

# Appendix E

## Alternative Measures for the Energy Content of Noncombustible Renewables

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# 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.<sup>1</sup>

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.<sup>2</sup> 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.<sup>3</sup>

## EIA now using the captured energy approach

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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.

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

	Production				Trade			Stock Change and Other <sup>d</sup>	Consumption			
	Fossil Fuels <sup>a</sup>	Nuclear Electric Power	Renewable Energy <sup>b</sup>	Total	Imports	Exports	Net Imports <sup>c</sup>		Fossil Fuels <sup>e</sup>	Nuclear Electric Power	Renewable Energy <sup>b</sup>	Total <sup>f</sup>
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
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	69.599	8.338	9.795	87.732	23.241	12.270	10.971	-.409	80.017	8.338	9.758	98.294
2015 Total	70.171	8.337	9.760	88.267	23.794	12.902	10.892	-1.761	79.090	8.337	9.743	97.398
2016 Total	65.442	8.427	10.467	84.336	25.378	14.119	11.259	1.776	78.319	8.427	10.399	97.371
2017 Total	68.448	8.419	11.249	88.117	25.458	17.946	7.512	2.017	77.907	8.419	11.128	97.647
2018 Total	75.798	8.438	11.569	95.805	24.833	21.224	3.610	1.815	81.281	8.438	11.360	101.230
2019 Total	81.405	8.452	11.617	101.474	22.865	23.476	-.610	-.396	80.425	8.452	11.458	100.468
2020 Total	76.155	8.251	11.578	95.983	19.988	23.464	-3.476	.487	73.169	8.251	11.413	92.994
2021 Total	77.987	8.131	12.198	98.316	21.455	25.071	-3.616	3.054	77.454	8.131	12.035	97.754
2022 January	R 6.696	.737	1.098	R 8.531	1.841	R 2.170	R -.329	R 1.235	R 7.623	.737	1.067	R 9.437
February	R 6.135	.646	1.045	R 7.826	1.687	R 2.016	-.330	R .896	R 6.719	.646	1.021	R 8.392
March	R 6.933	.660	1.194	R 8.787	1.848	R 2.305	R -.457	R .180	R 6.666	.660	1.176	R 8.509
April	R 6.654	.578	1.179	R 8.411	1.747	R 2.303	-.555	R -.151	R 5.952	.578	1.167	R 7.705
May	R 6.905	.662	1.218	R 8.786	1.795	R 2.335	-.540	R -.342	R 6.032	.662	1.200	R 7.904
June	R 6.739	.687	1.175	R 8.600	1.805	R 2.297	-.492	R -.021	R 6.227	.687	1.159	R 8.088
July	R 7.004	.719	1.131	R 8.855	1.913	R 2.294	-.381	R .050	R 6.675	.719	1.110	R 8.523
August	R 7.120	.720	1.038	R 8.878	1.826	R 2.331	-.505	R .106	R 6.709	.720	1.030	R 8.479
September	R 6.995	.666	.980	R 8.642	1.705	R 2.266	-.561	R -.345	R 6.091	.666	.966	R 7.736
October	R 7.183	.616	1.011	R 8.811	1.771	R 2.294	-.523	R -.553	R 6.110	.616	.999	R 7.734
November	R 6.941	.648	1.079	R 8.668	1.767	R 2.316	R -.549	R .077	R 6.481	.648	1.058	R 8.196
December	R 6.919	.722	1.063	R 8.704	1.802	R 2.408	R -.606	R .926	R 7.244	.722	1.044	R 9.023
Total	82.225	8.061	13.214	103.500	21.507	27.335	-5.828	2.057	78.529	8.061	12.997	99.728
2023 January	R 7.207	.741	1.084	R 9.032	1.853	R 2.276	-.423	R .251	R 7.043	.741	1.065	R 8.859
February	R 6.500	.636	1.059	R 8.195	1.746	R 2.210	-.464	R .269	R 6.315	.636	1.042	R 7.999
March	R 7.335	.657	1.177	R 9.169	1.789	R 2.653	-.865	R .276	R 6.753	.657	1.161	R 8.580
April	R 6.989	.592	1.156	R 8.737	1.754	R 2.370	-.615	R -.505	R 5.875	.592	1.143	R 7.617
May	R 7.261	.639	1.190	R 9.090	1.810	R 2.460	-.650	R -.660	R 5.948	.639	1.185	R 7.781
June	R 7.046	.677	1.093	R 8.816	1.825	R 2.387	-.562	R -.350	R 6.138	.677	1.083	R 7.904
July	R 7.269	.730	1.122	R 9.122	1.804	R 2.482	-.679	R .041	R 6.645	.730	1.104	R 8.483
August	R 7.407	.729	1.111	R 9.247	1.915	R 2.564	-.649	R .019	R 6.781	.729	1.102	R 8.617
September	R 7.201	.685	1.032	R 8.917	1.785	R 2.439	-.654	R -.476	R 6.087	.685	1.015	R 7.787
October	R 7.383	.642	1.076	R 9.101	1.705	R 2.540	-.836	R -.340	R 6.216	.642	1.067	R 7.926
November	R 7.242	.651	1.049	R 8.942	1.818	R 2.462	-.644	R -.091	R 6.525	.651	1.029	R 8.207
December	R 7.405	.720	1.097	R 9.222	1.853	R 2.801	-.947	R .464	R 6.946	.720	1.069	R 8.739
Total	86.245	8.099	13.246	107.590	21.657	29.645	-7.988	-1.102	77.271	8.099	13.065	98.499
2024 January	7.108	.722	1.064	8.894	1.900	2.559	-.658	R 1.123	R 7.588	.722	1.043	R 9.359
February	6.929	.675	1.120	8.724	1.710	2.546	-.835	R .246	R 6.356	.675	1.103	R 8.135
March	R 7.228	.662	1.257	R 9.147	1.737	2.641	-.904	R -.045	R 6.301	.662	1.236	R 8.198
April	6.898	.602	1.246	8.747	1.772	2.389	-.617	R -.486	R 5.811	.602	1.232	R 7.643
May	7.171	.679	1.248	R 9.098	1.935	2.540	-.605	R -.523	R 6.046	.679	1.244	R 7.970
June	7.083	.713	1.245	9.041	1.815	2.603	-.788	R -.181	R 6.125	.713	1.229	R 8.072
July	7.315	.730	1.181	9.227	1.967	2.536	-.569	R -.030	R 6.717	.730	1.169	R 8.627
August	R 7.402	.729	1.189	R 9.320	1.786	2.627	-.841	R .115	R 6.685	.729	1.170	R 8.594
September	R 7.113	.655	1.084	R 8.852	1.726	2.517	-.792	R -.273	R 6.057	.655	1.068	R 7.787
October	7.366	.611	1.170	9.147	1.721	2.562	-.841	-.342	6.191	.611	1.157	7.965
10-Month Total	71.614	6.779	11.803	90.196	18.069	25.520	-7.451	-.396	63.879	6.779	11.650	82.350
2023 10-Month Total	71.598	6.729	11.099	89.426	17.986	24.383	-6.397	-1.476	63.800	6.729	10.967	81.553
2022 10-Month Total	68.365	6.691	11.071	86.127	17.938	22.611	-4.673	1.054	64.805	6.691	10.895	82.509

<sup>a</sup> Coal, natural gas (dry), crude oil, and natural gas plant liquids.

<sup>b</sup> See Table E4 for notes on series components and estimation.

<sup>c</sup> Net imports equal imports minus exports.

<sup>d</sup> 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.

<sup>e</sup> Coal, coal coke net imports, natural gas, and petroleum.

<sup>f</sup> 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 <sup>a</sup>						Total
	Coal <sup>b</sup>	Natural Gas (Dry)	Crude Oil <sup>c</sup>	NGPL <sup>d</sup>	Total		Hydro-electric Power <sup>e</sup>	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
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	18.590	4.005	69.599	8.338	2.466	.214	.337	1.727	5.049	9.795	87.732
2015 Total	17.946	28.067	19.682	4.476	70.171	8.337	2.320	.212	.427	1.776	5.025	9.760	88.267
2016 Total	14.667	27.576	18.534	4.665	65.442	8.427	2.471	.210	.570	2.095	5.122	10.467	84.336
2017 Total	15.625	28.289	19.547	4.987	68.448	8.419	2.765	.210	.777	2.342	5.156	11.249	88.117
2018 Total	15.363	31.882	22.825	5.727	75.798	8.438	2.661	.209	.915	2.481	5.304	11.569	95.805
2019 Total	14.256	35.187	25.610	6.352	81.405	8.452	2.562	.201	1.016	2.633	5.205	11.617	101.474
2020 Total	10.703	35.062	23.585	6.805	76.155	8.251	2.501	.203	1.211	2.963	4.700	11.578	95.983
2021 Total	11.596	35.807	23.485	7.099	77.987	8.131	2.225	.205	1.520	3.345	4.904	12.198	98.316
2022 January	1.012	R 3.057	2.016	.610	R 6.696	.737	.213	.018	.102	.330	.434	1.098	R 8.531
February	.970	R 2.788	1.825	.552	R 6.135	.646	.188	.016	.116	.332	.393	1.045	R 7.826
March	1.044	R 3.137	2.092	.660	R 6.933	.660	.215	.017	.154	.379	.430	1.194	R 8.787
April	.940	R 3.066	2.014	.635	R 6.654	.578	.177	.017	.174	.407	.405	1.179	R 8.411
May	1.006	R 3.170	2.069	.661	R 6.905	.662	.206	.017	.195	.371	.429	1.218	R 8.786
June	.986	R 3.077	2.031	.644	R 6.739	.687	.229	.016	.203	.298	.429	1.175	R 8.600
July	1.000	R 3.205	2.113	.686	R 7.004	.719	.217	.017	.202	.260	.435	1.131	R 8.855
August	1.087	R 3.226	2.136	.672	R 7.120	.720	.186	.017	.189	.218	.428	1.038	R 8.878
September	1.044	R 3.170	2.121	.660	R 6.995	.666	.150	.017	.172	.241	.401	.980	R 8.642
October	1.040	R 3.270	2.190	.684	R 7.183	.616	.127	.017	.155	.289	.425	1.011	R 8.811
November	.988	R 3.168	2.126	.658	R 6.941	.648	.158	.018	.114	.363	.427	1.079	R 8.668
December	.926	R 3.227	2.145	.621	R 6.919	.722	.180	.018	.096	.341	.428	1.063	R 8.704
Total	12.043	37.560	24.880	7.742	82.225	8.061	2.245	.205	1.872	3.827	5.063	13.214	103.500
2023 January	1.036	R 3.277	2.224	.669	R 7.207	.741	.196	.018	.105	.331	.434	1.084	R 9.032
February	.930	R 2.953	2.006	.612	R 6.500	.636	.172	.016	.123	.357	.390	1.059	R 8.195
March	1.056	R 3.315	2.260	.704	R 7.335	.657	.184	.018	.163	.376	.436	1.177	R 9.169
April	.954	R 3.179	2.164	.691	R 6.989	.592	.171	.017	.194	.369	.405	1.156	R 8.737
May	.980	R 3.324	2.245	.712	R 7.261	.639	.239	.017	.221	.278	.435	1.190	R 9.090
June	.958	R 3.205	2.196	.687	R 7.046	.677	.186	.016	.224	.238	.428	1.093	R 8.816
July	.948	R 3.319	2.281	.721	R 7.269	.730	.190	.017	.237	.242	.438	1.122	R 9.122
August	1.029	R 3.342	2.301	.735	R 7.407	.729	.184	.016	.225	.245	.441	1.111	R 9.247
September	.985	R 3.238	2.249	.729	R 7.201	.685	.146	.017	.197	.245	.427	1.032	R 8.917
October	.967	R 3.342	2.319	.754	R 7.383	.642	.135	.018	.180	.311	.433	1.076	R 9.101
November	.967	R 3.280	2.267	.727	R 7.242	.651	.147	.018	.137	.315	.433	1.049	R 8.942
December	.932	R 3.390	2.347	.737	R 7.405	.720	.164	.018	.121	.328	.465	1.097	R 9.222
Total	11.743	39.164	26.858	8.480	86.245	8.099	2.114	.205	2.127	3.634	5.165	13.246	107.590
2024 January	.898	E 3.325	E 2.214	.671	7.108	.722	.189	.018	.129	.301	.427	1.064	8.894
February	.896	E 3.183	E 2.162	.688	6.929	.675	.173	.016	.158	.358	.414	1.120	8.724
March	.852	RE 3.296	E 2.323	.757	R 7.228	.662	.201	.016	.203	.393	.443	1.257	R 9.147
April	.728	E 3.161	E 2.261	.748	6.898	.602	.167	.017	.239	.408	.416	1.246	8.747
May	.800	E 3.261	E 2.328	.781	7.171	.679	.195	.016	.272	.333	.432	1.248	R 9.098
June	.876	E 3.195	E 2.260	.752	7.083	.713	.183	.016	.290	.328	.428	1.245	9.041
July	.879	E 3.346	E 2.327	.764	7.315	.730	.183	.017	.291	.241	.449	1.181	9.227
August	.955	RE 3.311	RE 2.357	.779	R 7.402	.729	.184	.017	.286	.248	.453	1.189	R 9.320
September	.927	RE 3.166	RE 2.252	.768	R 7.113	.655	.144	.016	.245	.249	.430	1.084	R 8.852
October	.885	E 3.307	E 2.373	.801	7.366	.611	.137	.016	.232	.345	.440	1.170	9.147
10-Month Total	8.696	E 32.551	E 22.856	7.511	71.614	6.779	1.756	.165	2.345	3.203	4.333	11.803	90.196
2023 10-Month Total	9.844	32.494	22.245	7.016	71.598	6.729	1.803	.169	1.869	2.992	4.267	11.099	89.426
2022 10-Month Total	10.129	31.165	20.609	6.463	68.365	6.691	1.908	.169	1.662	3.123	4.209	11.071	86.127

<sup>a</sup> Most data are estimates. See Table E4 for notes on series components and estimation.

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

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

<sup>d</sup> 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).

<sup>e</sup> 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 <sup>a</sup>				Nuclear Electric Power	Renewable Energy <sup>b</sup>						Total <sup>g</sup>
	Coal	Natural Gas <sup>c</sup>	Petroleum <sup>d</sup>	Total <sup>e</sup>		Hydroelectric Power <sup>f</sup>	Geo-thermal	Solar	Wind	Bio-mass	Total	
<b>1950 Total</b> .....	12.347	5.968	13.298	31.615	0.000	1.415	NA	NA	NA	1.562	2.978	34.599
<b>1955 Total</b> .....	11.167	8.998	17.225	37.380	.000	1.360	NA	NA	NA	1.424	2.784	40.178
<b>1960 Total</b> .....	9.838	12.385	19.874	42.091	.006	1.608	(s)	NA	NA	1.320	2.928	45.041
<b>1965 Total</b> .....	11.581	15.769	23.184	50.515	.043	2.059	.002	NA	NA	1.335	3.396	53.953
<b>1970 Total</b> .....	12.265	21.795	29.499	63.501	.239	2.634	.006	NA	NA	1.431	4.070	67.817
<b>1975 Total</b> .....	12.663	19.948	32.699	65.323	1.900	3.155	.034	NA	NA	1.499	4.687	71.931
<b>1980 Total</b> .....	15.423	20.235	34.159	69.782	2.739	2.900	.053	NA	NA	2.475	5.428	78.021
<b>1985 Total</b> .....	17.478	17.703	30.866	66.035	4.076	2.970	.097	(s)	(s)	3.016	6.084	76.334
<b>1990 Total</b> .....	19.173	19.603	33.500	72.281	6.104	3.046	.171	.059	.029	2.735	6.040	84.433
<b>1995 Total</b> .....	20.089	22.671	34.341	77.162	7.075	3.205	.152	.068	.033	3.101	6.559	90.931
<b>2000 Total</b> .....	22.580	23.824	38.152	84.620	7.862	2.811	.164	.063	.057	3.008	6.104	98.702
<b>2005 Total</b> .....	22.797	22.565	40.217	85.623	8.161	2.703	.181	.058	.178	3.114	6.233	100.101
<b>2010 Total</b> .....	20.834	24.575	35.321	80.723	8.434	2.539	.208	.090	.923	4.506	8.266	97.512
<b>2011 Total</b> .....	19.658	24.955	34.639	79.263	8.269	3.103	.212	.110	1.168	4.616	9.210	96.868
<b>2012 Total</b> .....	17.378	26.089	33.833	77.304	8.062	2.629	.212	.156	1.340	4.517	8.853	94.380
<b>2013 Total</b> .....	18.039	26.805	34.398	79.224	8.244	2.562	.214	.225	1.601	4.861	9.464	97.130
<b>2014 Total</b> .....	17.998	27.383	34.658	80.017	8.338	2.466	.214	.337	1.727	5.013	9.758	98.294
<b>2015 Total</b> .....	15.549	28.191	35.368	79.090	8.337	2.320	.212	.427	1.776	5.008	9.743	97.398
<b>2016 Total</b> .....	14.226	28.400	35.712	78.319	8.427	2.471	.210	.570	2.095	5.053	10.399	97.371
<b>2017 Total</b> .....	13.837	28.055	36.043	77.907	8.419	2.765	.210	.777	2.342	5.035	11.128	97.647
<b>2018 Total</b> .....	13.252	31.163	36.892	81.281	8.438	2.661	.209	.915	2.481	5.094	11.360	101.230
<b>2019 Total</b> .....	11.316	32.264	36.866	80.425	8.452	2.562	.201	1.016	2.633	5.046	11.458	100.468
<b>2020 Total</b> .....	9.181	31.669	32.331	73.169	8.251	2.501	.203	1.211	2.963	4.535	11.413	92.994
<b>2021 Total</b> .....	10.549	31.711	35.243	77.454	8.131	2.225	.205	1.520	3.345	4.740	12.035	97.754
<b>2022 January</b> .....	1.008	R 3.705	2.915	R 7.623	.737	.213	.018	.102	.330	.403	1.067	R 9.437
February .....	.838	R 3.157	2.726	R 6.719	.646	.188	.016	.116	.332	.369	1.021	R 8.392
March .....	.733	R 2.876	3.063	R 6.666	.660	.215	.017	.154	.379	.411	1.176	R 8.509
April .....	.663	R 2.437	2.858	R 5.952	.578	.177	.017	.174	.407	.392	1.167	R 7.705
May .....	.745	R 2.314	2.982	R 6.032	.662	.206	.017	.195	.371	.411	1.200	7.904
June .....	.870	R 2.394	2.967	R 6.227	.687	.229	.016	.203	.298	.413	1.159	8.088
July .....	1.018	R 2.676	2.986	R 6.675	.719	.217	.017	.202	.260	.414	1.110	R 8.523
August .....	.997	R 2.653	3.064	R 6.709	.720	.186	.017	.189	.218	.420	1.030	8.479
September .....	.783	2.370	2.943	6.091	.666	.150	.017	.172	.241	.386	.966	7.736
October .....	.673	2.441	2.999	6.110	.616	.127	.017	.155	.289	.412	.999	7.734
November .....	.690	2.862	2.931	R 6.481	.648	.158	.018	.114	.363	.406	1.058	8.196
December .....	.871	3.494	2.884	R 7.244	.722	.180	.018	.096	.341	.408	1.044	9.023
<b>Total</b> .....	<b>9.888</b>	<b>33.379</b>	<b>35.319</b>	<b>78.529</b>	<b>8.061</b>	<b>2.245</b>	<b>.205</b>	<b>1.872</b>	<b>3.827</b>	<b>4.847</b>	<b>12.997</b>	<b>99.728</b>
<b>2023 January</b> .....	.750	R 3.428	2.868	R 7.043	.741	.196	.018	.105	.331	.415	1.065	R 8.859
February .....	.582	R 3.057	2.678	R 6.315	.636	.172	.016	.123	.357	.373	1.042	R 7.999
March .....	.620	R 3.129	3.006	R 6.753	.657	.184	.018	.163	.376	.421	1.161	R 8.580
April .....	.500	R 2.499	2.878	R 5.875	.592	.171	.017	.194	.369	.392	1.143	R 7.617
May .....	.550	R 2.386	3.014	R 5.948	.639	.239	.017	.221	.278	.430	1.185	R 7.781
June .....	.705	R 2.445	2.991	R 6.138	.677	.186	.016	.224	.238	.418	1.083	R 7.904
July .....	.913	R 2.760	2.975	R 6.645	.730	.190	.017	.237	.242	.420	1.104	R 8.483
August .....	.903	R 2.773	3.108	R 6.781	.729	.184	.016	.225	.245	.433	1.102	R 8.617
September .....	.716	R 2.464	2.911	R 6.087	.685	.146	.017	.197	.245	.410	1.015	R 7.787
October .....	.628	R 2.523	3.067	R 6.216	.642	.135	.018	.180	.311	.424	1.067	R 7.926
November .....	.629	R 2.920	2.978	R 6.525	.651	.147	.018	.137	.315	.413	1.029	R 8.207
December .....	.676	R 3.300	2.975	R 6.946	.720	.164	.018	.121	.328	.437	1.069	R 8.739
<b>Total</b> .....	<b>8.172</b>	<b>33.683</b>	<b>35.448</b>	<b>77.271</b>	<b>8.099</b>	<b>2.114</b>	<b>.205</b>	<b>2.127</b>	<b>3.634</b>	<b>4.984</b>	<b>13.065</b>	<b>98.499</b>
<b>2024 January</b> .....	.876	R 3.828	2.885	R 7.588	.722	.189	.018	.129	.301	.406	1.043	R 9.359
February .....	.559	R 3.071	2.728	R 6.356	.675	.173	.016	.158	.358	.397	1.103	R 8.135
March .....	.490	R 2.892	2.924	R 6.301	.662	.201	.016	.203	.393	.422	1.236	R 8.198
April .....	.467	R 2.474	2.875	R 5.811	.602	.167	.017	.239	.408	.401	1.232	R 7.643
May .....	.560	R 2.410	3.079	R 6.046	.679	.195	.016	.272	.333	.428	1.244	R 7.970
June .....	.718	R 2.511	2.901	R 6.125	.713	.183	.016	.290	.328	.412	1.229	R 8.072
July .....	.833	R 2.836	3.051	R 6.717	.730	.183	.017	.291	.241	.437	1.169	R 8.627
August .....	.814	R 2.808	3.067	R 6.685	.729	.184	.017	.286	.248	.434	1.170	R 8.594
September .....	.663	R 2.505	2.893	R 6.057	.655	.144	.016	.245	.249	.414	1.068	R 7.787
October .....	.588	2.514	3.091	6.191	.611	.137	.016	.232	.345	.427	1.157	7.965
<b>10-Month Total</b> ...	<b>6.565</b>	<b>27.848</b>	<b>29.494</b>	<b>63.879</b>	<b>6.779</b>	<b>1.756</b>	<b>.165</b>	<b>2.345</b>	<b>3.203</b>	<b>4.180</b>	<b>11.650</b>	<b>82.350</b>
<b>2023 10-Month Total</b> ...	<b>6.867</b>	<b>27.463</b>	<b>29.495</b>	<b>63.800</b>	<b>6.729</b>	<b>1.803</b>	<b>.169</b>	<b>1.869</b>	<b>2.992</b>	<b>4.134</b>	<b>10.967</b>	<b>81.553</b>
<b>2022 10-Month Total</b> ...	<b>8.327</b>	<b>27.022</b>	<b>29.503</b>	<b>64.805</b>	<b>6.691</b>	<b>1.908</b>	<b>.169</b>	<b>1.662</b>	<b>3.123</b>	<b>4.032</b>	<b>10.895</b>	<b>82.509</b>

<sup>a</sup> Includes non-combustion use of fossil fuels.  
<sup>b</sup> Most data are estimates. See Table E4 for notes on series components and estimation.  
<sup>c</sup> Natural gas only; excludes supplemental gaseous fuels. See Note 3, "Supplemental Gaseous Fuels," at end of Section 4.  
<sup>d</sup> Petroleum products supplied; excludes biofuels. Biofuels are included in "Biomass."  
<sup>e</sup> Includes coal coke net imports. See Tables 1.4c.  
<sup>f</sup> Conventional hydroelectric power.  
<sup>g</sup> 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 <sup>a</sup>				Consumption								
	Biomass			Total Renewable Energy <sup>e</sup>	Noncombustible (Fossil Fuel Equivalent)				Biomass				Total Renewable Energy
	Wood <sup>b</sup>	Bio-fuels <sup>c</sup>	Total <sup>d</sup>		Hydro-electric Power <sup>f</sup>	Geo-thermal <sup>g</sup>	Solar <sup>h</sup>	Wind <sup>i</sup>	Wood <sup>j</sup>	Waste <sup>k</sup>	Bio-fuels <sup>l</sup>	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	NA	(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
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 .....	2,398	2,135	5,049	9,795	2,466	214	337	1,727	2,398	516	2,099	5,013	9,758
2015 Total .....	2,305	2,201	5,025	9,760	2,320	212	427	1,776	2,305	518	2,185	5,008	9,743
2016 Total .....	2,289	2,329	5,122	10,467	2,471	210	570	2,095	2,216	503	2,333	5,053	10,399
2017 Total .....	2,254	2,407	5,156	11,249	2,765	210	777	2,342	2,175	495	2,364	5,035	11,128
2018 Total .....	2,346	2,471	5,304	11,569	2,661	209	915	2,481	2,252	487	2,355	5,094	11,360
2019 Total .....	2,331	2,432	5,205	11,617	2,562	201	1,016	2,633	2,227	442	2,376	5,046	11,458
2020 Total .....	2,066	2,194	4,700	11,578	2,501	203	1,211	2,963	1,960	440	2,136	4,535	11,413
2021 Total .....	2,099	2,374	4,904	12,198	2,225	205	1,520	3,345	1,979	430	2,331	4,740	12,035
2022 January .....	184	214	434	1,098	213	18	102	330	174	37	193	403	1,067
February .....	170	190	393	1,045	188	16	116	332	159	33	177	369	1,021
March .....	180	212	430	1,194	215	17	154	379	168	37	207	411	1,176
April .....	172	198	405	1,179	177	17	174	407	163	34	195	392	1,167
May .....	181	214	429	1,218	206	17	195	371	169	35	208	411	1,200
June .....	182	214	429	1,175	229	16	203	298	167	33	213	413	1,159
July .....	184	218	435	1,131	217	17	202	260	174	34	206	414	1,110
August .....	183	211	428	1,038	186	17	189	218	173	34	213	420	1,030
September .....	176	193	401	980	150	17	172	241	162	32	192	386	966
October .....	173	217	425	1,011	127	17	155	289	162	34	216	412	999
November .....	173	219	427	1,079	158	18	114	363	163	34	209	406	1,058
December .....	182	211	428	1,063	180	18	96	341	168	35	205	408	1,044
Total .....	2,140	2,511	5,063	13,214	2,245	205	1,872	3,827	2,002	412	2,433	4,847	12,997
2023 January .....	179	219	434	1,084	196	18	105	331	172	35	208	415	1,065
February .....	161	198	390	1,059	172	16	123	357	152	31	189	373	1,042
March .....	181	221	436	1,177	184	18	163	376	167	34	220	421	1,161
April .....	161	212	405	1,156	171	17	194	369	153	32	207	392	1,143
May .....	174	228	435	1,190	239	17	221	278	163	34	234	430	1,185
June .....	167	229	428	1,093	186	16	224	238	155	32	231	418	1,083
July .....	173	232	438	1,122	190	17	237	242	163	33	224	420	1,104
August .....	179	230	441	1,111	184	16	225	245	165	33	235	433	1,102
September .....	171	226	427	1,032	146	17	197	245	157	31	222	410	1,015
October .....	168	232	433	1,076	135	18	180	311	157	33	234	424	1,067
November .....	170	230	433	1,049	147	18	137	315	160	33	219	413	1,029
December .....	182	248	465	1,097	164	18	121	328	166	36	235	437	1,069
Total .....	2,066	2,705	5,165	13,246	2,114	205	2,127	3,634	1,931	394	2,659	4,984	13,065
2024 January .....	168	225	427	1,064	189	18	129	301	160	34	212	406	1,043
February .....	157	227	414	1,120	173	16	158	358	145	31	221	397	1,103
March .....	169	241	443	1,257	201	16	203	393	156	33	233	422	1,236
April .....	163	222	416	1,246	167	17	239	408	152	31	219	401	1,232
May .....	168	232	432	1,248	195	16	272	333	156	33	240	428	1,244
June .....	160	237	428	1,245	183	16	290	328	149	30	233	412	1,229
July .....	166	252	449	1,181	183	17	291	241	154	32	251	437	1,169
August .....	172	250	453	1,189	184	17	286	248	159	31	244	434	1,170
September .....	165	235	430	1,084	144	16	245	249	154	30	231	414	1,068
October .....	162	247	440	1,170	137	16	232	345	150	32	246	427	1,157
10-Month Total ...	1,650	2,368	4,333	11,803	1,756	165	2,345	3,203	1,535	315	2,329	4,180	11,650
2022 10-Month Total ...	1,714	2,227	4,267	11,099	1,803	169	1,869	2,992	1,604	326	2,204	4,134	10,967
2021 10-Month Total ...	1,785	2,080	4,209	11,071	1,908	169	1,662	3,123	1,670	343	2,019	4,032	10,895

<sup>a</sup> For hydroelectric power, geothermal, solar, wind, and biomass waste, production equals consumption.

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

<sup>c</sup> 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.

<sup>d</sup> Includes biomass waste.

<sup>e</sup> Hydroelectric power, geothermal, solar, wind, and biomass.

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

<sup>g</sup> 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.

<sup>h</sup> 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.

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

<sup>j</sup> Wood and wood-derived fuels.

<sup>k</sup> 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).

<sup>l</sup> 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.

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.

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