



Elements of the Transportation Sector of the Economy: the players, the technologies

- Orf 467 Fall 2017 Syllabus ([pdf](#))
- Transportation Defined
 - Transportation is an intermediate good. It is a *derived* demand (demand a bi-product of another demand)
 - Transportation is the creation of **place** and **time utility** while incurring a **cost**.
 - Purchaser of transportation acquires a bundle of services
 - place, time, comfort (l&d) , convenience (information)
 - utility of goods = $f(1 / \text{landed costs, time, ...})$
 - Place Utility: [Lardner's Law: law of squares](#) in transportation:
 - For a system that has ubiquitous accessibility, then $\text{Trans\$} = f(\text{Dist})$ therefore 1-Dimensional:
 - Let MarketArea (πR^2) be that area for which $\text{Fixed\$} + \text{Trans\$} \leq \text{Demand\$}$
 - Let $\text{Trans\$} = C * D$, $C = \text{Const}(\text{technology, management, policy})$, $D = \text{distance}$
 - Then $R = (\text{Demand\$} - \text{Fixed\$})/C$
 - So.. MarketArea = $(\pi (\text{Demand\$} - \text{Fixed\$})^2)/C^2 = K / C^2$; where $K = (\pi (\text{Demand\$} - \text{Fixed\$})^2)$, a const.
 - So... If, say, technology causes $C_{\text{new}} = \frac{1}{2} C_{\text{old}}$,then $\text{MarketArea}_{\text{new}} = 4 * \text{MarketArea}_{\text{old}}$
 - Demand for transportation:
 - Elasticities: % change quantity / % change in attribute
 - Attributes: price, travel time, reliability, accessibility, security, l&d, information, comfort, etc



- “Modes” of transportation: Major Categorization, by what it carries, by function, by what is carrying (supporting) it
 - Carries:
 - People
 - Non-people (freight)
 - Regulation split this way
 - Function (purpose)
 - Intra-urban
 - Inter-urban
 - by “way” (the support of the transportation or other physical characteristic or function)
 - highway, airway, railway, waterway, pipeway,
 - intermodal
 - by “technologies”
 - bus, car, light rail, heavy rail, Metro, truck, LTL, TL, overnight, Automated People Mover (APM), Personal Rapid Transit (PRT), Automated Transit Networks (ATN), dial-a-ride, jitney, autonomousTaxis (aTaxis), ...
- Externalities:
 - Safety, Environment, Environment, Economy,
- [*The End of Traffic and the Future of Transport. Slide Summary*](#)
- [Basic background on Transportation in the US \(Pocket Guide 2017\)](#)



Macro-economic Aspects of the US economy

	1990	2011
Resident population (thousands)	248,791	311,592
Total area (thousand sq. mi.) ^a	3,718	3,797
Total civilian labor force (thousands)	125,840	153,617
Real gross domestic product ^b (trillions)	8.0	13.3
Median household income ^{b,c}	41,430	44,151
Average household income ^{b,c}	44,122	56,175
Average household expenditures ^{b,c}	39,320	43,681
Number of households (thousands)	94,312	121,084
Life expectancy at birth (years) ^d	75.4	78.7

^aTotal area updated every 10 years; area last updated in 2010. Increase in Total area due to change in methodology used to calculate the data from 1990 to 2011. ^bData are in 2005 chained dollars (see Glossary for definition). ^cBTS calculations, September 2012. ^dLife expectancy shown for 2011 is for 2010.

2017 Population

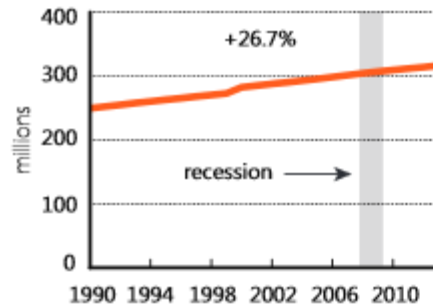
According to the [U.S. Census Bureau's](#), the United States entered 2015 with 320,090,857 people while the planet Earth overall will had more than 7.2 billion living souls on it.

Overall the U.S. is the third most populous country in the world, behind China (nearly 1.4 billion) and India (nearly 1.3 billion) and ahead of Indonesia (nearly 256 million). The U.S. population was 2,334,187 people larger than the start of 2014,

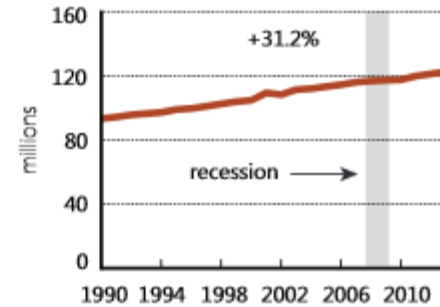


The American Landscape: 1990–2013

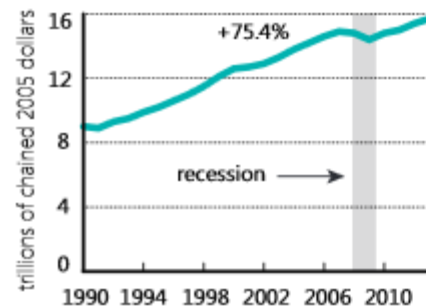
Resident population



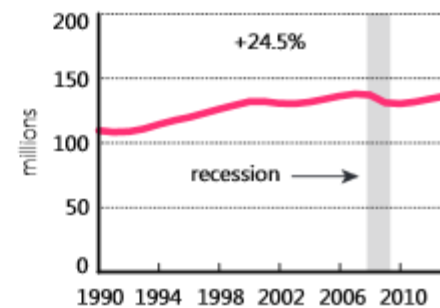
Households



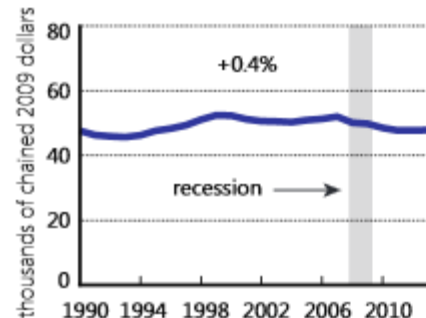
Real GDP



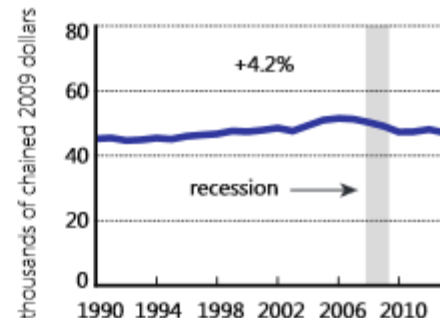
Employment^a



Median household income^b



Average household expenditures^b



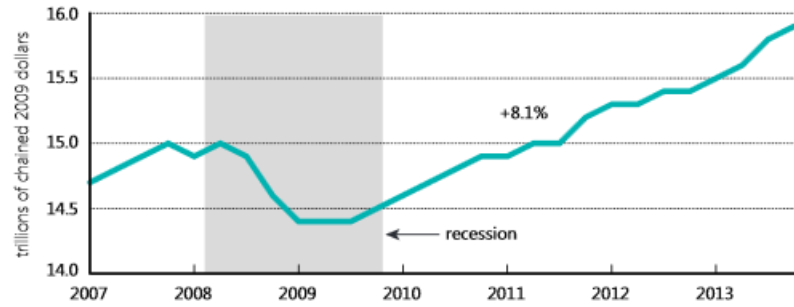
^aNonfarm payroll employment. ^bConverted to chained 2009 dollars by the Bureau of Transportation Statistics using the CPI-U-RS price index.

Key: GDP – gross domestic product

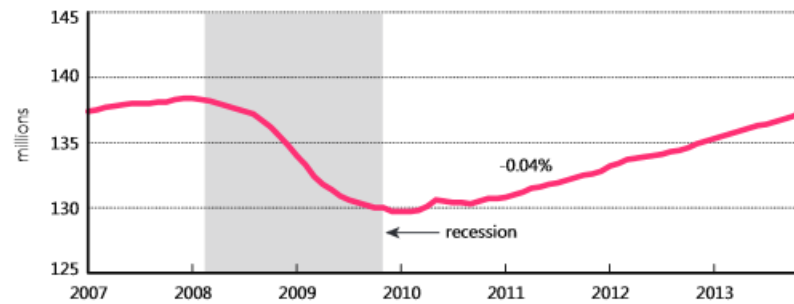


A Closer Look: Jan. 2007–Dec. 2013

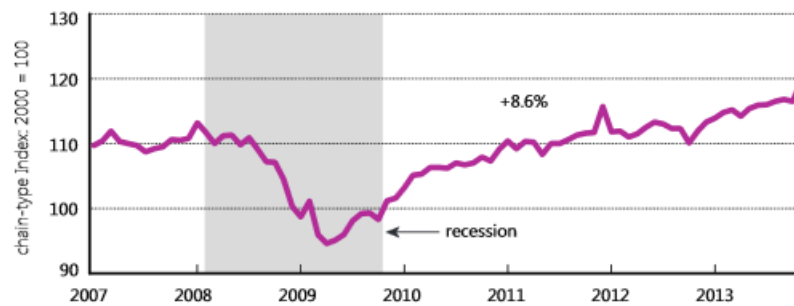
Real GDP



Employment^a



Transportation Services Index



^aNonfarm payroll employment.

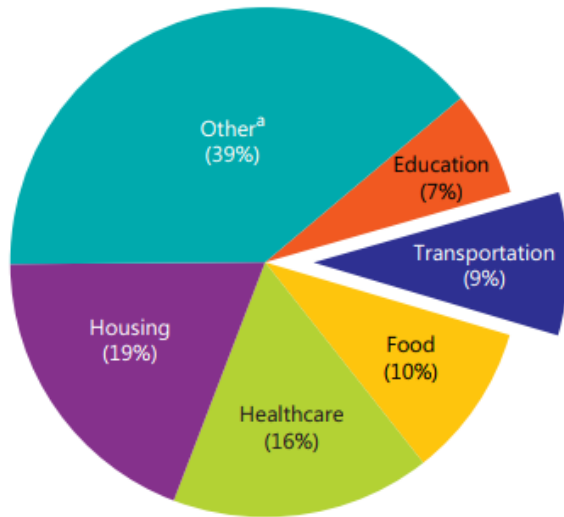
Key: GDP = gross domestic product.

Note: Graph scales are not comparable.

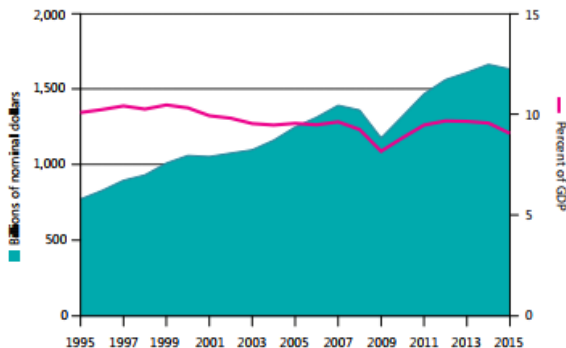


Macro-economic Aspects of Transportation

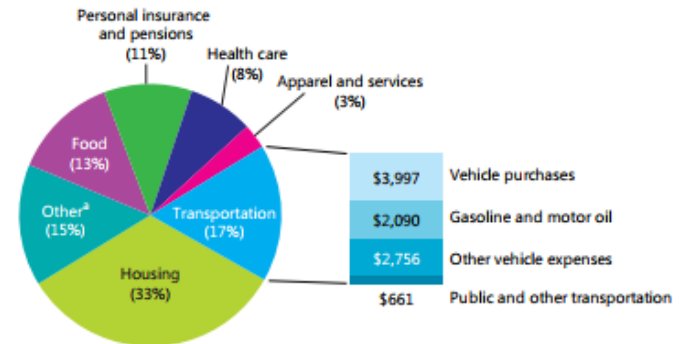
6-1 U.S. GDP by Spending Category: 2015
percent of GDP



6-2 U.S. Transportation Spending: 1995–2015



6-4 Household Expenses by Category: 2015
percent of average annual household expenses

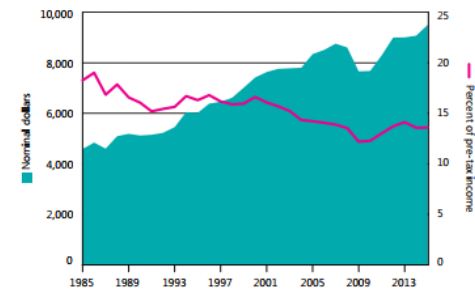


^a Includes alcoholic beverages, cash contributions, education, entertainment, personal care products and services, reading, tobacco products and smoking supplies, and other miscellaneous items.

Household Transportation-Related Expenditures

Private vehicle expenditures	=	\$7,778
Vehicle purchases	=	\$2,669
Gasoline and motor oil	=	\$2,655
Other vehicle expenditures	=	\$2,454
Public transportation expenditures	=	\$516
Airline fares	=	\$342
Mass transit fares	=	\$75
Ship fares	=	\$36
Taxi fares	=	\$22
Intercity train fares	=	\$16
Local transportation on out-of-town trips	=	\$12
Intercity bus fares	=	\$11
School bus	=	\$3
Total	=	\$8,293

6-5 Household Transportation Expenses: 1985–2015





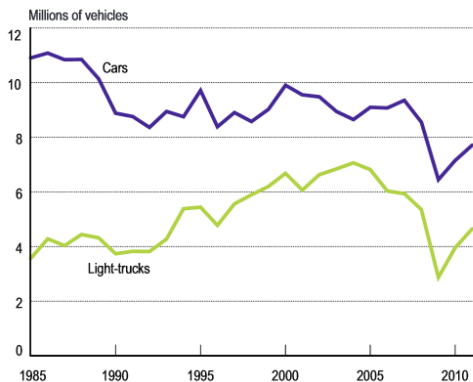
3-5 Passenger Travel and Freight Transportation Per Person

Passenger Transportation (2009)	Daily	Annual
Person trips per person	3.8	1,383.4
Person miles of travel per person	36.1	13,187.5
Vehicle trips per driver	3.0	1,102.3
Vehicle miles of travel per driver	29.0	10,574.1

Domestic Freight Transportation (2010)	Annual
Tons per capita	55.2
Ton-miles per capita	17,957.4

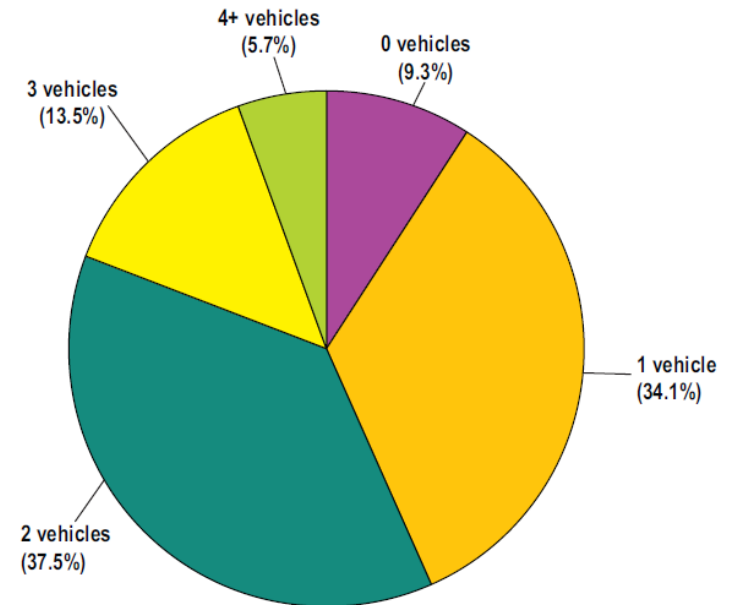
Notes: Tons per capita is calculated the *Freight Analysis Framework*. The selected modal and economic trend *Travel Survey* presented here use the not include persons under 5 years c

4-13 New U.S. Passenger Car and Light Truck Production: Model Years 1985–2011



Notes: Historical data are revised. Light trucks include SUVs, minivans/vans, and pick-up trucks

3-6 Households by Number of Motor Vehicles: 2011



Note: Data cover the household populations and excludes the population living in institutions, college dorms and other group quarters

Driven to Extremes
Has Growth in Automobile Use Ended?
May 23, 2013



Volpe The National Transportation Systems Center
Advancing transportation innovation for the public good

U.S. Department of Transportation
Research and Innovative Technology Administration
U.S. National Transportation System Center

http://www.princeton.edu/~alaink/Orf467F13/HasGrowthInAutomobileUseEnded_Pace-Pickrel.pdf

Fatalities



I Safety

The safety of the traveling public is the number one concern of the U.S. Department of Transportation. Although progress has been made in reducing fatalities, roughly 94 percent of transportation fatalities arose from motor vehicle crashes. Injuries from crashes are a major U.S. public health issue.

1-1 Transportation Fatalities by Mode: 1990, 2000, 2010, 2011

Mode	1990	2000	2010	2011
Air^a				
Large U.S. air carrier	39	92	2	0
Commuter air carrier	6	5	0	0
On-demand air taxi	51	71	17	41
General aviation	770	596	454	443
Highway ^b	44,599	41,945	32,999	32,367
Pipeline, gas and hazardous liquid	9	38	22	14
Railroad ^c	729	631	592	569
Transit ^d	235	208	215	229
Waterborne				
Vessel-related, commercial ship	85	53	41	28
Nonvessel-related, commercial ship ^e	101	134	52	34
Recreational boating	865	701	672	758

1-2 Distribution of Transportation Fatalities: 2011

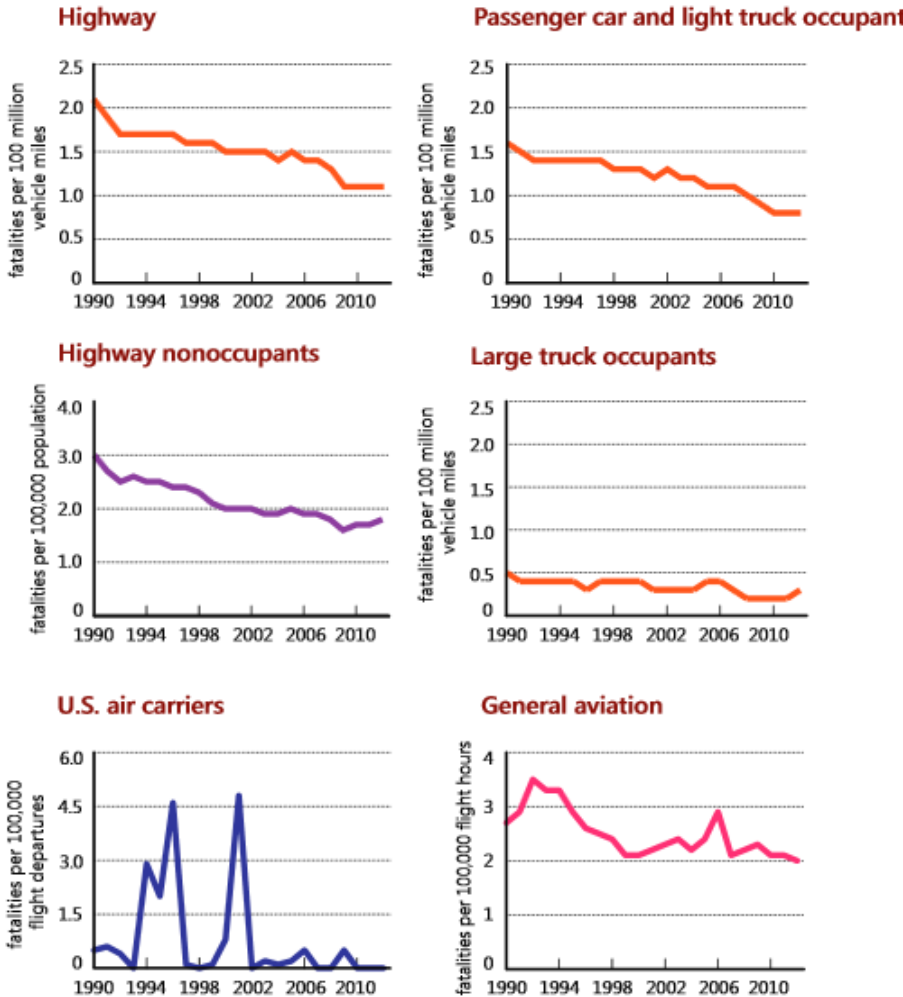
Category	Number	Percent
Passenger car occupants	11,981	35.09
Light-truck occupants	9,272	27.15
Motorcyclists	4,612	13.51
Pedestrians struck by motor vehicles	4,432	12.98
Recreational boating	758	2.22
Pedalcyclists struck by motor vehicles	677	1.98
Large-truck occupants	635	1.86
Other and unknown motor vehicle occupants	506	1.48
General aviation	443	1.30
Other nonoccupants struck by motor vehicles ^a	198	0.58
Railroad trespassers (excluding grade crossings) ^b	134	0.39
Heavy rail transit (subway)	97	0.28
Transit buses (motorbus)	92	0.27
Grade crossings, not involving motor vehicles ^c	88	0.26
Bus occupants (school, intercity, transit)	54	0.16
On-demand air taxi	41	0.12
Light rail transit	36	0.11
Waterborne transportation (nonvessel-related)	34	0.10
Rail employees on duty and contractors ^b	32	0.09
Waterborne transportation (vessel-related)	28	0.08
Gas distribution pipelines	13	0.04
Demand response transit	4	0.01
Railroad, other (off-duty and nontrespassers)	3	0.01
Hazardous liquid pipelines	1	<0.01
Other counts, redundant with above		
Crashes involving large trucks ^d	3,757	
Commuter rail ^e	57	

^aIncludes nonoccupant fatalities in motor vehicle crashes, except pedalcyclists and pedestrians. ^bIncludes fatalities outside trains. ^cPublic grade crossing fatalities involving motor vehicles are included in motor vehicle counts. ^dUnless otherwise noted, includes fatalities outside vehicles. ^eIncludes fatalities on directly operated systems, excluding suicides.

Fatalities

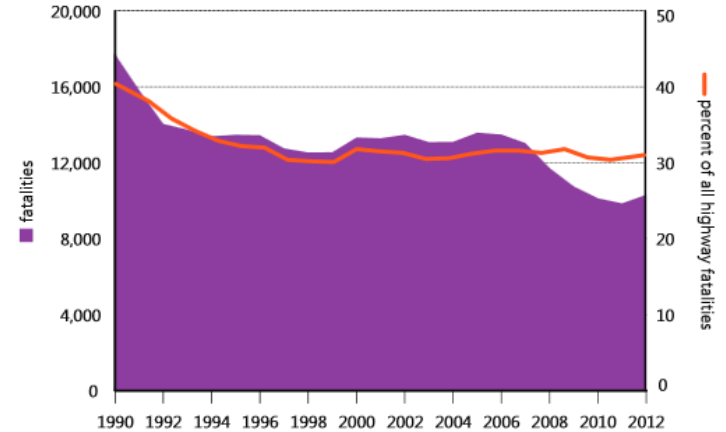


6-3 Fatality Rates by Mode: 1990–2012



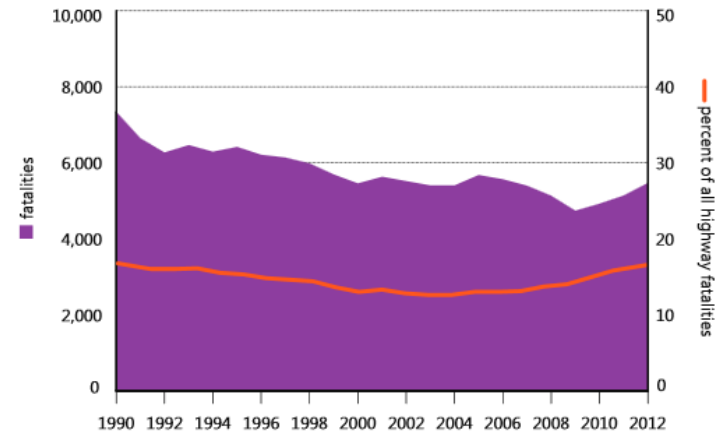
Notes: Graphs with same color trend lines have identical scales. Air carrier fatalities resulting from the Sept. 11, 2001 terrorist acts include only onboard fatalities.

6-4 Alcohol-Impaired Driving Fatalities: 1990–2012



Note: Includes fatalities occurring in any crash involving a driver with a blood alcohol concentration (BAC) of 0.08 grams per deciliter or higher.
Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, available at www.nhtsa.gov as of September 2014.

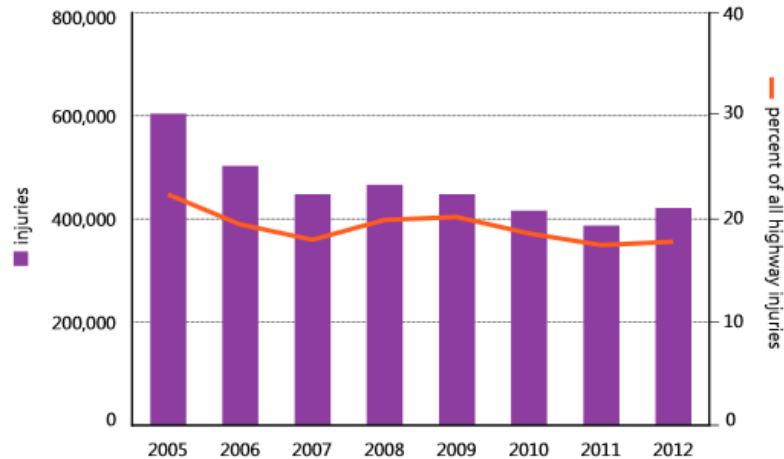
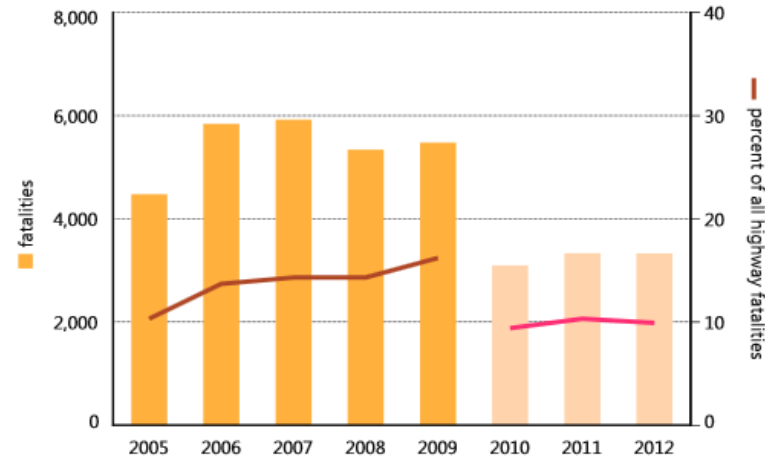
6-5 Pedestrian and Bicyclist Fatalities: 1990–2012



Fatalities



6-6 Distracted Driving Fatalities and Injuries: 2005–2012



Note: Distracted driving fatality data for 2010 and on are not comparable with previous years due to changes in methodology.



Early Estimate of Motor Vehicle Traffic Fatalities in 2012

[Link](#)

Summary

A statistical projection of traffic fatalities shows that an estimated 34,080 people died in motor vehicle traffic crashes in 2012. This represents an increase of about 5.3 percent as compared to the 32,367 fatalities that occurred in 2011, as shown in Table 1. If these projections are realized, 2012 will be first year with a year-to-year increase in fatalities since 2005. Traffic fatalities have been steadily declining over the previous six years since reaching a near-term peak in 2005, decreasing by about 26 percent from 2005 to 2011. Also, in 2012, fatalities increased in the first (up 12.6%), second (up 5.3%), third (up 3.2%) and fourth (up 1.7 %) quarters, as compared to the respective

quarters in 2011. Preliminary data reported by the Federal Highway Administration (FHWA) shows that vehicle miles traveled (VMT) in 2012 increased by about 9.1 billion miles, or about a 0.3-percent increase. On a quarterly basis, the 2012 VMT increased by 1.4 percent and by 0.8 percent in the first and second quarter, respectively, and decreased by 0.2 percent and by 0.7 percent in the third and fourth quarters, respectively. The fatality rate, per 100 million VMT, for 2012 is projected to increase to 1.16 fatalities per 100 million VMT, up from 1.10 fatalities per 100 million VMT in 2011. This rate surpasses the rate of 1.15 last reported in 2009.

Table 1: Fatalities and Fatality Rate by Quarter, Full Year, and the Percentage Change From the Corresponding Quarter or Full Year in the Previous Year

Quarter	1st Quarter (Jan–Mar)	2nd Quarter (Apr–Jun)	3rd Quarter (Jul–Sep)	4th Quarter (Oct–Dec)	Total (Full Year)
Fatalities and Percentage Change in Fatalities for the Corresponding Quarter From the Prior Year					
2005	9,239	11,005	11,897	11,369	43,510
2006	9,558 [+3.5%]	10,942 [-0.6%]	11,395 [-4.2%]	10,813 [-4.9%]	42,708 [-1.8%]
2007	9,354 [-2.1%]	10,611 [-3.0%]	11,056 [-3.0%]	10,238 [-5.3%]	41,259 [-3.4%]
2008	8,459 [-9.6%]	9,435 [-11.1%]	9,947 [-10.0%]	9,582 [-6.4%]	37,423 [-9.3%]
2009	7,552 [-10.7%]	8,975 [-4.9%]	9,104 [-8.5%]	8,252 [-13.9%]	33,883 [-9.5%]
2010	6,755 [-10.6%]	8,522 [-5.0%]	9,226 [+1.3%]	8,496 [+3.0%]	32,999 [-2.6%]
2011	6,708 [-0.7%]	8,216 [-3.6%]	8,960 [-2.9%]	8,483 [-0.2%]	32,367 [-1.9%]
2012 [†]	7,550 [+12.6%]	8,650 [+5.3%]	9,250 [+3.2%]	8,630 [+1.7%]	34,080 [+5.3%]
Fatality Rate per 100 Million Vehicle Miles of Travel (VMT)					
2005	1.32	1.42	1.54	1.54	1.46
2006	1.35	1.41	1.47	1.44	1.42
2007	1.31	1.35	1.41	1.37	1.36
2008	1.22	1.25	1.33	1.32	1.26
2009	1.09	1.16	1.17	1.12	1.15
2010	0.98	1.09	1.18	1.14	1.11
2011	0.98	1.08	1.18	1.16	1.10
2012 [†]	1.09	1.13	1.22	1.19	1.16

[†]2012 statistical projections and rates based on these projections.
Source: Fatalities: 2005-2010 FARS Final File, 2011 FARS Annual Report File

*A marginal part of the increase is attributed to 2012 being a leap year.
VMT: FHWA December 2012 Traffic Volume Trends, February 2013



Early Estimate of Motor Vehicle Traffic Fatalities for the First Quarter of 2014

Summary

A statistical projection of traffic fatalities for the first quarter of 2014 shows that an estimated 6,800 people died in motor vehicle traffic crashes. This represents a decrease of about 4.9 percent as compared to the 7,150 fatalities that were projected to have occurred in the first quarter of 2013, as shown in Table 1. Preliminary data reported by the Federal Highway Administration (FHWA) shows that vehicle miles traveled (VMT) in the first three months of 2014 decreased by about 4.2 billion miles, or about a 0.6-percent decrease. Also shown in Table 1 are the fatality rates per 100 million

VMT, by quarter. The fatality rate for the first quarter of 2014 decreased to 0.99 fatalities per 100 million VMT down from 1.04 fatalities per 100 million VMT in the first quarter of 2013. The actual counts for 2013 and 2014 and the ensuing percentage change from 2013 to 2014 will be further revised as the annual reporting FARS files for 2013 are available later this year as well as when the final file for 2013 and the annual reporting file for 2014 are available next year. These estimates will be further refined when the projections for the first 6 months of 2014 are released in late September.

Table 1: Fatalities and Fatality Rate by Quarter, Full Year, and the Percentage Change From the Corresponding Quarter or Full Year in the Previous Year

Quarter	1st Quarter (Jan–Mar)	2nd Quarter (Apr–Jun)	3rd Quarter (Jul–Sep)	4th Quarter (Oct–Dec)	Total (Full Year)
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2010	6,755 [-10.6%]	8,522 [-5.0%]	9,226 [+1.3%]	8,496 [+3.0%]	32,999 [-2.6%]
2011	6,726 [-0.4%]	8,227 [-3.5%]	8,984 [-2.6%]	8,542 [+0.5%]	32,479 [-1.6%]
2012 ^a	7,504 [+11.6%]	8,583 [+4.3%]	9,127 [+1.6%]	8,347 [-2.3%]	33,561 [+3.3%]
2013 ^b	7,150 [-4.7%]	8,200 [-4.5%]	9,000 [-1.4%]	8,500 [+1.8%]	32,850 [-2.1%]
2014 ^c	6,800 [-4.9%]	–	–	–	–
Fatality Rate per 100 Million Vehicle Miles of Travel (VMT)					
2005	1.32	1.42	1.54	1.54	1.46
2006	1.35	1.41	1.47	1.44	1.42
2007	1.31	1.35	1.41	1.37	1.36
2008	1.22	1.25	1.33	1.32	1.26
2009	1.09	1.16	1.17	1.12	1.15
2010	0.98	1.09	1.18	1.14	1.11
2011	0.98	1.09	1.18	1.17	1.10
2012 ^a	1.08	1.12	1.20	1.14	1.13
2013 ^b	1.04	1.06	1.17	1.15	1.11
2014 ^c	0.99	–	–	–	–

Week 0

^aA marginal part of the increase is attributed to 2012 being a leap year.
Source: Fatalities: 2005–2011 FARS Final File, 2012 FARS Annual Report File

^{b,c}2013 and 2014 statistical projections and rates based on these projections.
VMT: FHWA April 2014 Traffic Volume Trends, June 2014



We Love the Freedom & Mobility

But...Continuous Vigilance is an unrealistic requirement for drivers





Highway Sign-A-Long *Buttercup Edition*

http://orfe.princeton.edu/~alaink/SmartDrivingCars/Videos/HIGHWAY_SING-A-LONG_%20BuildMeUpButtercup.mp4





State Laws on Distracted Driving—Bans on Handheld Devices and Texting While Driving accessed September 2012

1-7 Highway Crashes Involving Distraction by Severity: 2005-2010

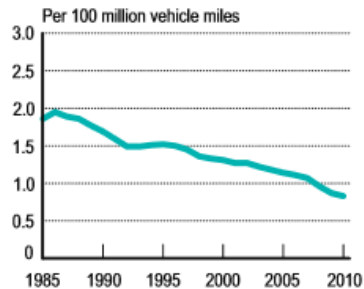
	2005	2006	2007	2008	2009	2010
Fatal Crashes						
Overall	39,252	38,648	37,435	34,172	30,797	30,196
Distraction	4,026	5,245	5,329	5,307	4,898	2,843
Percentage	10.3	13.6	14.2	15.5	15.9	9.4
Injury Crashes						
Overall	1,816,000	1,746,000	1,711,000	1,630,000	1,517,000	1,542,000
Distraction	399,000	339,000	309,000	314,000	307,000	279,000
Percentage	22.0	19.4	18.1	19.3	20.2	18.1
Property Damage Only Crashes						
Overall	4,304,000	4,189,000	4,275,000	4,146,000	3,957,000	3,847,000
Distraction	900,000	676,000	689,000	650,000	647,000	618,000
Percentage	20.9	16.1	16.1	15.7	16.4	16.1

Notes: Crashes involving distraction in 2010 should not be compared to crashes involving distraction for prior years due to significant changes in data collection and methodology. Fatal crashes include those in which at least one person was killed. Injury crashes include nonfatal crashes in which at least one person was injured. Crashes include single-vehicle, multi-vehicle, pedestrian-vehicle, and bicycle-vehicle crashes. Distracted driving is any activity that could divert a person’s attention away from the primary task of driving. Fatal crash data are reported in the Fatality Analysis Reporting System (FARS), a nationwide census providing data regarding fatal injuries suffered in motor vehicle crashes. Injury and property damage only crash data are estimates from the National Automotive Sampling System (NASS)

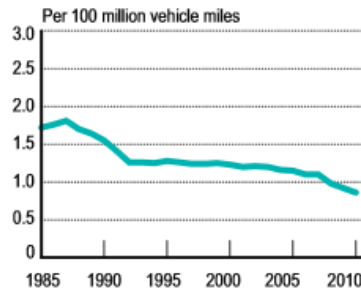


1-4 Fatality Rates for Selected Modes: 1985–2010

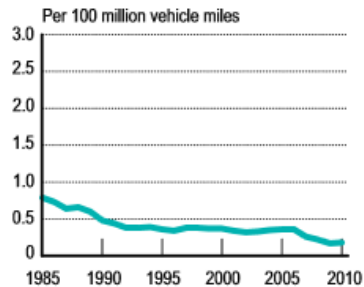
Passenger car occupants



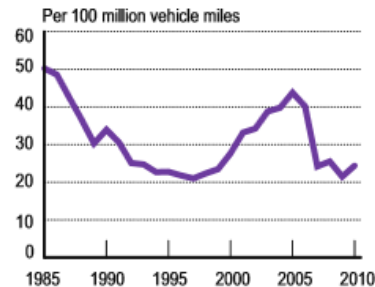
Light-truck occupants



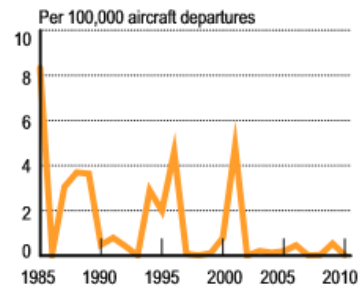
Large-truck occupants



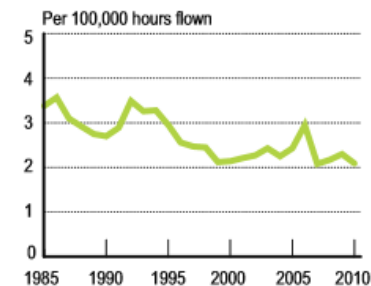
Motorcycle riders



Large air carriers



General aviation



1-3 Alcohol-Related Fatalities in Motor Vehicle Crashes by Person Type and Crash Type: 2010

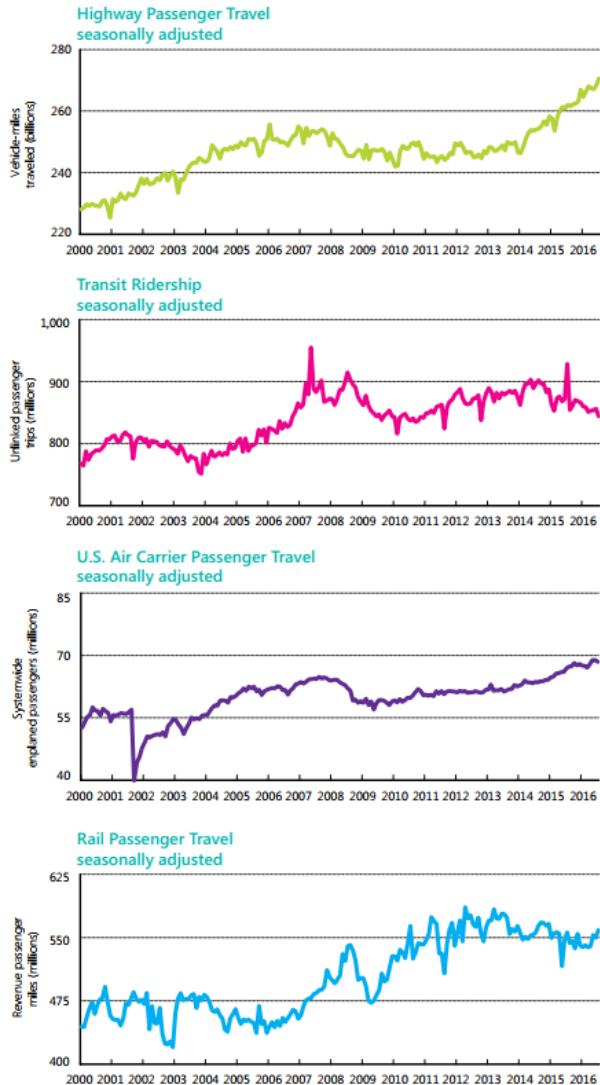
Person type, crash category	Total fatalities	Alcohol-related fatalities	Alcohol-related fatalities as a percentage of total fatalities
Occupants	27,805	11,087	39.9
Single-vehicle crashes	14,567	7,165	49.2
Two-vehicle crashes	11,197	3,313	29.6
More than two-vehicle crashes	2,041	608	29.8
Pedestrians	4,280	2,020	47.2
Single-vehicle crashes	3,682	1,731	47.0
Multiple-vehicle crashes	598	290	48.5
Pedalcyclists	618	209	33.8
Single-vehicle crashes	592	196	33.1
Multiple-vehicle crashes	26	13	50.0
Others/unknown	182	49	26.9
Total	32,885	13,364	40.6

Notes: Category numbers may not sum to totals due to rounding. A motor vehicle crash is considered alcohol-related if at least one driver or nonoccupant (e.g., a pedestrian or pedalcyclist) involved in the crash has a blood alcohol concentration of 0.01 grams per deciliter or greater. The National Highway Traffic Safety Administration estimates alcohol involvement when test results of alcohol concentration are unknown.



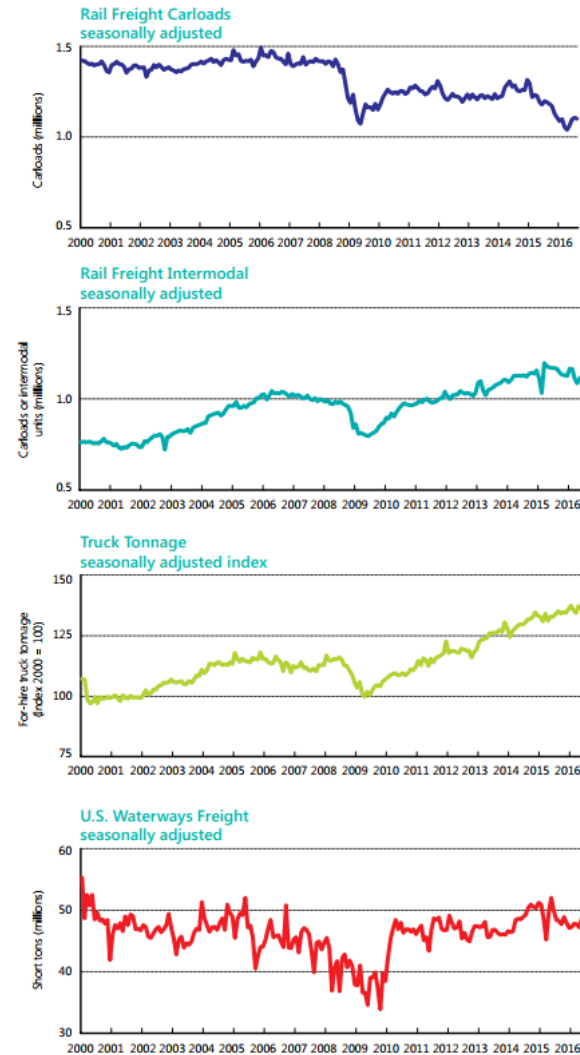
Major Trends

Moving People: January 2000–July 2016



Major Trends

Moving Goods: January 2000–August 2016





1-1 Transportation Network Length

miles

Mode	2004	2014
Highway		
Public roads	3,981,512	4,177,073
Public road lanes ^a	8,338,821	8,766,049
Pipeline		
Gas distribution	1,925,748	2,169,155
Gas transmission and gathering	327,994	319,313
Rail		
Class I freight railroad	97,662	94,372
Amtrak	22,256	21,356
Transit		
Commuter rail ^b	6,875	7,795
Heavy rail ^b	1,596	1,622
Light rail ^{b,c}	1,187	1,877
Water		
Navigable waterways ^d	25,000	25,000

1-2 Transportation Facilities

number

Mode	2004	2014
Air		
Certificated airports ^a	599	537
General aviation airports	19,221	18,762
Highway		
Bridges	593,812	610,749
Pipeline		
LNG facilities	U	125
Rail		
Amtrak stations	529	518
Transit rail		
Commuter rail stations	1,163	1,245
Heavy rail stations	1,023	1,130
Light rail stations ^b	723	969
Water		
Ports ^c	191	183
Cargo handling docks ^d	*	8,229
Lock chambers	257	239

1-3 Transportation Vehicles

number

Mode	2004	2014
Air		
Air carrier aircraft	7,764	6,676
General aviation aircraft	219,426	204,408
Highway		
Light-duty vehicle ^a	228,275,978	240,155,238
Truck	8,171,364	10,905,956
Motorcycle	5,767,934	8,417,718
Rail		
Class I freight locomotive	22,015	25,916
Class I freight car	473,773	371,642
Amtrak locomotive	276	428
Amtrak car	1,211	1,419
Transit rail		
Commuter rail ^b	6,130	7,177
Heavy rail ^b	10,858	10,551
Light rail ^{b,c}	1,622	2,444
Water		
Nonself-propelled vessel	31,296	31,043
Self-propelled vessel	8,994	9,039
Oceangoing vessel	233	179
Recreational boat	12,781,476	11,804,002

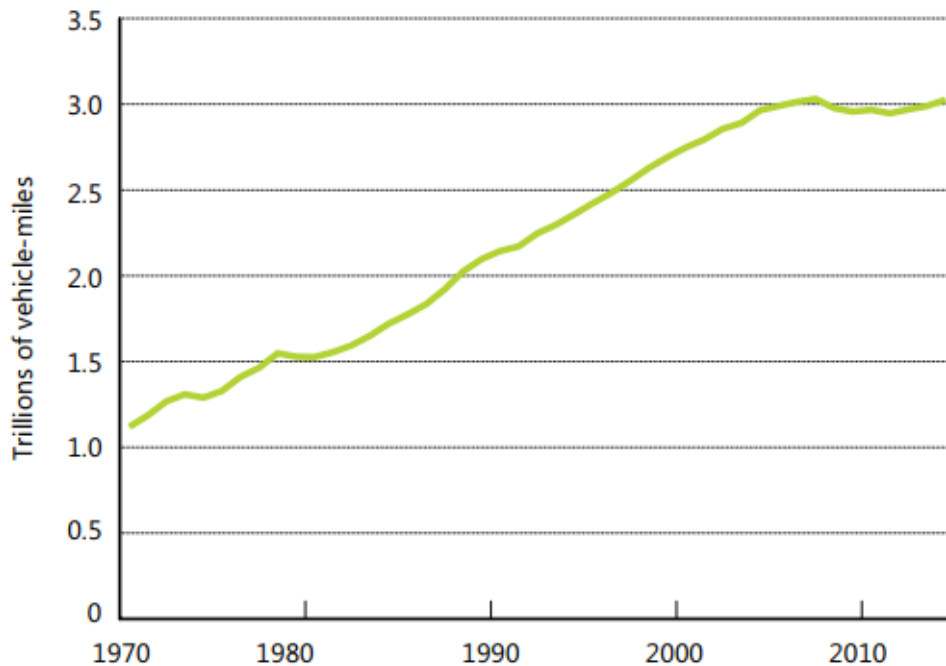


2-1 Vehicle-Miles Traveled

millions

Mode	2007	2014
Air		
U.S. air carrier, domestic ^a	6,733	5,947
Highway		
Light-duty vehicle ^b	2,691,034	2,710,556
Motorcycle	21,396	19,970
Truck	304,178	279,132
Bus	14,516	15,999
Passenger rail		
Amtrak ^c	267	325
Commuter rail	325	367
Heavy rail ^c	657	676
Light rail ^{c, d}	84	114

2-2 Highway Travel: 1970–2014



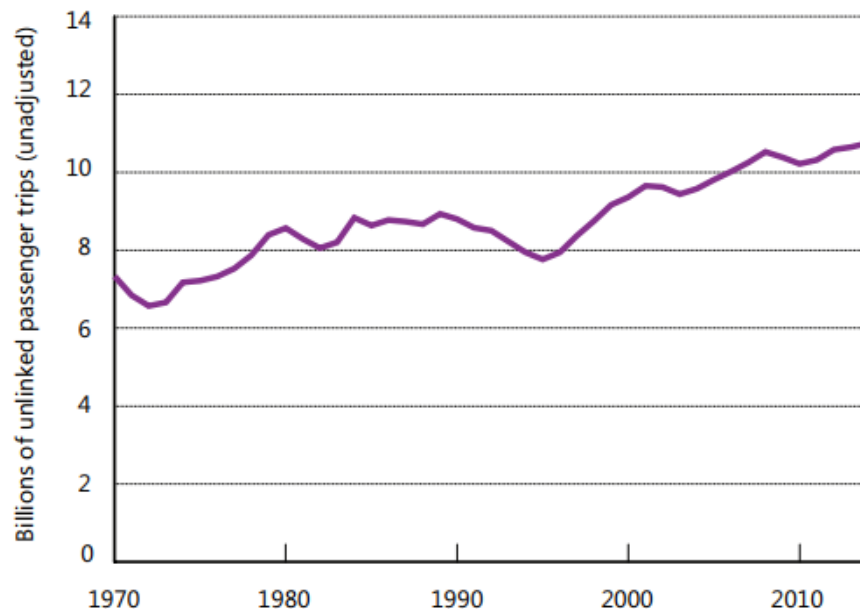


2-3 Passenger-Miles Traveled

millions

Mode	2007	2014
Air		
U.S. air carrier, domestic	607,564	607,772
Highway		
Light-duty vehicle ^a	4,341,984	3,731,888
Motorcycle	27,173	21,510
Truck	304,178	279,132
Bus	307,753	339,177
Passenger rail		
Amtrak ^b	5,784	6,675
Commuter rail	11,137	11,600
Heavy rail	16,138	18,339
Light rail ^c	1,930	2,675

2-4 Transit Ridership: 1970–2014



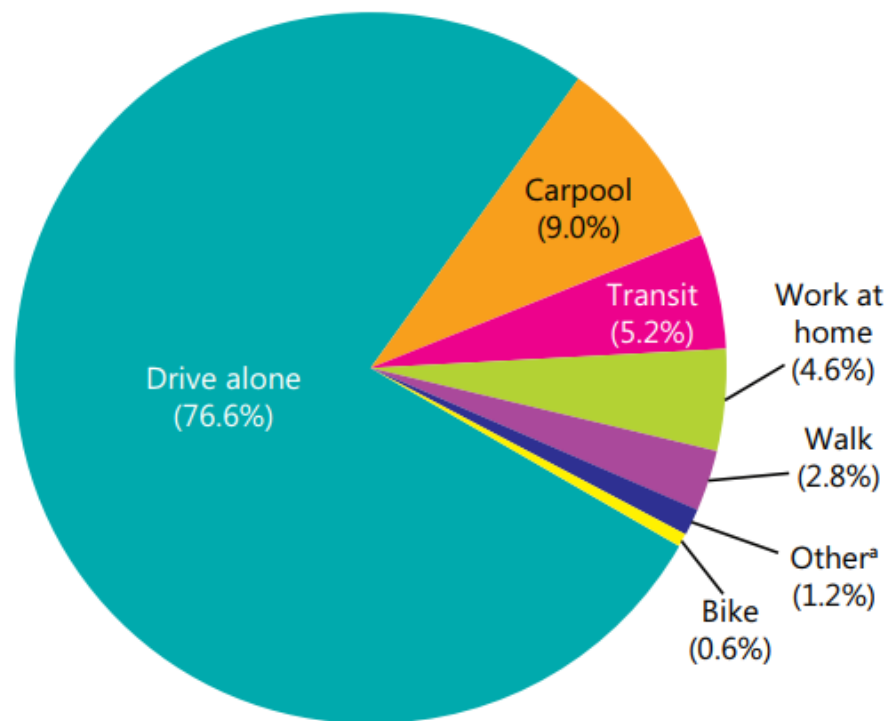


2-5 Daily Passenger Travel

	1995	2001	2009
Travel per person			
Daily person trips	4.3	3.7	3.8
Daily person-miles	38.7	36.9	36.1
Travel per driver			
Daily vehicle trips	3.6	3.4	3.0
Daily vehicle-miles of travel	32.1	32.7	29.0
Average commute			
Length in miles	11.6	12.1	11.8
Travel time in minutes	20.7	23.3	23.9
Percent of trips by mode			
Private vehicle	89.3	86.4	83.4
Bus ^a	3.0	2.8	3.3
Rail ^b	0.6	0.6	0.6
Walk	5.5	8.7	10.4
Bike	0.9	0.8	1.0
Air	0.1	0.1	0.1
Other ^c	0.5	0.6	1.1

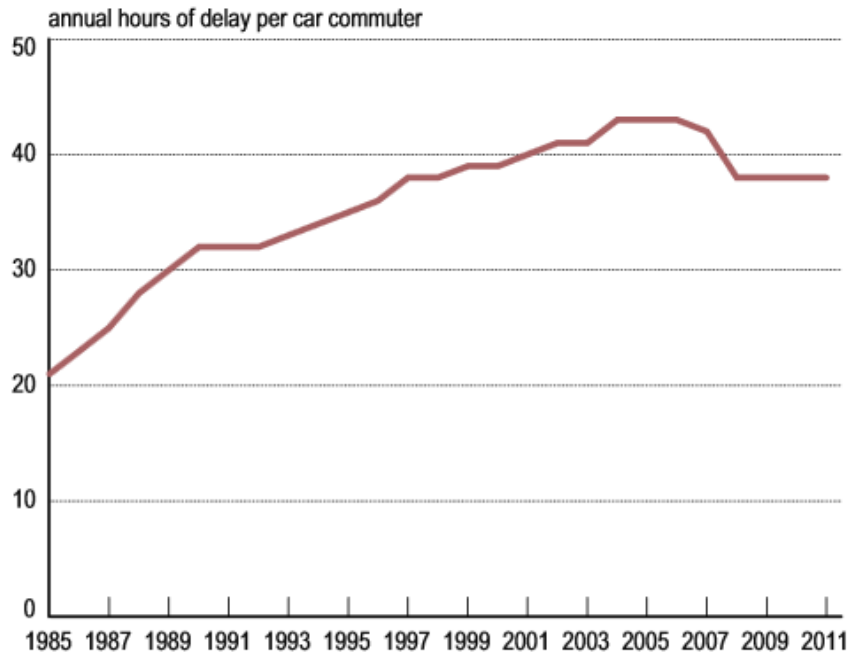
2-6 Commute Mode Share: 2015

percent of workers age 16 and older

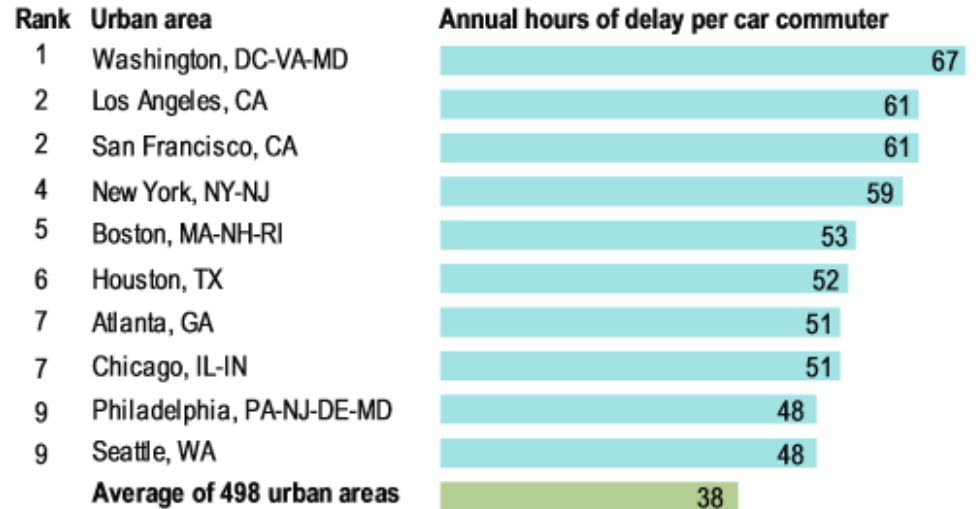




4-1 Road Congestion: 1985–2011



4-2 Top 10 Urban Area Congestion Rankings: 2011 by hours of delay per car commuter





4-1 Transportation Fatalities by Mode

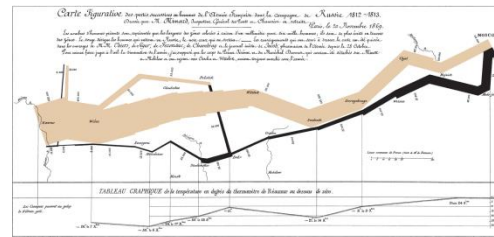
Mode	2004	2014	2015
Air	637	444	404
U.S. air carrier	14	0	0
Commuter carrier	0	0	1
On-demand air taxi	64	20	27
General aviation	559	424	376
Highway	42,836	32,744	35,092
Passenger car occupants	19,192	11,947	12,628
Motorcyclists	4,028	4,594	4,976
Light-truck occupants	12,674	9,103	9,813
Heavy-truck occupants	766	656	667
Bus occupants	42	44	49
Pedestrians	4,675	4,910	5,376
Pedalcyclists	727	729	818
Other	732	761	765
Pipeline	23	19	10
Rail	891	767	759
Train accidents	13	5	13
Highway-rail grade crossing ^a	371	262	235
Trespassers	472	470	459
Other	35	30	52
Transit^{a,b}	177	236	254
Water	815	674	692
Freight vessel and Industrial/Other	84	50	52
Passenger vessel and Recreational boating	731	624	640

4-2 Transportation Injuries by Mode

Mode	2004	2014	2015
Air	297	262	282
U.S. air carrier	15	13	21
Commuter carrier	0	0	4
On-demand air taxi	17	15	9
General aviation	265	234	248
Highway	2,788,378	2,332,000	2,424,000
Passenger car occupants	1,642,549	1,292,000	1,378,000
Motorcyclists	76,379	92,000	88,000
Light-truck occupants	900,171	782,000	803,000
Heavy-truck occupants	27,287	27,000	30,000
Bus occupants	16,410	14,000	U
Pedestrians	67,985	65,000	70,000
Pedalcyclists	41,086	50,000	45,000
Other	16,511	10,000	10,000
Pipeline	56	93	49
Rail	9,194	8,731	8,962
Train Accidents	346	137	547
Highway-rail grade crossing ^a	1,094	870	1,023
Trespassers	406	422	414
Other	7,348	7,302	6,978
Transit^b	20,478	24,045	24,252
Water	3,974	3,384	3,231
Freight vessel and Industrial/Other	389	369	239
Passenger vessel and Recreational boating	3,585	3,015	2,992



What is this?:



A Flow map! I like Flow maps!

(I may have drawn or have caused to be drawn more flow maps than anyone else in the world, but who's counting. 😊)



Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.

Russie par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite. Paris, le 20 Novembre 1869.

Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en travers des zones. Le rouge désigne les hommes qui entrent en Russie, le noir ceux qui en sortent. — Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de M. M. Chiers, de Légar, de Fezensac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre.

Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davout qui avaient été détachés sur Minsk et Mohilow et qui rejoignent vers Orscha et Witebsk, avaient toujours marché avec l'armée.

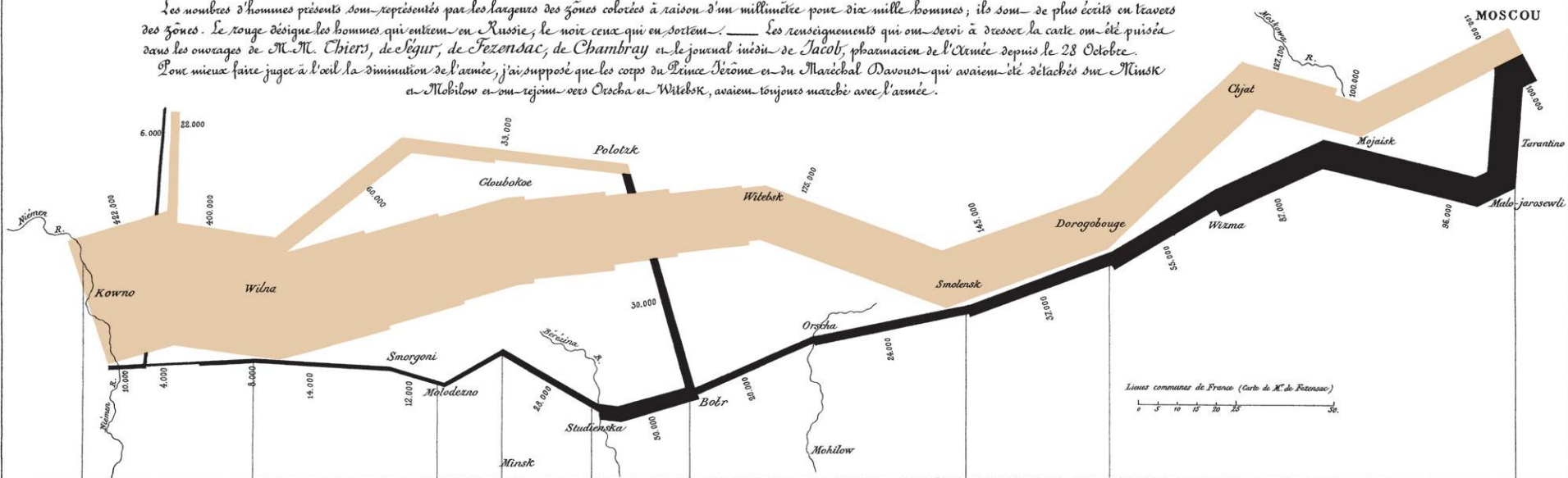
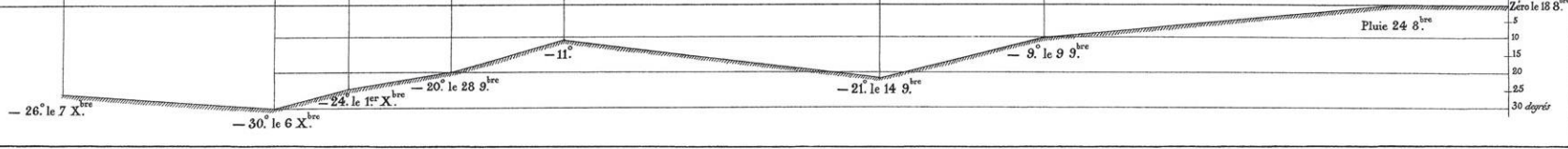


TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.

Les Cosaques passent au galop le Niémen gelé.

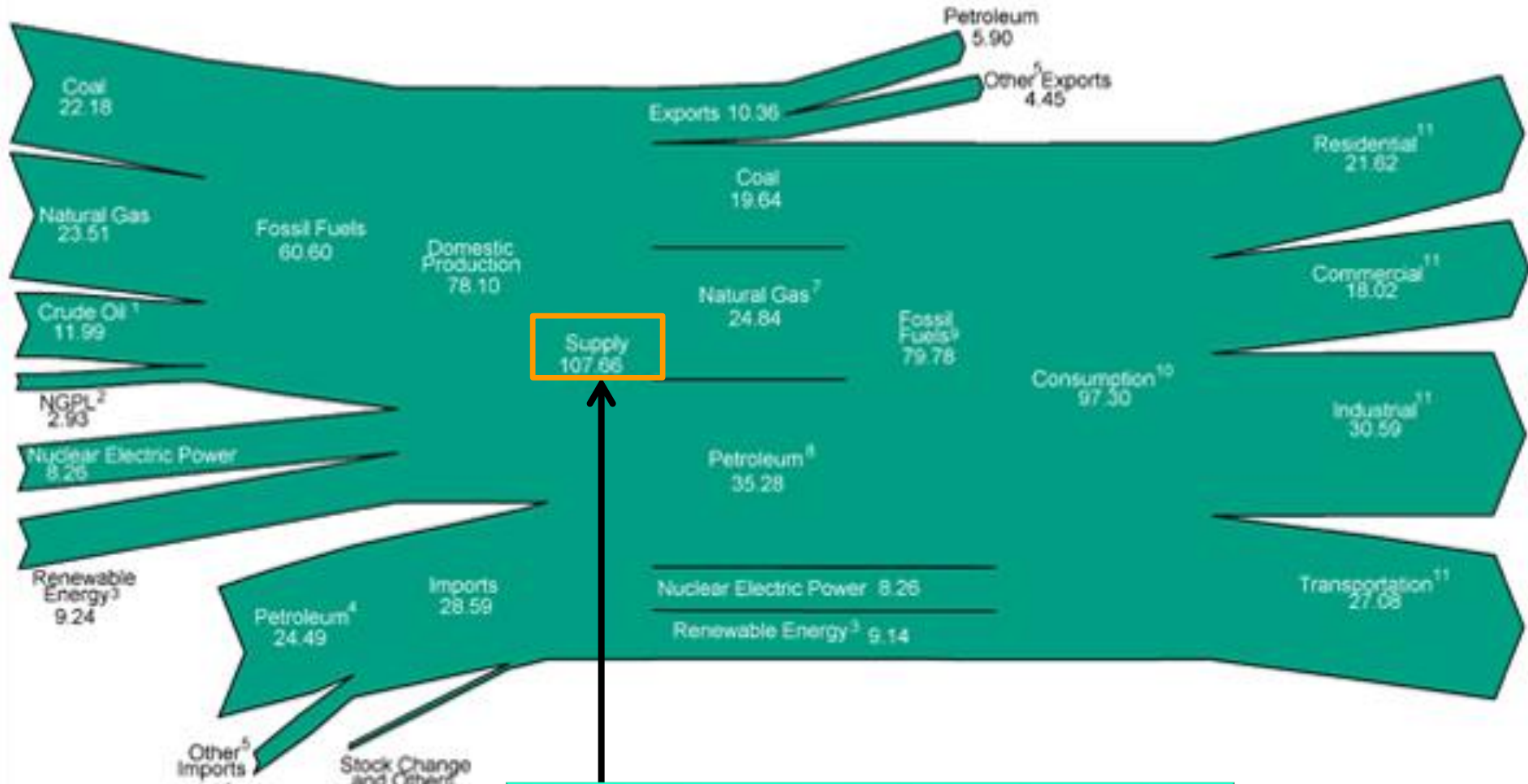


Autog. par Regnier, 8. Rue. S^{te} Marie S^t G^{er}main à Paris.

Imp. Lith. Regnier et Bourdet.

<http://www.princeton.edu/~alaink/Orf467F13/FreightFacts&Figures2012.pdf>

Energy Flow 2011

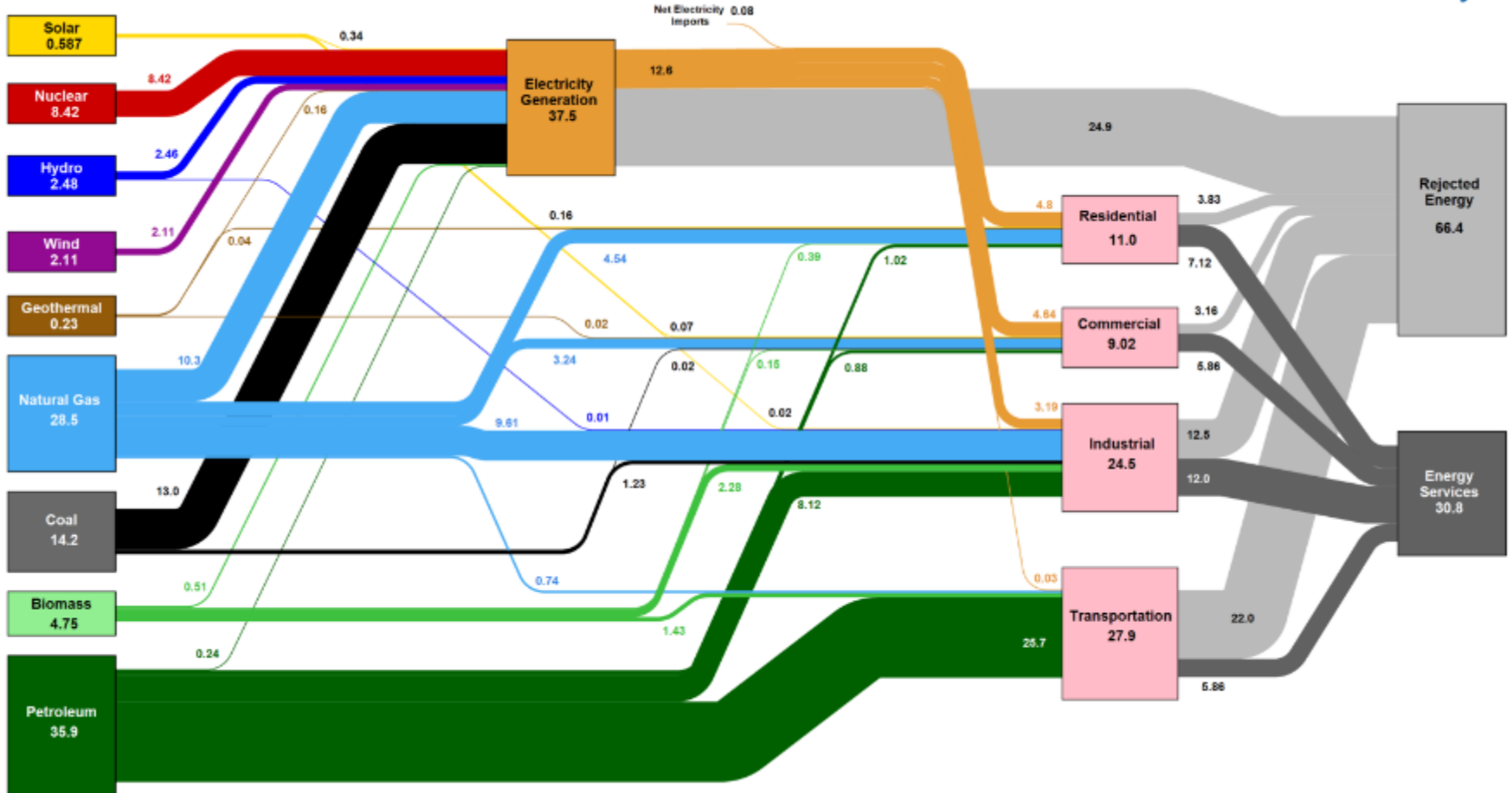


Implies chart can be read as %

Energy Flow 2016



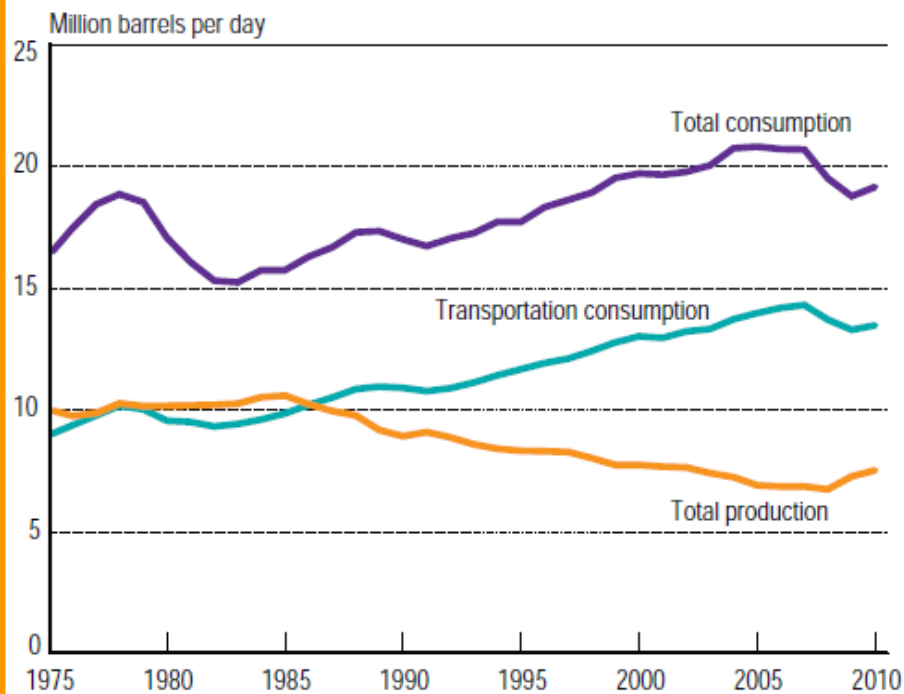
Estimated U.S. Energy Consumption in 2016: 97.3 Quads





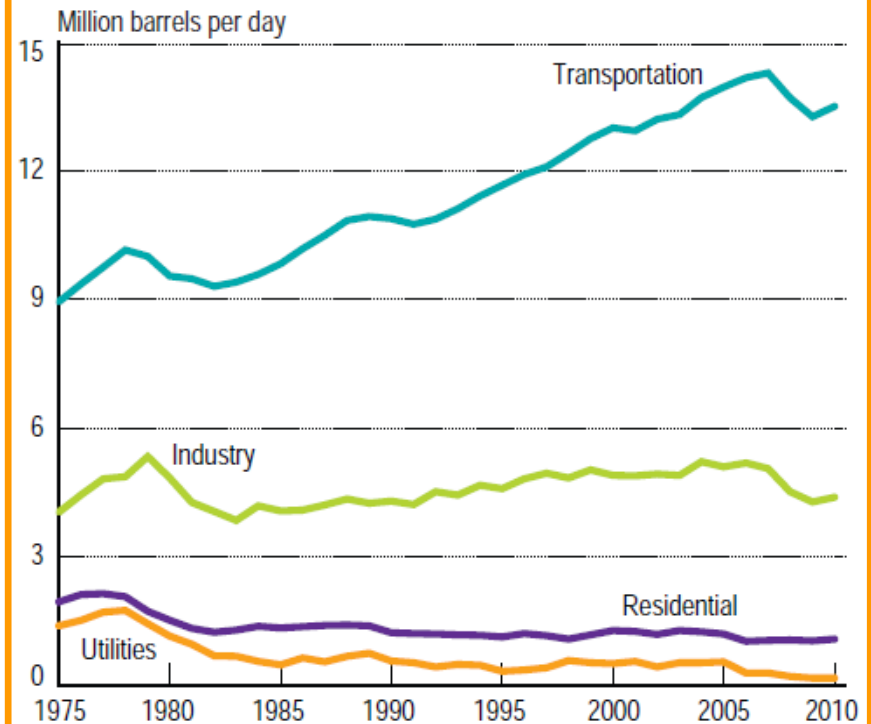
Petroleum Consumption

5-5 U.S. Petroleum Production and Consumption: 1975–2010



Notes: Data for 2010 are preliminary. Data for 2008 are revised.

5-6 Transportation's Share of U.S. Petroleum Use: 1975–2010

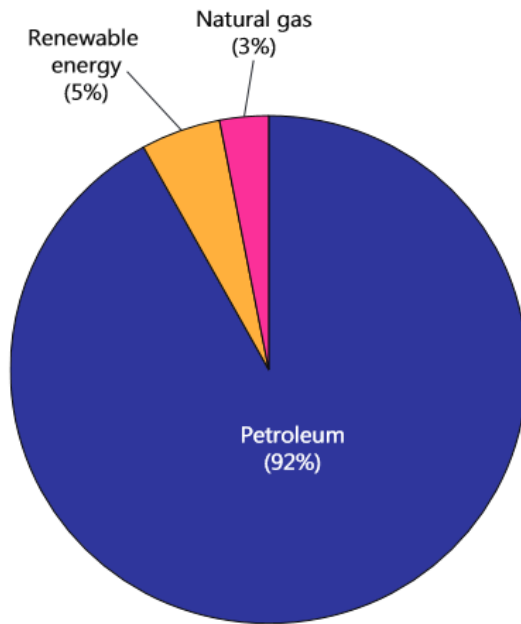


Note: The 2010 data are preliminary.



7-2 Transportation Energy Consumption by Source: 2013

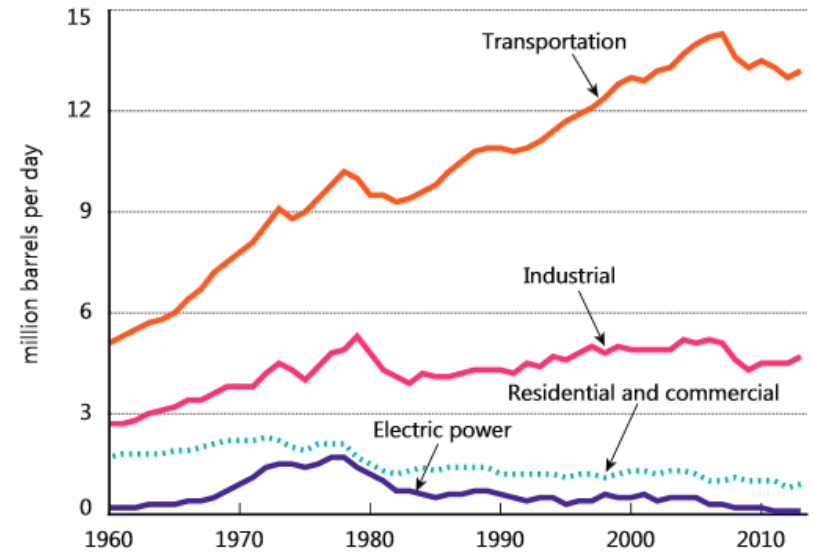
percent of Btu consumed



Key: Btu = British thermal unit.

Note: Excludes electricity retail sales and electrical system energy losses.

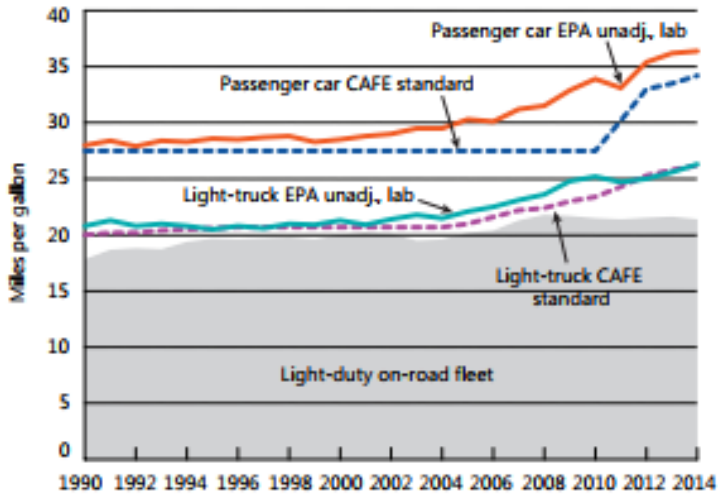
7-3 Petroleum Consumption by Sector: 1960–2013



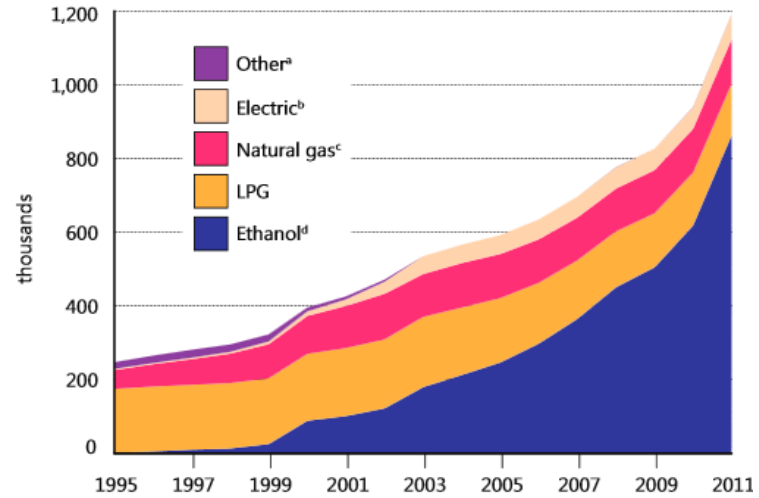
Source: U.S. Department of Energy, U.S. Energy Information Administration, *Monthly Energy Review*, available at www.eia.gov/totalenergy/data/monthly as of September 2014.



7-7 Fuel Economy of Light-Duty Vehicles: 1990–2014

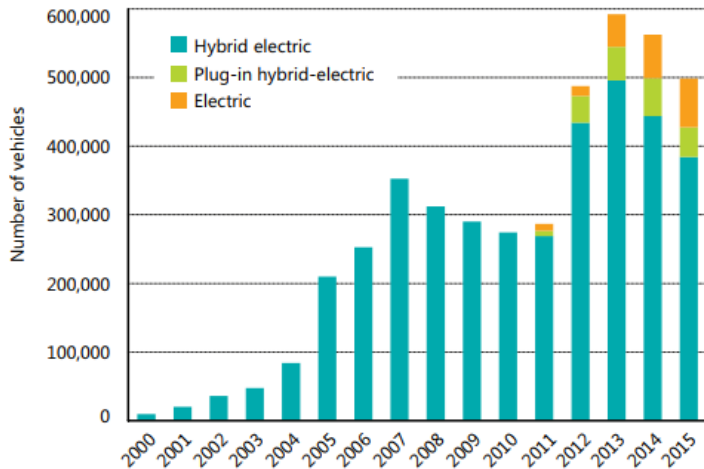


7-8 Alternative Fuel Vehicles in Use: 1995–2011



^aIncludes 85% methanol (M85), neat methanol (M100), and hydrogen fuels.
^bExcludes gasoline-electric hybrids. ^cIncludes compressed natural gas (CNG) and liquefied natural gas (LNG). ^dIncludes 85% ethanol (E85) and 95% ethanol (E95). E85 includes only fleet-based vehicles and excludes vehicles with E85 fueling capability owned by individuals.

7-9 Gasoline Hybrid and Electric Vehicle Sales: 2000–2015

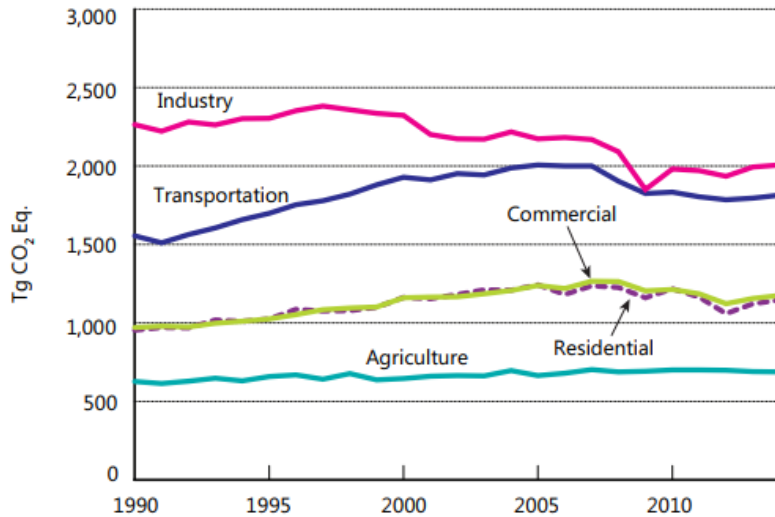


<http://www.hybridcars.com/may-2017-dashboard/>

Transportation and Air Quality

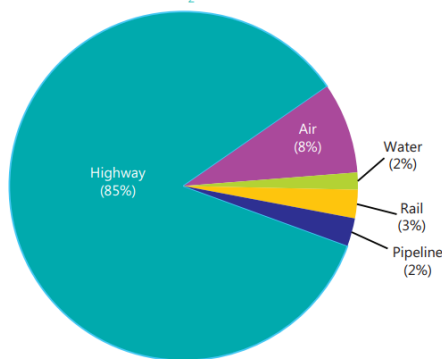


7-4 Greenhouse Gas Emissions by Sector: 1990–2014



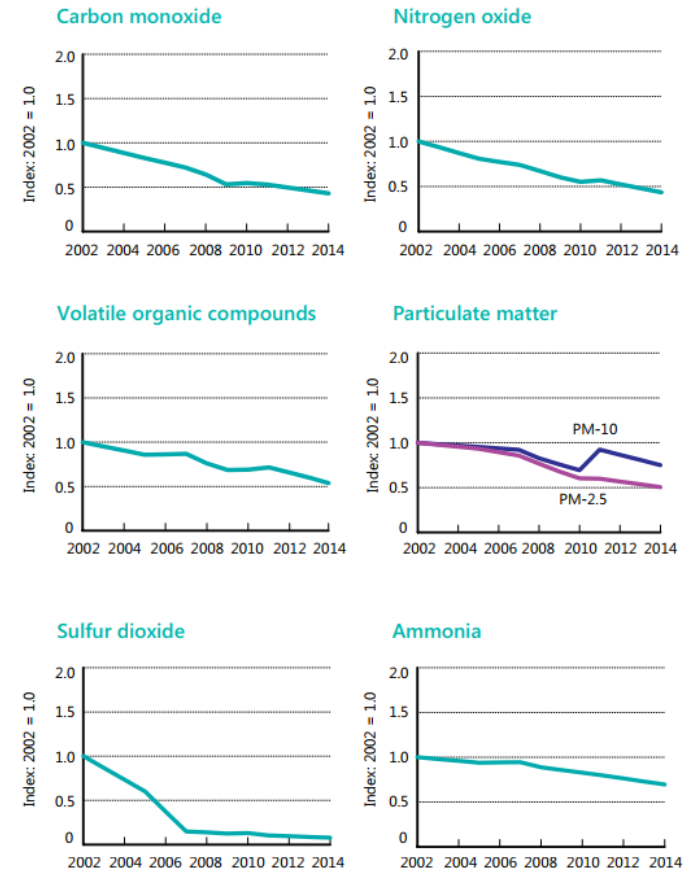
7-5 Greenhouse Gas Emissions by Transportation Mode: 2014

Percent of Tg CO₂ Eq.



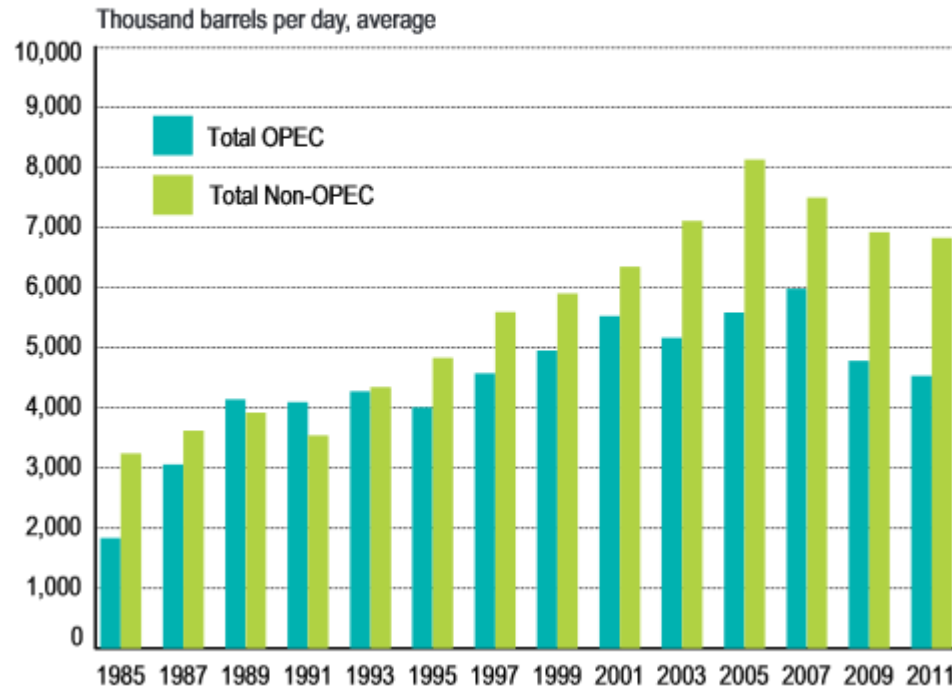
Key: Tg CO₂ Eq. = teragrams of carbon dioxide equivalent. A teragram = 1 million metric tons.

7-6 Highway Vehicle Air Pollutant Emissions: 2002–2014





4-14 U.S. Petroleum Imports: 1985–2011

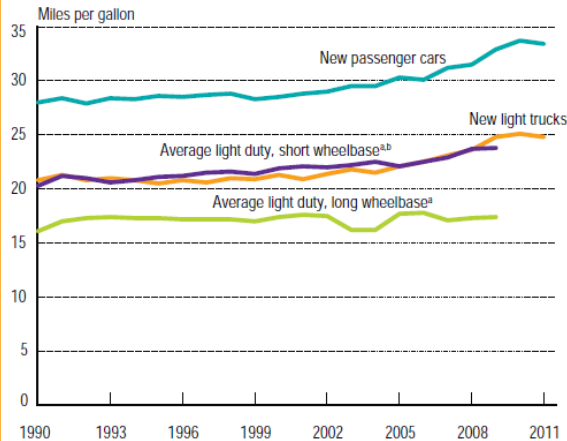


4-15 Major Sources of Petroleum Consumed in the U.S.: 1990, 2000, 2010, 2011 (thousand barrels per day, average)

	Rank (2011)	1990	2000	2010	2011
United States	1	7,355	5,822	5,479	5,647
Canada	2	934	1,807	2,535	2,706
Mexico	3	755	1,373	1,284	1,205
Saudi Arabia (OPEC)	4	1,339	1,572	1,096	1,195
Venezuela (OPEC)	5	1,025	1,546	988	944
Nigeria (OPEC)	6	800	896	1,023	817
Russia	7	45	72	612	621
Iraq (OPEC)	8	518	620	415	460
Colombia	9	182	342	365	422
Algeria (OPEC)	10	280	225	510	358
Angola (OPEC)	11	NR	NR	393	346
Brazil	12	49	51	272	249
Ecuador (OPEC)	13	49	NR	212	192
Kuwait (OPEC)	14	86	272	197	191
U.S. Virgin Islands	15	282	291	253	187
United Kingdom	16	189	366	256	158
Norway	17	102	343	89	113
Netherlands	18	55	30	108	100
Libya (OPEC)	19	0	0	70	15
Total, U.S. Petroleum Imports		8,018	11,459	11,793	11,360
Total, U.S. Domestic and Imports		15,373	17,281	17,272	17,007
U.S. Imports Share of Total		52%	66%	68%	67%

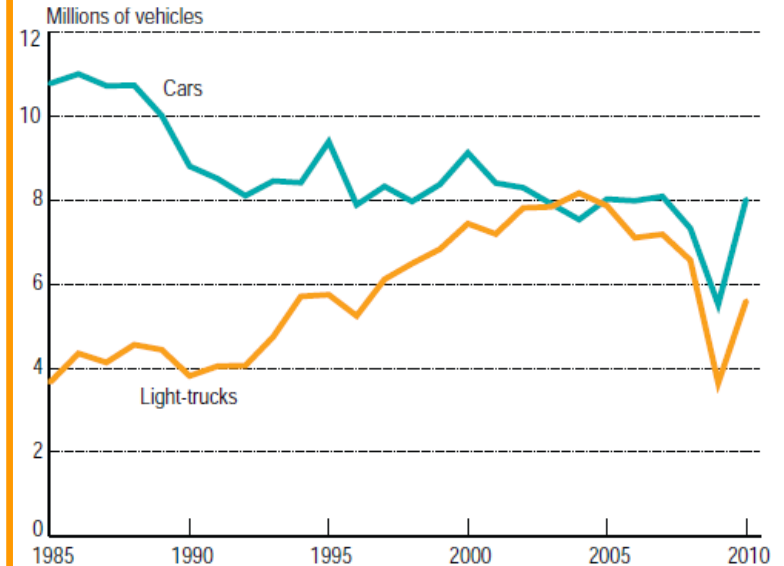


5-3 New Passenger Car and Light Truck Fuel Economy Averages: 1990–2011



^aData before 2007 are for passenger car and other 2-axle, 4-tire vehicles, respectively. ^bBefore 1995, light duty vehicle, short wheel base (previously passenger car) fuel efficiency includes motorcycles.

4-13 New Passenger Car and Light-Truck Production: Model Years 1985–2010

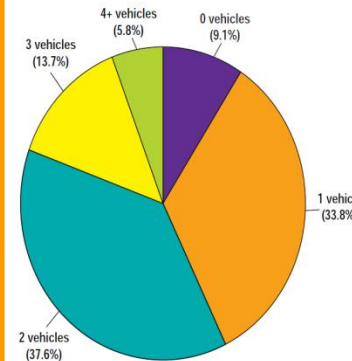


5-4 Hybrid Vehicle Sales^a in the United States: 1999–2010^c

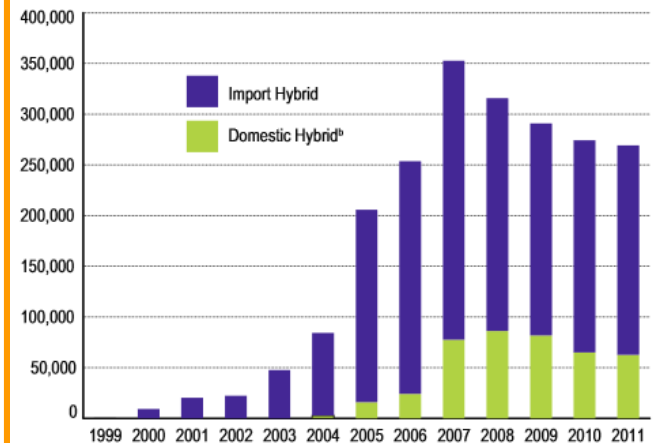
Year	Domestic hybrid ^b	Import hybrid	Total hybrid
1999	0	17	17
2000	0	9,350	9,350
2001	0	20,282	20,282
2002	0	22,335	22,335
2003	0	47,566	47,566
2004	2,993	81,206	84,199
2005	15,960	189,868	205,828
2006	24,198	229,320	253,518
2007	77,629	275,233	352,862
2008	86,082	229,606	315,688
2009	81,882	208,858	290,740
2010	64,893	209,528	274,421

^a Sales include leased vehicles and fleet sales. ^b Includes vehicles produced in Canada and Mexico. ^c Calendar year vehicle sales.

3-6 Households by Number of Motor Vehicles: 2010

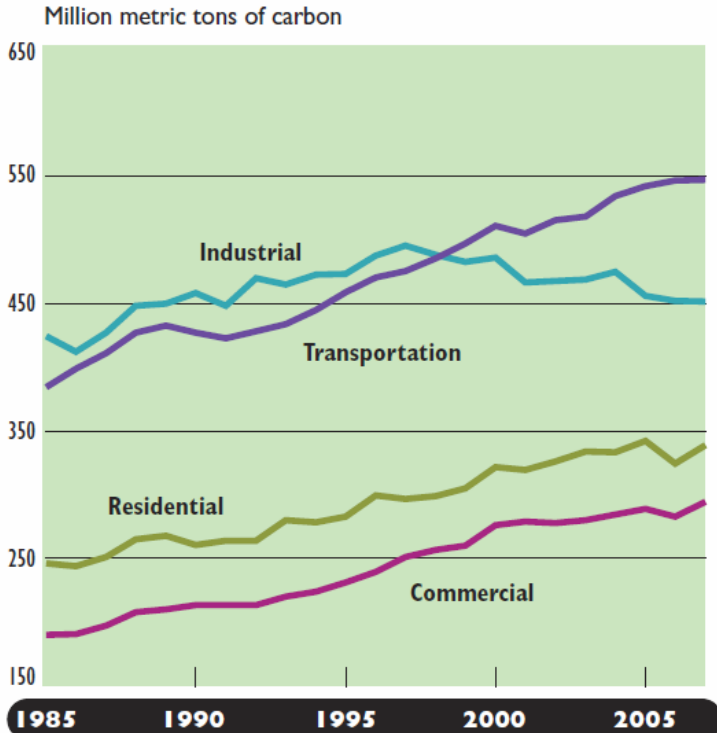


5-4 Hybrid Vehicle Sales^a in the United States: 1999–2011^c





U.S. Carbon Dioxide Emissions from Energy Use: 1985–2007



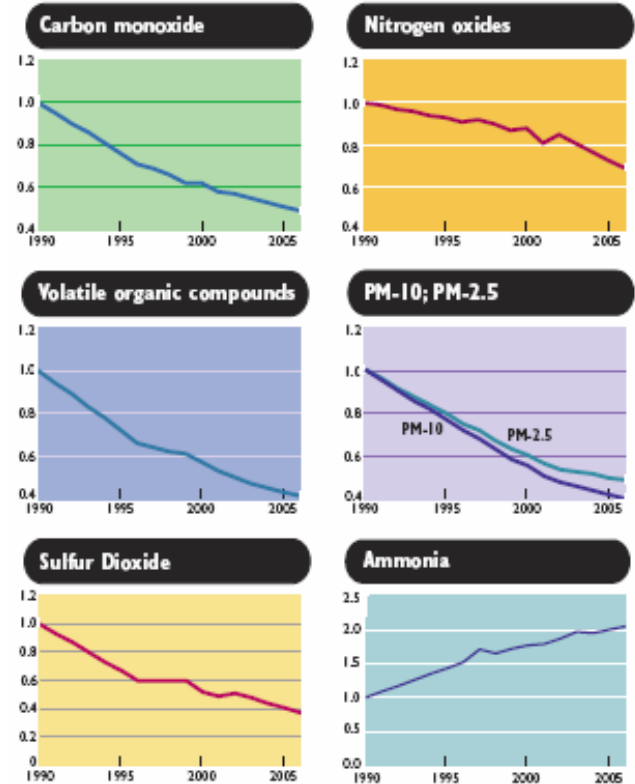
Notes: 2007 data are preliminary. One ton of carbon equals 3.667 tons of carbon dioxide gas. Electric utility emissions are distributed across sectors.

Sources: 1985–1989—U.S. Department of Energy (USDOE), Energy Information Administration (EIA), *Emissions of Greenhouse Gases in the United States*, appendix E, available at <http://www.eia.doe.gov/oiaf/1605/1605aold.html> as of December 2005. 1990–2007—USDOE, EIA, *U.S. Carbon Dioxide from Energy Sources 2008 Flash Estimate*, available at <http://www.eia.doe.gov/oiaf/1605/flash/flash.html> as of October 2008.

6-4

Index of Key Air Pollutant Emissions from U.S. Transportation: 1990–2006

Index: 1990 = 1.0

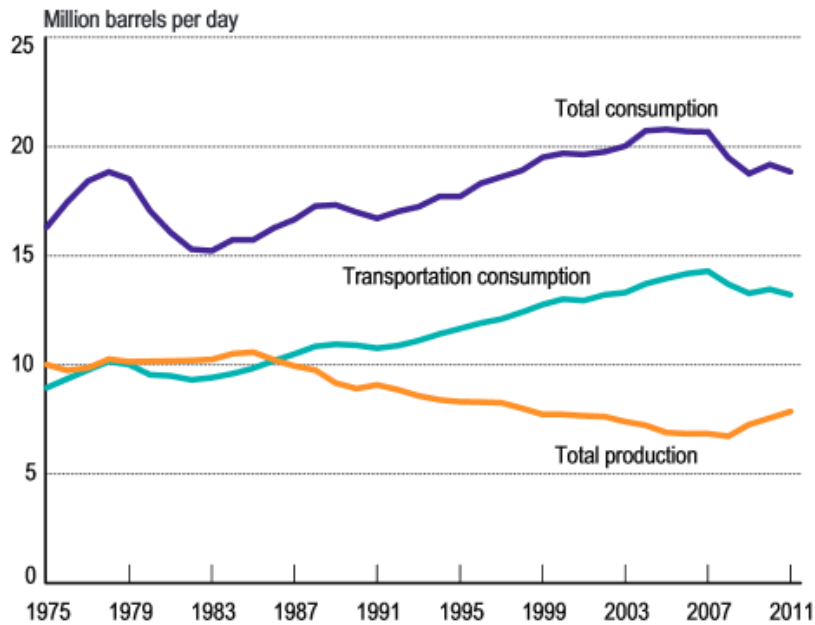


Key: PM-10 and PM-2.5 = airborne particulates of less than 10 microns or 2.5 microns, respectively.

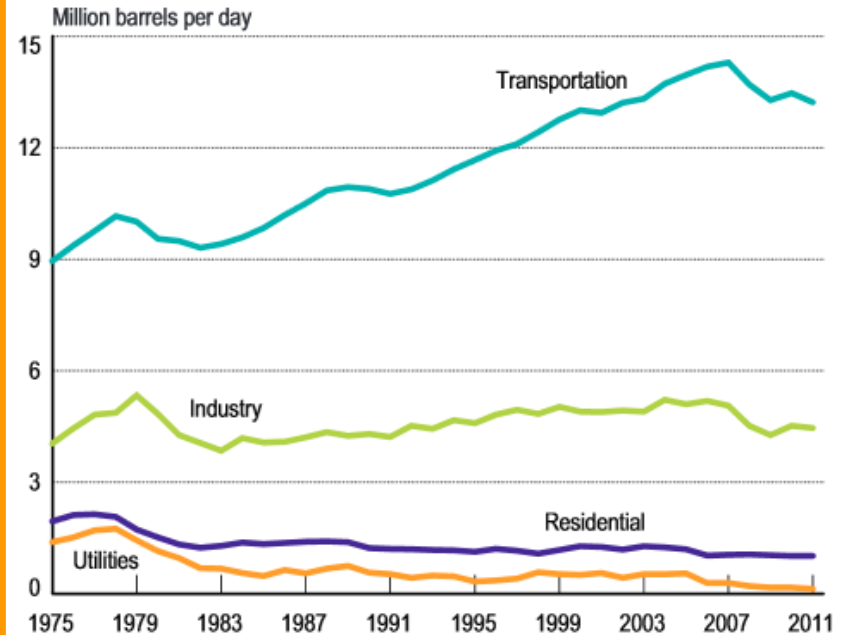
Notes: Data include emissions from onroad mobile sources only. EPA revised the emissions estimation methodology for onroad mobile sources. EPA discontinued lead emissions estimated in 2001.



5-5 U.S. Petroleum Production and Consumption: 1975–2011



5-6 Transportation's Share of U.S. Petroleum Use: 1975–2011





2-10 Top 10 U.S. Airports: 2013

by enplaned passengers

Rank	Station	'12-'13 change	Millions of passengers
1	Atlanta, GA	▼ -1.0%	45.3
2	Los Angeles, CA	▲ 3.2%	32.3
3	Chicago O'Hare, IL	▲ 0.3%	32.2
4	Dallas/Fort Worth, TX	▲ 3.6%	29.0
5	Denver, CO	▼ -1.2%	25.5
6	New York JFK, NY	▲ 2.2%	25.0
7	San Francisco, CA	▲ 1.7%	21.7
8	Charlotte, NC	▲ 6.6%	21.3
9	Las Vegas, NV	▲ 0.2%	19.8
10	Phoenix, AZ	▼ -0.2%	19.5

2-11 Top 10 World Airports: 2013

by enplaned, deplaned, and in-transit passengers

Rank	Airport	'12-'13 change	Millions of passengers
1	Atlanta, USA	▼ -1.1%	94.4
2	Beijing, China	▲ 2.2%	83.7
3	London, United Kingdom	▲ 3.3%	72.4
4	Tokyo, Japan	▲ 3.2%	68.9
5	Chicago, USA	▲ 0.2%	66.8
6	Los Angeles, USA	▲ 4.7%	66.7
7	Dubai, United Arab Emirates	▲ 15.2%	66.4
8	Paris, France	▲ 0.7%	62.1
9	Dallas/Fort Worth, USA	▲ 3.2%	60.5
10	Jakarta, Indonesia	▲ 4.1%	60.1



2-10 Top 10 U.S. Airports: 2015

by enplaned passengers

Rank	Station	'14-'15 change	Millions of passengers
1	Atlanta, GA	▲ 6.1%	49.8
2	Los Angeles, CA	▲ 6.0%	37.1
3	Chicago O'Hare, IL	▲ 7.5%	36.5
4	Dallas/Fort Worth, TX	▲ 2.7%	31.7
5	New York JFK, NY	▲ 6.4%	28.0
6	Denver, CO	▲ 0.8%	26.6
7	San Francisco, CA	▲ 6.5%	24.4
8	Charlotte, NC	▲ 1.3%	22.2
9	Las Vegas, NV	▲ 5.8%	22.1
10	Phoenix, AZ	▲ 4.5%	21.9

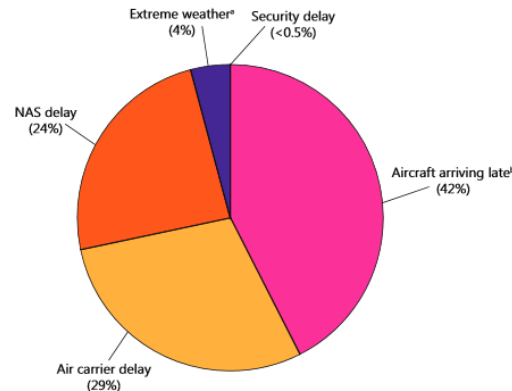
2-11 Top 10 World Airports: 2015

by enplaned, deplaned, and in-transit passengers

Rank	Airport	'14-'15 change	Millions of passengers
1	Atlanta, USA	▲ 5.5%	101.5
2	Beijing, China	▲ 4.4%	89.9
3	Dubai, United Arab Emirates	▲ 10.7%	78.0
4	Chicago, USA	▲ 9.9%	76.9
5	Tokyo, Japan	▲ 3.4%	75.3
6	London, United Kingdom	▲ 2.2%	75.0
7	Los Angeles, USA	▲ 6.0%	74.9
8	Hong Kong, China	▲ 8.2%	68.3
9	Paris, France	▲ 3.1%	65.8
10	Dallas/Fort Worth, USA	▲ 0.8%	64.1

4-4 U.S. Airport Delays by Cause, 2015

percent of delayed time





International Trade

4-7 Value of U.S. International Merchandise Trade by Mode of Transportation: 2010 (millions of current U.S. dollars)

	Exports	Modal percentage	Imports	Modal percentage	Total trade	Total modal percentage
Total	1,277,504	100.0	1,912,092	100.0	3,189,596	100.0
Water	455,460	35.7	978,799	51.2	1,434,259	45.0
Air	392,634	30.7	444,319	23.2	836,953	26.2
Truck	284,698	22.3	272,186	14.2	556,884	17.5
Rail	45,748	3.6	85,480	4.5	131,228	4.1
Pipeline	5,189	0.4	57,744	3.0	62,933	2.0
Other, unknown & miscellaneous	93,774	7.3	73,564	3.8	167,337	5.2

4-5 U.S. Trade in Transportation-Related Commodities: 2010 (millions of current U.S. dollars)

Commodity and HTS code	Exports	Imports	Total trade ^a	Trade balance ^b
Motor vehicles and parts (87)	98,997	182,925	281,922	-83,928
Aircraft, spacecraft, and parts (88)	79,266	18,949	98,215	60,318
Ships, boats, and floating structures (89)	2,618	1,589	4,206	1,029
Railway or tramway locomotives and parts (86)	2,487	1,405	3,892	1,082
Total, transportation commodities	183,368	204,867	388,235	-21,500
Total, all commodities	1,277,504	1,912,092	3,189,596	-634,588
Transportation commodities share of trade	14.4%	10.7%	12.2%	3.4%

^aTotal trade = exports plus imports. ^bTrade balance = exports minus imports.

Key: HTS = Harmonized Tariff Schedule.

Government & Transportation



4-16 Government Transportation Revenues by Mode and Level of Government: 1995, 2000, 2007, 2008
(millions of current dollars)

	R ¹⁹⁹⁵	R ²⁰⁰⁰	R ²⁰⁰⁷	2008
Highway total	67,544	90,981	114,396	111,980
Federal: Highway Trust Fund ^a	22,200	34,986	40,061	37,080
State and local	45,344	55,995	74,336	74,900
Toll revenue	4,748	6,438	10,130	10,653
Transit total ^b	8,575	10,670	13,874	14,592
Toll revenue	0	335	287	314
Railroad ^c	36	1	0	0
Air total	14,497	22,235	29,384	30,702
Federal: Airport and Airway Trust Fund ^d	6,291	10,544	11,994	12,484
State and local	8,206	11,691	17,390	18,218
Water total	3,832	4,058	6,191	6,551
Federal: water receipts ^e	1,909	1,551	2,325	2,412
State and local	1,923	2,507	3,866	4,139
Pipeline ^c	35	30	60	63
General support ^c	7	26	16	14
Total, all modes	94,526	134,774	174,337	174,868
Federal	30,478	47,138	54,456	52,053
State and local	64,048	87,636	119,882	122,815

Key: R = revised

^a Includes both Highway and Transit Accounts of the Highway Trust Fund (HTF). Also includes other receipts from motor fuel and motor vehicle taxes not deposited in the HTF. ^b Includes state and local government only. ^c Includes federal only. ^d Receipts from aviation user and aviation security fees are also included. ^e Includes Harbor Maintenance Trust Fund, St. Lawrence Seaway tolls, Inland Waterway Trust Fund, Panama Canal receipts through 2000, Oil Spill Liability

4-17 Government Transportation Expenditures by Mode and Level of Government: 1995, 2000, 2007, 2008
(millions of current dollars)

	R ¹⁹⁹⁵	R ²⁰⁰⁰	R ²⁰⁰⁷	2008
Highway total	90,075	119,903	175,456	182,007
Federal	1,685	2,182	2,932	3,803
State and local	88,391	117,720	172,524	178,204
Transit total	25,460	34,823	45,753	50,893
Federal	1,277	3,672	98	90
State and local	24,183	31,150	45,655	50,803
Rail total	1,049	778	1,528	1,526
Federal	1,023	765	1,523	1,525
State and local	26	13	5	1
Air total	19,184	22,352	43,584	46,430
Federal	10,787	9,192	23,523	25,166
State and local	8,397	13,160	20,061	21,264
Water total	6,666	7,634	12,069	12,758
Federal	4,357	4,493	7,308	7,818
State and local	2,309	3,141	4,761	4,940
Pipeline total	26	55	89	92
Federal	14	37	66	61
State and local	12	18	23	31
General support	775	653	834	675
Federal	769	645	821	663
State and local	6	8	13	12
Total, all modes	143,235	186,197	279,312	294,381
Federal	19,911	20,987	36,271	39,126
State and local	123,323	165,210	243,041	255,255

Key: R = revised

Notes: Federal expenditure includes direct Federal spending, excluding grants to State and local governments. State and local expenditure includes outlays from all sources of funds including funds from federal grants, except railroad and pipeline modes. State and local expenditure for rail and pipeline modes include outlays that are funded by Federal grants only. The part of expenditure that may be funded by other funding sources of State and local governments are not covered due to lack of data. Outlays for civilian transportation-related activities of the U.S. Army Corps of Engineers for construction, operation, and maintenance of channels, harbors, locks, and dams, and protection of navigation are not included for all years due to lack of data. The revisions for transportation expenditures include: 1) outlays for air transportation, 2) Federal water outlays for 1995 and 2007, 3) Federal expenditures on highway, transit and pipeline for 2000, 4) highway data for 2007, and 5) outlays for State and local transit and Federal general support for 2007.



- **Societal oversight on transportation.**

- Transportation is a **derived** good
- an industry that impacts public interests; a “business affected with the public interest”

- Government Involvement / Influence:

- **Why?**

- To create or replace the attributes of: *competition* and *free markets*
 - Products are justified only by the willingness of people to produce them and buy them
 - People are Utility maximizers (do things that make them better off)
 - Product should not be sold at price less than marginal cost of last unit.
- Issues of Externalities, Equity
- Is it a Utility, Is it a Ubiquitous Public Good (Should it be nationalize) ?



- ***What?***
 - Control externalities: Safety, Environment
 - Maintain competition (Courts enforce anti-trust)
 - Invest, assume ownership
 - Regulation has involved: Regulation of entry and exit (Granting of charters); Pricing (filed rate doctrine), Employee relations, Operations, Safety

- ***How?***
- Controlled by the legal system based on Common law (judicial precedent; principles of law developed from former court decisions) augmented by Statutory law enacted by legislative bodies.
 - Concept of “business affected with the public interest”
 - Concept of **common carriage**: serve all shippers on a similar basis, at reasonable rates and without discrimination.
- Who’s involved:
- Legislature, courts, administrative bodies
 - Started with states, moved to the federal Gov in 1887 with the ICC,
 - ICC was an administrative layer that provides continuity to regulation that the legislature and the judiciary don’t provide. (Surface Transportation Board replaced ICC)
 - added “executive decisions” to legislative and judicial actions.



- **Evolution of Regulation:**
 - Granger laws: problem- high rates where competition didn't exist
 - Wabash case 1886: Supreme court ruled that states could not control rates on interstate commerce.
 - ICC 1887 regulate interstate commerce (RR): promulgate common carriage concepts
 - 1935 Motor Carrier Act:
 - Control of Entry
 - CAB Act 1938; purpose:
 - **promote** aviation by establishing and establishing an airport airways system
 - **safety** (regulate entry)
 - Transport Act 1940 national policy statement
 - Regulation of all modes of transportation
 - Need a unified perspective
 - Reed - Bulwinkle Act of 1948: Joint rate-making anti-trust protection.
 - 1956 ND & IH Act
 - 1966 Creation of Exec branch Department of Transportation
 - 3R, 4R, '78 Air Dereg. Act, Motor carrier Dereg. Act, Staggers,
 - 1994 Sunset of ICC, Transportation Board
- **Current Federal Laws:** [U.S. Code](#)
 - Title 23 Highways; Title 45 Railroads; Title 49 Transportation