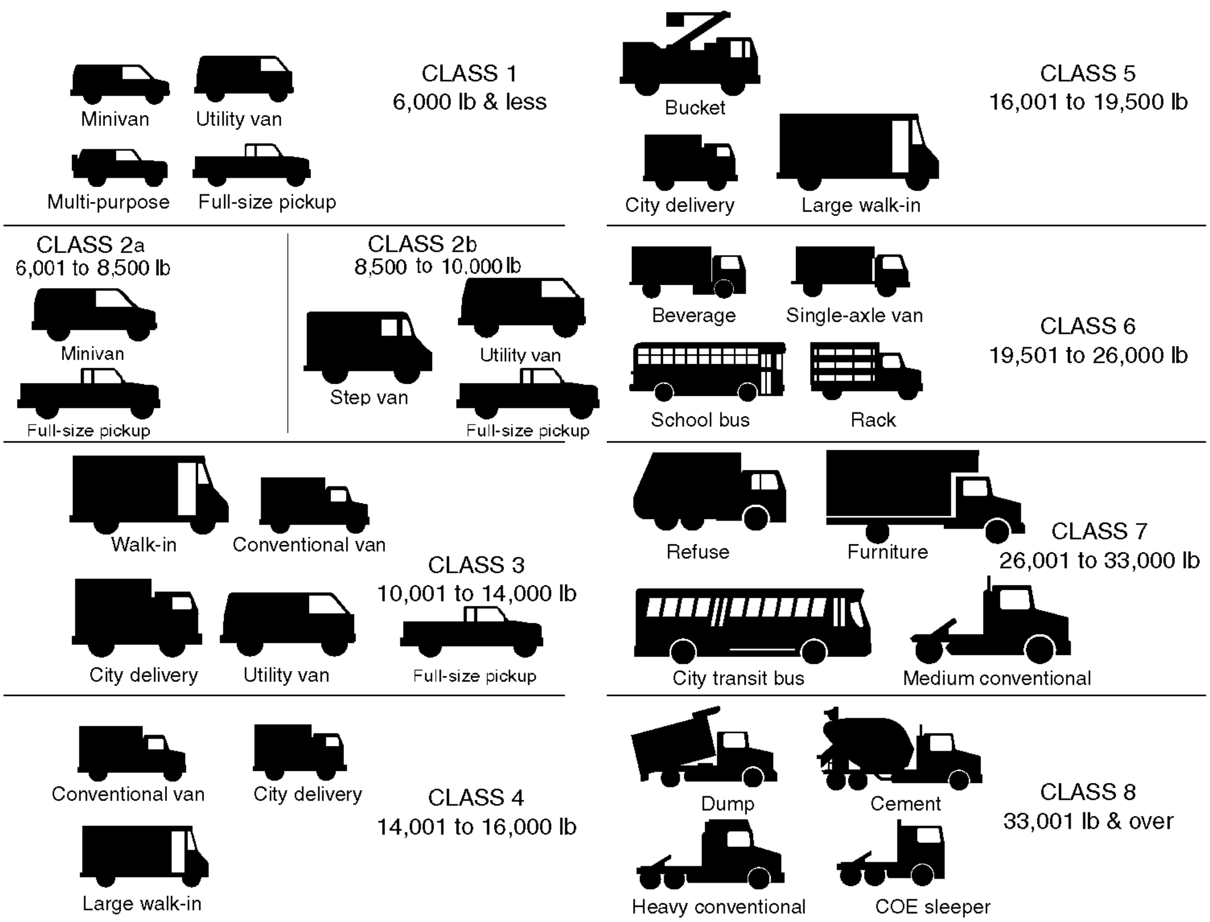
Chapter 1: Industry Characterization

1.1 Introduction:

1.1.1 Overview

In order to assess the impacts of greenhouse gas (GHG) regulations upon the affected industries, it is important to understand the nature of the industries impacted by the regulations. These industries include the manufacturers of Class 2b through Class 8 trucks, engines, and some equipment. This chapter provides market information for each of these affected industries for background purposes. Vehicles in these classes range from over 8,500 pounds (lbs) gross vehicle weight rating (GVWR) to upwards of 80,000 lbs and can be used in applications ranging from ambulances to vehicles that transport the fuel that powers them Figure 1-1 shows the difference in vehicle classes in terms of GVWR and the different applications found in these classes.

Figure 1-1 Description and Weight Ratings of Vehicle Classes



Source: Commercial Carrier Journal http://www.ccjmagazine.com

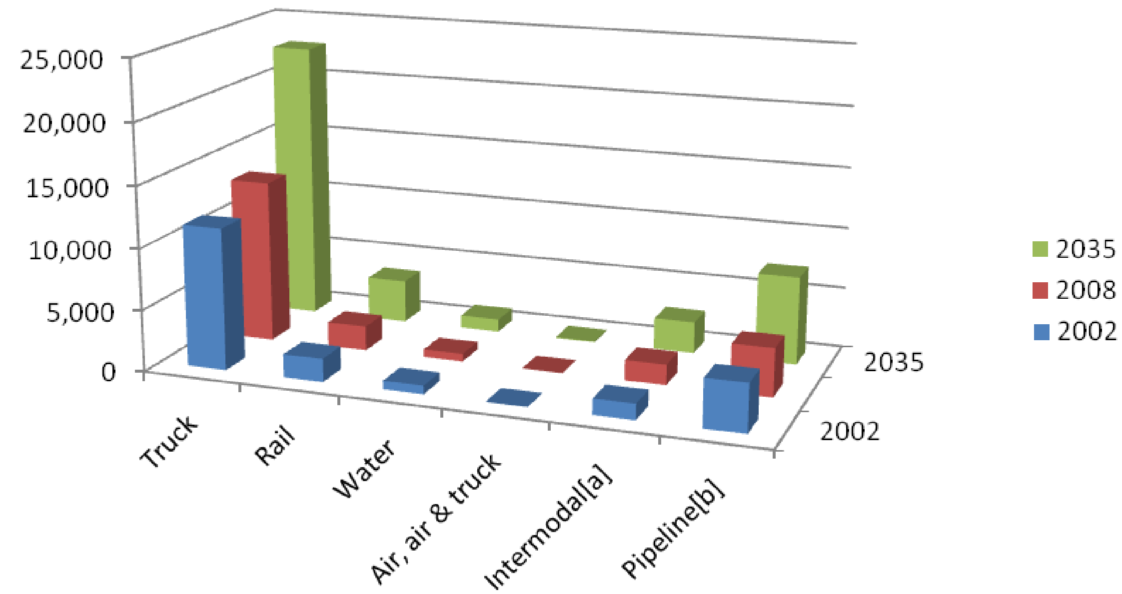
Heavy duty trucks in this rulemaking are defined as on-highway vehicles with a GVWR greater than 8,500 lbs and are not defined as Medium Duty Passenger Vehicles (MDPV). The EPA and NHTSA jointly developed the Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards; Final Rule 75 FR 25323 (May 7, 2010) which sets standards for Light Duty Vehicles, Light Duty Trucks, and Medium Duty Passenger Vehicles (EPA-420-F-10-014). Light duty trucks are vehicles with GVWR less than 8,500 lbs. MDPV are vehicles with GVWR less than 10,000 pounds which meet the criteria outlined in 40 C.F.R. §86.1803-01. This grouping typically includes large sport utility vehicles, small trucks, and mini-vans.

The heavy duty segment is very diverse both in terms of its type of vehicles and vehicle usage patterns. Unlike the light duty segment whose primary mission tends to be transporting passengers for personal travel, the heavy duty segment has many different missions. Some pickup trucks may be used for personal transportation to and from work with an average annual mileage of 15,000 miles. Class 8 sleeper cab tractor/trailers are primarily used for freight transportation, can carry up to 50,000 pounds of payload, and can travel more than 150,000 miles per year. For the purposes of this report, the medium- and heavy-duty segment has been separated as follows: Class 2b and 3 pickup trucks and vans, Class 2b through 8 vocational trucks, Class 7 and 8 combination tractors, trailers, and transit buses.

1.1.2 Freight

In 2008, heavy and medium-duty trucks carried more freight in terms of tonnage and value in the U.S. than all other modes of freight transportation combined, and are expected to move freight at an even greater rate in the future.[1] According to the U.S. Department of Transportation (DOT), the U.S. transportation system moved, on average an estimated 59 million tons of goods worth an estimated $55 billion (in U.S. $2008) per day in 2008, or over 21 billion tons of freight worth more than $20 trillion in the year 2008.[2] Of this, trucks moved over 13 billion tons of freight worth an estimated $13 trillion in 2008, or an average of nearly 36 million tons of freight worth $37 billion a day. The DOT's Freight Analysis Framework estimates that this tonnage will increase nearly 73 percent by 2035, and that the value of the freight moved is increasing faster than the tons transported. Figure 1-2 shows the total tons of freight moved by each mode of freight transportation in 2002, 2008 and projections for 2035.

Figure 1-2 Total Weight of Shipments by Transportation Mode (millions of tons)



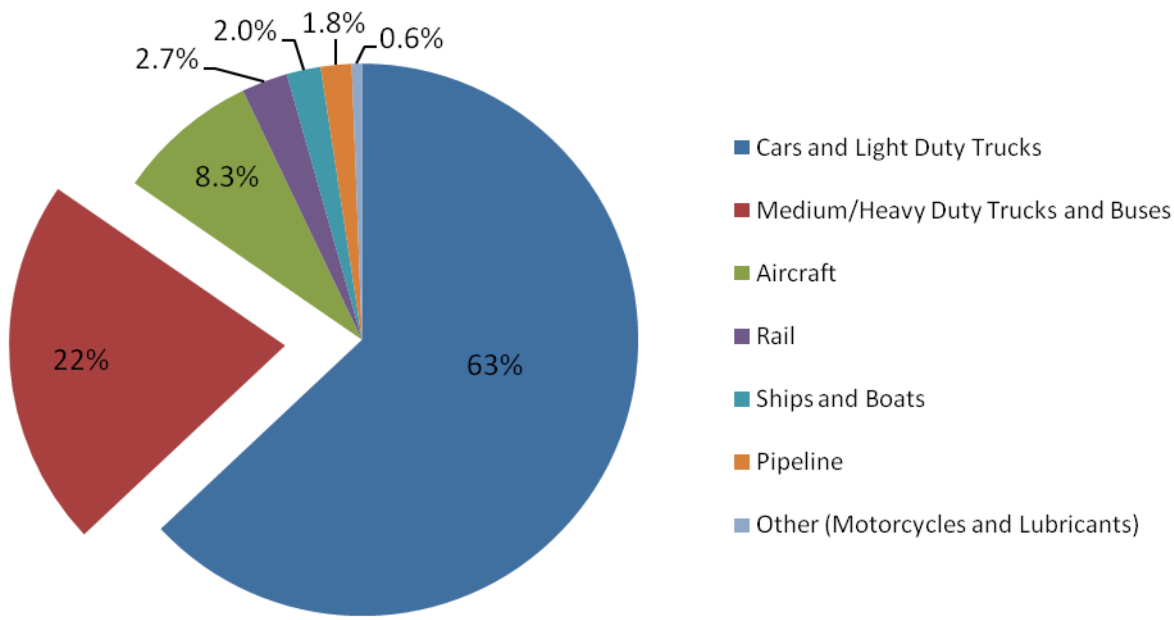
Notes: [a] Intermodal includes U.S. Postal Service and courier shipments and all intermodal combinations, except air and truck. Intermodal also includes oceangoing exports and imports that move between ports and interior domestic locations by modes other than water.
[b] Pipeline also includes unknown shipments as data on region-to-region flows by pipeline are statistically uncertain.

Source: U.S. DOT, Federal Highway Administration, "Freight Facts and Figures

1.1.3 Greenhouse Gases

The importance of this proposed rulemaking is highlighted by the fact that heavy- and medium-duty trucks are the largest source of GHG emissions in the transportation sector after light-duty vehicles. This sector represents approximately 22 percent of all transportation related GHG emissions as shown in Figure 1-3. Heavy and medium-duty trucks are also a fast growing source of GHG emissions; total GHG emissions from this sector increased over 72 percent from 1990-2008 while GHG emissions from passenger cars grew approximately 20 percent over the same period.[3] Available technologies developed through EPA's SmartWay program and through DOE's 21st Century Truck Partnership can achieve reductions from 10-20 percent and are applicable to the majority of heavy and medium-duty vehicles; examples of these technologies include aerodynamic bumpers, mirrors, and fairings.[4]

Figure 1-3 Transportation Related Greenhouse Gas Emissions (Tg CO_2 Eq.) in 2008



Source: U.S. EPA, Inventory of Greenhouse Gas Emissions and Sinks: 1990-2008, published April, 2010

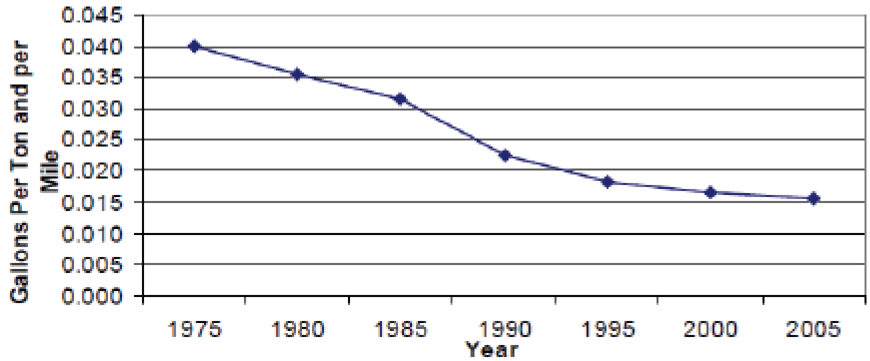
1.1.4 Fuel Economy

Discussion:

While there is a corporate average fuel economy (CAFE) program for light duty trucks and vehicles, the nature of the commercial truck market can present complications to such a structure in particular due to the production process, diversity of products, and usage patterns.[5] For example, in the light-duty market a manufacturer builds a complete vehicle and therefore, is responsible to certify that vehicle. In the medium- and heavy-duty truck market, there may be separate: chassis, engine, body and equipment manufacturers that contribute to the build process of a single truck; in addition, there are no companies that produce trucks and trailers and a given tractor may pull hundreds of different trailer types over the course its life. Further, fuel economy is highly dependent on the configuration of a truck, for example: the type of body or box, engine, axle/gear ratios, cab, or other equipment installed on the vehicle; whether or not a truck carries cargo or has a specialized function (e.g. a bucket truck). Due to the varying needs of the industry, many of these trucks are custom built resulting in literally thousands of different truck configuration. Finally, usage patterns and duty cycles also greatly affect fuel economy, for example how trucks are loaded (cubed or weighed out) and how they are driven (delivery trucks travel at lower speeds and make frequent stops compared to a line-haul combination truck). The potential to reduce fuel consumption, therefore, is also highly dependent on the truck configuration and usage.

Looking at the total fuel consumed, total miles traveled, and total tons shipped in the U.S. or the average payload specific fuel consumption for the entire medium- and heavy duty fleet from 1975 through 2005, the amount of fuel required to move a given amount of freight a given distance has been reduced by more than half as a result of improvements in technology, as shown in Figure 1-4.[5]

1-4 U.S. Average Payload-Specific Fuel Consumption



(Source: NAS, Technologies and Approaches to Reducing Fuel Consumption of Medium- and Heavy-Duty Vehicles) available here: http://www.nap.edu/openbook.php?record_id=12845&page=R1

Currently, manufacturer of vehicles with a GVW of over 8,500 are not required to test and report fuel economy values, however, fuel economy ranges as of 2007 by vehicle class are presented in a study completed by the National Academy of Sciences (NAS), the U.S. Department of Transportation (DOT), and the National Highway Traffic Safety Administration (NHTSA). As one would expect, the larger the truck class the lower the fuel economy, for example, a typical mile per gallon (mpg) estimate for Class 2b vehicle is 10-15 mpg where a typical Class 8 combination truck is estimated to get 4-7.5 mpg, shown in

1-1 Estimated Fuel Economy by Truck Class

CLASS	EXAMPLE PRODUCTION VEHICLE	GVW	TYPICAL MPG RANGE IN 2007	TYPICAL TON-MPG	ANNUAL FUEL CONSUMPTION RANGE (THOUSANDS OF GALLONS)
2b	Dodge Ram 2500 Pickup Truck	8,501-10,000	10-15	26	1.5-2.7
3	Chevrolet Silverado 3500 Pickup Truck	10,001-14,000	8-13	30	2.5-3.8
4	Ford F-450	14,001-16,000	7-12	42	2.9-5.0
5	Kenworth T170	16,001-19,500	6-12	39	3.3-5.0
6	Peterbilt Model 330	19,501-26,000	5-12	49	5.0-7.0
7	Kenworth T370	26,001-33,000	4-8	55	6.0-8.0
8 Combination Trucks	International Lone Star	33,001-80,000	4-7.5	155	19 - 27

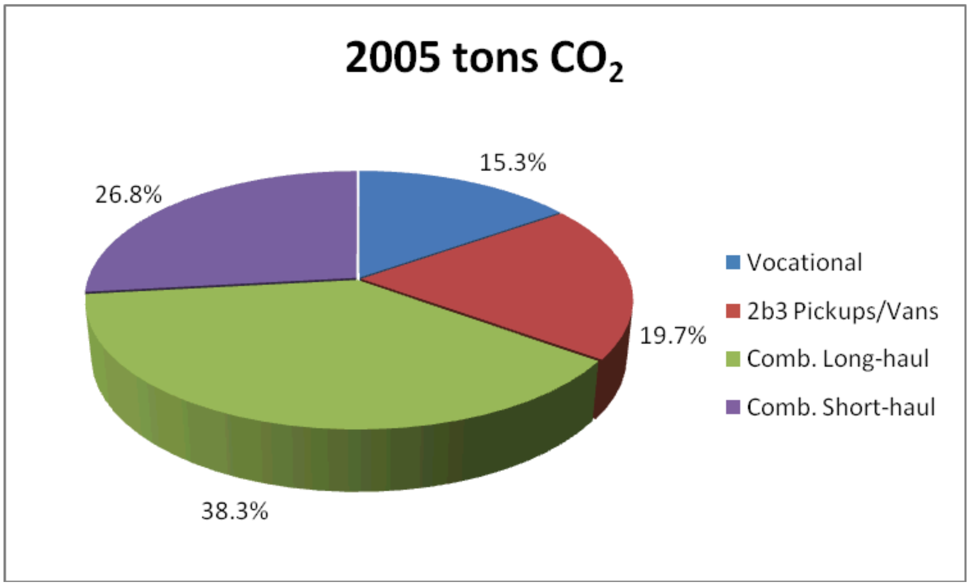
8 Other	Mack Granite GU814	33,001-80,000	2.5-6	115	10 - 13

1.2 Truck Classes

This program addresses vehicles that fall into the following four categories: Class 2b and 3 Pickups and Vans, Class 2b-8 Vocational trucks, Class 8 combination tractors.[A] Class 2b and 3 pickups and vans are used for commercial purposes such as ambulances, shuttle buses, etc. The U.S. Energy Information Administration (EIA) estimates that Class 2b vehicles get approximately 14.5 – 15.6 miles per gallon (mpg) in 2010.[6] Class 2b-8 vocational trucks encompass a wide range of medium and heavy-duty vehicles such as delivery trucks, school buses, etc. Fuel economy estimates for Class 3-6 are 7.8 mpg in 2010.[7] Class 8 combinations tractors operate as either short-haul or long-haul trucks. Combination tractors that operate as short-haul trucks also known as day cabs, are tractor trailers that do not have sleeping quarters for the driver and haul trailers only short distances, typically into metropolitan areas. Combination tractors that operate as long-haul trucks are those equipped with sleeping quarters for the driver, and tend to drive well over 1,000 miles per trip; this category contributed the most GHG emissions of these four categories at just over 38 percent of the total CO_2 emissions in 2005 as shown in Figure 1-5. The EIA estimates that in 2010, Class 8 freight hauling trucks get slightly over 6 mpg.[6]

[A] For purposes of this document, the term “heavy-duty” or “HD” is used to apply to all highway vehicles and engines that are not within the range of light-duty vehicles, light-duty trucks, and medium-duty passenger vehicles (MDPV) covered by the GHG and Corporate Average Fuel Economy (CAFE) standards issued for model years (MY) 2012-2016. Unless specified otherwise, the heavy-duty category incorporates all vehicles rated at a gross vehicle weight of 8,500 pounds, and the engines that power them, except for MDPVs.

Figure 1-5 Tons of CO_2 Emitted from Medium/Heavy Duty Trucking in 2005



1.2.1 Sales

Although not first in terms of GHG emissions, Class 2b and 3 pickup trucks and vans are first in terms of sales volumes, with sales of over 1.3 million units in 2005, or nearly 66 percent of the heavy- and medium-duty market. Sales of Class 3-8 vocational trucks are the second most numerous, selling over one-half million units in 2005, or nearly 25 percent of the heavy- and medium-duty market. Since 2005, sales of all heavy-duty trucks have decreased as the economy contracted; the U.S. EPA's MOVES model based on proprietary sales projections combined with the U.S. Energy Information Administration's Annual Energy Outlook reflects a slow recovery in sales.[6] Figure 1-5 and Figure 1-6 show the sales volumes for 2005 and projected sales for 2014 respectively, reflecting the market slowdown and recovery.

Figure 1-6 2005 Heavy-Duty Truck Sales by Category

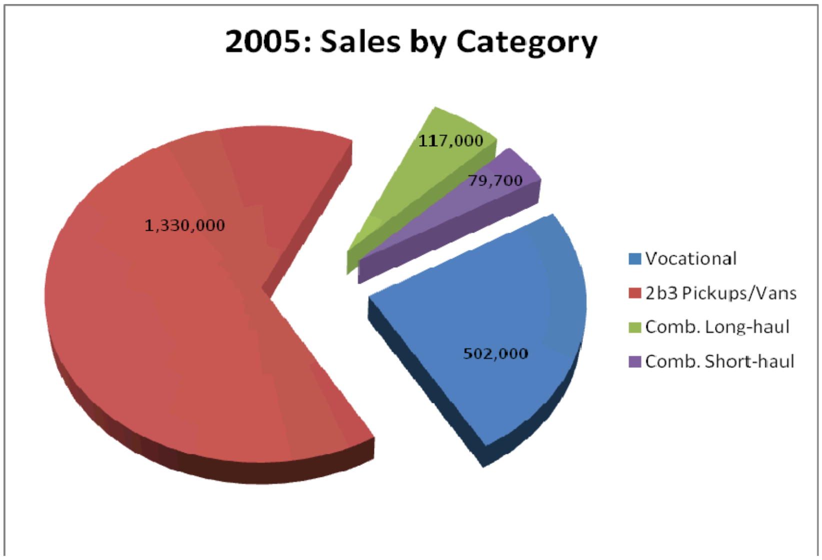
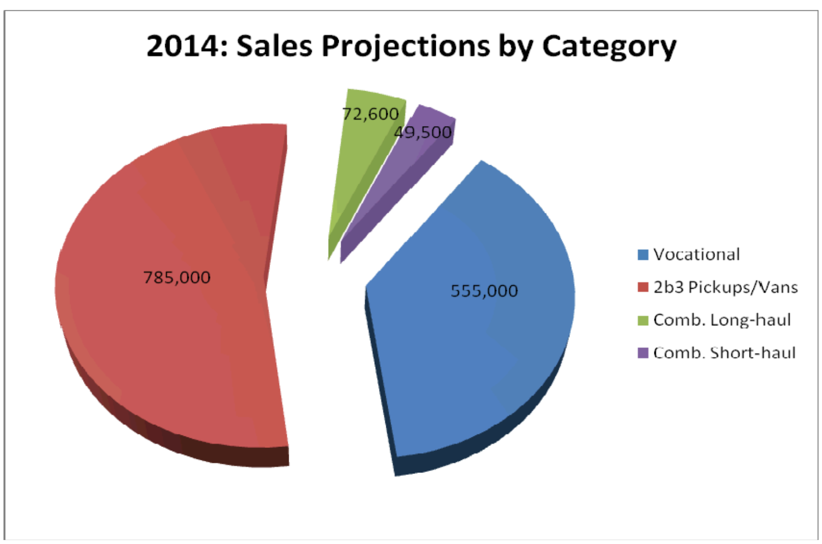


Figure 1-7 Projected Truck Sales for 2014 by Category



1.3 Medium- and Heavy-Duty Truck Segments

1.3.1 Class 2b and 3 Pickup Trucks and Vans

Class 2b and 3 pickup trucks and vans rank highest in terms of sales volumes, but together make up the third largest sector contributing to the medium- and heavy-duty truck GHG emissions (Class 2b through Class 8). There are number of reasons to explain this difference, but mainly it is the vehicle usage patterns and engine size. Class 2b/3 consists of pickup trucks and vans with a GVW between 8,500 and 14,000 pounds. Class 2b/3 truck manufacturers are predominately GM, Ford, and Chrysler, with Isuzu, Mitsubishi FUSO, and Nissan also offering vehicles in this market segment. Figure 1-7 shows two examples of this category, a Ford F350 pickup and a GM Chevrolet Express G3500.

Figure 1-8 Examples of Class 2b and 3 Pickup Trucks and Vans

Source: http://www.truckpaper.com

Class 2b/3 vehicles are sold either as complete or incomplete vehicles. For example a 'complete vehicle' can be a chassis cab (engine, chassis, wheels, and cab) or a rolling chassis (engine, chassis and wheels), while an 'incomplete chassis' could be sold as an engine and chassis only - no wheels. The technologies that can be used to reduce GHG emissions from this segment are very similar to the ones used for lighter pickup trucks and vans (Class 2a), which are part of the Light Duty GHG program. These technologies include engine improvements such as friction reduction, cylinder deactivation, cam phasing, and gasoline direct injection; aerodynamic improvements; low rolling resistance tires; and transmission improvements. The Class 2b/3 gasoline trucks and vans are currently certified with chassis dynamometer testing. The Class 2b/3 diesel trucks have an option to certify using the chassis dynamometer test procedure.

1.3.2 Class 2b-8 Vocational

This market segment includes a wide range of medium and heavy duty vehicles ranging from 8,501 pounds to greater than 33,000 pounds GVW. In 2005, sales of these vehicles were the second most numerous sold in the heavy and medium-duty truck market, with over 500,000 units sold, making up nearly one-quarter of all medium- and heavy-duty truck sales. The vocational segment was also responsible for emitting 15.3 percent of the GHG emissions in 2005 from the total medium- and heavy-duty truck market. A majority of these vehicles are powered by diesel engines; primary examples of this truck type include delivery trucks, dump trucks, cement trucks, buses, cranes, etc. Figure 1-8 shows two examples of this vehicle category including a United Parcel Service (UPS) delivery truck, and a Ford F750 Bucket Truck.

Figure 1-9 Examples of Class 3-8 Vocation Truck Applications

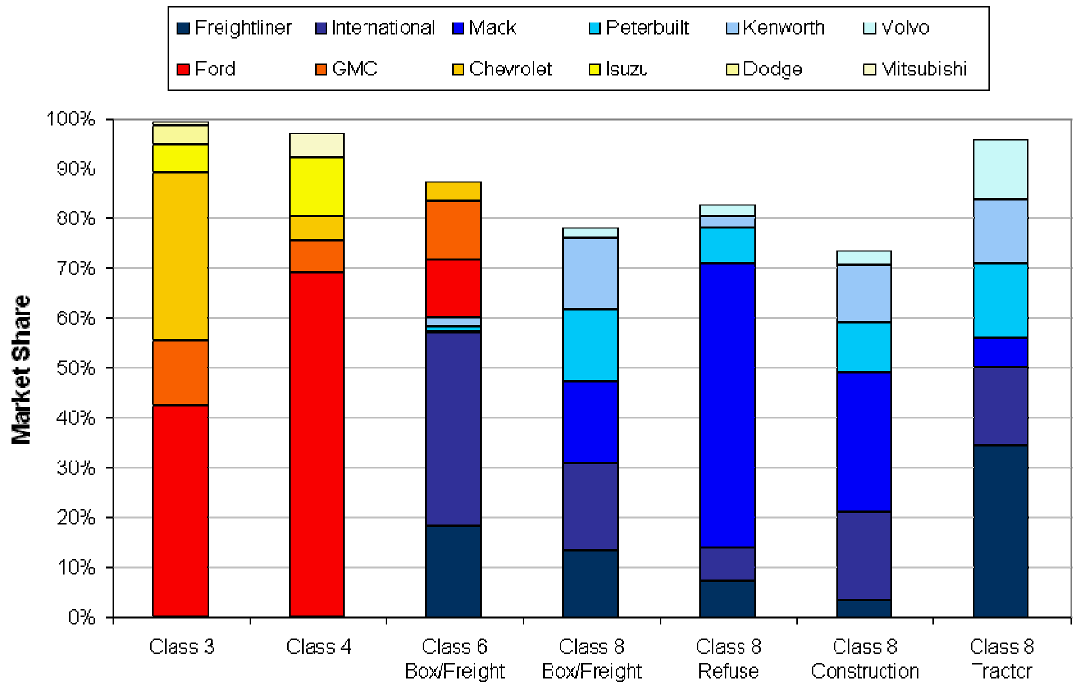
www.versalifteast.com/Rent-Bucket-Trucks.htm

www.seedmagazine.com/images/uploads/upstruck.jpg

Class 2b – 8 vocational trucks are typically sold as an incomplete chassis with multiple "outfitters" for example, an engine manufacturer, a body manufacturer, and an equipment manufacturer (e.g. a crane manufacturer). Manufacturers of vehicles within this segment vary widely and shift with class, as Figure 1-9 highlights. Vocational truck manufacturers include: GM, Ford, Chrysler, Isuzu, Mitsubishi, Volvo, Daimler, International, and PACCAR, while engine manufacturers include: Cummins, GM, Navistar, Hino, Isuzu, Volvo, Detroit Diesel, and PACCAR. Manufacturers of vocational truck bodies are numerous, according to the 2002 Census, there were 759 companies classified under the North American Industry Classification System (NAICS) 336211, "Motor Vehicle Body Manufacturers," examples of these companies include: Utilimaster and Heller Truck Body Corp.

Opportunities for GHG reductions can include both engine and vehicle improvements. Currently, there are a limited number of available Class 2b-8 vocational trucks produced in a hybrid configuration. International (owned by Navistar) makes the DuraStar™ Hybrid and claims that this option offers a 30 to 40 percent fuel economy benefit over standard in-city pickup and delivery applications, and offers a more than a 60 percent increase in fuel economy in utility-type applications where the vehicle can be shut off while electric power still operates the vehicle.[8]

Figure 1-10 Class 3-8 Vocational Truck Manufacturer Shift with Class



Source; ICCT

1.3.3 Class 8 Combination Tractors

Class 8 trucks are the largest and most powerful trucks of the heavy duty vehicle fleet. These trucks use almost two-thirds of all truck fuel, and are typically categorized into two smaller segments – short-haul and long-haul.[9] Combination tractors operating as short-haul trucks are tractor trailers typically used for routes less than 500 miles, and tend to travel at lower average speeds than long-haul trucks. Short-haul combination tractors therefore, do not include sleeping accommodations for the driver.

Long-haul combination tractors typically travel at least 1,000 miles along a trip route. Long-haul operation occurs primarily on highways and accounts for 60 to 70 percent of the fuel use in this class. The remaining 30 to 40 percent of fuel is used by other short-and medium-haul regional applications.[10] The most common trailer hauled by both short- and long-haul combination tractors is a 53-foot dry box van trailer, which accounts for nearly 60 to 70 percent of heavy-duty Class 8 on-road mileage. Leading U.S. manufacturers of Class 8 trucks include companies such as International, Freightliner, Peterbilt, PACCAR, Kenworth, Mack, Volvo, Western Star; while common engine manufacturers include companies such as Cummins, Navistar, and Detroit Diesel. The price of a new Class 8 vehicle can range from $90,000 to well over $110,000 for fully equipped models.[11]

Figure 1-11 Example Day Cab and Sleeper Cab Tractors

Source: www.internationaltrucks.com/Trucks/Trucks/Series/LoneStar

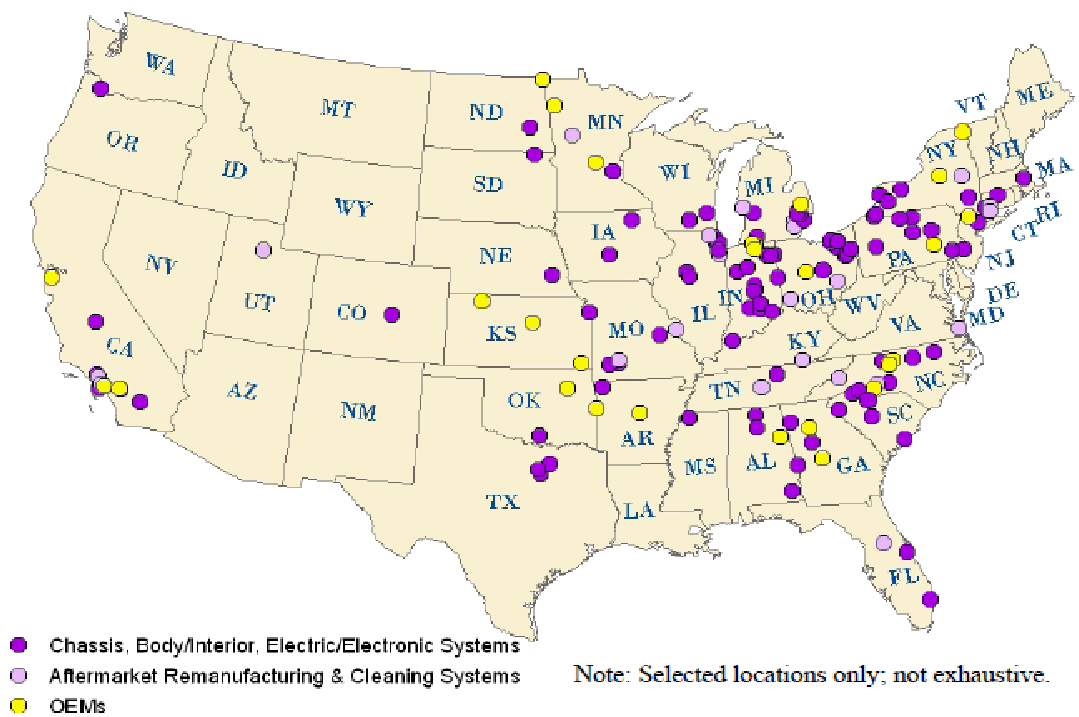
Source: www.freightlijnertrucks.com/media/pdf/coronado_brochure.pdf

1.3.4 Buses

Buses generally fall into either Class 6 or Class 7 categories and can come in many forms, including: transit buses, large school buses, small school buses, and motorcoaches. Typically, most bus manufacturers assemble the entire chassis from systems manufactured by a variety of suppliers, while their engines are commonly manufactured by companies such as Detroit Diesel, and Navistar.[12] Typically, transit buses have about a 12 year lifespan, and approximately 5000-5500 units a year enter the fleet, where school buses can last upwards of fifteen years or longer as school buses are not eligible for Federal Transit Administration funding as most transit buses are.[13] Currently, about 32 percent of U.S. buses have an alternative energy source and are powered by a source other than diesel or gas. According to the American Public Transportation Association's (APTA) "2008 Public Transportation Fact Book," in 2007, 22 percent of approximately 80,000 transit buses operated on alternative power, primarily compressed or liquefied natural gas (as well as recent interest in and growth of hybrid electric buses). Additionally, according to the Union of Concerned Scientists' "School Bus Pollution Report Card 2006 Grading the Schools" (May, 2006), less than 1 percent (4,145) of the approximately 505,000 school buses in the U.S. run on LNG/CNG; less than 2 percent (8,632) run on biodiesel, mostly B20. There are several types of bus fleets operating on alternative power. For example, CNG (Los Angeles Metropolitan Transit Authority) has the largest operational fleet, HEV (GM-Allison Transmission, BAE Systems, ISE Corporation, and Ebus (22' shuttles)) manufacture hybrid buses, while New York City Transit had a pilot program, and BEV (Proterra), Fuel Cell (fuel cell bus projects with New Flyer, Van Hool, Gilig, Daimler (Orion), EBus).

In 2008, transit buses were responsible for moving 53 percent of all unlinked passenger mass-transit trips which is just over 5.5 billion passenger trips.[14] In addition, APTA reports that in terms of passenger miles by mode, busing is also responsible for the largest share (over 39 percent) of passenger tranportation, at nearly 22 billion passenger miles. Although the number of buses manufactured in the U.S. is less than 5,500 per year, the number of manufacturing facilities involved in producing these buses is spread throughout the U.S., as shown in Figure 1-11.[15] While transit buses are typically used for two full shifts nearly every day and can average up to 30,000 miles per year of usage, school buses are used only twice a day and only on days when school is in session and typically accumulate just over 11,000 miles per year. School buses transport over 25 million children each year with a fleet of buses that is 94 percent diesel engine powered.

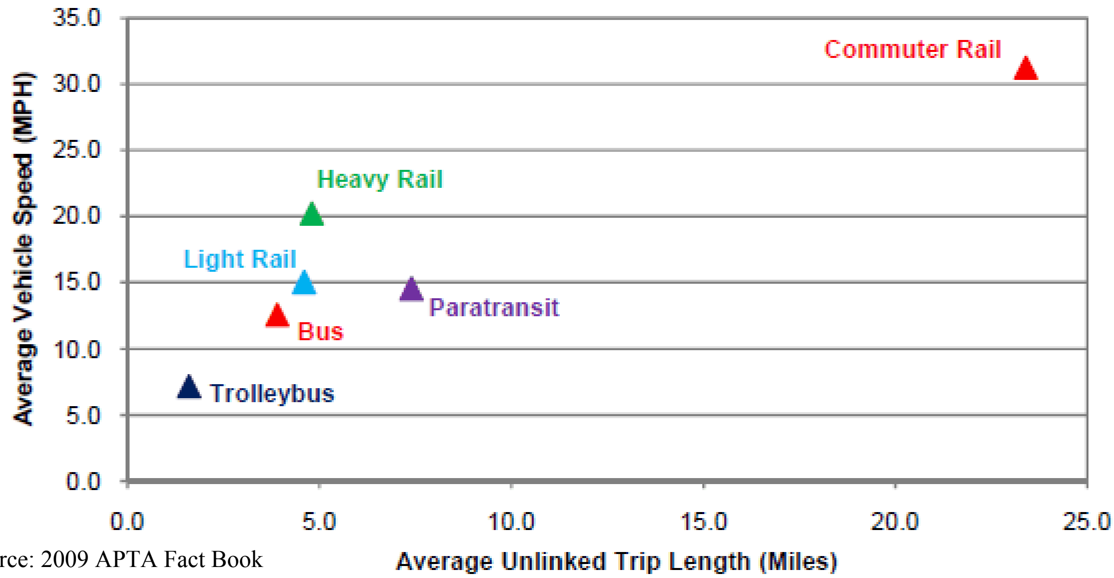
Figure 1-12 Selected U.S. Manufacturing Locations for Transit Buses and Components



Source: Center on Globalization, Governance & Competitiveness, 2009

Compared to other modes of mass transit, and even other types of medium- and heavy-duty truck operations, buses travel generally operates at the lowest speed and tends to stop much more frequently than other HD vehicles. Figure 1-12 shows a comparison of average operational speed and length of trip for different modes of mass transit. Buses also make up one of the largest fleets of vehicles within the HD sector, having over 66,000 buses available for service in 2008. At the beginning of 2009 they were approximately 7.5 years old with 5.5 percent having been rehabilitated during their lifetime.

Figure 1-13 Vehicle Speed vs. Trip Length by Mode in 2008



Source: 2009 APTA Fact Book

1.4 Operations

1.4.1 Trucking as a Mode of Freight Transportation

Trucks travel over a considerably larger domain than trains do, for example, in 2007 there were over 4 million miles of public roads compared to 140,000 miles of track.[16] In 2007 there were over 2 million combination trucks registered in the U.S, and over 5.5 million trailers (including all commercial type vehicles and semitrailers that are in private or for hire use).[17] Table 1-1 presents the number of trucks compared to the number of vessels and other modes of transportation that move freight.

Table 1-2 Number of U.S. Vehicles, Vessels, and Other Conveyances: 1980-2007

	1980	1990	2000	2007
Highway	**161,490,159**	**193,057,376**	**225,821,241**	**254,403,081**
Truck, single-unit 2-axle 6-tire or more	4,373,784	4,486,981	5,926,030	6,806,630
Truck, combination	1,416,869	1,708,895	2,096,619	2,220,995
Truck, total	5,790,653	6,195,876	8,022,649	9,027,625
Trucks as percent of all highway vehicles	3.6	3.2	3.6	3.5
Rail				
Class I, locomotive	28,094	18,835	20,028	24,143
Class I, freight cars[1]	1,168,114	658,902	560,154	460,172
Nonclass I, freight cars[1]	102,161	103,527	132,448	120,463
Car companies and shippers freight cars[1]	440,552	449,832	688,194	805,074
Water	**38,788**	**39,445**	**41,354**	**40,695**
Nonself-propelled vessels[2]	31,662	31,209	33,152	31,654
Self-propelled vessels[3]	7,126	8,236	8,202	9,041
Oceangoing steam and motor ships[4]	864	636	454	216
U.S. Flag fleet as percent of world fleet[4]	3.5	2.7	1.6	0.7

[1]Beginning with 2001 data, Canadian-owned U.S. railroads are excluded. Canadian-owned U.S. railroads accounted for approximately 176,275 freight cars in 2009.
[2]Nonself-propelled vessels include dry-cargo barges, tank barges, and railroad-car floats.
[3]Self-propelled vessels include dry cargo, passenger, off-shore support, tankers, and towboats.
[4]1,000 gross tons and over.

Source: The Federal Highway Administration "Freight Facts and Figures 2009."

Trucks move more than one-half of all hazardous materials within the U.S.; however, truck ton miles of hazardous shipments account for only about one-third of all transportation ton-miles due to the relatively short distances these materials are typically carried. In terms of growing international trade, trucks are the most common mode used to move imports and exports between both borders and inland locations. Table 1-2 shows the tons and value moved by truck compared to other transportation methods.

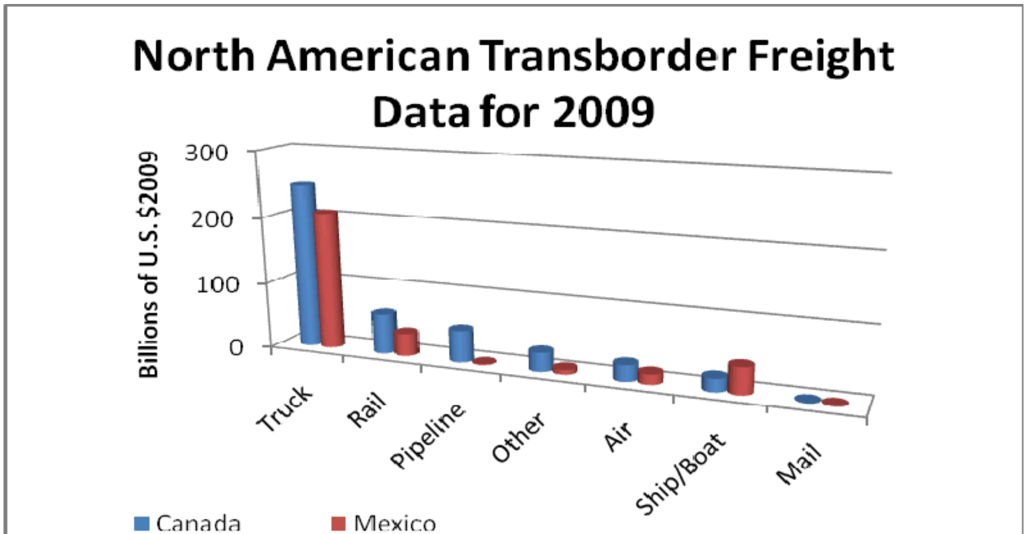
Table 1-3 Domestic Mode of Exports and Imports by Tonnage and Value in 2002 and Projections for 2035.[32]

	MILLIONS OF TONS		BILLIONS OF DOLLARS (U.S. $2002)	
	2002	*2035*	*2002*	*2035*
Truck[a]	797	2116	1198	6193
Rail	200	397	114	275
Water	106	168	26	49
Air, air and truck[b]	9	54	614	5242
Intermodal[c]	22	50	52	281
Pipeline and unknown[d]	524	760	141	238

Notes: [a] Excludes truck moves to and from airports.
[b] Includes truck moves to and from airports.
[c] Intermodal includes U.S. Postal Service and courier shipments and all intermodal combinations, except air and truck. In this table, oceangoing exports and imports that move between ports and domestic locations by single modes are classified by the domestic mode rather than the intermodal.
[d] Pipeline and unknown shipments are combined because data on region-to-region flows by pipeline are statistically uncertain.

Conversely, transportation of foreign trade is dominated by movement via water with trucks hauling approximately 16 percent of imported freight followed by rail and pipeline.[18] As of 2009, Canada was the top trading partner with the United States in terms of the value of the merchandise traded ($430 billion in U.S. $2009), second was China ($366 billion in U.S. $2009), and third was Mexico ($305 billion in U.S. $2008).[19] Truck traffic dominates transportation modes from the two North American trade partners. As of 2009, over 58 percent of total imported and exported freight moved between the U.S. and Canada was hauled by truck between Canada and the U.S., while over 68 percent of total imported and exported freight moved between the U.S. and Mexico was hauled by truck between Mexico and the U.S.[20]

Figure 1-14 North American Transborder Freight



Source: Bureau of Transportation Statistics: North American Transborder Freight Data

The number of truck configurations is only limited by technical compatibility and customer demand; order lead times can vary from a few months to a year when demand is high. Truck purchasers (individual owner-operators and fleets) custom order their trucks to meet very specific needs, e.g. fleets in Kansas choose high gear ratios for good fuel economy on flat roads, fleets in the Rocky Mountains choose lower gear ratios to allow adequate performance in the mountains, etc.

1.4.2 Operational Costs

One of the largest component of truck operational costs can be fuel costs, although this is dependent on the price of fuel, and can be as much as $70,000 - $125,000 annually per truck.[33] High fuel price is a key driver for adopting new technologies as the lifetime fuel cost to operate a Class 8 truck is nearly five times that of the original price of the truck, compared to about a one-to-one ratio for passenger vehicle. HD truck fleets typically operate on a very thin profit margin (1-2 percent); therefore, increased truck fuel economy can greatly increase a company's profitability.[31] New technologies are generally introduced on Class 8 vehicles first, and then are quickly implemented into other truck class segments due to the similarity of these vehicles.

1.4.3 Operators

There are nearly nine million people in trucking related jobs, with 15 percent involved in manufacturing of the vehicles and trailers, and the majority of over three million, working as truck drivers. Many drivers are not part of large fleets, but are independent owner-operators where the driver independently owns his or her vehicle, leaving 87 percent of trucking fleets operating less than 6 percent of all trucks.

The U.S. Department of Transportation's Federal Motor Carrier Safety Administration has developed Hours-of-Service regulations that limit when and how long commercial motor vehicle drivers may drive (Table 1-3 summarizes these rules). In general, drivers must take a ten consecutive hour rest / break per 24 hour day, and they may not drive for more than a week without taking a 34 consecutive hour break. These regulations have increased the importance of idle reduction technologies, as drivers can have a significant amount of downtime during a trip in order to comply with these mandates. During their required off-duty hours, drivers face additional regulations they must abide by if they rest in their truck and idle the main engine to provide cab comfort. Currently, regulations that prohibit trucks from idling can differ from state to state, county to county, and city to city. The American Transportation Research Institute has compiled a list of nearly 45 different regulations that exist in different locals with fines for non-compliance ranging from $50 to $25,000 and can include up to two years in prison.

The need for auxiliary cab heating, cooling, and sources of electricity such as those provided by idle reduction devices such as auxiliary power units, is highlighted by the fact that driver comfort is not typically included as an exemption to allow idling, nor are, in some cases, the idling of trailer refrigeration units that require power to keep freight at a controlled temperature.

Table 1-4 Summary of Hours of Service Rules

PROPERTY-CARRYING CMV DRIVERS	PASSENGER-CARRYING CMV DRIVERS
11-Hour Driving Limit	**10-Hour Driving Limit**
May drive a maximum of 11 hours after 10 consecutive hours off duty.	May drive a maximum of 10 hours after 8 consecutive hours off duty.
14-Hour Limit	**15-Hour On-Duty Limit**
May not drive beyond the 14th consecutive hour after coming on duty, following 10 consecutive hours off duty. Off-duty time does not extend the 14-hour period.	May not drive after having been on duty for 15 hours, following 8 consecutive hours off duty. Off-duty time is not included in the 15-hour period.
60/70-Hour On-Duty Limit	**60/70-Hour On-Duty Limit**
May not drive after 60/70 hours on duty in 7/8 consecutive days. A driver may restart a 7/8 consecutive day period after taking 34 or more consecutive hours off duty.	May not drive after 60/70 hours on duty in 7/8 consecutive days.
Sleeper Berth Provision	**Sleeper Berth Provision**
Drivers using the sleeper berth provision must take at least 8 consecutive hours in the sleeper berth, plus a separate 2 consecutive hours either in the sleeper berth, off duty, or any combination of the two.	Drivers using a sleeper berth must take at least 8 hours in the sleeper berth, and may split the sleeper-berth time into two periods provided neither is less than 2 hours.

Source: Federal Motor Carrier Safety Administration

1.4.4 Operating Speeds

In addition to the federal operating regulations, drivers must be aware of the variety of speed limits along their route, as these can vary both interstate and intrastate.[21,22] Currently, eight states have different speed limits for cars than they do for trucks, one state has different truck speed limits for night and day, and one state has a different speed limit for hazmat haulers than other trucks. In all, there are thirteen different car and truck speed combinations in the U.S. today; Table 1-5 shows the different combination of vehicle and truck speed limits, as well as the different speed limits by location.

Table 1-5 U.S. Truck and Vehicle Speed Limits

SPEED LIMIT	STATES WITH THE SAME SPEED LIMIT
Trucks 75 / Autos 75	Arizona, Colorado, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, South Dakota, Utah[c], Wyoming
Trucks 70 / Autos 70	Alabama, Florida, Georgia, Iowa, Kansas, Louisiana, Minnesota, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, West Virginia,
Trucks 65 / Autos 65	Alaska, Connecticut, Delaware, Illinois, Kentucky[a], Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia[d], Wisconsin
Trucks 60 / Autos 60	Hawaii
Trucks 55 / Autos 55	District of Columbia
Trucks 65 / Autos 75	Montana, Idaho
Trucks 65 / Autos 70	Arkansas, Indiana
Trucks 60 / Autos 70	Washington, Michigan
Trucks 55 / Autos 70	California
Trucks 55 / Autos 65	Oregon
Trucks 65 (on the Turnpike Only)	Ohio
Trucks and Autos 70 (65 at night)	Texas[b]
Hazmat Trucks 55mph	Alabama

Notes: [a] Effective as of July 10, 2007, the posted speed limit is 70 mph in designated areas on I-75 and I-71.
[b] In sections of I-10 and I-20 in rural West Texas, the speed limit for passenger cars and light trucks is 80 mph. For large trucks, the speed limit is 70 mph in the daytime and 65 mph at night. For cars, it is also 65 mph at night.
[c] Based on 2008 Utah House Bill 406, which became effective on May 5, 2008, portions of I-15 have a posted limit of 80 mph.
[d] Effective July 1, 2006, the posted speed limit on I-85 may be as high as 70 mph.

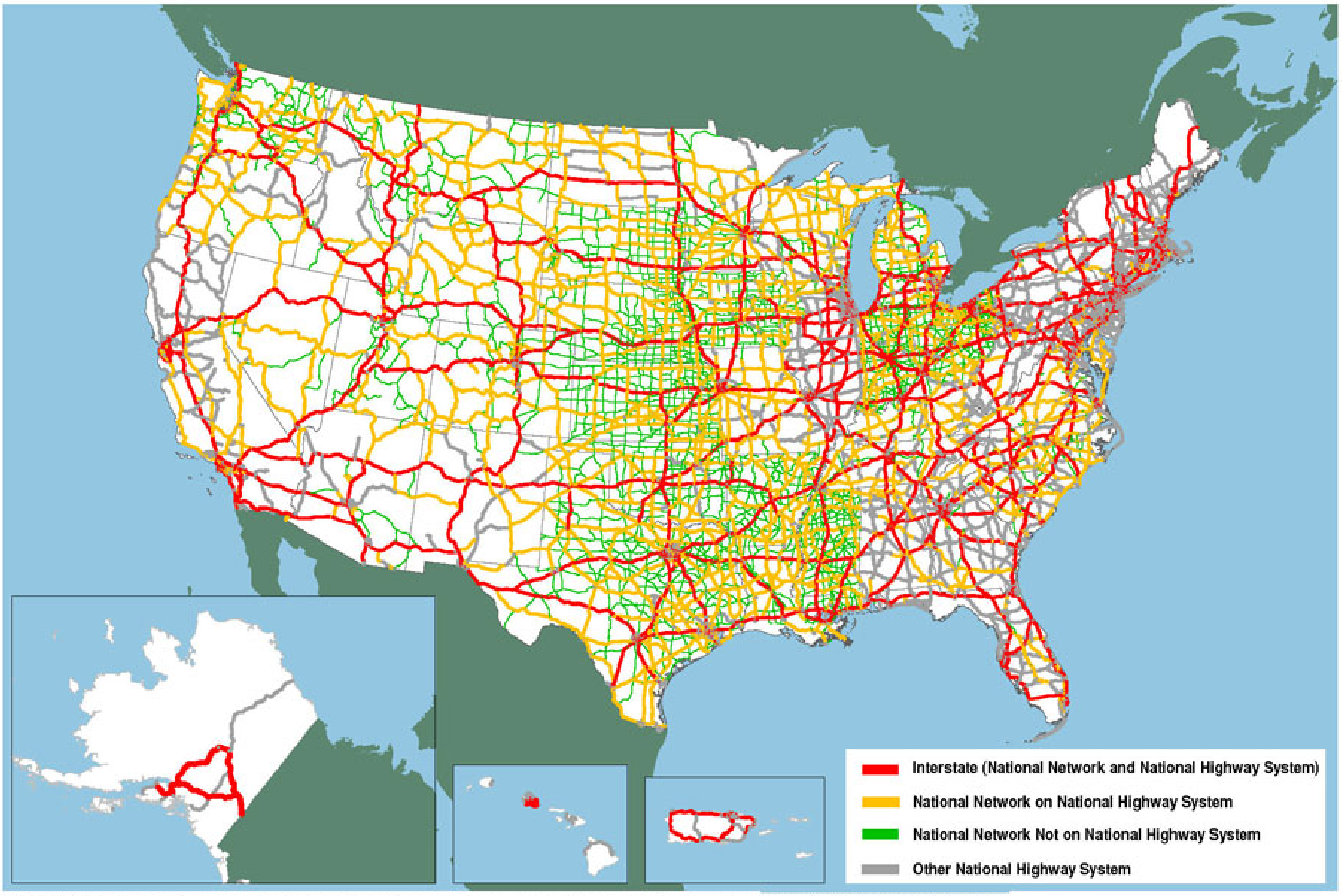
1.4.5 Trucking Roadways

The main function of the National Network is to support interstate commerce by regulating the size of trucks. Its authority stems from the Surface Transportation Assistance Act of 1982 (P.L. 97-424) which authorized the National Network to allow conventional combinationson “the Interstate System and those portions of the Federal-aid Primary System … serving to link principal cities and densely developed portions of the States … [on] high volume route[s] utilized extensively by large vehicles for interstate commerce … [which do] not have any unusual characteristics causing current or anticipated safety problems.”[23] The National Network has not changed significantly since its inception and is only modified if states petition to have segments outside of the current network added or deleted, Figure 1-16 shows the National Network of the U.S. [B]

Additionally, there is the National Highway System (NHS), which was created by the National Highway System Designation Act of 1995 (P.L. 104-59). The main focus of the NHS is to support interstate commerce by focusing on federal investments. Currently, there is a portion of the NHS that is over 4,000 miles long which supports a minimum of 10,000 trucks per day and can have sections where at least every fourth vehicle is a truck.[24] Both the National Network and the NHS are approximately the same length, roughly 200,000 miles, but the National Network includes approximately 65,000 miles of highways in addition to the NHS, and the NHS includes about 50,000 miles of highways that are not in the National Network.

[B] Tractors with one semitrailer up to 48 feet in length or with one 28-foot semitrailer and one 28-foot trailer, and can be up to 102 inches wide. Single 53-foot trailers are allowed in 25 states without special permits and in an additional 3 states subject to limits on distance of kingpin to rearmost axle.

Figure 1-15 The National Network for Conventional Combination Trucks



Note: This shall not be interpreted as the official National Network nor shall it be used for truck size and weight enforcement purposes.
Source: U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework, version 2.2, 2007.

1.4.6 Weigh Stations

Individual overweight trucks can damage roads and bridges; therefore, both federal and state governments are concerned about trucks that exceed the maximum weight limits operating without permits on U.S. roadways. In order to ensure that the trucks are operating within the correct weight boundaries, weigh stations are distributed throughout the U.S. roadways to ensure individual trucks are in compliance. In 2008, there were approximately 200 million truck weight measurements taken with less than one percent of those found to have a violation.[24]

There are two types of weigh stations, dynamic, or ‘weigh-in-motion’, where the operator drives across the scales at normal speed, and static scales where the operator must stop the vehicle on the scale to obtain the weight. As of 2008, 60 percent of the scales in the U.S. were dynamic and 40 percent were static. The main advantage of the dynamic weigh-in-motion scales are that they allow weight measurements to be taken while trucks are operating at highway speeds, reducing the time it takes for them to be weighed individually, as well as reducing idle time and emissions.[25,26] Officers at weigh stations are primarily interested in ensuring the truck is compliant with weight regulations; however, they can also inspect equipment for defects or safety violations, and review log books to ensure drivers have not violated their limited hours of service.

1.4.7 Types of Freight Carried

Prior to 2002, the U.S. Census Bureau completed a "Vehicle Inventory and Use Survey" (VIUS), which has since been discontinued. It provided data on the physical and operational characteristics of the nation's private and commercial truck fleet, and had a primary goal of producing national and state-level estimates of the total number of trucks. The VIUS also tallied the amount and type of freight that was hauled by medium and heavy duty trucks. The most prevalent type of freight hauled in 2002, according to the survey was mixed freight, followed by nonpowered tools. Three fourths of the miles traveled by trucks larger than panel trucks, pickups, minivans, other light vans, and government owned vehicles were for the movement of products from electronics to sand and gravel. Most of the remaining mileage is for empty backhauls and empty shipping containers, Table 1-5 shows the twenty most commonly hauled types of freight in terms of miles moved.[24]

Table 1-6 Top Twenty Types of Freight Hauled in 2002 in Terms of Mileage

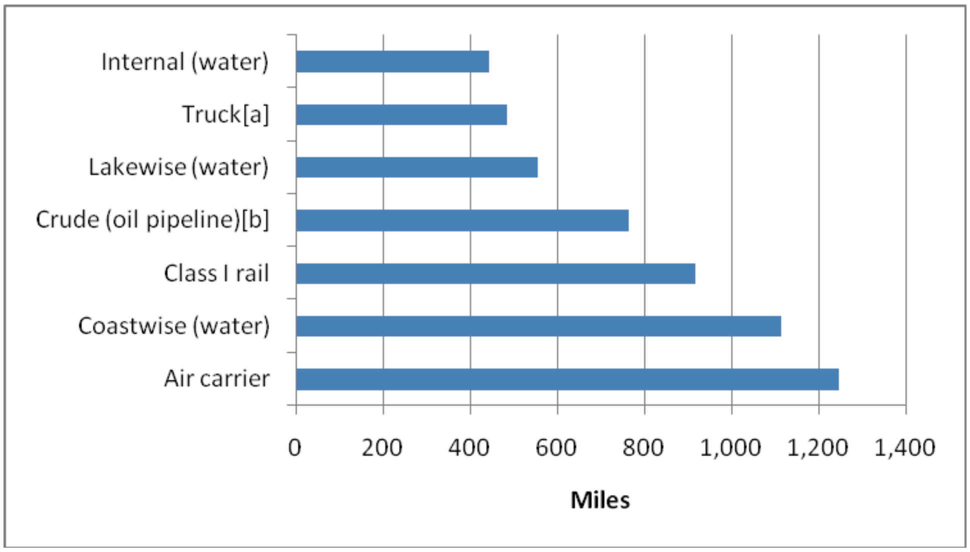
TYPE OF PRODUCT CARRIER	MILLIONS OF MILES
Mixed freight	14,659
Tools, nonpowered	7,759
All other prepared foodstuffs	7,428
Tools, powered	6,478
Products not specified	6,358
Mail and courier parcels	4,760
Miscellaneous manufactured products	4,008
Vehicles, including parts	3,844
Wood products	3,561
Bakery and milled grain products	3,553
Articles of base metal	3,294
Machinery	3,225
Paper or paperboard articles	3,140
Meat, seafood, and their preparations	3,056
Non-metallic mineral products	3,049
Electronic and other electrical equipment	3,024
Base metal in primary or semi-fnished forms	2,881
Gravel or rushed stone	2,790
All other agricultural products	2,661
All other waste and scrape (non-EPA manifest)	2,647

Source: The U.S. Census Bureau "Vehicle Inventory and Use Survey" 2002

1.4.8 Traffic

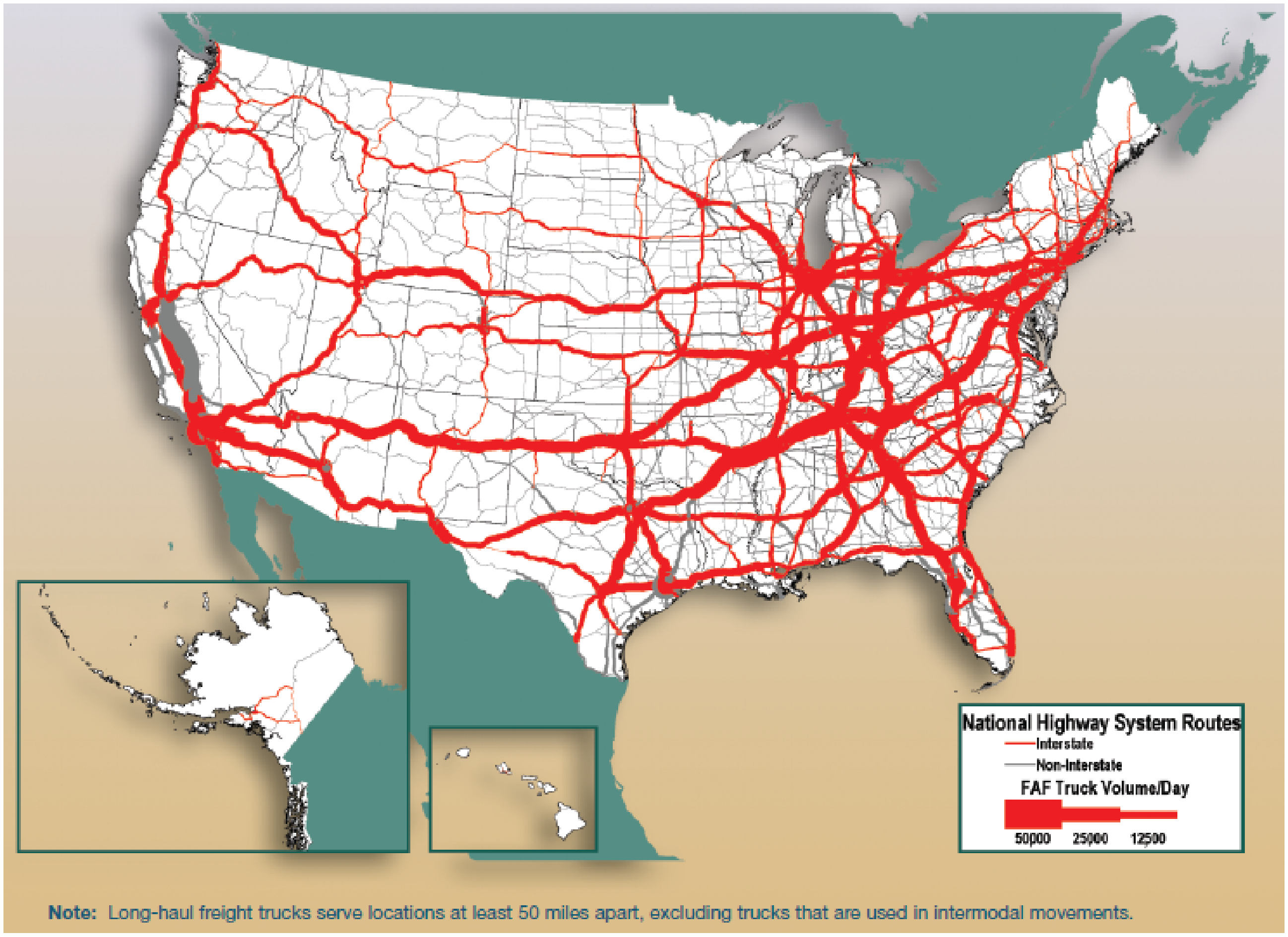
One of the advantages inherent in the trucking industry is that trucks can not only carry freight over long distances, but due to their relatively smaller size and increased maneuverability they are able to deliver freight to more destinations than other modes such as rail. Figure 1-17 shows the different modes of freight transportation and the average length of their routes. However, this also means they are in direct competition with light-duty vehicles for road space, and that they are more prone to experiencing traffic congestion delays than other modes of freight transportation.

Figure 1-16 Lengths of Routes by Type of Freight Transportation Mode



The Federal Highway Administration (FHWA) projects that long-haul trucking between places which are at least 50 miles apart will increase substantially on Interstate highways and other roads throughout the U.S, forecast data indicates that this traffic may reach up to 600 million miles per day.[24] In addition, the FHWA projects that segments of the NHS supporting more than 10,000 trucks per day will exceed 14,000 miles, an increase of almost 230 percent over 2002 levels. Furthermore, if no changes are made to alleviate current congestion levels, the FHWA predicts that these increases in truck traffic combined with increases in passenger vehicle traffic could slow traffic overall on nearly 20,000 miles of the NHS and create stop-and-go conditions on an additional 45,000 miles. Figure 1-17 shows the projected impacts of traffic congestion. These predicted congestion areas would also have an increase in localized engine emissions; advances in hybrid truck technology could provide large benefits and help combat the increased emissions that occur with traffic congestion.

Figure 1-17 Federal Highway Administration's Projected Average Daily Long-Haul Truck Traffic on the National Highway System in 2035



Source: The Federal Highway Administration: 2009 Facts and Figures

1.4.9 Intermodal Freight Movement

Since trucks are more maneuverable than other common modes of freight shipment, trucks are often used in conjunction with these modes to transit goods across the country, known as intermodal shipping. Intermodal traffic typically begins with containers carried on ships, then they are loaded onto railcars, and finally transported to their end destination via truck. There are two primary types of rail intermodal transportation which are trailer-on-flatcar (TOFC) and container-on-flatcar (COFC), both are used throughout the U.S. with the largest usage found on routes between West Coast ports and Chicago, and between Chicago and New York. The use of TOFCs (see Figure 1-18) allows for faster transition from rail to truck, but is more difficult to stack on a vessel; therefore the use of COFCs (see Figure 1-19) has been increasing steadily.

Figure 1-18 Trailer-on-Flatcar (TOFC)

Figure 1-19 Container-on-Flatcar (COFC)

1.4.10 Purchase and Operational Related Taxes

Currently, there is a Federal retail tax of 12 percent of the sales price (at the first retail sale) on heavy trucks, trailers, and tractors. This tax does not apply to truck chassis and bodies suitable for use with a vehicle that has a gross vehicle weight of 33,000 pounds or less. It also does not apply to truck trailer and semitrailer chassis or bodies suitable for use with a trailer or semitrailer that has a gross vehicle weight of 26,000 pounds or less. Tractors that have a gross vehicle weight of 19,500 pounds or less and a gross combined weight of 33,000 pounds or less are excluded from the 12 percent retail tax.[27] This tax is applied to the vehicles as well as any parts or accessories sold on or in connection with the sale of the truck. However, idle reduction devices affixed to the tractor and determined by the Administrator of the EPA, in consultation of the Secretary of Energy and Secretary of Transportation are generally exempt from this tax. There are other exemptions for certain truck body types, such as refuse packer truck bodies with load capacities of 20 cubic yards or less, other specific installed equipment, and sales to certain entities such as state or local governments for their exclusive use.

There is also a tire tax for tires used on some medium and heavy duty trucks. This tax is based on the pounds of maximum rated load capacity over 3,500 pounds rather than the actual weight of the tire, as was done in the past.[28] Singlewide tires can provide some tax savings both in terms of a lower tax rate and the weight reduction achieved as these tires typically weigh less than two standard tires, mostly due to the elimination of two sidewalls.

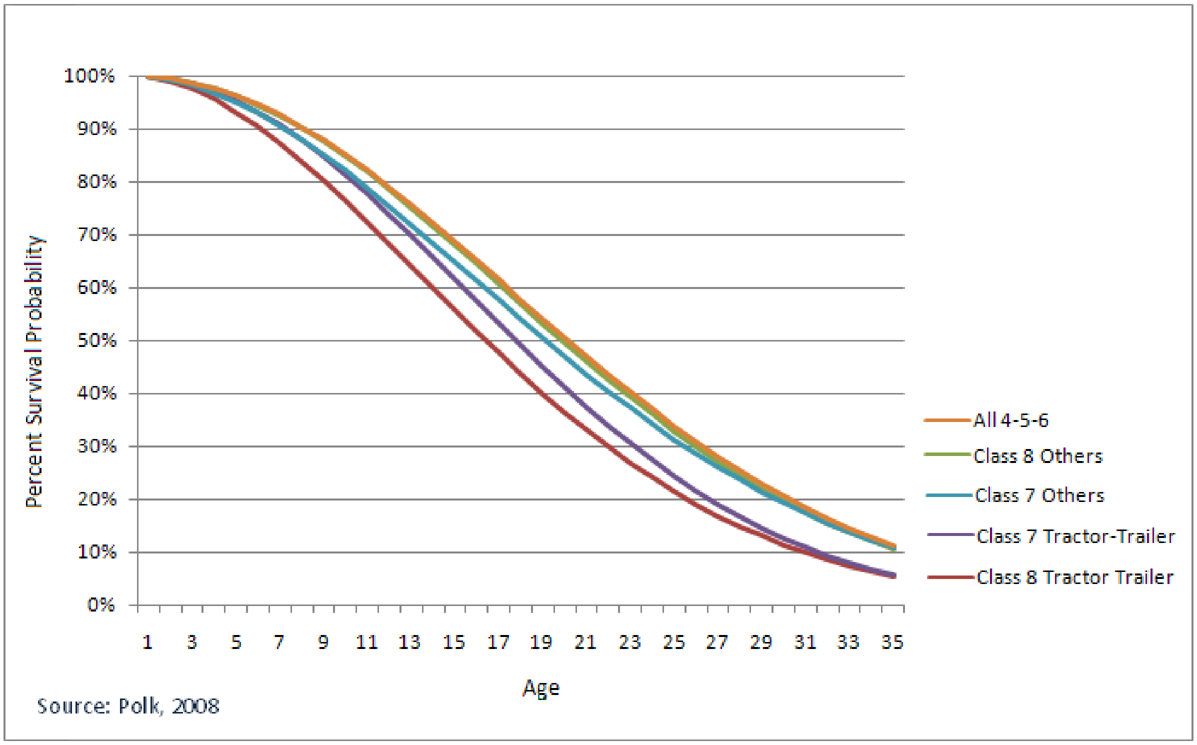
A new method of calculating the federal excise tax (FET) on tires was included in the American Jobs Creation Act that changed the method for calculating the FET on truck tires. Previously, the tax was based on the actual weight of the tire, where before, for a tire weighing more than 90 pounds there was a 50¢ tax for every 10 pounds of weight above 90 pounds plus a flat fee of $10.50. Since truck and trailer tires can weigh on average 120 pounds, this would carry a tax penalty of approximately $25 per tire; this method gave singlewide tires a tax advantage as they weigh less in part because they have two fewer sidewalls. The new FET is based on the load-carrying capacity of the tire. For every 10-pound increment in load-carrying capacity above 3,500 pounds, a tax of 9.45¢ cents is levied. A typical heavy-duty tire has a load carrying capacity of over approximately 6,000 pounds and would therefore carry a similar tax burden as before.[29] The change, however, is that the tax rate for bias ply and single wide tires is half that of a standard tire.

Finally, there is a usage tax for heavy duty vehicles driven over 5,000 miles per year (or over 7,500 miles for agricultural vehicles). This tax is based on the gross weight of the truck, and includes a rate discounted 25 percent for logging trucks.[30] For trucks with a GVW of 55,000 – 75,000 pounds the tax rate is $100 plus $22 for each additional 1,000 pounds in excess of 55,000 pounds; trucks with a GVW over 75,000 pay $550.

1.4.11 Vehicle Age

Class 8 long-haul combination tractors are typically sold after the first three to five years of ownership and operation by large fleets, however, smaller fleets and owner-operators will continue to use these trucks for many years thereafter.[31] As of 2009, the average age of the U.S. Class 8 fleet was 7.87 years.[32] These newest trucks travel between 150,000 – 200,000 miles per year, and 50 percent of the trucks in this Class 8 segment use 80 percent of the fuel.[33] Although the overall fleet average age is less than ten years old, Figure 1-20 shows that nearly half of all of Class 4-8 trucks live well past 20 years of age, and that smaller Class 4-6 trucks typically remain in the U.S. fleet longer than other classes.

Figure 1-20 Survival Probability of Class 4-8 Trucks



1.5 Tire Manufacturers

The three largest suppliers to the U.S. commercial new truck tire market (medium and heavy duty truck tires) are Bridgestone Americas Tire Operations LLC, Goodyear Tire and Rubber Company, and Michelin North America, Incorporated. Collectively, these companies account for over two-thirds of the new commercial truck tire market. Continental Tire of the Americas LLC, Yokohama Tire Company, Toyo Tires U.S.A. Corporation, Hankook Tire America Corporation, and others also supply this market. New commercial tire shipments totaled 12.5 million tires in 2009. This number was down nearly 20 percent from the previous year, due to the economic downturn, which hit the trucking industry especially hard. [34]

1.5.1 Single Wide Tires:

A typical configuration for a tractor-trailer combination truck is five axles and 18 wheels and tires, hence the name, "18-wheeler." There are two wheel/tire sets on the steer axle, one at each axle end, and four wheel/tire sets on each of the two drive and two trailer axles, with two at each axle end (dual tires), Figure 1-20 shows the position and name of each axle.

Steer tires and dual drive and trailer tires vary in size. A typical tire size for a tractor-trailer highway truck is 295/75R22.5. This refers to a tire that is 295 millimeters (or 11.6") wide with an aspect ratio (the sidewall height to tire section width, expressed as a percent) of

75, for use on a 22.5" wheel. The higher the aspect ratio the taller the tire is relative to its section width. Conversely, the lower the aspect ratio the shorter the tire is relative to its section width. Truck tires with a sidewall height between 70 percent and 80 percent of the tire section width use this metric sizing; other common highway truck tire sizes are 275/80R22.5, 285/75R24.5, and 275/80R24.5. Tire size can also be expressed in inches. 11R22.5 and 11R24.5 refer to tires that are 11 inches wide for use on a 22.5" and 24.5" wheel, respectively. Tires expressed in this non-metric nomenclature typically have an aspect ratio of 90, meaning the sidewall height is 90 percent of the tire section width.

Figure 1-21 Class 8 Standard "18 Wheeler" Axle Identification

Single wide tires have a much wider "base" or section width than tires used in dual configurations and have a very low aspect ratio. A typical size for a single wide tire used on a highway tractor trailer is 455/50R22.5. This refers to a tire that is 455 millimeters wide with a sidewall height that is 50 percent of its section width, for use on a 22.5" wheel. As implied by its name, a single wide tire is not installed in a dual configuration. Only one tire is needed at each end of the four drive and trailer axles, effectively converting an "18-wheeler" heavy duty truck into a 10-wheeler, including the two steer tires. Except for certain applications like refuse trucks, in which the additional weight capacity over the steer axle could be beneficial, single wide tires are not used on the steer axle.

Proponents of single wide tires cite a number of advantages relative to conventional dual tires. These include lower weight, less maintenance, and cost savings from replacing 16 dual tire/wheel sets with 8 single wide tire/wheel sets; improved truck handling and braking, especially for applications like bulk haulers that benefit from the lower center of gravity; reduced noise; fewer scrapped tires to recycle or add to the waste stream; and better fuel economy. A recent in-use study conducted by the Department of Energy's Oak Ridge National Laboratory found fuel efficiency improvement for single wide tires compared to dual tires of at least 6 percent up to 10 percent. These findings are consistent with assessments by EPA using vehicle simulation modeling and in controlled track testing conducted by EPA's SmartWay program.[35]

Sales of single wide tires have grown steadily since today's single wide tires entered the U.S. market in 2000. However, overall market share of single wide tires is still low relative to dual tires. There are several reasons why trucking fleets or drivers might be slow to adopt single wide tires. Fleets might be concerned that in the event of a tire failure with a single wide tire, the driver would need to immediately pull to the side of the road rather than "limping along" to an exit. "Limping along" on one dual tire after the other dual tire fails places the entire weight of the axle end on the one remaining good tire. In most cases, this is a dangerous practice that should be avoided regardless of tire type; however, some truck operators still use "limp along" capability. Fleets might also be concerned that replacement single wide tires are not widely available on the road. As single wide tires continue to gain broader acceptance, tire availability will increase for road service calls. Trucking fleets might not want to change tire usage practices. For example, some fleets like to switch tires between the steer and trailer axles or retreaded steer tires for use on trailers. Since single wide tires are not used on the steer position of tractor-trailers, using single wide tires on the trailer constrains steer-trailer tire and retreaded tire interchangeability.

New trucks and trailers can be ordered with single wide tires, and existing vehicles can be retrofit to accommodate single wide tires. If a truck or trailer is retrofit with single wide tires, the dual wheels will need to be replaced with wider single wheels. Also, if a trailer is retrofit or newly purchased with single wide tires, it may be preferable to use the heavier, non-tapered "P" type trailer axles rather than the narrow, lighter, tapered "N" spindle axles, because of changes in load stress at the axle end. Single wide tires are typically outset by 2 inches due to the wider track width, and outset wheels may require a slight de-rating of the hub load. Industry is developing advanced hub and bearing components optimized for use with single wide wheels and tires, which could make hub load de-rating unnecessary. Whatever type of wheels and tires are used, it is important that trucking fleets follow the guidance and recommended practices issued by equipment manufacturers, the Tire and Rim Association, and the American Trucking Association's Technology and Maintenance Council, regarding inflation pressure, speed and load ratings.

When today's single wide tires were first introduced in 2000, there were questions about adverse pavement impacts. This is because in the early 1980's, a number of "super single" tires were marketed which studies subsequently showed to be more detrimental to pavement than dual tires. These circa-1980s wide tires were fundamentally different than today's single wide tires. They were much narrower (16 percent to 18 percent) and taller, with aspect ratios in the range of 70 percent, rather than the 45 – 55 percent of today's single wide tires. The early wide tires were constructed differently as well, lacking the engineering sophistication of today's single wide tires. The steel belts were oriented in a way that concentrated contact stresses in the crown, leading to increased pavement damage. The tires also flexed more, which increased rolling resistance.

In contrast, today's single wide tires are designed to provide more uniform tire-pavement contact stress, with a tire architecture that allows wider widths at low aspect ratios and reduces the amount of interaction between the crown and sides of the tire, to reduce flexing and improve rolling resistance. Research on pavement response using instrumented roads and finite element modeling shows that depending upon pavement structure, single wide tires with a 55 percent aspect ratio produce similar bottom-up cracking and rutting damage as dual tires, and improve top-down cracking. Single wide tires with a 45 percent aspect ratio showed slightly more pavement damage. The new studies found that earlier research failed to take into account differences in tire pressure between two tires in a dual configuration; a situation that is common in the real world. Uneven inflation pressure with dual tire configurations can be very detrimental to pavement. The research also found that conventional steer tires damage pavement more than other tires, including single wide tires.[36]

Research is ongoing to provide pavement engineers the data they need to optimize road and pavement characteristics to fit current and emerging tire technologies.

1.5.2 Retreaded Tires:

Although retreading tires is no longer a common practice for passenger vehicles, it is very common in commercial trucking. Even the federal government is directed by Executive Order to use retreaded tires in its fleets whenever feasible.[37] Retreading a tire greatly increases its mileage and lifetime, saving both money and resources. It costs about one-third to one-half of the cost of a new truck tire to retread it, and uses a lot less rubber. On average, it takes about 325 pounds of rubber to produce a new medium or heavy duty truck tire, but only about 24 pounds of rubber to retread the same tire.[38]

The Department of Transportation Federal Motor Carrier Safety Administration (FMSCA) issues federal regulations that govern the minimum amount of tread depth allowable before a commercial truck tire must be retreaded or replaced. These regulations prohibit "Any tire on any steering axle of a power unit with less than 4/32 inch tread when measured at any point on a major tread groove. …All tires other than those found on the steering axle of a power unit with less than 2/32 inch tread when measured at any point on a major tread groove."[39] Trucking fleets often retread tires before tire treads reach this minimum depth in order to preserve the integrity of the tire casing for retreading. If the casing remains in good condition, a truck tire can be safely retreaded multiple times. Heavy truck tires in line haul operation can be retread 2 to 3 times and medium duty truck tires in urban use can be retread 5 or more times.[40] To accommodate this practice, many commercial truck tire manufacturers warranty their casings for up to five years, excluding damage from road hazards or improper maintenance.

In 2009, the number of retreaded tires sold to the commercial trucking industry outsold the number of new replacement tire shipments by half a million units – 13 million retreaded tires were sold, versus 12.5 million replacement tires.[41] Retreaded tire sales (without casings) totaled $1.64 billion in 2009.[42] All the top commercial truck tire manufacturers are involved in tire retread manufacturing. Bridgestone Bandag Tire Solutions accounts for 42 percent of the domestic retreaded truck tire market with its Bandag retread products; Goodyear Tire and Rubber Company accounts for 28 percent, mostly through its Wingfoot Commercial Tire Systems; Michelin Retread Technologies Incorporated, with Megamile, Oliver, and Michelin retread products, accounts for 23 percent. Other tire companies like Continental and independent retread suppliers like Marangoni Tread North America (which also produces the Continental "ContiTread" retread product) make up the remaining 7 percent.[43]

Although the "big 3" tire companies produce the majority of retread products through their retread operations, the retreading industry itself consists of hundreds of retreaders who sell and service retreaded tires, often (but not always) using machinery and practices identified with one of the "big 3" retread producers. There are about 800 retread plants in North America.[44] The top 100 retreaders in the U.S. retread 47,473 truck tires per day. They also retread 2,625 light truck tires and 625 off road tires daily. Tire retreaders are industryranked by the amount of rubber they use annually in their businesses. In 2009, the top 12 retreaders in the US accounted for nearly 150 million pounds of rubber used to retread tires. [45]

1.6 Current U.S. and international GHG voluntary actions and regulations

Heavy duty trucks in the U.S. today are not required to meet national GHG standards or regulations. The only national requirement for heavy duty trucks is currently for non-GHG emissions, as the heavy-duty engines must meet Non-Methane Hydrocarbons (NMHC), nitrous oxides (NOx), particulate matter (PM), and carbon monoxide (CO) standards. U.S. efforts to reduce GHG emissions from the heavy duty truck sector to date have been limited to voluntary measures and actions by the States. Congress has mandated the U.S. Department of Transportation to take action to set fuel efficiency standards for heavy-duty trucks through the Energy Independence and Security Act (EISA) of 2007. International GHG regulations have been implemented in Japan and are under consideration in other countries.

Additionally, there are existing heavy-duty engine certification and useful life requirements. Heavy Duty Engines have a single full life standard. Manufacturers certify results are cleaner than their test results to account for production and testing variability. Manufacturers also develop a deterioration factor which is used to demonstrate compliance at end of life.

Figure 1-22 Current Medium- and Heavy-Duty Useful Life

	Years	Miles
Spark Ignited (SI) Engines	10	110,000
Light Heavy Duty Diesel Engines	10	110,000
Medium Heavy Duty Diesel Engines	10	185,000
Heavy Heavy Duty Diesel Engines	10	435,000

1.6.1 U.S. EPA SmartWay™ Transport Partnership

While there are currently no national regulations for the heavy duty trucking sector, there is a highly recognized voluntary program established in the U.S. The U.S. EPA SmartWay Transport Partnership is a collaborative program between EPA and the freight industry that will increase the energy efficiency of heavy duty trucks while significantly reducing air pollution and GHG emissions. The Partnership provides strong market-based incentives to companies shipping products and the truck companies delivering these products, to improve the environmental performance of freight operations. SmartWay Transport partners improve their energy efficiency, save money, reduce greenhouse gas emissions and improve air quality.

SmartWay is a collaborative effort between the government and business, to improve the efficiency of goods movement from global supply chains while reducing fuel consumption and emissions. SmartWay was launched by the Environmental Protection Agency in 2004 with full support of the trucking industry and their freight shipping customers. SmartWay started with fifty initial partners including 15 Charter Partners. Since that time, the number of Partners has grown to over 2,700 members including most of the largest trucking fleets in the United States, and many of the largest multi-national shippers. SmartWay trucking fleet partners operate over 650,000 trucks, which represent 10 percent of all heavy duty trucks. The SmartWay program promotes the benefits of key truck technologies including idle reduction, aerodynamics, efficient tires, and operational strategies that include enhanced logistics management, reduced packaging, driver training, equipment maintenance, and intermodal options. SmartWay partners employ these strategies and technologies on new and existing equipment to reduce emissions and save fuel, contributing to environmental, energy security, and economic goals. SmartWay partners have helped to reduce CO_2 emissions from trucks by nearly 15 million metric tons, NOx by 215,000 tons, and PM by 8,000 tons, and have saved 1.5 billion gallons of diesel fuel as well as $3.6 billion in fuel costs. Other countries have expressed significant interest in SmartWay, and EPA has participated in workshops and pilot projects to demonstrate SmartWay tools and approaches internationally. Beginning in 2007, working with truck, trailer and engine manufacturers as well as states and public interest groups, SmartWay developed specifications to designate the cleanest and most efficient Class 8 tractor-trailers. SmartWay-certified trucks now represent more than 5 percent of new Class 8 sleeper truck sales, and every major truck maker offers at least one EPA SmartWay Certified Tractor.

1.6.2 The 21st Century Truck Partnership

Additionally, the DOE, EPA, DOT, Department of Defense (DOD), and national laboratories together with members of the heavy-duty truck industry work toward making freight and passenger transportation more efficient, cleaner, and safer under the 21st Century Truck Partnership[46]. The Partnership has several activities related to reducing greenhouse gas emissions, including:

- Integrated vehicle systems research and development to validate and deploy advanced technologies.
- Research for engine, combustion, exhaust aftertreatment, fuels, and advanced materials to achieve both higher efficiency and lower emissions.
- Research on advanced heavy-duty hybrid propulsion systems, reduced parasitic losses, and reduced idling emissions.

The Partnership provides a forum for parties to exchange information on the heavy-duty sector across government and industry. The Partnership has developed, among many other aspects, the widely referenced vehicle energy balance for heavy trucks and specific research goals for improvement efficiency.

1.6.3 California Assembly Bill 32

The state of California passed the Global Warming Solutions Act of 2006 (Assembly Bill 32) , enacting the state's 2020 greenhouse gas emissions reduction goal into law. Pursuant to this Act, the California Air Resource Board (ARB) was required to begin developing early actions to reduce GHG emissions. Accordingly, the California Air Resource Board issued the Regulation to Reduce Greenhouse Gas Emissions from Heavy-Duty Vehicles[47] in December 2008.

This regulation reduces GHG emissions by requiring improvement in the efficiency of heavy-duty tractors and 53 foot or longer dry and refrigerated box trailers which operate in California. The program begins in 2010, although small fleets are allowed special compliance opportunities to phase in the retrofits of their existing trailer fleets through 2017. The regulation requires that new tractors and trailers subject to the rule be certified by SmartWay and existing tractors and trailers are retrofit with SmartWay verified technologies. The efficiency improvements are achieved through the use of aerodynamic equipment and low rolling resistance tires on both the tractor and trailer.

1.6.4 U.S. Energy Independence and Security Act

The U.S. Energy Independence and Security Act (EISA) of 2007 was enacted by Congress in December of 2007.[48] EISA requires the Department of Transportation, in consultation with DOE and EPA, to study the fuel efficiency of medium- and heavy-duty trucks and determine: the appropriate test procedures and metric for measuring and expressing fuel efficiency; of MD/HD vehicles; the range of factors that affect fuel efficiency of such vehicles; and factors that could have an impact on a program to improve these vehicles' fuel efficiency. In addition, EISA directed the Department of Transportation, in consultation with DOE and the EPA, to implement, via rulemaking and regulations, "a commercial medium-and heavy-duty on-highway vehicle and work truck fuel efficiency improvement program" and to "adopt and implement appropriate test methods, measurement metrics, fuel economy standards, and compliance and enforcement protocols that are appropriate, cost-effective, and technologically feasible for commercial medium- and heavy-duty on-highway vehicles and work trucks." This authority permits DOT to set "separate standards for different classes of vehicles." The standards must provide at least 4 full model years of regulatory lead time and 3 full model years of regulatory stability.

Section 108 of the Act directed the Secretary of Transportation to execute an agreement with the National Academy of Sciences (NAS) to develop a report evaluating medium- and heavy-duty truck fuel economy standards. The study included an assessment of technologies and costs to evaluate MD/HD vehicle fuel economy; an analysis of existing and potential technologies to improve such vehicles' fuel economy; analysis of how the technologies may be integrated into the manufacturing process; assessment of how technologies may be used to meet fuel economy standards; and associated costs and other impacts on operation. The NAS panel published this study, titled "Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-duty Vehicles" March 31, 2010."

1.6.5 International GHG Emissions Activities

The international regulatory actions to reduce GHG emissions from heavy-duty trucks have been limited in scope. Japan has been at the forefront of heavy-duty truck GHG regulations while other nations, such as China and the European Union, are still in the development stage of potential regulatory programs for this sector.

Japan introduced legislation which set the minimum fuel economy standards for new heavy-duty vehicles with Gross Vehicle Weight Rating (GVWR) of greater than 7,700 pounds beginning in 2015 model year.

1.7 Trailers

1.7.1 Overview

A trailer is a vehicle designed to haul cargo while being pulled by another powered motor vehicle. It may be constructed to rest upon the tractor that tows it (a semi-trailer), or be constructed so no part of its weight rests on the tractor (a full trailer or a semitrailer equipped with an auxiliary front axle called a "converter dolly.") The most common configuration of large freight trucks consists of a Class 7 or 8 tractor hauling one or more semi-trailers. A truck in this configuration is called a "tractor-trailer." The semi-trailer is attached to the tractor by a coupling consisting of a horseshoe-shaped coupling device called a *fifth wheel* on the rear of the towing vehicle, and a *coupling pin* (or *king pin*) on the front of the semi-trailer or converter dolly. A tractor can also pull an ocean container mounted on an open-frame chassis, which when driven together on the road functions as a trailer. The Department of Transportation issues federal regulations that govern trailer length (separately or in combination), width, height, and weight, as well as trailer safety requirements (lights, reflective materials, bumpers, turn signals, tire and rim specifications, brakes, load-securing devices, tow balls, etc.) The Truck Trailer Manufacturers Association, an industry trade group for manufacturers of Class 7 and 8 truck trailers, also provides technical bulletins covering many aspects of trailer manufacture. Each trailer, like any other road vehicle, must have a Vehicle Identification Number (VIN).

1.7.2 Trailer Types

There are numerous types of trailers hauled by Class 7 and 8 tractors that are designed to handle any freight transport need. Dry box van trailers are enclosed trailers that can haul most types of mixed freight. Despite their similar shape and purpose, box trailers can vary widely in size and configuration although most are commonly found in 28', 48', and 53' lengths and 102" or 96" widths. Drop floor trailers have a lowered floor, often seen in moving vans. Other van trailers are curtain-sided with tarp or have roll up doors on the sides, as seen in beverage haulers. Another type of specialty box trailer is the refrigerated van trailer (reefer). This is an enclosed, insulated trailer that hauls temperature sensitive freight, with a transportation refrigeration unit (TRU) mounted in the front of the trailer powered by a small (9-36 hp) diesel engine. Enclosed box trailers – whether dry van, reefer, curtainside, drop floor, or other configuration, can have different axle configurations (single axle, fixed tandem, sliding tandem, tag-along axle) and door types (roll up, side-by-side). Figure 1-23 shows an example of a dry freight van semi-trailer with side-by-side doors.

Figure 1-23 Example Dry Box Van Trailer

Source: http://www.wabashnational.com/Images/popups/DuraPlatePop.jpg

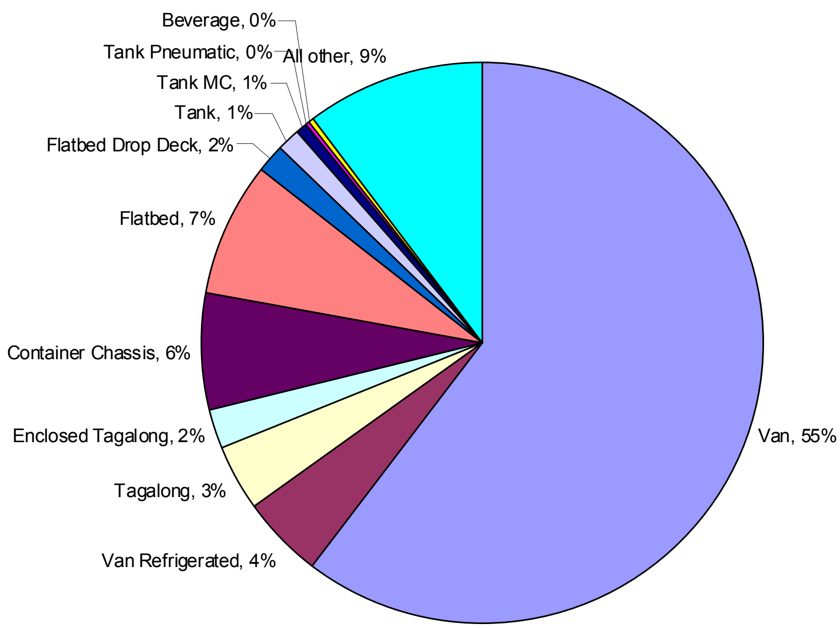
Flatbed trailers are platform-type trailers which also come in different configurations from standard flatbed platform trailers to gooseneck and drop deck flatbeds which are built such that the trailer platform is lower to the ground than the hitch would normally allow. There are also a number of other specialized trailers such as grain trailers (with and without hoppers), dump trailers (frameless, framed, bottom dump, demolition), automobile hauler trailers (open or enclosed), livestock trailers (belly or straight), dry bulk and liquid tanker trailers, construction and heavy-hauling trailers (tilt bed, hydraulic), even trailers designed to travel on both highways and railroad tracks. Figure 1-24 shows an example of a drop-deck platform trailer.

Figure 1-24 Example Drop-Deck Trailer

Source: http://www.transcraft.com/Transcraft/images/products/D-Eagle.jpg

The most common type of trailer in use today is the dry van trailer. Table 1-8 shows the various trailer types and their share of the trucking market. Despite considerable improvements in suspension, material, safety, durability, and other advancements, the basic shape of the van trailer has not changed much over the past decades, although its dimensions have increased incrementally from what used to be the industry's standard length of 40' to today's standard 53' long van trailer. The van trailer's boxy shape – while not particularly aerodynamic – is designed to maximize cargo volume hauling capacity, since the majority of freight shipped by truck cubes out (is volume-limited) before it grosses out (is weight-limited). EPA's SmartWay program has demonstrated that adding aerodynamic features to van trailer designs and the use of low rolling resistance tires can substantially reduce fuel consumption from tractor trailers. SmartWay verifies aerodynamic equipment and low rolling resistance tires for use on SmartWay-certified trailers, which can be new or retrofit.

Table 1-7 Trailer Types and Volumes (Source: ICCT Report)



1.7.3 Trailer Manufacturers

This diverse variety of van, platform, tanker and specialty trailers are produced by a large number of trailer manufacturers. The twelve manufacturers with the largest overall North American output are: Utility Trailer Manufacturing, Great Dane Limited Partnership, Wabash National Corporation, Hyundai Translead, Timpte Inc., Wilson Trailer Company, Stoughton Trailers, Heil Trailer International, Fontaine Trailer Company, MANAC, Vanguard National Trailer Corporation, and Polar Tank Trailer. Trailer manufacturing is still done mostly by hand, although the various trailer parts can be mass-produced and even shipped from abroad for assembly in the U.S. Altogether, 30-some companies account for most of this industry's manufacturing base, although there are dozens and dozens additional manufacturers producing for niche trailer markets. Despite this variety, trailers are far less mechanically complex than are the trucks that haul them. This low barrier to entry for trailer manufacturing accounts in part for the large numbers of trailer manufacturers. Nearly half of all trailer manufacturers – including those that might be considered "large" in their industry segment -- meet SBA's definition of a small business.

The trailer industry was particularly hard hit by the recent recession. Trailer manufacturers saw deep declines in new trailer sales of 46 percent in 2009; some trailer manufacturers saw sales drop as much as 71 percent. This followed overall trailer industry declines of over 30 percent in 2008. The 30 largest trailer manufacturers saw sales decline 72% overall from their highest recent sales volumes, from 277,992 in 2006, to only 78,258 in 2009. [49] Several trailer manufacturers shut down entire production facilities and a few went out of business altogether. Of the most common trailer types of trailers sold, refrigerated trailers were the least affected; platform trailers were the most affected. As of mid-2010, the trailer industry has yet to recover from the devastating effects of the economic downturn.

1.7.4 Trailer Operations

Trailers are the primary vehicle for moving freight in the United States. Despite their significance to the goods movement industry and opportunities to improve fuel efficiency and reduce greenhouse gas emissions from trailer improvements, the broad diversity of the trailer industry and its end-user practices make this a challenging industry to address and engage.

Truck drivers and trucking fleets frequently do not control all or even any of the trailers that they haul. Trailers can be owned by freight customers, large equipment leasing companies, third party logistics companies (3PLS), and even other trucking companies. Containers on chassis, which function as trailers, are rarely owned by truck operators. Rather, they are owned or leased by ocean-going shipping companies, port authorities or others. This distinction between who hauls the freight and who owns the equipment in which it is hauled means that truck owners and operators have limited ability to be selective about the trailers they carry, and very little incentive or ability to take steps to reduce the fuel use of trailers that they neither own or control.

The ratio of the number of trailers in the fleet relative to the number of tractors in the legacy fleet is typically three-to-one.[50] At any one time, two trailers are typically parked while one is on the road. For certain private fleets, this ratio can be greater, as high as six-to-one. This means that on average a trailer will travel only one third of the miles travelled by a tractor. Lower annual mileage combined with the less complex machinery of a trailer mean that trailers do not need to be purchased as frequently as the trucks that haul them. The initial owner may keep a trailer for a decade or even longer; typically, the initial owner of a class 7 or 8 tractor keeps his or her vehicle for three to six years. Less frequent procurement cycles result in slower turnover of trailers in the in-use fleet, with many older trailers still in use.

For refrigerated trailers, the story is slightly different. These trailers are used more intensely and accumulate more annual miles than other trailers. Over time, refrigerated trailers can also develop problems that interfere with their ability to keep freight temperature-controlled. For example, the insulating material inside a refrigerated trailer's walls can gradually loose its thermal capabilities due to aging or damage from forklift punctures. The door seals on a refrigerated trailer can also become damaged or loose with age, which greatly affects the insulation characteristics of the trailer, similar to how the door seal on a home refrigerator can reduce the efficiency of that appliance. As a result of age-related problems and more intense usage, refrigerated trailers tend to have shorter procurement cycles than dry van trailers, which means a faster turnover rate, although still not nearly as fast as for trucks in their first use.

1.8 Hybrids

Following the trends in the lighter duty passenger vehicles, heavy duty trucks are starting to look at hybrid vehicles to help optimize their performance and exhaust emissions. There are three main types of hybrid vehicles, hydraulic, electric, and 'plug-in' which are discussed in more detail below. Typically, trucks that have shorter or 'stop and go' type operations, such as utility (bucket) trucks, pickup and delivery, refuse, busses, and combination trucks, are the best candidates for a hybrid vehicle. On average, the conventional annual sales for these truck types range from 10,000 – 150,000 units per year.

Hydraulic hybrids use a combination of pumps, motors, and accumulators in conjunction with the diesel engine. The engine powers a hydraulic pump-motor, which charges a high-pressure accumulator, which in turn drives an additional pump-motor at the rear of the vehicle to provide propulsion. There are two main types of hydraulic hybrids, those that operate in parallel and those that operate in series. The parallel hydraulic vehicle has a conventional driveline that is supplemented by hybrid (also known as hydraulic launch assist). This type of vehicle is best suited for stop-and-go duty cycles such as refuse and bus.

The series style hydraulic hybrid vehicle does not have a conventional driveline as it is replaced by hybrid system; therefore, the transmission is removed. This allows the engine to operate in a "sweet spot", and to shut-off the engine when it is not needed. These vehicle types have broader applications than the parallel hybrids, but their best benefit is still in stop-and-go duty cycles. Typical applications for these hybrids include refuse, commercial construction, yard hostler, etc.

Electric hybrids operate by combining the traditional internal combustion engine with an electric propulsion system. There are several types of electric hybrid combinations within the heavy duty fleet. Motive type blends diesel and electric power as demanded and operates in a parallel system. Motive & Auxiliary power type hybrid provides motive power from diesel and electric motors and provides electric auxiliary power to the vehicle. Dual Mode hybrid operates as a series hybrid at low speeds and parallel hybrid at higher speeds. Typical applications for electric hybrids include utility, bus, pickup and delivery, etc.

The third type of HD hybrid vehicle is a 'plug-in'. These vehicles can blend diesel and electric power as demanded for propulsion and are typically outfitted to 'plug-into' an electrical outlet to recharge their battery pack. These trucks can use electric power for auxiliary system power and operations and can have range-extended batteries as they can switch propulsive power to the diesel engine when the battery runs low. Typical applications for this type of vehicle include utility (powering the grid), small pickup and delivery trucks, and shuttle buses.

There are many companies currently designing, demonstrating, and / or producing hybrid systems for the HD trucking industry, as well as industry associations such as Hybrid Truck Users Forum (H-TUF), Next Energy Hydraulic Hybrid Working Group, and the

Electric Drive Transportation Association. By creating these vehicles for the HD industry, CO_2, NOx, HC, and PM emissions will all be reduced, the vehicle's overall noise will be reduced due to engine-off idling, and owners should notice a reduction in maintenance and operating costs as there is reduced usage of brakes and engine operating hours.

Today for hybrid trucks there are several incentive programs in place. The federal government has Federal Tax incentives, for purchasers to receive up to 40 percent of the incremental cost of the hybrid, dependent on the fuel economy improvement. Additionally, there are currently 13 states that have hybrid incentive programs, and some of the smaller localities also have incentive programs. Government funding through programs such as the National Clean Diesel Program, SmartWay, Clean Automotive Technology, and Clean Cities is also available.

As with any new technology, there are some issues that arise with hybrid technologies. For example the overall system cost is generally more than conventional power systems, and some of the battery technology (such as size, weight, cold weather operations, charging time, etc) is still relatively untested – and in some cases – unknown. Additionally, to maximize the efficiency of the vehicle, the hybrid technology needs to be properly matched to the applicable duty cycle, and the engines need to be properly optimized for the vehicle and its operation.

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