

Appendix E

Alternative Measures for the Energy Content of Noncombustible Renewables

Alternative Measures for the Energy Content of Noncombustible Renewables

Energy sources are measured in different physical units: liquid fuels in barrels or gallons, gases in cubic feet, coal in short tons, and electricity in kilowatthours. EIA converts each source into common British thermal units (Btu) to allow comparison among different types of energy and to calculate total energy concepts.

Noncombustible renewables (hydroelectric, geothermal, solar, and wind energy) are resources from which energy is extracted without burning or combusting fuel. When noncombustible renewables generate electricity, there is no fuel combustion and, therefore, no set Btu conversion factors for the energy sources.¹

There are three broadly accepted ways to convert electricity generated from noncombustible renewables into Btu of primary energy—the captured energy, fossil fuel equivalency, and incident energy approaches. Each of these methods are described in detail below.

Captured Energy Approach

The captured energy approach converts primary energy consumption of noncombustible renewables from kilowatthours (kWh) to Btu using the constant conversion factor representing the heat content of electricity—3,412 Btu per kWh. Captured energy reflects the primary energy captured for economic use and does not include losses. In other words, it represents the net energy available for direct consumption after the transformation of a noncombustible renewable source of energy into electricity, where 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 portion of the energy transformation associated with renewable energy sources. 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.² This approach is preferred by the *UN International Recommendations for Energy Statistics* (IRES) because the detailed data needed to estimate quantities of incident energy are not available now and are not likely to develop soon. This approach is also more closely tied to a physical market commodity, that is, electricity net generation, than the conceptual measure derived using the fossil fuel equivalency approach.

Fossil Fuel Equivalency Approach

The fossil fuel equivalency approach converts the consumption of noncombustible renewable electricity (in kWh) to Btu by applying a fossil fuel equivalency factor, based on the fossil-fuels heat rate (Table A6). The fossil-fuels heat rate is equal to the average thermal efficiency across fossil-fueled fired generating plants based on fuel consumption and net generation data reported to EIA. The fossil fuel equivalent consumption represents the energy consumed as if the electricity were generated by fossil fuels and is useful for analysis when considering the amount of primary fossil fuel energy displaced by renewable energy sources.

However, unlike the captured energy approach, the fossil fuel equivalency approach is not as directly tied to any real market or physical quantity. The fossil fuel equivalency approach measures neither primary energy consumption nor fossil fuels actually displaced. Additionally, its use becomes increasingly problematic as noncombustible renewables begin to displace other renewables instead of fossil fuels.

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 converts noncombustible renewable electricity to Btu by accounting for the “losses” that result from an inability to convert 100% of incident energy to a useful form of energy. EIA has not published total primary energy consumption statistics based on this approach because it is difficult to obtain accurate estimates of input energy without creating undue burden on survey respondents and possible concern about the quality of the resulting data. 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.³

EIA now using the captured energy approach

Starting with the September 2023 *Monthly Energy Review* (MER), EIA began converting electricity generation from noncombustible renewables into Btu using the captured energy approach rather than the fossil fuel equivalency approach in its main data tables (reflected in MER Sections 1, 2, and 10). The Btu values of hydroelectric, geothermal, solar, and wind energy consumption and, consequently, total primary energy consumption and total energy production are lower for all time periods because of the new conversion factor (the heat content of electricity from Table A6).

After a thorough review of the alternative approaches, EIA made the change for two primary reasons. First, adopting the captured energy approach promotes international comparability in energy statistics by adopting the standards provided in IRES. Second, as renewable energy continues to represent an increasingly larger portion of U.S. energy consumption over time, the fossil fuel equivalent values of generation from renewable sources become less relevant to our data users than the electrical energy provided by renewable sources.

Some analysts may still prefer to use the measures based on the fossil fuel equivalency approach, which was previously used by EIA. MER Tables E1–E4 present noncombustible renewable energy statistics using the fossil fuel equivalency approach.

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

²There 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.

³Based 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 E1. Primary Energy Overview, Fossil Fuel Equivalency Approach
(Quadrillion Btu)

	Production				Trade			Stock Change and Other ^d	Consumption			
	Fossil Fuels ^a	Nuclear Electric Power	Renewable Energy ^b	Total	Imports	Exports	Net Imports ^c		Fossil Fuels ^e	Nuclear Electric Power	Renewable Energy ^b	Total ^f
1950 Total	32.553	0.000	2.978	35.531	1.913	1.465	0.448	-1.380	31.615	0.000	2.978	34.599
1955 Total	37.347	.000	2.784	40.131	2.790	2.286	.504	-.457	37.380	.000	2.784	40.178
1960 Total	39.855	.006	2.928	42.789	4.188	1.477	2.710	-.458	42.091	.006	2.928	45.041
1965 Total	47.205	.043	3.396	50.644	5.892	1.829	4.063	-.754	50.515	.043	3.396	53.953
1970 Total	59.152	.239	4.070	63.462	8.342	2.632	5.709	-1.354	63.501	.239	4.070	67.817
1975 Total	54.697	1.900	4.687	61.284	14.032	2.323	11.709	-1.062	65.323	1.900	4.687	71.931
1980 Total	58.979	2.739	5.428	67.147	15.796	3.695	12.101	-1.227	69.782	2.739	5.428	78.021
1985 Total	57.502	4.076	6.084	67.661	11.781	4.196	7.584	1.088	66.035	4.076	6.084	76.334
1990 Total	58.523	6.104	6.040	70.668	18.817	4.752	14.065	-.299	72.281	6.104	6.040	84.433
1995 Total	57.496	7.075	6.557	71.129	22.180	4.496	17.684	2.118	77.162	7.075	6.559	90.931
2000 Total	57.307	7.862	6.102	71.271	28.865	3.962	24.904	2.528	84.620	7.862	6.104	98.702
2005 Total	54.995	8.161	6.221	69.377	34.659	4.462	30.197	.527	85.623	8.161	6.233	100.101
2006 Total	55.877	8.215	6.586	70.677	34.649	4.727	29.921	-1.207	84.477	8.215	6.637	99.391
2007 Total	56.369	8.459	6.510	71.338	34.679	5.338	29.341	.215	85.805	8.459	6.523	100.893
2008 Total	57.527	8.426	7.191	73.144	32.970	6.949	26.021	-.412	83.041	8.426	7.174	98.753
2009 Total	56.612	8.355	7.624	72.591	29.690	6.920	22.770	-1.420	77.862	8.355	7.607	93.941
2010 Total	58.159	8.434	8.312	74.906	29.866	8.176	21.690	.916	80.723	8.434	8.266	97.512
2011 Total	60.529	8.269	9.306	78.104	28.748	10.373	18.375	.389	79.263	8.269	9.210	96.868
2012 Total	62.298	8.062	8.890	79.249	27.068	11.267	15.801	-.670	77.304	8.062	8.853	94.380
2013 Total	64.180	8.244	9.438	81.862	24.623	11.788	12.835	2.433	79.224	8.244	9.464	97.130
2014 Total	69.619	8.338	9.798	87.754	23.241	12.270	10.971	-.428	80.017	8.338	9.761	98.297
2015 Total	70.186	8.337	9.766	88.289	23.794	12.902	10.892	-1.776	79.090	8.337	9.749	97.404
2016 Total	65.435	8.427	10.477	84.339	25.378	14.119	11.259	1.784	78.319	8.427	10.409	97.381
2017 Total	68.448	8.419	11.259	88.127	25.458	17.946	7.512	2.017	77.907	8.419	11.138	97.657
2018 Total	75.780	8.438	11.580	95.798	24.833	21.224	3.610	1.832	81.281	8.438	11.370	101.240
2019 Total	81.399	8.452	11.627	101.478	22.865	23.476	-.610	-.390	80.425	8.452	11.468	100.478
2020 Total	76.145	8.251	11.588	95.984	19.988	23.464	-3.476	.467	73.139	8.251	11.423	92.975
2021 January	6.497	.748	.987	8.232	1.772	2.083	-.311	1.008	7.210	.748	.956	8.929
February	5.318	.657	.865	6.840	1.566	1.667	-.101	1.400	6.614	.657	.858	8.138
March	6.603	.664	1.086	8.353	1.788	2.067	-.279	.037	6.359	.664	1.075	8.111
April	6.362	.595	1.044	8.001	1.703	2.104	-.402	-.082	5.876	.595	1.035	7.517
May	6.624	.661	1.102	8.387	1.799	2.131	-.332	-.332	5.955	.661	1.094	7.723
June	6.433	.689	1.030	8.152	1.890	2.204	-.314	.205	6.320	.689	1.018	8.042
July	6.642	.718	.991	8.350	1.878	2.085	-.208	.267	6.699	.718	.978	8.410
August	6.671	.725	1.005	8.401	1.846	2.183	-.337	.456	6.784	.725	.999	8.519
September	6.439	.673	.963	8.075	1.829	1.925	-.096	-.261	6.083	.673	.952	7.717
October	6.783	.609	.996	8.388	1.752	2.063	-.311	-.312	6.159	.609	.988	7.765
November	6.671	.654	1.031	8.356	1.774	2.172	-.397	.182	6.472	.654	1.010	8.141
December	6.862	.738	1.108	8.708	1.859	2.386	-.527	.571	6.924	.738	1.081	8.751
Total	77.903	8.131	12.208	98.242	21.455	25.071	-3.616	3.138	77.454	8.131	12.045	97.764
2022 January	6.736	.737	1.099	8.572	1.841	2.170	-.329	1.194	7.622	.737	1.067	9.437
February	6.098	.646	1.046	7.790	1.687	2.016	-.330	.929	6.715	.646	1.022	8.389
March	6.919	.660	1.195	8.774	1.848	2.305	-.457	.190	6.663	.660	1.177	8.507
April	6.637	.578	1.180	8.395	1.747	2.303	-.555	-.137	5.949	.578	1.168	7.703
May	6.917	.662	1.219	8.798	1.795	2.335	-.540	-.355	6.031	.662	1.201	7.903
June	6.730	.687	1.176	8.593	1.805	2.297	-.492	-.014	6.225	.687	1.160	8.087
July	6.995	.719	1.132	8.847	1.913	2.294	-.381	.056	6.673	.719	1.111	8.522
August	7.110	.720	1.039	8.870	1.826	2.331	-.505	.113	6.706	.720	1.031	8.478
September	6.987	.666	.981	8.634	1.705	2.266	-.561	-.339	6.089	.666	.966	7.735
October	7.188	.616	1.012	8.816	1.771	2.294	-.523	-.560	6.108	.616	1.000	7.733
November	6.935	.648	1.080	8.663	1.767	2.314	-.547	.079	6.478	.648	1.059	8.194
December	6.905	.722	1.064	8.691	1.802	2.407	-.605	.934	7.240	.722	1.045	9.020
Total	82.157	8.061	13.224	103.442	21.507	27.332	-5.826	2.091	78.498	8.061	13.007	99.707
2023 January	R 7.170	.740	1.107	R 9.018	R 1.854	R 2.299	R -.445	R .282	R 7.013	.740	R 1.090	R 8.854
February	R 6.478	.635	R 1.070	R 8.183	R 1.745	R 2.204	R -.459	R .265	R 6.294	.635	R 1.053	R 7.989
March	R 7.297	.656	1.190	R 9.144	R 1.793	R 2.726	R -.933	R .357	R 6.729	.656	1.174	R 8.568
April	R 6.984	.592	R 1.151	R 8.726	R 1.754	R 2.344	R -.590	R -.504	R 5.896	.592	R 1.138	R 7.632
May	R 7.247	.642	1.202	R 9.092	R 1.817	R 2.421	R -.604	R -.665	R 5.975	.642	1.196	R 7.823
June	R 7.064	.679	1.088	R 8.831	R 1.826	R 2.379	R -.553	R -.389	R 6.127	.679	R 1.078	R 7.889
July	R 7.259	.730	R 1.128	R 9.117	R 1.805	R 2.439	R -.634	R .027	R 6.666	.730	1.109	R 8.510
August	R 7.407	.729	R 1.125	R 9.260	R 1.927	R 2.489	R -.563	R -.046	R 6.803	.729	R 1.116	R 8.652
September	R 7.214	.685	1.037	R 8.936	R 1.782	R 2.435	R -.653	R -.496	R 6.080	.685	1.020	R 7.786
October	7.426	.642	R 1.112	R 9.180	R 1.711	R 2.524	R -.813	R -.384	R 6.238	.642	R 1.102	R 7.982
November	R 7.283	.650	R 1.072	R 9.005	R 1.826	R 2.464	R -.638	R -.126	R 6.536	.650	R 1.052	R 8.241
December	7.420	.720	1.107	9.247	1.858	2.794	-.935	.414	6.919	.720	1.083	8.726
Total	86.248	8.101	13.389	107.738	21.697	29.518	-7.821	-1.264	77.276	8.101	13.212	98.653

a Coal, natural gas (dry), crude oil, and natural gas plant liquids.
b See Table E4 for notes on series components and estimation.
c Net imports equal imports minus exports.
d Includes petroleum stock change and adjustments; natural gas net storage withdrawals and balancing item; coal stock change, losses, and unaccounted for; fuel ethanol stock change; and biodiesel stock change and balancing item.
e Coal, coal coke net imports, natural gas, and petroleum.
f Also includes electricity net imports.
R=Revised.
Notes: • See "Primary Energy," "Primary Energy Production," and "Primary

Energy Consumption," in Glossary. • 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 and monthly data beginning in 1973.
Sources: • Production: Table E2. • Trade: Tables 1.4a and 1.4b. • Stock Change and Other: Calculated as consumption minus production and net imports. • Consumption: Table E3.

Table E2. Primary Energy Production by Source, Fossil Fuel Equivalency Approach
(Quadrillion Btu)

	Fossil Fuels					Nuclear Electric Power	Renewable Energy ^a						Total
	Coal ^b	Natural Gas (Dry)	Crude Oil ^c	NGPL ^d	Total		Hydroelectric Power ^e	Geo-thermal	Solar	Wind	Bio-mass	Total	
1950 Total	14.060	6.233	11.447	0.813	32.553	0.000	1.415	NA	NA	NA	1.562	2.978	35.531
1955 Total	12.370	9.345	14.410	1.223	37.347	.000	1.360	NA	NA	NA	1.424	2.784	40.131
1960 Total	10.817	12.656	14.935	1.447	39.855	.006	1.608	(s)	NA	NA	1.320	2.928	42.789
1965 Total	13.055	15.775	16.521	1.853	47.205	.043	2.059	.002	NA	NA	1.335	3.396	50.644
1970 Total	14.607	21.666	20.401	2.478	59.152	.239	2.634	.006	NA	NA	1.431	4.070	63.462
1975 Total	14.989	19.640	17.729	2.338	54.697	1.900	3.155	.034	NA	NA	1.499	4.687	61.284
1980 Total	18.598	19.908	18.249	2.225	58.979	2.739	2.900	.053	NA	NA	2.475	5.428	67.147
1985 Total	19.325	16.980	18.992	2.204	57.502	4.076	2.970	.097	(s)	(s)	3.016	6.084	67.661
1990 Total	22.488	18.326	15.571	2.138	58.523	6.104	3.046	.171	.059	.029	2.735	6.040	70.668
1995 Total	22.130	19.082	13.887	2.398	57.496	7.075	3.205	.152	.068	.033	3.099	6.557	71.129
2000 Total	22.735	19.662	12.358	2.551	57.307	7.862	2.811	.164	.063	.057	3.006	6.102	71.271
2005 Total	23.185	18.556	10.974	2.280	54.995	8.161	2.703	.181	.058	.178	3.101	6.221	69.377
2006 Total	23.790	19.022	10.767	2.299	55.877	8.215	2.869	.181	.060	.264	3.212	6.586	70.677
2007 Total	23.493	19.786	10.741	2.349	56.369	8.459	2.446	.186	.065	.341	3.472	6.510	71.338
2008 Total	23.851	20.703	10.613	2.359	57.527	8.426	2.511	.192	.074	.546	3.868	7.191	73.144
2009 Total	21.624	21.139	11.340	2.508	56.612	8.355	2.669	.200	.077	.721	3.957	7.624	72.591
2010 Total	22.038	21.806	11.610	2.705	58.159	8.434	2.539	.208	.090	.923	4.553	8.312	74.906
2011 Total	22.221	23.406	12.012	2.890	60.529	8.269	3.103	.212	.110	1.168	4.712	9.306	78.104
2012 Total	20.677	24.610	13.849	3.162	62.298	8.062	2.629	.212	.156	1.340	4.554	8.890	79.249
2013 Total	20.001	24.859	15.868	3.451	64.180	8.244	2.562	.214	.225	1.601	4.835	9.438	81.862
2014 Total	20.286	26.718	18.610	4.005	69.619	8.338	2.466	.214	.337	1.727	5.052	9.798	87.754
2015 Total	17.946	28.067	19.697	4.476	70.186	8.337	2.320	.212	.427	1.776	5.031	9.766	88.289
2016 Total	14.667	27.576	18.527	4.665	65.435	8.427	2.471	.210	.570	2.095	5.132	10.477	84.339
2017 Total	15.625	28.289	19.547	4.987	68.448	8.419	2.765	.210	.777	2.342	5.166	11.259	88.127
2018 Total	15.363	31.882	22.808	5.727	75.780	8.438	2.661	.209	.915	2.481	5.314	11.580	95.798
2019 Total	14.256	35.187	25.604	6.352	81.399	8.452	2.562	.201	1.016	2.633	5.215	11.627	101.478
2020 Total	10.703	35.062	23.575	6.805	76.145	8.251	2.501	.203	1.211	2.963	4.710	11.588	95.984
2021													
January	.974	2.978	1.965	.580	6.497	.748	.217	.017	.077	.266	.409	.987	8.232
February	.821	2.491	1.580	.426	5.318	.657	.178	.016	.086	.236	.348	.865	6.840
March	1.021	3.007	2.002	.572	6.603	.664	.188	.016	.125	.347	.411	1.086	8.353
April	.907	2.933	1.932	.589	6.362	.595	.171	.017	.143	.320	.393	1.044	8.001
May	.975	3.029	2.009	.611	6.624	.661	.206	.017	.162	.299	.418	1.102	8.387
June	.979	2.920	1.940	.593	6.433	.689	.207	.017	.160	.236	.410	1.030	8.152
July	.974	3.046	2.010	.611	6.642	.718	.195	.017	.161	.192	.426	.991	8.350
August	1.005	3.055	1.989	.622	6.671	.725	.180	.017	.156	.239	.413	1.005	8.401
September	.999	2.977	1.864	.599	6.439	.673	.151	.017	.144	.256	.395	.963	8.075
October	.982	3.125	2.040	.636	6.783	.609	.152	.017	.121	.285	.422	.996	8.388
November	.980	3.058	2.011	.621	6.671	.654	.171	.017	.102	.316	.424	1.031	8.356
December	.977	3.187	2.060	.638	6.862	.738	.208	.019	.084	.352	.445	1.108	8.708
Total	11.596	35.807	23.401	7.099	77.903	8.131	2.225	.205	1.520	3.345	4.914	12.208	98.242
2022													
January	1.012	3.090	2.023	.610	6.736	.737	.213	.018	.102	.330	.435	1.099	8.572
February	.970	2.784	1.792	.552	6.098	.646	.188	.016	.116	.332	.394	1.046	7.790
March	1.044	3.135	2.080	.660	6.919	.660	.215	.017	.154	.379	.430	1.195	8.774
April	.940	3.056	2.007	.635	6.637	.578	.177	.017	.174	.407	.406	1.180	8.395
May	1.006	3.183	2.068	.661	6.917	.662	.206	.017	.195	.371	.430	1.219	8.798
June	.986	3.087	2.012	.644	6.730	.687	.229	.016	.203	.298	.430	1.176	8.593
July	1.000	3.224	2.085	.686	6.995	.719	.217	.017	.203	.260	.436	1.132	8.847
August	1.087	3.240	2.112	.672	7.110	.720	.186	.017	.189	.218	.429	1.039	8.870
September	1.044	3.181	2.102	.660	6.987	.666	.150	.017	.172	.241	.402	.981	8.634
October	1.040	3.284	2.181	.684	7.188	.616	.127	.017	.155	.289	.425	1.012	8.816
November	.988	3.178	2.110	.658	6.935	.648	.158	.018	.114	.363	.427	1.080	8.663
December	.926	3.219	2.139	.621	6.905	.722	.180	.018	.096	.341	.429	1.064	8.691
Total	12.043	37.662	24.710	7.742	82.157	8.061	2.245	.205	1.872	3.827	5.073	13.224	103.442
2023													
January	1.033	E 3.273	RE 2.217	.648	R 7.170	.740	.196	.019	.109	R .346	.437	1.107	R 9.018
February	.927	E 2.958	RE 1.996	.597	R 6.478	.635	.165	.016	.124	R .372	.393	R 1.070	R 8.183
March	1.053	E 3.304	RE 2.252	.688	R 7.297	.656	.178	.018	.165	R .393	.436	1.190	R 9.144
April	.951	E 3.190	RE 2.159	R .683	R 6.984	.592	.154	.017	.196	R .380	.404	R 1.151	R 8.726
May	.976	E 3.326	RE 2.239	R .706	R 7.247	.642	.242	.017	.222	R .283	.438	1.202	R 9.092
June	.955	E 3.209	RE 2.201	.700	R 7.064	.679	.172	.016	.227	R .243	.430	1.088	R 8.831
July	.945	E 3.320	RE 2.280	.714	R 7.259	.730	.187	.017	R .242	.246	.437	R 1.128	R 9.117
August	1.025	E 3.357	RE 2.300	.726	R 7.407	.729	.186	.017	.230	R .252	.440	R 1.125	R 9.260
September	.981	E 3.247	RE 2.261	.724	R 7.214	.685	.145	.017	.201	R .249	.425	1.037	R 8.936
October	.994	RE 3.351	RE 2.331	.750	R 7.426	.642	.159	.018	.183	R .322	.430	R 1.112	R 9.180
November	.993	RE 3.292	RE 2.273	.725	R 7.283	.650	.160	.018	.138	R .326	R .430	R 1.072	R 9.005
December	.925	E 3.419	E 2.348	.728	R 7.420	.720	.170	.018	.125	.338	.456	1.107	9.247
Total	11.756	E 39.246	E 26.856	8.389	86.248	8.101	2.114	.209	2.164	3.748	5.155	13.389	107.738

^a Most data are estimates. See Table E4 for notes on series components and estimation.

^b Beginning in 1989, includes waste coal supplied. Beginning in 2001, also includes a small amount of refuse recovery. See Table 6.1.

^c Includes lease condensate.

^d Natural gas processing plant production of natural gas liquids (ethane, propane, normal butane, isobutane, and natural gasoline). Through 1980, also includes natural gas processing plant production of finished petroleum products (aviation gasoline, distillate fuel oil, jet fuel, kerosene, motor gasoline, special naphthas, and miscellaneous products).

^e Conventional hydroelectric power.

R=Revised. E=Estimate. NA=Not available. (s)=Less than 0.5 trillion Btu.

Notes: • See "Primary Energy Production" in Glossary. • 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 and monthly data beginning in 1973.

Sources: • Fossil Fuels and Nuclear Electric Power: Table 1.2. • Renewable Energy: Table E4. • Total: Calculated as the sum of Fossil Fuels, Nuclear Electric Power, and Renewable Energy.

Table E3. Primary Energy Consumption by Source, Fossil Fuel Equivalency Approach
(Quadrillion Btu)

	Fossil Fuels ^a				Nuclear Electric Power	Renewable Energy ^b						Total ^g
	Coal	Natural Gas ^c	Petro-leum ^d	Total ^e		Hydro-electric Power ^f	Geo-thermal	Solar	Wind	Bio-mass	Total	
1950 Total	12.347	5.968	13.298	31.615	0.000	1.415	NA	NA	NA	1.562	2.978	34.599
1955 Total	11.167	8.998	17.225	37.380	.000	1.360	NA	NA	NA	1.424	2.784	40.178
1960 Total	9.838	12.385	19.874	42.091	.006	1.608	(s)	NA	NA	1.320	2.928	45.041
1965 Total	11.581	15.769	23.184	50.515	.043	2.059	.002	NA	NA	1.335	3.396	53.953
1970 Total	12.265	21.795	29.499	63.501	.239	2.634	.006	NA	NA	1.431	4.070	67.817
1975 Total	12.663	19.948	32.699	65.323	1.900	3.155	.034	NA	NA	1.499	4.687	71.931
1980 Total	15.423	20.235	34.159	69.782	2.739	2.900	.053	NA	NA	2.475	5.428	78.021
1985 Total	17.478	17.703	30.866	66.035	4.076	2.970	.097	(s)	(s)	3.016	6.084	76.334
1990 Total	19.173	19.603	33.500	72.281	6.104	3.046	.171	.059	.029	2.735	6.040	84.433
1995 Total	20.089	22.671	34.341	77.162	7.075	3.205	.152	.068	.033	3.101	6.559	90.931
2000 Total	22.580	23.824	38.152	84.620	7.862	2.811	.164	.063	.057	3.008	6.104	98.702
2005 Total	22.797	22.565	40.217	85.623	8.161	2.703	.181	.058	.178	3.114	6.233	100.101
2006 Total	22.447	22.239	39.731	84.477	8.215	2.869	.181	.060	.264	3.262	6.637	99.391
2007 Total	22.749	23.663	39.368	85.805	8.459	2.446	.186	.065	.341	3.485	6.523	100.893
2008 Total	22.387	23.843	36.769	83.041	8.426	2.511	.192	.074	.546	3.851	7.174	98.753
2009 Total	19.691	23.416	34.779	77.862	8.355	2.669	.200	.077	.721	3.940	7.607	93.941
2010 Total	20.834	24.575	35.321	80.723	8.434	2.539	.208	.090	.923	4.506	8.266	97.512
2011 Total	19.658	24.955	34.639	79.263	8.269	3.103	.212	.110	1.168	4.616	9.210	96.868
2012 Total	17.378	26.089	33.833	77.304	8.062	2.629	.212	.156	1.340	4.517	8.853	94.380
2013 Total	18.039	26.805	34.398	79.224	8.244	2.562	.214	.225	1.601	4.861	9.464	97.130
2014 Total	17.998	27.383	34.658	80.017	8.338	2.466	.214	.337	1.727	5.016	9.761	98.297
2015 Total	15.549	28.191	35.368	79.090	8.337	2.320	.212	.427	1.776	5.015	9.749	97.404
2016 Total	14.226	28.400	35.712	78.319	8.427	2.471	.210	.570	2.095	5.063	10.409	97.381
2017 Total	13.837	28.055	36.043	77.907	8.419	2.765	.210	.777	2.342	5.045	11.138	97.657
2018 Total	13.252	31.163	36.892	81.281	8.438	2.661	.209	.915	2.481	5.105	11.370	101.240
2019 Total	11.316	32.264	36.866	80.425	8.452	2.562	.201	1.016	2.633	5.056	11.468	100.478
2020 Total	9.181	31.640	32.331	73.139	8.251	2.501	.203	1.211	2.963	4.545	11.423	92.975
2021 January	.947	3.453	2.813	7.210	.748	.217	.017	.077	.266	.379	.956	8.929
February	.996	3.205	2.415	6.614	.657	.178	.016	.086	.236	.342	.858	8.138
March	.741	2.732	2.886	6.359	.664	.188	.016	.125	.347	.399	1.075	8.111
April	.650	2.350	2.880	5.876	.595	.171	.017	.143	.320	.383	1.035	7.517
May	.759	2.189	3.010	5.955	.661	.206	.017	.162	.299	.410	1.094	7.723
June	.997	2.319	3.009	6.320	.689	.207	.017	.160	.236	.398	1.018	8.042
July	1.160	2.501	3.040	6.699	.718	.195	.017	.161	.192	.413	.978	8.410
August	1.158	2.521	3.111	6.784	.725	.180	.017	.156	.239	.407	.999	8.519
September	.927	2.212	2.950	6.083	.673	.151	.017	.144	.256	.385	.952	7.717
October	.762	2.337	3.063	6.159	.609	.152	.017	.121	.285	.413	.988	7.765
November	.708	2.778	2.991	6.472	.654	.171	.017	.102	.316	.403	1.010	8.141
December	.742	3.113	3.076	6.924	.738	.208	.019	.084	.352	.418	1.081	8.751
Total	10.549	31.711	35.243	77.454	8.131	2.225	.205	1.520	3.345	4.751	12.045	97.764
2022 January	1.008	3.704	2.915	7.622	.737	.213	.018	.102	.330	.404	1.067	9.437
February	.838	3.153	2.726	6.715	.646	.188	.016	.116	.332	.370	1.022	8.389
March	.733	2.872	3.063	6.663	.660	.215	.017	.154	.379	.412	1.177	8.507
April	.663	2.434	2.858	5.949	.578	.177	.017	.174	.407	.393	1.168	7.703
May	.745	2.313	2.982	6.031	.662	.206	.017	.195	.371	.412	1.201	7.903
June	.870	2.393	2.967	6.225	.687	.229	.016	.203	.298	.414	1.160	8.087
July	1.018	2.674	2.986	6.673	.719	.217	.017	.203	.260	.415	1.111	8.522
August	.997	2.650	3.064	6.706	.720	.186	.017	.189	.218	.421	1.031	8.478
September	.783	2.368	2.943	6.089	.666	.150	.017	.172	.241	.387	.966	7.735
October	.673	2.439	2.999	6.108	.616	.127	.017	.155	.289	.413	1.000	7.733
November	.690	2.859	2.931	6.478	.648	.158	.018	.114	.363	.407	1.059	8.194
December	.871	3.490	2.884	7.240	.722	.180	.018	.096	.341	.409	1.045	9.020
Total	9.888	33.347	35.319	78.498	8.061	2.245	.205	1.872	3.827	4.857	13.007	99.707
2023 January	R .749	R 3.417	R 2.850	R 7.013	.740	.196	.019	.109	R .346	.420	R 1.090	R 8.854
February	.583	3.047	R 2.666	R 6.294	.635	.165	.016	.124	R .372	.376	R 1.053	R 7.989
March	.619	R 3.114	R 2.999	R 6.729	.656	.178	.018	.165	R .393	.420	R 1.174	R 8.568
April	.499	2.503	R 2.895	R 5.896	.592	.154	.017	.196	R .380	.391	R 1.138	R 7.632
May	.552	R 2.392	R 3.034	R 5.975	.642	.242	.017	.222	R .283	.432	R 1.196	R 7.823
June	.703	R 2.441	R 2.986	R 6.127	.679	.172	.016	.227	R .243	R .420	R 1.078	R 7.889
July	R .914	2.755	R 3.001	R 6.666	.730	.187	.017	R .242	.246	.418	1.109	R 8.510
August	.902	2.765	R 3.138	R 6.803	.729	.186	.017	.230	R .252	.431	R 1.116	R 8.652
September	R .716	R 2.455	R 2.913	R 6.080	.685	.145	.017	.201	R .249	.408	1.020	R 7.786
October	.635	R 2.523	R 3.082	R 6.238	.642	.159	.018	.183	R .322	.420	R 1.102	R 7.982
November	.633	R 2.920	R 2.986	R 6.536	.650	.160	.018	.138	R .326	.410	R 1.052	R 8.241
December	.676	3.277	2.970	6.919	.720	.170	.018	.125	.338	.432	1.083	8.726
Total	8.180	33.608	35.519	77.276	8.101	2.114	.209	2.164	3.748	4.978	13.212	98.653

^a Includes non-combustion use of fossil fuels.
^b Most data are estimates. See Table E4 for notes on series components and estimation.
^c Natural gas only; excludes supplemental gaseous fuels. See Note 3, "Supplemental Gaseous Fuels," at end of Section 4.
^d Petroleum products supplied; excludes biofuels. Biofuels are included in "Biomass."
^e Includes coal coke net imports. See Tables 1.4c.
^f Conventional hydroelectric power.
^g Includes coal coke net imports and electricity net imports, which are not separately displayed. See Tables 1.4c.
R=Revised. NA=Not available. (s)=Less than 0.5 trillion Btu.

Notes: • See "Primary Energy Consumption" in Glossary.
• See Table D1 for estimated energy consumption for 1635–1945. • 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 and monthly data beginning in 1973.
Sources: • **Fossil Fuels** and **Nuclear Electric Power:** Table 1.3. • **Renewable Energy:** Table E4. • **Total:** Calculated as the sum of Fossil Fuels, Nuclear Electric Power, Renewable Energy, and Electricity Net Imports (see Table 1.4c).

Table E4. Renewable Energy Production and Consumption by Source, Fossil Fuel Equivalency Approach (Trillion Btu)

	Production ^a				Consumption								
	Biomass			Total Renewable Energy ^e	Noncombustible (Fossil Fuel Equivalent)				Biomass				Total Renewable Energy
	Wood ^b	Bio-fuels ^c	Total ^d		Hydroelectric Power ^f	Geothermal ^g	Solar ^h	Wind ⁱ	Wood ^j	Waste ^k	Bio-fuels ^l	Total	
1950 Total	1,562	NA	1,562	2,978	1,415	NA	NA	NA	1,562	NA	NA	1,562	2,978
1955 Total	1,424	NA	1,424	2,784	1,360	NA	NA	NA	1,424	NA	NA	1,424	2,784
1960 Total	1,320	NA	1,320	2,928	1,608	(s)	NA	NA	1,320	NA	NA	1,320	2,928
1965 Total	1,335	NA	1,335	3,396	2,059	2	NA	NA	1,335	NA	NA	1,335	3,396
1970 Total	1,429	NA	1,431	4,070	2,634	6	NA	NA	1,429	2	NA	1,431	4,070
1975 Total	1,497	NA	1,499	4,687	3,155	34	NA	NA	1,497	2	NA	1,499	4,687
1980 Total	2,474	NA	2,475	5,428	2,900	53	NA	NA	2,474	2	NA	2,475	5,428
1985 Total	2,687	93	3,016	6,084	2,970	97	(s)	(s)	2,687	236	93	3,016	6,084
1990 Total	2,216	111	2,735	6,040	3,046	171	59	29	2,216	408	111	2,735	6,040
1995 Total	2,370	198	3,099	6,557	3,205	152	68	33	2,370	531	200	3,101	6,559
2000 Total	2,262	233	3,006	6,102	2,811	164	63	57	2,262	511	236	3,008	6,104
2005 Total	2,137	561	3,101	6,221	2,703	181	58	178	2,137	403	574	3,114	6,233
2006 Total	2,099	716	3,212	6,586	2,869	181	60	264	2,099	397	766	3,262	6,637
2007 Total	2,089	970	3,472	6,510	2,446	186	65	341	2,089	413	983	3,485	6,523
2008 Total	2,059	1,374	3,868	7,191	2,511	192	74	546	2,059	435	1,357	3,851	7,174
2009 Total	1,935	1,570	3,957	7,624	2,669	200	77	721	1,935	452	1,553	3,940	7,607
2010 Total	2,217	1,868	4,553	8,312	2,539	208	90	923	2,217	468	1,821	4,506	8,266
2011 Total	2,213	2,037	4,712	9,306	3,103	212	110	1,168	2,213	462	1,941	4,616	9,210
2012 Total	2,151	1,936	4,554	8,890	2,629	212	156	1,340	2,151	467	1,899	4,517	8,853
2013 Total	2,338	2,000	4,835	9,438	2,562	214	225	1,601	2,338	496	2,026	4,861	9,464
2014 Total	2,401	2,135	5,052	9,798	2,466	214	337	1,727	2,401	516	2,099	5,016	9,761
2015 Total	2,312	2,201	5,031	9,766	2,320	212	427	1,776	2,312	518	2,185	5,015	9,749
2016 Total	2,299	2,329	5,132	10,477	2,471	210	570	2,095	2,227	503	2,333	5,063	10,409
2017 Total	2,264	2,407	5,166	11,259	2,765	210	777	2,342	2,185	495	2,364	5,045	11,138
2018 Total	2,356	2,471	5,314	11,580	2,661	209	915	2,481	2,262	487	2,355	5,105	11,370
2019 Total	2,341	2,432	5,215	11,627	2,562	201	1,016	2,633	2,237	442	2,376	5,056	11,468
2020 Total	2,076	2,194	4,710	11,588	2,501	203	1,211	2,963	1,970	440	2,136	4,545	11,423
2021 January	180	191	409	987	217	17	77	266	172	38	169	379	956
February	162	152	348	865	178	16	86	236	154	34	154	342	858
March	179	194	411	1,086	188	16	125	347	167	38	194	399	1,075
April	171	187	393	1,044	171	17	143	320	162	36	186	383	1,035
May	176	206	418	1,102	206	17	162	299	168	36	207	410	1,094
June	175	201	410	1,030	207	17	160	236	164	34	200	398	1,018
July	181	209	426	991	195	17	161	192	173	36	204	413	978
August	182	195	413	1,005	180	17	156	239	172	35	200	407	999
September	175	185	395	963	151	17	144	256	164	34	186	385	952
October	172	214	422	996	152	17	121	285	164	35	214	413	988
November	173	216	424	1,031	171	17	102	316	161	35	207	403	1,010
December	183	224	445	1,108	208	19	84	352	171	38	209	418	1,081
Total	2,109	2,374	4,914	12,208	2,225	205	1,520	3,345	1,989	430	2,331	4,751	12,045
2022 January	184	214	435	1,099	213	18	102	330	175	37	193	404	1,067
February	171	190	394	1,046	188	16	116	332	159	33	177	370	1,022
March	181	212	430	1,195	215	17	154	379	169	37	207	412	1,177
April	173	198	406	1,180	177	17	174	407	164	34	195	393	1,168
May	182	214	430	1,219	206	17	195	371	170	35	208	412	1,201
June	182	214	430	1,176	229	16	203	298	168	33	213	414	1,160
July	185	218	436	1,132	217	17	203	260	175	31	206	415	1,111
August	184	211	429	1,039	186	17	189	218	174	34	213	421	1,031
September	177	193	402	981	150	17	172	241	162	32	192	387	966
October	174	217	425	1,012	127	17	155	289	163	34	216	413	1,000
November	174	219	427	1,080	158	18	114	363	164	34	209	407	1,059
December	183	211	429	1,064	180	18	96	341	169	35	205	409	1,045
Total	2,150	2,511	5,073	13,224	2,245	205	1,872	3,827	2,012	412	2,433	4,857	13,007
2023 January	^R 182	220	437	1,107	196	19	109	^R 346	174	36	210	420	^R 1,090
February	162	198	393	^R 1,070	165	16	124	^R 372	154	32	190	376	^R 1,053
March	180	222	436	1,190	178	18	165	^R 393	165	34	220	420	1,174
April	160	212	404	^R 1,151	154	17	196	^R 380	152	32	207	391	^R 1,138
May	^R 175	229	438	1,202	242	17	222	^R 283	^R 164	34	234	432	1,196
June	168	230	430	1,088	172	16	227	^R 243	156	32	232	^R 420	^R 1,078
July	172	232	437	^R 1,128	187	17	^R 242	246	162	33	223	418	1,109
August	177	230	440	^R 1,125	186	17	230	^R 252	163	33	235	431	^R 1,116
September	166	227	425	1,037	145	17	201	^R 249	153	32	224	408	1,020
October	166	231	430	^R 1,112	159	18	183	^R 322	154	33	233	420	^R 1,102
November	^R 168	229	^R 430	^R 1,072	160	18	138	^R 326	159	32	219	410	^R 1,052
December	173	248	456	1,107	170	18	125	338	162	36	235	432	1,083
Total	2,049	2,708	5,155	13,389	2,114	209	2,164	3,748	1,918	398	2,662	4,978	13,212

^a For hydroelectric power, geothermal, solar, wind, and biomass waste, production equals consumption.

^b Wood and wood-derived fuels. Through 2015, wood production equals consumption. Beginning in 2016, wood production equals consumption plus densified biomass exports.

^c Total biomass inputs to the production of fuel ethanol and biodiesel. Beginning in 2011, also includes production of renewable diesel fuel. Beginning in 2014, also includes production of other biofuels.

^d Includes biomass waste.

^e Hydroelectric power, geothermal, solar, wind, and biomass.

^f Conventional hydroelectricity net generation (converted to Btu by multiplying by the total fossil fuels heat rate factors in Table A6).

^g Geothermal electricity net generation (converted to Btu by multiplying by the total fossil fuels heat rate factors in Table A6), and geothermal heat pump and direct use energy.

^h Solar photovoltaic (PV) and solar thermal electricity net generation (converted to Btu by multiplying by the total fossil fuels heat rate factors in Table A6), and solar thermal direct use energy.

ⁱ Wind electricity net generation (converted to Btu by multiplying by the total fossil fuels heat rate factors in Table A6).

^j Wood and wood-derived fuels.

^k Municipal solid waste from biogenic sources, landfill gas, sludge waste, agricultural byproducts, and other biomass. Through 2000, also includes non-renewable waste (municipal solid waste from non-biogenic sources, and

tire-derived fuels).

^l Fuel ethanol (minus denaturant), biodiesel, renewable diesel fuel, and other biofuels consumption; plus losses and co-products from the production of fuel ethanol and biodiesel.

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

Notes: • Production data are estimates. Consumption data are estimates, except for hydroelectric power in 1949–1978 and 1989 forward, and wind. • 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 and monthly data beginning in 1973.

Sources: • **Biomass:** Table 10.1. • **Hydroelectric Power and Wind:** Calculated as electricity net generation (see Table 7.2a) multiplied by the total fossil fuels heat rate factors (see Table A6). • **Geothermal:** Calculated as geothermal electricity net generation (see Table 7.2a) multiplied by the total fossil fuels heat rate factors (see Table A6); plus geothermal heat pump and direct use energy in the residential, commercial, and industrial sectors (see Tables 10.2a and 10.2b). • **Solar:** Calculated as solar electricity net generation (see Table 7.2a) multiplied by the total fossil fuels heat rate factors (see Table A6); plus solar thermal direct use energy (see Table 10.5). • **Total Production:** Calculated as the sum of biomass production and noncombustible consumption. • **Total Consumption:** Calculated as the sum of biomass consumption and noncombustible consumption.

THIS PAGE INTENTIONALLY LEFT BLANK