

Section 5. Renewable Energy

Renewable energy sources included in the State Energy Data System (SEDS) comprise fuel ethanol, wood, waste, hydroelectric, geothermal, wind, photovoltaic, and solar thermal energy.

Fuel Ethanol

Fuel ethanol is used as a gasoline octane enhancer and oxygenate (blended up to 10 percent concentration). A small amount of fuel ethanol is used as an alternative fuel, such as E85. It is typically produced chemically from ethylene, or biologically from fermentation of various sugars from carbohydrates found in agricultural crops and cellulosic residues from crops or wood. For 1981 forward, fuel ethanol estimates are maintained separately from motor gasoline in SEDS and shown in the State energy consumption data tables to illustrate renewable energy use.

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 (prior to 2005), finished motor gasoline and motor gasoline blending components adjustments (2005 forward), and refinery and blender net inputs of fuel ethanol (all years). The fuel ethanol series used in SEDS 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).

Beginning in 2005, the State data series is based on several EIA data series and estimates:

- 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 Petroleum Administration for Defense (PAD) District and Refining District;
- a standard ethanol-to-motor gasoline "blend ratio" of 10 percent for all States except California (5.7 percent) and Minnesota (12 percent); and
- estimated fuel ethanol "product supplied" by PAD District and Refining District.

First, a set of preliminary estimates for fuel ethanol blended into motor gasoline is calculated by multiplying the prime supplier sales for the two types of gasoline with the corresponding percent of gasoline blended with alcohol and the "blend ratio," and summing them together for each State. Next, total fuel ethanol "product supplied" by PAD District and Refining District is estimated by adding motor gasoline blending components and finished motor gasoline adjustments (disaggregated to the districts by applying the district shares derived from the fuel ethanol refinery and blending net inputs data) to the fuel ethanol refinery and blending net inputs. Finally, the preliminary fuel ethanol estimates are scaled to the fuel ethanol "product supplied" values by district.

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

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

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

Fuel ethanol total consumed 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 consumed by State in Btu is calculated by multiplying total consumed by State in physical units by the U.S. conversion factor, which is derived from the U.S. fuel ethanol total consumed in physical units and Btu. Total U.S. consumption in Btu is the sum of the sectors' consumption:

$$\begin{aligned} \text{ENTCKUS} &= \text{ENTCBUS} / \text{ENTCPUS} \\ \text{ENTCBZZ} &= \text{ENTCPZZ} * \text{ENTCKUS} \end{aligned}$$

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

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

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.

$$\text{EMTCBZZ} = (\text{ENTCBZZ} / \text{EMTCBUS}) * \text{EMTCBUS}$$

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

$$\begin{aligned} \text{EMACBZZ} &= (\text{MGACPZZ} / \text{MGTCPZZ}) * \text{EMTCBZZ} \\ \text{EMCCBZZ} &= (\text{MGCCPZZ} / \text{MGTCPZZ}) * \text{EMTCBZZ} \\ \text{EMICBZZ} &= (\text{MGICPZZ} / \text{MGTCPZZ}) * \text{EMTCBZZ} \\ \text{EMACBUS} &= \Sigma \text{EMACBZZ} \\ \text{EMCCBUS} &= \Sigma \text{EMCCBZZ} \\ \text{EMICBUS} &= \Sigma \text{EMICBZZ} \end{aligned}$$

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 U.S. 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.
- EMPRBZZ = production of fuel ethanol, excluding denaturant, by State, in billion Btu.
- EMLCBZZ = $(EMPRBZZ / EMPRBUS) * EMLCBUS$

Additional Notes

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.
- 1981 forward: EIA, *Annual Energy Review*, Table 10.3.
- EMPRBUS — Production of fuel ethanol excluding denaturant for the United States.
- 1981 forward: EIA, *Annual Energy Review*, Table 10.3.
- EMPRBZZ — Production of fuel ethanol excluding denaturant by State.
- 1981 forward: EIA, State Energy Data System, production estimates.
- EMTCBUS — Fuel ethanol excluding denaturant consumed in the United States in billion Btu.
- 1981 forward: EIA, *Annual Energy Review*, Table 10.3.

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

- 1981 forward: EIA, *Annual Energy Review*, Table 10.3.

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

- 1960 through 1980: No data are 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.

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 87.
- 2005 forward: EIA estimates based on sales of motor gasoline from the *Prime Supplier Report*, production of motor gasoline (with and without alcohol) and estimated ethanol "product supplied" from *PSA*, and State-level ethanol-to-motor-gasoline "blend ratios." See explanation of the estimation methodology on page 85.

Geothermal Energy

Geothermal energy used as direct heat or from heat pumps in the residential, commercial, and industrial sectors is included in the State Energy Data System (SEDS) for 1989 forward. Electric power sector consumption in SEDS includes geothermal energy input at electric utilities for all years, 1960 forward, and includes geothermal energy used to generate electricity by nonutility power producers for 1989 forward. 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):

- GECCBZZ = direct use of geothermal energy and geothermal heat pumps in the commercial sector by State, in billion British thermal units (Btu);
- GEEGPZZ = electricity produced from geothermal energy by the electric power sector by State, in million kilowatt-hours;
- GEICBZZ = direct use of geothermal energy and geothermal heat pumps in the industrial sector by State, in billion Btu; and
- GERCBZZ = direct use of geothermal energy and geothermal heat pumps in the residential sector by State, in billion Btu.

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

$$\begin{aligned} \text{GECCBUS} &= \Sigma \text{GECCBZZ} & \text{GEICBUS} &= \Sigma \text{GEICBZZ} \\ \text{GEEGPUS} &= \Sigma \text{GEEGPZZ} & \text{GERCBUS} &= \Sigma \text{GERCBZZ} \end{aligned}$$

Electricity produced from geothermal energy is converted from kilowatt-hours 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.cfm>.

$$\text{FFETKUS} = \text{factor for converting electricity produced from geothermal energy from kilowatt-hours to Btu.}$$

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:

$$\begin{aligned} \text{GEEGBZZ} &= \text{GEEGPZZ} * \text{FFETKUS} \\ \text{GEEGBUS} &= \Sigma \text{GEEGBZZ} \end{aligned}$$

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.

$$\begin{aligned} \text{GETCBZZ} &= \text{GERCBZZ} + \text{GECCBZZ} + \text{GEICBZZ} + \text{GEEGBZZ} \\ \text{GETCBUS} &= \Sigma \text{GETCBZZ} \end{aligned}$$

Additional Notes

Consumption estimates of geothermal energy from direct use and heat pumps 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.

GECCBZZ — Direct use and heat pump geothermal energy in the commercial sector.

- 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 88.
- 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 88.

- 1998 forward: Oregon Institute of Technology Geo-Heat Center, unpublished tables based on informal surveys and estimations.

GEEGPZZ — Electricity produced from geothermal energy by the electric power sector for each State.

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

GEICBZZ — Direct use and heat pump geothermal energy in the industrial sector.

- 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 88.
- 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 88.
- 1998 forward: Oregon Institute of Technology Geo-Heat Center, unpublished tables based on informal surveys and estimations.

GERCBZZ — Direct use and heat pump geothermal energy in the residential sector.

- 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 88.

- 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 88.
- 1998 forward: Oregon Institute of Technology Geo-Heat Center, unpublished tables based on informal surveys and estimations.

Hydroelectric Power

Electricity produced 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 hydroelectric power: conventional hydroelectric power and pumped storage hydroelectricity. Conventional hydroelectric power 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. The hydroelectric power 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 = electricity produced by conventional hydroelectric power in the electric power sector by State, in million kilowatt-hours;
- HVC5PZZ = electricity produced by conventional hydroelectric power at commercial facilities by State, in million kilowatt-hours;
- HVI5PZZ = electricity produced by conventional hydroelectric power at industrial facilities by State, in million kilowatt-hours;

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

Total use of hydroelectric power in the commercial, industrial, and electric power sectors is assumed to be the electricity produced by conventional

hydroelectric power. The U.S. total for each sector is the sum of the State values:

$$\begin{aligned} \text{HYCCPZZ} &= \text{HVC5PZZ} \\ \text{HYCCPUS} &= \Sigma \text{HYCCPZZ} \end{aligned}$$

$$\begin{aligned} \text{HYICPZZ} &= \text{HVI5PZZ} \\ \text{HYICPUS} &= \Sigma \text{HYICPZZ} \end{aligned}$$

$$\begin{aligned} \text{HYEGPZZ} &= \text{HVEGPZZ} \\ \text{HYEGPUS} &= \Sigma \text{HYEGPZZ} \end{aligned}$$

Electricity produced from hydroelectric power 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.cfm>.

FFETKUS = factor for converting hydroelectric power from kilowatthours to Btu.

$$\begin{aligned} \text{HYCCBZZ} &= \text{HYCCPZZ} * \text{FFETKUS} \\ \text{HYICBZZ} &= \text{HYICPZZ} * \text{FFETKUS} \\ \text{HYEGBZZ} &= \text{HYEGPZZ} * \text{FFETKUS} \end{aligned}$$

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.

$$\begin{aligned} \text{HYTCPZZ} &= \text{HYCCPZZ} + \text{HYICPZZ} + \text{HYEGPZZ} \\ \text{HYTCPUS} &= \Sigma \text{HYTCPZZ} \end{aligned}$$

$$\begin{aligned} \text{HYTCBZZ} &= \text{HYCCBZZ} + \text{HYICBZZ} + \text{HYEGBZZ} \\ \text{HYTCBUS} &= \Sigma \text{HYTCBZZ} \end{aligned}$$

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.

HVC5PZZ — Electricity produced from conventional hydroelectric power at the commercial 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 — Electricity produced from conventional hydroelectric power at industrial 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, Forms EIA-923, "Power Plant Operations Report," and predecessor forms.

HVEGPZZ — Electricity produced from conventional hydroelectric power by 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, Forms EIA-923, "Power Plant Operations Report," and predecessor forms.

Solar Energy

Estimates of solar energy use for the residential and commercial sectors combined and the industrial sector are included in the State Energy Data System (SEDS) for 1989 forward. Generation of electricity by the electric power sector from solar energy sources is included in SEDS for 1984 forward.

Residential/Commercial Sector

Solar thermal direct use energy and photovoltaic electricity net generation in the residential and commercial sectors for the United States are estimated by the U.S. Energy Information Administration (EIA) in billion British thermal units (Btu) and published in the EIA *Annual Energy Review* for 1989 forward. Since the amount of commercial use is very small, it is combined with residential consumption in SEDS. Through 2009, 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 the EIA Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey," and predecessor forms. The data are published for recent years 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 92 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):

SOHCBUS = solar thermal direct use energy, and photovoltaic electricity net generation (converted to Btu using the fossil-fueled

plants heat rate), in the residential and commercial sectors combined in the United States, in billion Btu; and
 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, and the U.S. residential/commercial solar energy use is allocated to the States as follows:

$$\begin{aligned} \text{SOTTPUS} &= \Sigma \text{SOTTPZZ} \\ \text{SOHCBZZ} &= (\text{SOTTPZZ} / \text{SOTTPUS}) * \text{SOHCBUS} \end{aligned}$$

EIA-63A was terminated for data year 2010, and no alternative data source is available. State shares (SOTTPZZ/SOTTPUS) from 2009 are used to allocate the U.S. total to the states.

Electric Power Sector

The electric power sector includes estimates of electricity produced from photovoltaic and solar thermal energy sources by electric utilities for 1984 forward, and by both electric utilities and nonutility 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 = electricity produced from photovoltaic and solar thermal energy sources by 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:

$$\text{SOEGPUS} = \Sigma \text{SOEGPZZ}$$

Electricity produced from photovoltaic and solar thermal energy in the electric power sector is converted from kilowatthours to 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.cfm>.

FFETKUS = factor for converting electricity produced from solar energy sources 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:

$$\begin{aligned} \text{SOEGBZZ} &= \text{SOEGPZZ} * \text{FFETKUS} \\ \text{SOEGBUS} &= \Sigma \text{SOEGBZZ} \end{aligned}$$

Each State’s total use of photovoltaic and solar thermal energy sources is the sum of the sectors’ values, and the U.S. total is the sum of the States’ totals:

$$\begin{aligned} \text{SOTCBZZ} &= \text{SOHCBZZ} + \text{SOEGBZZ} \\ \text{SOTCBUS} &= \Sigma \text{SOTCBZZ} \end{aligned}$$

Additional Notes on Solar Energy

Shipments of solar thermal collectors in the United States, in thousand square feet, for 1974 through 2009 are collected on the EIA 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 *Renewable Energy Annual*. See SOTTPZZ Data Sources on page 92 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.

SOEGPZZ — Electricity produced from photovoltaic and solar thermal energy sources by the electric power sector by State.

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

SOHCBUS — Solar thermal direct use energy, and photovoltaic electricity net generation (converted to Btu using the fossil-fueled plants heat rate), in the residential and commercial sectors combined in the United States.

- 1960 through 1988: No data available. Values are zero.
- 1989 forward: EIA, *Annual Energy Review*, Table 10.2a.

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 SOHCBUS.
- 1989 forward: Shipments of solar thermal collectors in the United States, in thousand square feet, for 1974 forward are collected on the EIA 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 forward: 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 forward: 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 energy used to produce electricity by the electric power sector is included in the State Energy Data System (SEDS) for 1983 forward. 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 = electricity produced from wind energy by the electric power sector, by State, in million kilowatthours.

The U.S. total is calculated as the sum of the State data:

WYEGPUS = Σ WYEGPZZ

Electricity produced from wind energy by 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.cfm>.

FFETKUS = factor for converting electricity produced from wind energy 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:

WYEGBZZ = WYEGPZZ * FFETKUS

WYEBUS = Σ WYEGBZZ

The State and U.S. totals for wind energy are calculated:

WYTCBZZ = WYEGBZZ

WYTCBUS = Σ WYTCBZZ

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.

WYEGPZZ — Electricity produced from wind energy by the electric power sector by State.

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

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 by-products 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. Prior to 2001, waste also

includes non-biomass waste (municipal solid waste from non-biogenic sources, and tire-derived fuels).

Residential Sector

Physical Units

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*. For 1980 forward, State estimates are developed from U.S. totals published in the EIA *Annual Energy Review (AER)*, from Census division data collected on the EIA triennial survey, *Residential Energy Consumption Survey (RECS)* for 1981, 1984, 1987, 1990, 1993, 1997, 2001, and 2005 and from U.S. Department of Commerce, Bureau of the Census, annual estimates of number of housing units per State. The 1981 *RECS* provides wood consumption data for the national total and Census regions. For all other years, *RECS* provides data for the national total and Census divisions. In addition, the survey sample size of the 1993, 1997, and 2001 *RECS* were large enough to provide data for California, Florida, New York, and Texas. For 2005, *RECS* only provides data for California, New York, and Texas. An estimate for Florida is derived from the 2005 *RECS* microdata. Estimates for the other States in 1993, 1997, 2001, and 2005, and for all States in the other years are developed by allocating the U.S. total from the *AER* to the Census divisions or regions in proportion to *RECS* data. Estimates for the years intervening the *RECS* surveys are based on the annual U.S. totals from the *AER* and the State proportions of the preceding available *RECS*, i.e., 1982 and 1983 estimates are based on the State proportions of the 1981 data.

The regional values derived from the *RECS* data are then allocated to the States within the regions in proportion to Census Bureau data on housing units per State. For years prior to 2005, total housing units by State from the Population Division are used, and it is assumed that no wood is consumed in the residential sector in Hawaii. Beginning in 2005, the number of occupied housing units that use wood as primary heating fuel from the American Community Survey is used to allocate the regional values to the States.

The State data derived above are used in SEDS as wood consumption in the residential sector, identified in the system as WDRCPZZ. “ZZ” in the following variable name represents the two-letter State code that differs for each State.

WDRCPZZ = wood consumed in the residential sector of each State, in thousand cords.

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

WDRCPUS = Σ WDRCPZZ

British Thermal Units (Btu)

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 = Σ WDRCBZZ

Data Sources

WDRCPZZ — 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. Data published in thousand short tons are converted to thousand cords by 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).
- 1980 forward: U.S. totals published in the EIA *Annual Energy Review*, Table 10.2a are converted from trillion Btu to thousand cords (by using the factor of 20 million Btu per cord) and allocated to the States as described below. Hawaii residential wood consumption is assumed to be zero for all years.
 - 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, Bureau of the Census, *American Housing Survey*, “Total Housing Units for States, July 1, 1981.” This derived 1981 State series is used to

allocate the *AER* annual U.S. residential wood consumption to the States for 1980 through 1983.

- 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, Bureau of the Census, *American Housing Survey*, “Total Housing Units for States, July 1, 1984.” This derived 1984 State series is used to allocate the *AER* annual U.S. residential wood consumption to the States for 1984 through 1986.
- 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, Bureau of the Census, *American Housing Survey*, “Total Housing Units for States, July 1, 1987.” This derived 1987 series is used to allocate the *AER* annual U.S. residential wood consumption to the States for 1987 through 1989.
- 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 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, Bureau of the Census, 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>. This derived 1990 State series is used to allocate the *AER* annual U.S. residential wood consumption to the States for 1990 through 1992.
- 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, Bureau of the Census, 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>. This derived 1993 State series is used to allocate the *AER* annual U.S. residential wood consumption to the States for 1993 through 1996.
- 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, Bureau of the Census, 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>. This derived 1997 State series is used to allocate the *AER* annual U.S. residential wood consumption to the States for 1997 through 2000.
- 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, Bureau of the Census, 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/popest/data/historical/index.html>. This derived 2001 State series is used to allocate the *AER* annual U.S. residential wood consumption to the States for 2001 through 2004.
- 2005 forward: 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, Bureau of the Census, 2005-2007 American Community Survey 3-Year Estimates, Series B25040, by State, Occupied Housing Units by House Heating Fuel,” item titled “Wood,” at <http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>. This derived 2005

State series is used to allocate the *AER* annual U.S. residential wood consumption to the States for 2005 forward.

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*. 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 the EIA, 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*. The U.S. total of the State commercial CHP and electricity-only plant wood consumption is subtracted from the *AER* 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):

- WDRCPZZ = wood consumed in the residential sector of each State, in thousand cords;
- 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.

$$\begin{aligned} \text{WDRCPUS} &= \Sigma \text{WDRCPZZ} \\ \text{WDC3BUS} &= \Sigma \text{WDC3BZZ} \\ \text{WSC3BUS} &= \Sigma \text{WSC3BZZ} \end{aligned}$$

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:

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

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:

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

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/cneaf/electricity/page/eia906_920.html.

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. Data published in thousand short tons are converted to Btu using the factor of one short ton equals 17.2 million Btu (as stated in the footnote of Table A7).
- 1980 forward: EIA, data in billion Btu shown in trillion Btu in the *Annual 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/cneaf/electricity/page/eia906_920.html.

WDRCPZZ — Wood energy consumed by the residential sector by State. See sources on page 95.

Industrial Sector

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 1 short ton equals 17.2 million Btu.

Estimates for 1980 through 1995 are based on a national-level data series published for 1949 forward in the EIA *Annual Energy Review (AER)*. 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, Bureau of the Census, *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 Bureau of the Census *Economic Census* data for 1997 forward use North American Industry Classification System (NAICS) instead of Standard Industrial Classifications. Some categories used in the two classification systems are directly comparable (NAICS 311221 to SIC 2046, NAICS 311311 to SIC 2061, and NAICS 322130 to SIC 2631), some are closely (over 97 percent) comparable (NAICS 337122 to SIC 2511 and the sum of NAICS 321113 and 321912 to SIC 2421), and one is roughly (74 percent) comparable (NAICS 322121 to SIC 2621). The EIA survey Form EIA-846, MECS, also uses NAICS codes in the surveys for 1998, 2002, and 2006. 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, from 2006 forward, NAICS subtotals are allocated to the States using the State-level series from the U.S. Department of Commerce, *2007 Economic Census*, Manufacturing, Geographic Area Series, column titled “Value of shipments” data for NAICS series 311221, 311311, 313, 321113, 3212, 32191, 322121, 322122, 322130, and 3372..

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 the EIA, 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). Industrial wood and waste 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):

- WDI3BZZ = wood consumed by CHP and electricity-only facilities in the industrial sector in each State, in billion Btu;
 WDI4BZZ = wood consumed by the manufacturing portion of the industrial sector of each State, in billion Btu;
 WSI3BZZ = waste consumed by CHP and electricity-only facilities in the industrial sector in each State, in billion Btu; and
 WSI4BZZ = waste consumed by the manufacturing portion of the industrial sector of each State, in billion Btu.

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

- WDI3BUS = Σ WDI3BZZ
 WDI4BUS = Σ WDI4BZZ
 WSI3BUS = Σ WSI3BZZ
 WSI4BUS = Σ WSI4BZZ

The U.S. total for wood consumed by the industrial sector is calculated as the sum of consumption by CHP and electricity-only facilities and the manufacturing sector, and the U.S. total is calculated as the sum of the State data:

- WDICBZZ = WDI3BZZ + WDI4BZZ
 WDICBUS = Σ WDICBZZ

The U.S. total for waste consumed by the industrial sector is calculated as the sum of consumption by CHP and electricity-only facilities and the manufacturing sector, and the U.S. total is calculated as the sum of the State data:

- WSICBZZ = WSI3BZZ + WSI4BZZ
 WSICBUS = Σ WSICBZZ

The total manufacturing 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:

- WWI4BZZ = WDI4BZZ + WSI4BZZ

- WWI4BUS = Σ WWI4BZZ

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:

- WWICBZZ = WDICBZZ + WSICBZZ
 WWICBUS = Σ WWICBZZ

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.

WDI4BZZ — Wood consumed by the manufacturing sector by State.

- 1960 through 1979: EIA, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981*, Table A10. Data published in thousand short tons are converted to Btu by using the factor of one short ton equals 17.2 million Btu (as published in the footnote of 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.
 - 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, Bureau of the Census, *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, Bureau of the Census, *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, Bureau of the Census, *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, Bureau of the Census, *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, Bureau of the Census, *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* 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), and 2006 (for 2006 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, Bureau of the Census, *Economic Census* for 1997 (1998–2000), 2002 (2001–2005), and 2007 (2006 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, the state series are the “Value of Shipments” data for the specific industries. *Economic Census* data are available at <http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>.

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/cneaf/electricity/page/eia906_920.html.

WSI4BZZ — Waste consumed by the manufacturing sector 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.
 - 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, Bureau of the Census, *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, Bureau of the Census, *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, Bureau of the Census, *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, Bureau of the Census, *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, Bureau of the Census, *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 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* 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 forward), Table A7, 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, Bureau of the Census, *Economic Census* for 1997 (1998–2000), 2002 (2001–2005), and 2007 (2006 forward). 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 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). For 2007, the state series are the "Value of Shipments" data for the specific industries. *Economic Census* data are available at <http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>.

Electric Power Sector

Electric power sector use of wood and waste to generate electricity is based on data series from EIA Form EIA-923, “Power Plant Operations Report,” and predecessor forms and is estimated in SEDS using two methods. 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. Prior to 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 (includes 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:

$$WDEIBUS = \Sigma WDEIBZZ$$

$$WSEIBUS = \Sigma WSEIBZZ$$

$$WWEIBZZ = WDEIBZZ + WSEIBZZ$$

$$WWEIBUS = \Sigma WWEIBZZ$$

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.cfm>).
- 2001 forward: EIA Form EIA-923, “Power Plant Operations Report” and predecessor forms, http://www.eia.gov/cneaf/electricity/page/eia906_920.html.

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.cfm>).
- 2001 forward: EIA, Form EIA-923, “Power Plant Operations Report” and predecessor forms, http://www.eia.gov/cneaf/electricity/page/eia906_920.html.

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:

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

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

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

Additional Calculations

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

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

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 fuel ethanol (EMLCB).

$$\begin{aligned}
 \text{RERCB} &= \text{GERCB} + \text{SOHCB} + \text{WDRCB} \\
 \text{RECCB} &= \text{EMCCB} + \text{GECCB} + \text{HYCCB} + \text{WWCCB} \\
 \text{REICB} &= \text{EMICB} + \text{EMLCB} + \text{GEICB} + \text{HYICB} + \text{WWICB} \\
 \text{REACB} &= \text{EMACB}
 \end{aligned}$$

$$\text{REEIB} = \text{GEEGB} + \text{HYEGB} + \text{SOEGB} + \text{WWEIB} + \text{WYEGB}$$

$$\text{RETCB} = \text{RERCB} + \text{RECCB} + \text{REICB} + \text{REACB} + \text{REEIB}$$

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.