Overview of CAFE Standards and The Estimation of Petroleum Saving Potentials by Japanese Automobiles in the United States

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Abstract:

In December 2007, the United States Congress passed a comprehensive energy bill (H.R. 6) that included provisions to achieve 35 miles per gallon (mpg) as the fuel economy of new automobiles by 2020. The United States is a major automobile nation, with about 240 million of 900 million automobiles worldwide. Passenger cars and light trucks account for approximately 40% of total oil consumption and about 20% of total CO_2 emissions in USA. Therefore, fuel economy regulation are crucial for ensuring the nation's energy security and tackling with global warming issues in USA. With the sharp rise in crude oil prices and accelerating emphasis on reducing global warming, Japan and European countries are also tightening their regulations on the fuel economy of automobiles. This global trend is expected to impact car manufacturers in Japan and other countries in formulating product development strategies, such as stepping up their efforts to develop fuel economy technologies and alterative fuel vehicles.

Figure 1 Oil consumption of automobiles (passenger cars and light trucks) in the United States
(Estimated reduction in oil consumption by different bills for fuel economy regulation)

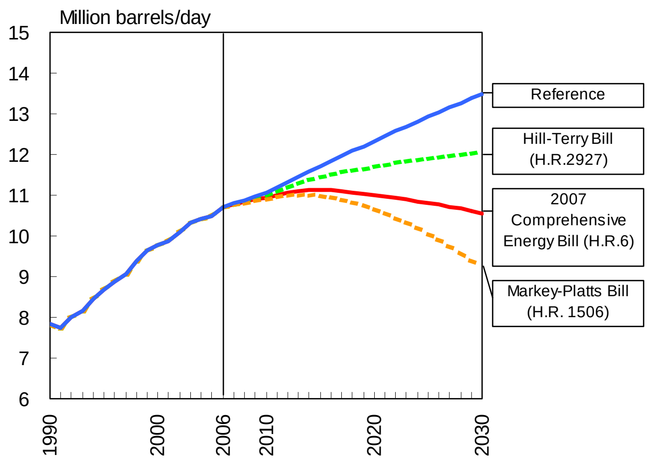
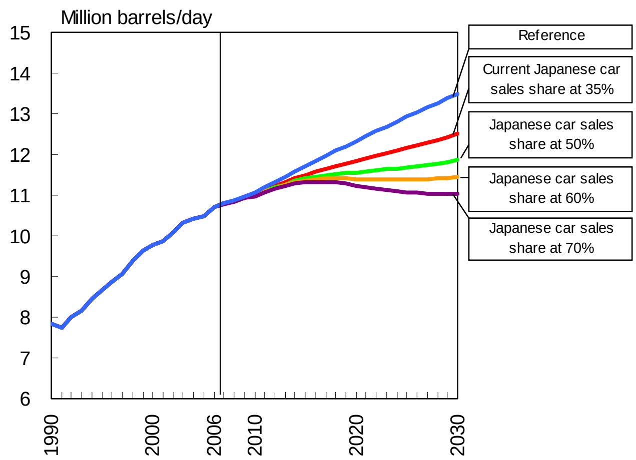


Figure 2 Oil consumption of automobiles (passenger cars and light trucks) in the United States
(Estimated reduction in oil consumption by Japanese cars)



Assumption: By 2020, the CAFE of new Japanese passenger cars will reach 45 mpg and the CAFE of new Japanese light trucks will reach 35 mpg. The CAFE improvement of European and American automobiles will be the general continuation of prevailing trends (2020: 31.5 mpg for passenger cars and 24.7 mpg for light trucks).

This paper reviews the Corporate Average Fuel Economy (CAFE) standards of the United States and analyzes how the tightening of fuel economy standards proposed by the 2007 Comprehensive Energy

Bill (H.R. 6) and the growing sales share of Japanese automobiles in the U.S. market may reduce oil consumption. According to our estimation, if the fuel economy of all new automobiles sold in the United States improves steadily under the fuel economy standards proposed by the 2007 Comprehensive Energy Bill in compliance with the 35 mpg target, it will lead to the following results in 2020 (improvement from the reference scenario that assumes no alternative actions): reduction of oil consumption by 1.3 million B/D in 2020 (13% of the United States' crude oil import in 2006 and equivalent to the oil consumed by 21 million automobiles) as shown in Figure 1, and the reduction of CO_2 emissions by 51 Mt-C in 2020 (3% of present emissions by the United States).

As to the petroleum saving and CO_2 abatement potentials achievable with Japanese cars, we estimate that if the fuel economy of new Japanese cars improves steadily to meet the 35 mpg target mandated by the 2007 Comprehensive Energy Bill, the contribution of Japanese automobiles will be as follows in 2020: reduction of oil consumption by 0.3–0.7 million B/D in 2020 (3–7% of the United States' crude oil import and equivalent to the amount of oil consumed by 4–11 million automobiles) and reduction of CO_2 emissions by 10–27 Mt-C in 2020 (3–8% of CO_2 emissions by Japan), depending on Japanese car sales share in USA. Furthermore, if the average fuel economy of new Japanese passenger cars in 2020 equals that of the current most fuel-efficient model (according to the Top Runner Approach of the Japanese government), the contribution of Japanese automobiles will be as follows in 2020 as shown in Figure 2: reduction of oil consumption by 0.5–1.1 million B/D in 2020 (5–11% of the United States' crude oil import and equivalent to the amount of oil consumed by 8–17 million automobiles) and reduction of CO_2 emissions by 19–42 Mt-C in 2020 (5–12% of CO_2 emissions by Japan), depending on Japanese car sales share in USA.

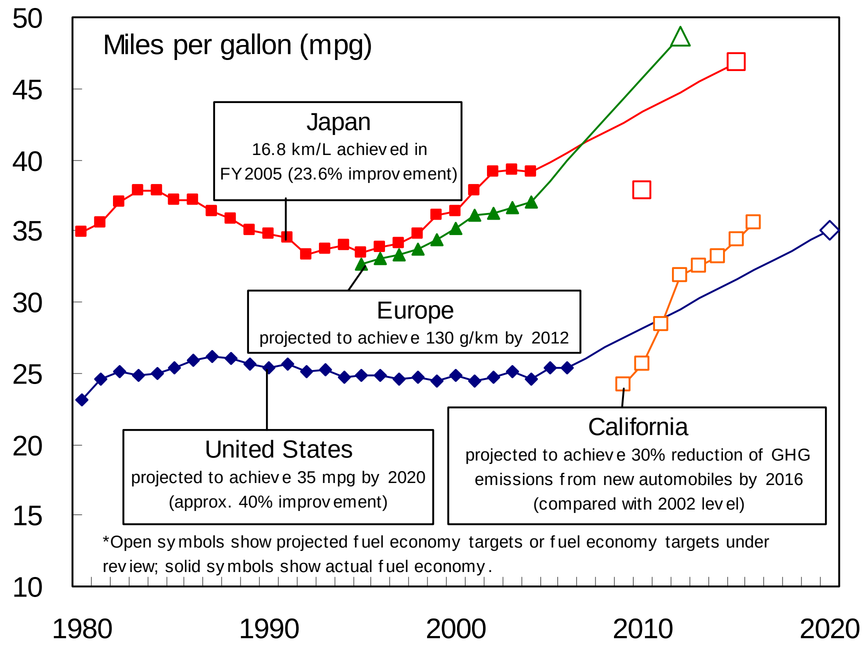
For Japanese car manufacturers to expand their sales share in the international market, they must penetrate actively the existing markets in the United States and Europe and also the emerging markets in BRICs. While boosting their international competitiveness, Japanese manufacturers should utilize the excellent fuel economy and environmental performance of their cars as a kind of resource for ensuring global energy security and addressing global warming issues.

1. INTRODUCTION

1-1 Global Trend of Fuel Economy Regulation

With rising crude oil prices and greater efforts against global warming, Japan, Europe and the United States are tightening their regulations on the fuel economy of automobiles (Figure 1-1 and Table 1-1). At present in Japan, the transportation sector is responsible for about 20% of CO_2 emissions, of which about 90% comes from automobiles. With the objective of reducing CO_2 emissions by the transportation sector, the government established new fuel economy standards in 2007 for passenger cars, small buses and light trucks. For passenger cars, the new standards set 16.8 km/L as a target for 2015 (23.5% improvement from the 2004 level of 13.6 km/L).

Figure 1-1 Passenger car fuel economy achieved and projected by the United States, Japan and Europe



Note: The United States, Japan and Europe use different test methods to determine the fuel economy of automobiles (CAFE for the United States, JC08 for Japan and NEDC for Europe). A simple comparison by converting measuring units is therefore not appropriate. When producing this chart, we converted fuel economy values (actual or required) into CAFE values under the United States' test method by using the compensation expressions for different fuel economy test methods described in ICCT's "Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update" (2007). Data for Japan is presented by fiscal year, and data for other countries by calendar year.

In February 2007, the European Union (EU) issued a document that stipulated an obligation to significantly reduce CO_2 emissions from automobiles by 2012, restricting CO_2 emissions from new automobiles sold in EU countries to 130 g/km or lower by 2012. Since the average CO_2 emission from European cars sold in EU countries is presently around 160 g/km, the new policy calls for a reduction of approximately 20%. Comparing Europe with Japan in terms of fuel economy standards formulated in 2007, the European standard for 2015 appears to be stricter than the Japanese standard in respect of the target year and fuel economy requirements.

Also in 2007, the United States significantly strengthened its fuel economy standards for automobiles for the first time in 32 years. Indeed, the United States Congress had not raised its fuel standards for passenger cars since 1975 (after the first oil crisis). This time, the Congress passed a comprehensive energy bill (H.R. 6) requiring a fuel economy for new automobiles of 35 mpg by 2020 (40% improvement from the present level).[1] This global trend toward tightening of fuel economy regulations is expected to impact the product development strategies of car manufacturers in Japan and other countries, promoting the development of fuel economy technologies and alternative-fuel vehicles.

The state government of California established its own emission control act, which requires car manufacturers to achieve, by 2016, an approximately 30% reduction of emissions from new automobiles (compared with the 2002 level). The U.S. Environmental Protection Agency (EPA), however, did not approve this emission control act which is unique to California. The state government of California, objecting to this decision, took the case to the federal court of appeals in San Francisco where it is now pending.

Table 1 Overview of fuel economy standards in the world

	The United States	Europe	California	Japan
Target	Fuel economy	CO_2 emissions	GHG emissions	Fuel economy
Fuel economy measuring unit	mpg	g/km	g/mile	km/L
Fuel economy test	CAFE	NEDC	CAFE	JC08
Outline	Single standard for all passenger cars; size-based standards for light trucks	Single standard	Two standards (based on vehicle type)	Different standards for different vehicle weight classes
Fuel economy standards	35 mpg by 2020 (40% improvement on average)	CO_2 emission of 130 g/km by 2012 (20% improvement compared to the present level)	GHG emissions from new automobiles in 2016 to be about 30% less, compared with the 2002 level	Average fuel consumption of passenger cars in fiscal 2015 to be 16.8 km/L (23.5% reduction on average)

1-2 2007 Comprehensive Energy Bill (H.R. 6)

On June 21, 2007, the Senate of the United States passed an energy bill (Renewable Fuels, Consumer Protection, and Energy Efficiency Act of 2007; H.R. 6, modified by the House of Representatives) after reaching a compromise with nonpartisans concerning the strengthening of Corporate Average Fuel Economy (CAFE) standards, which had been preventing the progress of energy bill discussions in plenary sessions. This bill already contained provisions to raise the fuel economy target for passenger cars and light trucks (including SUVs) to 35 mpg by 2020. On August 5, 2007, the House of Representatives passed another energy bill (New Direction for Energy Independence, National Security, and Consumer Protection Act, Renewable Energy and Energy Conservation Tax Act of 2007; H.R. 3221, prepared by the House of Representatives). However, they did not reach a consensus about provisions concerning CAFE standards. As a result, this energy bill from the House did not include fuel economy provisions. Later, the two Houses modified provisions through joint conferences to finalize their bills.

[1] See the White House press releases such as the following:
(http://www.whitehouse.gov/news/releases/2007/12/20071219-6.htm, http://www.whitehouse.gov/news/releases/2007/12/20071218-8.html

Subsequently, a consensus on the CAFE standards was achieved in both houses. The Senate's proposal to revise them to achieve 35 mpg by 2020 (H.R. 6) was accepted and the assembly reached an agreement on December 4, formulating the Energy Independence and Security Act (H.R. 6). On December 6, the bill was approved by the plenary session of the House (235 vs. 181), and passed to discussion in the plenary session of the Senate. However, it was not approved in the Senate on December 7 by a vote of 53 to 42 against, falling short of the 60 votes required for preventing filibuster in the plenary session.

After subsequent negotiations on revising the energy bill, a revised energy bill from which the provisions on the Renewable Electricity Standard or RES (requiring electric power utilities to increase the share of alternative generation sources to 15% by 2020) had been removed, was discussed in the plenary session in the morning of December 13, but again failed to pass. Subsequent discussions resulted in the removal of tax provisions that demanded, among other things, the abolition of tax deductions for oil and natural gas companies. The revised energy bill was again discussed in the Senate, and was passed in the evening of December 13 (86 vs. 8). On December 18, this revised energy bill was approved in the plenary session of the House (314 vs. 100).

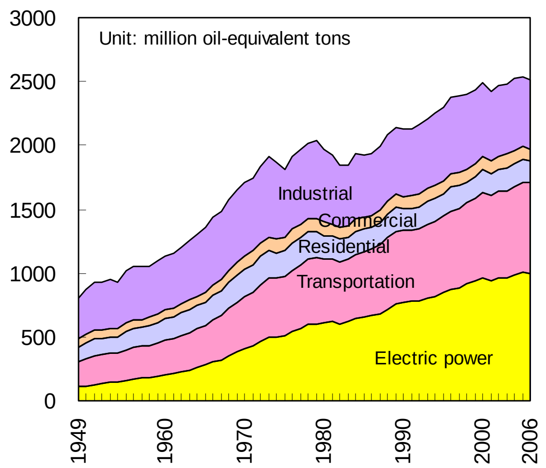
The bill explicitly stated the goal of raising the CAFE target value to 35 mpg by 2020. Besides strengthening the regulation on the fuel economy of automobiles, another major purpose of the bill was to tighten the Renewable Fuel Standard, with the aim of expanding the production of renewable fuels to 36 billion gallons (five times the present production) by 2022, 21 gallons of which should be produced from materials other than corn. President Bush signed and enacted the new energy bill on December 19.

The following sections outline the CAFE standards and analyze quantitatively how the tightening of fuel economy standards proposed by this 2007 Comprehensive Energy Bill and the growing sales share of Japanese cars in the U.S. market may reduce oil consumption in the future.

2. ENERGY SUPPLY AND DEMAND IN THE UNITED STATES

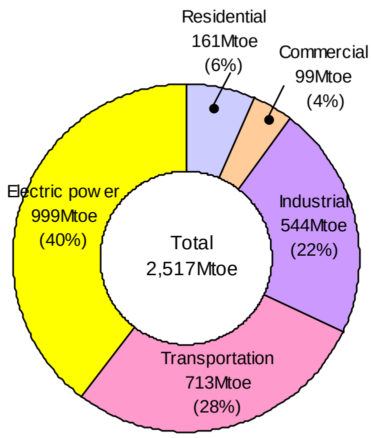
Primary energy consumption by the United States in 2006 was about 2.5 billion oil equivalent tons (hereafter referred to as "tons"), five times as large as Japan whose primary energy consumption is approximately 0.5 billion tons. As to primary energy consumption by sector in 2006, consumption by the power generation sector amounted to about 1 billion tons, accounting for about 40% of the total (Figures 2-1 and 2-2). This was followed by the transportation sector with about 0.7 billion tons (about 30% of the total), and the industrial sector amounting to 0.54 billion tons (about 20% of the total). Primary energy consumption by *each* of these sectors exceeded the primary energy consumption of Japan as a whole. Consumption of approximately 0.16 billion tons by the residential sector and approximately 0.1 billion tons by the commercial sector, which constitute the "consumer sector," accounted for about 10% of the total. In terms of change in energy consumption from 1996 to 2006, there was little increase in the residential, commercial and industrial sectors: the mean annual growth rate was -0.8% in the industrial sector, -0.8% in the commercial sector, and -1.5% in the residential sector. Consumptions in the transportation and power generation sectors, on the other hand, grew steadily: the mean annual growth rate was 1.5% in the transportation sector and 1.4% in the power generation sector.

Figure 2-1 Energy consumption by sector in the United States



Source: EIA/DOE, "Annual Energy Review 2006," Report No. DOE/EIA-0384 (2006)

Figure 2-2 Energy consumption by sector in 2006



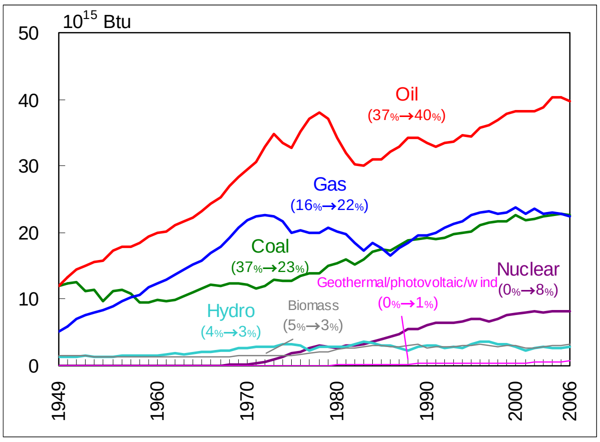
Source: EIA/DOE, "Annual Energy Review 2006," Report No. DOE/EIA-0384 (2006)

As to primary energy consumption in the United States by source, the consumption of oil has long been dominant, presently accounting for 40% of total consumption (Figure 2-3), followed by coal with 23% and gas with 22%. Fossil fuels, therefore, account for 85% of total consumption. As to non-fossil resources, their contributions to primary energy consumption are as follows: nuclear power 8%, hydro 3%, biomass 3%, and other renewable resources 1%. As to oil consumption by sector, the oil sector presently accounts for about 70% of total oil consumption, increasing from 54% in 1949 to 68% in 2006. Oil consumption continues to grow mainly because of increasing consumption by the transportation sector (Figure 2-4).

One energy security issue for the United States in recent years is its increasing volume of imported oil. On the back of economic growth since the 1990s, oil consumption has been growing steadily particularly in the transportation sector, and oil remains the dominant source of energy. Crude oil production in the United States, on the other hand, peaked in 1970 (at 11.3 million B/D) and then started to decrease (Figure 2-5).

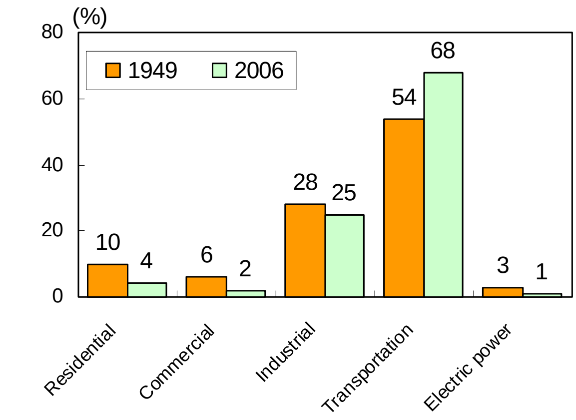
As a result, the net import volume of oil grew from 0.3 million B/D in 1949 to 12 million B/D in 2006, sharply raising the import dependency (net import divided by consumption) from 6% to 60%. Since oil remains the primary source of energy for the United States, balancing its supply and demand by cutting oil consumption through energy saving, particularly in the transportation sector, and by securing stable supplies of oil, is a major challenge for its energy policies.

Figure 2-3 Primary energy consumption in the United States (by source)



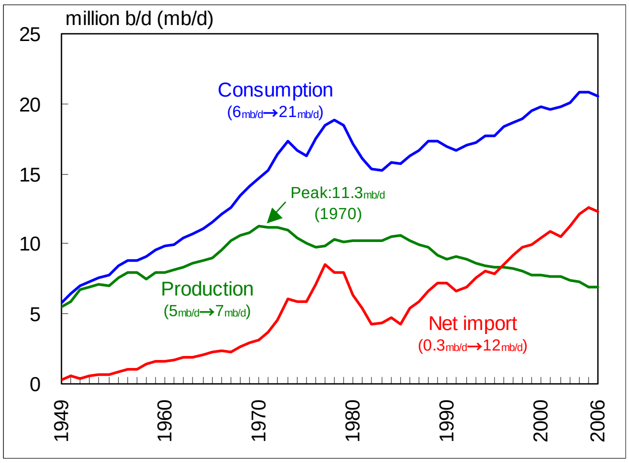
Source: EIA/DOE, "Annual Energy Review 2006," Report No. DOE/EIA-0384 (2006)

Figure 2-4 The Share of Oil consumption in the United States (by sector)



Source: EIA/DOE, "Annual Energy Review 2006," Report No. DOE/EIA-0384 (2006)

Figure 2-5 Oil supply and demand in the United States

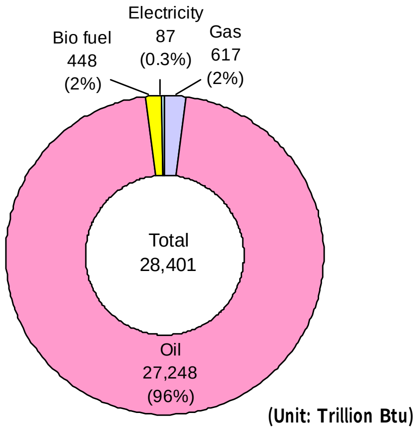


Source: EIA/DOE, "Annual Energy Review 2006," Report No. DOE/EIA-0384 (2006)

3. ENERGY CONSUMPTION BY THE TRANSPORTATION SECTOR IN THE UNITED STATES

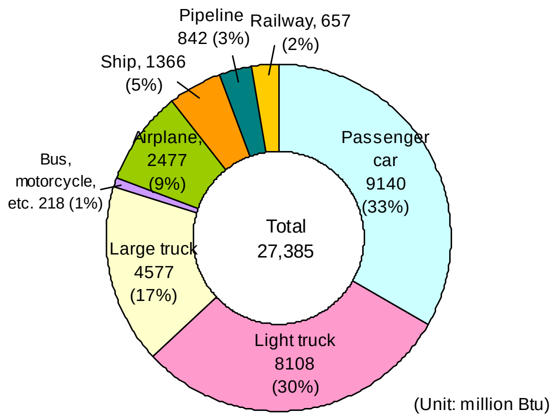
According to the breakdown of energy consumption by the transportation sector in the United States by source, the consumption of oil accounts for 96% of the total, followed by biofuel (2%) and gas (2%). This indicates the country's heavy dependency on oil (Figure 3-1).[2]

Figure 3-1 Energy consumption by the transportation sector in the United States (by source, 2006)



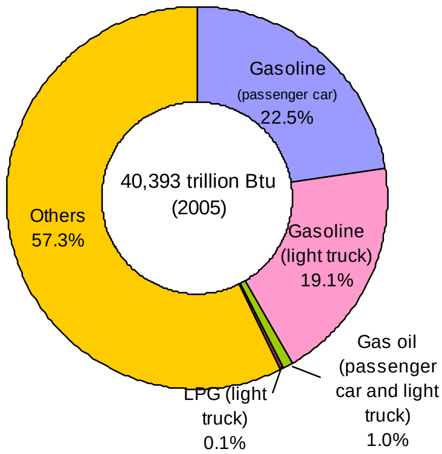
Source: EIA/DOE, "Annual Energy Review 2006," Report No. DOE/EIA-0384 (2006)

Figure 3-2 Energy consumption by the transportation sector in the United States (by transportation category, 2005)



Source: "Transportation Energy Data Book," ORNL

Figure 3-3 Breakdown of oil consumption in the United States



Source: "Transportation Energy Data Book," ORNL

According to the breakdown of energy consumption by the transportation sector in the United States by transportation category, consumption by road vehicles, including passenger cars, light trucks (mainly of vans, pickup trucks and SUVs)[3] and large trucks (mainly for freight transportation), constitutes

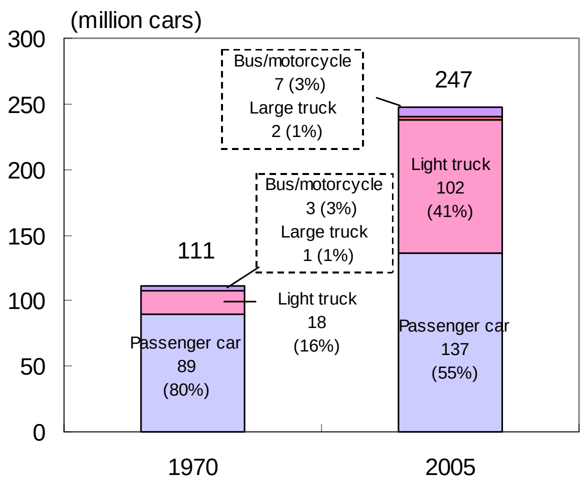
[2] Breakdown by fuel type of oil demand by the transportation sector in 2005: 66% gasoline, 21% gas oil, 9% jet fuel, and 3% heavy oil.

[3] Breakdown by fuel type of energy demand by passenger cars and light trucks in 2005: gasoline 97.3%, gas oil 2.4%, and LPG 0.3%.

approximately 80% of the total consumption, while the remaining 20% arises from nonroad vehicles such as airplanes, ships and railways (Figure 3-2). Of the total oil consumption in the United States in 2005, 22.5% was consumed as gasoline by passenger cars; 19.1% as gasoline by light trucks; 1.0% as gas oil by passenger cars and light trucks; and 0.1% as LPG by light trucks. Thus, passenger cars and light trucks are responsible for approximately 40% of oil consumption by the nation (Figure 3-3). Therefore, the regulation of fuel economy of passenger cars and light trucks and its achievement will crucially affect the mid- to long-term oil supply and demand in the United States.

The number of registered automobiles, particularly light trucks including SUVs, in the United States grew from 111 million in 1970 to 247 million in 2005 (Figure 3-4). The number of registered light trucks grew significantly from 18 million to 120 million, or from 16% to 41% in terms of share. In the meantime, the number of registered passenger cars grew from 89 million to 137 million, but the share decreased from 80% to 55%.

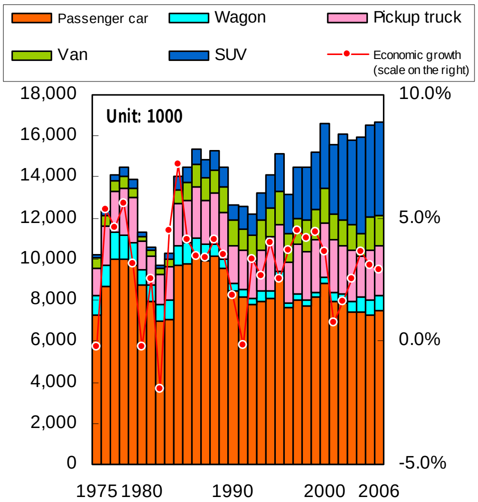
Figure 3-4 Number of registered automobiles in the United States



Source: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 2005, Washington, DC

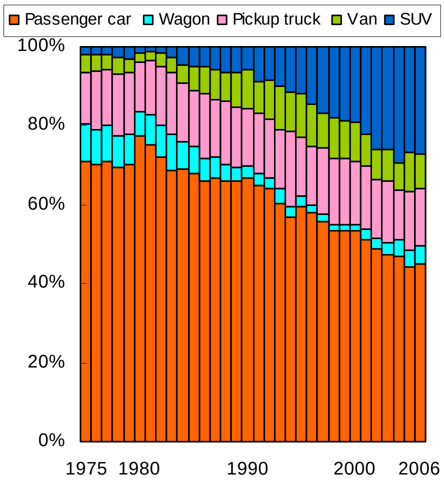
Automobile sales in the United States rise and fall with the nation’s economic growth. The number of automobiles sold in 2006 was about 16.7 million (Figure 3-5). According to the breakdown by vehicle type, the share of passenger cars in sales has been falling while that of SUVs has been growing (Figure 3-6). Although the share of passenger cars fell from 71% in 1975 to 45% in 2006, the share of SUVs rose sharply from 2% to 27%, boosting the overall growth of automobile sales.

Figure 3-5 Number of automobiles sales in the United States



Source: U.S. Environmental Protection Agency, Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2006, July 2006

Figure 3-6 The Share of automobile sales in the United States by vehicle type

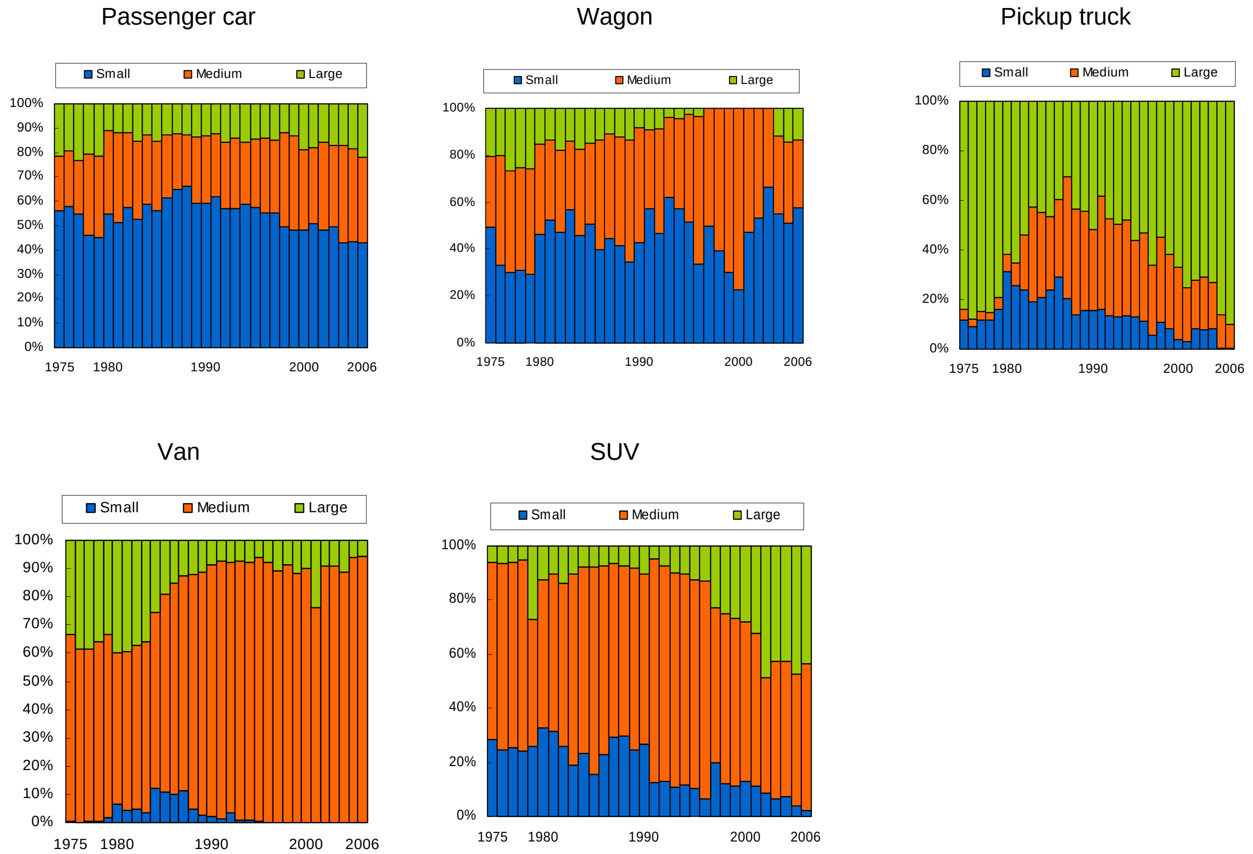


Source: U.S. Environmental Protection Agency, Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2006, July 2006

Since 2002, the sales volume of light trucks (including SUVs, pickup trucks and vans) has amounted to about half of the number of light automobiles (passenger cars and light trucks) sold in the United States. The sales share of light trucks has been growing for about 20 years since 1980. Among different types of light trucks, the share of SUVs has grown dramatically: it was less than 10% in 1990 but has increased to about 30% in recent years.

Since the fuel economy of light trucks is worse than passenger cars by 6–7 mpg on average, the growth in the sales share of light trucks has worsened the average fuel economy of automobiles. The change in the number of automobiles sold by size of different types of automobiles shows that sales of passenger cars have increased particularly in middle size models, the sales of wagons in small size models, the sales of pickup trucks in large size models, the sales of vans in middle size models, and the sales of SUVs in large size models. This size-weighted analysis indicates that the recent growth in sales of automobiles is mainly due to the sales of large SUVs (Figure 3-7).

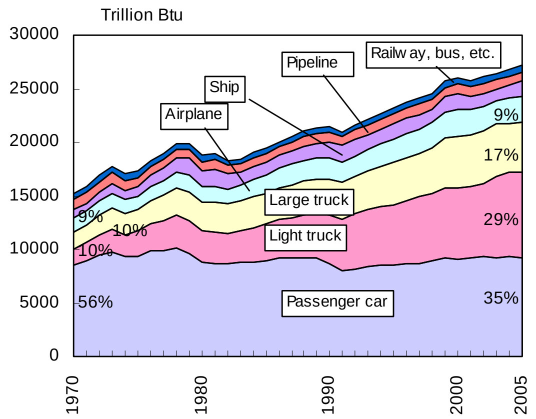
Figure 3-7 The Share of automobiles sales by size



Source: U.S. Environmental Protection Agency, Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2006, July 2006

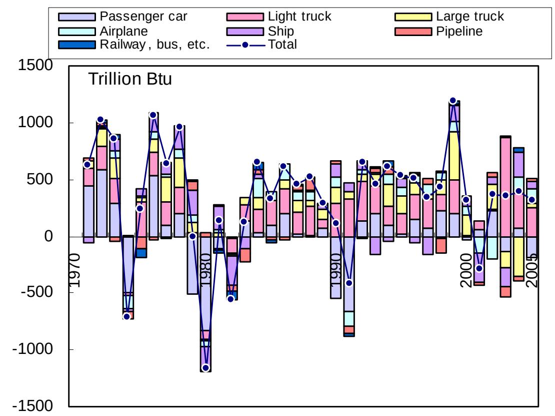
As to the trend of energy consumption by different categories of transportation means, energy consumption by the transportation sector in the United States is driven mainly by growth in sales of light trucks (Figure 3-8).

Figure 3-8 Fuel consumption by the transportation sector in the United States by transportation category



Source: "Transportation Energy Data Book," ORNL

Figure 3-9 Growth in energy consumption by the transportation sector in the United States

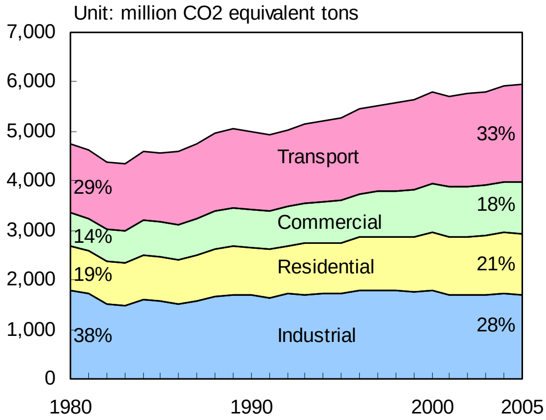


Source: "Transportation Energy Data Book," ORNL

While the fuel consumption of light trucks in the transportation sector grew from 10% in 1970 to 29% in 2005, that of passenger cars fell from 56% to 35%, resulting in little increase in fuel consumption by passenger cars (Figures 3-8 and 3-9). Of the total growth in fuel consumption by the transportation sector from 1970 to date, approximately 60% is attributable to light trucks, and about 30% to large trucks. Growth in the sales share of light trucks, which are inferior to passenger cars in terms of fuel economy, has made light trucks most responsible for the increase in consumption of oil.

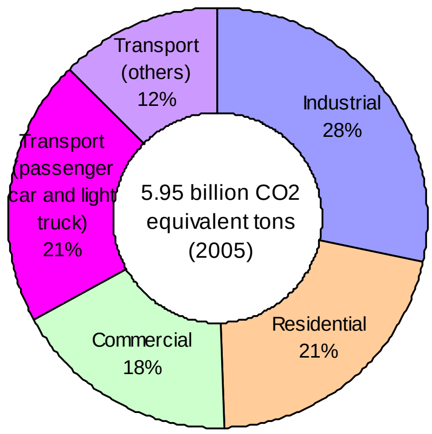
According to the breakdown of CO_2 emissions by sector in 2005, the transportation sector was responsible for 33% of total emissions, making the transportation sector the largest source of CO_2 emissions among all final consumption sectors (Figure 3-10). This was followed by the industrial sector with 28%, the residential sector with 21% and the commercial sector with 18%. Moreover, the transportation sector is responsible for about nearly 50% of the growth in CO_2 emissions between 1980 and 2005. Therefore, the reduction of CO_2 emissions in the transportation sector is an important challenge in curbing global warming. The commercial sector and the residential sector each account for about 30% of the increase in CO_2 emissions, showing the largest increases in emissions next to the transportation sector. The consumption of fuels by passenger cars and light trucks contributes to about 20% of the total CO_2 emissions in the United States (Figure 3-11).

Figure 3-10 CO_2 emissions by sector in the United States



Source: EIA/DOE, “Annual Energy Review 2006,” Report No. DOE/EIA-0384 (2006)

Figure 3-11 Breakdown of CO_2 emissions in 2005



Source: EIA/DOE, “Annual Energy Review 2006,” Report No. DOE/EIA-0384 (2006)

4. CORPORATE AVERAGE FUEL ECONOMY (CAFE) STANDARDS OF THE UNITED STATES

As described in the previous section, the fuel economy of passenger cars and light trucks is closely related to energy security, crude oil prices and GHG emissions. In other words:
(1) The fact that oil consumed by passenger cars and light trucks accounts for about 40% of total oil consumption in the United States and the country's growing dependency on imported oil suggest that the fuel economy of passenger cars and light trucks is inextricably linked with energy security.
(2) Automobile fuel economy directly affects car users' spending on fuel. Higher crude oil prices may change consumer behavior such as switching to more fuel-efficient models.
(3) CO_2 emissions arising from the consumption of fuels by passenger cars and light trucks account for about 20% of the total emissions in the United States, and therefore are of great significance in the nation's efforts to address global warming. The regulation of fuel economy by the United States and its achievement are thus of global concern. Accordingly, this section outlines the regulation and achievement of fuel economy by the United States.

4-1 Overview of CAFE Standards of the United States

Automobiles sold in the United Standards are placed under Corporate Average Fuel Economy (CAFE) standards that control the CAFE of passenger cars and light trucks sold in the United States. CAFE is the sales-weighted corporate average fuel economy, in which the number of new passenger cars and light trucks sold by manufacturers is considered. The following formula is used to calculate a given manufacturer's CAFE as the sales-weighted corporate average fuel economy based on the production volume of passenger cars or light trucks manufactured for sale in the given model year (see reference 7, etc.). The fuel economy is expressed in terms of miles per gallon (mpg).

$$CAFE = \frac{N}{\sum_i \frac{N_i}{MPG_i}} \qquad (1)$$

where,
N: a given manufacturer's total production volume for passenger cars or light trucks
N_i: the manufacturer's production volume of model i for passenger cars or light trucks
MPG_i: the fuel economy of model i for passenger cars or light trucks of the manufacturer

CAFE targets applicable to each manufacturer are calculated using the following formula:

$$CAFETARGET = \frac{N}{\sum_i \frac{N_i}{MPGTARGET_i}} \qquad (2)$$

$MPGTARGET_i$: the fuel economy target for model i for passenger cars or light trucks determined by the Department of Transportation (DOT)

If the value of CAFE from (1) exceeds the value of CAFETARGET from (2), the given manufacturer passes the standard. The fuel economy of each model is calculated based on the measurement taken by following the test method determined by EPA and NHTSA. The test methods for fuel economy differ around the world (Table 4-1) and different test methods yield different fuel economy values even for the same model (Table 4-2), so care is required when making cross-national comparisons of fuel economy.

Table 4-1 Overview of different fuel economy test methods

	Duration (s)	Travel distance (thousand mile)	Average speed (mph)	Max. speed (mph)	Max. acceleration (mph/s)
JC08 mode (Japan)	1204	5.1	15.2	50.7	3.8
10/15 mode (Japan)	631	2.6	14.8	43.5	1.78
NEDC(New European Driving Cycle):Europe	1,181	6.84	20.9	74.6	2.4
U.S. EPA city cycle:United States	1,372	7.5	19.5	56.7	3.3
U.S. EPA highway cycle:United States	765	17.8	48.2	59.9	3.3
U.S. CAFE cycle:United States	2,137	10.3	29.9	59.9	3.3

Source: Compiled from ICCT "Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update"

Table 4-1 Fuel economy measurements from different test methods

Test method	Measured fuel economy
10/15 mode:Japan	17.5 mpg
NEDC(New European Driving Cycle):Europe	22.0 mpg
U.S. EPA city cycle:United States	19.8 mpg
U.S. EPA highway cycle:United States	32.1 mpg
U.S. CAFE cycle:United States	23.9 mpg

Note: Measured for 1995 middle size models (Chevrolet Lumina, Chrysler Concord, Ford Taurus, etc.)

Source: Santini, D., A. Vyas, J. Anderson, and F. An, Estimating Trade-Offs along the Path to the PNGV 3X Goal, Transportation Research Board 80th Annual Meeting, Washington, DC, January 2001

4-2 Regulatory Agency

The U.S. Department of Transportation (DOT) consigns the formulation of CAFE standards to the National Highway Traffic Safety Administration (NHTSA), which is responsible for a broad range of administrative tasks related to automobiles including reviewing regulatory exemptions for small manufacturers of automobiles, examining applications submitted by foreign automobile manufacturers for sales in the United States, classifying vehicle models, and collecting information on fuel economy. The U.S. Environmental Protection Agency (EPA) supports NHTSA in areas such as the test methods for fuel economy.

4-3 Target Vehicle Types

CAFE standards are different between passenger cars and light trucks. For 2007, the target is 27.5 mpg for passenger cars and 22.2 mpg for light trucks. By the definition of federal laws (49 CFR 523), a passenger car is any 4-wheel vehicle manufactured primarily for use in transporting 10 people or less. A light truck, on the other hand, is any 4-wheel vehicle designated to perform at least one of the following functions: (1) transport more than 10 people; (2) provide temporary living quarters; (3) can be converted to an open bed vehicle by removing rear seats to form a flat continuous floor; (4) has greater cargo-carrying capacity than passenger-carrying capacity; or (5) can be converted to a freight vehicle by upgrading specific functions. Examples of light trucks include pickup trucks, vans, mini-vans and sport utility vehicles (SUVs). At present, standards apply to vehicles with a gross vehicle weight rating (GVWR) of 10000 lbs. or less.[4]

4-4 CAFE Standards for Light Trucks

CAFE standards for light trucks have been established by NHTSA, and were first applied to light trucks in 1979. The standards were, however, initially applicable only to light trucks with a GVWR of 6000 lbs. or less, and the target was 17.2 mpg for 2WD vehicles and 15.8 mpg for 4WD vehicles. The scope of target models was broadened from 1980 until the standards were made applicable to light trucks with a GVWR of 8500 lbs. or less. Later on, the standards were raised gradually as high as 20.7 mpg for 2WD vehicles and 19.1 mpg for 4WD vehicles before 1991.

From 1982 to 1991, with more freedom in the interpretation of CAFE standards, the fuel economy of light trucks was required to meet the 2WD-4WD averaged target or either of them. The distinction between 2WD and 4WD was eliminated in 1992, and replaced by a single target for light trucks (20.2 mpg). At present, CAFE standards address two vehicle categories, passenger cars and light trucks, and each category has its own target. The target for light trucks rose gradually up to 1996 and then was fixed at 20.7 mpg until 2004. Following the formulation of new fuel economy standards for light trucks in March 2003, the target rose to 21.0 mpg in 2005, 21.6 mpg in 2006, and 22.2 mpg in 2007.

In April 2006, the Bush administration announced a revised scheme of fuel standards for light trucks based on a new concept that decides standards according to vehicle size. Under this scheme, the target is expected to be raised gradually to as much as 24 mpg by 2011. This was the first major reform since fuel economy standards for light trucks were introduced in 1979. The new standards will be applied stepwise to models manufactured between 2008 and 2011. From 2008 to 2010, car manufacturers are free to choose between the current and new CAFE standards, but from the production of model year 2011, they are required to comply with the new standards. The new standards are applicable also to vehicles with a GVWR between 8,500 and 10,000 lbs., which are unregulated by the present standards. The new standards set targets based on vehicle size, or “footprint.” The “footprint” of a light truck is calculated by multiplying the track width (distance between the centerlines of the right and left wheels) by the wheelbase (distance between the centers of the front and rear axles).

As described earlier, the current CAFE standards are aimed at regulating the average fuel efficiency of the entire fleet of light trucks for each manufacturer. The new standards, on the other hand, set targets based on footprints. The new CAFE standards require automobile manufacturers not only to raise the average fuel economy of the entire fleet by increasing the production of compact automobiles, but also to improve the fuel economy of every vehicle model.

Under the new CAFE standards for light trucks, the target is calculated from footprints using the formula below. As with the current CAFE standards, the calculation is based on “harmonic mean.”[5]

$$\text{CAFE standard for light trucks} = \frac{N}{\sum_i \frac{N_i}{T_i}} \qquad (3)$$

[4] Gross vehicle weight rating (GVWR) is based on the gross vehicle weight after the loading of passengers, cargo and fuel within allowable limits.
[5] See the NHTSA web site (http://www.nhtsa.dot.gov/) for details.

$$\text{where,} \quad T = \frac{1}{\frac{1}{a} + \left(\frac{1}{b} - \frac{1}{a}\right)\frac{e^{(x-c)/d}}{1+e^{(x-c)/d}}} \qquad (4)$$

x = Footprint of a given vehicle

a = Maximum fuel economy target (mpg)

b = Minimum fuel economy target (mpg)

d = Parameter for footprint change

The table below shows the parameter values for model years 2008-2011 established by NHTSA:

Parameter	Model Year			
	2008	2009	2010	2011
a	28.56	30.07	29.96	30.42
b	19.99	20.87	21.20	21.79
c	49.30	48.00	48.49	47.74
d	5.58	5.81	5.50	4.65

4-5 Classification of Domestic and Imported Cars

CAFE calculations are different between passenger cars and light trucks. The so-called "two-fleet rule" applies to passenger cars. That is, if the entire fleet of passenger cars consists of domestic and imported cars, the domestic fleet and imported fleet must independently meet the fuel economy standard (currently 27.5 mpg). Regardless of the nationality of manufacturer, any car is considered to be domestic if 75% or more of its components are procured in the United States, Canada or Mexico. Any car that does not meet this criterion is deemed imported. The two-fleet rule used to apply also to light trucks in the early 1980s but was abolished for light trucks in 1996.

4.6 Fuel Economy Measurement

Automobile fuel economy statistics are published by NHTSA and EPA. NHTSA manages CAFE standards and CAFE statistics, while EPA is responsible for realistic aspects of fuel economy, such as values adjusted to real driving conditions. Data pertaining to fuel economy regulations is available from NHTSA statistics accordingly. Fuel economy is measured mainly by EPA and is based on carbon emissions. The procedure is defined in detail in 40 CFR Part 600 – "Fuel Economy of Motor Vehicles" in Code of Federal Regulation.[6] EPA determines ADJ-MPG (fuel economy values adjusted to real driving

[6] Fuel economy of gasoline-fueled vehicle is determined using the following identical equation. (See 40 CFR Part 600 "Fuel Economy of Motor Vehicles" for details.)
mpg = (5174 × 104 × CWF × SG) / [((CWF × HC) + (0.429 × CO)) + (0.273 × CO_2)] × ((0.6 × SG × NHV) + 5471)]
HC: hydrocarbon emission measurement (grams/mile)
CO: carbon monoxide emission measurement (grams/mile)
CO_2: carbon dioxide emission measurement (grams/mile)
CWF: carbon weight fraction of test fuel
NHV: net heating value per unit mass (Btu/lb)
SG: specific gravity of fuel

The fuel economy of a diesel oil-fueled vehicle is given by dividing 2778 by the sum of the following three: (i) 0.866 × HC (grams/mile); (ii) 0.429 × CO (grams/mile); and (iii) 0.273 × CO_2 (Grams/mile)

The fuel economy of a methanol-fueled vehicle is given by the following expression:

conditions) and LAB-MPG (laboratory generated mpg). In either case, the values are generated for driving in cities, on highways, or the composite of these two (city 55% and highway 45%). In 2006, EPA revised their method for obtaining fuel economy values adjusted to real driving conditions to allow it to reflect various factors that may affect fuel economy (such as heavier use of air conditioner, change in driving habit, higher speed on highways, etc.) in the calculation. Before the revision, driving speeds were assumed lower than in real life, with no use of air conditioning, and at the external ambient temperature of 75°F (approx. 24°C). The revised method, on the other hand, assumes the external ambient temperature of 20°F (–7°C) and higher driving speeds, and takes into account the use of air conditioning, road conditions and cargo load. The relationship between LAB MPG and ADG MPG is shown in the equation below (Reference 16). Since the test method for LAB MPG values has not essentially changed since the mid 1970s, those values can be used to assess the long-term evolution of vehicle performance.

$$\mathrm{MPG(adjusted)_{city}} = \frac{1}{0.003259 + \dfrac{1.1805}{\mathrm{MPG(unadjusted)_{city}}}} \qquad (5)$$

$$\mathrm{MPG(adjusted)_{highway}} = \frac{1}{0.001376 + \dfrac{1.3466}{\mathrm{MPG(unadjusted)_{highway}}}} \qquad (6)$$

EPA obtains the composite fuel economy using the following formula assuming 55% for city and 45% for highway (Reference 16):

$$\mathrm{MPG} = \frac{1}{\dfrac{0.55}{\mathrm{MPG_{city}}} + \dfrac{0.45}{\mathrm{MPG_{highway}}}} \qquad (7)$$

The official CAFE values (for judgment of CAFE standard compliance) announced by NHTSA are based on fuel economy measurements taken by EPA but differ from the values generated by EPA due to further adjustments (e.g. for vehicles running on alternative fuels). As a result, the CAFE values announced by NHTSA are better than the values by EPA.

4-7 Treatment of Alternative Fuels

The Alternative Motor Fuels Act of 1988 allows preferential calculations for the fuel economy of alternative-fuel vehicles and of hybrid vehicles (so-called “the Dual Fuel Program”). For such vehicles, gasoline or gas oil equivalent fuel economy is divided by 0.15 to obtain the fuel economy for reference. This division by 0.15 for obtaining the fuel economy for CAFE calculations is a preferential treatment

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mpg = (CWF × SG × 3781.8) / ((CWFe x HC × HC) + (0.429 × CO) + (0.273 × CO_2) + (0.375 × CH_3OH) + (0.400 × HCHO))
CWFexHC: carbon weight fraction of exhaust hydrocarbons
CH3OH: methanol emission measurement (grams/mile)
HCHO: formaldehyde emission measurement (grams/mile)

The fuel economy of a natural gas fueled-vehicle is given by the following expression:

$$mpg_e = \frac{CWF_{HC/NG} D_{NG} \; 121.5}{(0.749) CH_4 + (CWF_{NMHC}) NMHC + (0.429) CO + (0.273)(CO_2 - CO_{2NG})}$$

mpg_e: fuel economy (natural gas equivalent)
$CWF_{HC/NG}$: carbon weight fraction based on the hydrocarbon constituents in the natural gas fuel
DNG: natural gas density [grams/ft^3 at 68°F (20°C) and 760 mm Hg (101.3 kPa)]
NMHC: non-methane hydrocarbon emission measurement (grams/mile).
CWF_{NMHC}: carbon weight fraction of exhaust non-methane hydrocarbons
CO_{2NG}: carbon dioxide in consumed natural gas (grams per mile of travel)

granted to any vehicle that runs on alternative fuel instead of gasoline or gas oil (such alternative fuels include E85, 85-to-15 mixture of ethanol and gasoline). In other words, a vehicle that achieves 15 mpg with alternative fuel alone is deemed to have the fuel economy of 100 mpg (= 15/0.15).

In the case of a bi-fuel vehicle (simultaneous consumption of renewable fuel and gasoline or gas oil), the average of the fuel economy for gasoline or gas oil and the fuel economy for renewable fuel divided by 0.15 is taken. Assuming (1) 50% consumption of gasoline or gas oil and 50% consumption of renewable fuel, (2) fuel economy for renewable fuel at 15 mpg (taken as 100 mpg after being divided by 0.15), and (3) fuel economy for gasoline or gas oil at 25 mpg, for example, then the vehicle is deemed to have the fuel economy given by the formula (see Reference 7, etc.):

CAFE = 1 / (0.5/25 + 0.5/100) = 40 mpg

However, there is an upper limit to this preferential treatment granted to promote the production of alternative-fuel vehicles. Currently, the highest accountable CAFE improvement by this preferential treatment is set at 1.2 mpg, and it will be so until 2010.

4-8 Penalty Provisions

Any manufacturer that fails to comply with CAFE standards is liable to penalties. The provisions apply to any manufacturer that sells passenger cars and/or light trucks in the United States. (The penalty for each manufacturer is published on the NHTSA website (http://www.nhtsa.dot.gov/)). The amount of penalty is calculated by the following expression (Reference 7, etc.):

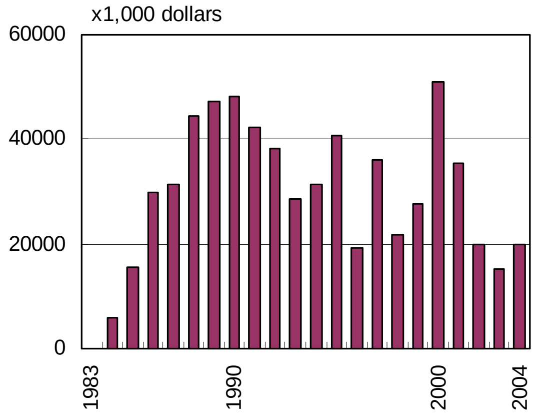
5.5$ ÷ ((CAFE target – specific CAFE for a given manufacturer) / 10) × sales volume in a given model year

For example, supposing that CAFE for a manufacturer that sold 350,000 vehicles in 2006 was 21.31 mpg, while the CAFE target value was 21.6 mpg, then the penalty is calculated as follows:

(21.6 – 21.31) × 10 × $5.5 × 350,000 = $5,582,500

From 1983 to 2004, different manufacturers paid as much as 670 million dollars in total penalties (Figure 4-1). NHTSA evaluates compliance with the standards and notifies manufacturers of the results. It should be noted that the calculation of CAFE for each manufacturer allows the use of “credits.” Specifically, when the average fuel economy of either the passenger car or light truck fleet for a particular model year exceeds the established standard, the manufacturer earns credits for such achievement in excess and can “bank” the credits. These credits can be applied to three years immediately prior to or subsequent to the model year in which the credits are earned. Each manufacturer is not required to meet the established standard in every model year, but may use credits to offset deficiencies in their CAFE performances within this timeframe. The credits earned and applied to any of the three model years prior to the model year for which the credits are earned are termed “carry back” credits, while those applied to model years subsequent to the model year in which the credits are earned are known as “carry forward” credits. Failure to exercise carry-forward credits within the three years immediately following the year in which they are earned will result in the forfeiture of those credits. Credits cannot be passed between manufacturers or between fleets, e.g., from domestic passenger cars to light trucks. If the established standard can not be met even after applying credits, the given manufacturer must pay penalties.

Figure 4-1 Changes in penalties paid

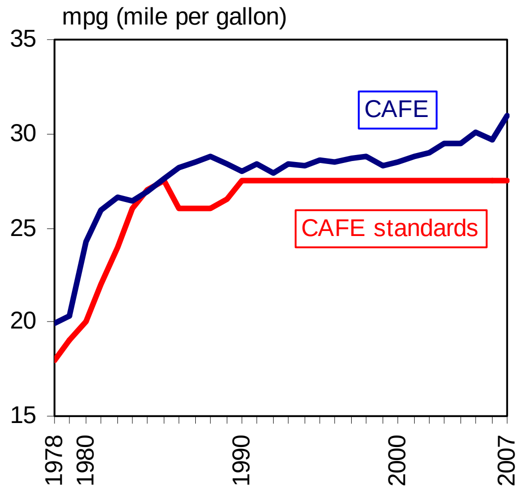


Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, Office of Vehicle Safety Compliance, Washington, DC, June 2006

5. CAFE AND CAFE STANDARDS

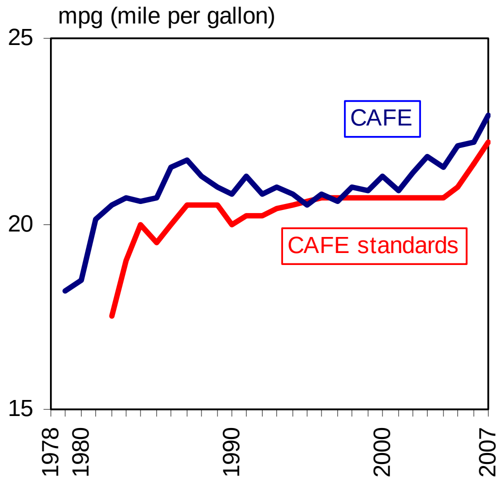
In 1975, the United States Congress approved the Energy Policy Conservation Act (EPACT) that included provisions on fuel economy standards. Following the first oil crisis (1973–1974), EPACT aimed at doubling fuel economy by 1985. Following the establishment of EPACT, fuel economy targets were raised each year until 1985. However, the passenger car fuel economy target was not raised for a long time after 1985 (and was even reduced from 1986 to 1989), while the light truck fuel economy target remained at around 20 mpg from 1984 to 2005 (the target has been raised since 2005 due to the establishment of new standards). Thus, there was no major tightening of fuel economy standards in those years.

Figure 5-1 CAFE vs. CAFE standards (passenger cars)



Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

Figure 5-2 CAFE vs. CAFE standards (light trucks)



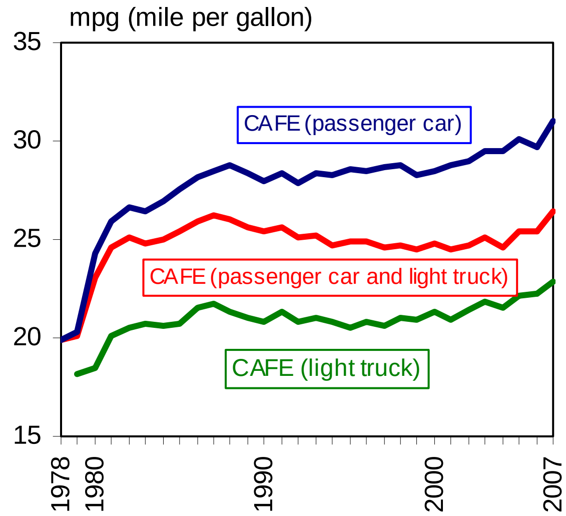
Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

Amid the global trend toward stricter regulations of fuel economy due to the sharp rise in crude oil prices and the promotion of efforts against global warming, in 2001 the Bush Administration discussed the strengthening of CAFE standards in formulating national energy policies. As a result, a decision was made in 2004 to raise the fuel economy targets for light trucks from 2005 to 2007. Furthermore, in December 2007, Congress approved a comprehensive energy bill that stipulated, among other things, the strengthening of CAFE standards for automobiles. This was the first time since 1975 that Congress had taken the initiative in raising fuel economy standards: the bill included a provision to raise the target to 35 mpg by 2020. This section describes the changes in CAFE and CAFE standards.

5-1 CAFE vs. CAFE Standards

The change in CAFE achieved in the past by passenger cars and light trucks corresponds to the CAFE standards for each year. Firstly, the strengthening of CAFE standards from 1975 to the early 1980s after the second oil crisis resulted in a rapid improvement of fuel economy (Figures 5-1 and 5-2). The CAFE of passenger cars rose to 28.8 mpg in 1988, while the CAFE of light trucks rose to 21.7 mpg in 1987. The composite CAFE for light automobiles (passenger cars and light trucks) rose to 26.2 mpg in 1987. Later, however, as crude oil prices fell in the mid 1980s, neither passenger cars nor light trucks achieved any significant improvement in fuel economy: consequently, the passenger car fuel economy showed little improvement until it was raised to 28.8 mpg in 1988, while the light truck fuel economy also stopped growing until it was increased to 22.1 mpg in 2005 following a revision of CAFE standards.

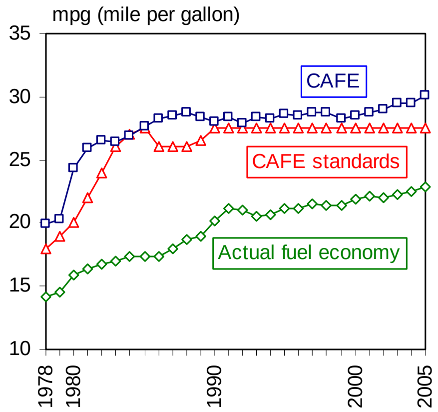
Figure 5-3　Changes in CAFE



Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

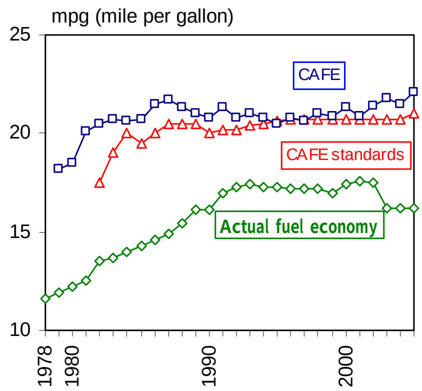
Nevertheless, it is assumed that the fall in crude oil prices in the 1980s and 1990s did not cause a significant drop in fuel economy because the CAFE standards controlled the fuel economy. The CAFE of light automobiles (passenger cars and light trucks) hardly changed for some time after peaking in 1987, but started to increase again from 2004. It is expected to reach 26.4 mpg in 2007, exceeding the fuel economy achieved in 1987 (Figure 5-3).

Figure 5-4 CAFE vs. actual fuel economy (passenger cars)



Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

Figure 5-5 CAFE vs. actual fuel economy (light trucks)

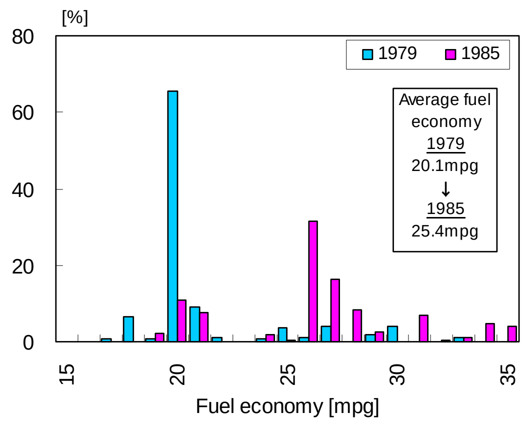


Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

The actual fuel economy (actual fuel consumption divided by actual travel distance) shows a long-term steady improvement with CAFE (Figures 5-4 and 5-5). From 1970 to 2005, in the case of passenger cars, travel distance grew at the mean annual rate of 1.8% while fuel consumption grew at the mean annual rate of 0.2%, resulting in a mean annual improvement of actual fuel economy of 1.5%. In the case of light trucks, travel distance grew at the mean annual rate of 6.3% while fuel consumption grew at the mean annual rate of 4.9%, thus improving the actual fuel economy by the mean annual rate of 1.4%. In the case of light trucks, however, travel distance grew at the mean annual rate of 3.7% while fuel consumption grew at 3.0% from 1995 to 2005, resulting in a mean annual improvement in the actual fuel economy of 0.7%.

As to passenger cars and light trucks, the significant increase in CAFE standards in the early 1980s resulted in a substantial improvement in the average fuel economy of new automobiles and had an impact on the average new car fuel economy distributions (Figure 5-6). The distributions show how the average fuel economy of new automobiles shifted from 1979 to 1985.

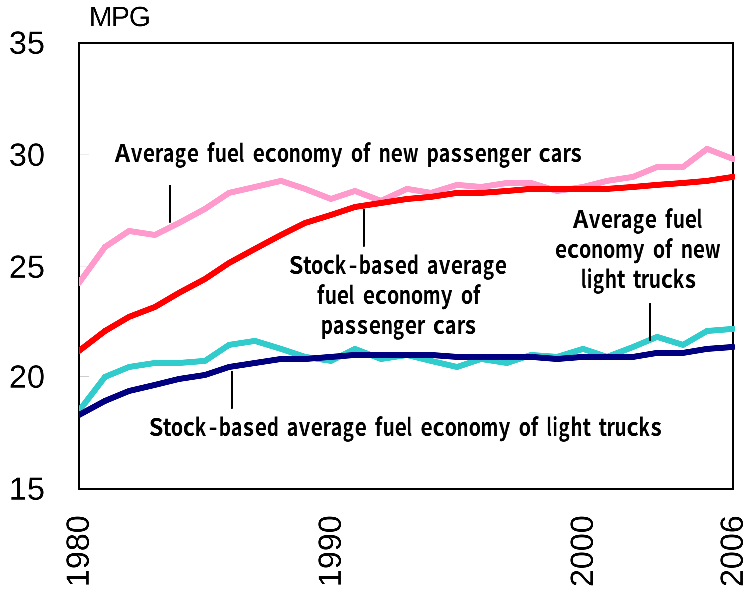
Figure 5-6 Average new car average fuel economy distributions in the United States (passenger cars and light trucks)



Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006, "Transportation Energy Data Book," ORNL

The average fuel economy of all registered passenger cars and light trucks estimated from the sales volume of new vehicles and the scrap rate in each year (Figure 5-7) shows that without a significant improvement in CAFE standards for both passenger cars and light trucks, there was little improvement in the average new car fuel economy after 1990. Consequently, the improvement of the average fuel economy of all registered automobiles was limited.

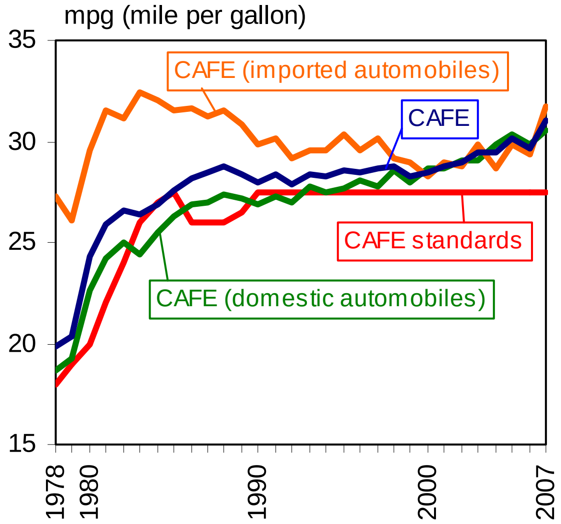
Figure 5-7 Average fuel economy for new cars vs. stock-based average fuel economy for registered cars in the United States (passenger cars and light trucks)



Source: Produced by the author based on NHTSA statistics. The average fuel economy for registered cars was estimated using the scrap rates given by ORNL (Schmoyer, Richard L., unpublished study on scrappage rates, Oak Ridge National Laboratory, Oak Ridge, TN, 2001).

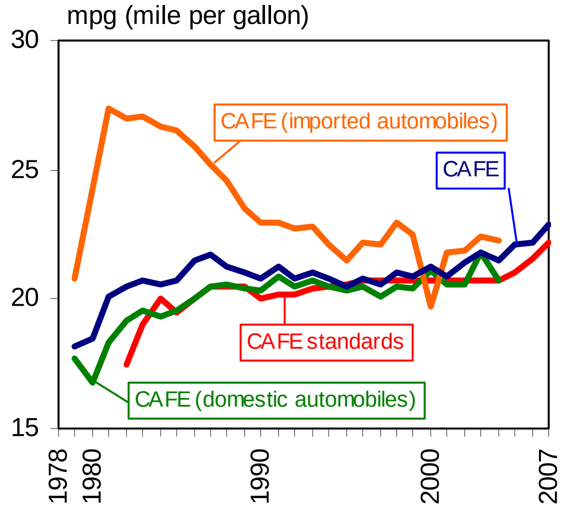
The changes in fuel economy between domestic and imported fleets show that, for both passenger cars and light trucks, throughout the 1980s and 1990s, the fuel economy of imported fleets surpassed that of domestic fleets with a difference of up to 6–7 mpg (Figures 5-8 and 5-9), although this difference has shrunk in recent years.

Figure 5-8 CAFE comparison between domestic and imported fleets (passenger cars)



Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

Figure 5-9 CAFE comparison between domestic and imported fleets (light trucks)

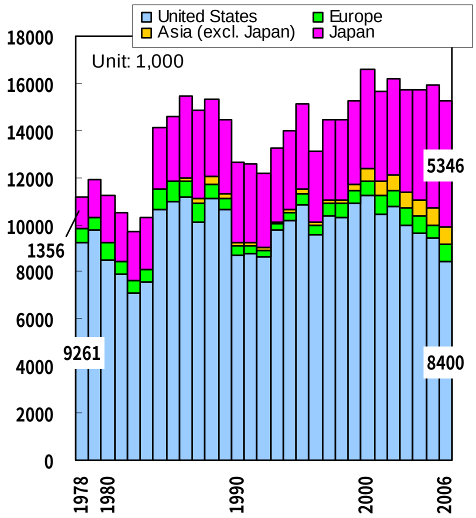


Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

5-2 Comparison of Fuel Economy Performances by Country of Origin

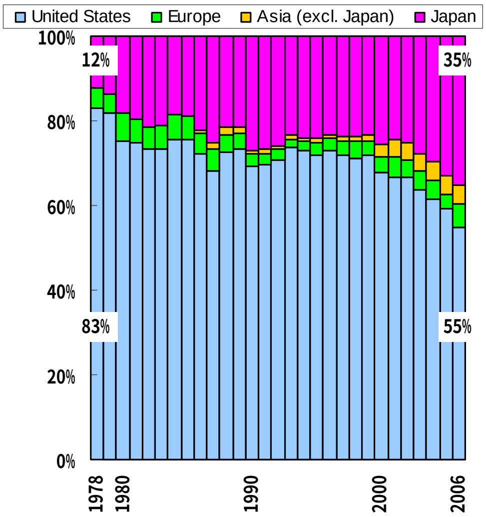
Automobile sales statistics by country of origin (Figures 5-10 and 5-11) show that domestic automobiles accounted for 70–80% of the U.S. market for light automobiles from the late 1970s throughout the 1990s. Since 2000, however, with the rise in crude oil prices, Japanese automobiles. which have better fuel economy performance, have increased their sales shares. The sales share of Japanese automobiles rose from around 10% in the late 1970s to 35% in 2006, while the sales share of domestic automobiles fell from 83% to 55%.

Figure 5-10 Automobile sales volume by country of origin (passenger cars and light trucks)



Source: U.S. Department of Transportation, NHTSA, “Summary of Fuel Economy Performance,” Washington, DC, March 2006

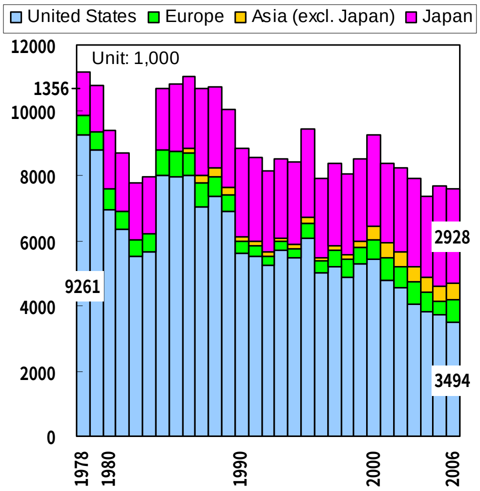
Figure 5-11 Automobile sales share by country of origin (passenger cars and light trucks)



Source: U.S. Department of Transportation, NHTSA, “Summary of Fuel Economy Performance,” Washington, DC, March 2006

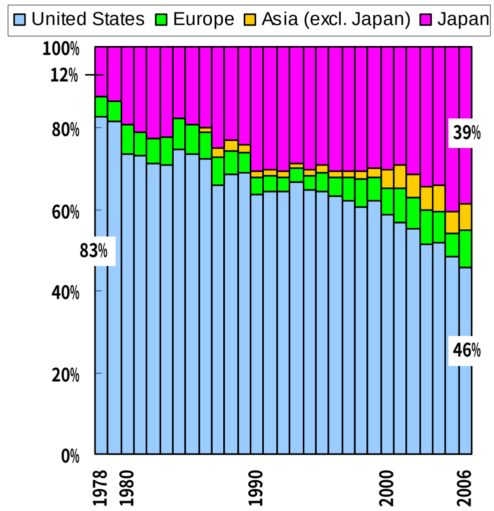
Passenger car sales statistics by country of origin (Figures 5-12 and 5-13) show that domestic passenger cars had the sales share of 83% in 1978. However, Japanese passenger cars, which have better fuel economy performance, increased their sales shares from around 10% at the end of the 1970s to 39% in 2006. The sales share of domestic passenger cars, on the other hand, fell from 83% to 46%.

Figure 5-12 Passenger car sales volume by country of origin



Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

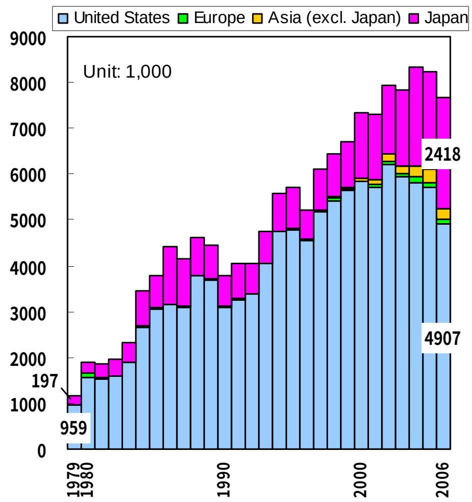
Figure 5-13 Passenger car sales share by country of origin



Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

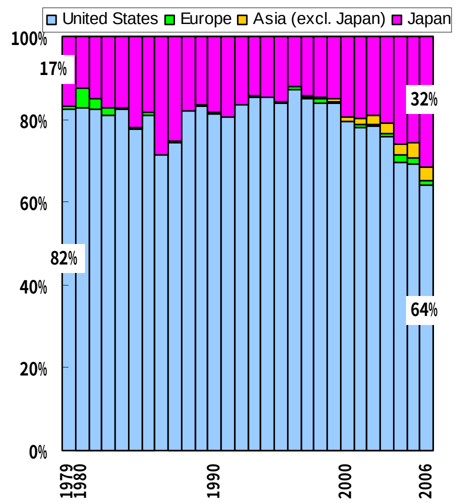
Light truck sales statistics by country of origin show that the sales share of domestic light trucks fell from 82% in 1979 to 64% in 2006 (Figures 5-14 and 5-15). The share of Japanese light trucks increased from 17% in 1979 to 32% in 2006.

Figure 5-14 Light truck sales volume by country of origin



Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

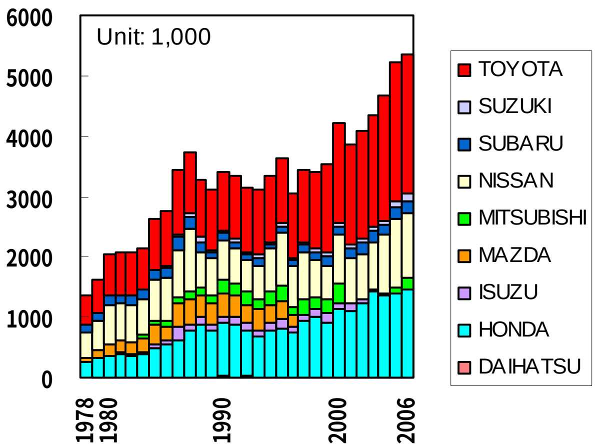
Figure 5-15 Light truck sales share by country of origin



Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

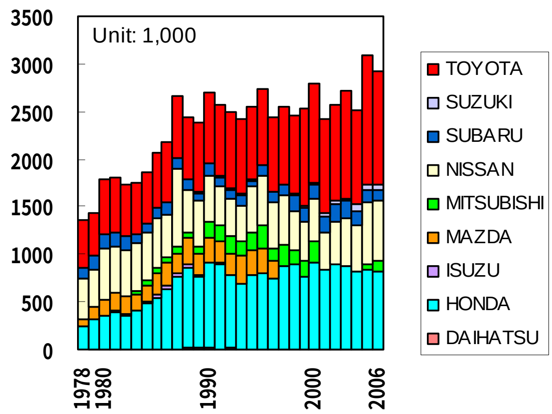
Statistics on the sales volume of Japanese automobiles (Figures 5-16, 5-17 and 5-18) show rapid growth since 2000. The respective manufacturers have approximately the following shares in the total sales volume of Japanese light automobiles in the United States: Toyota 40%, Honda 30% and Nissan 20%. In the passenger car market, the proportions are the same as for light automobiles: Toyota 40%, Honda 30% and Nissan 20%. In the light truck market, the shares are Toyota 50%, Honda 30% and Nissan 20%.

Figure 5-16 Sales volume of new Japanese automobiles (passenger cars and light trucks)



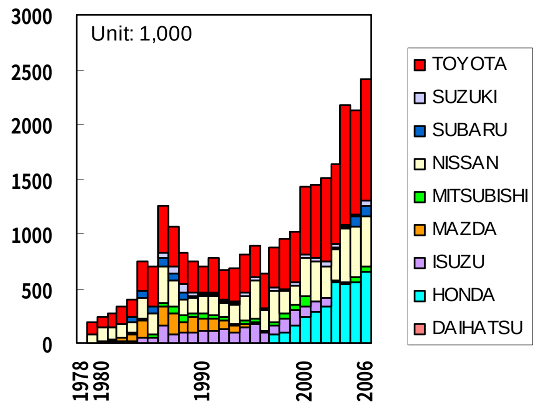
Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

Figure 5-17 Sales volume of new Japanese passenger cars



Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

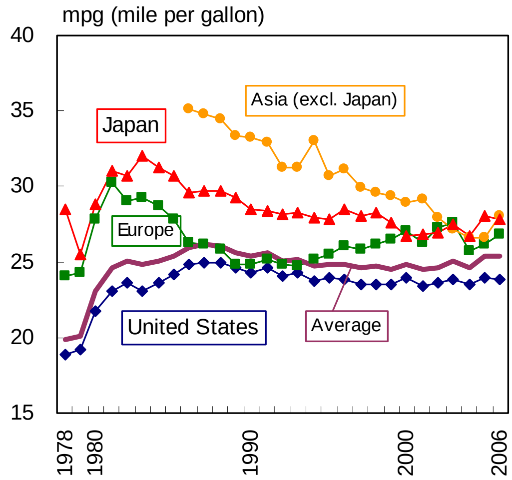
Figure 5-18 Sales volume of new Japanese light trucks



Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

Changes in CAFE among domestic, Japanese and European automobiles sold in the United States show that the Japanese fleet surpassed the domestic fleet by up to 10 mpg in the early 1980s, but the difference has diminished to 3–4 mpg in recent years. The average fuel economy of Japanese automobiles began to fall from the early 1980s but has leveled off in recent years as the sales volume of light trucks with relatively poorer fuel economy has increased. Combining passenger cars and light trucks, the average fuel economy of Japanese automobiles still exceeds that of European automobiles as well as the total average fuel economy (Figure 5-19). The average fuel economy of domestic automobiles continues to fall below the total average.

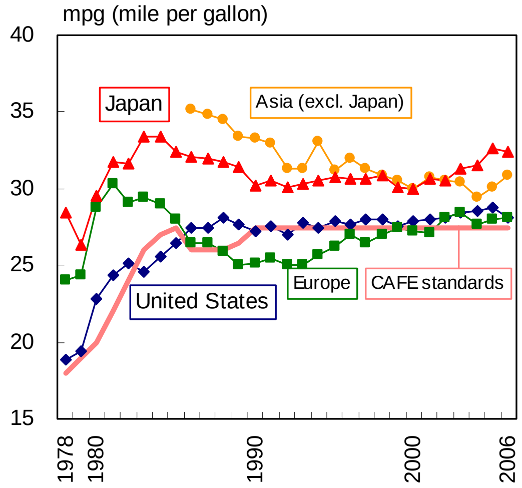
Figure 5-19 New car fuel economy by country of origin (passenger cars and light trucks)



Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

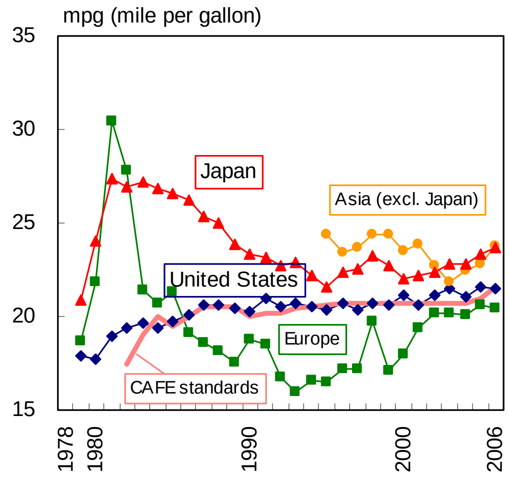
Figures 5-20 and 5-21 show respective changes in CAFE of domestic, Japanese and European automobiles sold in the United States for passenger cars and for light trucks. As to passenger cars, the fuel economy of the domestic and European fleets fell below the CAFE standards for some periods in the 1980s and 1990s, but in recent years it has been improved and now exceeds the standards. The fuel economy of the Japanese fleet continues to surpass both the European and the domestic fleets. The fuel economy of the domestic fleet evolved generally in line with the CAFE standards. As to light trucks, the fuel economy of the Japanese fleet has continued to be the best, except in the early 1980s. As with passenger cars, the fuel economy of the domestic fleet evolved generally in line with the CAFE standards. The fuel economy of light trucks from European manufacturers has been lower than the CAFE standards since the mid 1980s.

Figure 5-20 New car fuel economy by country of origin (passenger cars)



Source: U.S. Department of Transportation, NHTSA, “Summary of Fuel Economy Performance,” Washington, DC, March 2006

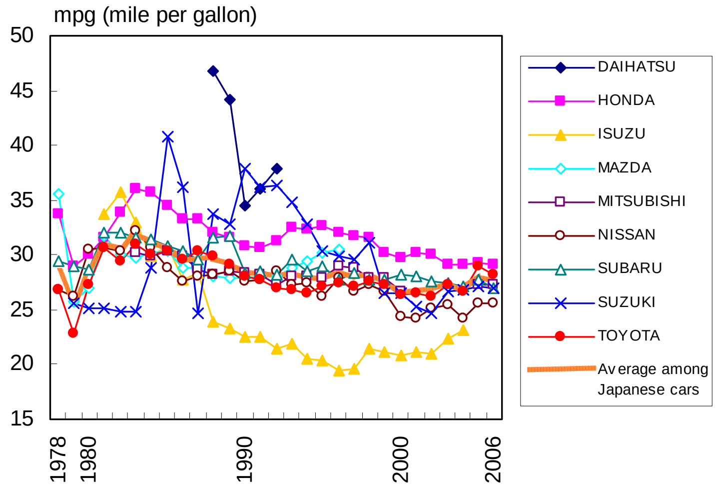
Figure 5-21 New car fuel economy by country of origin (light trucks)



Source: U.S. Department of Transportation, NHTSA, “Summary of Fuel Economy Performance,” Washington, DC, March 2006

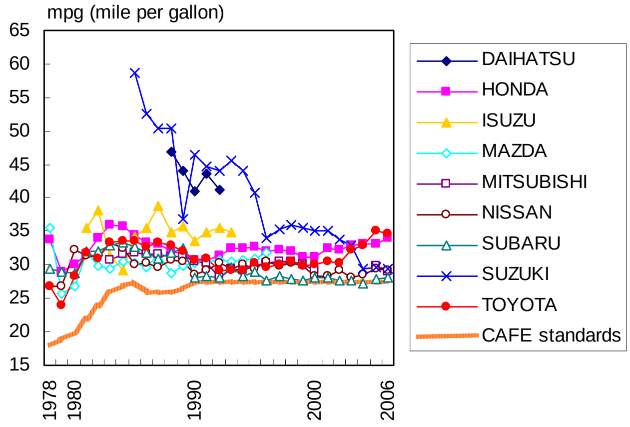
In the passenger car category and in the light truck category, the fuel economy of the Japanese fleet has continued to surpass the CAFE standards except for some short periods, maintaining its superiority over the domestic and European fleets in terms of fuel economy and environmental performance (Figures 5-22, 5-23 and 5-24).

Figure 5-22 New car fuel economy of Japanese automobiles (passenger cars and light trucks)



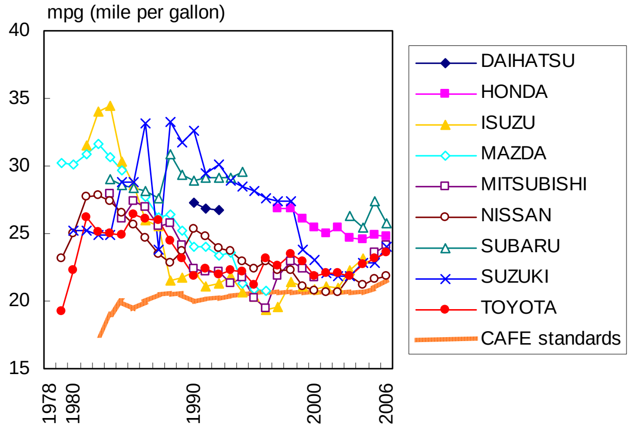
Source: U.S. Department of Transportation, NHTSA, “Summary of Fuel Economy Performance,” Washington, DC, March 2006

Figure 5-23 New car fuel economy of Japanese passenger cars



Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

Figure 5-24 New car fuel economy of Japanese light trucks



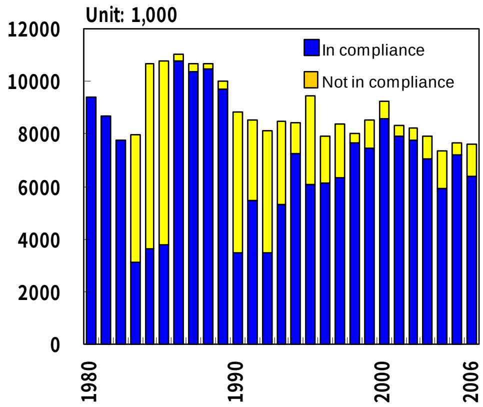
Source: U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, March 2006

5-3 Compliance with the CAFE Standards

According to the changes shown in Figures 5-25 and 5-26, in the mid 1980s and early 1990s with respect to passenger cars, and in the mid-to-late 1980s and mid-to-late 1990s with respect to light trucks, the number of vehicles that failed to attain CAFE standards sometimes amounted to more than half of the total sales volume, although in recent years, the number of such vehicles has decreased.

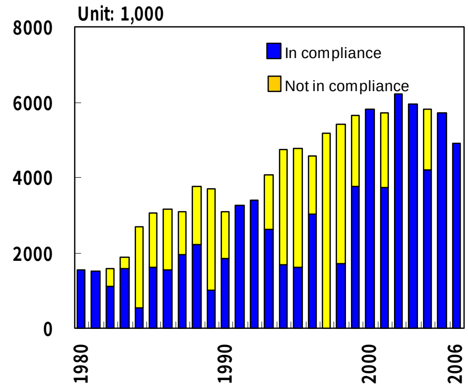
Looking at the proportions of vehicles that met and failed to meet CAFE standards between the domestic fleet and the Japanese fleet (Figures 5-27 and 5-28), the domestic fleet resembles the aforementioned general trend: that is, in the mid 1980s and early 1990s as to passenger cars, and in the mid 1980s and the first half of the 1990s for light trucks, the number of vehicles that failed to attain the standards sometimes amounted to almost 90% of the total sales volume. In recent years, the number of such vehicles has decreased in both the passenger car category and the light truck category. In the case of Japanese automobiles, the proportion of vehicles that failed to attain the standards has remained constantly small.

Figure 5-25　Number of vehicles in compliance with CAFE (passenger cars)



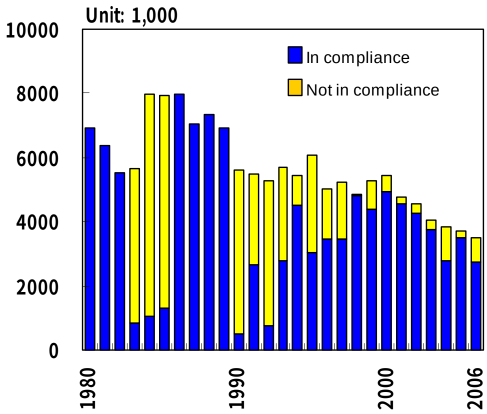
Source:　U.S. Department of Transportation, NHTSA, “Summary of Fuel Economy Performance,” Washington, DC, March 2006

Figure 5-26　Number of vehicles in compliance with CAFE (light trucks)

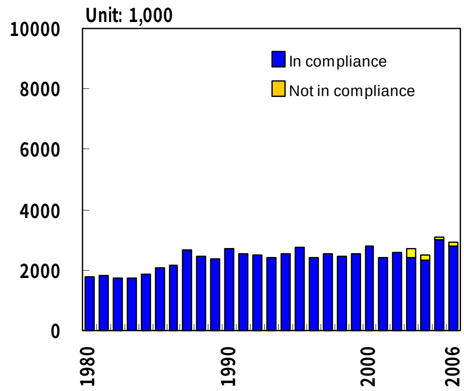


Source:　U.S. Department of Transportation, NHTSA, “Summary of Fuel Economy Performance,” Washington, DC, March 2006

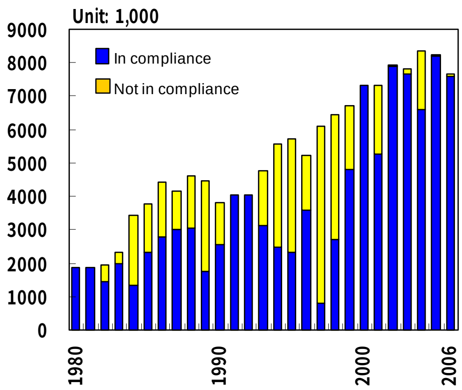
Figure 5-27　Number of vehicles in compliance with CAFE



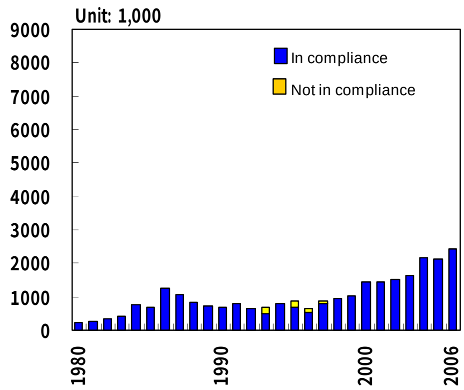
US domestic passenger cars



Japanese passenger cars



US domestic light trucks

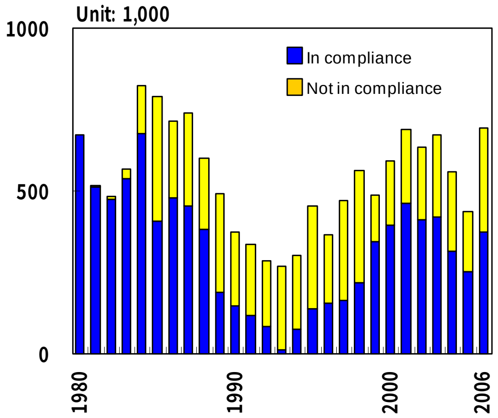


Japanese light trucks

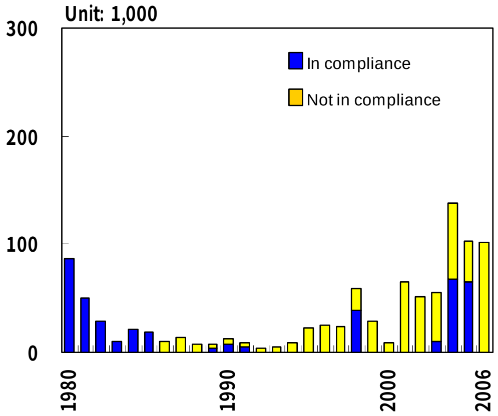
Source:　U.S. Department of Transportation, NHTSA, “Summary of Fuel Economy Performance,” Washington, DC, March 2006

The statistics show that the European fleet has had a high proportion of vehicles that failed to meet the CAFE, even though the sales volume is smaller than that of the domestic fleet and the Japanese fleet.

Figure 5-28 Number of vehicles in compliance with CAFE (European fleet)



European passenger cars



European light trucks

Source: U.S. Department of Transportation, NHTSA, “Summary of Fuel Economy Performance,” Washington, DC, March 2006

6. OUTLOOK ON OIL CONSUMPTION BY THE AUTOMOBILE SECTOR IN THE UNITED STATES

In a plenary session on December 13, 2007, the Senate of the United States passed by a majority vote the comprehensive energy bill (H.R. 6) that stipulated, among other things, the strengthening of corporate average fuel economy (CAFE) standards for automobiles. The bill was approved by the House of Representatives on December 18, and then signed and enacted by President Bush on December 19. This was the first time since 1975 that Congress had taken the initiative in strengthening fuel economy standards. The bill included measures to raise the CAFE target value for automobiles to 35 mpg by 2020. While the CAFE target for 2007 is 27.5 mpg for passenger cars and 22.2 mpg for light trucks, both of them will be raised to 35 mpg by 2020. The CAFE target for passenger cars has remained unchanged at 27.5 mpg since 1990. Compared with the average fuel economy achieved in 2006 of 25.4 mpg (29.8 mpg for passenger cars and 22.2 mpg for light trucks), the average new car fuel economy will be improved by approximately 40% under the new CAFE standards.

Besides the comprehensive energy bill, two bills were submitted in the past for discussion, demanding stricter CAFE standards. One of them was the Markey-Platts Bill (H.R. 1506) that stipulated a policy to raise the target, for both passenger cars and light trucks, to 27.5 mpg by 2012, and to 35 mpg by 2018. Furthermore, the bill called for a 4% annual increase of the fuel economy target even after 2018, which would be eventually left to the discretion of NHTSA in the light of technological and economic considerations. The other bill, namely, the Hill-Terry Bill (H.R. 2927), with broad support from the automobile industry, proposed a more moderate regulatory approach compared with the Markey-Platts Bill (H.R. 1506) or with the 2007 Comprehensive Energy Bill, calling for the average new car fuel economy to be raised to 32 mpg by 2022. However, neither H.R. 1506 nor H.R. 2927 was enacted.

6-1 Outlook on Oil Consumption Assuming Fuel Economy Regulation under Each Bill

We estimated the total oil consumption by automobiles in the United States up to 2030 with the assumption of the fuel economy regulation proposed by each of these bills, namely the 2007 Comprehensive Energy Bill (H.R. 6), the Markey-Platts Bill (H.R. 1506) and the Hill-Terry Bill (H.R. 2927). The estimations were performed under four scenarios: the reference case scenario in which the prevailing trends of economic growth and energy consumption continue, and three scenarios, each with the CAFE targets proposed by the respective bills. Table 6-1 outlines the four scenarios.

Table 6-1 Fuel economy scenarios

Case	Description
Reference	General continuation of recent trends in economy, energy supply-demand and automobile fuel economy performance
2007 Comprehensive Energy Bill (H.R. 6)	CAFE of passenger cars and light trucks will rise to 35 mpg by 2020.
Markey-Platts Bill (H.R. 1506)	CAFE of passenger cars and light trucks will rise to 27.5 mpg by 2012, and to 35 mpg by 2018.
Hill, Terry Bill (H.R. 2927)	CAFE of passenger cars and light trucks will rise to 32 mpg by 2022.

* Estimations on fuel economy after 2020 assume that the evolution of fuel economy up to 2020 will continue up to 2030.

The evolution of CAFE under the reference case scenario was estimated based on the fuel economy improvement rates given by the DOE's Annual Energy Outlook 2008 (AEO2008): the average new car CAFE (of passenger cars and light trucks) will rise to 28.1 mpg by 2020 and to 30.1 mpg by 2030. The scenario for the 2007 Comprehensive Energy Bill (H.R. 6) assumes the achievement of CAFE standards stipulated in this bill signed by President Bush on December 19, 2007: the CAFE of passenger cars and light trucks will be raised uniformly to 35 mpg by 2020. The scenario for the Markey-Platts Bill (H.R. 1506) assumes that the CAFE of passenger cars and light trucks will be increased uniformly to 27.5 mpg by 2012, and to 35 mpg by 2018. The scenario for the Hill-Terry Bill (H.R. 2927) assumes that the CAFE of passenger cars and light trucks will be raised to 32 mpg by 2022.

The estimation was performed using the same econometric model that the Institute of Energy Economics, Japan used to produce the Asian and Global Energy Outlook. Specifically, we used regression equations to estimate the total oil consumption by automobiles from a series of parameters including economic growth, crude oil prices, automobile sales volume, total number of registered automobiles, travel distance per automobile, and fuel economy (new car average and registered car average) (Figure 6-1). The economic growth rate (real GDP growth rate), which affects the estimates of the total number of registered automobiles and travel distance per automobile, was assumed to be 2.6% per annum up to 2030 based on the forecast by AEO2008. In the same manner, using the same source, we assumed that the crude oil price (real U.S. refinery import price) changes from $66/bbl in 2006 to $61/bbl in 2020 and $72/bbl in 2030.

As to the CAFE average of all registered automobiles, we constructed bottom-up models (one for passenger cars and one for light trucks) based on annual new car sales volumes and average fuel economy values (Figure 6-2). Our estimations on biofuels (bio ethanol and bio diesel fuels) are again based on AEO2008. The total automobile sales volume (inclusive of passenger cars and light trucks) was estimated as follows from postulated economic growth rates using regression equations: 15.3 million (actual) in 2006, 17.9 million in 2020 and 20 million in 2030 (18.7 million in 2020 and 20 million in 2030 by AEO's estimates).

Figure 6-1 Model configuration

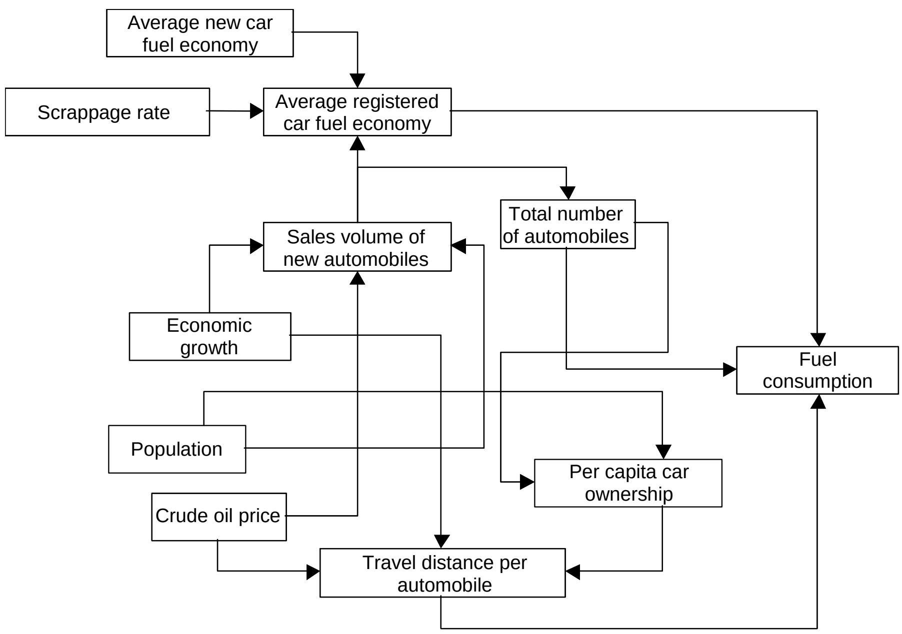
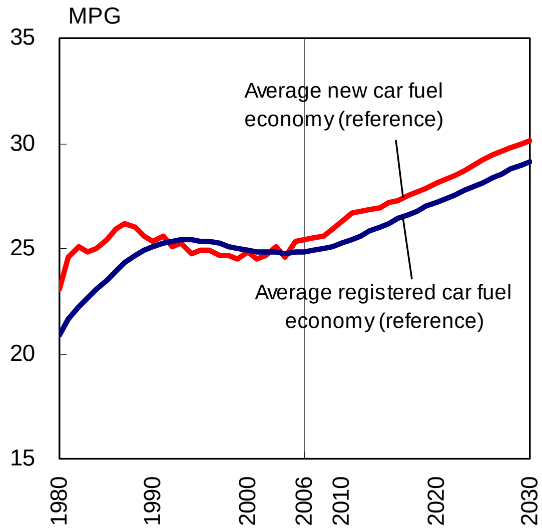


Figure 6-2 Average new car fuel economy vs. average registered car fuel economy in the United States (passenger cars and light trucks)

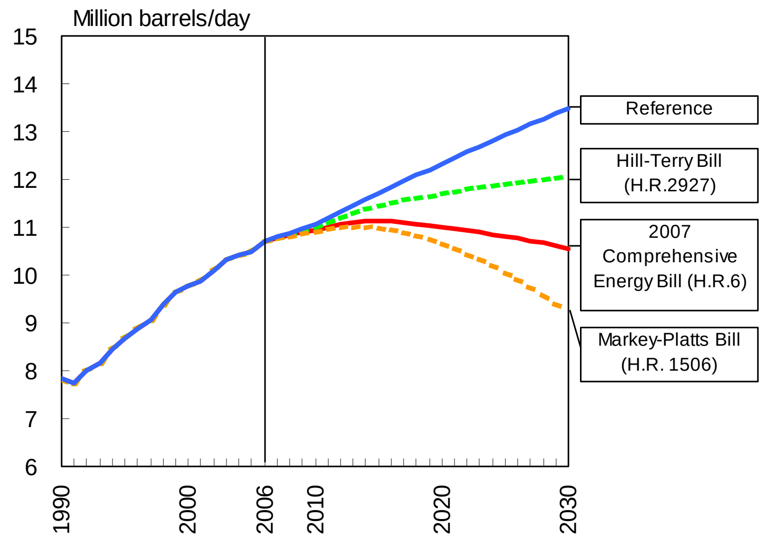


Source: Calculated by the author based on NHTSA statistics. The average registered car fuel economy was estimated using the scrappage rates given by the ORNL (Schmoyer, Richard L., unpublished study on scrappage rates, Oak Ridge National Laboratory, Oak Ridge, TN, 2001).

The following describes our outlook on the total oil consumption by automobiles in the United States (Figure 6-3). According to the reference case scenario, the total oil consumption by automobiles in the United States will grow from 10.7 million B/D in 2006 to 12.3 million B/D in 2020, and to 13.5 million B/D in 2030. If the average fuel economy of passenger cars and light trucks rises to 35 mpg by 2020, as envisaged by the 2007 Comprehensive Energy Bill (H.R. 6) signed by President Bush on December 19, 2007, the total oil consumption by automobiles in the United States will be limited to 11 million B/D in 2020 and 10.6 million B/D in 2030. According to this scenario, oil consumption will peak in the mid 2010s and then begin to fall, returning to near the 2010 level in 2020 and eventually to the current level in 2030. Compared with the oil consumption estimated under the reference case scenario, this will result in energy saving of 1.3 million B/D in 2020[7] (13% of the United States' crude oil import in 2006) and 2.9 million B/D in 2030 (29% of the United States' crude oil import in 2006). The fuel saving in 2020 is equivalent to the oil consumed by 21 million automobiles, and the fuel saving in 2030 is equivalent to the oil consumed by 47 million automobiles. The reduction of CO_2 emissions by energy saving will amount to 51 million t-C in 2020 and to 113 million t-C in 2030 (3% and 7%, respectively, of the present CO_2 emissions in the United States).

[7] The DOE (the EERE) (Jan. 2, 2008, http://www.eere.energy.gov/news/enn.cfm) and the ASE (http://www.ase.org/content/news/detail/4141) expect oil consumption to be cut by 1.1 million B/D in 2020, which is close to our estimate presented in this paper.

Figure 6-3 Outlook on the oil consumption by automobiles in the United States



Source: Calculated by the author.

If the CAFE of passenger cars and light trucks is increased to 32 mpg by 2022 as envisaged by the Hill-Terry Bill (H.R. 2927), the oil consumption by automobiles in the United States will be 11.7 million B/D in 2020 and 12.1 million B/D in 2030. If the CAFE of passenger cars and light trucks is raised to 27.5 mpg by 2012 and to 35 mpg by 2018 as envisaged by the Markey-Platts Bill (H.R. 1506), the oil consumption by automobiles in the United States will be 10.7 million B/D in 2020 and 9.3 million B/D in 2030. Similar to the 2007 Energy Comprehensive Bill scenario, the oil consumption under this scenario will peak in the mid 2010s and then begin gradually to fall, returning to today's consumption level in 2020 and eventually to the level of the mid 1990s in 2030.

6-2 Energy Saving and CO_2 Abatement Potentials Achievable with Japanese Automobiles in the United States

This subsection describes our calculations on how Japanese automobiles in the U.S. automobile market could help reduce oil consumption and CO_2 emissions. In 2006, the share and sales volume of Japanese automobiles in the United States were as follows: 38.5% (2.93 million) in the passenger car market, 31.5% (2.42 million) in the light truck market, and 35.0% (5.35 million) in the combined light automobile market. In 2006, the average new car CAFE of Japanese automobiles, in comparison with that of European and domestic automobiles, was 32.7 mpg (European/domestic: 28.6 mpg) for passenger cars and 23.9 mpg (European/domestic: 21.8 mpg) for lift trucks. Historically speaking, therefore, Japanese automobiles have surpassed European and domestic automobiles in terms of fuel economy. Today in 2007, some Japanese passenger cars in the market have the fuel economy performance of 46 mpg, which is significantly higher than the average, and this figure is expected to be steadily improved in the future.

Table 6-2 Scenarios for the fuel economy performance of Japanese automobiles

Case	Description
Reference	General continuation of recent trends in economy, energy supply-demand and automobile fuel economy performance
Improvement of Japanese car fuel economy according to the 2007 Comprehensive Energy Bill	Average new car fuel economy of Japanese passenger cars and light trucks will reach 35 mpg by 2020, which is the CAFE target stipulated in the 2007 Comprehensive Energy Bill (H.R. 6).
Improvement of Japanese car fuel economy according to the Top Runner Approach	By 2020, the CAFE of new Japanese passenger cars will reach 46 mpg and the CAFE of new Japanese light trucks will reach 35 mpg.

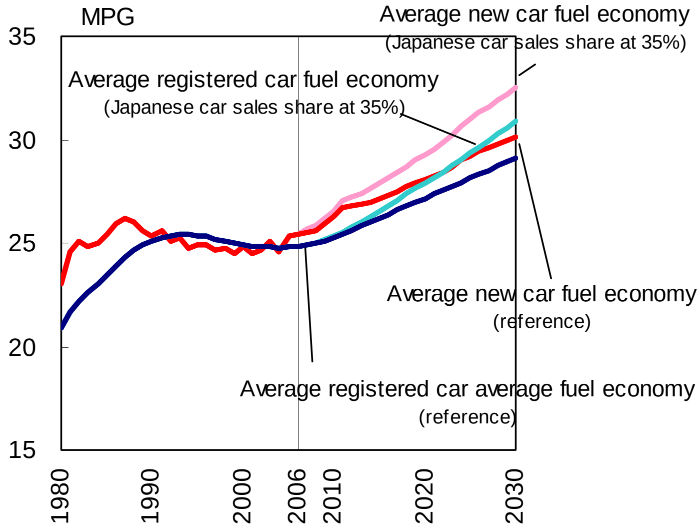
Note: We assumed that the improvement of the CAFE of European and domestic automobiles would follow the prevailing trends. Specifically, we assumed that the average new car CAFE of European and domestic passenger cars would improve from 28.4 mpg in 2006 to 31.5 mpg in 2020, and that the average new car CAFE of European and domestic light trucks would improve from 21.6 mpg in 2006 to 24.7 mpg in 2020.

When estimating the energy saving potential achievable with Japanese automobiles, we postulated two scenarios concerning the future evolution of the new car fuel economy performance of Japanese automobiles (Table 6-2). The first scenario assumes that the average new car CAFE of Japanese passenger cars and light trucks will reach 35 mpg by 2020 in compliance with the 2007 Comprehensive Energy Bill (H.R. 6). This supposition is supported by their improvements in fuel economy and the fact that they have been mostly in compliance with CAFE standards. For European and domestic automobiles, on the other hand, this scenario assumes that the improvement of their CAFE will follow the prevailing trends. Specifically, we assumed that the average new car CAFE of European and domestic passenger cars would improve from 28.4 mpg in 2006 to 31.5 mpg in 2020, and that the average new car CAFE of European and domestic light trucks would improve from 21.6 mpg in 2006 to 24.7 mpg in 2020.

The second scenario assumes that the average new car CAFE of Japanese passenger cars will reach 46 mpg by 2020, which is currently the best fuel economy standard, and that the average new car CAFE of Japanese light trucks will improve steadily and reach 35 mpg by 2020 in compliance with the 2007 Comprehensive Energy Bill (H.R. 6). (For European and domestic automobiles, we again assumed that the improvement of their CAFE would follow the prevailing trends.)

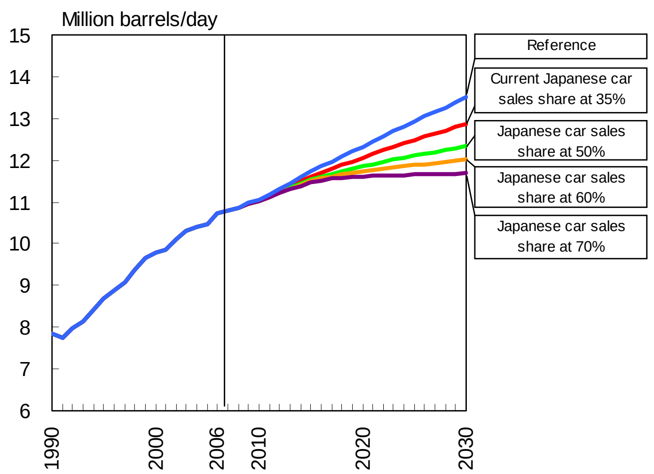
Under the two scenarios concerning the fuel economy improvement of Japanese automobiles, we employed different assumptions on the share of Japanese automobiles in the sales of new cars in the U.S. market. Specifically, we postulated the following cases: (1) the sales share of Japanese automobiles still at the present 35% level in 2020 (sales volume of 6.23 million in 2020); (2) sales share at 50% (8.95 million); (3) sales share at 60% (10.74 million); and (4) sales share at 70% (12.53 million). In each of the cases, we assumed that the sales share in 2030 would remain the same as in 2020. Assuming that the sales share of Japanese automobiles continues to remain at the present level of 35%, and that the average new car CAFE of Japanese passenger cars and light trucks will reach 35 mpg by 2020 in compliance with the 2007 Comprehensive Energy Bill, the average new car fuel economy for all automobiles sold in a year in the United States will improve from 25.4 mpg in 2006 to 29.3 mpg in 2020, while the average registered car fuel economy will improve from 24.9 mpg in 2006 to 27.9 mpg in 2020 (Figure 6-4).

Figure 6-4 Average new car fuel economy and average registered car fuel economy in the United States (passenger cars and light trucks)



Source: Calculated by the author based on NHTSA statistics. The average registered fuel economy was estimated using the scrappage rates given by the ORNL (Schmoyer, Richard L., unpublished study on scrappage rates, Oak Ridge National Laboratory, Oak Ridge, TN, 2001).

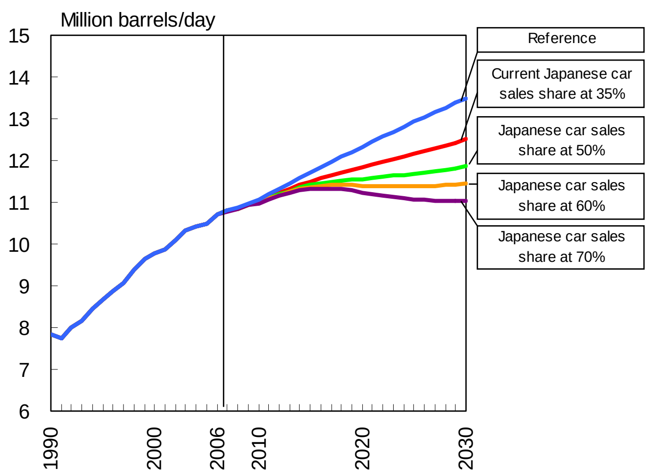
Figure 6-5 Oil consumption by automobiles in the United States assuming that Japanese car fuel economy improves according to the 2007 Comprehensive Energy Bill



Assumption: The CAFE of new Japanese passenger cars and light trucks will reach 35 mpg by 2020, while the improvement of CAFE of European and domestic automobiles will follow the prevailing trends.

Source: Calculated by the author.

Figure 6-6 Oil consumption by automobiles in the United States assuming that Japanese car fuel economy improves according to the Top Runner Approach



Assumption: By 2020, the CAFE of new Japanese passenger cars will reach 46 mpg and the CAFE of new Japanese light trucks will reach 35 mpg. The improvement of CAFE of European and domestic automobiles will follow the prevailing trends (2020: 31.5 mpg for passenger cars and 24.7 mpg for light trucks).

Source: Calculated by the author.

In the scenario assuming that Japanese car fuel economy improves according to the 2007 Comprehensive Energy Bill, supposing that the sales share of Japanese automobiles in 2020 still remains at the present level of 35%, the oil consumption by automobiles in the United States will be 12.1 million B/D in 2020 and 12.9 million B/D in 2030 (Figure 6-5). Compared with the oil consumption estimated under the reference case scenario, this will result in the energy saving of 0.3 million B/D in

2020 (3% of the United States' crude oil import in 2006) and 0.6 million B/D in 2030 (6% of the United States' crude oil import in 2006), reducing CO_2 emissions by 10 million t-C in 2020 (3% of present emissions by Japan) and by 24.5 million t-C in 2030 (7% of present emissions by Japan). The fuel saving in 2020 is equivalent to the oil consumed by 4 million automobiles, and by 10 million automobiles in 2030. This energy saving and CO_2 emissions cut can be expected from the fuel economy performance of Japanese automobiles alone even if the sales share of Japanese automobiles remains at the present level, provided that the CAFE of Japanese automobiles continues to improve steadily according to the CAFE standards. If we assume that the sales share of Japanese automobiles reaches 50%, 60% or 70% by 2020, the oil consumption by automobiles in the United States will be reduced even more, provided that the fuel economy of Japanese automobiles continues to improve steadily according to the CAFE standards. The amount of energy saved will increase as the sales share of Japanese automobiles increases: a 50% share in 2020 will save 0.5 million B/D (5% of the United States' crude oil import in 2006); a 60% share in 2020 will save 0.6 million B/D (6% of the United States' crude oil import in 2006); and a 70% share in 2020 will save 0.7 million B/D (7% of the United States' crude oil import in 2006). The fuel saving in 2020 is equivalent to the amount of oil consumed by 8 million automobiles, 10 million automobiles and 11 million automobiles, respectively. The CO_2 emissions reduction in 2020 will amount to 18 million t-C, 23 million t-C and 27 million t-C, respectively (which are equivalent to 5%, 7% and 8%, respectively, of present emissions by Japan).

In the scenario assuming that Japanese car fuel economy improves according to the Top Runner Approach, supposing that the sales share of Japanese automobiles in 2020 remains at the present level of 35%, the oil consumption by automobiles in the United States will be 11.8 million B/D in 2020 and 12.5 million B/D in 2030 (Figure 6-6). Compared with the oil consumption estimated under the reference case scenario, this will result in the energy saving of 0.5 million B/D in 2020 (5% of the United States' crude oil import in 2006) and 1 million B/D in 2030 (10% of the United States' crude oil import in 2006), and a reduction of CO_2 emissions by 19 million t-C in 2020 (5% of present emissions by Japan) and by 38 million t-C in 2030 (11% of present emissions by Japan). The fuel saving in 2020 is equivalent to the oil consumed by 8 million automobiles and the fuel saving in 2030 is equivalent to the oil consumed by 16 million automobiles. The amount of energy saved in 2020 will increase as the sales share of Japanese automobiles increases: a 50% share in 2020 will save 0.8 million B/D (8% of the United States' crude oil import in 2006); a 60% share in 2020 will save 0.9 million B/D (9% of the United States' crude oil import in 2006); and a 70% share in 2020 will save 1.1 million B/D (11% of the United States' crude oil import in 2006). The fuel saving in 2020 is equivalent to the amount of oil consumed by 12 million automobiles, 15 million automobiles and 17 million automobiles, respectively. The CO_2 emissions reduction in 2020 will amount to 29 million t-C, 36 million t-C and 42 million t-C, respectively (which are equivalent to 8%, 10% and 12%, respectively, of present emissions by Japan).

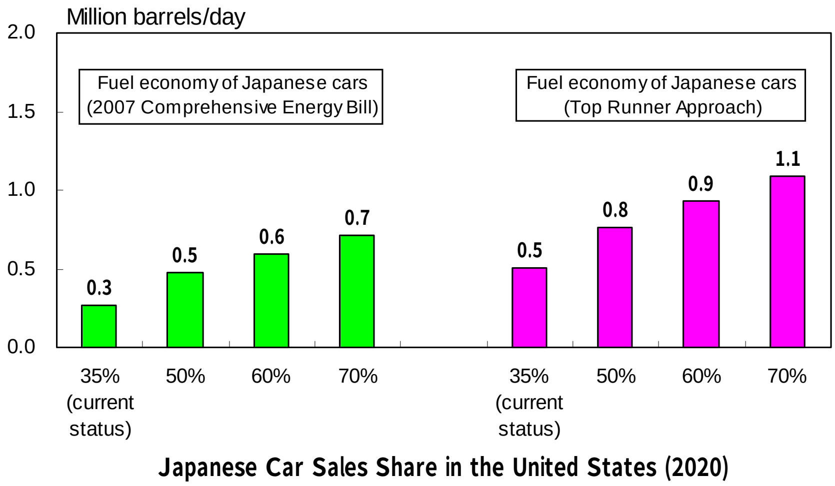
In conclusion, if the average new car fuel economy of Japanese passenger cars and light trucks improves steadily in compliance with the 35 mpg target mandated by the 2007 Comprehensive Energy Bill, the contribution of Japanese automobiles in the energy saved in 2020 is estimated to be 0.3–0.7 million B/D (3–7% of the United States' crude oil import in 2006), depending on the sales share of Japanese automobiles, which is equivalent to the amount of oil consumed by 4–11 million automobiles, thus reducing CO_2 emissions by 10–27 million t-C (3–8% of CO_2 emissions by Japan). If the average new car fuel economy of Japanese passenger cars improves further to 46 mpg (the Top Runner), which is the best performance level today, by 2020, and the average new car fuel economy of Japanese light trucks improves steadily in compliance with the 35 mpg target mandated by the 2007 Comprehensive Energy Bill, the energy saved in 2020 with Japanese automobiles will be 0.5–1.1 million B/D (5–11% of the United States' crude oil import in 2006), depending on the sales share of Japanese automobiles, which is equivalent to the amount of oil consumed by 8–17 million automobiles, thus reducing CO_2 emissions by 19–42 million t-C (5–12% of CO_2 emissions by Japan).

7. CONCLUSION

With rising crude oil prices and the strengthening of international efforts against global warming, Japan, Europe and the United States are tightening their regulations over the fuel economy of automobiles. Such initiatives are of global concern because of their close relationship with energy security, crude oil prices, and GHG emissions. This paper provided a comprehensive overview of CAFE standards of the United States, which has the largest number of automobiles in the world, and then analyzed quantitatively how the strengthening of these fuel economy standards proposed by the 2007 Comprehensive Energy Bill and the growing sales share of Japanese automobiles in the U.S. market might reduce oil consumption by the United States in the future.

According to our estimation, if the fuel economy of all new automobiles sold in the United States improves steadily under the fuel economy standards proposed by the 2007 Comprehensive Energy Bill, it will lead to the following achievements in 2020 (in comparison with the reference case scenario that assumes no alternative actions): the reduction of oil consumption by 1.3 million B/D (equivalent to the amount of oil consumed by 21 million automobiles) and the reduction of CO_2 emissions by 51 million t-C (3% of present emissions by the United States).

Figure 7-1 Oil saving potential (scenario analysis using different assumptions for the sales and fuel economy performance of Japanese automobiles)



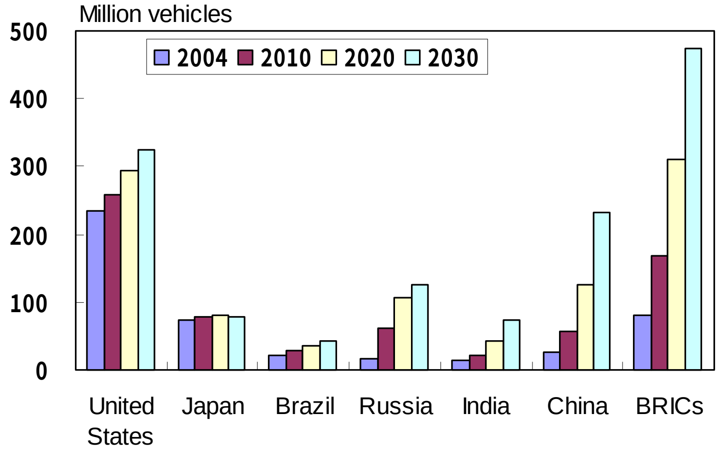
Note: Scenario for the left half of the chart:
Average new car fuel economy of Japanese passenger cars and light trucks will reach 35 mpg by 2020, which is the CAFE target stipulated in the 2007 Comprehensive Energy Bill.
Scenario for the right half of the chart:
By 2020, the average new car fuel economy of Japanese passenger cars will reach 46 mpg (the Top Runner), which is the present best performance level, and the average new car fuel economy of Japanese light trucks will reach 35 mpg, which is the CAFE target stipulated in the 2007 Comprehensive Energy Bill.

Source: Calculated by the author.

As to the energy saving potential achievable by Japanese automobiles, if the average new car fuel economy of Japanese passenger cars and light trucks improves steadily in compliance with the 35 mpg target mandated by the 2007 Comprehensive Energy Bill, the energy saved in 2020 with Japanese automobiles will be 0.3–0.7 B/D (3–7% of the United States' crude oil import in 2006), which is equivalent to the amount of oil consumed by 4–11 million automobiles, thus reducing CO_2 emissions by

10–27 million t-C (3–8% of CO_2 emissions by Japan). Furthermore, if the average new car fuel economy of Japanese passenger cars improves to achieve the present best performance level (the Top Runner) by 2020, the energy saved in 2020 with Japanese automobiles will be 0.5–1.1 million B/D (5–11% of the United States' crude oil import in 2006), depending on the sales share of Japanese automobiles, which is equivalent to the amount of oil consumed by 8–17 million automobiles, thus reducing CO_2 emissions by 19–42 million t-C (5–12% of CO_2 emissions by Japan).

Figure 7-2 Number of automobiles in the United States, Japan and BRICs



Source: Compiled from "Asian and Global Energy Outlook 2006" published by the Institute of Energy Economics, Japan, in 2006.

For Japanese car manufacturers to expand their sales in the future, it is essential that they penetrate actively the existing markets in the United States and Europe as well as the emerging markets in BRICs. To do this, it is crucial to promote the excellent fuel economy and environmental performance of Japanese cars which makes them internationally competitive (Figure 7-2). As crude oil prices rise and the impacts of global warming become more apparent, Japan should use the excellent energy saving potential of Japanese automobiles, to help protect global energy security and curb global warming.

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