

# **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	-.1354	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	-.1761	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 .....	6.721	.737	1.098	8.556	1.841	2.171	-.330	1.213	7.626	.737	1.067	9.440
February .....	6.124	.646	1.045	7.815	1.687	2.017	-.330	.906	6.718	.646	1.021	8.391
March .....	6.923	.660	1.194	8.777	1.848	2.306	-.458	.189	6.665	.660	1.176	8.508
April .....	6.636	.578	1.179	8.393	1.747	2.303	-.555	-.134	5.951	.578	1.167	7.704
May .....	6.909	.662	1.218	8.790	1.795	2.335	-.540	-.345	6.033	.662	1.200	7.904
June .....	6.741	.687	1.175	8.603	1.805	2.297	-.492	-.023	6.227	.687	1.159	8.088
July .....	7.014	.719	1.131	8.865	1.913	2.294	-.381	.040	6.676	.719	1.110	8.524
August .....	7.126	.720	1.038	8.884	1.826	2.331	-.505	.100	6.709	.720	1.030	8.479
September .....	6.998	.666	.980	8.644	1.705	2.266	-.561	-.347	6.091	.666	.966	7.736
October .....	7.188	.616	1.011	8.816	1.771	2.295	-.523	-.558	6.110	.616	.999	7.734
November .....	6.942	.648	1.079	8.669	1.767	2.315	-.548	.075	6.480	.648	1.058	8.196
December .....	6.903	.722	1.063	8.688	1.802	2.407	-.605	.940	7.243	.722	1.044	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 .....	7.194	.741	1.084	9.019	1.853	2.276	-.423	.256	7.036	.741	1.065	8.852
February .....	6.500	.636	1.059	8.194	1.746	2.210	-.464	.265	6.310	.636	1.042	7.995
March .....	7.318	.657	1.177	9.152	1.789	2.653	-.865	.291	6.752	.657	1.161	8.578
April .....	6.996	.592	1.156	8.744	1.754	2.370	-.615	-.511	5.876	.592	1.143	7.618
May .....	7.257	.639	1.190	9.086	1.810	2.460	-.650	-.655	5.949	.639	1.185	7.782
June .....	7.044	.677	1.093	8.814	1.825	2.387	-.562	-.347	6.140	.677	1.083	7.906
July .....	7.262	.730	1.122	9.115	1.804	2.482	-.679	.044	6.641	.730	1.104	8.480
August .....	7.414	.729	1.111	9.255	1.915	2.564	-.649	.013	6.782	.729	1.102	8.618
September .....	7.203	.685	1.032	8.920	1.785	2.439	-.654	-.477	6.088	.685	1.015	7.788
October .....	7.384	.642	1.076	9.103	1.705	2.540	-.836	-.339	6.219	.642	1.067	7.929
November .....	7.246	.651	1.049	8.946	1.818	2.462	-.644	-.092	6.528	.651	1.029	8.210
December .....	7.425	.720	1.097	9.242	1.853	2.801	-.947	.449	6.950	.720	1.069	8.744
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	R 2.559	-.658	R 1.118	R 7.584	.722	1.043	R 9.354
February .....	6.929	.675	1.120	8.724	1.710	R 2.546	-.835	.242	R 6.352	.675	1.103	8.131
March .....	7.229	.662	1.257	9.148	1.737	R 2.641	-.904	-.048	R 6.299	.662	1.236	8.196
April .....	6.898	.602	1.246	8.747	1.772	2.389	R -617	R -.489	R 5.808	.602	1.232	7.640
May .....	7.171	.679	1.248	9.099	1.935	R 2.540	R -.605	-.526	R 6.044	.679	1.244	R 7.968
June .....	7.083	.713	1.245	9.041	1.815	2.603	-.788	R -.184	R 6.122	.713	1.229	R 8.069
July .....	R 7.315	.730	1.181	R 9.227	1.967	R 2.536	R -.569	R -.034	R 6.714	.730	1.169	R 8.624
August .....	R 7.405	.729	1.189	R 9.322	1.786	R 2.627	R -.841	R .111	R 6.683	.729	1.170	R 8.592
September .....	7.123	.655	1.084	8.861	1.726	2.517	-.792	-.284	6.055	.655	1.068	7.785
9-Month Total ....	64.262	6.168	10.634	81.063	16.349	22.959	-6.610	-.093	57.662	6.168	10.493	74.360
2023 9-Month Total ....	64.189	6.086	10.023	80.299	16.281	21.842	-5.561	-1.121	57.574	6.086	9.900	73.617
2022 9-Month Total ....	61.192	6.075	10.060	77.327	16.167	20.319	-4.152	1.600	58.696	6.075	9.896	74.775

<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		
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	3,082	2,016	.610	6,721	.737	.213	.018	.102	.330	.434	1,098	8,556
February .....	970	2,776	1,825	.552	6,124	.646	.188	.016	.116	.332	.393	1,045	7,815
March .....	1,044	3,127	2,092	.660	6,923	.660	.215	.017	.154	.379	.430	1,194	8,777
April .....	940	3,048	2,014	.635	6,636	.578	.177	.017	.174	.407	.405	1,179	8,393
May .....	1,006	3,174	2,069	.661	6,909	.662	.206	.017	.195	.371	.429	1,218	8,790
June .....	986	3,079	2,031	.644	6,741	.687	.229	.016	.203	.298	.429	1,175	8,603
July .....	1,000	3,215	2,113	.686	7,014	.719	.217	.017	.202	.260	.435	1,131	8,865
August .....	1,087	3,232	2,136	.672	7,126	.720	.186	.017	.189	.218	.428	1,038	8,884
September .....	1,044	3,173	2,121	.660	6,998	.666	.150	.017	.172	.241	.401	.980	8,644
October .....	1,040	3,275	2,190	.684	7,188	.616	.127	.017	.155	.289	.425	1,011	8,816
November .....	988	3,169	2,126	.658	6,942	.648	.158	.018	.114	.363	.427	1,079	8,669
December .....	926	3,211	2,145	.621	6,903	.722	.180	.018	.096	.341	.428	1,063	8,688
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	3,265	2,224	.669	7,194	.741	.196	.018	.105	.331	.434	1,084	9,019
February .....	930	2,952	2,006	.612	6,500	.636	.172	.016	.123	.357	.390	1,059	8,194
March .....	1,056	3,298	2,260	.704	7,318	.657	.184	.018	.163	.376	.436	1,177	9,152
April .....	954	3,186	2,164	.691	6,996	.592	.171	.017	.194	.369	.405	1,156	8,744
May .....	980	3,320	2,245	.712	7,257	.639	.239	.017	.221	.278	.435	1,190	9,086
June .....	958	3,203	2,196	.687	7,044	.677	.186	.016	.224	.238	.428	1,093	8,814
July .....	948	3,312	2,281	.721	7,262	.730	.190	.017	.237	.242	.438	1,122	9,115
August .....	1,029	3,350	2,301	.735	7,414	.729	.184	.016	.225	.245	.441	1,111	9,255
September .....	985	3,240	2,249	.729	7,203	.685	.146	.017	.197	.245	.427	1,032	8,920
October .....	967	3,344	2,319	.754	7,384	.642	.135	.018	.180	.311	.433	1,076	9,103
November .....	967	3,285	2,267	.727	7,246	.651	.147	.018	.137	.315	.433	1,049	8,946
December .....	932	3,409	2,347	.737	7,425	.720	.164	.018	.121	.328	.465	1,097	9,242
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	E 3,297	E 2,323	.757	7,229	.662	.201	.016	.203	.393	.443	1,257	9,148
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	9,099
June .....	876	E 3,195	E 2,260	.752	7,083	.713	.183	.016	.290	.328	.428	1,245	9,041
July .....	R 879	RE 3,346	RE 2,327	.764	R 7,315	.730	.183	.017	.291	.241	.449	1,181	R 9,227
August .....	R 955	RE 3,314	RE 2,356	.779	R 7,405	.729	.184	.017	.286	.248	.453	1,189	R 9,322
September .....	927	E 3,174	E 2,254	.768	7,123	.655	.144	.016	.245	.249	.430	1,084	8,861
9-Month Total ...	7,811	E 29,257	E 20,484	6,709	64,262	6,168	1,620	.149	2,114	2,858	3,893	10,634	81,063
2023 9-Month Total ...	8,876	29,126	19,926	6,261	64,189	6,086	1,668	.151	1,689	2,681	3,834	10,023	80,299
2022 9-Month Total ...	9,089	27,906	18,418	5,779	61,192	6,075	1,781	.152	1,507	2,835	3,784	10,060	77,327

<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>		Hydro-electric Power <sup>f</sup>	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
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	5.013	9.758	98.294
2015 Total .....	15.549	28.191	35.368	79.090	8.337	2.320	.212	.427	1.776	5.008	9.743	97.398
2016 Total .....	14.226	28.400	35.712	78.319	8.427	2.471	.210	.570	2.095	5.053	10.399	97.371
2017 Total .....	13.837	28.055	36.043	77.907	8.419	2.765	.210	.777	2.342	5.035	11.128	97.647
2018 Total .....	13.252	31.163	36.892	81.281	8.438	2.661	.209	.915	2.481	5.094	11.360	101.230
2019 Total .....	11.316	32.264	36.866	80.425	8.452	2.562	.201	1.016	2.633	5.046	11.458	100.468
2020 Total .....	9.181	31.669	32.331	73.169	8.251	2.501	.203	1.211	2.963	4.535	11.413	92.994
2021 Total .....	10.549	31.711	35.243	77.454	8.131	2.225	.205	1.520	3.345	4.740	12.035	97.754
2022 January .....	1.008	3.708	2.915	7.626	.737	.213	.018	.102	.330	.403	1.067	9.440
February .....	.838	3.156	2.726	6.718	.646	.188	.016	.116	.332	.369	1.021	8.391
March .....	.733	2.875	3.063	6.665	.660	.215	.017	.154	.379	.411	1.176	8.508
April .....	.663	2.436	2.858	5.951	.578	.177	.017	.174	.407	.392	1.167	7.704
May .....	.745	2.315	2.982	6.033	.662	.206	.017	.195	.371	.411	1.200	7.904
June .....	.870	2.395	2.967	6.227	.687	.229	.016	.203	.298	.413	1.159	8.088
July .....	1.018	2.677	2.986	6.676	.719	.217	.017	.202	.260	.414	1.110	8.524
August .....	.997	2.652	3.064	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	6.480	.648	.158	.018	.114	.363	.406	1.058	8.196
December .....	.871	3.494	2.884	7.243	.722	.180	.018	.096	.341	.408	1.044	9.023
Total .....	9.888	33.379	35.319	78.529	8.061	2.245	.205	1.872	3.827	4.847	12.997	99.728
2023 January .....	.750	3.421	2.868	7.036	.741	.196	.018	.105	.331	.415	1.065	8.852
February .....	.582	3.053	2.678	6.310	.636	.172	.016	.123	.357	.373	1.042	7.995
March .....	.620	3.128	3.006	6.752	.657	.184	.018	.163	.376	.421	1.161	8.578
April .....	.500	2.500	2.878	5.876	.592	.171	.017	.194	.369	.392	1.143	7.618
May .....	.550	2.387	3.014	5.949	.639	.239	.017	.221	.278	.430	1.185	7.782
June .....	.705	2.446	2.991	6.140	.677	.186	.016	.224	.238	.418	1.083	7.906
July .....	.913	2.757	2.975	6.641	.730	.190	.017	.237	.242	.420	1.104	8.480
August .....	.903	2.774	3.108	6.782	.729	.184	.016	.225	.245	.433	1.102	8.618
September .....	.716	2.465	2.911	6.088	.685	.146	.017	.197	.245	.410	1.015	7.788
October .....	.628	2.526	3.067	6.219	.642	.135	.018	.180	.311	.424	1.067	7.929
November .....	.629	2.923	2.978	6.528	.651	.147	.018	.137	.315	.413	1.029	8.210
December .....	.676	3.305	2.975	6.950	.720	.164	.018	.121	.328	.437	1.069	8.744
Total .....	8.172	33.683	35.448	77.271	8.099	2.114	.205	2.127	3.634	4.984	13.065	98.499
2024 January .....	.876	R 3.823	2.885	R 7.584	.722	.189	.018	.129	.301	.406	1.043	R 9.354
February .....	.559	3.068	2.728	R 6.352	.675	.173	.016	.158	.358	.397	1.103	8.131
March .....	.490	R 2.889	2.924	6.299	.662	.201	.016	.203	.393	.422	1.236	8.196
April .....	.467	R 2.471	2.875	R 5.808	.602	.167	.017	.239	.408	.401	1.232	7.640
May .....	.560	R 2.408	3.079	R 6.044	.679	.195	.016	.272	.333	.428	1.244	R 7.968
June .....	.718	R 2.508	2.901	R 6.122	.713	.183	.016	.290	.328	.412	1.229	R 8.069
July .....	.833	R 2.832	3.051	R 6.714	.730	.183	.017	.291	.241	.437	1.169	R 8.624
August .....	.814	R 2.806	3.067	R 6.683	.729	.184	.017	.286	.248	.434	1.170	R 8.592
September .....	.663	2.503	2.893	6.055	.655	.144	.016	.245	.249	.414	1.068	7.785
9-Month Total ....	5.978	25.309	26.403	57.662	6.168	1.620	.149	2.114	2.858	3.752	10.493	74.360
2023 9-Month Total ....	6.239	24.930	26.429	57.574	6.086	1.668	.151	1.689	2.681	3.711	9.900	73.617
2022 9-Month Total ....	7.654	24.582	26.504	58.696	6.075	1.781	.152	1.507	2.835	3.621	9.896	74.775

<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									Total Renewable Energy	
	Biomass			Total Renewable Energy <sup>e</sup>	Noncombustible (Fossil Fuel Equivalent)				Biomass					
	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	
9-Month Total ....	1,468	2,121	3,893	10,634	1,620	149	2,114	2,858	1,385	284	2,083	3,752	10,493	
2022 9-Month Total ....	1,546	1,995	3,834	10,023	1,668	151	1,689	2,681	1,448	293	1,970	3,711	9,900	
2021 9-Month Total ....	1,612	1,863	3,784	10,060	1,781	152	1,507	2,835	1,509	309	1,803	3,621	9,896	

<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 hydroelectric 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.

<sup>m</sup> 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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