



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

- Orf 467 Fall 2016 Syllabus ([pdf](#)) [Enrolled Students](#)
- 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 $\text{Trans\$} = C * D$, $C = \text{Const}(\text{technology, management, policy})$, $D = \text{distance}$
 - Market Area R extends until $\text{Demand\$} = \text{Fixed\$} + \text{Trans\$}$
 - 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 $C_{\text{new}} = 1/2 C_{\text{old}}$,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 \(Pocket Guide 2016\)](#)
- [Watch a cute animation showing how traffic flow problems happen.](#)

By Kenji Semoto <https://www.youtube.com/watch?v=iHzzSao6ypE> Also watch: [Humans Need Not Apply](#)



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.

According to the [U.S. Census Bureau's](#), the United States in 2015 had 321,418,820 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).

Week 0

United States

2015 Population Estimate

321,418,820

Source: Vintage 2015 Population Estimates: Population Estimates

Median Household Income

\$ 53,482

Source: 2010-2014 American Community Survey 5-Year Estimates

Educational Attainment: Percent high school graduate or higher

86.3 %

Source: 2010-2014 American Community Survey 5-Year Profiles

2015 Poverty Statistics, All People Below Poverty Level Percent

13.5 %

Source: 2016 Current Population Survey, Annual Social and Economic Supplement (CPS ASEC)

Persons without health insurance, under age 65 years, percent

14.2 %

Source: 2010-2014 American Community Survey 5-Year Profiles

Median Housing Value

\$ 175,700

Source: 2010-2014 American Community Survey 5-Year Estimates

Total Housing Units

132,741,033

Source: 2010-2014 American Community Survey 5-Year Estimates

Number of Companies

27,626,360

Source: 2012 Survey of Business Owners: Company Summary

Veterans

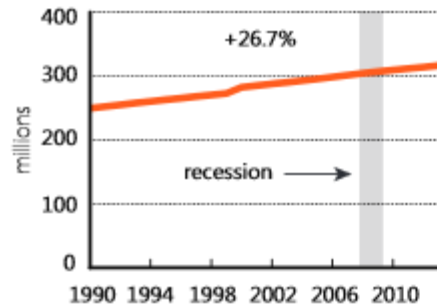
20,700,711

Source: 2010-2014 American Community Survey 5-Year Profiles

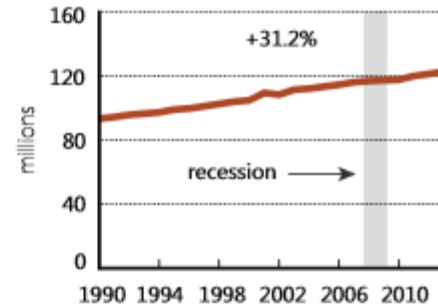


The American Landscape: 1990–2013

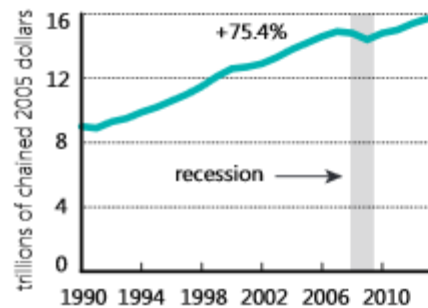
Resident population



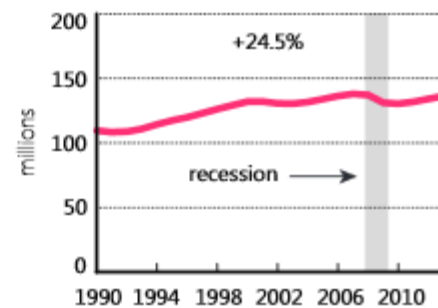
Households



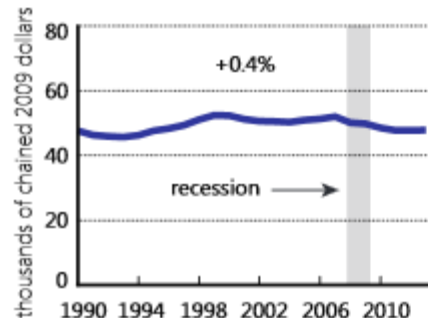
Real GDP



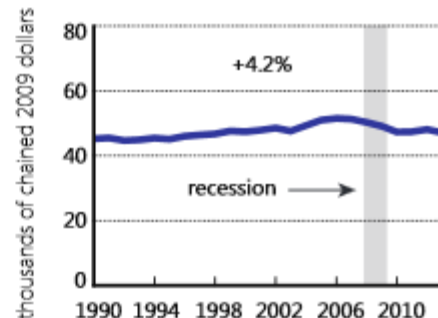
Employment^a



Median household income^b



Average household expenditures^b



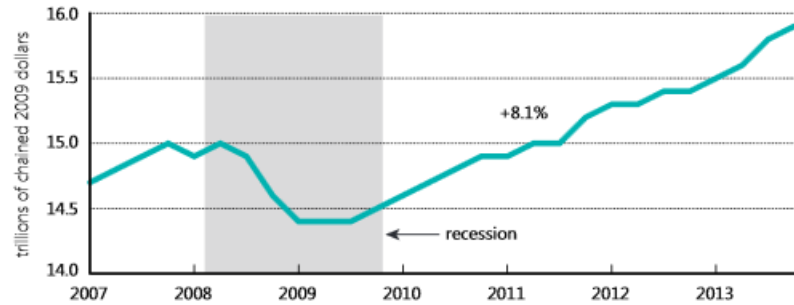
^aNonfarm payroll employment. ^bConverted to chained 2009 dollars by the Bureau of Transportation Statistics using the CPI-U-RS price index.

Key: GDP – gross domestic product

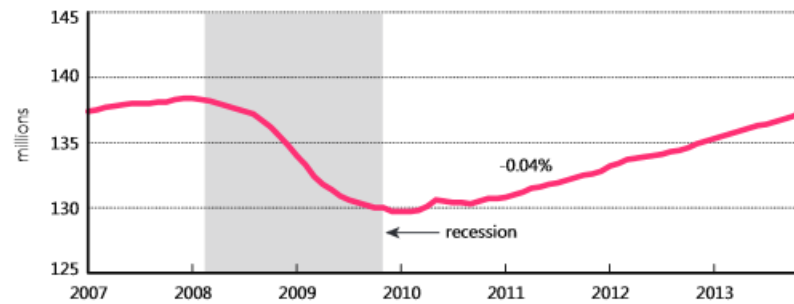


A Closer Look: Jan. 2007–Dec. 2013

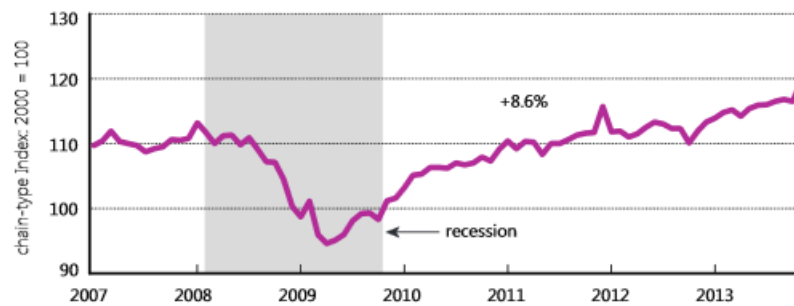
Real GDP



Employment^a



Transportation Services Index



^aNonfarm payroll employment.

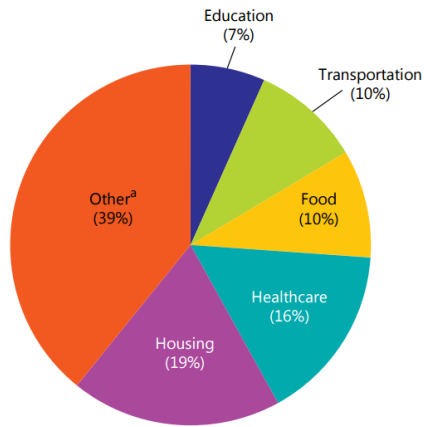
Key: GDP = gross domestic product.

Note: Graph scales are not comparable.



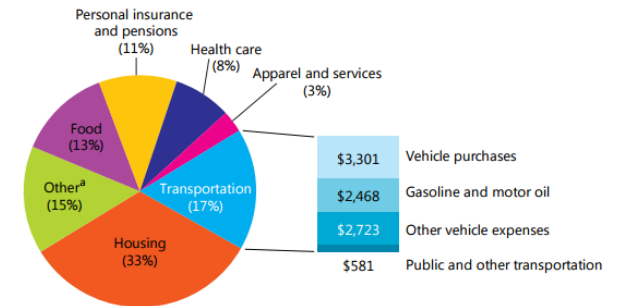
Macro-economic Aspects of Transportation

5-1 U.S. GDP by Spending Category: 2013
percent of GDP



^aIncludes all other categories (e.g. entertainment, personal care products and services, and payments to pension plans). Percentages do not add to 100 due to rounding.

5-4 Household Expenses by Category: 2014
percent of average annual household expenses

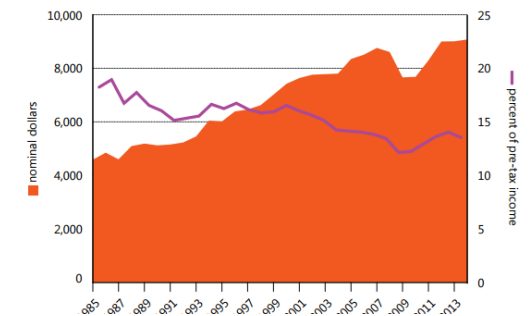


^a Includes alcoholic beverages, cash contributions, education, entertainment, personal care products and services, reading, tobacco products and smoking supplies, and other items.

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

5-5 Household Transportation Expenses: 1985–2014





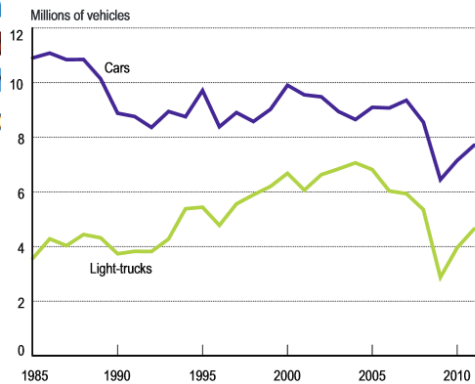
3-5 Passenger Travel and Freight Transportation Per Person

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

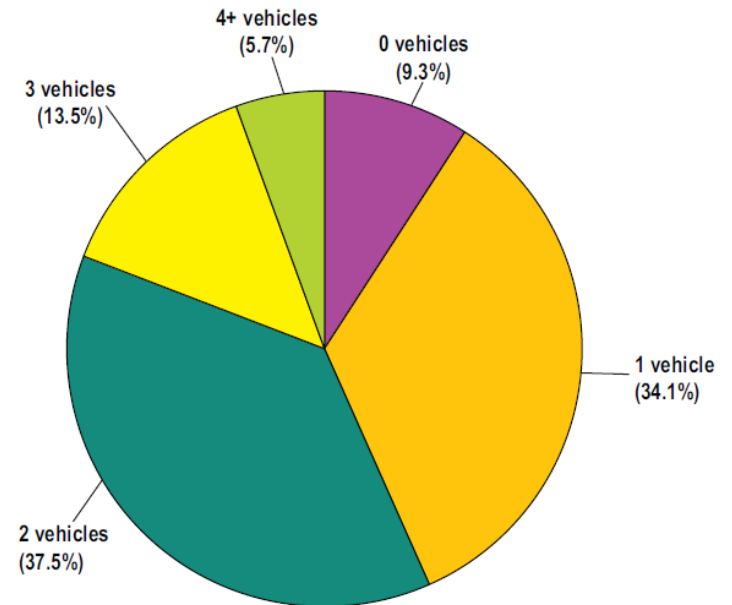
Notes: Tons per capita is calculated using the *Freight Analysis Framework*. The selected modal and economic trend data presented here use the *Travel Survey* presented here use the data and do not include persons under 5 years of age.

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 pickup 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 Systems 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

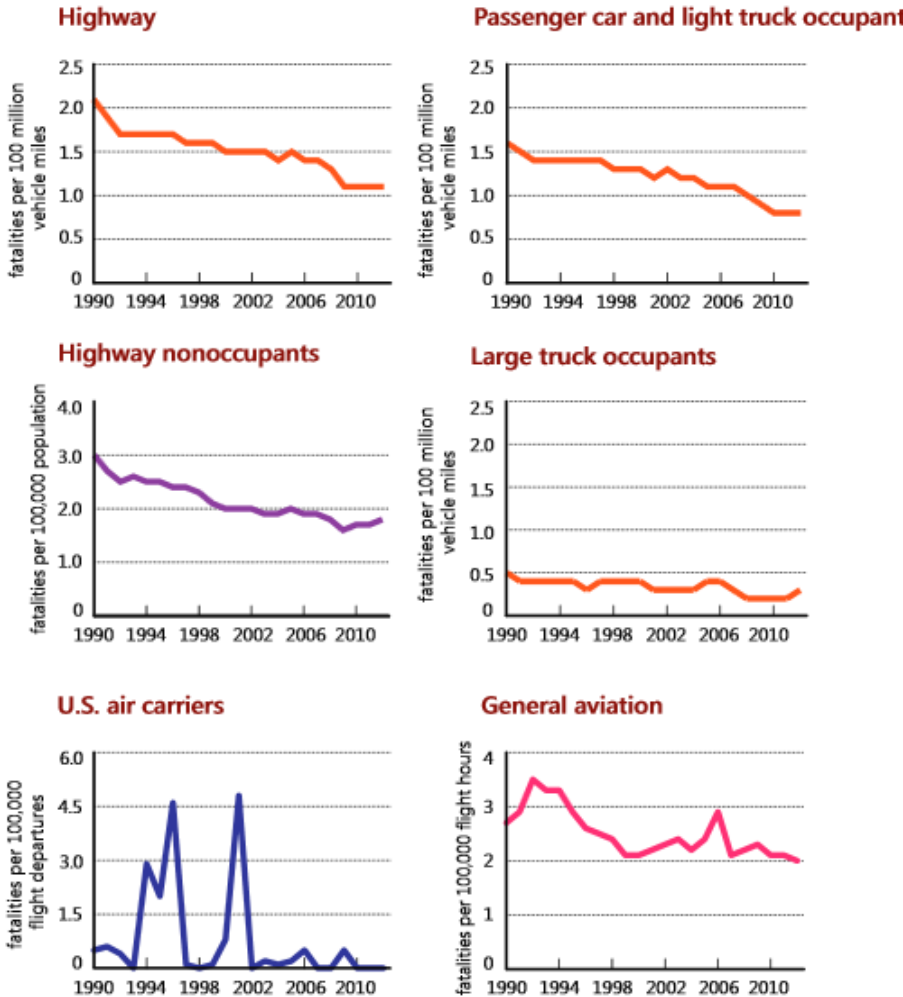
Category	Number	Percent
Passenger car occupants	11,981	35.09
Light-truck occupants	9,272	27.15
Motorcyclists	4,612	13.51
Pedestrians struck by motor vehicles	4,432	12.98
Recreational boating	758	2.22
Pedalcyclists struck by motor vehicles	677	1.98
Large-truck occupants	635	1.86
Other and unknown motor 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

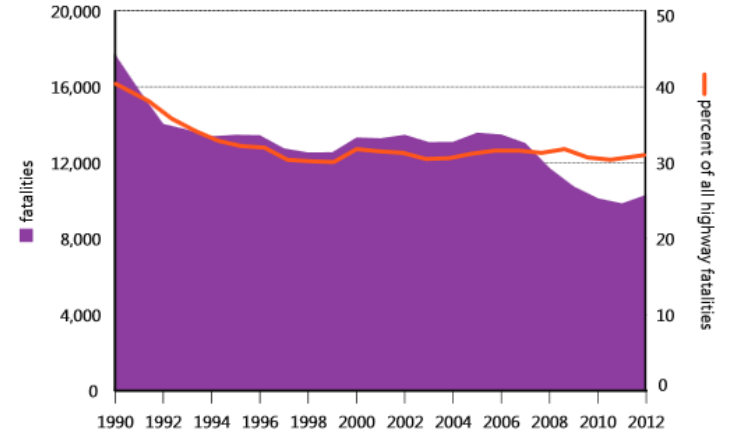


6-3 Fatality Rates by Mode: 1990–2012



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.

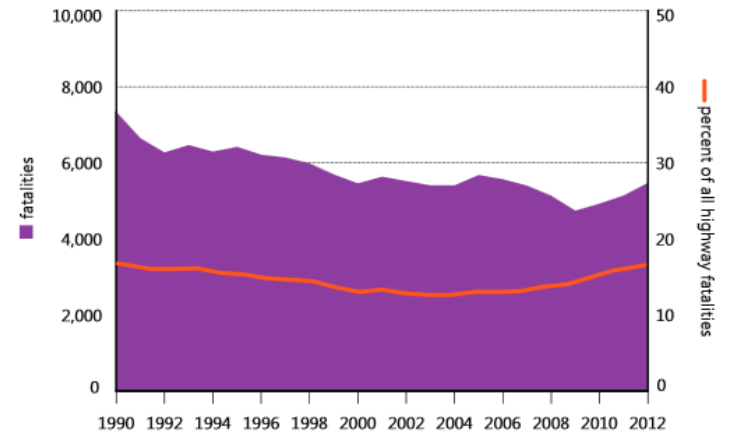
6-4 Alcohol-Impaired Driving Fatalities: 1990–2012



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.

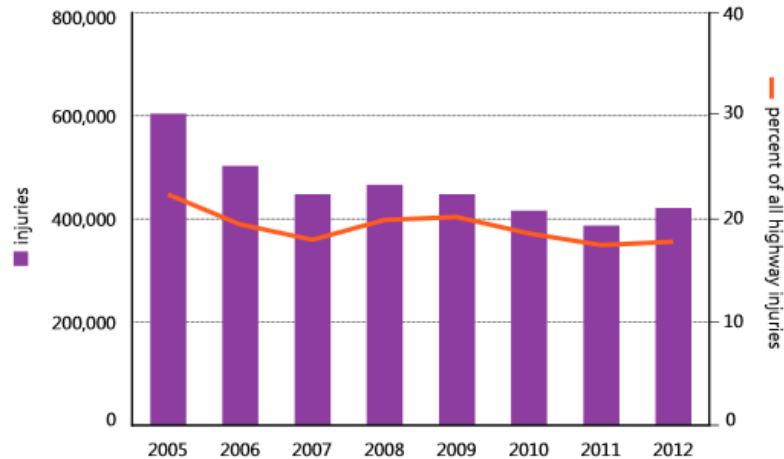
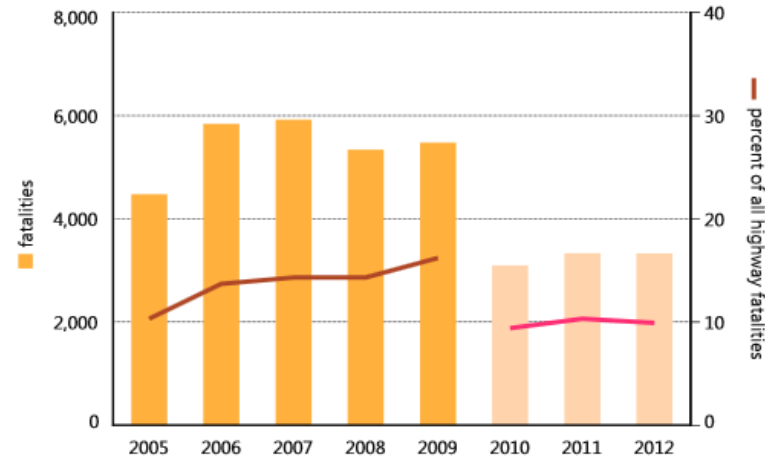
6-5 Pedestrian and Bicyclist Fatalities: 1990–2012



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

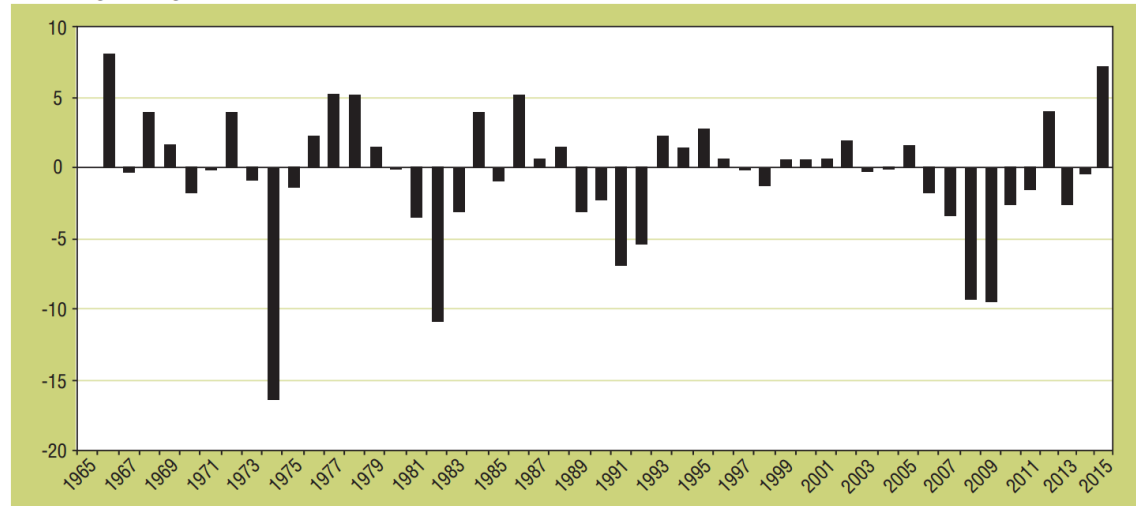
Quarter	1st Quarter (Jan–Mar)	2nd Quarter (Apr–Jun)	3rd Quarter (Jul–Sep)	4th Quarter (Oct–Dec)	Total (Full Year)
Fatalities and Percentage Change in Fatalities for the Corresponding Quarter From the Prior Year					
2005	9,239	11,005	11,897	11,369	43,510
2006	9,558 [+3.5%]	10,942 [-0.6%]	11,395 [-4.2%]	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 ¹	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	1.09	1.13	1.22	1.19	1.16

¹2012 statistical projections and rates based on these projections.
Source: Fatalities: 2005-2010 FARS Final File, 2011 FARS Annual Report File

¹A marginal part of the increase is attributed to 2012 being a leap year.
VMT: FHWA December 2012 Traffic Volume Trends, February 2013



Figure 1
Percentage Change in Total Traffic Fatalities, 1965–2015

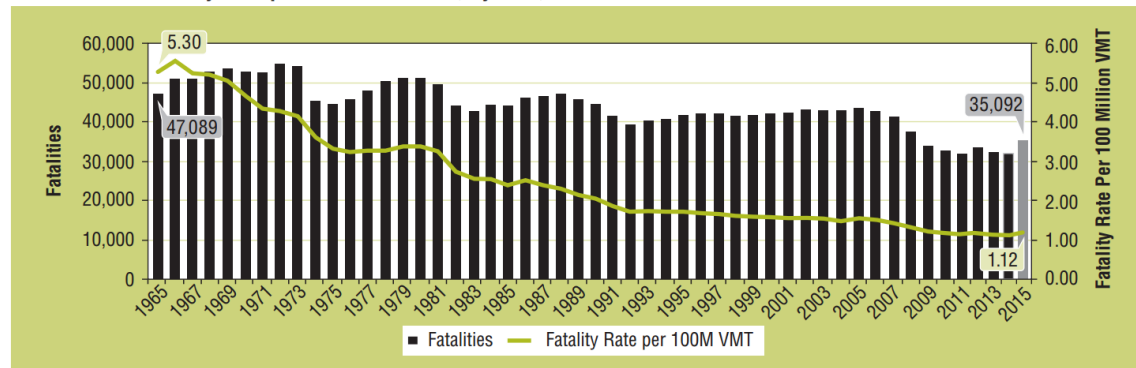


Sources: 1965–1974: National Center for Health Statistics, HEW, and State Accident Summaries (Adjusted to 30-Day Traffic Deaths by NHTSA); FARS 1975-2014 Final File, 2015 Annual Report File (ARF)

Figure 2 shows the number of fatalities and the fatality rate per 100 million VMT since 1966. The 2015 fatality count (35,092) is the highest number since 2008. In 2015 an estimated 2.44 million people were injured in motor vehicle traffic crashes, com-

pared to 2.34 million in 2014 as shown in Figure 3 according to NHTSA's National Automotive Sampling System (NASS) General Estimates System (GES), a statistically significant increase of 4.5 percent.

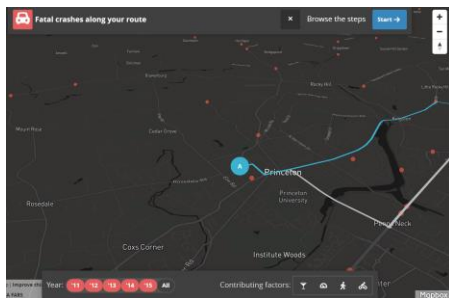
Figure 2
Fatalities and Fatality Rate per 100 Million VMT, by Year, 1965–2015



Sources: 1965–1974: National Center for Health Statistics, HEW, and State Accident Summaries (Adjusted to 30-Day Traffic Deaths by NHTSA); FARS 1975-2014 Final File, 2015 Annual Report File (ARF); Vehicle Miles Traveled (VMT): FHWA.

<https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812318>

[Open data and traffic fatalities](#)





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





How cars are sold today Camery/Monaco



<https://www.ispot.tv/ad/ADQv/2017-toyota-camry-wish-bold>



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

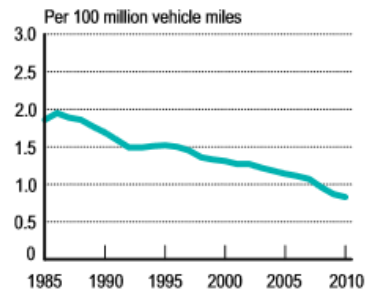
	2005	2006	2007	2008	2009	2010
Fatal Crashes						
Overall	39,252	38,648	37,435	34,172	30,797	30,196
Distraction	4,026	5,245	5,329	5,307	4,898	2,843
Percentage	10.3	13.6	14.2	15.5	15.9	9.4
Injury Crashes						
Overall	1,816,000	1,746,000	1,711,000	1,630,000	1,517,000	1,542,000
Distraction	399,000	339,000	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)

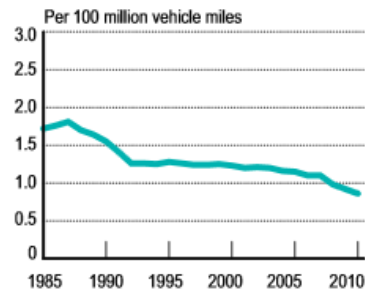


1-4 Fatality Rates for Selected Modes: 1985–2010

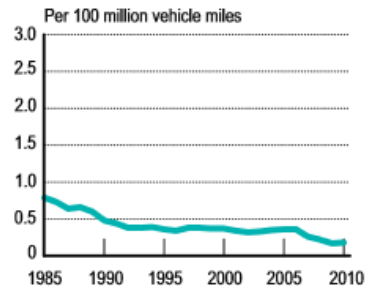
Passenger car occupants



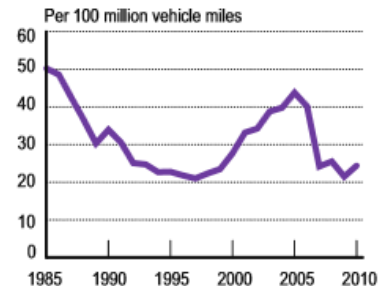
Light-truck occupants



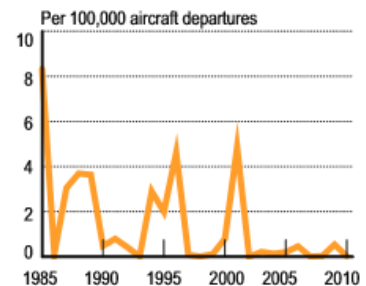
Large-truck occupants



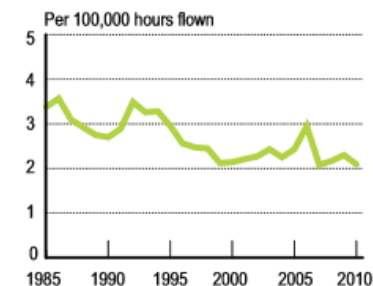
Motorcycle riders



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.



2-1 The Transportation Network: 2011

Mode	Components	
Highway	Miles of public road	4,059,339
	Interstate Highway System (2008)	47,011
	Other National Highway System (2008)	117,084
	Other roads (2008)	3,895,244
Air	Airports	19,782
	Public use	5,172
	Private use	14,339
	Military	271
Rail	Miles of railroad operated	161,195
	Class I freight railroads ^a	95,514
	Regional freight railroads (2010)	12,000
	Local freight railroads (2010)	32,456
	Amtrak (passenger) ^b	21,225
Public transit	Directional route-miles ^c	242,306
	Bus ^d	220,076
	Bus rapid transit ^d	119
	Commuter bus ^d	10,721
	Trolley bus ^d	456
	Commuter rail	7,576
	Heavy rail	1,617
	Hybrid rail	207
	Light rail	1,398
	Streetcar rail	136

The Transportation Network: 2011

Mode	Components	
Public transit (cont.)	Stations	3,155
	Commuter rail	1,219
	Heavy rail	1,041
	Hybrid rail	49
	Light rail	761
	Streetcar rail	85
Water	Miles of navigable waterways	25,320
	Direction route-miles of ferry routes (2010)	697
	Commercial waterway facilities ^e (2010)	8,184
	Great Lakes	647
	Inland	1,949
	Ocean	5,588
	Lock chambers (2010)	238
Pipeline	Miles of pipeline	1,735,237
	Hazardous liquid	177,631
	Gas transmission and gathering	324,606
	Gas distribution	1,233,000

1-3 Transportation Vehicles number



Mode	2001	2011
Air		
Air carrier aircraft	8,497	7,028
General aviation aircraft	211,446	222,250
Highway		
Light duty vehicle ^a	221,821,103	233,841,422
Truck	7,857,675	10,270,693
Motorcycle	4,903,056	8,330,210
Rail		
Class I freight locomotive	19,745	24,250
Class I freight car	499,860	380,699
Amtrak locomotive	401	287
Amtrak car	2,084	1,301
Transit rail		
Commuter rail ^b	5,528	6,971
Heavy rail ^b	10,718	14,942
Light rail ^b	1,359	1,969
Water		
Nonself-propelled vessel	33,042	31,498
Self-propelled vessel	8,546	8,979
Oceangoing vessel	274	214
Recreational boat	12,876,346	12,173,935

^aIncludes passenger cars, light trucks, vans, and sport utility vehicles.

^bIncludes revenue vehicles available for maximum service.



3-1 Vehicle-Miles: 2007–2010 (millions)

Mode	2007	2008	2009	2010
Air				
Air carrier	6,733	6,446	5,935	5,976
Highway				
Light duty vehicles ^a	2,691,034	2,630,213	2,633,248	2,647,659
Motorcycles	21,396	20,811	20,822	18,462
Buses ^b	14,516	14,823	14,387	13,789
Trucks	304,178	310,680	288,306	286,585
Rail ^c				
Transit ^d	741	762	775	759
Commuter	325	337	337	342
Intercity/Amtrak ^e	267	272	282,764	295
Class I freight	38,186	37,226	32,115	35,541
Other transit ^f	916	989	1,061	1,055

^aLight duty vehicles include passenger cars, light trucks, vans and sport utility vehicles regardless of wheelbase. ^bIncludes municipally owned transit and commercial, Federal, and school buses. ^cCar-miles. ^dIncludes light and heavy rail only. ^eFiscal year data. ^fIncludes on-demand service and other unspecified forms of transit.

3-2 Passenger-Miles: 2007–2010 (millions)

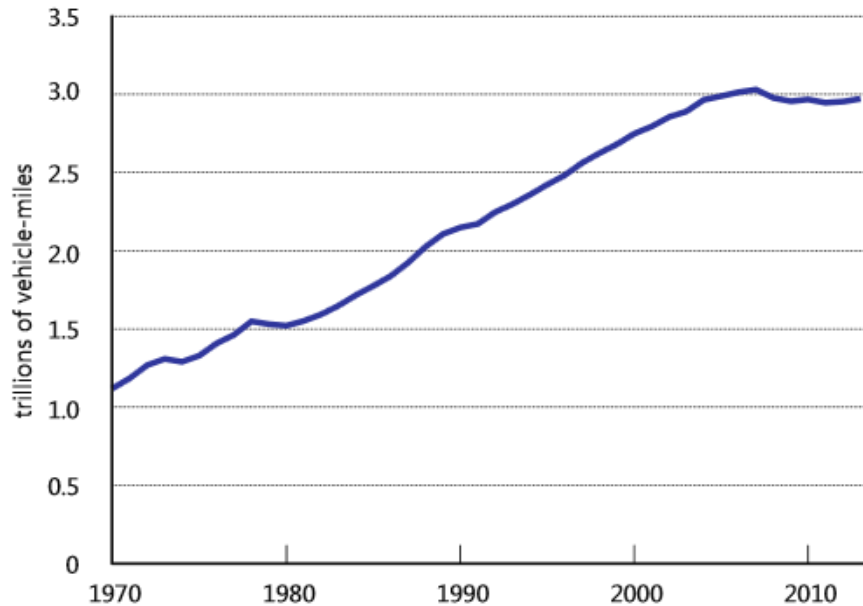
Mode	2007	2008	2009	2010
Air				
Air carrier	607,564	583,292	551,741	564,790
Highway				
Light duty vehicles ^a	4,341,984	4,248,783	3,625,598	3,645,368
Motorcycles	27,173	26,430	22,428	19,886
Buses ^b	307,753	314,278	305,014	292,319
Trucks	304,178	310,680	288,306	286,585
Rail				
Transit ^c	18,068	18,931	19,001	18,580
Commuter	11,137	11,032	11,129	10,774
Intercity/Amtrak ^d	5,784	6,179	5,914	6,420
Other transit ^e	2,125	2,390	2,500	2,535

3-3 Annual Percent of Person Trips by Transportation Mode: 1990, 1995, 2001, 2009

	1990	1995	2001	2009
Private vehicle	87.8	89.3	86.3	83.4
Transit	1.8	1.8	1.6	1.9
Walk	7.2	5.4	8.6	10.4
Other	3.2	3.2	3.4	4.2
Total	100%	100%	100%	100%

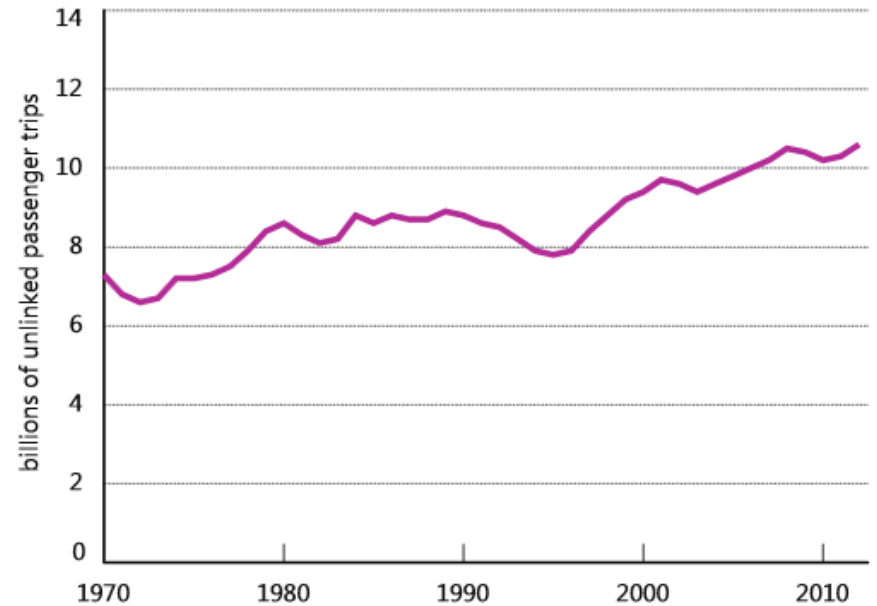


2-2 Highway Travel: 1970–2013



Note: Data for 2007 and later years may not be comparable to previous years due to changes in methodology.

2-4 Transit Ridership: 1970–2012



Note: Includes bus, commuter rail, demand response, heavy rail, light rail, trolley bus, ferry boat, aerial tramway, automated guideway, cable car, inclined plane, monorail, and other.



2-5 Daily Passenger Travel

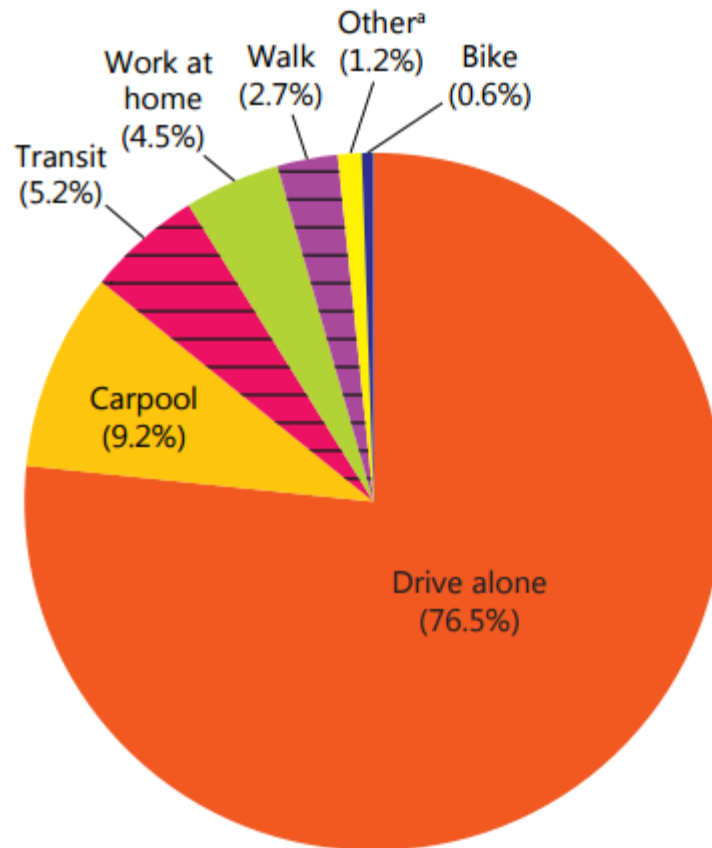
	1995	2001	2009
Travel per person			
Daily person trips	4.3	4.1	3.8
Daily person-miles of travel	38.7	40.3	36.1
Travel per driver			
Daily vehicle trips	3.6	3.4	3.0
Daily vehicle-miles of travel	32.1	32.7	29.0
Average commute			
Length in miles	11.6	12.1	11.8
Travel time in minutes	20.7	23.3	23.9
Percent 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

^aIncludes local transit bus, commuter bus, school bus, charter/tour bus, city-to-city bus. ^bIncludes subway/elevated rail, street car/trolley, and Amtrak/inter-city train. ^cIncludes ferry, hotel/airport shuttle, light electric vehicle, limousine, passenger line/ferry, sailboat/motorboat/yacht, ship/cruise, special transit, taxicab, other, and unknown.



2-6 Commute Mode Share: 2014

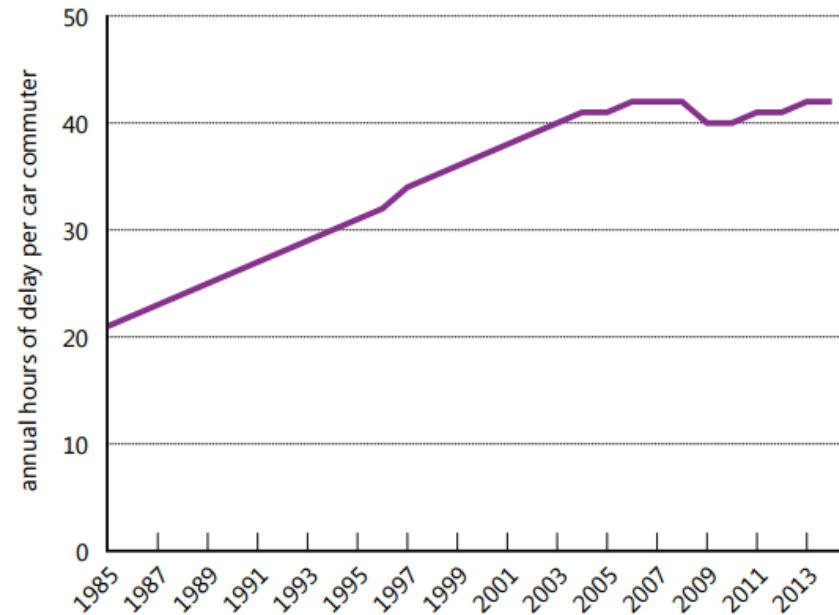
percent of workers age 16 and older



^a Includes motorcycle, taxi, and other means.



4-1 Road Congestion: 1985–2014



Notes: The methodology used to calculate congestion performance measures was updated to reflect more comprehensive data collection, including congestion estimates for each of the 471 U.S. urban areas.

Source: Texas A&M Transportation Institute, *2015 Urban Mobility Scorecard*, available at mobility.tamu.edu as of September 2015.

4-2 Top 10 Urban Congested Area Rankings: 2014 by hours of delay per car commuter

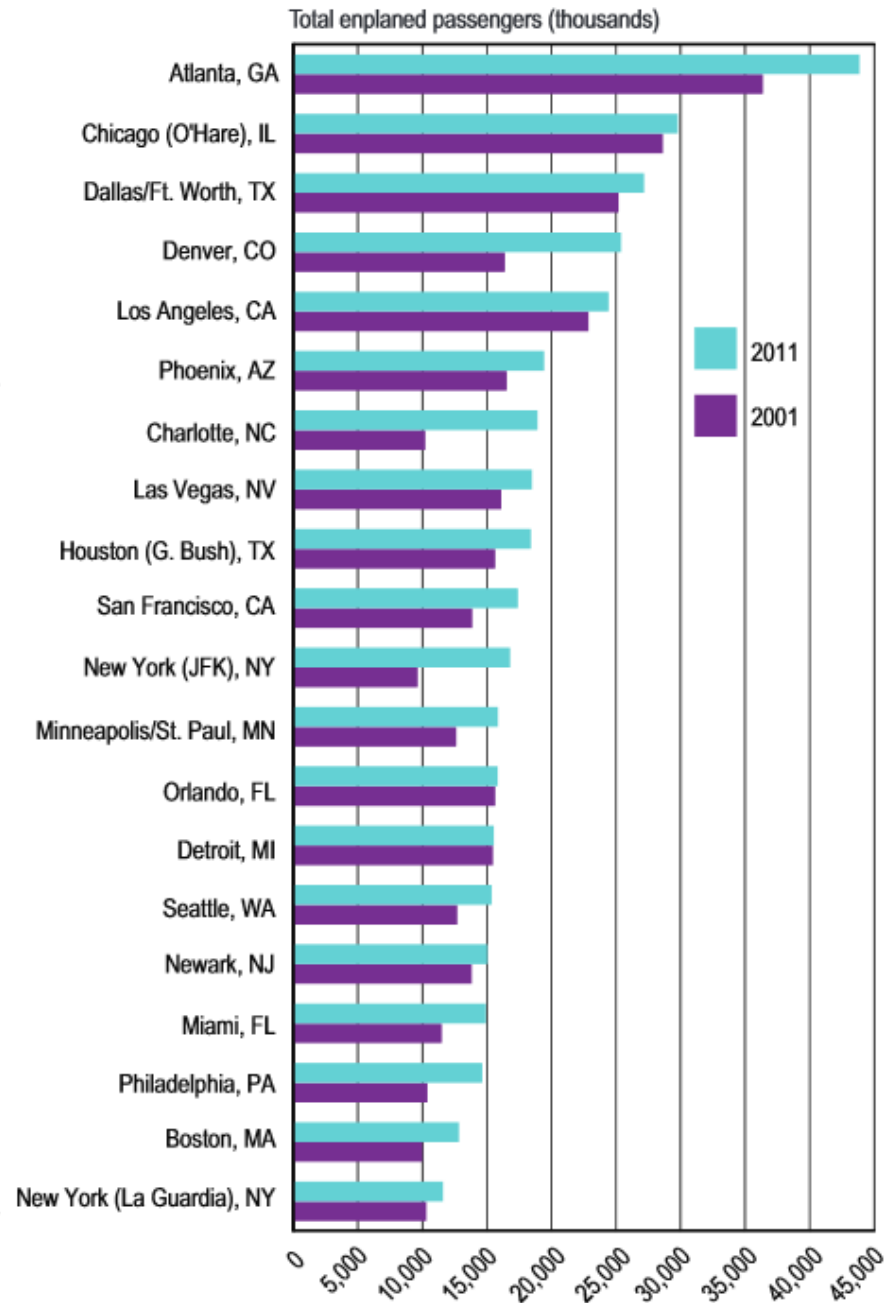
Rank	Urban area	Annual hours of delay per car commuter
1	Washington, DC-VA-MD	82
2	Los Angeles, CA	80
2	San Francisco, CA	78
4	New York, NY-NJ	74
5	Boston, MA-NH-RI	64
6	Seattle, WA	63
7	Chicago, IL-IN	61
7	Houston, TX	61
9	Dallas-Fort Worth-Arlington, TX	53
9	Atlanta, GA	52
	Average of 471 area average	42

Note: The methodology used was updated to reflect more comprehensive data collection efforts for each of the 471 U.S. urban areas.

**3-13 Top 20 World Airports by Passenger Movements^a:
2009 and 2010 (Thousands of passengers enplaned,
deplaned, and in-transit at airport)**

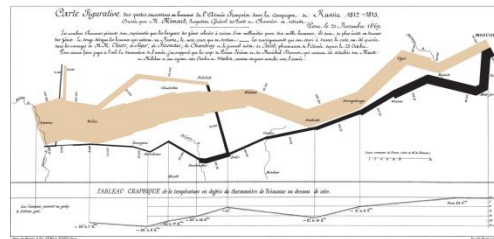
Rank (2010)	City (airport)	2009	2010	Percentage change 2009–2010
1	Atlanta, GA (Hartsfield)	88,032	89,332	1.5
2	Beijing, China (Beijing Capital)	65,372	73,948	13.1
3	Chicago, IL (O'Hare)	64,158	66,775	4.1
4	London, England (Heathrow)	66,038	65,884	-0.2
5	Tokyo, Japan (Haneda)	61,904	64,211	3.7
6	Los Angeles, CA (Los Angeles)	56,521	59,070	4.5
7	Paris, France (Charles de Gaulle)	57,907	58,167	0.4
8	Dallas/Ft Worth, TX (Dallas/Ft. Worth)	56,030	56,907	1.6
9	Frankfurt, Germany (Frankfurt)	50,933	53,009	4.1
10	Denver, CO (Denver)	50,167	52,209	4.1
11	Hong Kong, China (Hong Kong)	45,559	50,349	10.5
12	Madrid, Spain (Barajas)	48,251	49,845	3.3
13	Dubai, United Arab Emirates (Dubai)	40,902	47,181	15.4
14	New York, NY (JFK)	45,915	46,514	1.3
15	Amsterdam, Netherlands (Schiphol)	43,570	45,212	3.8
16	Jakarta, Indonesia (Soekarno–Hatta)	37,144	44,356	19.4
17	Bangkok, Thailand (Suvarnabhumi)	40,500	42,785	5.6
18	Changi, Singapore (Singapore)	37,204	42,039	13.0
19	Guangzhou, China (Guangzhou Baiyun)	37,049	40,976	10.6
20	Shanghai, China (Shanghai Pudong)	32,103	40,579	26.4

**3-11 Top 20 U.S. Passenger Airports, Enplaned
Passengers: 2001 and 2011**





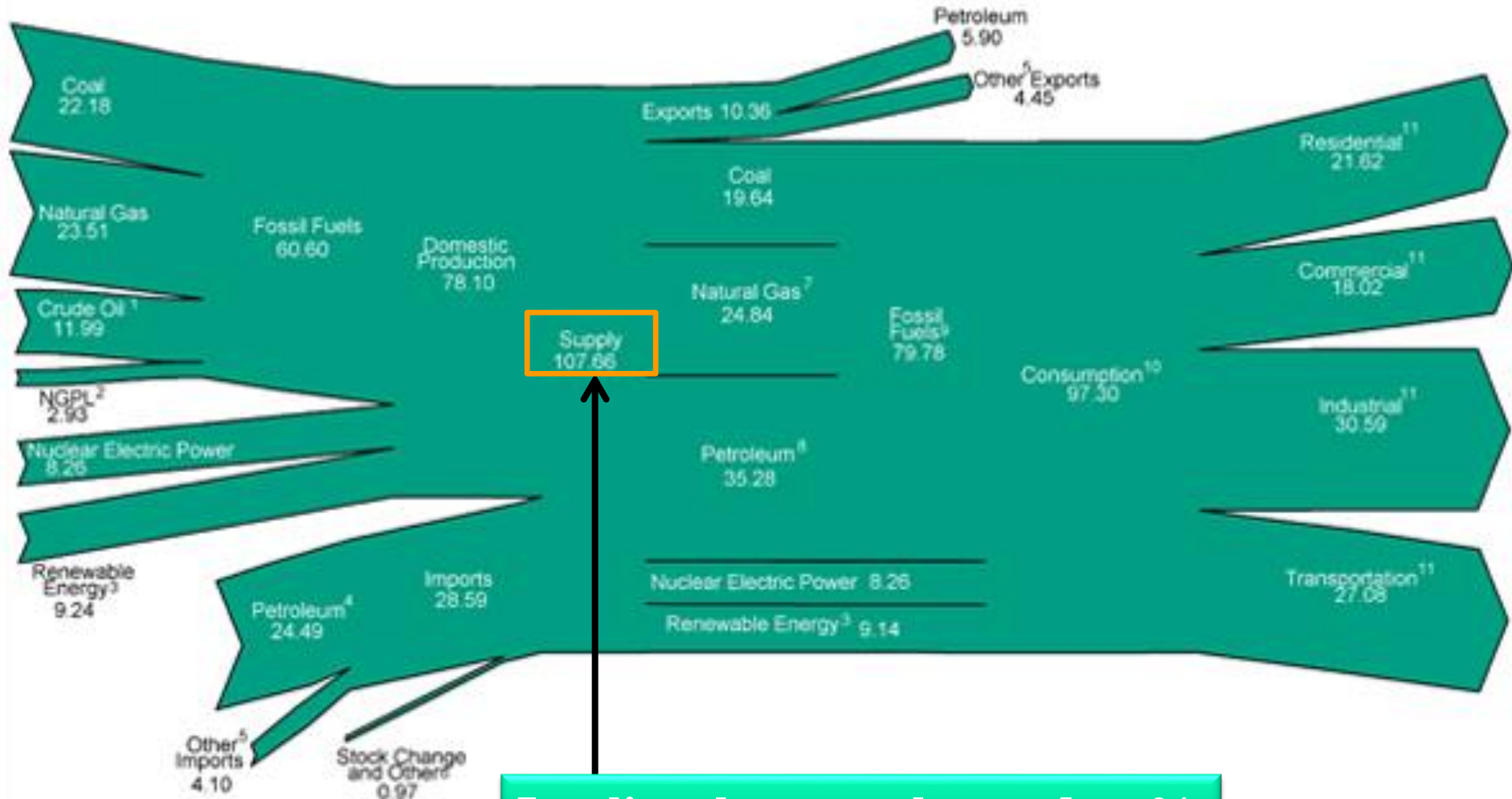
What is this?:



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. 😊)

Energy Flow 2011

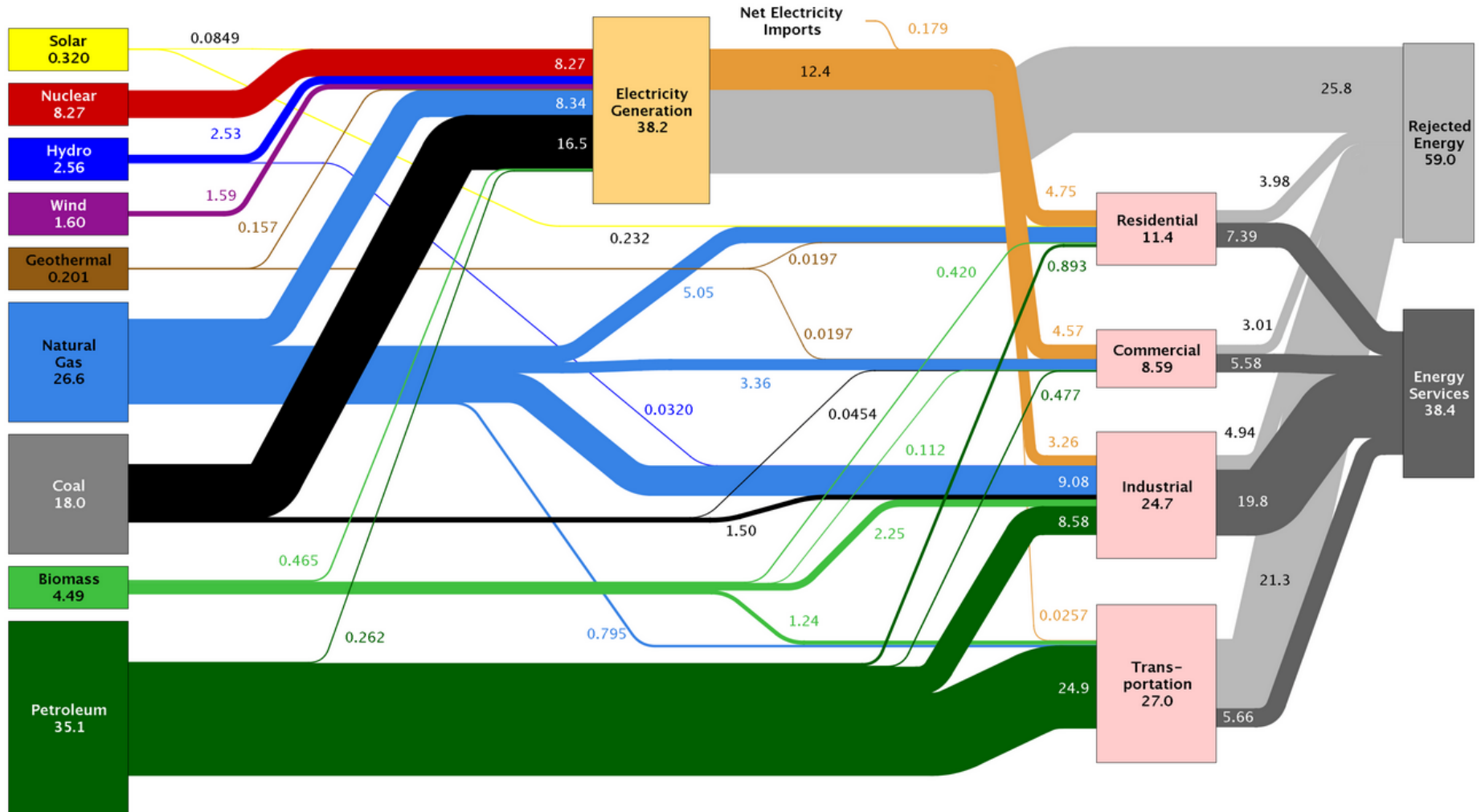


Implies chart can be read as %

Energy Flow 2013



Estimated U.S. Energy Use in 2013: ~97.4 Quads



Source: LLNL 2014. Data is based on DOE/EIA-0035(2014-03), March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527



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.

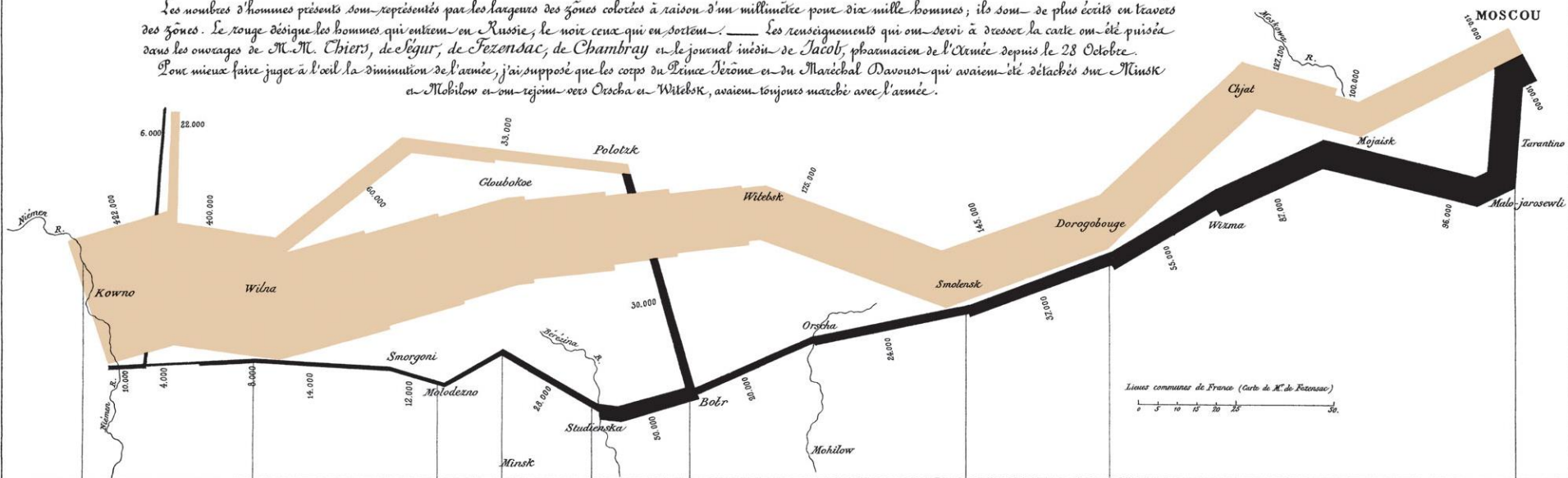
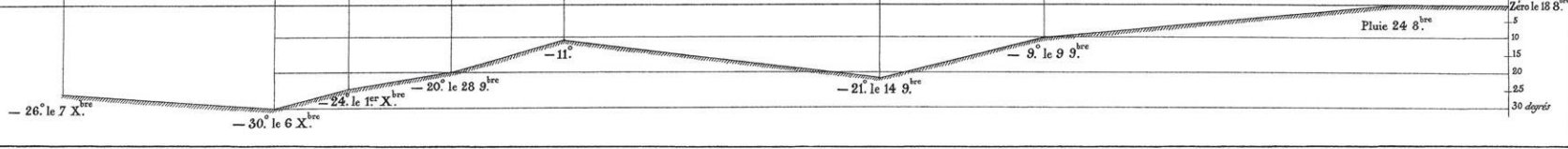


TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.

Les Cosaques passent au galop le Niemen gelé.



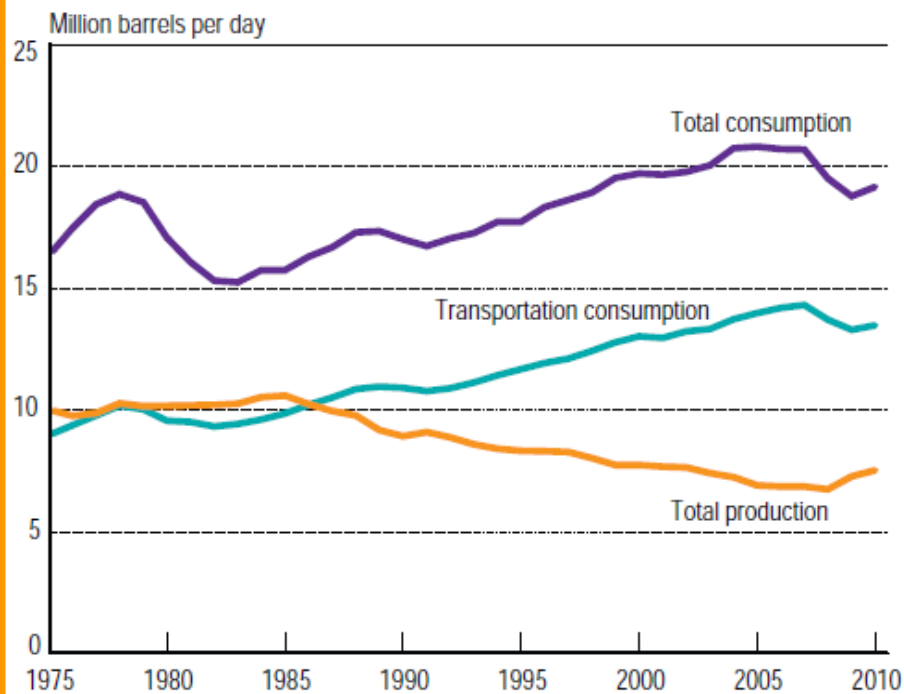
Autog. par Regnier, 8. Rue. S^{te} Marie S^t G^{ermain} à Paris.

Imp. Lith. Regnier et Bourdet.



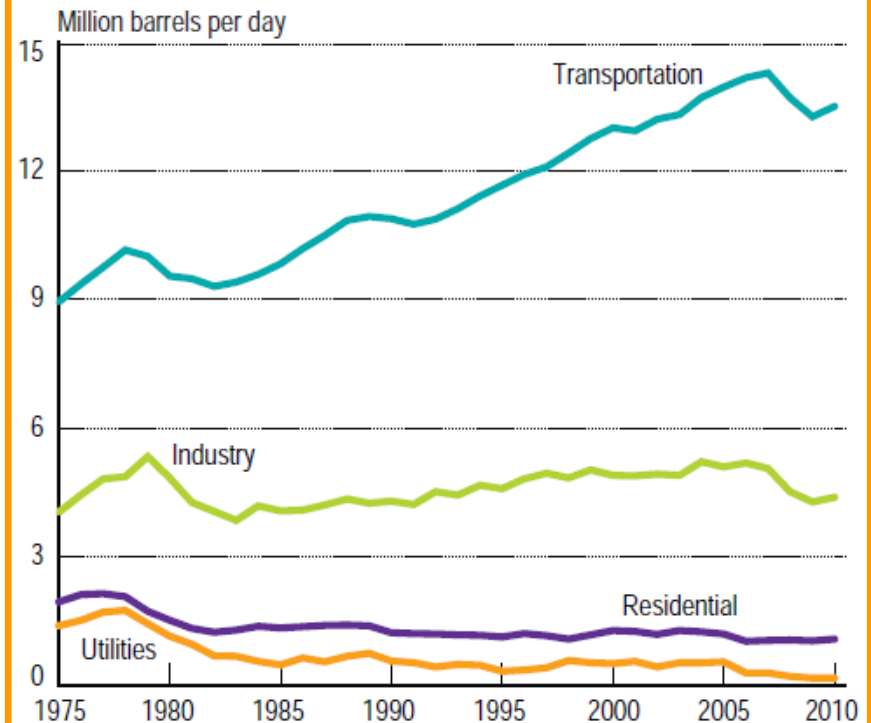
Petroleum Consumption

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

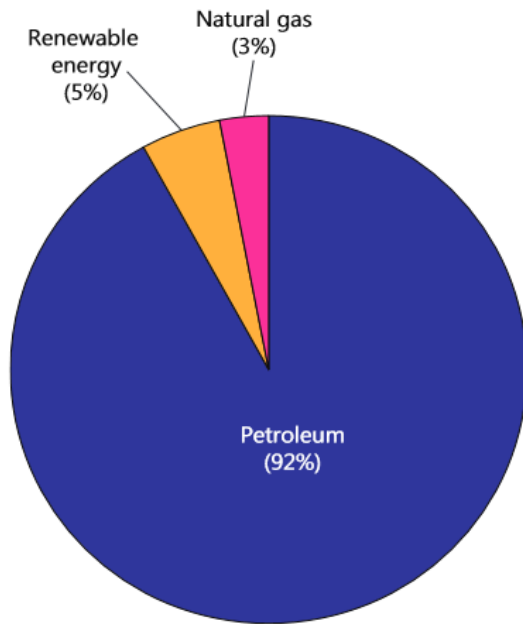


Note: The 2010 data are preliminary.



7-2 Transportation Energy Consumption by Source: 2013

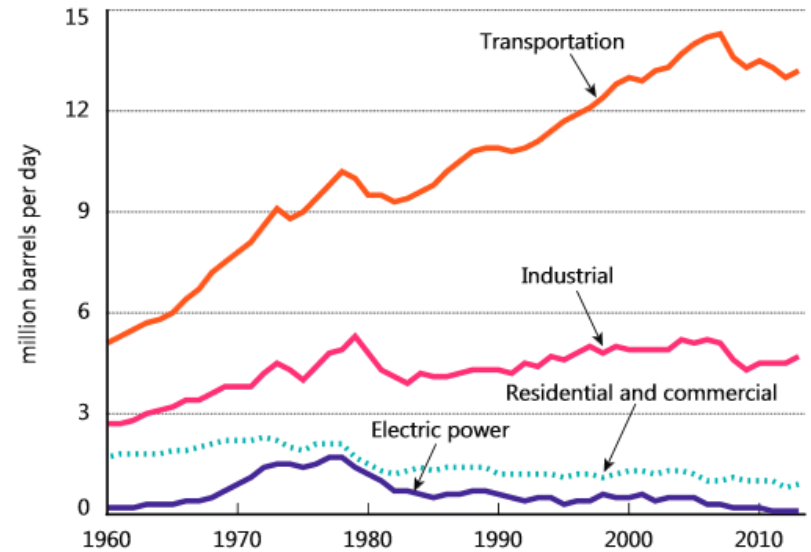
percent of Btu consumed



Key: Btu = British thermal unit.

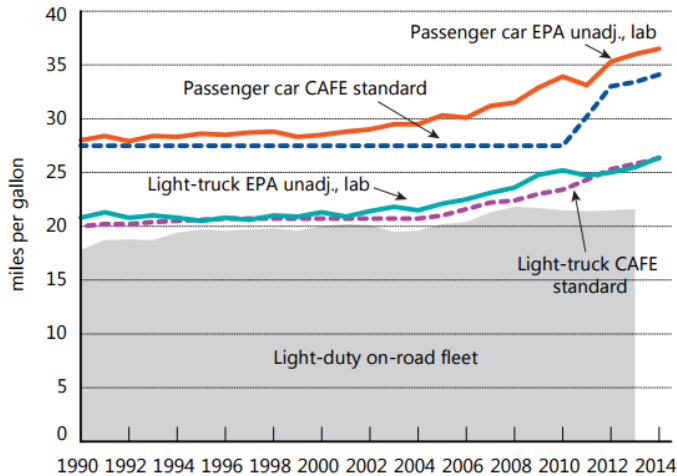
Note: Excludes electricity retail sales and electrical system energy losses.

7-3 Petroleum Consumption by Sector: 1960–2013



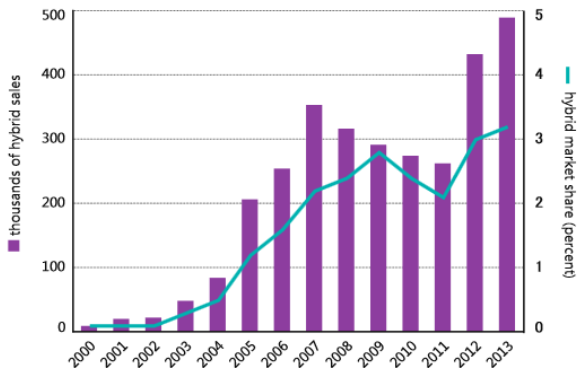
Source: U.S. Department of Energy, U.S. Energy Information Administration, *Monthly Energy Review*, available at www.eia.gov/totalenergy/data/monthly as of September 2014.

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



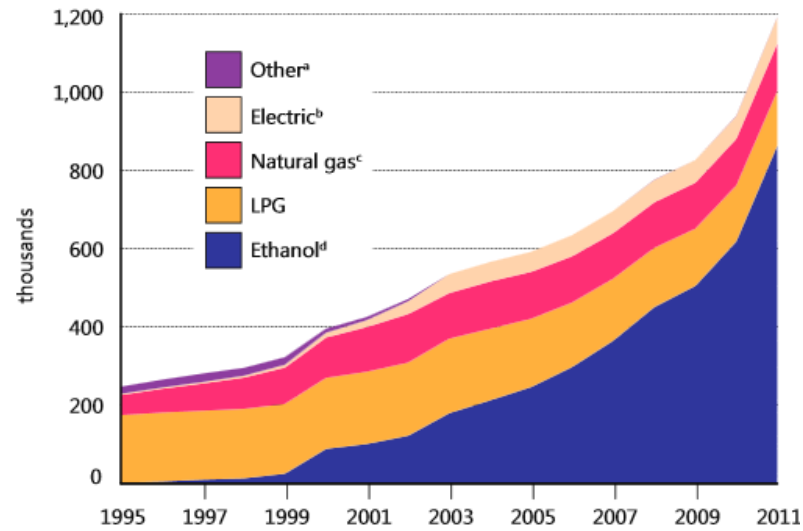
Key: CAFE = Corporate Average Fuel Economy

7-9 Hybrid Vehicle Sales: 2000–2013



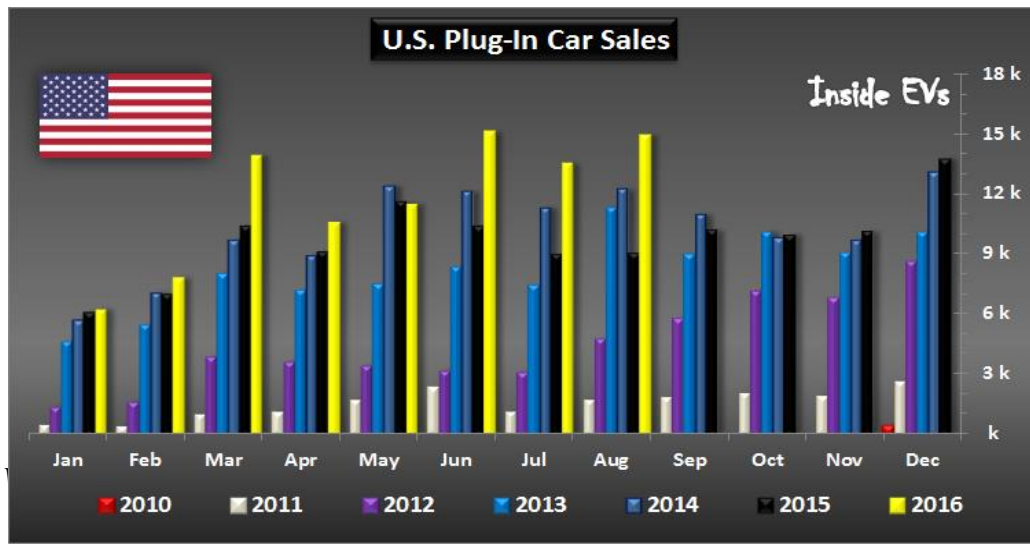
Source: Ward's Automotive Group, www.wardsauto.com as of September 2014.

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 liquified 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.

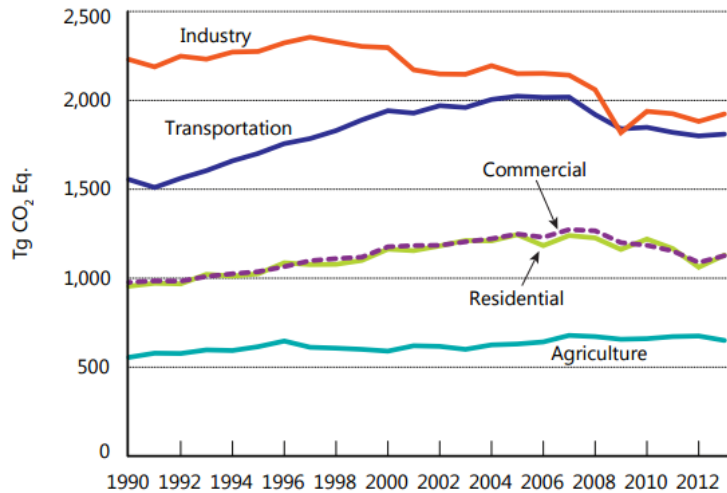
Inside EVs



Transportation and Air Quality



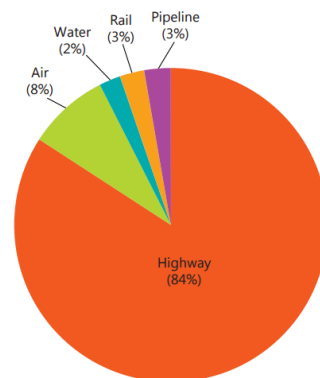
7-4 Greenhouse Gas Emissions by Sector: 1990–2013



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

7-5 Greenhouse Gas Emissions by Transportation Mode: 2013

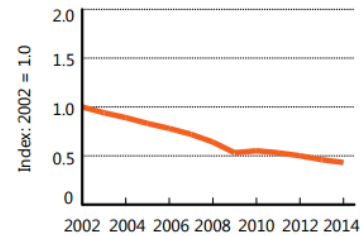
Percent of Tg CO₂ Eq.



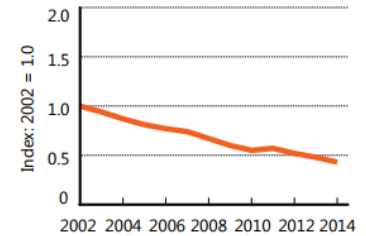
Key: GHG = greenhouse gas. Tg CO₂ Eq. = teragrams of carbon dioxide equivalent. A teragram = 1 million metric tons.

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

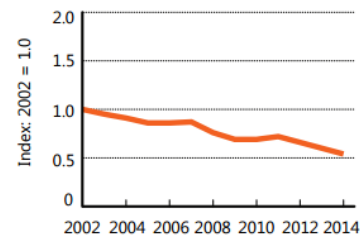
Carbon monoxide



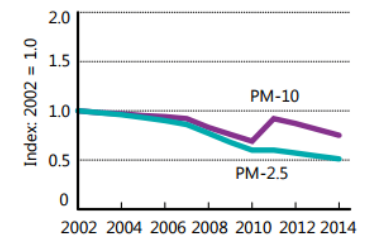
Nitrogen oxide



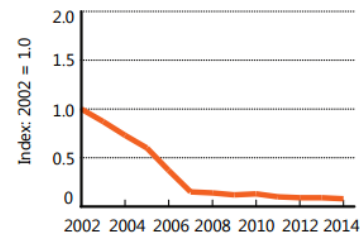
Volatile organic compounds



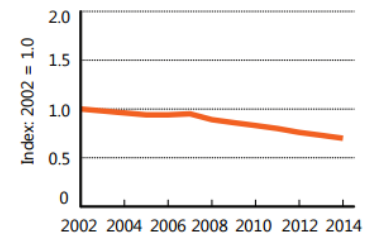
Particulate matter



Sulfur dioxide



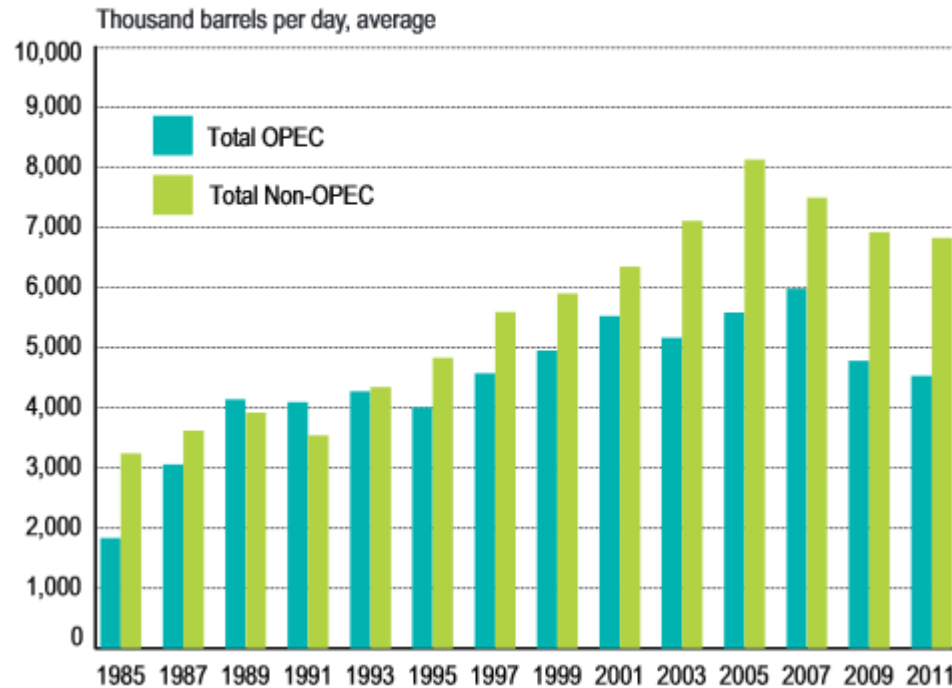
Ammonia



Key: PM-10 = airborne particulates of less than 10 microns; PM-2.5 = airborne particulates of less than 2.5 microns.



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

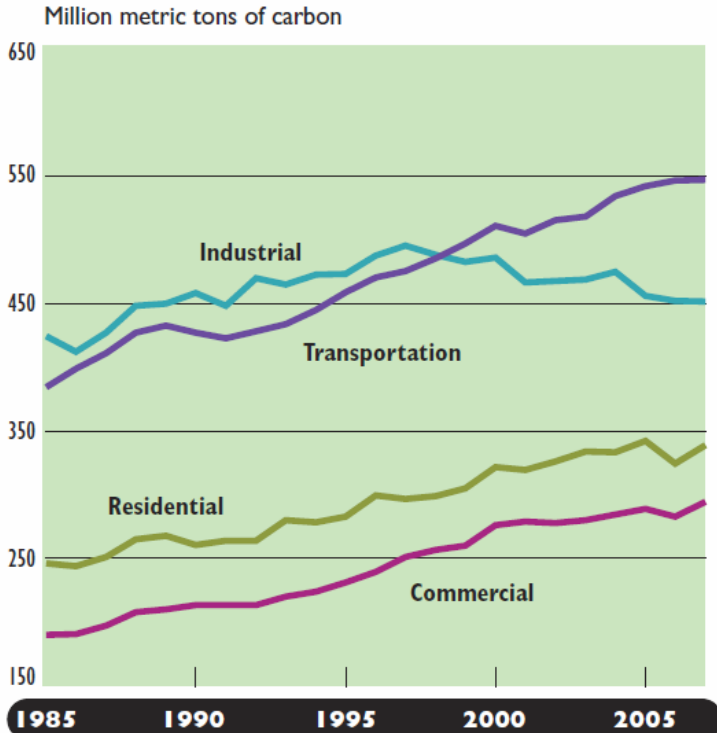


4-15 Major Sources of Petroleum Consumed in the U.S.: 1990, 2000, 2010, 2011 (thousand barrels per day, average)

	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%



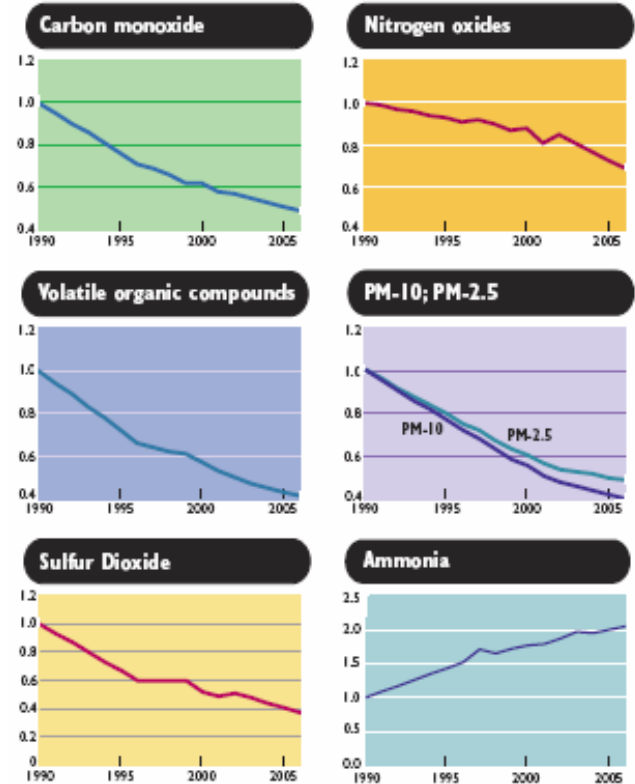
U.S. Carbon Dioxide Emissions from Energy Use: 1985–2007



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

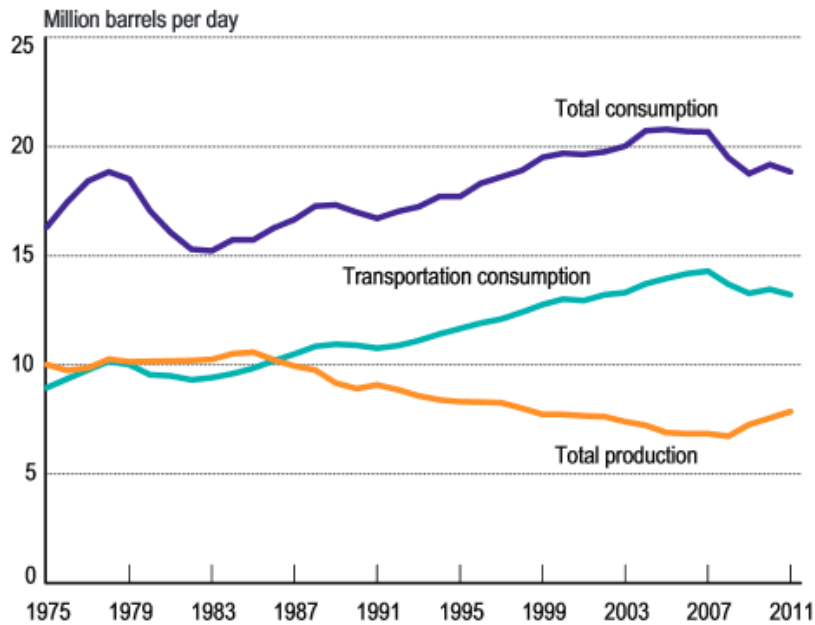


Key: PM-10 and PM-2.5 = airborne particulates of less than 10 microns or 2.5 microns, respectively.

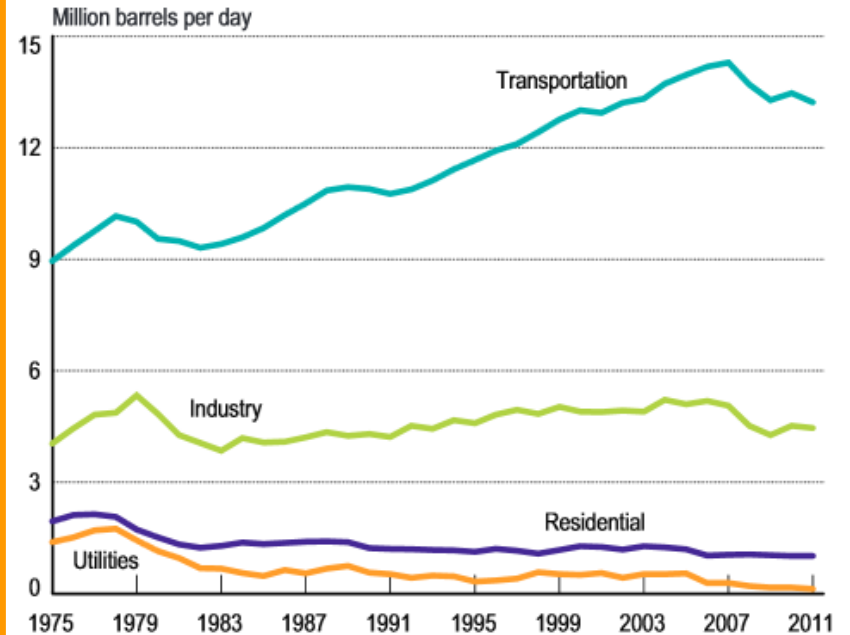
Notes: Data include emissions from onroad mobile sources only. EPA revised the emissions estimation methodology for onroad mobile sources. EPA discontinued lead emissions estimated in 2001.



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

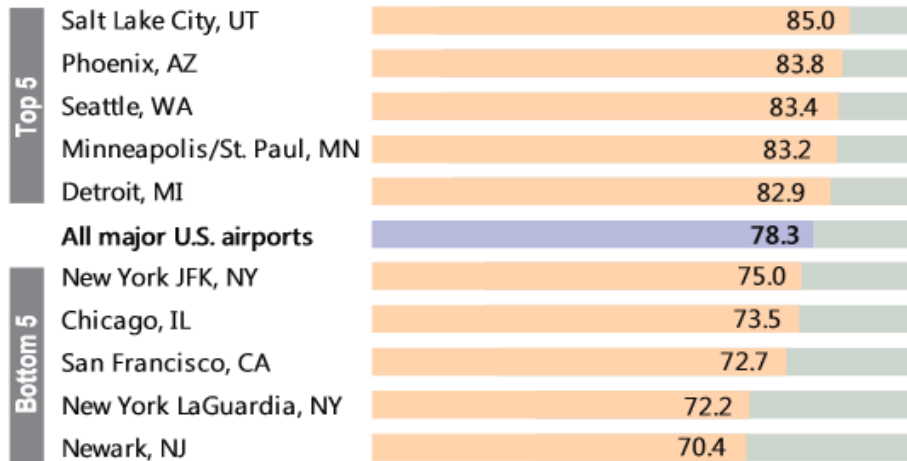
by enplaned, deplaned, and in-transit passengers

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



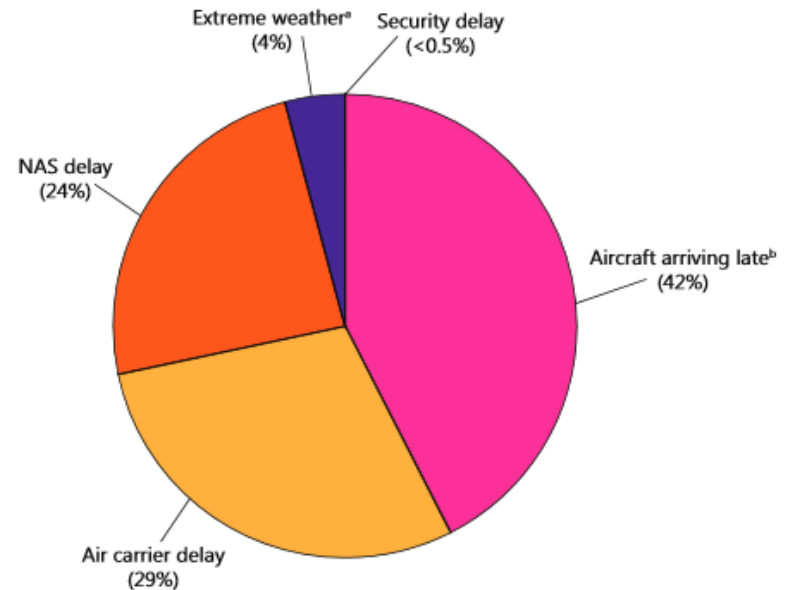
4-5 U.S. Major Airport Performance Rankings: 2013

by percent of on-time arrivals



4-4 U.S. Airport Delays by Cause: 2013

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