

Transportation Energy Use: Comparison Including and Excluding Upstream Energy Use



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Energy and Transportation Science Division

**TRANSPORTATION ENERGY:
A COMPARISON INCLUDING AND EXCLUDING UPSTREAM ENERGY**

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1. INTRODUCTION

Thirty-eight editions of the Transportation Energy Data Book (Data Book) have been published since the report began in 1976. It was designed as a desk-top reference of statistics and information that characterize transportation activity. The most recent Data Book, edition 38, has 226 tables and 70 figures in the body of the report, with an additional 51 tables in appendices.

One of the most-often used tables in the Data Book is referred to by the authors as “the big energy table.” It has transportation energy use in British thermal units (Btu) by mode and fuel type. The data are compiled from about 20 different sources and combined to create a detailed picture of transportation energy use. From the first edition to edition 35 of the Data Book, electricity use in the big energy table was converted from the original kilowatt-hours (kWh) to Btu using the net generation heat rate for fossil fuels (Table 1). In those days, electricity was used mainly by transit rail. As electricity began to be used in the highway modes with consumer sales of electric vehicles, that process was revisited. Since energy use in the Data Book’s big energy table for all other fuels did not include the upstream energy to create the fuel, it seemed inconsistent to include upstream energy for generation of electricity. Beginning with edition 36, electricity use for the big energy table was converted from kilowatt hours to Btu using the heat content of electricity (Table 1). Using heat content instead of net generation reduced electricity use data by about two-thirds.

Feedback in recent years on the change in process for electricity led to an investigation of the differences in transportation energy use when adding estimates of upstream energy use to all the fuels used in transportation. This report documents the result of that effort.

Table 1. Approximate Heat Rates and Heat Content of Electricity, 1970-2018
(Btu per kilowatt-hour)

Year	Electricity Net Generation Heat Rate	Heat Content of Electricity	Year	Electricity Net Generation Heat Rate	Heat Content of Electricity
1970	10,494	3,412	1995	10,312	3,412
1971	10,478	3,412	1996	10,340	3,412
1972	10,379	3,412	1997	10,213	3,412
1973	10,389	3,412	1998	10,197	3,412
1974	10,442	3,412	1999	10,226	3,412
1975	10,406	3,412	2000	10,201	3,412
1976	10,373	3,412	2001	10,333	3,412
1977	10,435	3,412	2002	10,173	3,412
1978	10,361	3,412	2003	10,125	3,412
1979	10,353	3,412	2004	10,016	3,412
1980	10,388	3,412	2005	9,999	3,412
1981	10,453	3,412	2006	9,919	3,412
1982	10,454	3,412	2007	9,884	3,412
1983	10,520	3,412	2008	9,854	3,412
1984	10,440	3,412	2009	9,760	3,412
1985	10,447	3,412	2010	9,756	3,412
1986	10,446	3,412	2011	9,716	3,412
1987	10,419	3,412	2012	9,516	3,412
1988	10,324	3,412	2013	9,541	3,412
1989	10,432	3,412	2014	9,510	3,412
1990	10,402	3,412	2015	9,319	3,412
1991	10,436	3,412	2016	9,232	3,412
1992	10,342	3,412	2017	9,213	3,412
1993	10,309	3,412	2018	9,213	3,412
1994	10,316	3,412			

Source: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, Washington, DC, March 2019, Table A6.

^a For fossil fuels and noncombustible renewable energy. Does not include nuclear energy generation.

2. TRANSPORTATION VEHICLE ENERGY USE

The Data Book's big energy table includes light vehicles, buses, and medium/heavy trucks in the highway mode, and air, water, pipeline, and rail in the nonhighway mode. Fuel types include gasoline, diesel fuel, liquefied petroleum gas, jet fuel, residual fuel oil, natural gas, and electricity. Table 2 is the Data Book's big energy table with energy used by the vehicles, not including upstream energy use for any fuel. For 2017, total energy use is 26.6 quadrillion Btu (quads).

Table 2. Domestic Consumption of Transportation Energy by Mode and Fuel Type, 2017^a
(trillion Btu)

	Gasoline	Diesel fuel	Liquefied petroleum gas	Jet fuel	Residual fuel oil	Natural gas	Electricity	Total ^b
<u>HIGHWAY</u>	15,495.3	6,266.5	75.5	-	-	24.6	6.8	21,868.7
Light vehicles	14,853.3	445.9	53.9	-	-	-	6.6	15,359.8
Cars	6,297.2	36.2					5.8	6,339.3
Light trucks ^c	8,498.8	409.6	53.9				0.8	8,963.2
Motorcycles	57.3							57.3
Buses	9.9	185.0	0.6	-	-	24.6	0.2	220.3
Transit	1.6	64.6	0.6			24.6	0.2	91.6
Intercity		37.3						37.3
School	8.3	83.1						91.4
Medium/heavy trucks	632.0	5,635.6	21.0	-	-	-	-	6,288.6
Class 3-6 trucks	581.4	789.0	20.8					1,391.2
Class 7-8 trucks	50.6	4,846.6	0.2					4,897.4
<u>NONHIGHWAY</u>	214.8	818.5	-	2,208.2	669.5	743.9	104.7	4,723.2
Air	22.6	-	-	2,208.2	-	-	-	2,230.8
General aviation	22.6			209.1				231.7
Domestic air carriers				1,564.3				1,564.3
International air carriers ^d				434.8				434.8
Water	170.4	290.5	-	-	669.5	-	-	1,130.4
Freight		250.7			669.5			920.2
Recreational	170.4	39.9						210.3
Pipeline	-	-	-	-	-	743.9	81.1	825.0
Rail	-	513.3	-	-	-	-	23.6	536.9
Freight (Class I)		490.5						490.5
Passenger		22.8					23.6	46.4
Transit							15.9	15.9
Commuter		14.5					6.1	20.5
Intercity		8.3					1.7	10.0
TOTAL HWY & NONHWY^c	15,688.3	7,070.4	75.5	2,208.2	669.5	768.4	111.6	26,591.9

Source: Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 38*, ORNL/TM-2019/1333, February 2020, Table 2.7.

^a Civilian consumption only. Totals may not include all possible uses of fuels for transportation (e.g., snowmobiles).

^b Totals may not sum due to rounding.

^c Two-axle, four-tire trucks.

^d One half of fuel used by domestic carriers in international operation.

Historical energy summaries are also provided in the Data Book. Table 3 shows highway modes for 1970-2017 using the same vehicle energy use data as the previous table, and Table 4 shows nonhighway modes.

Table 3. Highway Transportation Energy Consumption by Mode, 1970–2017
(trillion Btu)

Year	Cars	Light trucks	Light vehicles subtotal	Motor-cycles	Buses	Class 3-6 trucks	Class 7-8 trucks	Heavy trucks subtotal	Highway subtotal	Total transportation ^a
1970	8,479	1,539	10,018	7	129	333	1,220	1,553	11,707	15,192
1975	9,298	2,384	11,682	14	124	430	1,574	2,003	13,823	17,204
1976	9,826	2,602	12,428	15	134	453	1,661	2,114	14,691	18,266
1977	9,928	2,797	12,725	16	137	503	1,841	2,344	15,222	18,951
1978	10,134	3,020	13,154	18	141	672	1,935	2,607	15,920	19,922
1979	9,629	3,056	12,685	22	144	813	1,884	2,697	15,548	19,473
1980	8,800	2,975	11,775	26	143	929	1,757	2,686	14,630	18,760
1981	8,693	2,963	11,656	27	145	1,065	1,659	2,724	14,552	18,558
1982	8,673	2,837	11,510	25	151	1,182	1,525	2,707	14,393	18,055
1983	8,802	2,990	11,792	22	152	1,121	1,649	2,770	14,736	18,188
1984	8,837	3,197	12,034	22	146	1,072	1,801	2,873	15,075	18,773
1985	8,932	3,413	12,345	23	153	986	1,897	2,883	15,404	19,017
1986	9,138	3,629	12,767	23	160	920	2,038	2,958	15,908	20,086
1987	9,157	3,819	12,976	24	164	858	2,203	3,061	16,225	20,578
1988	9,158	4,078	13,236	25	169	860	2,257	3,118	16,548	21,131
1989	9,232	4,156	13,388	26	169	869	2,330	3,199	16,782	21,487
1990	8,688	4,451	13,139	24	167	891	2,442	3,334	16,664	21,383
1991	8,029	4,774	12,803	23	177	895	2,507	3,402	16,405	20,985
1992	8,169	5,117	13,286	24	184	897	2,570	3,468	16,962	21,646
1993	8,368	5,356	13,724	25	183	906	2,671	3,577	17,509	22,125
1994	8,470	5,515	13,985	26	183	936	2,842	3,778	17,972	22,729
1995	8,489	5,695	14,184	25	184	954	2,983	3,937	18,330	23,263
1996	8,634	5,917	14,551	24	186	958	3,088	4,045	18,806	23,773
1997	8,710	6,169	14,879	25	192	945	3,141	4,086	19,182	24,126
1998	8,936	6,303	15,239	26	196	967	3,251	4,218	19,679	24,461
1999	9,134	6,602	15,736	26	203	1,054	3,584	4,638	20,603	25,760
2000	9,100	6,607	15,707	26	209	1,085	3,734	4,819	20,761	26,071
2001	9,161	6,678	15,839	24	196	1,074	3,738	4,813	20,872	25,741
2002	9,391	6,883	16,274	24	192	1,114	3,921	5,035	21,525	26,329
2003	9,255	7,551	16,806	24	190	1,083	3,812	4,895	21,915	26,509
2004	9,331	7,861	17,192	25	194	1,003	3,532	4,535	21,946	26,965
2005	9,579	7,296	16,875	24	196	1,126	3,963	5,088	22,183	27,373
2006	9,316	7,550	16,866	28	199	1,149	4,045	5,193 ^b	22,286	27,546
2007	9,221	7,679	16,900	59	195	1,429	5,031	6,460	23,615	29,004
2008	8,831	7,572	16,404	61	200	1,444	5,083	6,527	23,192	28,365
2009	8,209	7,635	15,843	60	200	1,341	4,720	6,061	22,165	26,878
2010	7,657	7,971	15,628	53	190	1,363	4,797	6,160	22,032	26,949
2011	7,336	8,104	15,440	53	195	1,283	4,517	5,801	21,489	26,357
2012	7,121	8,180	15,300	61	200	1,282	4,512	5,794	21,356	25,966
2013	7,047	8,077	15,124	58	204	1,310	4,613	5,924	21,310	25,868
2014	6,951	8,506	15,454	57	206	1,332	4,689	6,022	21,742	25,949
2015	6,716	8,654	15,370	56	210	1,324	4,660	5,984	21,619	26,084
2016	6,577	8,890	15,467	58	214	1,359	4,783	6,142	21,881	26,485
2017	6,339	8,963	15,302	57	220	1,391	4,897	6,289	21,869	26,592
<i>Average annual percentage change</i>										
1970-2017	-0.6%	3.8%	0.9%	4.6%	1.1%	3.1%	3.0%	3.0%	1.3%	1.2%
2007-2017	-3.7%	1.6%	-1.0%	-0.4%	1.3%	-0.3%	-0.3%	-0.3%	-0.8%	-0.9%

Source: Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 38*, ORNL/TM-2019/1333, February 2020, Table 2.9.

^a Total transportation figures do not include military and off-highway energy use and may not include all possible uses of fuel for transportation (e.g., snowmobiles).

^b Due to changes in the FHWA fuel use methodology, motorcycle, bus, and heavy truck data are not comparable with data before the year 2007. Car and light truck data changed after 2008.

Table 4. Nonhighway Transportation Energy Consumption by Mode, 1970–2017
(trillion Btu)

Year	Air	Water	Pipeline	Rail	Nonhighway subtotal	Total transportation ^a
1970	1,287	836	826	537	3,486	15,192
1975	1,234	927	680	540	3,381	17,204
1976	1,285	1,083	644	562	3,574	18,266
1977	1,350	1,177	627	574	3,728	18,951
1978	1,423	1,382	625	572	4,002	19,922
1979	1,488	1,149	699	588	3,925	19,473
1980	1,434	1,393	734	570	4,130	18,760
1981	1,453	1,270	742	541	4,006	18,558
1982	1,445	1,063	694	460	3,662	18,055
1983	1,440	974	583	455	3,452	18,188
1984	1,609	964	623	502	3,699	18,773
1985	1,677	871	597	468	3,613	19,017
1986	1,823	1,323	578	454	4,178	20,086
1987	1,899	1,378	613	464	4,354	20,578
1988	1,978	1,417	712	476	4,583	21,131
1989	1,981	1,516	729	478	4,705	21,487
1990	2,046	1,442	760	471	4,719	21,383
1991	1,916	1,523	699	442	4,580	20,985
1992	1,945	1,599	685	455	4,684	21,646
1993	1,986	1,437	723	469	4,615	22,125
1994	2,075	1,394	787	502	4,758	22,729
1995	2,141	1,468	803	523	4,935	23,263
1996	2,206	1,411	814	536	4,967	23,773
1997	2,300	1,250	856	537	4,943	24,126
1998	2,275	1,232	735	540	4,782	24,461
1999	2,483	1,370	745	560	5,156	25,760
2000	2,554	1,455	742	559	5,309	26,071
2001	2,397	1,187	724	561	4,869	25,741
2002	2,229	1,246	768	563	4,807	26,329
2003	2,260	1,071	689	575	4,597	26,509
2004	2,456	1,293	662	607	5,024	26,965
2005	2,532	1,363	681	613	5,194	27,373
2006	2,511	1,442	681	626	5,269	27,546
2007	2,509	1,550	720	610	5,399	29,004
2008	2,396	1,444	748	586	5,190	28,365
2009	2,127	1,323	771	492	4,731	26,878
2010	2,149	1,460	775	533	4,942	26,949
2011	2,157	1,362	790	560	4,900	26,357
2012	2,077	1,148	835	549	4,644	25,966
2013	2,037	1,017	942	562	4,596	25,868
2014	2,060	876	803	587	4,367	25,949
2015	2,118	1,005	780	563	4,505	26,084
2016	2,178	1,116	789	520	4,642	26,485
2017	2,231	1,130	825	537	4,760	26,592
<i>Average annual percentage change</i>						
1970-2017	1.2%	0.7%	0.0%	0.0%	0.7%	1.2%
2007-2017	-1.2%	-2.9%	1.4%	-1.3%	-1.3%	-0.9%

Source: Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 38*, ORNL/TM-2019/1333, February 2020, Table 2.10.

^a Total transportation figures do not include military and off-highway energy use and may not include all possible uses of fuel for transportation (e.g., snowmobiles).

3. TRANSPORTATION ENERGY USE INCLUDING VEHICLE ENERGY USE PLUS UPSTREAM ENERGY USE

Argonne National Laboratory's Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET) Model has a [Well-to-Wheels \(WTW\) calculator](#) which provides factors for the energy used to produce transportation fuels (upstream energy). Table 5 shows the factors by fuel type that were used to convert vehicle energy consumption to include upstream energy consumption for all fuels except electricity. Electricity consumption was converted to include upstream energy using the net generation heat rate on Table 1. The next three tables are the same as in section 2, but the data have upstream energy use included (Tables 6-8). Total transportation energy use including upstream energy was 33.0 quads in 2017.

Table 5. Factors for Including Upstream Energy Consumption

Fuel Type	Upstream Energy Factor
Gasoline (E0)	1.24
Gasoline (E10)	1.28
Diesel	1.19
Biodiesel	1.50
CNG	1.15
LNG	1.20
LPG	1.15
Jet Fuel (conventional)	1.15
Marine Heavy Fuel Oil (2.7% Sulfur)	1.14

Source: Argonne National Laboratory, [GREET 2019 WTW Calculator](#), accessed March 6, 2020.

**Table 6. Domestic Consumption of Transportation Energy Including Upstream Energy
by Mode and Fuel Type, 2017^a**
(trillion Btu)

	Gasoline	Diesel fuel	Liquefied petroleum gas	Jet fuel	Residual fuel oil	Natural gas	Electricity	Total ^b
<u>HIGHWAY</u>	19,793.7	7,458.6	86.8	-	-	28.3	18.5	27,385.9
Light vehicles	18,997.7	530.6	62.0	-	-	-	17.9	19,608.2
Cars	8,048.7	43.1					15.6	8,107.4
Light trucks ^c	10,877.7	487.5	62.0				2.3	11,429.5
Motorcycles	71.3							71.3
Buses	12.3	221.6	0.7	-	-	28.3	0.6	263.5
Transit	2.0	78.3	0.7			28.3	0.6	109.9
Intercity		44.4						44.4
School	10.3	98.9						109.2
Medium/heavy trucks	783.7	6,706.4	24.1	-	-	-	-	7,514.2
Class 3-6 trucks	721	938.9	23.9					1,683.8
Class 7-8 trucks	62.7	5,767.50	0.2					5,830.4
<u>NONHIGHWAY</u>	240.0	956.5	-	2,539.5	763.2	890.1	274.2	5,663.5
Air	28.7	-	-	2,539.5	-	-	-	2,568.2
General aviation	28.7			240.4				269.1
Domestic air carriers				1,799.00				1,799.0
International air carriers ^d				500.1				500.1
Water	211.3	345.7	-	-	763.2	-	-	1,320.2
Freight		298.3			763.2			1,061.5
Recreational	211.3	47.4						258.7
Pipeline	-	-	-	-	-	890.1	219	1,109.1
Rail	-	610.8	-	-	-	-	55.2	666.0
Freight (Class I)		583.7						583.7
Passenger		27.1					55.2	82.3
Transit							34.3	34.3
Commuter		17.2					16.4	33.6
Intercity		9.9					4.5	14.4
TOTAL HWY & NONHWY^c	20,033.7	8,415.1	86.8	2,539.5	763.2	918.4	292.7	33,049.4

Source: Vehicle energy use from the Data Book plus upstream energy use for all fuels.

^a Civilian consumption only. Totals may not include all possible uses of fuels for transportation (e.g., snowmobiles).

^b Totals may not sum due to rounding.

^c Two-axle, four-tire trucks.

^d One half of fuel used by domestic carriers in international operation.

**Table 7. Highway Transportation Energy Consumption Including Upstream Energy
by Mode, 1970–2017**
(trillion Btu)

Year	Cars	Light trucks	Light vehicles subtotal	Motor-cycles	Buses	Class 3-6 trucks	Class 7-8 trucks	Heavy trucks subtotal	Highway subtotal	Total transportation ^a
1970	10,513	1,906	12,419	9	153	403	1,452	1,855	14,437	18,698
1975	11,514	2,953	14,467	17	147	520	1,873	2,393	17,025	21,153
1976	12,164	3,223	15,388	19	159	549	1,977	2,526	18,092	22,438
1977	12,287	3,464	15,751	20	164	608	2,192	2,801	18,735	23,259
1978	12,539	3,739	16,279	22	168	817	2,304	3,122	19,590	24,426
1979	11,912	3,783	15,695	27	172	993	2,244	3,237	19,130	23,877
1980	10,886	3,683	14,569	32	171	1,137	2,093	3,231	18,002	22,990
1981	10,753	3,667	14,420	33	173	1,306	1,978	3,284	17,911	22,761
1982	10,742	3,513	14,255	31	180	1,452	1,819	3,271	17,737	22,185
1983	10,917	3,704	14,621	27	181	1,376	1,966	3,342	18,170	22,372
1984	10,966	3,963	14,929	27	175	1,314	2,146	3,460	18,591	23,086
1985	11,095	4,233	15,328	28	182	1,206	2,261	3,467	19,005	23,399
1986	11,351	4,501	15,851	29	192	1,124	2,428	3,552	19,624	24,673
1987	11,371	4,735	16,106	29	196	1,046	2,623	3,669	20,001	25,256
1988	11,376	5,057	16,433	31	203	1,048	2,689	3,737	20,404	25,929
1989	11,464	5,153	16,617	32	202	1,058	2,775	3,833	20,685	26,355
1990	10,790	5,521	16,311	30	199	1,085	2,909	3,993	20,533	26,221
1991	9,976	5,924	15,900	28	212	1,089	2,985	4,074	20,215	25,736
1992	10,149	6,351	16,500	30	220	1,091	3,061	4,152	20,901	26,538
1993	10,399	6,649	17,049	31	218	1,101	3,181	4,282	21,579	27,140
1994	10,528	6,847	17,375	32	218	1,137	3,384	4,520	22,145	27,879
1995	10,557	7,074	17,631	31	219	1,157	3,552	4,709	22,590	28,528
1996	10,735	7,348	18,083	30	222	1,161	3,676	4,838	23,173	29,153
1997	10,837	7,666	18,503	31	229	1,145	3,740	4,885	23,648	29,602
1998	11,116	7,830	18,946	32	234	1,172	3,871	5,043	24,254	30,013
1999	11,362	8,199	19,561	33	241	1,277	4,267	5,544	25,379	31,572
2000	11,326	8,209	19,536	32	248	1,314	4,445	5,760	25,576	31,943
2001	11,403	8,297	19,700	30	233	1,301	4,451	5,751	25,714	31,581
2002	11,699	8,557	20,256	30	228	1,348	4,668	6,016	26,530	32,319
2003	11,561	9,414	20,975	30	226	1,311	4,538	5,849	27,079	32,619
2004	11,685	9,825	21,510	31	230	1,214	4,205	5,419	27,191	33,216
2005	11,997	9,120	21,117	29	233	1,362	4,718	6,080	27,460	33,684
2006	11,626	9,403	21,029	34	237	1,391	4,815	6,206	27,506	33,808
2007	11,527	9,581	21,108	74	233	1,730	5,990	7,719	29,133	35,584
2008	11,079	9,480	20,559	76	239	1,748	6,051	7,799	28,673	34,876
2009	10,317	9,576	19,893	75	239	1,623	5,620	7,243	27,449	33,119
2010	9,643	10,019	19,662	66	228	1,649	5,711	7,361	27,316	33,221
2011	9,241	10,189	19,430	66	233	1,553	5,378	6,931	26,660	32,512
2012	8,971	10,283	19,254	76	240	1,551	5,372	6,924	26,494	32,040
2013	8,879	10,153	19,032	72	245	1,586	5,492	7,078	26,428	31,922
2014	8,751	10,685	19,436	71	246	1,612	5,583	7,195	26,949	32,166
2015	8,556	10,983	19,539	69	251	1,602	5,548	7,150	27,009	32,383
2016	8,409	11,318	19,726	72	256	1,645	5,695	7,339	27,394	32,919
2017	8,107	11,429	19,537	71	264	1,684	5,830	7,514	27,386	33,049
<i>Average annual percentage change</i>										
1970-2017	-0.6%	3.9%	1.0%	4.4%	1.2%	3.1%	3.0%	3.0%	1.4%	1.2%
2007-2017	-3.5%	1.8%	-0.8%	-0.4%	1.3%	-0.3%	-0.3%	-0.3%	-0.6%	-0.7%

Source: Vehicle energy use from the Data Book plus upstream energy use for all fuels.

^a Total transportation figures do not include military and off-highway energy use and may not include all possible uses of fuel for transportation (e.g., snowmobiles).

^b Due to changes in the FHWA fuel use methodology, motorcycle, bus, and heavy truck data are not comparable with data before the year 2007.

**Table 8. Nonhighway Transportation Energy Consumption Including Upstream Energy
by Mode, 1970–2017**
(trillion Btu)

Year	Air	Water	Pipeline	Rail	Nonhighway subtotal	Total transportation ^a
1970	1,486	974	1,145	655	4,261	18,698
1975	1,423	1,081	964	660	4,127	21,153
1976	1,482	1,260	918	686	4,346	22,438
1977	1,557	1,368	900	698	4,524	23,259
1978	1,642	1,603	895	695	4,835	24,426
1979	1,718	1,327	985	717	4,746	23,877
1980	1,655	1,609	1,030	694	4,988	22,990
1981	1,677	1,470	1,041	662	4,850	22,761
1982	1,666	1,233	982	567	4,449	22,185
1983	1,660	1,132	847	563	4,202	22,372
1984	1,856	1,120	895	625	4,495	23,086
1985	1,934	1,013	863	584	4,394	23,399
1986	2,101	1,540	839	569	5,049	24,673
1987	2,188	1,604	882	581	5,255	25,256
1988	2,279	1,650	1,001	595	5,525	25,929
1989	2,282	1,763	1,024	600	5,670	26,355
1990	2,357	1,678	1,062	590	5,688	26,221
1991	2,207	1,770	988	556	5,521	25,736
1992	2,240	1,858	968	570	5,636	26,538
1993	2,286	1,672	1,014	588	5,561	27,140
1994	2,389	1,624	1,093	628	5,734	27,879
1995	2,465	1,709	1,112	652	5,938	28,528
1996	2,540	1,645	1,127	667	5,980	29,153
1997	2,648	1,462	1,175	668	5,953	29,602
1998	2,620	1,441	1,026	672	5,759	30,013
1999	2,859	1,599	1,039	697	6,193	31,572
2000	2,940	1,696	1,034	696	6,367	31,943
2001	2,760	1,390	1,016	700	5,866	31,581
2002	2,566	1,457	1,065	701	5,790	32,319
2003	2,601	1,256	967	716	5,540	32,619
2004	2,827	1,513	932	754	6,025	33,216
2005	2,918	1,591	954	761	6,224	33,684
2006	2,892	1,681	953	776	6,301	33,808
2007	2,889	1,803	999	759	6,451	35,584
2008	2,759	1,681	1,033	731	6,203	34,876
2009	2,449	1,544	1,058	618	5,669	33,119
2010	2,473	1,702	1,063	667	5,905	33,221
2011	2,483	1,590	1,080	699	5,852	32,512
2012	2,391	1,341	1,129	684	5,546	32,040
2013	2,344	1,190	1,261	699	5,494	31,922
2014	2,371	1,029	1,090	728	5,218	32,166
2015	2,437	1,181	1,057	698	5,373	32,383
2016	2,507	1,305	1,065	647	5,524	32,919
2017	2,568	1,320	1,109	666	5,664	33,049
<i>Average annual percentage change</i>						
1970-2017	1.2%	0.6%	-0.1%	0.0%	0.6%	1.2%
2007-2017	-1.2%	-3.1%	1.0%	-1.3%	-1.3%	-0.7%

Source: Vehicle energy use from the Data Book plus upstream energy use for all fuels.

^a Total transportation figures do not include military and off-highway energy use and may not include all possible uses of fuel for transportation (e.g., snowmobiles).

4. COMPARISON OF TRANSPORTATION ENERGY CONSUMPTION WITH AND WITHOUT UPSTREAM ENERGY

By including upstream energy into transportation energy consumption, total energy use changed from 26.6 quads to 33.0 quads. A graphical comparison of transportation energy consumption with and without upstream energy by mode and fuel type is shown in Figures 1 and 2. Neither the modal shares nor the fuel shares were greatly affected by including upstream energy, except for rail and pipeline. These two modes have the highest electricity consumption and that is where the largest differences lie.

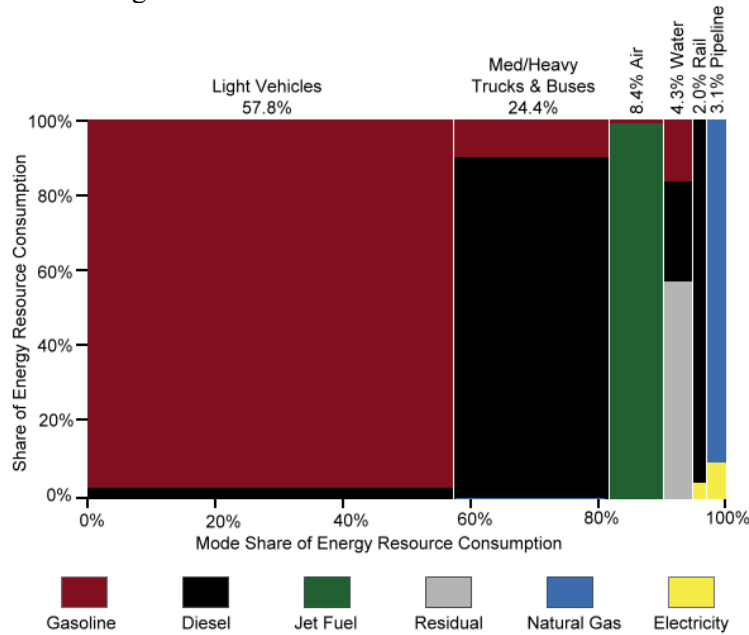


Figure 1. Transportation energy consumption without upstream energy included.

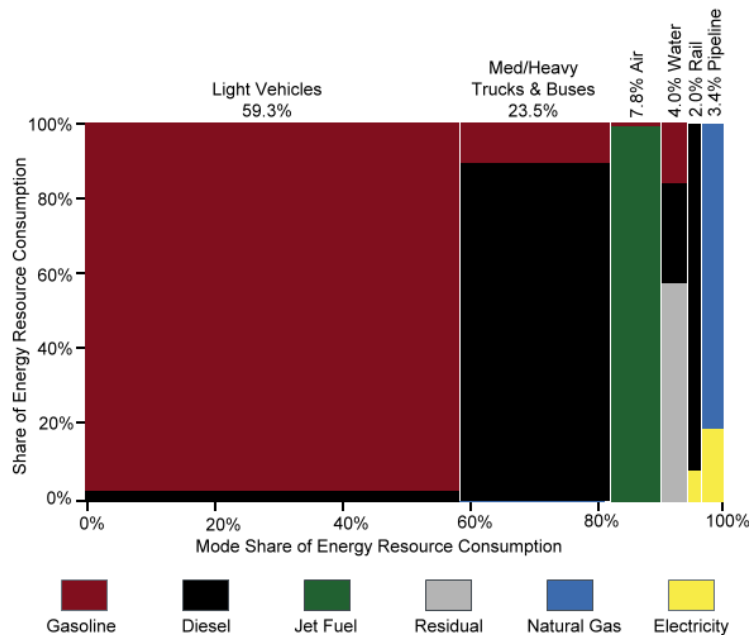


Figure 2. Transportation energy consumption with upstream energy included.

A full comparison of the data with and without upstream energy by mode is shown on Table 9, along with the modal shares for each. The modal shares are quite similar between the two data series. The differences in the modal shares are less than 1% for each mode with one exception. The light vehicle subcategory increased by 1.5% when including upstream energy.

Table 9. Transportation Energy Use With and Without Upstream Energy by Mode, 2017^a

	Trillion Btu		Percentage of total based on Btus	
	Vehicle Only	With Upstream	Vehicle Only	With Upstream
<u>HIGHWAY</u>	21,868.7	27,385.9	82.2%	82.9%
Light vehicles	15,359.8	19,608.2	57.8%	59.3%
Cars	6,339.3	8,107.4	23.8%	24.5%
Light trucks ^b	8,963.2	11,429.5	33.7%	34.6%
Motorcycles	57.3	71.3	0.2%	0.2%
Buses	220.3	263.5	0.8%	0.8%
Transit	91.6	109.9	0.3%	0.3%
Intercity	37.3	44.4	0.1%	0.1%
School	91.4	109.2	0.3%	0.3%
Medium/heavy trucks	6,288.6	7,514.2	23.6%	22.7%
Class 3-6 trucks	1,391.2	1,683.8	5.2%	5.1%
Class 7-8 trucks	4,897.4	5,830.4	18.4%	17.6%
<u>NONHIGHWAY</u>	4,723.2	5,663.5	17.8%	17.1%
Air	2,230.8	2,568.2	8.4%	7.8%
General aviation	231.7	269.1	0.9%	0.8%
Domestic air carriers	1,564.3	1,799.0	5.9%	5.4%
International air	434.8	500.1	1.6%	1.5%
Water	1,130.4	1,320.2	4.3%	4.0%
Freight	920.2	1,061.5	3.5%	3.2%
Recreational	210.3	258.7	0.8%	0.8%
Pipeline	825.0	1,109.1	3.1%	3.4%
Rail	536.9	666.0	2.0%	2.0%
Freight (Class I)	490.5	583.7	1.8%	1.8%
Passenger	46.4	82.3	0.2%	0.2%
Transit	15.9	34.3	0.1%	0.1%
Commuter	20.5	33.6	0.1%	0.1%
Intercity	10.0	14.4	0.0%	0.0%
HWY & NONHWY TOTAL	26,591.9	33,049.4	100.0%	100.0%

Source: Tables 2 and 6.

^a Civilian consumption only. Totals may not include all possible uses of fuels for transportation (e.g., snowmobiles).

^b Two-axle, four-tire trucks.

Figure 3 shows the percent change from the vehicle-only energy use to the energy use including upstream energy by mode, while Figure 4 shows the percent change by fuel type. Again, the modes using electricity, pipeline and passenger rail, show the largest changes by mode, and electricity shows the largest changes of the fuel types.

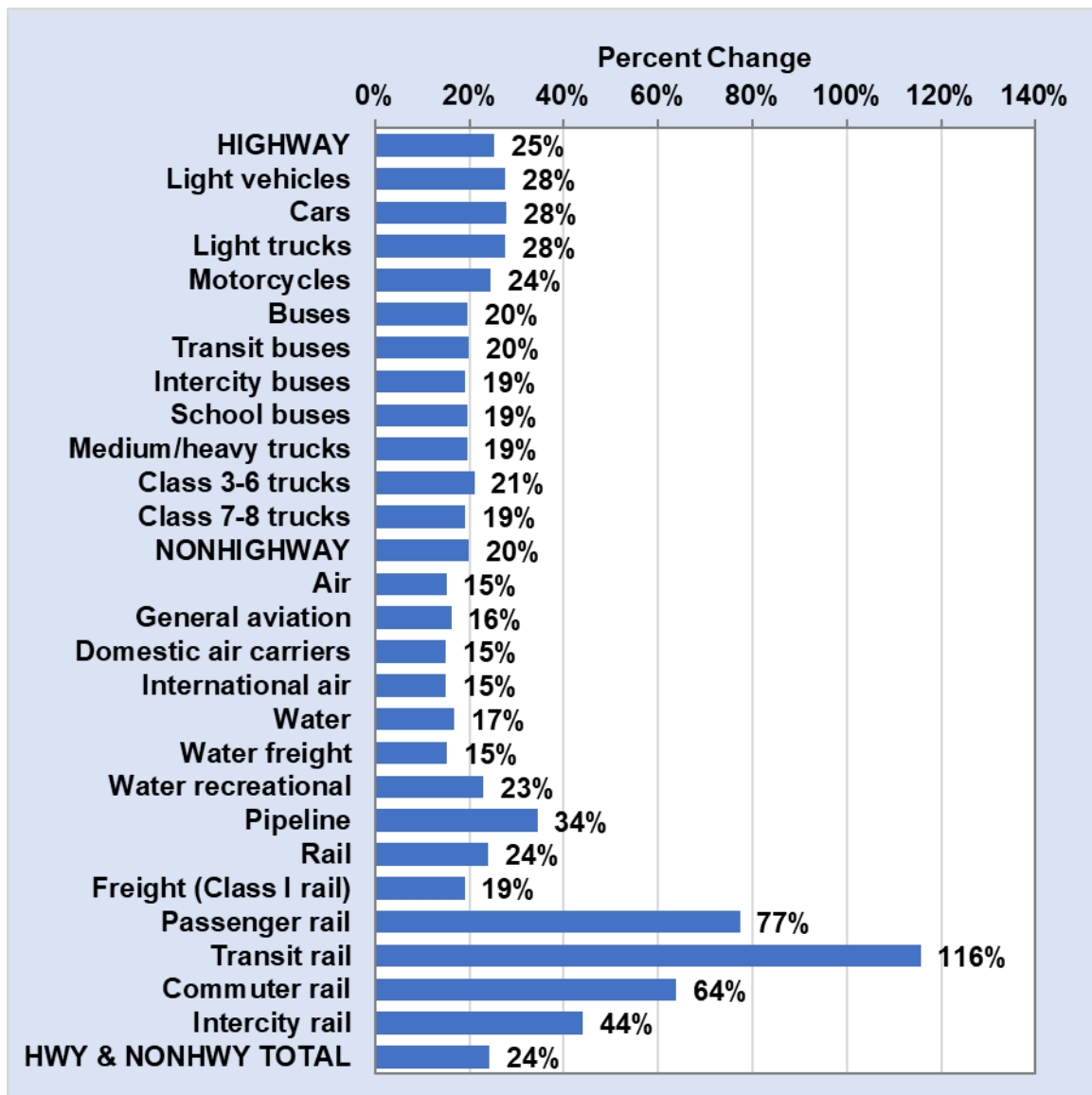


Figure 3. Percent change of vehicle energy use to energy use including upstream energy by mode, 2017.

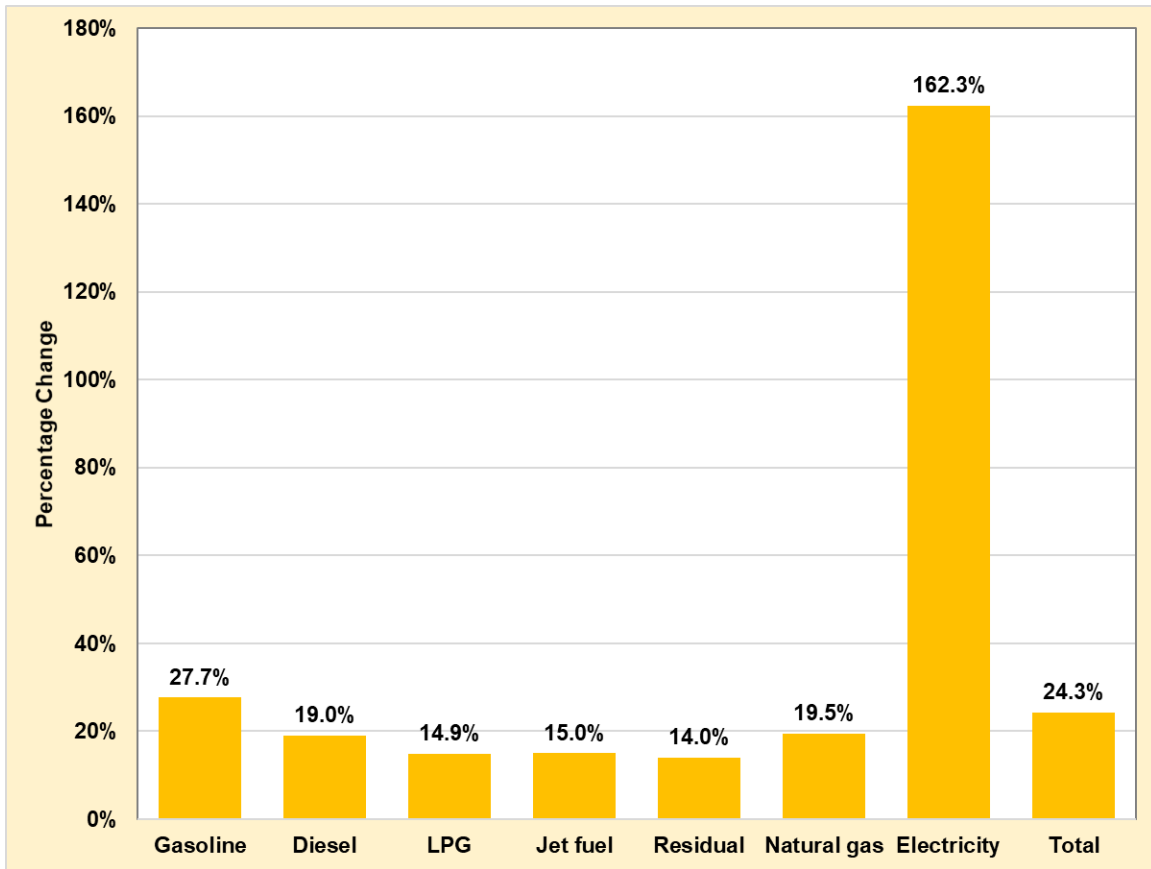


Figure 4. Percent change of vehicle energy use to energy use including upstream energy by fuel type, 2017.

In terms of historical changes, the two series mirror each other (Figure 5). This was expected because, except for electricity, the factors used to include upstream energy were the same for every year (Table 1 for electricity and Table 5 for all other fuels). The GREET calculator does not include unique estimates of upstream energy use for historical years, thus the 2019 factors were used historically.

The gap between the two data series is widening. In 1970 the two lines in Figure 5 differ by 3,505 Btu and in 2017, by 6,457 Btu. The greater use of fuels that have higher upstream energy use, like electricity and gasoline, is the reason for the gap increase. The gap would be even wider if not for the increase in efficiency for electricity net generation (Table 1).

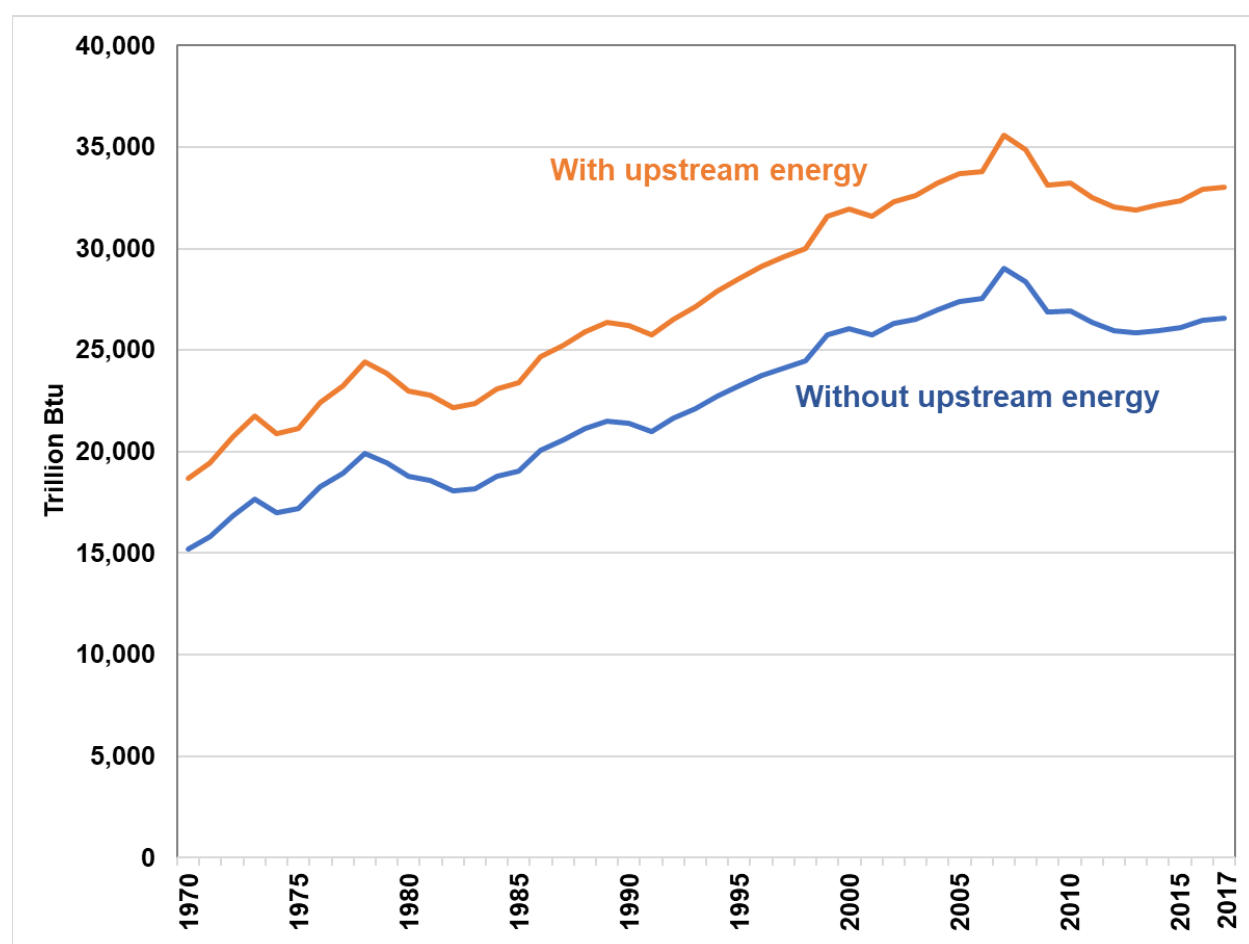


Figure 5. Historical transportation energy consumption with and without upstream energy, 1970-2017.

5. CONCLUSIONS

A comparison of transportation energy use with and without upstream energy by mode and fuel type was performed for the Data Book's big energy table. The data to include upstream energy for electricity came from the Energy Information Administration's Monthly Energy Review and for other fuels came from ANL's GREET model WTW 2019 Calculator. Including upstream energy added 24% (6.4 quads) to the vehicle fuel consumption that is published on Table 2.7 of the Data Book. For most of the transportation modes, the share of consumption by mode and fuel type looked the same whether including upstream energy or not. However, the modes with the largest use of electricity, rail and pipeline, showed differences in fuel mix due to the high upstream energy use for that fuel. Electricity use increased by 162% when upstream energy was added. Gasoline, the second highest in percent change, increased by 28% with the addition of upstream energy. When including upstream energy, total transit rail energy use increased by 116%, commuter rail by 64%, and intercity rail by 44%. Pipeline was the only other mode with over a 30% increase. Historically, the trend with upstream energy included and without show similar trends with a gradual widening of the gap between the two data series. The greater use of fuels that have higher upstream energy use, like electricity and gasoline, is the reason for the gap increase. As the highway sector transitions towards heavier use of electricity, the differences between including and excluding upstream energy will become more pronounced.