

# Appendix A

## British Thermal Unit Conversion Factors

The thermal conversion factors presented in the following tables can be used to estimate the heat content in British thermal units (Btu) of a given amount of energy measured in physical units, such as barrels or cubic feet. For example, 10 barrels of asphalt has a heat content of approximately 66.36 million Btu (10 barrels x 6.636 million Btu per barrel = 66.36 million Btu).

The heat content rates (i.e., thermal conversion factors) provided in this section represent the gross (or higher or upper) energy content of the fuels. Gross heat content rates are applied in all Btu calculations for the *Monthly Energy Review* and are commonly used in energy calculations in the United States; net (or lower) heat content rates are typically used in European energy calculations. The difference between the two rates is the amount of energy that is consumed to vaporize water that is created during the

combustion process. Generally, the difference ranges from 2% to 10%, depending on the specific fuel and its hydrogen content. Some fuels, such as unseasoned wood, can be more than 40% different in their gross and net heat content rates. See “Heat Content” and “British Thermal Unit (Btu)” in the Glossary for more information.

In general, the annual thermal conversion factors presented in Tables A2 through A6 are computed from final annual data or from the best available data and labeled “preliminary.” Often, the current year’s factors are labeled “estimate,” and are set equal to the previous year’s values until data become available to calculate the factors. The source of each factor is described in the section entitled “Thermal Conversion Factor Source Documentation,” which follows Table A6 in this appendix.

**Table A1. Approximate Heat Content of Petroleum and Other Liquids**  
(Million Btu per Barrel, Except as Noted)

Commodity	Heat Content	Commodity	Heat Content
Asphalt and Road Oil	6.636	Motor Gasoline Blending Components (MGBC)	
Aviation Gasoline (Finished)	5.048	Through 2006	5.253
Aviation Gasoline Blending Components	5.048	Beginning in 2007	5.222
Biodiesel	5.359	Oxygenates (excluding Fuel Ethanol)	4.247
Crude Oil—see Table A2		Petrochemical Feedstocks	
Distillate Fuel Oil—see Table A3 for averages		Naphtha Less Than 401°F	5.248
15 ppm sulfur and under	5.770	Other Oils Equal to or Greater Than 401°F	5.825
Greater than 15 ppm to 500 ppm sulfur	5.817	Petroleum Coke—see Table A3 for averages	
Greater than 500 ppm sulfur	5.825	Total, through 2003	6.024
Fuel Ethanol—see Table A3		Catalyst, beginning in 2004	<sup>a</sup> 6.287
Hydrocarbon Gas Liquids		Marketable, beginning in 2004	5.719
Ethane/Ethylene	3.082	Plant Condensate	5.418
Propane/Propylene	3.836	Renewable Fuels Except Fuel Ethanol	<sup>b</sup> 5.359; <sup>b</sup> 5.494
Normal Butane/Butylene	4.326	Residual Fuel Oil	6.287
Isobutane/Isobutylene	3.974	Special Naphthas	5.248
Natural Gasoline (Pentanes Plus)	4.620	Still Gas	<sup>c</sup> 6.287; <sup>c</sup> 6.000
Hydrogen	<sup>a</sup> 6.287	Unfinished Oils	5.825
Jet Fuel, Kerosene Type	5.670	Unfractionated Stream	5.418
Jet Fuel, Naphtha Type	5.355	Waxes	5.537
Kerosene	5.670	Miscellaneous Products	5.796
Lubricants	6.065	Other Hydrocarbons	5.825
Motor Gasoline (Finished)—see Tables A2/A3			

<sup>a</sup> Per residual fuel oil equivalent barrel (6.287 million Btu per barrel).

<sup>b</sup> The biodiesel heat content factor, 5.359 million Btu per barrel, is used for “Biomass-Based Diesel Fuel” and “Other Renewable Fuels”; however, a factor of 5.494 million Btu per barrel is used for “Other Renewable Diesel Fuel.”

<sup>c</sup> Through 2015, the still gas heat content factor is 6.000 million Btu per fuel oil equivalent barrel; beginning in 2016, the factor is 6.287 million Btu per residual fuel oil equivalent barrel.

Note: The values in this table are for gross heat contents. See “Heat Content” in Glossary.

Web Page: <http://www.eia.gov/totalenergy/data/monthly/#appendices>.

Sources: See “Thermal Conversion Factor Source Documentation,” which follows Table A6.

**Table A2. Approximate Heat Content of Petroleum Production, Imports, and Exports**  
(Million Btu per Barrel)

	Production		Imports				Exports			
			Crude Oil <sup>a</sup>	Petroleum Products		Total	Crude Oil <sup>a</sup>	Petroleum Products		Total
	Natural Gas Plant Liquids	Motor Gasoline <sup>b</sup>		Total Products	Motor Gasoline <sup>c</sup>			Total Products		
1950	5.800	4.522	5.943	5.253	6.263	6.080	5.800	5.253	5.751	5.766
1955	5.800	4.406	5.924	5.253	6.234	6.040	5.800	5.253	5.765	5.768
1960	5.800	4.295	5.911	5.253	6.161	6.021	5.800	5.253	5.835	5.834
1965	5.800	4.264	5.872	5.253	6.123	5.997	5.800	5.253	5.742	5.743
1970	5.800	4.146	5.822	5.253	6.088	5.985	5.800	5.253	5.811	5.810
1975	5.800	3.984	5.821	5.253	5.935	5.858	5.800	5.253	5.747	5.748
1980	5.800	3.914	5.812	5.253	5.748	5.796	5.800	5.253	5.841	5.820
1981	5.800	3.930	5.818	5.253	5.659	5.775	5.800	5.253	5.837	5.821
1982	5.800	3.872	5.826	5.253	5.664	5.775	5.800	5.253	5.829	5.820
1983	5.800	3.839	5.825	5.253	5.677	5.774	5.800	5.253	5.800	5.800
1984	5.800	3.812	5.823	5.253	5.613	5.745	5.800	5.253	5.867	5.850
1985	5.800	3.815	5.832	5.253	5.572	5.736	5.800	5.253	5.819	5.814
1986	5.800	3.797	5.903	5.253	5.624	5.808	5.800	5.253	5.839	5.832
1987	5.800	3.804	5.901	5.253	5.599	5.820	5.800	5.253	5.860	5.858
1988	5.800	3.800	5.900	5.253	5.618	5.820	5.800	5.253	5.842	5.840
1989	5.800	3.826	5.906	5.253	5.641	5.833	5.800	5.253	5.869	5.857
1990	5.800	3.822	5.934	5.253	5.614	5.849	5.800	5.253	5.838	5.833
1991	5.800	3.807	5.948	5.253	5.636	5.873	5.800	5.253	5.827	5.823
1992	5.800	3.804	5.953	5.253	5.623	5.877	5.800	5.253	5.774	5.777
1993	5.800	3.801	5.954	5.253	5.539	5.866	5.800	5.253	5.681	5.693
1994	5.800	3.794	5.950	5.253	5.416	5.835	5.800	5.253	5.693	5.704
1995	5.800	3.796	5.938	5.253	5.345	5.830	5.800	5.253	5.692	5.703
1996	5.800	3.777	5.947	5.253	5.373	5.828	5.800	5.253	5.663	5.678
1997	5.800	3.762	5.954	5.253	5.333	5.836	5.800	5.253	5.663	5.678
1998	5.800	3.769	5.953	5.253	5.314	5.833	5.800	5.253	5.505	5.539
1999	5.800	3.744	5.942	5.253	5.291	5.815	5.800	5.253	5.530	5.564
2000	5.800	3.733	5.959	5.253	5.309	5.823	5.800	5.253	5.529	5.542
2001	5.800	3.735	5.976	5.253	5.330	5.838	5.800	5.253	5.637	5.641
2002	5.800	3.729	5.971	5.253	5.362	5.845	5.800	5.253	5.517	5.519
2003	5.800	3.739	5.970	5.253	5.381	5.845	5.800	5.253	5.628	5.630
2004	5.800	3.724	5.981	5.253	5.429	5.853	5.800	5.253	5.532	5.539
2005	5.800	3.724	5.977	5.253	5.436	5.835	5.800	5.253	5.504	5.513
2006	5.800	3.712	5.980	5.253	5.431	5.836	5.800	5.219	5.415	5.423
2007	5.800	3.701	5.985	5.222	5.483	5.857	5.800	5.188	5.465	5.471
2008	5.800	3.706	5.990	5.222	5.459	5.861	5.800	5.215	5.587	5.591
2009	5.800	3.692	5.988	5.222	5.509	5.878	5.800	5.221	5.674	5.677
2010	5.800	3.674	5.989	5.222	5.545	5.892	5.800	5.214	5.601	5.604
2011	5.800	3.672	6.008	5.222	5.538	5.905	5.800	5.216	5.526	5.530
2012	5.800	3.683	6.165	5.222	5.501	6.035	5.800	5.217	5.520	5.526
2013	5.800	3.714	6.010	5.222	5.497	5.899	5.800	5.216	5.470	5.482
2014	5.800	3.723	6.035	5.222	5.518	5.929	5.800	5.218	5.369	5.406
2015	5.717	3.744	6.065	5.222	5.504	5.941	5.682	5.218	5.279	5.319
2016	5.722	3.714	6.053	5.222	5.491	5.929	5.724	5.218	5.184	5.245
2017	P 5.722	P 3.700	P 6.061	P 5.222	P 5.492	P 5.939	P 5.736	P 5.221	P 5.154	P 5.257
2018	E 5.722	E 3.700	E 6.061	E 5.222	E 5.492	E 5.939	E 5.736	E 5.221	E 5.154	E 5.257

<sup>a</sup> Includes lease condensate.

<sup>b</sup> Excludes fuel ethanol, methyl tertiary butyl ether (MTBE), and other oxygenates blended into motor gasoline.

<sup>c</sup> Through 2005, excludes fuel ethanol, MTBE, and other oxygenates blended into motor gasoline. Beginning in 2006, includes MTBE, but excludes fuel ethanol and other oxygenates blended into motor gasoline.

P=Preliminary. E=Estimate.

Note: The values in this table are for gross heat contents. See "Heat Content" in Glossary.

Web Page: See <http://www.eia.gov/totalenergy/data/monthly/#appendices> (Excel and CSV files) for all available annual data beginning in 1949.

Sources: See "Thermal Conversion Factor Source Documentation," which follows Table A6.

**Table A3. Approximate Heat Content of Petroleum Consumption and Fuel Ethanol**  
(Million Btu per Barrel)

	Total Petroleum <sup>a</sup> Consumption by Sector						Distillate Fuel Oil Consumption <sup>f</sup>	Hydrocarbon Gas Liquids Consumption <sup>g</sup>	Motor Gasoline (Finished) Consumption <sup>h</sup>	Petroleum Coke Consumption <sup>i</sup>	Fuel Ethanol <sup>j</sup>	Fuel Ethanol Feedstock Factor <sup>k</sup>
	Residential	Commercial <sup>b</sup>	Industrial <sup>b</sup>	Transportation <sup>b,c</sup>	Electric Power <sup>d,e</sup>	Total <sup>b,c</sup>						
1950	5.473	5.817	5.953	5.461	6.254	5.649	5.825	4.011	5.253	6.024	NA	NA
1955	5.469	5.781	5.881	5.407	6.254	5.591	5.825	4.011	5.253	6.024	NA	NA
1960	5.417	5.781	5.818	5.387	6.267	5.555	5.825	4.011	5.253	6.024	NA	NA
1965	5.364	5.760	5.748	5.386	6.267	5.532	5.825	4.011	5.253	6.024	NA	NA
1970	5.260	5.708	5.595	5.393	6.252	5.503	5.825	<sup>g</sup> 3.779	5.253	6.024	NA	NA
1975	5.253	5.649	5.513	5.392	6.250	5.494	5.825	3.739	5.253	6.024	NA	NA
1980	5.321	5.751	5.366	5.441	6.254	5.479	5.825	3.746	5.253	6.024	3.563	6.586
1981	5.283	5.693	5.299	5.433	6.258	5.448	5.825	3.715	5.253	6.024	3.563	6.562
1982	5.266	5.698	5.247	5.423	6.258	5.415	5.825	3.678	5.253	6.024	3.563	6.539
1983	5.140	5.591	5.254	5.416	6.255	5.406	5.825	3.633	5.253	6.024	3.563	6.515
1984	5.307	5.657	5.207	5.418	6.251	5.395	5.825	3.677	5.253	6.024	3.563	6.492
1985	5.263	5.598	5.199	5.423	6.247	5.387	5.825	3.676	5.253	6.024	3.563	6.469
1986	5.268	5.632	5.269	5.426	6.257	5.418	5.825	3.710	5.253	6.024	3.563	6.446
1987	5.239	5.594	5.233	5.429	6.249	5.403	5.825	3.734	5.253	6.024	3.563	6.423
1988	5.257	5.597	5.228	5.433	6.250	5.410	5.825	3.719	5.253	6.024	3.563	6.400
1989	5.194	5.549	5.219	5.438	<sup>d</sup> 6.240	5.410	5.825	3.747	5.253	6.024	3.563	6.377
1990	5.145	5.553	5.253	5.442	6.244	5.411	5.825	3.712	5.253	6.024	3.563	6.355
1991	5.094	5.528	5.167	5.441	6.246	5.384	5.825	3.708	5.253	6.024	3.563	6.332
1992	5.124	5.513	5.168	5.443	6.238	5.378	5.825	3.722	5.253	6.024	3.563	6.309
1993	5.102	<sup>b</sup> 5.504	<sup>b</sup> 5.177	<sup>b</sup> 5.422	6.230	<sup>b</sup> 5.370	5.825	3.709	<sup>h</sup> 5.232	6.024	3.563	6.287
1994	5.095	5.512	5.149	5.424	6.213	5.360	<sup>f</sup> 5.820	3.730	5.231	6.024	3.563	6.264
1995	5.060	5.475	5.121	5.418	6.187	5.342	5.820	3.718	5.218	6.024	3.563	6.242
1996	4.995	5.430	5.114	5.420	6.194	5.336	5.820	3.708	5.218	6.024	3.563	6.220
1997	4.986	5.388	5.119	5.416	6.198	5.336	5.820	3.704	5.215	6.024	3.563	6.198
1998	4.972	5.362	5.136	5.414	6.210	5.349	5.819	3.697	5.215	6.024	3.563	6.176
1999	4.899	5.288	5.091	5.413	6.204	5.328	5.819	3.706	5.213	6.024	3.563	6.167
2000	4.905	5.313	5.056	5.423	6.188	5.326	5.819	3.692	5.214	6.024	3.563	6.159
2001	4.934	5.322	5.141	5.413	6.199	5.346	5.819	3.685	5.214	6.024	3.563	6.151
2002	4.883	5.290	5.092	5.411	6.172	5.324	5.819	3.671	5.211	6.024	3.563	6.143
2003	4.918	5.312	5.143	5.404	6.182	5.338	5.819	3.688	5.203	6.024	3.563	6.106
2004	4.949	5.323	5.144	5.410	6.134	5.341	5.818	3.677	5.201	<sup>i</sup> 5.982	3.563	6.069
2005	4.913	5.359	5.179	5.412	6.126	5.353	5.818	3.674	5.198	5.982	3.563	6.032
2006	4.883	5.296	5.159	5.409	6.038	5.336	5.803	3.644	5.191	5.987	3.563	5.995
2007	4.830	5.270	5.122	5.384	6.064	5.309	5.784	3.641	5.155	5.996	3.563	5.959
2008	4.769	5.156	5.147	5.355	6.013	5.287	5.780	3.645	5.126	5.992	3.563	5.922
2009	4.661	5.216	5.014	<sup>c</sup> 5.328	5.987	<sup>c</sup> 5.328	5.781	3.595	5.101	6.017	3.563	5.901
2010	4.661	5.194	4.977	5.323	5.956	5.222	5.778	3.599	5.078	6.059	3.561	5.880
2011	4.654	5.174	4.951	5.319	5.900	5.211	5.776	3.543	5.068	6.077	3.560	5.859
2012	4.711	5.124	4.903	5.307	5.925	5.191	5.774	3.558	5.063	6.084	3.560	5.838
2013	4.645	5.052	4.861	5.305	5.892	5.174	5.774	3.579	5.062	6.089	3.559	5.817
2014	4.661	5.014	4.868	5.302	5.906	5.177	5.773	3.558	5.060	6.100	3.558	5.797
2015	4.718	5.050	4.830	5.306	5.915	5.172	5.773	3.576	5.060	6.085	3.558	5.776
2016	4.628	5.022	4.865	5.308	5.885	5.181	5.773	3.543	5.059	6.104	3.558	5.755
2017	<sup>E</sup> 4.624	<sup>E</sup> 5.023	<sup>E</sup> 4.838	<sup>E</sup> 5.312	<sup>P</sup> 5.896	<sup>P</sup> 5.177	<sup>P</sup> 5.773	<sup>P</sup> 3.527	<sup>P</sup> 5.058	<sup>P</sup> 6.126	<sup>P</sup> 3.556	<sup>E</sup> 5.735
2018	<sup>E</sup> 4.624	<sup>E</sup> 5.023	<sup>E</sup> 4.838	<sup>E</sup> 5.312	<sup>E</sup> 5.896	<sup>E</sup> 5.177	<sup>E</sup> 5.773	<sup>E</sup> 3.527	<sup>E</sup> 5.058	<sup>E</sup> 6.126	<sup>E</sup> 3.556	<sup>E</sup> 5.715

<sup>a</sup> Petroleum products supplied, including natural gas plant liquids and crude oil burned directly as fuel. Quantity-weighted averages of the petroleum products included in each category are calculated by using heat content values for individual products shown in Tables A1 and A3.

<sup>b</sup> Beginning in 1993, includes fuel ethanol blended into motor gasoline.

<sup>c</sup> Beginning in 2009, includes renewable diesel fuel (including biodiesel) blended into distillate fuel oil.

<sup>d</sup> Electricity-only and combined-heat-and-power (CHP) plants within the NAICS 22 category whose primary business is to sell electricity, or electricity and heat, to the public. Through 1988, data are for electric utilities only; beginning in 1989, data are for electric utilities and independent power producers.

<sup>e</sup> Electric power sector factors are weighted average heat contents for distillate fuel oil, petroleum coke, and residual fuel oil; they exclude other liquids.

<sup>f</sup> There is a discontinuity in this time series between 1993 and 1994; beginning in 1994, the single constant factor is replaced by a quantity-weighted factor.

Quantity-weighted averages of the sulfur-content categories of distillate fuel oil are calculated by using heat content values shown in Table A1. Excludes renewable diesel fuel (including biodiesel) blended into distillate fuel oil.

<sup>g</sup> There is a discontinuity in this time series between 1966 and 1967; beginning in 1967, the single constant factor is replaced by a quantity-weighted factor.

Quantity-weighted averages of the major components of hydrocarbon gas liquids are calculated by using heat content values shown in Table A1.

<sup>h</sup> Through 1992, excludes oxygenates. Beginning in 1993, includes fuel ethanol blended into motor gasoline; and for 1993–2006, also includes methyl tertiary butyl ether (MTBE) and other oxygenates blended into motor gasoline.

<sup>i</sup> There is a discontinuity in this time series between 2003 and 2004; beginning in 2004, the single constant factor is replaced by a quantity-weighted factor.

Quantity-weighted averages of the two categories of petroleum coke are calculated by using heat content values shown in Table A1.

<sup>j</sup> Includes denaturant (petroleum added to ethanol to make it undrinkable). Fuel ethanol factors are weighted average heat contents for undenatured ethanol (3.539 million Btu per barrel) and products used as denaturant (natural gasoline, finished motor gasoline, and motor gasoline blending components—see Tables A1 and A3 for factors). The factor for 2009 is used as the estimated factor for 1980–2008.

<sup>k</sup> Corn input to the production of undenatured ethanol (million Btu corn per barrel undenatured ethanol), used as the factor to estimate total biomass inputs to the production of undenatured ethanol. Observed ethanol yields (gallons undenatured ethanol per bushel of corn) are 2.5 in 1980, 2.666 in 1998, 2.68 in 2002, 2.78 in 2008, and 2.82 in 2012; yields in other years are estimated. Corn is assumed to have a gross heat content of 0.392 million Btu per bushel. Undenatured ethanol is assumed to have a gross heat content of 3.539 million Btu per barrel.

<sup>P</sup>=Preliminary. <sup>E</sup>=Estimate. NA=Not available.

Note: The heat content values in this table are for gross heat contents. See "Heat Content" in Glossary.

Web Page: See <http://www.eia.gov/totalenergy/data/monthly/#appendices> (Excel and CSV files) for all available annual data beginning in 1949.

Sources: See "Thermal Conversion Factor Source Documentation," which follows Table A6.

**Table A4. Approximate Heat Content of Natural Gas**  
(Btu per Cubic Foot)

	Production		Consumption <sup>a</sup>			Imports	Exports
	Marketed	Dry	End-Use Sectors <sup>b</sup>	Electric Power Sector <sup>c</sup>	Total		
1950 .....	1,119	1,035	1,035	1,035	1,035	--	1,035
1955 .....	1,120	1,035	1,035	1,035	1,035	1,035	1,035
1960 .....	1,107	1,035	1,035	1,035	1,035	1,035	1,035
1965 .....	1,101	1,032	1,032	1,032	1,032	1,032	1,032
1970 .....	1,102	1,031	1,031	1,031	1,031	1,031	1,031
1975 .....	1,095	1,021	1,020	1,026	1,021	1,026	1,014
1980 .....	1,098	1,026	1,024	1,035	1,026	1,022	1,013
1981 .....	1,103	1,027	1,025	1,035	1,027	1,014	1,011
1982 .....	1,107	1,028	1,026	1,036	1,028	1,018	1,011
1983 .....	1,115	1,031	1,031	1,030	1,031	1,024	1,010
1984 .....	1,109	1,031	1,030	1,035	1,031	1,005	1,010
1985 .....	1,112	1,032	1,031	1,038	1,032	1,002	1,011
1986 .....	1,110	1,030	1,029	1,034	1,030	997	1,008
1987 .....	1,112	1,031	1,031	1,032	1,031	999	1,011
1988 .....	1,109	1,029	1,029	1,028	1,029	1,002	1,018
1989 .....	1,107	1,031	1,031	<sup>c</sup> 1,028	1,031	1,004	1,019
1990 .....	1,105	1,029	1,030	1,027	1,029	1,012	1,018
1991 .....	1,108	1,030	1,031	1,025	1,030	1,014	1,022
1992 .....	1,110	1,030	1,031	1,025	1,030	1,011	1,018
1993 .....	1,106	1,027	1,028	1,025	1,027	1,020	1,016
1994 .....	1,105	1,028	1,029	1,025	1,028	1,022	1,011
1995 .....	1,106	1,026	1,027	1,021	1,026	1,021	1,011
1996 .....	1,109	1,026	1,027	1,020	1,026	1,022	1,011
1997 .....	1,107	1,026	1,027	1,020	1,026	1,023	1,011
1998 .....	1,109	1,031	1,033	1,024	1,031	1,023	1,011
1999 .....	1,107	1,027	1,028	1,022	1,027	1,022	1,006
2000 .....	1,107	1,025	1,026	1,021	1,025	1,023	1,006
2001 .....	1,105	1,028	1,029	1,026	1,028	1,023	1,010
2002 .....	1,103	1,024	1,025	1,020	1,024	1,022	1,008
2003 .....	1,103	1,028	1,029	1,025	1,028	1,025	1,009
2004 .....	1,104	1,026	1,026	1,027	1,026	1,025	1,009
2005 .....	1,104	1,028	1,028	1,028	1,028	1,025	1,009
2006 .....	1,103	1,028	1,028	1,028	1,028	1,025	1,009
2007 .....	1,102	1,027	1,027	1,027	1,027	1,025	1,009
2008 .....	1,100	1,027	1,027	1,027	1,027	1,025	1,009
2009 .....	1,101	1,025	1,025	1,025	1,025	1,025	1,009
2010 .....	1,098	1,023	1,023	1,022	1,023	1,025	1,009
2011 .....	1,142	1,022	1,022	1,021	1,022	1,025	1,009
2012 .....	1,091	1,024	1,025	1,022	1,024	1,025	1,009
2013 .....	1,101	1,027	1,028	1,025	1,027	1,025	1,009
2014 .....	1,116	1,032	1,033	1,029	1,032	1,025	1,009
2015 .....	1,124	1,037	1,038	1,035	1,037	1,025	1,009
2016 .....	1,127	1,037	1,037	1,034	1,037	1,025	1,009
2017 .....	<sup>E</sup> 1,127	<sup>E</sup> 1,037	<sup>E</sup> 1,037	<sup>P</sup> 1,033	<sup>P</sup> 1,037	<sup>E</sup> 1,025	<sup>E</sup> 1,009
2018 .....	<sup>E</sup> 1,127	<sup>E</sup> 1,037	<sup>E</sup> 1,037	<sup>E</sup> 1,033	<sup>E</sup> 1,037	<sup>E</sup> 1,025	<sup>E</sup> 1,009

<sup>a</sup> Consumption factors are for natural gas, plus a small amount of supplemental gaseous fuels.

<sup>b</sup> Residential, commercial, industrial, and transportation sectors.

<sup>c</sup> Electricity-only and combined-heat-and-power (CHP) plants within the NAICS 22 category whose primary business is to sell electricity, or electricity and heat, to the public. Through 1988, data are for electric utilities only; beginning in 1989, data are for electric utilities and independent power producers.

P=Preliminary. E=Estimate. -- =Not applicable.

Note: The values in this table are for gross heat contents. See "Heat Content" in Glossary.

Web Page: See <http://www.eia.gov/totalenergy/data/monthly/#appendices> (Excel and CSV files) for all available annual data beginning in 1949.

Sources: See "Thermal Conversion Factor Source Documentation," which follows Table A6.

**Table A5. Approximate Heat Content of Coal and Coal Coke**

(Million Btu per Short Ton)

	Coal									Coal Coke	
	Production <sup>a</sup>	Waste Coal Supplied <sup>b</sup>	Consumption					Imports	Exports		Imports and Exports
			Residential and Commercial Sectors <sup>c</sup>	Industrial Sector		Electric Power Sector <sup>e,f</sup>	Total				
				Coke Plants	Other <sup>d</sup>						
1950	25.090	NA	24.461	26.798	24.820	23.937	24.989	25.020	26.788	24.800	
1955	25.201	NA	24.373	26.794	24.821	24.056	24.982	25.000	26.907	24.800	
1960	24.906	NA	24.226	26.791	24.609	23.927	24.713	25.003	26.939	24.800	
1965	24.775	NA	24.028	26.787	24.385	23.780	24.537	25.000	26.973	24.800	
1970	23.842	NA	23.203	26.784	22.983	22.573	23.440	25.000	26.982	24.800	
1975	22.897	NA	22.261	26.782	22.436	21.642	22.506	25.000	26.562	24.800	
1980	22.415	NA	22.543	26.790	22.690	21.295	21.947	25.000	26.384	24.800	
1981	22.308	NA	22.474	26.794	22.585	21.085	21.713	25.000	26.160	24.800	
1982	22.239	NA	22.695	26.797	22.712	21.194	21.674	25.000	26.223	24.800	
1983	22.052	NA	22.775	26.798	22.691	21.133	21.576	25.000	26.291	24.800	
1984	22.010	NA	22.844	26.799	22.543	21.101	21.573	25.000	26.402	24.800	
1985	21.870	NA	22.646	26.798	22.020	20.959	21.366	25.000	26.307	24.800	
1986	21.913	NA	22.947	26.798	22.198	21.084	21.462	25.000	26.292	24.800	
1987	21.922	NA	23.404	26.799	22.381	21.136	21.517	25.000	26.291	24.800	
1988	21.823	NA	23.571	26.799	22.360	20.900	21.328	25.000	26.299	24.800	
1989	21.765	<sup>b</sup> 10.391	23.650	26.800	22.347	<sup>g</sup> 20.898	21.307	25.000	26.160	24.800	
1990	21.822	9.303	23.137	26.799	22.457	20.779	21.197	25.000	26.202	24.800	
1991	21.681	10.758	23.114	26.799	22.460	20.730	21.120	25.000	26.188	24.800	
1992	21.682	10.396	23.105	26.799	22.250	20.709	21.068	25.000	26.161	24.800	
1993	21.418	10.638	22.994	26.800	22.123	20.677	21.010	25.000	26.335	24.800	
1994	21.394	11.097	23.112	26.800	22.068	20.589	20.929	25.000	26.329	24.800	
1995	21.326	11.722	23.118	26.800	21.950	20.543	20.880	25.000	26.180	24.800	
1996	21.322	12.147	23.011	26.800	22.105	20.547	20.870	25.000	26.174	24.800	
1997	21.296	12.158	22.494	26.800	22.172	20.518	20.830	25.000	26.251	24.800	
1998	21.418	12.639	21.620	27.426	23.164	20.516	20.881	25.000	26.800	24.800	
1999	21.070	12.552	23.880	27.426	22.489	20.490	20.818	25.000	26.081	24.800	
2000	21.072	12.360	25.020	27.426	22.433	20.511	20.828	25.000	26.117	24.800	
2001	<sup>a</sup> 20.772	12.169	24.909	27.426	22.622	20.337	20.671	25.000	25.998	24.800	
2002	20.673	12.165	22.962	27.426	22.562	20.238	20.541	25.000	26.062	24.800	
2003	20.499	12.360	22.242	27.425	22.468	20.082	20.387	25.000	25.972	24.800	
2004	20.424	12.266	22.324	27.426	22.473	19.980	20.290	25.000	26.108	24.800	
2005	20.348	12.093	22.342	26.279	22.178	19.988	20.246	25.000	25.494	24.800	
2006	20.310	12.080	22.066	26.271	22.050	19.931	20.181	25.000	25.453	24.800	
2007	20.340	12.090	22.069	26.329	22.371	19.909	20.168	25.000	25.466	24.800	
2008	20.208	12.121	<sup>c</sup> 23.035	26.281	22.304	19.713	19.979	25.000	25.399	24.800	
2009	19.963	12.076	22.852	26.334	21.823	19.521	19.741	25.000	25.633	24.800	
2010	20.173	11.960	22.611	26.295	21.846	19.623	19.870	25.000	25.713	24.800	
2011	20.142	11.604	22.099	26.299	21.568	19.341	19.600	25.000	25.645	24.800	
2012	20.215	11.539	21.300	28.636	21.449	19.211	19.544	23.128	24.551	24.800	
2013	20.182	11.103	21.233	28.705	21.600	19.174	19.513	22.379	24.605	24.800	
2014	20.146	11.474	21.307	28.458	21.525	19.290	19.611	22.187	25.032	24.800	
2015	19.880	11.527	20.699	28.526	21.258	19.146	19.482	22.633	25.048	24.800	
2016	19.977	11.496	20.078	28.608	21.055	19.153	19.459	22.327	25.655	24.800	
2017	<sup>P</sup> 20.033	<sup>P</sup> 12.798	<sup>P</sup> 19.465	<sup>P</sup> 28.673	<sup>P</sup> 20.779	<sup>P</sup> 19.015	<sup>RP</sup> 19.334	<sup>P</sup> 21.480	<sup>P</sup> 24.631	<sup>P</sup> 24.800	
2018	<sup>E</sup> 20.033	<sup>E</sup> 12.798	<sup>E</sup> 19.465	<sup>E</sup> 28.673	<sup>E</sup> 20.779	<sup>E</sup> 19.015	<sup>RE</sup> 19.334	<sup>E</sup> 21.480	<sup>E</sup> 24.631	<sup>E</sup> 24.800	

<sup>a</sup> Beginning in 2001, includes a small amount of refuse recovery (coal recaptured from a refuse mine, and cleaned to reduce the concentration of noncombustible materials).

<sup>b</sup> Waste coal (including fine coal, coal obtained from a refuse bank or slurry dam, anthracite culm, bituminous gob, and lignite waste) consumed by the electric power and industrial sectors. Beginning in 1989, waste coal supplied is counted as a supply-side item to balance the same amount of waste coal included in "Consumption."

<sup>c</sup> Through 2007, used as the thermal conversion factor for coal consumption by the residential and commercial sectors. Beginning in 2008, used as the thermal conversion factor for coal consumption by the commercial sector only.

<sup>d</sup> Includes transportation. Excludes coal synfuel plants.

<sup>e</sup> Electricity-only and combined-heat-and-power (CHP) plants within the NAICS 22 category whose primary business is to sell electricity, or electricity and heat, to the public. Through 1988, data are for electric utilities only; beginning in 1989, data are for electric utilities and independent power producers.

<sup>f</sup> Electric power sector factors are for anthracite, bituminous coal, subbituminous coal, lignite, waste coal, and, beginning in 1998, coal synfuel.

R=Revised. P=Preliminary. E=Estimate. NA=Not available.

Note: The values in this table are for gross heat contents. See "Heat Content" in Glossary.

Web Page: See <http://www.eia.gov/totalenergy/data/monthly/#appendices> (Excel and CSV files) for all available annual data beginning in 1949.

Sources: See "Thermal Conversion Factor Source Documentation," which follows Table A6.

**Table A6. Approximate Heat Rates for Electricity, and Heat Content of Electricity**  
(Btu per Kilowatthour)

	Approximate Heat Rates <sup>a</sup> for Electricity Net Generation						Heat Content <sup>j</sup> of Electricity <sup>k</sup>
	Fossil Fuels <sup>b</sup>				Nuclear <sup>h</sup>	Noncombustible Renewable Energy <sup>g,i</sup>	
	Coal <sup>c</sup>	Petroleum <sup>d</sup>	Natural Gas <sup>e</sup>	Total Fossil Fuels <sup>f,g</sup>			
1950	NA	NA	NA	14,030	--	14,030	3,412
1955	NA	NA	NA	11,699	--	11,699	3,412
1960	NA	NA	NA	10,760	11,629	10,760	3,412
1965	NA	NA	NA	10,453	11,804	10,453	3,412
1970	NA	NA	NA	10,494	10,977	10,494	3,412
1975	NA	NA	NA	10,406	11,013	10,406	3,412
1980	NA	NA	NA	10,388	10,908	10,388	3,412
1981	NA	NA	NA	10,453	11,030	10,453	3,412
1982	NA	NA	NA	10,454	11,073	10,454	3,412
1983	NA	NA	NA	10,520	10,905	10,520	3,412
1984	NA	NA	NA	10,440	10,843	10,440	3,412
1985	NA	NA	NA	10,447	10,622	10,447	3,412
1986	NA	NA	NA	10,446	10,579	10,446	3,412
1987	NA	NA	NA	10,419	10,442	10,419	3,412
1988	NA	NA	NA	10,324	10,602	10,324	3,412
1989	NA	NA	NA	10,432	10,583	10,432	3,412
1990	NA	NA	NA	10,402	10,582	10,402	3,412
1991	NA	NA	NA	10,436	10,484	10,436	3,412
1992	NA	NA	NA	10,342	10,471	10,342	3,412
1993	NA	NA	NA	10,309	10,504	10,309	3,412
1994	NA	NA	NA	10,316	10,452	10,316	3,412
1995	NA	NA	NA	10,312	10,507	10,312	3,412
1996	NA	NA	NA	10,340	10,503	10,340	3,412
1997	NA	NA	NA	10,213	10,494	10,213	3,412
1998	NA	NA	NA	10,197	10,491	10,197	3,412
1999	NA	NA	NA	10,226	10,450	10,226	3,412
2000	NA	NA	NA	10,201	10,429	10,201	3,412
2001	10,378	10,742	10,051	<sup>b</sup> 10,333	10,443	10,333	3,412
2002	10,314	10,641	9,533	10,173	10,442	10,173	3,412
2003	10,297	10,610	9,207	10,125	10,422	10,125	3,412
2004	10,331	10,571	8,647	10,016	10,428	10,016	3,412
2005	10,373	10,631	8,551	9,999	10,436	9,999	3,412
2006	10,351	10,809	8,471	9,919	10,435	9,919	3,412
2007	10,375	10,794	8,403	9,884	10,489	9,884	3,412
2008	10,378	11,015	8,305	9,854	10,452	9,854	3,412
2009	10,414	10,923	8,160	9,760	10,459	9,760	3,412
2010	10,415	10,984	8,185	9,756	10,452	9,756	3,412
2011	10,444	10,829	8,152	9,716	10,464	9,716	3,412
2012	10,498	10,991	8,039	9,516	10,479	9,516	3,412
2013	10,459	10,713	7,948	9,541	10,449	9,541	3,412
2014	10,428	10,814	7,907	9,510	10,459	9,510	3,412
2015	10,495	10,687	7,878	9,319	10,458	9,319	3,412
2016	10,493	10,811	7,870	9,232	10,459	9,232	3,412
2017	<sup>E</sup> 10,493	<sup>E</sup> 10,811	<sup>E</sup> 7,870	<sup>E</sup> 9,232	<sup>E</sup> 10,459	<sup>E</sup> 9,232	3,412
2018	<sup>E</sup> 10,493	<sup>E</sup> 10,811	<sup>E</sup> 7,870	<sup>E</sup> 9,232	<sup>E</sup> 10,459	<sup>E</sup> 9,232	3,412

<sup>a</sup> The values in columns 1–6 of this table are for net heat rates. See "Heat Rate" in Glossary.

<sup>b</sup> Through 2000, heat rates are for fossil-fueled steam-electric plants at electric utilities. Beginning in 2001, heat rates are for all fossil-fueled plants at electric utilities and electricity-only independent power producers.

<sup>c</sup> Includes anthracite, bituminous coal, subbituminous coal, lignite, and, beginning in 2002, waste coal and coal synfuel.

<sup>d</sup> Includes distillate fuel oil, residual fuel oil, jet fuel, kerosene, petroleum coke, and waste oil.

<sup>e</sup> Includes natural gas and supplemental gaseous fuels.

<sup>f</sup> Includes coal, petroleum, natural gas, and, beginning in 2001, other gases (blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuels).

<sup>g</sup> The fossil-fuels heat rate is used as the thermal conversion factor for electricity net generation from noncombustible renewable energy (hydro, geothermal, solar thermal, photovoltaic, and wind) to approximate the quantity of fossil fuels replaced by these sources. Through 2000, also used as the thermal conversion factor for wood and waste electricity net generation at electric utilities; beginning in 2001, Btu data for wood and waste at electric utilities are available from surveys.

<sup>h</sup> Used as the thermal conversion factor for nuclear electricity net generation.

<sup>i</sup> Technology-based geothermal heat rates are no longer used in Btu calculations in this report. For technology-based geothermal heat rates for 1960–2010, see the *Annual Energy Review 2010*, Table A6.

<sup>j</sup> See "Heat Content" in Glossary.

<sup>k</sup> The value of 3,412 Btu per kilowatthour is a constant. It is used as the thermal conversion factor for electricity retail sales, and electricity imports and exports.

<sup>E</sup>=Estimate. NA=Not available. --=Not applicable.

Web Page: See <http://www.eia.gov/totalenergy/data/monthly/#appendices> (Excel and CSV files) for all available annual data beginning in 1949.

Sources: See "Thermal Conversion Factor Source Documentation," which follows this table.

# Thermal Conversion Factor Source Documentation

## Approximate Heat Content of Petroleum and Natural Gas Liquids

**Asphalt.** The U.S. Energy Information Administration (EIA) adopted the thermal conversion factor of 6.636 million British thermal units (Btu) per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

**Aviation Gasoline Blending Components.** Assumed by EIA to be 5.048 million Btu per barrel or equal to the thermal conversion factor for **Aviation Gasoline (Finished)**.

**Aviation Gasoline (Finished).** EIA adopted the thermal conversion factor of 5.048 million Btu per barrel as adopted by the Bureau of Mines from the Texas Eastern Transmission Corporation publication *Competition and Growth in American Energy Markets 1947–1985*, a 1968 release of historical and projected statistics.

**Butane-Propane Mixture.** EIA adopted the Bureau of Mines calculation of 4.130 million Btu per barrel based on an assumed mixture of 60% normal butane and 40% propane. See **Normal Butane/Butylene and Propane/Propylene**.

**Crude Oil Exports.** • 1949–2014: Assumed by EIA to be 5.800 million Btu per barrel or equal to the thermal conversion factor for crude oil produced in the United States. See **Crude Oil Production.** • 2015 forward: Calculated annually by EIA based on conversion of American Petroleum Institute (API) gravity ranges of crude oil exports as reported in trade data from the U.S. Census Bureau. Specific gravity (SG) =  $141.5 / (131.5 + \text{API gravity})$ . The higher heating value (HHV) in million Btu per barrel =  $\text{SG} * (7.801796 - 1.3213 * \text{SG}^2)$ .

**Crude Oil Imports.** Calculated annually by EIA as the average of the thermal conversion factors for each type of crude oil imported weighted by the quantities imported. Thermal conversion factors for each type were calculated on a foreign country basis, by determining the average American Petroleum Institute (API) gravity of crude oil imported from each foreign country from Form ERA-60 in 1977 and converting average API gravity to average Btu content by using National Bureau of Standards, Miscellaneous Publication No. 97, *Thermal Properties of Petroleum Products*, 1933.

**Crude Oil Production.** • 1949–2014: EIA adopted the thermal conversion factor of 5.800 million Btu per barrel as reported in a Bureau of Mines internal memorandum, “Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950.” • 2015 forward: Calculated annually by EIA based on conversion of American Petroleum Institute (API) gravity ranges of crude oil

production as reported on Form EIA-914, “Monthly Crude Oil, Lease Condensate, and Natural Gas Production Report.” Specific gravity (SG) =  $141.5 / (131.5 + \text{API gravity})$ . The higher heating value (HHV) in million Btu per barrel =  $\text{SG} * (7.801796 - 1.3213 * \text{SG}^2)$ .

**Distillate Fuel Oil Consumption.** • 1949–1993: EIA adopted the Bureau of Mines thermal conversion factor of 5.825 million Btu per barrel as reported in a Bureau of Mines internal memorandum, “Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950.” • 1994 forward: Calculated by EIA as the annual quantity-weighted average of the conversion factors for **Distillate Fuel Oil, 15 ppm Sulfur and Under** (5.770 million Btu per barrel), **Distillate Fuel Oil, Greater Than 15 ppm to 500 ppm Sulfur** (5.817 million Btu per barrel), and **Distillate Fuel Oil, Greater Than 500 ppm Sulfur** (5.825 million Btu per barrel).

**Distillate Fuel Oil, 15 ppm Sulfur and Under.** EIA adopted the thermal conversion factor of 5.770 million Btu per barrel (137,380 Btu per gallon) for U.S. conventional diesel from U.S. Department of Energy, Argonne National Laboratory, “The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model” (GREET), version GREET1\_2013, October 2013.

**Distillate Fuel Oil, Greater Than 15 ppm to 500 ppm Sulfur.** EIA adopted the thermal conversion factor of 5.817 million Btu per barrel (138,490 Btu per gallon) for low-sulfur diesel from U.S. Department of Energy, Argonne Laboratory, “The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model” (GREET), version GREET1\_2013, October 2013.

**Distillate Fuel Oil, Greater Than 500 ppm Sulfur.** EIA adopted the Bureau of Mines thermal conversion factor of 5.825 million Btu per barrel as reported in a Bureau of Mines internal memorandum, “Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950.”

**Ethane/Ethylene.** EIA adopted the Bureau of Mines thermal conversion factor of 3.082 million Btu per barrel as published in the *California Oil World and Petroleum Industry*, First Issue, April 1942.

**Ethane-Propane Mixture.** EIA calculation of 3.308 million Btu per barrel based on an assumed mixture of 70% ethane and 30% propane. See **Ethane/Ethylene and Propane/Propylene**.

**Hydrocarbon Gas Liquids.** • 1949–1966: U.S. Department of the Interior, Bureau of Mines, Mineral Industry Surveys, “Crude Petroleum and Petroleum Products, 1956,” Table 4 footnote, constant value of 4.011 million Btu per barrel. • 1967 forward: Calculated annually by EIA as the average of the thermal conversion factors for all hydrocarbon gas liquids consumed (see Table A1) weighted by the quantities consumed. The component products of

hydrocarbon gas liquids are ethane (including ethylene), propane (including propylene), normal butane (including butylene), isobutane (including isobutylene), butane-propane mixtures, ethane-propane mixtures, and natural gasoline (pentanes plus). For 1967–1980, quantities consumed are from EIA, Energy Data Reports, “Petroleum Statement, Annual,” Table 1. For 1981 forward, quantities consumed are from EIA, *Petroleum Supply Annual*, Table 2.

**Hydrogen.** Assumed by EIA to be 6.287 million Btu per barrel or equal to the thermal conversion factor for **Residual Fuel Oil**.

**Isobutane/Isobutylene.** EIA adopted the Bureau of Mines thermal conversion factor of 3.974 million Btu per barrel as published in the *California Oil World and Petroleum Industry*, First Issue, April 1942.

**Jet Fuel, Kerosene-Type.** EIA adopted the Bureau of Mines thermal conversion factor of 5.670 million Btu per barrel for “Jet Fuel, Commercial” as published by the Texas Eastern Transmission Corporation in the report *Competition and Growth in American Energy Markets 1947–1985*, a 1968 release of historical and projected statistics.

**Jet Fuel, Naphtha-Type.** EIA adopted the Bureau of Mines thermal conversion factor of 5.355 million Btu per barrel for “Jet Fuel, Military” as published by the Texas Eastern Transmission Corporation in the report *Competition and Growth in American Energy Markets 1947–1985*, a 1968 release of historical and projected statistics.

**Kerosene.** EIA adopted the Bureau of Mines thermal conversion factor of 5.670 million Btu per barrel as reported in a Bureau of Mines internal memorandum, “Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950.”

**Lubricants.** EIA adopted the thermal conversion factor of 6.065 million Btu per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

**Miscellaneous Products.** EIA adopted the thermal conversion factor of 5.796 million Btu per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

**Motor Gasoline Blending Components.** • 1949–2006: EIA adopted the Bureau of Mines thermal conversion factor of 5.253 million Btu per barrel for “Gasoline, Motor Fuel” as published by the Texas Eastern Transmission Corporation in Appendix V of *Competition and Growth in American Markets 1947–1985*, a 1968 release of historical and projected statistics. • 2007 forward: EIA adopted the thermal conversion factor of 5.222 million Btu per barrel (124,340 Btu per gallon) for gasoline blendstock from U.S. Department of Energy, Argonne National Laboratory, “The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model” (GREET), version GREET1\_2013, October 2013.

**Motor Gasoline Exports.** • 1949–2005: EIA adopted the Bureau of Mines thermal conversion factor of 5.253 million Btu per barrel for “Gasoline, Motor Fuel” as published by the Texas Eastern Transmission Corporation in Appendix V of *Competition and Growth in American Energy Markets 1947–1985*, a 1968 release of historical and projected statistics. • 2006 forward: Calculated by EIA as the annual quantity-weighted average of the conversion factors for gasoline blendstock and the methyl tertiary butyl ether (MTBE) blended into motor gasoline exports. The factor for gasoline blendstock is 5.253 million Btu per barrel in 2006 and 5.222 million Btu per barrel beginning in 2007 (see **Motor Gasoline Blending Components**). For MTBE, EIA adopted the thermal conversion factor of 4.247 million Btu per barrel (101,130 Btu per gallon) from U.S. Department of Energy, Argonne National Laboratory, “The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model” (GREET), version GREET1\_2013, October 2013.

**Motor Gasoline (Finished) Consumption.** • 1949–1992: EIA adopted the Bureau of Mines thermal conversion factor of 5.253 million Btu per barrel for “Gasoline, Motor Fuel” as published by the Texas Eastern Transmission Corporation in Appendix V of *Competition and Growth in American Markets 1947–1985*, a 1968 release of historical and projected statistics. • 1993–2006: Calculated by EIA as the annual quantity-weighted average of the conversion factors for gasoline blendstock and the oxygenates blended into motor gasoline. The factor for gasoline blendstock is 5.253 million Btu per barrel (the motor gasoline factor used for previous years). The factors for fuel ethanol are shown in Table A3 (see **Fuel Ethanol, Denatured**). The following factors for other oxygenates are from U.S. Department of Energy, Argonne National Laboratory, “The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model” (GREET), version GREET1\_2013, October 2013—methyl tertiary butyl ether (MTBE): 4.247 million Btu per barrel (101,130 Btu per gallon); tertiary amyl methyl ether (TAME): 4.560 million Btu per barrel (108,570 Btu per gallon); ethyl tertiary butyl ether (ETBE): 4.390 million Btu per barrel (104,530 Btu per gallon); methanol: 2.738 million Btu per barrel (65,200 Btu per gallon); and butanol: 4.555 million Btu per barrel (108,458 Btu per gallon). • 2007 forward: Calculated by EIA as the annual quantity-weighted average of the conversion factors for gasoline blendstock and fuel ethanol blended into motor gasoline. The factor for gasoline blendstock is 5.222 million Btu per barrel (124,340 Btu per gallon), which is from the GREET model (see above). The factors for fuel ethanol are shown in Table A3 (see **Fuel Ethanol, Denatured**).

**Motor Gasoline Imports.** • 1949–2006: EIA adopted the Bureau of Mines thermal conversion factor of 5.253 million Btu per barrel for “Gasoline, Motor Fuel” as published by the Texas Eastern Transmission Corporation in Appendix V of *Competition and Growth in American Energy Markets 1947–1985*, a 1968 release of historical and projected

statistics. • 2007 forward: EIA adopted the thermal conversion factor of 5.222 million Btu per barrel (124,340 Btu per gallon) for gasoline blendstock from U.S. Department of Energy, Argonne National Laboratory, “The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model” (GREET), version GREET1\_2013, October 2013.

**Natural Gas Plant Liquids Production.** Calculated annually by EIA as the average of the thermal conversion factors for each natural gas plant liquid produced weighted by the quantities produced.

**Natural Gasoline.** EIA adopted the thermal conversion factor of 4.620 million Btu per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual 1956*.

**Normal Butane/Butylene.** EIA adopted the Bureau of Mines thermal conversion factor of 4.326 million Btu per barrel as published in the *California Oil World and Petroleum Industry*, First Issue, April 1942.

**Other Hydrocarbons.** Assumed by EIA to be 5.825 million Btu per barrel or equal to the thermal conversion factor for **Unfinished Oils**.

**Oxygenates (Excluding Fuel Ethanol).** EIA adopted the thermal conversion factor of 4.247 million Btu per barrel (101,130 Btu per gallon) for methyl tertiary butyl ether (MTBE) from U.S. Department of Energy, Argonne National Laboratory, “The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model” (GREET), version GREET1\_2013, October 2013.

**Petrochemical Feedstocks, Naphtha Less Than 401 Degrees Fahrenheit.** Assumed by EIA to be 5.248 million Btu per barrel or equal to the thermal conversion factor for **Special Naphthas**.

**Petrochemical Feedstocks, Other Oils Equal to or Greater Than 401 Degrees Fahrenheit.** Assumed by EIA to be 5.825 million Btu per barrel or equal to the thermal conversion factor for **Distillate Fuel Oil**.

**Petrochemical Feedstocks, Still Gas.** Assumed by EIA to be 6.000 million Btu per barrel or equal to the thermal conversion factor for **Still Gas**.

**Petroleum Coke, Catalyst.** Assumed by EIA to be 6.287 million Btu per barrel or equal to the thermal conversion factor for **Residual Fuel Oil**.

**Petroleum Coke, Marketable.** EIA adopted the thermal conversion factor of 5.719 million Btu per barrel, calculated by dividing 28,595,925 Btu per short ton for petroleum coke (from U.S. Department of Energy, Argonne National Laboratory, “The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model” (GREET), version GREET1\_October 2013) by 5.0 barrels

per short ton (as given in the Bureau of Mines Form 6-1300-M and successor EIA forms).

**Petroleum Coke, Total.** • 1949–2003: EIA adopted the thermal conversion factor of 6.024 million Btu per barrel as reported in Btu per short ton in the Bureau of Mines internal memorandum, “Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950.” The Bureau of Mines calculated this factor by dividing 30.120 million Btu per short ton, as given in the referenced Bureau of Mines internal memorandum, by 5.0 barrels per short ton, as given in the Bureau of Mines Form 6-1300-M and successor EIA forms. • 2004 forward: Calculated by EIA as the annual quantity-weighted average of the conversion factors for **Petroleum Coke, Catalyst** (6.287 million Btu per barrel) and **Petroleum Coke, Marketable** (5.719 million Btu per barrel).

**Petroleum Consumption, Commercial Sector.** Calculated annually by EIA as the average of the thermal conversion factors for all petroleum products consumed by the commercial sector weighted by the estimated quantities consumed by the commercial sector. The quantities of petroleum products consumed by the commercial sector are estimated in the State Energy Data System—see documentation at [http://www.eia.gov/state/seds/sep\\_use/notes/use\\_petrol.pdf](http://www.eia.gov/state/seds/sep_use/notes/use_petrol.pdf).

**Petroleum Consumption, Electric Power Sector.** Calculated annually by EIA as the average of the thermal conversion factors for distillate fuel oil, petroleum coke, and residual fuel oil consumed by the electric power sector weighted by the quantities consumed by the electric power sector. Data are from Form EIA-923, “Power Plant Operations Report,” and predecessor forms.

**Petroleum Consumption, Industrial Sector.** Calculated annually by EIA as the average of the thermal conversion factors for all petroleum products consumed by the industrial sector weighted by the estimated quantities consumed by the industrial sector. The quantities of petroleum products consumed by the industrial sector are estimated in the State Energy Data System—see documentation at [http://www.eia.gov/state/seds/sep\\_use/notes/use\\_petrol.pdf](http://www.eia.gov/state/seds/sep_use/notes/use_petrol.pdf).

**Petroleum Consumption, Residential Sector.** Calculated annually by EIA as the average of the thermal conversion factors for all petroleum products consumed by the residential sector weighted by the estimated quantities consumed by the residential sector. The quantities of petroleum products consumed by the residential sector are estimated in the State Energy Data System—see documentation at [http://www.eia.gov/state/seds/sep\\_use/notes/use\\_petrol.pdf](http://www.eia.gov/state/seds/sep_use/notes/use_petrol.pdf).

**Petroleum Consumption, Total.** Calculated annually by EIA as the average of the thermal conversion factors for all petroleum products consumed weighted by the quantities consumed.

**Petroleum Consumption, Transportation Sector.** Calculated annually by EIA as the average of the thermal conversion factors for all petroleum products consumed by the transportation sector weighted by the estimated quantities consumed by the transportation sector. The quantities of petroleum products consumed by the transportation sector are estimated in the State Energy Data System—see documentation at [http://www.eia.gov/state/seds/sep\\_use/notes/use\\_petrol.pdf](http://www.eia.gov/state/seds/sep_use/notes/use_petrol.pdf).

**Petroleum Products Exports.** Calculated annually by EIA as the average of the thermal conversion factors for each petroleum product exported weighted by the quantities exported.

**Petroleum Products Imports.** Calculated annually by EIA as the average of the thermal conversion factors for each petroleum product imported weighted by the quantities imported.

**Plant Condensate.** Estimated to be 5.418 million Btu per barrel by EIA from data provided by McClanahan Consultants, Inc., Houston, Texas.

**Propane/Propylene.** EIA adopted the Bureau of Mines thermal conversion factor of 3.836 million Btu per barrel as published in the *California Oil World and Petroleum Industry*, First Issue, April 1942.

**Renewable Fuels Except Fuel Ethanol.** For “Biomass-Based Diesel Fuel” and “Other Renewable Fuels,” EIA assumed the thermal conversion factor to be 5.359 million Btu per barrel or equal to the thermal conversion factor for **Biodiesel**. For “Other Renewable Diesel Fuel,” EIA adopted the thermal conversion factor of 5.494 million Btu per barrel (130,817 Btu per gallon) for renewable diesel II (UOP-HDO) from U.S. Department of Energy, Argonne National Laboratory, “The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model” (GREET), version GREET1\_2013, October 2013.

**Residual Fuel Oil.** EIA adopted the thermal conversion factor of 6.287 million Btu per barrel as reported in the Bureau of Mines internal memorandum, “Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950.”

**Road Oil.** EIA adopted the Bureau of Mines thermal conversion factor of 6.636 million Btu per barrel, which was assumed to be equal to that of **Asphalt** and was first published by the Bureau of Mines in the *Petroleum Statement, Annual, 1970*.

**Special Naphthas.** EIA adopted the Bureau of Mines thermal conversion factor of 5.248 million Btu per barrel, which was assumed to be equal to that of the total gasoline (aviation and motor) factor and was first published in the *Petroleum Statement, Annual, 1970*.

**Still Gas.** • 1949–2015: EIA adopted the Bureau of Mines estimated thermal conversion factor of 6.000 million Btu per barrel, first published in the *Petroleum Statement, Annual, 1970*. • 2016 forward: Assumed by EIA to be 6.287 million Btu per barrel or equal to the thermal conversion factor for **Residual Fuel Oil**.

**Total Petroleum Exports.** Calculated annually by EIA as the average of the thermal conversion factors for crude oil and each petroleum product exported weighted by the quantities exported. See **Crude Oil Exports** and **Petroleum Products Exports**.

**Total Petroleum Imports.** Calculated annually by EIA as the average of the thermal conversion factors for each type of crude oil and petroleum product imported weighted by the quantities imported. See **Crude Oil Imports** and **Petroleum Products Imports**.

**Unfinished Oils.** EIA assumed the thermal conversion factor to be 5.825 million Btu per barrel or equal to that for **Distillate Fuel Oil** and first published it in EIA’s *Annual Report to Congress, Volume 3, 1977*.

**Unfractionated Stream.** EIA assumed the thermal conversion factor to be 5.418 million Btu per barrel or equal to that for **Plant Condensate** and first published it in EIA’s *Annual Report to Congress, Volume 2, 1981*.

**Waxes.** EIA adopted the thermal conversion factor of 5.537 million Btu per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

## Approximate Heat Content of Biofuels

**Biodiesel.** EIA estimated the thermal conversion factor for biodiesel to be 5.359 million Btu per barrel, or 17,253 Btu per pound.

**Biodiesel Feedstock.** EIA used soybean oil input to the production of biodiesel (million Btu soybean oil per barrel biodiesel) as the factor to estimate total biomass inputs to the production of biodiesel. EIA assumed that 7.65 pounds of soybean oil are needed to produce one gallon of biodiesel, and 5.433 million Btu of soybean oil are needed to produce one barrel of biodiesel. EIA also assumed that soybean oil has a gross heat content of 16,909 Btu per pound, or 5.483 million Btu per barrel.

**Ethanol (Undenatured).** EIA adopted the thermal conversion factor of 3.539 million Btu per barrel published in “Oxygenate Flexibility for Future Fuels,” a paper presented by William J. Piel of the ARCO Chemical Company at the National Conference on Reformulated Gasolines and Clean Air Act Implementation, Washington, DC, October 1991.

**Fuel Ethanol (Denatured).** • 1981–2008: EIA used the 2009 factor. • 2009 forward: Calculated by EIA as the annual quantity-weighted average of the thermal conversion factors for undenatured ethanol (3.539 million Btu per barrel), natural gasoline used as denaturant (4.620 million Btu per barrel), and conventional motor gasoline and motor gasoline blending components used as denaturant (5.253 million Btu per barrel). The quantity of ethanol consumed is from EIA's *Petroleum Supply Annual (PSA)* and *Petroleum Supply Monthly (PSM)*, Table 1, data for renewable fuels and oxygenate plant net production of fuel ethanol. The quantity of natural gasoline used as denaturant is from PSA/PSM, Table 1, data for renewable fuels and oxygenate plant net production of natural gasoline, multiplied by -1. The quantity of conventional motor gasoline and motor gasoline blending components used as denaturant is from PSA/PSM, Table 1, data for renewable fuels and oxygenate plant net production of conventional motor gasoline and motor gasoline blending components, multiplied by -1.

**Fuel Ethanol Feedstock.** EIA used corn input to the production of undenatured ethanol (million Btu corn per barrel undenatured ethanol) as the annual factor to estimate total biomass inputs to the production of undenatured ethanol. EIA used the following observed ethanol yields (in gallons undenatured ethanol per bushel of corn) from U.S. Department of Agriculture: 2.5 in 1980, 2.666 in 1998, 2.68 in 2002; and from University of Illinois at Chicago, Energy Resources Center, "2012 Corn Ethanol: Emerging Plant Energy and Environmental Technologies": 2.78 in 2008, and 2.82 in 2012. EIA estimated the ethanol yields in other years. EIA also assumed that corn has a gross heat content of 0.392 million Btu per bushel.

## Approximate Heat Content of Natural Gas

**Natural Gas Consumption, Electric Power Sector.** Calculated annually by EIA by dividing the heat content of natural gas consumed by the electric power sector by the quantity consumed. Data are from Form EIA-923, "Power Plant Operations Report," and predecessor forms.

**Natural Gas Consumption, End-Use Sectors.** Calculated annually by EIA by dividing the heat content of natural gas consumed by the end-use sectors (residential, commercial, industrial, and transportation) by the quantity consumed. Data are from Form EIA-176, "Annual Report of Natural and Supplemental Gas Supply and Disposition."

**Natural Gas Consumption, Total.** • 1949–1962: EIA adopted the thermal conversion factor of 1,035 Btu per cubic foot as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*. • 1963–1979: EIA adopted the thermal conversion factor calculated annually by the American Gas Association (AGA)

and published in *Gas Facts*, an AGA annual publication. • 1980 forward: Calculated annually by EIA by dividing the total heat content of natural gas consumed by the total quantity consumed.

**Natural Gas Exports.** • 1949–1972: Assumed by EIA to be equal to the thermal conversion factor for dry natural gas consumed (see **Natural Gas Consumption, Total**). • 1973 forward: Calculated annually by EIA by dividing the heat content of natural gas exported by the quantity exported. For 1973–1995, data are from Form FPC-14, "Annual Report for Importers and Exporters of Natural Gas." Beginning in 1996, data are from U.S. Department of Energy, Office of Fossil Energy, *Natural Gas Imports and Exports*.

**Natural Gas Imports.** • 1949–1972: Assumed by EIA to be equal to the thermal conversion factor for dry natural gas consumed (see **Natural Gas Consumption, Total**). • 1973 forward: Calculated annually by EIA by dividing the heat content of natural gas imported by the quantity imported. For 1973–1995, data are from Form FPC-14, "Annual Report for Importers and Exporters of Natural Gas." Beginning in 1996, data are from U.S. Department of Energy, Office of Fossil Energy, *Natural Gas Imports and Exports*.

**Natural Gas Production, Dry.** Assumed by EIA to be equal to the thermal conversion factor for dry natural gas consumed. See **Natural Gas Consumption, Total**.

**Natural Gas Production, Marketed.** Calculated annually by EIA by dividing the heat content of dry natural gas produced (see **Natural Gas Production, Dry**) and natural gas liquids produced (see **Natural Gas Liquids Production**) by the total quantity of marketed natural gas produced.

## Approximate Heat Content of Coal and Coal Coke

**Coal Coke Imports and Exports.** EIA adopted the Bureau of Mines estimate of 24.800 million Btu per short ton.

**Coal Consumption, Electric Power Sector.** Calculated annually by EIA by dividing the heat content of coal consumed by the electric power sector by the quantity consumed. Data are from Form EIA-923, "Power Plant Operations Report," and predecessor forms.

**Coal Consumption, Industrial Sector, Coke Plants.** • 1949–2011: Calculated annually by EIA based on the reported volatility (low, medium, or high) of coal received by coke plants. (For 2011, EIA used the following volatility factors, in million Btu per short ton: low volatile—26.680; medium volatile—27.506; and high volatile—25.652.) Data are from Form EIA-5, "Quarterly Coal Consumption and Quality Report—Coke Plants," and predecessor forms. • 2012 forward: Calculated annually by EIA by dividing the heat content of coal received by coke plants by the

quantity received. Through June 2014, data are from Form EIA-5, “Quarterly Coal Consumption and Quality Report—Coke Plants”; beginning in July 2014, data are from Form EIA-3, “Quarterly Survey of Industrial, Commercial, and Institutional Coal Users” (formerly called “Quarterly Survey of Non-Electric Sector Coal Data”).

#### **Coal Consumption, Industrial Sector, Other.**

• 1949–2007: Calculated annually by EIA by dividing the heat content of coal received by manufacturing plants by the quantity received. Data are from Form EIA-3, “Quarterly Coal Consumption and Quality Report—Manufacturing Plants,” and predecessor forms. • 2008 forward: Calculated annually by EIA by dividing the heat content of coal received by manufacturing, gasification, and liquefaction plants by the quantity received. Data are from Form EIA-3, “Quarterly Survey of Industrial, Commercial, and Institutional Coal Users” (formerly called “Quarterly Survey of Non-Electric Sector Coal Data”).

#### **Coal Consumption, Residential and Commercial Sectors.**

• 1949–1999: Calculated annually by EIA by dividing the heat content of coal received by the residential and commercial sectors by the quantity received. Data are from Form EIA-6, “Coal Distribution Report,” and predecessor forms. • 2000–2007: Calculated annually by EIA by dividing the heat content of coal consumed by commercial combined-heat-and-power (CHP) plants by the quantity consumed. Data are from Form EIA-923, “Power Plant Operations Report,” and predecessor forms. • 2008 forward: Calculated annually by EIA by dividing the heat content of coal received by commercial and institutional users by the quantity received. Data are from Form EIA-3, “Quarterly Survey of Industrial, Commercial, and Institutional Coal Users” (formerly called “Quarterly Survey of Non-Electric Sector Coal Data”).

**Coal Consumption, Total.** Calculated annually by EIA by dividing the total heat content of coal consumed by all sectors by the total quantity consumed.

**Coal Exports.** • 1949–2011: Calculated annually by EIA by dividing the heat content of steam coal and metallurgical coal exported by the quantity exported. Data are from U.S. Department of Commerce, U.S. Census Bureau, “Monthly Report EM 545,” and predecessor forms. • 2012 forward: Calculated annually by EIA by dividing the heat content of steam coal and metallurgical coal exported by the quantity exported. The average heat content of steam coal is derived from receipts data from Form EIA-3, “Quarterly Survey of Industrial, Commercial, and Institutional Coal Users” (formerly called “Quarterly Survey of Non-Electric Sector Coal Data”), and Form EIA-923, “Power Plant Operations Report.” Through June 2014, the average heat content of metallurgical coal is derived from receipts data from Form EIA-5, “Quarterly Coal Consumption and Quality Report—Coke Plants”; beginning in July 2014, the average heat content of metallurgical coal is derived from receipts data from Form EIA-3, “Quarterly Survey of Industrial, Commercial, and Institutional Coal Users” (formerly

called “Quarterly Survey of Non-Electric Sector Coal Data”). Data for export quantities are from U.S. Department of Commerce, U.S. Census Bureau, “Monthly Report EM 545.”

**Coal Imports.** • 1949–1963: Calculated annually by EIA by dividing the heat content of coal imported by the quantity imported. Data are from U.S. Department of Commerce, U.S. Census Bureau, “Monthly Report IM 145,” and predecessor forms. • 1964–2011: Assumed by EIA to be 25,000 million Btu per short ton. • 2012 forward: Calculated annually by EIA by dividing the heat content of coal imported (received) by the quantity imported (received). Data are from Form EIA-3, “Quarterly Survey of Industrial, Commercial, and Institutional Coal Users” (formerly called “Quarterly Survey of Non-Electric Sector Coal Data”); Form EIA-5, “Quarterly Coal Consumption and Quality Report—Coke Plants” (data through June 2014); and Form EIA-923, “Power Plant Operations Report.”

**Coal Production.** • 1949–2011: Calculated annually by EIA by dividing the heat content of domestic coal (excluding waste coal) received by the quantity received. Data are from Form EIA-3, “Quarterly Coal Consumption and Quality Report—Manufacturing and Transformation/Processing Coal Plants and Commercial and Institutional Users”; Form EIA-5, “Quarterly Coal Consumption and Quality Report—Coke Plants”; Form EIA-923, “Power Plant Operations Report”; and predecessor forms. • 2012 forward: Calculated annually by EIA by dividing the heat content of domestic coal (excluding waste coal) received and exported by the quantity received and exported. Data are from Form EIA-3, “Quarterly Survey of Industrial, Commercial, and Institutional Coal Users” (formerly called “Quarterly Survey of Non-Electric Sector Coal Data”); Form EIA-5, “Quarterly Coal Consumption and Quality Report—Coke Plants” (data through June 2014); Form EIA-923, “Power Plant Operations Report”; U.S. Department of Commerce, U.S. Census Bureau, “Monthly Report EM 545”; and predecessor forms.

**Waste Coal Supplied.** • 1989–2000: Calculated annually by EIA by dividing the heat content of waste coal consumed by the quantity consumed. Data are from Form EIA-860B, “Annual Electric Generator Report—Nonutility,” and predecessor form. • 2001 forward: Calculated by EIA by dividing the heat content of waste coal received (or consumed) by the quantity received (or consumed). Receipts data are from Form EIA-3, “Quarterly Survey of Industrial, Commercial, and Institutional Coal Users” (formerly called “Quarterly Survey of Non-Electric Sector Coal Data”), and predecessor forms. Consumption data are from Form EIA-923, “Power Plant Operations Report,” and predecessor forms.

## **Approximate Heat Rates for Electricity**

**Electricity Net Generation, Coal.** • 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 anthracite, bituminous coal, subbituminous coal, lignite, and beginning in 2002, waste coal and coal synfuel.

**Electricity Net Generation, Natural Gas.** • 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 natural gas and supplemental gaseous fuels.

**Electricity Net Generation, Noncombustible Renewable Energy.** There is no generally accepted practice for measuring the thermal conversion rates for power plants that generate electricity from hydro, geothermal, solar thermal, photovoltaic, and wind energy sources. Therefore, EIA calculates a rate factor that is equal to the annual average heat rate factor for fossil-fueled power plants in the United States (see “Electricity Net Generation, Total Fossil Fuels”). By using that factor it is possible to evaluate fossil fuel requirements for replacing those sources during periods of interruption, such as droughts. See Appendix E for more information.

**Electricity Net Generation, Nuclear.** • 1957–1984: Calculated annually by dividing the total heat content consumed in nuclear generating units by the total (net) electricity generated by nuclear generating units. The heat content and electricity generation were reported on Form FERC-1, “Annual Report of Major Electric Utilities, Licensees, and Others”; Form EIA-412, “Annual Report of Public Electric Utilities”; and predecessor forms. For 1982, the factors were published in EIA, *Historical Plant Cost and Annual Production Expenses for Selected Electric Plants 1982*, page 215. For 1983 and 1984, the factors were

published in EIA, *Electric Plant Cost and Power Production Expenses 1991*, Table 13. • 1985 forward: Calculated annually by EIA by using the heat rate data reported on Form EIA-860, “Annual Electric Generator Report,” and predecessor forms.

**Electricity Net Generation, Petroleum.** • 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 distillate fuel oil, residual fuel oil, jet fuel, kerosene, petroleum coke, and waste oil.

**Electricity Net Generation, Total Fossil Fuels.**

• 1949–1955: The weighted annual average heat rate for fossil-fueled steam-electric power plants in the United States, as published by EIA in *Thermal-Electric Plant Construction Cost and Annual Production Expenses—1981* and *Steam-Electric Plant Construction Cost and Annual Production Expenses—1978*. • 1956–1988: The weighted annual average heat rate for fossil-fueled steam-electric power plants in the United States, as published in EIA, *Electric Plant Cost and Power Production Expenses 1991*, Table 9. • 1989–2000: 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 coal, petroleum, natural gas, and other gases (blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuels).

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# Appendix B

## Metric Conversion Factors, Metric Prefixes, and Other Physical Conversion Factors

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Data presented in the *Monthly Energy Review* and in other U.S. Energy Information Administration publications are expressed predominately in units that historically have been used in the United States, such as British thermal units, barrels, cubic feet, and short tons. The metric conversion factors presented in Table B1 can be used to calculate the metric-unit equivalents of values expressed in U.S. Customary units. For example, 500 short tons are the equivalent of 453.6 metric tons (500 short tons x 0.9071847 metric tons/short ton = 453.6 metric tons).

In the metric system of weights and measures, the names of multiples and subdivisions of any unit may be derived

by combining the name of the unit with prefixes, such as deka, hecto, and kilo, meaning, respectively, 10, 100, 1,000, and deci, centi, and milli, meaning, respectively, one-tenth, one-hundredth, and one-thousandth. Common metric prefixes can be found in Table B2.

The conversion factors presented in Table B3 can be used to calculate equivalents in various physical units commonly used in energy analyses. For example, 10 barrels are the equivalent of 420 U.S. gallons (10 barrels x 42 gallons/barrel = 420 gallons).

**Table B1. Metric Conversion Factors**

Type of Unit	U.S. Unit		Equivalent in	Metric Units
<b>Mass</b>	1 short ton (2,000 lb)	=	0.907 184 7	metric tons (t)
	1 long ton	=	1.016 047	metric tons (t)
	1 pound (lb)	=	0.453 592 37 <sup>a</sup>	kilograms (kg)
	1 pound uranium oxide (lb U <sub>3</sub> O <sub>8</sub> )	=	0.384 647 <sup>b</sup>	kilograms uranium (kgU)
	1 ounce, avoirdupois (avdp oz)	=	28.349 52	grams (g)
<b>Volume</b>	1 barrel of oil (bbl)	=	0.158 987 3	cubic meters (m <sup>3</sup> )
	1 cubic yard (yd <sup>3</sup> )	=	0.764 555	cubic meters (m <sup>3</sup> )
	1 cubic foot (ft <sup>3</sup> )	=	0.028 316 85	cubic meters (m <sup>3</sup> )
	1 U.S. gallon (gal)	=	3.785 412	liters (L)
	1 ounce, fluid (fl oz)	=	29.573 53	milliliters (mL)
	1 cubic inch (in <sup>3</sup> )	=	16.387 06	milliliters (mL)
<b>Length</b>	1 mile (mi)	=	1.609 344 <sup>a</sup>	kilometers (km)
	1 yard (yd)	=	0.914 4 <sup>a</sup>	meters (m)
	1 foot (ft)	=	0.304 8 <sup>a</sup>	meters (m)
	1 inch (in)	=	2.54 <sup>a</sup>	centimeters (cm)
<b>Area</b>	1 acre	=	0.404 69	hectares (ha)
	1 square mile (mi <sup>2</sup> )	=	2.589 988	square kilometers (km <sup>2</sup> )
	1 square yard (yd <sup>2</sup> )	=	0.836 127 4	square meters (m <sup>2</sup> )
	1 square foot (ft <sup>2</sup> )	=	0.092 903 04 <sup>a</sup>	square meters (m <sup>2</sup> )
	1 square inch (in <sup>2</sup> )	=	6.451 6 <sup>a</sup>	square centimeters (cm <sup>2</sup> )
<b>Energy</b>	1 British thermal unit (Btu) <sup>c</sup>	=	1,055.055 852 62 <sup>a</sup>	joules (J)
	1 calorie (cal)	=	4.186 8 <sup>a</sup>	joules (J)
	1 kilowatthour (kWh)	=	3.6 <sup>a</sup>	megajoules (MJ)
<b>Temperature<sup>d</sup></b>	32 degrees Fahrenheit (°F)	=	0 <sup>a</sup>	degrees Celsius (°C)
	212 degrees Fahrenheit (°F)	=	100 <sup>a</sup>	degrees Celsius (°C)

<sup>a</sup>Exact conversion.

<sup>b</sup>Calculated by the U.S. Energy Information Administration.

<sup>c</sup>The Btu used in this table is the International Table Btu adopted by the Fifth International Conference on Properties of Steam, London, 1956.

<sup>d</sup>To convert degrees Fahrenheit (°F) to degrees Celsius (°C) exactly, subtract 32, then multiply by 5/9.

Notes: • Spaces have been inserted after every third digit to the right of the decimal for ease of reading. • Most metric units belong to the International System of Units (SI), and the liter, hectare, and metric ton are accepted for use with the SI units. For more information about the SI units, see <http://physics.nist.gov/cuu/Units/index.html>.

Web Page: <http://www.eia.gov/totalenergy/data/monthly/#appendices>.

Sources: • General Services Administration, Federal Standard 376B, *Preferred Metric Units for General Use by the Federal Government* (Washington, DC, January 1993), pp. 9–11, 13, and 16. • U.S. Department of Commerce, National Institute of Standards and Technology, Special Publications 330, 811, and 814. • American National Standards Institute/Institute of Electrical and Electronic Engineers, ANSI/IEEE Std 268-1992, pp. 28 and 29.

**Table B2. Metric Prefixes**

Unit Multiple	Prefix	Symbol	Unit Subdivision	Prefix	Symbol
10 <sup>1</sup>	deka	da	10 <sup>-1</sup>	deci	d
10 <sup>2</sup>	hecto	h	10 <sup>-2</sup>	centi	c
10 <sup>3</sup>	kilo	k	10 <sup>-3</sup>	milli	m
10 <sup>6</sup>	mega	M	10 <sup>-6</sup>	micro	μ
10 <sup>9</sup>	giga	G	10 <sup>-9</sup>	nano	n
10 <sup>12</sup>	tera	T	10 <sup>-12</sup>	pico	p
10 <sup>15</sup>	peta	P	10 <sup>-15</sup>	femto	f
10 <sup>18</sup>	exa	E	10 <sup>-18</sup>	atto	a
10 <sup>21</sup>	zetta	Z	10 <sup>-21</sup>	zepto	z
10 <sup>24</sup>	yotta	Y	10 <sup>-24</sup>	yocto	y

Web Page: <http://www.eia.gov/totalenergy/data/monthly/#appendices>.

Source: U.S. Department of Commerce, National Institute of Standards and Technology, *The International System of Units (SI)*, NIST Special Publication 330, 1991 Edition (Washington, DC, August 1991), p.10.

**Table B3. Other Physical Conversion Factors**

Energy Source	Original Unit		Equivalent in Final Units
<b>Petroleum</b>	1 barrel (bbl)	=	42 <sup>a</sup> U.S. gallons (gal)
<b>Coal</b>	1 short ton	=	2,000 <sup>a</sup> pounds (lb)
	1 long ton	=	2,240 <sup>a</sup> pounds (lb)
	1 metric ton (t)	=	1,000 <sup>a</sup> kilograms (kg)
<b>Wood</b>	1 cord (cd)	=	1.25 <sup>b</sup> shorts tons
	1 cord (cd)	=	128 <sup>a</sup> cubic feet (ft <sup>3</sup> )

<sup>a</sup>Exact conversion.

<sup>b</sup>Calculated by the U.S. Energy Information Administration.

Web Page: <http://www.eia.gov/totalenergy/data/monthly/#appendices>.

Source: U.S. Department of Commerce, National Institute of Standards and Technology, *Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices*, NIST Handbook 44, 1994 Edition (Washington, DC, October 1993), pp. B-10, C-17, and C-21.

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# Appendix C

## Population, U.S. Gross Domestic Product, and U.S. Gross Output

**Table C1. Population, U.S. Gross Domestic Product, and U.S. Gross Output**

	Population			U.S. Gross Domestic Product			U.S. Gross Output <sup>a</sup>
	United States <sup>b</sup>	World	United States as Share of World	Billion Nominal Dollars <sup>d</sup>	Billion Chained (2009) Dollars <sup>e</sup>	Implicit Price Deflator <sup>c</sup> (2009 = 1.00000)	Billion Nominal Dollars <sup>d</sup>
	Million People		Percent				
1950	152.3	2,557.6	6.0	300.2	2,184.0	0.13745	NA
1955	165.9	2,782.1	6.0	426.2	2,739.0	.15559	NA
1960	180.7	3,043.0	5.9	543.3	3,108.7	.17476	NA
1965	194.3	3,350.7	5.8	743.7	3,976.7	.18702	NA
1970	205.1	3,713.3	5.5	1,075.9	4,722.0	.22784	NA
1975	216.0	4,088.8	5.3	1,688.9	5,385.4	.31361	NA
1980	227.2	4,445.4	5.1	2,862.5	6,450.4	.44377	NA
1981	229.5	4,526.8	5.1	3,211.0	6,617.7	.48520	NA
1982	231.7	4,607.2	5.0	3,345.0	6,491.3	.51530	NA
1983	233.8	4,688.6	5.0	3,638.1	6,792.0	.53565	NA
1984	235.8	4,767.7	4.9	4,040.7	7,285.0	.55466	NA
1985	237.9	4,849.9	4.9	4,346.7	7,593.8	.57240	NA
1986	240.1	4,934.2	4.9	4,590.2	7,860.5	.58395	NA
1987	242.3	5,021.1	4.8	4,870.2	8,132.6	.59885	8,639.9
1988	244.5	5,108.7	4.8	5,252.6	8,474.5	.61982	9,359.5
1989	246.8	5,196.0	4.8	5,657.7	8,786.4	.64392	9,969.6
1990	249.6	5,284.3	4.7	5,979.6	8,955.0	.66773	10,511.1
1991	253.0	5,367.5	4.7	6,174.0	8,948.4	.68996	10,676.5
1992	256.5	5,452.2	4.7	6,539.3	9,266.6	.70569	11,242.4
1993	259.9	5,534.4	4.7	6,878.7	9,521.0	.72248	11,857.6
1994	263.1	5,614.5	4.7	7,308.8	9,905.4	.73785	12,647.2
1995	266.3	5,695.8	4.7	7,664.1	10,174.8	.75324	13,451.6
1996	269.4	5,776.3	4.7	8,100.2	10,561.0	.76699	14,259.9
1997	272.6	5,854.8	4.7	8,608.5	11,034.9	.78012	15,355.4
1998	275.9	5,932.0	4.7	9,089.2	11,525.9	.78859	16,171.3
1999	279.0	6,008.6	4.6	9,660.6	12,065.9	.80065	17,244.8
2000	282.2	6,084.7	4.6	10,284.8	12,559.7	.81887	18,564.6
2001	285.0	6,160.9	4.6	10,621.8	12,682.2	.83754	18,863.1
2002	287.6	6,237.2	4.6	10,977.5	12,908.8	.85039	19,175.0
2003	290.1	6,313.9	4.6	11,510.7	13,271.1	.86735	20,135.1
2004	292.8	6,390.6	4.6	12,274.9	13,773.5	.89120	21,697.3
2005	295.5	6,467.4	4.6	13,093.7	14,234.2	.91988	23,514.9
2006	298.4	6,545.2	4.6	13,855.9	14,613.8	.94814	24,888.0
2007	301.2	6,623.5	4.5	14,477.6	14,873.7	.97337	26,151.3
2008	304.1	6,702.2	4.5	14,718.6	14,830.4	.99246	26,825.7
2009	306.8	6,780.8	4.5	14,418.7	14,418.7	1.00000	24,657.2
2010	309.3	6,858.6	4.5	14,964.4	14,783.8	1.01221	26,093.5
2011	311.6	6,936.0	4.5	15,517.9	15,020.6	1.03311	27,536.0
2012	314.0	7,013.9	4.5	16,155.3	15,354.6	1.05214	28,663.2
2013	316.2	7,092.1	4.5	16,691.5	15,612.2	1.06913	29,601.2
2014	318.6	7,170.0	4.4	17,427.6	16,013.3	1.08832	31,034.0
2015	321.0	7,247.9	4.4	18,120.7	16,471.5	1.10012	31,431.4
2016	323.4	7,326.0	4.4	18,624.5	16,716.2	1.11416	32,084.9
2017	325.7	7,405.1	4.4	19,386.8	17,092.7	1.13422	NA

<sup>a</sup> Gross output is the value of gross domestic product (GDP) plus the value of intermediate inputs used to produce GDP.

<sup>b</sup> Resident population of the 50 states and the District of Columbia estimated for July 1 of each year.

<sup>c</sup> The gross domestic product implicit price deflator is used to convert nominal dollars to chained (2009) dollars.

<sup>d</sup> See "Nominal Dollars" in Glossary.

<sup>e</sup> See "Chained Dollars" in Glossary.

NA=Not available.

Notes: • Data are estimates. • U.S. geographic coverage is the 50 states and the District of Columbia.

Web Page: See <http://www.eia.gov/totalenergy/data/monthly/#appendices> (Excel and CSV files) for all available annual data beginning in 1949.

Sources: • **United States Population: 1949–1989**—U.S. Department of

Commerce (DOC), U.S. Census Bureau, Current Population Reports Series P-25 (June 2000). **1990–1999**—DOC, U.S. Census Bureau, "Time Series of Intercensal State Population Estimates" (April 2002). **2000–2009**—DOC, U.S. Census Bureau, "Intercensal Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico" (September 2011). **2010 forward**—DOC, U.S. Census Bureau, "Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico" (December 2017). • **World Population: 1950 forward**—DOC, U.S. Census Bureau, International Database (December 2017). • **United States as Share of World Population:** Calculated as U.S. population divided by world population. • **U.S. Gross Domestic Product: 1949 forward**—DOC, Bureau of Economic Analysis (BEA), National Income and Product Accounts (January 2018), Tables 1.1.5, 1.1.6, and 1.1.9. • **U.S. Gross Output: 1987 forward**—DOC, BEA, GDP by Industry data (November 2017).

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# Appendix D

## Estimated Primary Energy Consumption in the United States, Selected Years, 1635–1945

**Table D1. Estimated Primary Energy Consumption in the United States, Selected Years, 1635–1945** (Quadrillion Btu)

	Fossil Fuels				Renewable Energy			Electricity Net Imports <sup>b</sup>	Total
	Coal	Natural Gas	Petroleum	Total	Conventional Hydroelectric Power	Biomass	Total		
						Wood <sup>a</sup>			
1635 .....	NA	--	--	NA	--	(s)	(s)	--	(s)
1645 .....	NA	--	--	NA	--	0.001	0.001	--	0.001
1655 .....	NA	--	--	NA	--	.002	.002	--	.002
1665 .....	NA	--	--	NA	--	.005	.005	--	.005
1675 .....	NA	--	--	NA	--	.007	.007	--	.007
1685 .....	NA	--	--	NA	--	.009	.009	--	.009
1695 .....	NA	--	--	NA	--	.014	.014	--	.014
1705 .....	NA	--	--	NA	--	.022	.022	--	.022
1715 .....	NA	--	--	NA	--	.037	.037	--	.037
1725 .....	NA	--	--	NA	--	.056	.056	--	.056
1735 .....	NA	--	--	NA	--	.080	.080	--	.080
1745 .....	NA	--	--	NA	--	.112	.112	--	.112
1755 .....	NA	--	--	NA	--	.155	.155	--	.155
1765 .....	NA	--	--	NA	--	.200	.200	--	.200
1775 .....	NA	--	--	NA	--	.249	.249	--	.249
1785 .....	NA	--	--	NA	--	.310	.310	--	.310
1795 .....	NA	--	--	NA	--	.402	.402	--	.402
1805 .....	NA	--	--	NA	--	.537	.537	--	.537
1815 .....	NA	--	--	NA	--	.714	.714	--	.714
1825 .....	NA	--	--	NA	--	.960	.960	--	.960
1835 .....	NA	--	--	NA	--	1.305	1.305	--	1.305
1845 .....	NA	--	--	NA	--	1.757	1.757	--	1.757
1850 .....	0.219	--	--	0.219	--	2.138	2.138	--	2.357
1855 .....	.421	--	--	.421	--	2.389	2.389	--	2.810
1860 .....	.518	--	0.003	.521	--	2.641	2.641	--	3.162
1865 .....	.632	--	.010	.642	--	2.767	2.767	--	3.409
1870 .....	1.048	--	.011	1.059	--	2.893	2.893	--	3.952
1875 .....	1.440	--	.011	1.451	--	2.872	2.872	--	4.323
1880 .....	2.054	--	.096	2.150	--	2.851	2.851	--	5.001
1885 .....	2.840	0.082	.040	2.962	--	2.683	2.683	--	5.645
1890 .....	4.062	.257	.156	4.475	0.022	2.515	2.537	--	7.012
1895 .....	4.950	.147	.168	5.265	.090	2.306	2.396	--	7.661
1900 .....	6.841	.252	.229	7.322	.250	2.015	2.265	--	9.587
1905 .....	10.001	.372	.610	10.983	.386	1.843	2.229	--	13.212
1910 .....	12.714	.540	1.007	14.261	.539	1.765	2.304	--	16.565
1915 .....	13.294	.673	1.418	15.385	.659	1.688	2.347	0.002	17.734
1920 .....	15.504	.813	2.676	18.993	.738	1.610	2.348	.003	21.344
1925 .....	14.706	1.191	4.280	20.177	.668	1.533	2.201	.004	22.382
1930 .....	13.639	1.932	5.897	21.468	.752	1.455	2.207	.005	23.680
1935 .....	10.634	1.919	5.675	18.228	.806	1.397	2.203	.005	20.436
1940 .....	12.535	2.665	7.760	22.960	.880	1.358	2.238	.007	25.205
1945 .....	15.972	3.871	10.110	29.953	1.442	<sup>a</sup> 1.261	2.703	.009	32.665

<sup>a</sup> There is a discontinuity in the "Wood" time series between 1945 (in this table) and 1949 (in Table 10.1). Through 1945, data are for fuelwood only; beginning in 1949, data are for wood and wood-derived fuels.

<sup>b</sup> Electricity transmitted across U.S. borders. Net imports equal imports minus exports.

NA=Not available. --=Not applicable. (s)=Less than 0.5 trillion Btu.

Notes: • For years not shown, data are not available. • See Tables 1.3 and 10.1 for continuation of these data series beginning in 1949. • See Note, "Geographic Coverage of Statistics for 1635–1945," at end of section.

Sources: • **Fossil Fuels:** *Energy in the American Economy, 1850–1975*, Table VII. • **Conventional Hydroelectric Power:** *Energy in the American Economy, 1850–1975*, Table II. • **Wood:** 1635–1845—U.S. Department of Agriculture,

Circular No. 641, *Fuel Wood Used in the United States 1630–1930*, February 1942. This source estimates fuelwood consumption in cords per decade, which were converted to Btu using the conversion factor of 20 million Btu per cord. The annual average value for each decade was assigned to the fifth year of the decade on the assumption that annual use was likely to increase during any given decade and the average annual value was more likely to reflect mid-decade yearly consumption than use at either the beginning or end of the decade. Values thus begin in 1635 and are plotted at 10-year intervals. 1850–1945—*Energy in the American Economy, 1850–1975*, Table VII. • **Electricity Net Imports:** *Energy in the American Economy, 1850–1975*, Tables I and VI. Electricity net imports are assumed to equal hydroelectric consumption minus hydroelectric production (data are converted to Btu by multiplying by 3,412 Btu per kilowatt-hour).

**Note. Geographic Coverage of Statistics for 1635–1945.**

Table D1 presents estimates of U.S. energy consumption by energy source for a period that begins a century and a half before the original 13 colonies formed a political union and continues through the decades during which the United States was still expanding territorially. The question thus arises, what exactly is meant by “U.S. consumption” of an energy source for those years when the United States did not formally exist or consisted of less territory than is now encompassed by the 50 states and the District of Columbia?

The documents used to assemble the estimates, and (as far as possible) the sources of those documents, were reviewed carefully for clues to geographic coverage. For most energy sources, the extent of coverage expanded more rapidly than the nation, defined as all the official states and the District of Columbia. Estimates or measurements of consumption of each energy source generally appear to follow settlement patterns. That is, they were made for areas of the continent that were settled enough to have economically significant consumption even though those areas were not to become states for years. The wood data series, for example, begins in 1635 and includes 12 of the original colonies (excepting Georgia), as well as Maine, Vermont, and the area that would become the District of Columbia. By the time the

series reaches 1810, the rest of the continental states are all included, although the last of the 48 states to achieve statehood did not do so until 1912. Likewise, the coal data series begins in 1850 but includes consumption in areas, such as Utah and Washington (state), which were significant coal producing regions but had not yet attained statehood. (Note: No data were available on state-level historical coal consumption. The coal data shown in Table D1 through 1945 describe *apparent* consumption, i.e., production plus imports minus exports. The geographic coverage for coal was therefore based on a tally of coal-producing states listed in various historical issues of *Minerals Yearbook*. It is likely that coal was consumed in states where it was not mined in significant quantities.)

By energy source, the extent of coverage can be summarized as follows: • **Coal**—35 coal-producing states by 1885. • **Natural Gas**—All 48 contiguous states, the District of Columbia, and Alaska by 1885. • **Petroleum**—All 48 contiguous states, the District of Columbia, and Alaska by 1885. • **Conventional Hydroelectric Power**—Coverage for 1890 and 1895 is uncertain, but probably the 48 contiguous states and the District of Columbia. Coverage for 1900–1945 is the 48 contiguous states, and the District of Columbia. • **Wood**—All 48 contiguous states and the District of Columbia by 1810.

# Appendix E

## Alternative Approaches for Deriving Energy Contents of Noncombustible Renewables

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EIA compiles data on most energy sources in physical units, such as barrels and cubic feet, in order to calculate total primary energy consumption. To sum data for different energy sources, EIA converts the data to the common unit of British thermal units (Btu), a measure that is based on the thermal conversion of energy resources to heat and power.

Noncombustible renewables are resources from which energy is extracted without burning or combusting fuel. They include hydroelectric, geothermal, solar, and wind energy. When noncombustible renewables are used to generate electricity, there is no fuel combustion and, therefore, no set Btu conversion factors for the energy sources.<sup>1</sup> However, there are several possible approaches for converting that electricity to Btu. Three of these approaches are described below.

### Fossil Fuel Equivalency Approach

In Sections 1, 2, and 10 of the *Monthly Energy Review*, EIA calculates total primary energy consumption for noncombustible renewable electricity in Btu by applying a fossil fuel equivalency factor. Under that approach, the primary energy consumption of noncombustible renewable electricity can be viewed as the sum of captured energy “transformed into electricity” and an “adjustment for fossil fuel equivalency.”

The adjustment for fossil fuel equivalency is equal to the difference between total primary consumption of noncombustible renewables for electricity generation in Btu (calculated using the fossil fuels heat rate in Table A6) and the captured energy of that electricity (calculated using the constant conversion factor of 3,412 Btu per kWh). The fossil fuels heat rate is equal to the thermal efficiency across fossil fuel-fired generating stations based on net generation. The fossil fuel equivalency adjustment represents the energy that would have been consumed if electricity had been generated by fossil fuels. By using that factor, it is possible, for example, to evaluate fossil fuel requirements for replacing electricity generation during periods of interruptions, such as droughts.

### Captured Energy Approach

Captured energy (Tables E1a and E1b) reflects the primary energy captured for economic use and does not include

losses. Thus, it is the net energy available for direct consumption after transformation of a noncombustible renewable into electricity. In other words, captured energy is the energy measured as the “output” of a generating unit, such as electricity from a wind turbine or solar plant. The captured energy approach is often used to show the economically significant energy transformations in the United States. There is no market for the resource-specific energy apart from its immediate, site-specific energy conversion, and there is no substantive opportunity cost to its continued exploitation.<sup>2</sup>

### Incident Energy Approach

Incident energy is the mechanical, radiation, or thermal energy that is measurable as the “input” of the device. EIA defines “incident energy” for noncombustible renewables as the gross energy that first strikes an energy conversion device:

- For hydroelectric, the energy contained in the water passing through the penstock (a closed conduit for carrying water to the turbines)
- For geothermal, the energy contained in the hot fluid at the surface of the wellbore
- For wind, the energy contained in the wind that passes through the rotor disc
- For solar, the energy contained in the sunlight that strikes the panel or collector mirror

The incident energy approach to converting noncombustible renewable electricity to Btu could, in theory, be used to account for “losses” that are due to the inability to convert 100% of incident energy to a useful form of energy. EIA does not publish total primary energy consumption estimates based on the incident energy approach because it would be difficult to obtain accurate estimates of input energy without creating undue burden on survey respondents. Few renewable electricity power plants track cumulative input energy due to its lack of economic significance or other purpose. In addition, estimated energy efficiencies of renewable conversion technologies vary significantly across technologies, site-specific configurations, and environmental factors.<sup>3</sup>

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<sup>1</sup>Direct use of noncombustible renewables in the form of heat (e.g., solar thermal heating) is estimated separately and is measured in Btu.

<sup>2</sup>There is an initial opportunity cost when a facility is first built: water behind a dam might flood land that could have been used for other purposes, or a solar panel might shade an area that could have used the sunlight. But that is a “fixed” opportunity cost that does not change during the operation of the plant.

<sup>3</sup>Based on EIA research conducted in 2016, engineering estimates of conversion efficiencies for noncombustible renewables range from less than 20% for solar photovoltaics and geothermal to 90% for large-scale hydroelectricity plants. Those estimates are notional indications of the energy output as a percent of energy input at each technology based on typical equipment operating within the normal operating range for that technology.

**Table E1a. Noncombustible Renewable Primary Energy Consumption: Conventional Hydroelectric Power, Geothermal, and Wind** (Trillion Btu)

	Conventional Hydroelectric Power <sup>a</sup>			Geothermal <sup>b</sup>				Wind <sup>c</sup>		
	Trans- formed Into Electricity <sup>d,e</sup>	Adjustment for Fossil Fuel Equivalence <sup>f</sup>	Total Primary Energy <sup>g</sup>	Direct Consump- tion <sup>h</sup>	Trans- formed Into Electricity <sup>d,i</sup>	Adjustment for Fossil Fuel Equivalence <sup>f</sup>	Total Primary Energy <sup>j</sup>	Trans- formed Into Electricity <sup>d,i</sup>	Adjustment for Fossil Fuel Equivalence <sup>f</sup>	Total Primary Energy <sup>g</sup>
1950 .....	344	1,071	1,415	NA	NA	NA	NA	NA	NA	NA
1955 .....	397	963	1,360	NA	NA	NA	NA	NA	NA	NA
1960 .....	510	1,098	1,608	NA	(s)	(s)	(s)	NA	NA	NA
1965 .....	672	1,387	2,059	NA	1	1	2	NA	NA	NA
1970 .....	856	1,777	2,634	NA	2	4	6	NA	NA	NA
1975 .....	1,034	2,120	3,155	NA	11	23	34	NA	NA	NA
1980 .....	953	1,948	2,900	NA	17	35	53	NA	NA	NA
1981 .....	900	1,858	2,758	NA	19	40	59	NA	NA	NA
1982 .....	1,066	2,200	3,266	NA	17	34	51	NA	NA	NA
1983 .....	1,144	2,383	3,527	NA	21	43	64	(s)	(s)	(s)
1984 .....	1,107	2,279	3,386	NA	26	54	81	(s)	(s)	(s)
1985 .....	970	2,000	2,970	NA	32	66	97	(s)	(s)	(s)
1986 .....	1,003	2,068	3,071	NA	35	73	108	(s)	(s)	(s)
1987 .....	863	1,772	2,635	NA	37	76	112	(s)	(s)	(s)
1988 .....	771	1,563	2,334	NA	35	71	106	(s)	(s)	(s)
1989 .....	<sup>e</sup> 928	1,909	2,837	9	<sup>i</sup> 50	102	162	<sup>i</sup> 7	15	22
1990 .....	999	2,047	3,046	10	53	108	171	10	19	29
1991 .....	986	2,030	3,016	11	54	112	178	10	21	31
1992 .....	864	1,754	2,617	12	55	112	179	10	20	30
1993 .....	957	1,935	2,892	13	57	116	186	10	21	31
1994 .....	888	1,796	2,683	13	53	107	173	12	24	36
1995 .....	1,061	2,145	3,205	14	46	92	152	11	22	33
1996 .....	1,185	2,405	3,590	15	49	99	163	11	22	33
1997 .....	1,216	2,424	3,640	16	50	100	167	11	22	34
1998 .....	1,103	2,194	3,297	18	50	100	168	10	21	31
1999 .....	1,090	2,177	3,268	19	51	101	171	15	31	46
2000 .....	940	1,871	2,811	21	48	96	164	19	38	57
2001 .....	740	1,502	2,242	22	47	95	164	23	47	70
2002 .....	902	1,787	2,689	24	49	98	171	35	70	105
2003 .....	941	1,851	2,793	27	49	97	173	38	75	113
2004 .....	916	1,773	2,688	30	51	98	178	48	93	142
2005 .....	922	1,781	2,703	34	50	97	181	61	117	178
2006 .....	987	1,882	2,869	37	50	95	181	91	173	264
2007 .....	845	1,602	2,446	41	50	95	186	118	223	341
2008 .....	869	1,642	2,511	46	51	96	192	189	357	546
2009 .....	933	1,736	2,669	54	51	95	200	252	469	721
2010 .....	888	1,651	2,539	60	52	97	208	323	600	923
2011 .....	1,090	2,013	3,103	64	52	97	212	410	758	1,168
2012 .....	943	1,686	2,629	64	53	95	212	480	860	1,340
2013 .....	916	1,646	2,562	64	54	97	214	573	1,029	1,601
2014 .....	885	1,582	2,467	64	54	97	214	620	1,108	1,728
2015 .....	850	1,471	2,321	64	54	94	212	651	1,127	1,777
2016 .....	914	1,559	2,472	64	54	92	210	774	1,321	2,096
2017 .....	1,024	1,746	2,770	64	55	93	211	868	1,480	2,347

<sup>a</sup> Conventional hydroelectricity net generation. Through 1989, also includes hydroelectric pumped storage.

<sup>b</sup> Geothermal heat pump and direct use energy; and geothermal electricity net generation.

<sup>c</sup> Wind electricity net generation.

<sup>d</sup> Electricity net generation in kilowatthours (kWh) multiplied by 3,412 Btu/kWh, the heat content of electricity (see Table A6).

<sup>e</sup> Through 1988, data are for electric utilities and industrial plants. Beginning in 1989, data are for electric utilities, independent power producers, commercial plants, and industrial plants.

<sup>f</sup> Equals the difference between the fossil-fuel equivalent value of electricity and the captured energy consumed as electricity. The fossil-fuel equivalent value of electricity equals electricity net generation in kilowatthours multiplied by the total fossil fuels heat rate factors (see Table A6). The captured energy consumed as electricity equals electricity net generation in kilowatthours multiplied by 3,412 Btu/kWh, the heat content of electricity (see Table A6).

<sup>g</sup> Electricity net generation in kilowatthours multiplied by the total fossil fuels

heat rate factors (see Table A6).

<sup>h</sup> Geothermal heat pump and direct use energy.

<sup>i</sup> Through 1988, data are for electric utilities only. Beginning in 1989, data are for electric utilities, independent power producers, commercial plants, and industrial plants.

<sup>j</sup> Direct consumption of energy; and energy used to generate electricity, calculated as electricity net generation in kilowatthours multiplied by the total fossil fuels heat rate factors (see Table A6).

NA=Not available. (s)=Less than 0.5 trillion Btu.

Notes: • Geothermal direct consumption data are estimates. • Totals may not equal sum of components due to independent rounding. • Geographic coverage is the 50 states and the District of Columbia.

Web Page: See <http://www.eia.gov/totalenergy/data/monthly/#appendices> (Excel and CSV files) for all available annual data beginning in 1949.

Sources: • **Conventional Hydroelectric Power** and **Wind**: Tables 7.2a, 10.1, and A6. • **Geothermal**: Tables 7.2a, 10.1, 10.2a, 10.2b, and A6.

**Table E1b. Noncombustible Renewable Primary Energy Consumption: Solar and Total**  
(Trillion Btu)

	Solar <sup>a</sup>						Total <sup>b</sup>		
	Distributed <sup>c</sup>			Utility-Scale <sup>d</sup>		Total Primary Energy <sup>i</sup>	Captured Energy <sup>j</sup>	Adjustment for Fossil Fuel Equivalence <sup>g</sup>	Total Primary Energy <sup>i</sup>
	Direct Consumption <sup>e</sup>	Transformed Into Electricity <sup>f</sup>	Adjustment for Fossil Fuel Equivalence <sup>g</sup>	Transformed Into Electricity <sup>f,h</sup>	Adjustment for Fossil Fuel Equivalence <sup>g</sup>				
1950 .....	NA	NA	NA	NA	NA	NA	344	1,071	1,415
1955 .....	NA	NA	NA	NA	NA	NA	397	963	1,360
1960 .....	NA	NA	NA	NA	NA	NA	510	1,098	1,608
1965 .....	NA	NA	NA	NA	NA	NA	673	1,388	2,061
1970 .....	NA	NA	NA	NA	NA	NA	858	1,781	2,639
1975 .....	NA	NA	NA	NA	NA	NA	1,045	2,143	3,188
1980 .....	NA	NA	NA	NA	NA	NA	970	1,983	2,953
1981 .....	NA	NA	NA	NA	NA	NA	920	1,898	2,817
1982 .....	NA	NA	NA	NA	NA	NA	1,082	2,234	3,316
1983 .....	NA	NA	NA	NA	NA	NA	1,165	2,426	3,591
1984 .....	NA	NA	NA	(s)	(s)	(s)	1,133	2,334	3,467
1985 .....	NA	NA	NA	(s)	(s)	(s)	1,002	2,066	3,068
1986 .....	NA	NA	NA	(s)	(s)	(s)	1,038	2,141	3,179
1987 .....	NA	NA	NA	(s)	(s)	(s)	900	1,847	2,747
1988 .....	NA	NA	NA	(s)	(s)	(s)	807	1,634	2,441
1989 .....	52	(s)	(s)	<sup>h</sup> 1	2	54	1,047	2,029	3,075
1990 .....	55	(s)	(s)	1	3	59	1,128	2,177	3,305
1991 .....	56	(s)	(s)	2	3	62	1,120	2,166	3,286
1992 .....	58	(s)	(s)	1	3	63	1,000	1,889	2,889
1993 .....	60	(s)	(s)	2	3	65	1,099	2,075	3,173
1994 .....	62	(s)	(s)	2	3	67	1,029	1,931	2,960
1995 .....	63	(s)	(s)	2	3	68	1,196	2,263	3,458
1996 .....	63	(s)	(s)	2	4	69	1,325	2,531	3,856
1997 .....	62	(s)	(s)	2	3	68	1,358	2,551	3,909
1998 .....	61	(s)	1	2	3	67	1,245	2,319	3,564
1999 .....	60	(s)	1	2	3	66	1,237	2,313	3,550
2000 .....	57	(s)	1	2	3	63	1,087	2,009	3,096
2001 .....	55	(s)	1	2	4	62	890	1,648	2,538
2002 .....	53	1	1	2	4	60	1,066	1,960	3,025
2003 .....	51	1	1	2	4	58	1,109	2,028	3,138
2004 .....	50	1	1	2	4	58	1,097	1,969	3,067
2005 .....	49	1	2	2	4	58	1,119	2,001	3,120
2006 .....	51	2	3	2	3	61	1,218	2,156	3,375
2007 .....	53	2	4	2	4	65	1,110	1,928	3,038
2008 .....	54	4	7	3	6	74	1,216	2,107	3,323
2009 .....	55	5	9	3	6	78	1,353	2,315	3,668
2010 .....	56	8	15	4	8	90	1,390	2,370	3,760
2011 .....	58	13	23	6	11	111	1,692	2,902	4,594
2012 .....	59	20	36	15	26	157	1,634	2,703	4,337
2013 .....	61	28	50	31	55	225	1,726	2,877	4,602
2014 .....	62	38	68	60	108	337	1,783	2,963	4,746
2015 .....	62	48	84	85	147	426	1,814	2,922	4,736
2016 .....	62	64	109	123	210	569	2,055	3,291	5,346
2017 .....	63	82	140	181	308	774	2,335	3,768	6,103

<sup>a</sup> Solar thermal direct use energy; and solar photovoltaic (PV) and solar thermal electricity net generation.

<sup>b</sup> Conventional hydroelectricity net generation; geothermal heat pump and direct use energy; geothermal electricity net generation; wind electricity net generation; solar thermal direct use energy; and solar photovoltaic (PV) and solar thermal electricity net generation.

<sup>c</sup> Distributed (small-scale) facilities (electric generators have a combined generator nameplate capacity of less than 1 megawatt).

<sup>d</sup> Utility-scale facilities (combined generator nameplate capacity of 1 megawatt or more).

<sup>e</sup> Solar thermal direct use energy.

<sup>f</sup> Electricity net generation in kilowatthours (kWh) multiplied by 3,412 Btu/kWh, the heat content of electricity (see Table A6).

<sup>g</sup> Equals the difference between the fossil-fuel equivalent value of electricity and the captured energy consumed as electricity. The fossil-fuel equivalent value of electricity equals electricity net generation in kilowatthours multiplied by the total fossil fuels heat rate factors (see Table A6). The captured energy consumed as electricity equals electricity net generation in kilowatthours multiplied by 3,412 Btu/kWh, the heat content of electricity (see Table A6).

<sup>h</sup> Through 1988, data are for electric utilities only. Beginning in 1989, data are for electric utilities, independent power producers, commercial plants, and industrial plants.

<sup>i</sup> Direct consumption of energy; and energy used to generate electricity, calculated as electricity net generation in kilowatthours multiplied by the total fossil fuels heat rate factors (see Table A6).

<sup>j</sup> Direct consumption of energy plus captured energy consumed as electricity, which is calculated as electricity net generation in kilowatthours (kWh) multiplied by 3,412 Btu/kWh, the heat content of electricity (see Table A6).

NA=Not available. (s)=Less than 0.5 trillion Btu.

Notes: • Beginning in 1989, data for distributed solar and total captured energy are estimates. For the current year, data for utility-scale solar are estimates.

• Totals may not equal sum of components due to independent rounding.

• Geographic coverage is the 50 states and the District of Columbia.

Web Page: See <http://www.eia.gov/totalenergy/data/monthly/#appendices> (Excel and CSV files) for all available annual data beginning in 1949.

Sources: • **Solar:** Tables 10.5, 10.6, and A6. • **Total:** Tables 7.2a, 10.1, 10.2a, 10.2b, 10.5, 10.6, and A6.

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