrial sector of each state, in billion Btu.

Industrial sector wood and waste consumption estimates by state for 1960 through 1979 are from the EIA, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981*. The data, published in thousand short tons, are converted to billion Btu using the factor of one short ton equals 17.2 million Btu.

Estimates for 1980 through 1995 are based on a national-level data series published in the EIA *Annual Energy Review* (AER) or *Monthly Energy Review* (MER). National wood and waste consumption by type is collected by Standard Industrial Classification (SIC) on the EIA triennial survey Form EIA-846, "Manufacturing Energy Consumption Survey" (MECS) for 1985, 1988, 1991, and 1994. The assumption is made that wood and waste use in

the manufacturing sector occurs primarily in the industries included in SIC series 2421 (sawmills and planing mills), 2511 (wood household furniture), 2621 (paper mills), 2046 (wet corn milling), and 2061 (raw cane sugar). The amount of wood and waste consumed by each of the SIC groups of industries is estimated from the MECS data, and the MECS proportions are used to allocate the U.S. totals from the AER to SIC groups for each year. The SIC annual subtotals are allocated to the states using state-level data on the value added in manufacturing processes for each of the SIC series listed above, as published in the U.S. Department of Commerce, Census Bureau, *Census of Manufactures, Industry Series*, for 1982, 1987, and 1992.

Estimates for 1996 forward use the same methodology used for 1980 through 1995 with the exception that the U.S. Census Bureau, *Economic Census* data for 1997 forward use North American Industry Classification System (NAICS) instead of SIC. Some categories used in the two classification systems are directly comparable and some are closely or roughly comparable. The NAICS codes used for estimating wood consumption are: 311221, 313, 321113, 3212, 322121, 322130, and 3372. The NAICS codes used for estimating waste consumption are: 311221, 311311 (for 2007 and earlier *Economic Census*) or 311314 (for 2012 *Economic Census*), 313, 32191, 322122, 322130, and 3372. The EIA survey Form EIA-846, MECS, also uses NAICS codes in the surveys for 1998 forward. The discontinuity in these state allocating series caused by the change from SIC to NAICS categories is not significant in light of the broad assumptions of the estimation methodology.

Also beginning in 2006, data on value of shipments from the *Economic Censuses* are used instead of value added data.

For 2011 forward, the method of estimating WSI4B is refined. Two-thirds of the U.S. industrial waste consumption is assumed to be landfill gas, which is used to generate heat or electricity. To allocate landfill gas consumption to the states, data on landfill gas flow for all operational landfill projects with capacity under 1 megawatt from the Landfill Methane Outreach Program maintained by the U.S. Environmental Protection Agency are used to compile the state shares. The remaining one-third of WSI4B is allocated to the states using the MECS data and Economic Census data as explained above. The two components are then summed together to form WSI4B.

The U.S. totals of the state series are calculated as the sum of the state data:

$$\begin{aligned} \text{WDI4BUS} &= \sum \text{WDI4BZZ} \\ \text{WSI4BUS} &= \sum \text{WSI4BZZ} \end{aligned}$$

Industrial sector wood and waste consumption is calculated as the sum of consumption by CHP and electricity-only facilities and consumption by other

industries:

$$\begin{aligned} \text{WDICBZZ} &= \text{WDI3BZZ} + \text{WDI4BZZ} \\ \text{WDICBUS} &= \Sigma \text{WDICBZZ} \\ \text{WSICBZZ} &= \text{WSI3BZZ} + \text{WSI4BZZ} \\ \text{WSICBUS} &= \Sigma \text{WSICBZZ} \end{aligned}$$

Total wood and waste consumed by other industries is calculated as the sum of wood consumption and the sum of waste consumption, and the U.S. total is calculated as the sum of the state data:

$$\begin{aligned} \text{WWI4BZZ} &= \text{WDI4BZZ} + \text{WSI4BZZ} \\ \text{WWI4BUS} &= \Sigma \text{WWI4BZZ} \end{aligned}$$

The total industrial sector is calculated as the sum of wood consumption and the sum of waste consumption, and the U.S. total is calculated as the sum of the state data:

$$\begin{aligned} \text{WWICBZZ} &= \text{WDICBZZ} + \text{WSICBZZ} \\ \text{WWICBUS} &= \Sigma \text{WWICBZZ} \end{aligned}$$

Data sources

WDI3BZZ — Wood consumed by CHP and electricity-only facilities in the industrial sector by state.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 forward: EIA, Form EIA-923, "Power Plant Operations Report," and predecessor forms, <http://www.eia.gov/electricity/data/eia923/>.

WDI4BZZ — Wood consumed by the industrial sector other than CHP and electricity-only facilities by state.

- 1960 through 1979: EIA, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981*, Table A10.
- 1980 forward: EIA estimates developed by using three data sources. U.S. totals for each year are as published for selected years in the EIA, *Annual Energy Review* (AER), Table 10.2b, or *Monthly Energy Review* (MER), Table 10.2b.
 - 1980 through 1985: U.S. totals from the AER are allocated to Standard Industrial Classification (SIC) groups 20, 24, 25, and 26 based on data from the Form EIA-846, "Manufacturing Energy Consumption Survey 1985," Table 3, Columns "Major Byproducts" and "Other." These SIC subtotals are allocated to the states using state-level series from the U.S. Department of Commerce, Census Bureau,

1982 *Census of Manufactures*, Table 2, column titled "Value Added by Manufacturer," from the publications for Industry 2061 Raw Cane Sugar, Industry 2046 Wet Corn Milling, Industry 2421 Sawmills and Planing Mills, Industry 2511 Wood Household Furniture, Industry 2621 Paper Mills, and Industry 2631 Paperboard Mills. The state values for each of the four SIC groups are summed to derive state total wood and waste industrial consumption estimates.

- 1986 through 1989: U.S. totals from the AER are allocated to SIC groups 20, 24, 25, and 26 based on data from the Form EIA-846, "Manufacturing Energy Consumption Survey 1988," Tables 2 and 18, columns "Pulping Liquor," "Roundwood," and "Wood Chips." These SIC subtotals are allocated to the states using state-level series from the U.S. Department of Commerce, Census Bureau, 1987 *Census of Manufactures*, Table 2, column titled "Value Added by Manufacturer," from the publications for Industry 2061 Raw Cane Sugar, Industry 2046 Wet Corn Milling, Industry 2421 Sawmills and Planing Mills, Industry 2511 Wood Household Furniture, Industry 2621 Paper Mills, and Industry 2631 Paperboard Mills. The state values for each of the four SIC groups are summed to derive state total industrial wood consumption estimates. For 1989 only, state-level data on wood consumption by combined heat and power (CHP) and electricity-only facilities are available from the Form EIA-867, "Annual Nonutility Power Producer Report" in billion Btu. These CHP and electricity-only state data are summed and subtracted from the AER U.S. total. The remaining value is assumed to be the manufacturing sector and is allocated to the states using the method above. The state values for each of the four SIC groups and the CHP and electricity-only facilities are summed to derive state total industrial wood consumption estimates.
- 1990 through 1993: State-level data on wood consumption by CHP and electricity-only facilities from the Form EIA-867, "Annual Nonutility Power Producer Report" in billion Btu are summed and subtracted from the AER U.S. total. The remaining national value is allocated to SIC groups 20, 24, 25, and 26 based on unpublished data on pulping liquor, roundwood, and wood chips from the Form EIA-846, "Manufacturing Energy Consumption Survey 1991 (MECS)." SIC groups 20 and 26 are grouped as "Other" in MECS. The proportions of those two groups in the 1988 and 1994 MECS are averaged and used to estimate the breakout for 1991. These SIC subtotals are allocated to the states using state-level series from the U.S. Department of Commerce, Census Bureau, 1992 *Census of Manufactures*, Table 2, column titled "Value Added by Manufacturer," from the publications for Industry 2061 Raw Cane Sugar, Industry

2046 Wet Corn Milling, Industry 2421 Sawmills and Planing Mills, Industry 2541 Wood Partitions and Fixtures, and Industry 2621 Paper Mills. The state values for each of the four SIC groups and the CHP and electricity-only facilities are summed to derive State total industrial wood consumption estimates.

- 1994 and 1995: State-level data on wood consumption by CHP and electricity-only facilities from the Form EIA-867, “Annual Nonutility Power Producer Report” in billion Btu are summed and subtracted from the AER U.S. total. The remaining national value is allocated to SIC groups 20, 24, 25, 26, and “Other” based on data from the Form EIA-846, “1994 Manufacturing Energy Consumption Survey,” Table A7, columns “Pulping or Black Liquor,” “Wood from Trees,” and “Wood from Mills.” These SIC subtotals are allocated to the states using state-level series from the U.S. Department of Commerce, Census Bureau, *1992 Census of Manufactures*, Table 2, column titled “Value Added by Manufacturer,” from the publications for Industry 2061 Raw Cane Sugar, Industry 2046 Wet Corn Milling, Industry 2421 Sawmills and Planing Mills, Industry 2511 Wood Household Furniture, Industry 2621 Paper Mills, and Industry 2631 Paperboard Mills. The state values for each of the five SIC groups and the CHP and electricity-only facilities are summed to derive state total industrial wood consumption estimates.
- 1996 and 1997: State-level data on wood consumption by CHP and electricity-only facilities from the Form EIA-867, “Annual Nonutility Power Producer Report,” in billion Btu are summed and subtracted from the AER U.S. total. The remaining national value is allocated to SIC groups 20, 24, 25, 26, and “Other” based on data from the Form EIA-846, “1994 Manufacturing Energy Consumption Survey,” Table A7, columns “Pulping or Black Liquor,” “Wood from Trees,” and “Wood from Mills.” These SIC subtotals are allocated to the states using state-level series from the U.S. Department of Commerce, Census Bureau, *1997 Economic Census*. In the *Economic Census* the SIC groupings for the state data are replaced by North American Industry Classification System (NAICS) industry groups. The two industry classification systems are not identical, but NAICS groups are chosen that compare with SIC categories as closely as possible. The state series are from Table 2, column titled “Value Added by Manufacturer,” from the publications for NAICS Industry 311221 Wet Corn Milling (for SIC 20 Food), Industry 321113 Sawmills, and Industry 3212 Engineered Wood Product Manufacturing (for SIC 24 Wood), Industry 3372 Office Furniture Manufacturing (for SIC 25 Furniture), Industry 322121 Paper Mills, and Industry 322130 Paperboard Mills (for SIC 26 Paper), and Industry 313 Textile Mills (for Other SIC).

The state values for each of the five NAICS group subtotals and the CHP and electricity-only facilities are summed to derive state total industrial wood consumption estimates.

- 1998 forward: State-level data on wood consumption by CHP and electricity-only facilities from the Form EIA-923, “Power Plant Operations Report,” and predecessor forms, in billion Btu are summed and subtracted from the AER/MER U.S. total. The remaining national value is allocated to NAICS industry groups 311, 321, 322, 337, and “Other” based on data from the Form EIA-846, “Manufacturing Energy Consumption Survey,” 1998 (for 1998-2001), 2002 (for 2002-2005), 2006 (for 2006-2010), 2010 (for 2011-2013), and 2014 (for 2014 forward), table entitled “Selected Wood and Wood-Related Products in Fuel Consumption,” columns “Pulping or Black Liquor,” “Wood from Trees,” and “Wood from Mills.” These NAICS subtotals are allocated to the states using state-level series from the U.S. Department of Commerce, Census Bureau, *Economic Census* for 1997 (1998-2000), 2002 (2001-2005), 2007 (2006-2010), and 2012 (2011 forward). For 1997 and 2002, the state series are from Table 2, column titled “Value Added by Manufacturer,” from the publications for NAICS Industry 311221 Wet Corn Milling (for NAICS 311 Food), Industry 321113 Sawmills, and Industry 3212 Engineered Wood Product Manufacturing (for NAICS 321 Wood products), Industry 3372 Office Furniture Manufacturing (for NAICS 337 Furniture), Industry 322121 Paper Mills, and Industry 322130 Paperboard Mills (for NAICS 322 Paper), and Industry 313 Textile Mills (for Other NAICS). For 2007 forward, the state series are the “Value of Shipments” data for the specific industries. *Economic Census* data are available at <https://data.census.gov/cedsci/>.

WSI3BZZ — Waste consumed by CHP and electricity-only facilities in the industrial sector by state.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 forward: EIA, Form EIA-923, “Power Plant Operations Report,” and predecessor forms, <http://www.eia.gov/electricity/data/eia923/>.

WSI4BZZ — Waste consumed by the industrial sector other than CHP and electricity-only facilities by state.

- 1960 through 1980: No data available. Values assumed to be zero.
- 1981 forward: EIA estimates developed by using three data sources. U.S. totals for each year are as published for selected years in the EIA, *Annual Energy Review* (AER), Table 10.2b, or *Monthly Energy Review*

(MER), Table 10.2b.

- 1981 through 1985: U.S. totals from the AER are allocated to Standard Industrial Classifications (SIC) groups 20, 24, 25, and 26 based on data from the EIA “Manufacturing Energy Consumption Survey 1985 (MECS),” Table 3, columns “Major By-products” and “Other.” These SIC subtotals are allocated to the states using state-level series from the U.S. Department of Commerce, Census Bureau, *1982 Census of Manufactures*, Table 2, column titled “Value Added by Manufacturer,” from the publications for Industry 2061 Raw Cane Sugar, Industry 2046 Wet Corn Milling, Industry 2421 Sawmills and Planing Mills, Industry 2511 Wood Household Furniture, Industry 2621 Paper Mills, and Industry 2631 Paperboard Mills. The state values for each of the four SIC groups are summed to derive state total industrial waste consumption estimates.
- 1986 through 1989: U.S. totals from the AER are allocated to SIC groups 20, 24, 25, and 26 based on data from the Form EIA-846, “Manufacturing Energy Consumption Survey 1988,” Tables 2 and 18, columns “Waste” and “Biomass.” These SIC subtotals are allocated to the states using state-level series from the U.S. Department of Commerce, Census Bureau, *1987 Census of Manufactures*, Table 2, column titled “Value Added by Manufacturer,” from the publications for Industry 2061 Raw Cane Sugar, Industry 2046 Wet Corn Milling, Industry 2421 Sawmills and Planing Mills, Industry 2511 Wood Household Furniture, Industry 2621 Paper Mills, and Industry 2631 Paperboard Mills. The state values for each of the four SIC groups are summed to derive state total industrial waste consumption estimates. For 1989 only, state-level data on waste consumption by CHP and electricity-only facilities are available from the Form EIA-867, “Annual Nonutility Power Producer Report” in billion Btu. These CHP and electricity-only state data are summed and subtracted from the AER U.S. total. The remaining value is assumed to be the manufacturing sector and is allocated to the states using the method above. The state values for each of the four SIC groups and the CHP and electricity-only facilities are summed to derive state total industrial waste consumption estimates.
- 1990 through 1993: State-level data on waste consumption by CHP and electricity-only facilities from the Form EIA-867, “Annual Nonutility Power Producer Report” in billion Btu are summed and subtracted from the AER U.S. total. The remaining national value is allocated to SIC groups 20, 24, 25, and 26 based on unpublished data on waste and biomass from the Form EIA-846, “Manufacturing Energy Consumption Survey 1991 (MECS).” SIC groups 20 and 26 are grouped as “Other” in MECS 1991. The proportions of those two

groups in the 1988 and 1994 MECS are averaged and used to estimate the breakout for 1991. These SIC subtotals are allocated to the states using state-level series from the U.S. Department of Commerce, Census Bureau, *1992 Census of Manufactures*, Table 2, column titled “Value Added by Manufacturer,” from the publications for Industry 2061 Raw Cane Sugar, Industry 2046 Wet Corn Milling, Industry 2421 Sawmills and Planing Mills, Industry 2541 Wood Partitions and Fixtures, and Industry 2621 Paper Mills. The state values for each of the four SIC groups and the CHP and electricity-only facilities are summed to derive state total industrial waste consumption estimates.

- 1994 and 1995: State-level data on waste consumption by CHP and electricity-only facilities from the Form EIA-867, “Annual Nonutility Power Producer Report” in billion Btu are summed and subtracted from the AER U.S. total. The remaining national value is allocated to SIC groups 20, 24, 25, 26, and “Other” based on data from the Form EIA-846, “1994 Manufacturing Energy Consumption Survey,” Table A7, columns “Agricultural Waste” and “Wood and Paper Refuse.” These SIC subtotals are allocated to the states using state-level series from the U.S. Department of Commerce, Census Bureau, *1992 Census of Manufactures*, Table 2, column titled “Value Added by Manufacturer,” from the publications for Industry 2061 Raw Cane Sugar, Industry 2046 Wet Corn Milling, Industry 2421 Sawmills and Planing Mills, Industry 2511 Wood Household Furniture, Industry 2621 Paper Mills, and Industry 2631 Paperboard Mills. The state values for each of the five SIC groups and the CHP and electricity-only facilities are summed to derive state total industrial waste consumption estimates.
- 1996 and 1997: State-level data on waste consumption by CHP and electricity-only facilities from the Form EIA-867, “Annual Nonutility Power Producer Report” or Form EIA-860, “Annual Electric Generator Report” in billion Btu are summed and subtracted from the AER U.S. total. The remaining national value is allocated to SIC groups 20, 24, 25, 26, and “Other” based on data from the Form EIA-846, “1994 Manufacturing Energy Consumption Survey,” Table A7, columns “Agricultural Waste” and “Wood and Paper Refuse.” These SIC subtotals are allocated to the states using state-level series from the U.S. Department of Commerce, Census Bureau, *1997 Economic Census*. In the *Economic Census* the SIC groupings for the state data are replaced by North American Industry Classification System (NAICS) industry groups. The two industry classification systems are not identical, but NAICS groups are chosen that compare with SIC categories as closely as possible. The state series are from Table 2,

column titled “Value Added by Manufacturer,” from the publications for NAICS Industry 311311 Sugar Cane Mills, and Industry 311221 Wet Corn Milling (for SIC 20 Food), Industry 321912 Cut Stock, Resawing Lumber, and Planing (for SIC 24 Wood), Industry 3372 Office Furniture Manufacturing (for SIC 25 Furniture), Industry 322122 Newsprint Mills, and Industry 322130 Paperboard Mills (for SIC 26 Paper), and Industry 313 Textile Mills (for Other SIC). The state values for each of the five NAICS group subtotals and the CHP and electricity-only facilities are summed to derive state total industrial waste consumption estimates.

- 1998 through 2010: State-level data on waste consumption by CHP and electricity-only facilities from the Form EIA-923, “Power Plant Operations Report,” and predecessor forms, in billion Btu are summed and subtracted from the AER/MER U.S. total. The remaining national value is allocated to NAICS industry groups 311, 321, 337, and 322, and “Other” based on data from the Form EIA-846, “Manufacturing Energy Consumption Survey,” 1998 (for 1998-2001), 2002 (for 2002-2005), and 2006 (for 2006-2010), table entitled “Selected Wood and Wood-Related Products in Fuel Consumption,” columns “Agricultural Waste” and “Wood and Paper Refuse.” These NAICS subtotals are allocated to the states using state-level series from the U.S. Department of Commerce, Census Bureau, *Economic Census* for 1997 (1998-2000), 2002 (2001-2005), and 2007 (2006-2010). For 1997 and 2002, the state series are from Table 2, column titled “Value Added by Manufacturer,” from the publications for NAICS Industry 311311 Sugar Cane Mills, and Industry 311221 Wet Corn Milling (for NAICS 311 Food), Industry 321912 Cut Stock, Resawing Lumber, and Planing (for NAICS 321 Wood), Industry 3372 Office Furniture Manufacturing (for NAICS 337 Furniture), Industry 322122 Newsprint Mills, and Industry 322130 Paperboard Mills (for NAICS 322 Paper), and Industry 313 Textile Mills (for Other NAICS). For 2007, the state series are the “Value of Shipments” data for the specific industries. *Economic Census* data are available at <https://data.census.gov/cedsci/>.
- 2011 forward: State-level data on waste consumption by CHP and electricity-only facilities from the Form EIA-923, “Power Plant Operations Report,” and predecessor forms, in billion Btu are summed and subtracted from the AER/MER U.S. total. Two-thirds of the remaining national value is allocated using data from U.S. Environmental Protection Agency, Landfill Methane Outreach Program, <http://www.epa.gov/lmop/>. One-third of the remaining national value is allocated to NAICS industry groups 311, 321, 337, and 322, and “Other” based on data from the Form EIA-846,

“Manufacturing Energy Consumption Survey,” 2010 (for 2011-2013) and 2014 (for 2014 forward), table entitled “Selected Wood and Wood-Related Products in Fuel Consumption,” columns “Agricultural Waste” and “Wood and Paper Refuse.” These NAICS subtotals are allocated to the states using state-level data from the U.S. Department of Commerce, Census Bureau, *Economic Census* for 2012. The state series are the “Value of Shipments” data for the specific industries: 311314 Sugar Cane Manufacturing and 311221 Wet Corn Milling (for NAICS 311 Food), 321912 Cut Stock, Resawing Lumber, and Planing (for NAICS 321 Wood), 3372 Office Furniture Manufacturing (for NAICS 337 Furniture), 322122 Newsprint Mills and 322130 Paperboard Mills (for NAICS 322 Paper), and 313 Textile Mills (for Other NAICS). *Economic Census* data are available at <https://data.census.gov/cedsci/>.

Electric power sector

Electric power sector use of wood and waste to generate electricity is based on data series from Form EIA-923, “Power Plant Operations Report,” and predecessor forms and is estimated in SEDS. From 2001 forward, the Btu content of the wood and waste consumed by electric power plants is reported on the data collection forms and used in SEDS. Before 2001, Btu data were not collected by the source data forms and data on electricity generation from wood and waste are used instead. Net generation of electricity is converted to equivalent Btu using the fossil-fueled steam-electric plant conversion factor, and the resulting Btu values are entered into SEDS. Rarely, power plants can use more electricity than they generate from wood and waste energy sources and a negative net generation (and, therefore, Btu consumption) value can be seen in SEDS. From 1960 through 1981, electricity generation from wood and waste are reported combined and from 1982 forward generation or Btu values from each source are reported separately.

The data series are identified in SEDS by the following names (“ZZ” in the variable name represents the two-letter state code that differs for each state):

- WDEIBZZ = wood consumed by the electric power sector in each state (included in waste energy for 1960 through 1981), in million Btu; and
- WSEIBZZ = waste consumed by the electric power sector in each state (included in wood energy for 1960 through 1981), in million Btu.

The U.S. totals are calculated as the sum of the state data, and wood and waste are summed to provide a total (WW) value:

$$\begin{aligned} \text{WDEIBUS} &= \Sigma \text{WDEIBZZ} \\ \text{WSEIBUS} &= \Sigma \text{WSEIBZZ} \end{aligned}$$

$$\begin{aligned} \text{WWEIBZZ} &= \text{WDEIBZZ} + \text{WSEIBZZ} \\ \text{WWEIBUS} &= \Sigma \text{WWEIBZZ} \end{aligned}$$

$$\begin{aligned} \text{WWTCBZZ} &= \text{WDTCBZZ} + \text{WSTCBZZ} \\ \text{WWTCBUS} &= \Sigma \text{WWTCBZZ} \end{aligned}$$

Data sources

WDEIBZZ — Wood consumed by the electric power sector by state.

- 1960 through 1981: Data included in waste energy sources, see WSEIBZZ.
- 1982 through 2000: EIA, Form EIA-759, “Monthly Power Plant Report,” electricity generation from wood converted to Btu using the fossil-fueled steam-electric power plant conversion factor shown in Table B1 (<http://www.eia.gov/state/seds/seds-technical-notes-complete.php>).
- 2001 forward: EIA, Form EIA-923, “Power Plant Operations Report,” and predecessor forms, <http://www.eia.gov/electricity/data/eia923/>.

WSEIBZZ — Waste consumed by the electric power sector by state.

- 1960 through 2000: EIA, Form EIA-759, “Monthly Power Plant Report” and predecessor forms, electricity generation from waste (includes wood energy sources from 1960 through 1981) converted to Btu using the fossil-fueled steam-electric power plant conversion factor shown in Table B1 (<http://www.eia.gov/state/seds/seds-technical-notes-complete.php>).
- 2001 forward: EIA, Form EIA-923, “Power Plant Operations Report,” and predecessor forms, <http://www.eia.gov/electricity/data/eia923/>.

Totals

State total consumption of wood and waste is calculated as the sum of the consumption in the residential, commercial, and industrial sectors as well as consumption by the electric power sector. The U.S. total is the sum of the state data:

$$\begin{aligned} \text{WDTCBZZ} &= \text{WDRCBZZ} + \text{WDCCBZZ} + \text{WDICBZZ} + \text{WDEIBZZ} \\ \text{WDTCBUS} &= \Sigma \text{WDTCBZZ} \end{aligned}$$

$$\begin{aligned} \text{WSTCBZZ} &= \text{WSCCBZZ} + \text{WSICBZZ} + \text{WSEIBZZ} \\ \text{WSTCBUS} &= \Sigma \text{WSTCBZZ} \end{aligned}$$

Biofuels

Biofuels are renewable liquid fuels and blending components produced from biomass feedstocks, primarily used for transportation. Additional calculations are made in SEDS to aggregate some data series to be shown in the tables of this report.

The losses and co-products from the production of biodiesel and fuel ethanol are combined to be shown under “biofuels losses and co-products” in the summary tables titled “Primary Energy Consumption Estimates by Source” and “Industrial Sector Energy Consumption Estimates” as follows:

$$\text{BFLCB} = \text{BDLCB} + \text{EMLCB}$$

Biofuel consumption is defined as biodiesel and fuel ethanol consumption as well as the losses and co-products from their production:

$$\text{BFTCB} = \text{BDTCB} + \text{EMTCB} + \text{BFLCB}$$

Biomass Total

Additional calculations are made in SEDS to aggregate some data series to be shown in the tables of this report. Biodiesel, fuel ethanol, losses and co-products from the production of biodiesel and fuel ethanol, and wood and biomass waste, are combined to be shown under “biomass” in the summary tables titled “Energy Consumption Estimates by Source” as follows:

$$\text{BMTCB} = \text{BDLCB} + \text{BDTCB} + \text{EMLCB} + \text{EMTCB} + \text{WWTCB}$$

Renewable Energy Total

Renewable energy subtotals for each consuming sector in billion Btu are calculated for each state and the U.S. totals. In addition, the industrial sector includes energy losses and co-products from the production of biodiesel (BDLCB) and fuel ethanol (EMLCB).

$$\begin{aligned}
 \text{RERCB} &= \text{GERCB} + \text{SORCB} + \text{WDRCB} \\
 \text{RECCB} &= \text{EMCCB} + \text{GECCB} + \text{HYCCB} + \text{SOCCB} + \text{WWCCB} + \\
 &\quad \text{WYCCB} \\
 \text{REICB} &= \text{BDLCB} + \text{EMICB} + \text{EMLCB} + \text{GEICB} + \text{HYICB} + \text{SOICB} + \\
 &\quad \text{WWICB} + \text{WYICB} \\
 \text{REACB} &= \text{BDACB} + \text{EMACB} \\
 \text{REEIB} &= \text{GEEGB} + \text{HYEGB} + \text{SOEGB} + \text{WWEIB} + \text{WYEGB}
 \end{aligned}$$

Total renewable energy consumption is also calculated for each state and the United States:

$$\begin{aligned}
 \text{RETCB} &= \text{BDLCB} + \text{BDTCB} + \text{EMLCB} + \text{EMTCB} + \text{GETCB} + \\
 &\quad \text{HYTCB} + \text{SOTCB} + \text{WWTCB} + \text{WYTCB}
 \end{aligned}$$

In the calculations of all aggregated series, data for any component series that are not available in the earlier years are assumed to be zero.