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.

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[1]Direct use of noncombustible renewables in the form of heat (e.g., solar thermal heating) is estimated separately and is measured in Btu.
[2]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.
[3]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[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**
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 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	7.175	.740	1.107	9.022	1.854	2.297	-.444	.266	7.003	.740	1.090	R8.845
February	6.482	.635	1.070	8.187	1.745	2.202	-.457	.253	R6.287	.635	1.053	R7.982
March	7.302	.656	1.190	9.148	1.793	2.723	-.930	.343	6.722	.656	1.174	8.561
April	6.988	.592	1.151	8.731	1.754	2.342	-.588	-.518	5.888	.592	1.138	7.624
May	7.252	.642	1.202	9.096	1.817	2.419	-.602	-.680	5.967	.642	1.196	7.815
June	7.068	.679	1.088	8.835	1.826	2.377	-.551	R-.400	R6.122	.679	1.078	R7.884
July	7.263	.730	1.128	9.121	1.806	2.437	-.632	.013	6.659	.730	1.109	8.503
August	7.412	.729	1.125	9.265	1.927	2.487	-.560	-.062	6.794	.729	1.116	8.643
September	7.218	.685	1.037	8.940	1.782	2.433	-.651	R-.510	6.073	.685	1.020	7.779
October	7.401	.642	1.112	9.154	1.711	2.522	-.811	-.376	6.223	.642	1.102	7.967
November	7.254	.650	1.072	8.977	1.826	2.462	-.636	R-.111	R6.524	.650	1.052	R8.229
December	7.419	.720	1.112	9.250	1.859	2.796	-.938	.404	6.909	.720	1.083	8.717
Total	**86.233**	**8.101**	**13.393**	**107.727**	**21.699**	**29.498**	**-7.799**	**-1.378**	**R77.172**	**8.101**	**13.212**	**98.550**
2024 January	R7.110	.722	1.072	R8.904	1.907	2.559	-.653	R1.109	R7.582	.722	1.051	R9.360
February	R6.930	.675	1.132	R8.738	1.716	2.547	-.830	R.237	R6.354	.675	1.115	R8.144
March	R7.234	.662	R1.272	R9.168	R1.743	R2.641	R-.899	R-.062	R6.296	.662	1.251	R8.208
April	6.840	.599	1.264	8.703	1.776	2.384	-.608	-.434	5.811	.599	1.250	7.661
4-Month Total	**28.115**	**2.657**	**4.741**	**35.513**	**7.141**	**10.131**	**-2.989**	**.851**	**26.043**	**2.657**	**4.667**	**33.374**
2023 4-Month Total	**27.946**	**2.624**	**4.517**	**35.088**	**7.146**	**9.565**	**-2.419**	**.344**	**25.901**	**2.624**	**4.455**	**33.013**
2022 4-Month Total	**26.390**	**2.621**	**4.520**	**33.531**	**7.123**	**8.795**	**-1.672**	**2.176**	**26.948**	**2.621**	**4.434**	**34.035**

[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						Renewable Energy[a]						
	Coal[b]	Natural Gas (Dry)	Crude Oil[c]	NGPL[d]	Total	Nuclear Electric Power	Hydro-electric Power[e]	Geo-thermal	Solar	Wind	Bio-mass	Total	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**	**18.610**	**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 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	.202	.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	1.037	E 3.273	E 2.217	.648	7.175	.740	.196	.019	.109	.346	.437	1.107	9.022
February	.931	E 2.958	E 1.996	.597	6.482	.635	.165	.016	.124	.372	.393	1.070	8.187
March	1.057	E 3.304	E 2.252	.688	7.302	.656	.178	.018	.165	.393	.436	1.190	9.148
April	.955	E 3.190	E 2.159	.683	6.988	.592	.154	.017	.196	.380	.404	1.151	8.731
May	.981	E 3.326	E 2.239	.706	7.252	.642	.242	.017	.222	.283	.438	1.202	9.096
June	.959	E 3.209	E 2.201	.700	7.068	.679	.172	.016	.227	.243	.430	1.088	8.835
July	.949	E 3.320	E 2.280	.714	7.263	.730	.187	.017	.242	.246	.437	1.128	9.121
August	1.030	E 3.357	E 2.300	.726	7.412	.729	.186	.017	.230	.252	.440	1.125	9.265
September	.986	E 3.247	E 2.261	.724	7.218	.685	.145	.017	.201	.249	.425	1.037	8.940
October	.968	E 3.351	E 2.331	.750	7.401	.642	.159	.018	.183	.322	.430	1.112	9.154
November	.968	E 3.291	E 2.269	.725	7.254	.650	.160	.018	.139	.326	.430	1.072	8.977
December	.933	E 3.419	E 2.339	.728	7.419	.720	.170	.018	.125	.338	.461	1.112	9.250
Total	**11.754**	**E 39.246**	**E 26.843**	**8.389**	**86.233**	**8.101**	**2.114**	**.209**	**2.164**	**3.748**	**5.160**	**13.393**	**107.727**
2024 January	R .899	E 3.326	E 2.214	.671	R 7.110	.722	.187	.017	.131	.308	.428	1.072	R 8.904
February	R .897	RE 3.184	E 2.162	.688	R 6.930	.675	.173	.016	.161	.367	.416	1.132	R 8.738
March	R .853	RE 3.301	RE 2.324	.757	R 7.234	.662	.202	.016	.206	.404	R .443	R 1.272	R 9.168
April	.672	E 3.159	E 2.261	.748	6.840	.599	.169	.017	.243	.420	.415	1.264	8.703
4-Month Total	**3.321**	**E 12.970**	**E 8.960**	**2.864**	**28.115**	**2.657**	**.731**	**.067**	**.741**	**1.500**	**1.702**	**4.741**	**35.513**
2023 4-Month Total	**3.981**	**E 12.725**	**E 8.624**	**2.616**	**27.946**	**2.624**	**.693**	**.070**	**.594**	**1.490**	**1.670**	**4.517**	**35.088**
2022 4-Month Total	**3.966**	**12.065**	**7.902**	**2.457**	**26.390**	**2.621**	**.793**	**.067**	**.546**	**1.448**	**1.665**	**4.520**	**33.531**

[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]					Renewable Energy[b]						
	Coal	Natural Gas[c]	Petroleum[d]	Total[e]	Nuclear Electric Power	Hydroelectric Power[f]	Geothermal	Solar	Wind	Biomass	Total	Total[g]
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**	**5.016**	**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 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	.202	.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	.749	3.415	2.842	7.003	.740	.196	.019	.109	.346	.420	1.090	R 8.845
February	.582	R 3.048	2.658	R 6.287	.635	.165	.016	.124	.372	.376	1.053	R 7.982
March	.618	3.115	2.991	6.722	.656	.178	.018	.165	.393	.420	1.174	8.561
April	.499	2.503	2.888	5.888	.592	.154	.017	.196	.380	.391	1.138	7.624
May	.552	2.392	3.026	5.967	.642	.242	.017	.222	.283	.432	1.196	7.815
June	.703	R 2.444	2.978	R 6.122	.679	.172	.016	.227	.243	.420	1.078	R 7.884
July	.913	2.755	2.993	6.659	.730	.187	.017	.242	.246	.418	1.109	8.503
August	.902	2.764	3.130	6.794	.729	.186	.017	.230	.252	.431	1.116	8.643
September	.716	2.455	2.906	6.073	.685	.145	.017	.201	.249	.408	1.020	7.779
October	.628	2.522	3.074	6.223	.642	.159	.018	.183	.322	.420	1.102	7.967
November	.630	R 2.919	2.978	R 6.524	.650	.160	.018	.139	.326	.410	1.052	R 8.229
December	.674	3.277	2.963	6.909	.720	.170	.018	.125	.338	.432	1.083	8.717
Total	**8.167**	**33.611**	**35.427**	**R 77.172**	**8.101**	**2.114**	**.209**	**2.164**	**3.748**	**4.978**	**13.212**	**98.550**
2024 January	R .875	R 3.822	2.886	R 7.582	.722	.187	.017	.131	.308	.407	1.051	R 9.360
February	R .558	R 3.070	2.728	R 6.354	.675	.173	.016	.161	.367	.399	1.115	R 8.144
March	R .489	R 2.887	2.924	R 6.296	.662	.202	.016	.206	.404	.422	1.251	R 8.208
April	.465	2.475	2.875	5.811	.599	.169	.017	.243	.420	.401	1.250	7.661
4-Month Total	**2.387**	**12.255**	**11.412**	**26.043**	**2.657**	**.731**	**.067**	**.741**	**1.500**	**1.629**	**4.667**	**33.374**
2023 4-Month Total	**2.449**	**12.082**	**11.379**	**25.901**	**2.624**	**.693**	**.070**	**.594**	**1.490**	**1.607**	**4.455**	**33.013**
2022 4-Month Total	**3.241**	**12.162**	**11.562**	**26.948**	**2.621**	**.793**	**.067**	**.546**	**1.448**	**1.579**	**4.434**	**34.035**

[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]	Biofuels[c]	Total[d]		Hydroelectric Power[f]	Geothermal[g]	Solar[h]	Wind[i]	Wood[j]	Waste[k]	Biofuels[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**	**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	**2,401**	**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 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	202	260	175	34	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	182	220	437	1,107	196	19	109	346	174	36	210	420	1,090
February	162	198	393	1,070	165	16	124	372	154	32	190	376	1,053
March	180	222	436	1,190	178	18	165	393	165	34	220	420	1,174
April	160	212	404	1,151	154	17	196	380	152	32	207	391	1,138
May	175	229	438	1,202	242	17	222	283	164	34	234	432	1,196
June	168	230	430	1,088	172	16	227	243	156	32	232	420	1,078
July	172	232	437	1,128	187	17	242	246	162	33	223	418	1,109
August	177	230	440	1,125	186	17	230	252	163	33	235	431	1,116
September	166	227	425	1,037	145	17	201	249	153	32	224	408	1,020
October	166	231	430	1,112	159	18	183	322	154	33	233	420	1,102
November	168	229	430	1,072	160	18	139	326	159	32	219	410	1,052
December	177	248	461	1,112	170	18	125	338	162	36	235	432	1,083
Total	**2,053**	**2,708**	**5,160**	**13,393**	**2,114**	**209**	**2,164**	**3,748**	**1,918**	**398**	**2,662**	**4,978**	**13,212**
2024 January	169	225	428	1,072	187	17	131	308	161	34	212	407	1,051
February	156	227	416	1,132	173	16	161	367	145	33	221	399	1,115
March	R 168	241	R 443	R 1,272	202	16	206	404	155	34	233	422	1,251
April	161	222	415	1,264	169	17	243	420	150	32	219	401	1,250
4-Month Total	**655**	**915**	**1,702**	**4,741**	**731**	**67**	**741**	**1,500**	**611**	**133**	**885**	**1,629**	**4,667**
2022 4-Month Total	**684**	**852**	**1,670**	**4,517**	**693**	**70**	**594**	**1,490**	**645**	**134**	**828**	**1,607**	**4,455**
2021 4-Month Total	**710**	**815**	**1,665**	**4,520**	**793**	**67**	**546**	**1,448**	**667**	**141**	**772**	**1,579**	**4,434**

[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.

R=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.

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