BACKGROUND REPORT:

VEHICLE FUEL ECONOMY IN CHINA

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Toward a sustainable energy future

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Chapter 1 Introduction

As the continually increasing of the GDP, China mobile industry developed rapidly in the 9th-five-years. The increasing of vehicle population, so that to increase fuel economy and reduce emissions are both very important for automobile and oil refining industries. The fuel economy of domestic vehicles is often 20%-30% higher than the same type of developed countries. The dominating factors are fuel quality and road conditions.

1.1 Influence of Fuel Quality on Fuel Economy

1.1.1 Present Situation of Gasoline

Gasoline is the main production of refinery industry, which contains 21% percent of total crude oil input in China. The technical level of the refinery and mobile industry can be refracted from the production and quality of the vehicular gasoline. In recent years, gasoline output was increased rapidly and gasoline quality was improved greatly in China.

1.1.1.1 Production and Consumption

Table 1-1 presents the gasoline production of China. The car-used gasoline consumption contains the 89%-90% of total gasoline consumption, motorcycle-used gasoline contains 8%-9% of total, and the rest consumption is from the agricultural and industrial machines.

Table1-1 Vehicular gasoline output (104 tons)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Output	2153	2345	2633.4	3019.5	2694.7	2840.8	3053.2	3253	3196.8

1.1.1.2 The Gasoline Quality in China

I. The proportion of high-grade vehicular gasoline increased continuously, while the proportion of low-grade vehicular gasoline dropped rapidly.

In China, gasoline quality, especially the octane rating of the gasoline was greatly improved from 1980s, while gasoline production in China was rapidly increased. The 70#, 90#, 93#, 95# and 97# gasoline are selled in Chinese markets. The 70# gasoline proportion of total consumption was dropped from 62.6% to 28.24% from 1990 to 1997, while the 90# gasoline proportion was doubled from 35.1% to 62.01%. And the high-grade gasoline consumption was increased smoothly. (See Table 1-2) According to the Requirements of Terminating Production, Sale and Use of Vehicular Leaded Gasoline announced by State Council Office (State Council Office Notice [1998]#129), the whole country had stopped the leaded gasoline production since Jan.1 2000 and converted to the 90# or higher unleaded gasoline. Since July 1, 2000, whole country vehicles have given up the leaded gasoline and converted to the unleaded gasoline.

Table 1-2 China Vehicular Gasoline Grade Proportion(%)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
70#	62.6	55.5	54.1	57.09	52.39	50.64	40.72	28.24	14.5
90#	35.1	41.7	43.0	39.94	40.97	42.10	51.33	62.01	73.9
93#	2.2	2.3	2.2	2.68	5.22	5.76	6.57	6.76	9.3
95# & above	0.1	0.5	0.7	0.29	1.42	1.47	1.38	1.88	2.3

II. Accelerated Unleaded Gasoline Proceeding

Vehicular unleaded gasoline output was greatly increased in recent years. Unleaded gasoline contained 51.82% of total vehicular gasoline in 1990, and this proportion increased to 56.30% in 1994 with 8.5% annual growth rate higher than that of total gasoline. The consumption of 90# and 93# unleaded gasoline was increased with higher speed. In 1997, the vehicular unleaded gasoline consumption hold the 65% percent of total, which increased to 80% percent in 1998. The lead content of gasoline was declined fleetly. According to the Requirements of Terminating Production, Sale and Use of Vehicular Leaded Gasoline announced by State Council Office (State Council Office Notice [1998]#129), the whole country has stopped the leaded gasoline production since Jan.1 2000. Since July 1, 2000, whole country vehicles have given up the leaded gasoline and converted to the unleaded gasoline.

III. Gasoline component structure changed

The reasonable optimization of vehicular gasoline component is the key factor of the gasoline quality enhancement. The composition of vehicular gasoline component in China is shown in Table 1-3.

In 1997, the proportion of straight-run gasoline decreased 9.4 percent than that of 1994. The capabilities of catalytic cracking, catalytic reforming, hydrocracking, alkylation and MTBE for high octane number gasoline production have been improved.

Table 1-3 Vehicular gasoline component composition in China (%)

Year	1992	1993	1994	1995	1996	1997
Straight-run gasoline	18.1	19.7	16	13	13	6.58
Catalytic gasoline	72.3	71.9	68.6	76.3	76.3	82.44
Reformed gasoline	3.8	3	7.8	6.2	5.4	6.19
Alkylate	1.2	1	1.1	0.3	0.27	0.26
Hydrogenant naphtha	2.2	1.2	1.2	0.9	1.01	1.16
Pyrogenic naphtha	0.8	1.6	0.9	0.65	0.27	0.24
Others	1.6	1.6	1.4	2.65	3.79	3.13
Average Lead Content(g/L)	0.037	0.035	0.031	0.031	0.028	0.019

1.1.2 Present Situation of Diesel

Light diesel in China is divided into 6 numbers according to solidifying points under the Light Diesel Standards (GB252-94): #10, #0, #-10, #-20, #-5 and #-50. The diesel output of 1998 in China was 45.5Mt and occupied 30% of crude oil processing amount. In recent years, #0 diesel occupied the largest proportion due to the geographic and climatic characteristics; for instance, #0 light diesel output in 1997 occupied 71.3% of the total amount. Light diesel output in China during recent years is shown in Table 4-10.

In China, Light diesel is divided into 6 catalogues by solidifying point according to the Light Diesel Standard (GB252-94): 10#, 0#, 10#, -20#, -35#, -50#. And in this standard, diesel is divided into 3 classes (excellent, fine and qualified) by sulfur content and oxidation stability. The allowed maximum sulfur content of excellent diesel, fine diesel and qualified diesel is 0.2%, 0.5% and 1.0% separately. The allowed minimum micetane number of all type of diesels is 45, while that number is relaxed to 40 for the intermediate base diesel, naphthenic base diesel and catalytic distillate mixed diesel. China light diesel output in recent years is shown in Table 1-4. In 1998, the diesel output of China was 45.5Mt, which occupied 30% of crude oil processing amount. In recent years, 0# diesel occupied the largest proportion, for instance, 0# light diesel output in 1997 occupied 71.3% of the total amount.

Table 1-4 Light Diesel Output of China (104 tons)

Year	1993	1994	1995	1996	1997	1998
Output	3385.97	3314.27	3684.30	4108.66	4593.99	4543.9

The sulfur content of domestic diesel is low due to low sulfur content of domestic crude oil.

Usually the sulfur content of straight-run distillate in China is below 0.05%, and the sulfur content of some diesel produced by high sulfur crude oil is about 0.2%-0.3%. However, the sulfur content of the secondary processing diesel is higher, usually around 0.2-0.5%. The sulfur content of diesel produced by imported crude oil is usually around 0.5%. The high sulfur content in China diesel is mainly due to the large proportion of secondary processing diesel fraction without hydrogen refinery contributed to the average sulfur content.

1.1.3 Present Situation of Alternative Fuels

LPG and CNG are widely used vehicular alternative fuels in China. The fuel economy and thermal efficiency are enhanced and the emissions are reduced observably by using LPG. The alternative fuels are extended to Chinese mega cities at present. Beijing government planed to refit 140,000 traditional vehicles to LPG vehicles during 1999 and 2002. 379,000 tons of LPG will be needed each year after all refit plans complete. LPG production, vehicle refit and LPG filling station should be developed together. The main issue of the plan is the slow speed of LPG filling station construction because of the fund lack.

1.1.4 Present Situation of Fuel Consumption of China

The automobile engine power is continuously enhanced as the mobile technology development. One of the important ways to enhancing engine power and reducing fuel consumption is to improve the compression ratio of engines. Higher octane number gasoline should be used after the compression ratio increasing due to the enhancement of the knock possibility when fuel burning in the engine. Generally, the octane number should be increased 6-8 research octane number (RON)units with one unit compression ratio increasing. Engine power would be increased about 14% and fuel consumption would be decreased about 12% when the compression ratio enhanced from 6 to 8. The average gasoline engine compression ratio in US is about 7-8 in 1950s while the average RON of general gasoline is 83-87 and that of high quality gasoline is 90-95. The average gasoline engine compression ratio in US is about 8.2-9.4 in 1960s and 1970s while the average RON of general gasoline is up to 92－94 and that of high quality gasoline is 97－99.

Old model vehicles take a large proportion of the whole vehicles in China. In 1992, the heavy duty truck, which mainly contains 4 series of Jiefang, Dongfeng, Beijing130 and Nanjin Yuejin, occupied 61% of total 6,000,000 vehicles. The compression ratio of old model vehicles is around 6.7-7.2 while that of new model vehicles is around 7.4-8.2. Light duty vehicles and cars take more and more large proportion of whole vehicles due to the inward vehicle product line putting into production in resent years. The compression of light duty vehicles and cars is around 8.5-9.4.

The low compression ratio result in high fuel consumption. The gasoline vehicle population of China is about 12% of that of Japan, while the annual gasoline consumption of China is about 70% of that of Japan. The annual average fuel consumption in Japan is about 0.7 ton/vehicle while in China it is about 3.8 ton/vehicle. (See Table 1-5)

Table 1-5 Comparison of Vehicle Population and Fuel Consumption between China and Japan

	Japan (1993)	China (1992)
Vehicle Population (10^4)	6700	700
Gasoline Vehicle	~5000	600
Car	4500	100
Gasoline Consumption (10^4 tons)	3516	2300
Average gasoline Consumption(ton/per vehicle year)	0.7	3.8

During 1982 and 1984, a bench test and road test on four types of domestic mobile engines and five types of vehicle models were made by China Petro-Chemical Corporation and China National Automotive Industry Corporation. It was presented that it might get a 8.1% of average oil saving by increasing the compression ratio from 6.7-7.2 to 7.4-7.8 and switching 70# gasoline to 90# gasoline.

1.2 The Road Traffic Impact on Fuel Economy

Another important influential factor of fuel economy is the traffic structure and the road status of the city. A lot of people swarmed into cities as the high-speed economic development and the acceleration of the urbanization progress of China. On the other hand, the economic and cultural activities of cities were increased as the enhancement of economic functions of the cities. All of those resulted in the rapidly increasing of the traffic needs of mega-cities. Some researches on resident traffic activity showed that the resident transport increased more than one time while the average trip time and distance increased about 15%-30%.

The investment and its share in the budget on city transportation infrastructure were expanded in resent years. Though the highway networks and road areas had been rapidly increased, and the overhead roads and crossroads in mega cities had relaxed the traffic jam, but the road areas were limited by the high density land utilization model in Chinese mega cities, which would cause to the sharp contradiction between the road supply and the traffic needs and the serious traffic jam.

Chinese Research Academy of Environmental Sciences investigated the road traffic operating condition of two typical cities of Beijing and Guangzhou. The road traffic operating condition curve of those two cities is presented in Figer1-1 and Figer1-2, and the operating condition parameters are presented in Table 1-6. The testing vehicle was steered 852km and 224,280 data were collected in Beijing while the testing vehicle was steered 1,580km and 617,040 data were collected in Guangzhou.

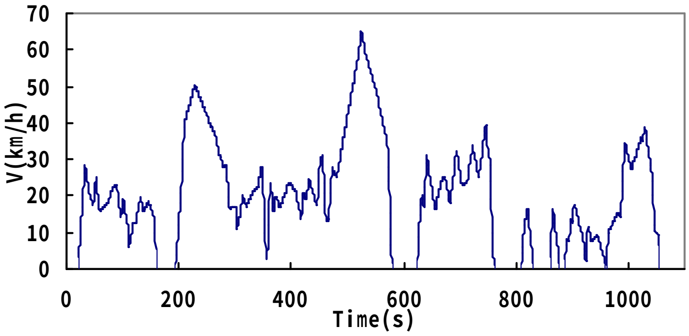


Figure 1-1 Road Traffic Operating Condition in Beijing

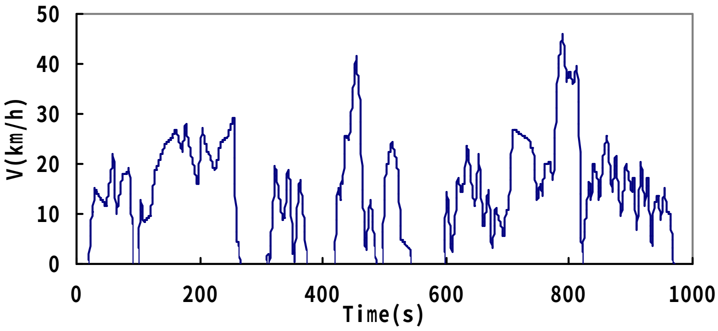


Figure 1-2 Road Traffic Operating Condition in Guangzhou

Table 1-6 Comparison of Operating Conditions Between Beijing and Guangzhou

City	Distance (km)	Time (s)	Max Speed (km/h)	Average Speed (km/h)	Idling Proportion (%)	Speed-up Proportion (%)	Speed-down Proportion (%)	Regularity Proportion (%)
Guangzhou	3.73	980	45.88	13.69	20.51	28.06	25.92	25.51
Beijing	5.70	1070	65.05	19.17	19.44	24.77	28.88	26.91

Some useful information can be discovered from the parameters shown in Table 1-6. The average on-road speed is very low, which causes to the heavy emissions of CO and HC from vehicles. The average vehicle speed is 13.69km/h in Guangzhou while it is 19.17km/h in Beijing. The Speed-up and Speed-down proportion in two cities are both high due to the mixture of walks, bicycles and vehicles that affected the vehicle travel speed badly. Vehicle emissions were deteriorated with the frequently speed-up and speed-down, which heavily impact the human health.

1.2.1 The Present Situation of National city road transport

The investment and its share in the budget on city transportation infrastructure were expanded in resent years. Though the highway networks and road areas had been rapidly increased, and the overhead roads and crossroads in mega cities had relaxed the traffic jam, but the road areas were limited by the high density land utilization model in Chinese mega cities, which would cause to the sharp contradiction between the road supply and the traffic needs and the serious traffic jam.

Public transport was rapidly developed as the important component of city transportation in recent years. The numbers of bus, electric car and transit line were fleetly increased in some mega cities. But the passengers carried were stagnant or even declined. The main reason is, travel demand was increased with the economic development, while travel types were diversified due to the high demand on convenience and coziness in traveling. The high demand on convenience and coziness in traveling could be satisfied by other non-transmit systems under the current traffic conditions. The basic status of Chinese city road transport is shown in Table 1-7.

Table 1-7 The Basic Status of Chinese City Road Transport

City	Public passenger traffic (Million people)		Bus proportion (Vehicle/104 people)		Road areas per person (m2/person)		Investment on Road, Bridge and Public Traffic(Million Yuan)	
	1993	1997	1993	1997	1993	1997	1993	1997
Beijing	2862.68	3373.89	14.0	19.2	4.8	5.8	1325.7	2355.7
Guangzhou	5626.87	2636.79	9.0	14.8	4.5	6.8	2013.0	7460.0
Shanghai	663.72	1073.56	13.2	35.2	5.1	6.5	5175.9	9991.1
National	27258.91	27348.88	6.0	8.6	6.5	7.8	21386	47552.8

1.2.2 Present Situation of Road Transport in Typical Cities

1.2.2.1 Present Situation of road transport in Beijing

Bus, subway and taxi shared 75%, 11% and 14% of total public traffic of Beijing respectively which amounted to 3.37 billion people in 1997. There are 5400 buses in Beijing including 4800 large gasoline and diesel buses and 609 electric bused. There are 198,000 trucks in Beijing which taken on the 88% of total freight traffic. There are 1100 km city roads in 650 km2 central regions. The road occupation of land and road density is 11.42% and 3.74km/km^2 respectively in the second ring regions.

The traffic jams were deteriorative as the expanded vehicle population in passed ten years. The government had made great efforts to enhance level the traffic facilities in order to lighten the traffic pressure. Some major traffic facilities were accomplished such as two rapid ring roads and several major extrorse roads. Some roads were widened, 119 crossroads and 202 overbridges were constructed, and the investment on public transport construction was increased. All of those constructions had taken the important rules in the traffic pressure remission. But the traffic facilities amount and structure are still conflicted with the increased traffic demands because of many historical reasons. The traffic jams can be seen frequently.

Table 1-8 Road Traffic Status in Beijing (1997)

Road (width > 6m) distance in urban regions (km)	1099
Throughway(no level crossing) (km)	122
Branch road (km)	210.2
Road distance for Bus (km)	27
Subway distance (km)	42
Daily passenger volume of Subway in 1997 (104 people)	122
Number of Crossroads in urban regions	160
Number of carfax with traffic lights	490

1.2.2.2 Present Situation of road transport in Guangzhou

The road areas and distance in Guangzhou were greatly increased since the reform and opening. The annual average growth rate of the road areas and road distance in Guangzhou is 13.87% and 12.82% respectively, which is lower than 25.4% of the growth rate of the vehicle population. However, the road construction still could not meet the tremendous needs of transportation development. (See Table 1-9) The public vehicles in Guangzhou include autobus and city middle-bus. In 1997, there are about 4611 buses in Guangzhou including 106 trolleys. Diesel buses share the 60% of total public buses while gasoline buses share other 40%. The daily travel mileage of public buses is around 180km. In 1997, there are around 15,500 taxies in Guangzhou containing 1.6% of total vehicle population. The total public traffic of Guangzhou amounted to 1.07 billion people in 1997.

Table 1-9 The growth rate of road in Guangzhou

Year	1990	1991	1992	1993	1994	1995
Distance (km)	945	951	964	1379	1404	1809
Annual growth rate(%)	36.7	0.63	1.37	43.05	1.81	28.85
Area (×104m2)	1085	1093	1118	1378	1469	1983
Annual growth rate (%)	33.33	0.74	2.29	23.26	6.6	34.99

Until 1995, there were total 1809 km roads in Guangzhou, and the total road areas amounted to 1983$\times 10^4 m^2$. The road network based on 1 inner ring road, 2 thruways, 13 artery roads and 10 extrorse roads have formed in Guangzhou. The 13 artery roads including 8 south-north roads and 5 east-west roads were distributed in Old City District, Tianhe District, Huangpu District and Fangcun District. Guangzhou street runs through the Tianhe District and Haizhu District from the south to the north. Guangyuan street, Round street-Zhongshan street and Dongfeng street-Huangpu street run through the whole Old City District and Tianhe District from the east to the west. Xingang street-Changgang street runs throuth the Haizhu strict from the east to the west. The inner ring street runs from City-round road to Nonglin street, South city-round road, Down-river street, Huangsha street, Nanan street , then back to City-round road. The width of those roads is around 22-66m, but he traffic jams can be seen frequently.

Table 1-10 Road traffic status in Guangzhou (1997)

Road (width > 6m) distance in urban regions(km)	1886
Throughway(no level crossing)(km)	14.56
Branch road (km)	121.80
Road distance for Bus(km)	53.67
Subway distance(km)	18.48
Number of Crossroads in urban regions	60
Number of carfax with traffic lights	172

1.2.2.3 Present Situation of road transport in Shanghai

Shanghai Government had enhanced the construction of basic infrastructure since 1980s. The investment of basic infrastructure occupied 2.4% of total gross domestic product in 1981 while the proportion was increased to more than 10% in recent years. The proportion reached to 13% and 12% in 1996 and 1997 respectively. The investment on city transportation occupied 20%-49% of total public utilities investment of 38.6 billion Yuan. The city transportation network has been designed with freeways, overhead roads and subways. The serious traffic jam was lightened.

By the end of 1997, the total road distance of Shanghai amounted to 5713 km, the total road areas amounted to 85.03 million m2, and the areas of traffic line amounted to 63.03 million m2. From 1991 to 1997, the road distance and areas were increased 895 km and 25 million m2 with the growth rate of 18.6% and 41.6% respectively, and the road areas per person were increased from 4.67 m2 to 6.51 m2.

By the end of 1997, there are 1078 transit lines and 16,200 buses including 600 air-conditioned bused in Shanghai. The 22.4 km 1# subway had put to use in 1994, but the rail transportation only occupied 1% of total passenger traffic volume. There are 41,000 taxis in Shanghai. Taxis occupied 50% of total volume of vehicle flow in central areas, but 40% taxis are empty. The total public traffic of Shanghai amounted to 2.64billion people in 1997.

Table 1-11 The Road Distance and Areas of Shanghai (1991-1997)

Year	Distance (km)	Area (104 m^2)	Road areas per person (m^2/person)
1991	4817.6	6004.8	4.67
1992	5043.2	6386.7	4.95
1993	5105.3	6569.2	5.07
1994	5192.3	6862.2	5.28
1995	5420.3	7399.9	5.69
1996	5599.3	8058.5	6.17
1997	5712.7	8503.2	6.51

1.3 Existed efforts and related opinion for increasing fuel economy in China

There is a huge gap on fuel economy between China and developed countries. The government should make great efforts to increase the fuel economy. It is a complex system engineering that must been proceeded with in many ways. The advices were presented as following based on vehicular emissions and city transportation management mechanism.

1.3.1 Policies about vehicles

One of the important ways to reduce the fuel consumption is to increase the compression ratio. The main reason of low increasing of Chinese vehicle compression ratio is the lack of high-grade gasoline that influenced both domestic designed vehicles and imported technology vehicles. According to the experimental results, fuel saving can obtained by using 90# gasoline without changing the compression ratio. 100 million tons of gasoline can be saved per year by switching some low compression ratio vehicles to 90# gasoline, so it is important to push high grade gasoline for increasing the fuel economy. According to the Requirements of Terminating Production, Sale and Use of Vehicular Leaded Gasoline announced by State Council Office (State Council Office Notice [1998]#129), the whole country had stopped the leaded gasoline production since Jan.1 2000 and converted to the 90# or higher unleaded gasoline. Since July 1, 2000, whole country vehicles have given up the leaded gasoline and converted to the unleaded gasoline. The progress of improving fuel economy was accelerated by the using of unleaded gasoline in nation wide. Petrochemical industry made large efforts to shorten the progress from decades to a few years.

The vehicle population of china is about 14 millions now. While these numbers are much lower than in developed countries such as the US and Japan, the total fuel consumption of China is similar to those countries because of the high fuel consumption for individual vehicle. The vehicle producers are inactive because of the protection policies of the government. According to the experience in western developed countries, one of the most effective ways to improve fuel economy is to implement mandatory vehicular fuel consumption standards. The feasibility of standards should have to be proven before the implementation. Both the detection method and mechanism of supervision and examination should be used to preventing the over-standard new vehicles into the market and punishing the violative manufacturers. High fuel consumed vehicles should be well maintained to decreasing fuel consumption. The vehicle manufacturers have to put large number of people, capital and time to develop and produce the high fuel economy vehicles, so government should encourage them and provide policy support. On the other hand, the supervision and examination of fuel quality should be enhanced. A cooperative team from the departments of environmental protection, business administration and quality supervision should be founded to monitoring the fuel quality in the market, punishing the violative seller, and controlling the fuel quality among its manufacturing, transportation, distributing and storage.

1.3.2 Related policies on urban transportation

I. Selecting proper landuse-transportation mode based on the character of land resource, and building proper transportation construction

Various transportation modes can cause different driving cycles then affect the fuel economy intensively. So changing the city transportation structure, i..e. travel mode and structure, can take large effect to vehicle fuel economy. We must consider that traffic jam is not only from the vehicle population but also from the landuse system. The formation of city transportation structure is lied on the city landuse mode, work mode and life fashion which are based on the characters of land resource and economic level. Actually, the environmental issue from transportation can be considered as a comprehensive system including city landuse mode, transportation mode, work and life mode, and sustainable use of resource.

A reasonable transportation system must have a leading plan which can represent the strategy of cooperative development between transportation and environment. The government should lead a cooperative institute including urban planning, urban construction, transport management, public utility and environmental protection to map a reasonable city transportation structure.

II. Strengthening the priority of public traffic, and accelerating the system reform of public traffic

The high density landuse mode in China mega-cities caused the lack of the road resource. The contradiction between the road supply and the traffic demand is sharpened and the traffic jam is more serious. So the public traffic will be the unique way in the future cities.

Some suggestions for developing public traffic are list as following.

Developing a high density and effective public traffic network, including special public traffic lines, subway and light rail.

Building a convenient, safe and comfortable ride environment.

Accelerating the system reform of public traffic and implementing a competition mechanism to improve the service quality.

III. Protection measure for appropriate bicycle development

Bicycle traffic is still the most important traffic type in China cities. More than 50% of total resident traffic volume is from bicycle, which is much higher than public traffic and other traffic types. Bicycle traffic has many advantages such as no-pollution, low cost and convenience, especially, travel by bicycle is usually faster than by bus or car in the serious traffic jam. But in many cities, vehicles and bicycles are blended on the road. The conflict among pedestrians, bicycles and vehicles not only impacts the vehicle efficiency but also increases the risk of traffic accident. In some cities, bicycles are restricted in some regions.

It is suggested that the government should take some necessary protection to bicycles. Any traffic mode has its unique advantages, special propose and living environment. The government should build and maintain the bicycle accommodation roads and strengthen the management measure of bicycle traffic to reduce the conflict of vehicles and bicycles.

IV. Making appropriate policies for vehicle developing and optimizing the construction

of vehicle population ratio

Motoliazation progress means the increasing of private car and private traffic ratio. The motoliazation level is correlative with economic development level. But the experience in some countries shows that it is unadvisable to limit the private car by economic and administrative measures. Though it could take effect, it would cause some reversed impact later. Vehicle population should not be an index of economic level, while the effective and convenient traffic system is one of the targets of city modernization. In Chinese mega-cities, the necessary project is how to lead the proper use of car and how to prevent the dominating station of cars and motorcycles.

Some suggestions are listed as following:

According to the economic object, road capacity and environmental impact, the private cars should be developed moderately and regularly, and the total population of private car should be controlled.

Taxi should be under control according to the actual travel demand.

Motorcycles should be restricted strictly.

Sell and use of the fuel … should be forbidden and in-use fuel … should be washed out rapidly.

V. Building scientific and intelligent traffic management system

Scientific traffic management system can improve the transport capacity and efficiency effectively, and decrease the traffic jam, air pollution, and economic losses by illogical transport management.

VI. Promoting the cooperation among traffic management department, environmental protection department and urban planning department.

Urban transportation pollution control is an integrated systems engineering, which need the powerful cooperation and treatment of related departments, but present system can not realize it.

Chapter 2 Current Situation of Vehicular Fuel Consumption in China

2.1 Vehicle Classification System

2.1.1 Definitions of Main Types

According to current standards and regulations of China, vehicles are classified into three following main types.

(1) Trucks, which are mainly used to carry cargo.

(2) Buses, which have rectangle carriage, used for transporting passengers and their luggage.

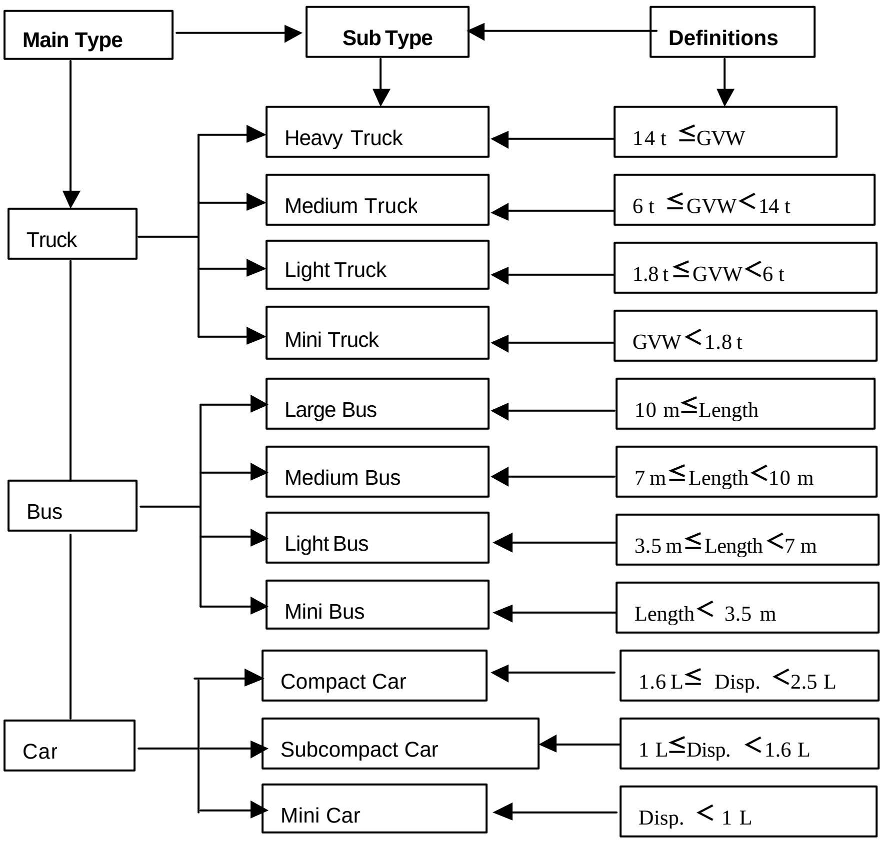
(3) Cars, which have four wheels and seats located between the front and rear axle of the vehicles, used for carrying passengers and luggage.

2.1.2 Definitions of Sub Types

According to current statistic standards and regulations of china, combining the requirements of this report, eleven sub types are gotten from the three main types, as Figure 2-1 shows.

2.2 Production and Vehicular Consumption of Gasoline and Diesel in 1998

In 1998, the production of crude oil was 160 million tons in China. Gasoline production was 34.65 million tons, 85% of which was used by vehicles, and diesel production is 48.84 million tons. Recently, as part of medium and light duty vehicles was switching fuel to diesel, the vehicular diesel consumption grew gradually, with a ratio of 18.9% of the diesel production in 1998. Table 2-1 and 2-2 respectively compare the production and vehicular consumption of gasoline and diesel from 1991 to 1998.



Note: Each sub type includes both of gasoline and diesel vehicles.

Figure 2-1 Definition of Vehicle Types

In 1998, consumed gasoline included 68.4% unleaded 90# gasoline， 20.2% 70# gasoline of leaded or unleaded, and 11.4% unleaded gasoline better than 90#. For diesel, the catalytic cracking diesel occupied more than 30%, while the ratio of hydrocracking diesel was relative low. The oxidation stability is bad and the sulfur content is very high with an average value of about 2000ppm. Cetane value of diesel from some industries was very low and even no more than 45.

Table 2-1 Production and Vehicular Consumption of Gasoline and Diesel in 1998 (million tons)

Production of Crude Oil	Gasoline			Diesel		
	Production	Vehicular Consumption	Ratio	Production	Vehicular Consumption	Ratio
161	34.65	29.456	85%	48.841	9.225	18.9%

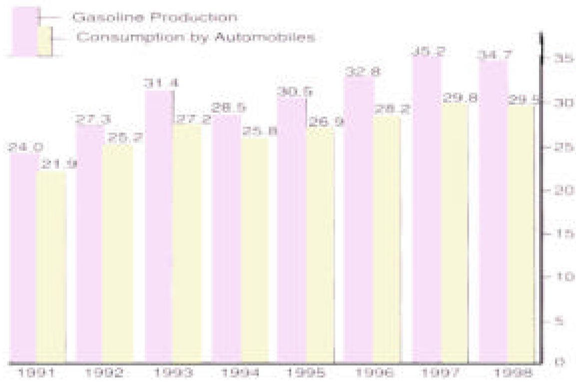


Figure 2-2 Compare of Production and Vehicular Consumption of Gasoline from 1991 to 1998

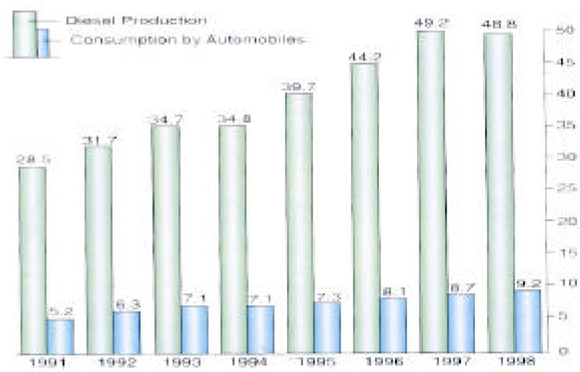


Figure 2-3 Compare of Production and Vehicular Consumption of Diesel from 1991 to 1998

2.3 Fuel Consumption of New Vehicles

2.3.1 Fuel Consumption of Domestic New Vehicles in 1998

2.3.1.1 Production and Sales of New Vehicle in 1998

In 1998, because of the influence from macrocontrol of national economy, auto market was still in situation of slow growth, and this influenced the vehicle production, whose growth rate was only. 2.9%. Large Bus' production and growth value were 6151 and 30.9% respectively, which was the highest. Car was 508 thousands and 4.1%, and there was no obvious change for production of Truck. Table 2-2 offers the detailed data.

Table 2-2 Production and Sales of Vehicle in 1998 (by sub type)

Types	1998	
	Production	Sales
Truck	661701	658051
Heavy-duty	34829	36676
Medium-duty	183617	187661
Light-duty	297351	292469
Mini-duty	145904	141245
Bus	459025	436719
Large	6025	5790
Medium	16952	16715
Light	179410	180166
Mini	256638	234048
Car	507861	508497
Compact	268358	270803
Subcompact	114106	102778
Mini	125397	134916
Total	1628587	1603267

2.3.1.2 Typical Vehicle models

Table 2-3 lists the main vehicle models of mayor vehicle makers. The vehicle models selected are most typical in their own types and their production and sales occupy larger proportion of their types, so they have representativity for fuel consumption computation.

Table 2-3 Vehicle Type Models

Company Name	Key Vehicle Model	Labeled fuel Consumption level L/100m	Production	Proportion	Sales	Proportion
Heavy Trucks			9229	/	8898	/
Dongfeng Motor Corporation	EQ1141G (Diesel)	20.5	6676	72.3%	6602	74.2%
Sichuan Motor Manufacturing	CQ1190B46A、1260 (Diesel)	36.0	744	8.1%	841	9.5%
China National Heavy Duty Truck Group	1291(Diesel)	26.0	650	7.0%	650	7.3%
Subtotal			8070	87.4%	8093	91%
Medium Trucks			86613	/	89688	/
Dongfeng Motor Corporation	EQ1092F、1108G (Diesel)	17.3	32279	37.3%	33211	37.0%
Dongfeng Liuzhou Motor Co., Ltd.	LZ1090MD3K (Diesel)	19.0	4020	4.6%	4191	4.7%
China FAW Group Corporation	CA1092	25.0	44120	50.9%	45169	50.4%
Hubei Special Vehicle Manufacturing	HQG1100F	26.5	1649		2315	
Subtotal			80419	92.8%	82571	92.1%
Light Trucks			244964		242371	
Qingling Motor (Group) Company Ltd.	(Diesel)	11.0	32686	13.3%	33324	13.7%
Yuejin Auto Group Corporation	NJ1043 (Diesel)	12.0	22336	9.1%	21536	8.9%
Jiangling Motor Group Corporation	NHR, NKR (Diesel)	12.0	16050	7.0%	18197	8.0%
Beijing Light Vehicle Co., Ltd.	BJ1041	14.0	21035	9.0%	21000	9.0%
China FAW Group Corporation	CA1046	12.5	20849	9.0%	20894	9.0%
China FAW Group Corporation	CA1026	10.5	10780	4.0%	11085	5.0%
Subtotal			123736	51.0%	126036	52.0%
Mini Trucks			142617		137615	
Liuzhou Minicar Factory	LZW1010	6.5	77480	54.0%	74781	54.0%
Chana Automobile Liability, Co., Ltd.	SC1010、1010A	6.7	36025	25.0%	34443	25.0%
Changhe Aircraft Industries Co.	HH1012A、HH1012BC	6.0	8045	6.0%	7896	6.0%
Subtotal			121550	85.0%	117120	85.0%
Large Buses			4155	/	4275	/
Dandong Automotive Manufacturing	DD (Diesel)	23	1244	29.9%	1408	33%
Shanghai Bus Manufacturing	SK6115HP2 (Diesel)	30.0	668	16.1%	668	15.6%
Guilin Bus Industry Co., ltd.	GL6120、GL6121 (Diesel)	22.5	440	10.6%	440	10.3%

Subtotal			2352	56.6%	2516	58.9%
Medium Buses			11572	/	11364	/
Jiangsu Yaxing Moto Coach Group Co., Ltd	(Diesel)	18.0	6457	55.8%	6217	54.7%
Guangzhou Weida Motor Co.	GZ6100、6890 (Diesel)	28.5	727	6.3%	748	6.6%
Hunan Sanxiang Bus (Group) Co., Ltd.	CK6892	28.0	225	2.0%	208	1.8%
Subtotal			7409	64.0%	7173	63.0%
Light Buses			94678	/	94922	/
Yuejin Auto Group Corporation	IVECOA40 (Diesel)	8.0	18337	19.4%	18087	19.1%
Jiangsu Yizheng Motor Vehicle Plant	YQC6450、6460 (Diesel)	13.0	1953	2.0%	2118	2.2%
FAW-Jinbei Automotive Co., Ltd.	SY6480、6475	8.0	29802	31.5%	30018	31.6%
China FAW Group Corporation	CA6440	10.5	7504	8.0%	7372	8.0%
Subtotal			57596	61.0%	57595	61.0%
Mini Buses			255947	/	229405	/
Changhe Aircraft Industries Co.	CH1018	6.2	91986	35.9%	82112	35.8%
Harbin Hafei Motor Co., Ltd.	HFJ6350、6351	6.0	50498	19.7%	49079	21.4%
Chana Automobile Liability, Co., Ltd.	SC6331、6350	6.9	39419	15.4%	35427	15.4%
Subtotal			181903	71.0%	166618	72.6%
Compact Cars			268358	/	270803	/
Shanghai Volkswagen Automotive Co., Ltd.	SANTANA	7.68	235000	87.6%	235020	86.7%
China FAW Group Corporation	CA7220	12.6	11703	4.4%	11832	4.4%
Beijing Jeep Corporation Ltd.	Cherokee	9.3	8344	3.1%	9222	3.4%
Subtotal			255047	95%	256074	94.6%
Subcompact Cars			114106	/	102778	/
FAW-VW Auto Co.	Jetta、Golf	6.9	60085	53%	60331	59%
Dongfeng Citroen Automotive Co. Ltd.	1.6L、1.4L	5.30	36240	32%	33364	32%
Tianjin Automotive Industry (Group) Co. Ltd.	TJ7130U	5	17781	16%	8923	9%
Subtotal			114106	100%	102618	100%
Mini Cars			125397	/	134916	/
Tianjin Automotive Industry (Group) Co. Ltd.	TJ7100、7100U	5	82240	66%	90911	67%
Chana Automobile Liability, Co., Ltd.	SC7080	5	35555	28%	36239	27%
Xian Qinchuan Automotive Co., Ltd.	QCJ7080	5	5008	4%	5011	4%
Subtotal			122803	98%	132161	98%

2.3.1.3 Methodology

Following functions are used for computing fuel consumption by type.

Methodology I:

If the vehicle sales by type is known:

$$\mathbf{FCTM = CP \times sales} \qquad \textbf{(1)}$$

Where:

FCTM: Fuel Consumption of each Typical vehicle Model

CP: Consumption per 100Km, L/100km

Sales: Sales of the vehicle model

$$\mathbf{AFCT = AFCM \div TSTV} \qquad \textbf{(2)}$$

Where:

AFCT: Average Fuel Consumption of each Type

AFCM: Accumulated AFCT

TSTV: Total Sales of three Typical Types of Vehicles

$$\mathbf{FC = AFCT \times TVT} \qquad \textbf{(3)}$$

Where:

FC: Fuel Consumption

TVT: Total sales of each Vehicle Type

Methodology II:

If the sales of gasoline and diesel vehicles are known:

$$\mathbf{FCTM = CP \times sales} \quad (1)$$

Where:

FCTM: Fuel Consumption of each Typical vehicle Model by fuel type

CP: fuel Consumption per 100Km

$$\mathbf{AFCT = AFCM \div TSTV} \quad (2)$$

Where:

AFCT: Average Fuel Consumption of each Type

AFCM: Accumulated AFCT by fuel type

TSTV: Total Sales of Typical types of Vehic le by type

$$\mathbf{FC = AFCT \times TVT} \quad (3)$$

Where:

FC: Fuel Consumption

TVT: Total Vehicle by fuel Type

Table 2-4 lists the related data.

Table 2-4 Related data

Company Name	Fuel Type	Labeled Fuel Consumption Level L/100Km	Sales	Total Fuel Consumption L/100Km	Total Consumption L/100Km	Average Fuel Consumption L/100Km
Heavy Trucks						
Dongfeng Motor Corporation	Diesel	20.5	6602	1315341.0	182517.0	22.6
Sichuan Motor Manufacturing		36.0	841	30276.0		
China National Heavy Duty Truck Group		26.0	650	16900.0		
Medium Trucks						
Dongfeng Motor Corporation	Diesel	17.3	33211	574550.3	654179.3	17.5
Dongfeng Liuzhou Motor Co., Ltd.		19.0	4191	79629.0		
China FAW Group Corporation	Gasoline	25.0	45169	1129225.0	1190572.5	25.1
Hubei Special Vehicle Manufacturing		26.5	2315	61347.5		
Light Trucks						
Qingling Motor (Group) Company Ltd.	Diesel	11.0	33324	366564.0	843360.0	11.5
Yuejin Auto Group Corporation		12.0	21536	258432.0		
Jiangling Motor Group Corporation		12.0	18197	218364.0		
Beijing Light Vehicle Co., Ltd.	Gasoline	14.0	21000	294000.0	671567.5	12.7
China FAW Group Corporation		12.5	20894	261175.0		
China FAW Group Corporation		10.5	11085	116392.5		
Mini Trucks						
Liuzhou Minicar Factory	Gasoline	6.5	74781	486076.5	764220.6	6.5
Chana Automobile Liability, Co., Ltd.		6.7	34443	230768.1		
Changhe Aircraft Industries Co.		6.0	7896	47376.0		
Large Buses						
Dandong Automotive Manufacturing	Diesel	23	1408	32384.0	62324.0	24.8
Shanghai Bus Manufacturing		30.0	668	20040.0		
Guilin Bus Industry Co., ltd.		22.5	440	9900.0		
Medium Buses						

Jiangsu Yaxing Moto Coach Group Co., Ltd	Diesel	18.0	6217	111906.0	133224.0	19.2
Guangzhou Weida Motor Co.		28.5	748	21318.0		
Hunan Sanxiang Bus (Group) Co., Ltd.	Gasoline	28.0	208	5824.0	5824.0	28
Light Buses						
Yuejin Auto Group Corporation	Diesel	8.0	18087	144696.0	172230.0	8.5
Jiangsu Yizheng Motor Vehicle Plant		13.0	2118	27534.0		
FAW-Jinbei Automotive Co., Ltd.	Gasoline	8.0	30018	240144.0	317550.0	8.5
China FAW Group Corporation		10.5	7372	77406.0		
Mini Buses						
Changhe Aircraft Industries Co.	Gasoline	6.2	82112	509094.4	1048014.7	6.3
Harbin Hafei Motor Co., Ltd.		6.0	49079	294474.0		
Chana Automobile Liability, Co., Ltd.		6.9	35427	244446.3		
Compact Cars						
Shanghai Volkswagen Automotive Co., Ltd.	Gasoline	7.68	235020	1804953.6	2039801.0	8.0
China FAW Group Corporation		12.6	11832	149083.2		
Beijing Jeep Corporation Ltd.		9.3	9222	85764.6		
Subcompact Cars						
FAW-VW Auto Co.	Gasoline	6.9	60331	416283.9	637728.1	6.2
Dongfeng Citroen Automotive Co. Ltd.		5.30	33364	176829.2		
Tianjin Automotive Industry (Group) Co. Ltd.		5	8923	44615.0		
Mini Cars						
Tianjin Automotive Industry (Group) Co. Ltd.	Gasoline	5	90911	454555.0	660805.0	5.0
Chana Automobile Liability, Co., Ltd.		5	36239	181195.0		
Xian Qinchuan Automotive Co., Ltd.		5	5011	25055.0		

2.3.1.4 Fuel Consumption of Domestic Vehicle in 1998

According the statistical results of related section, diesel vehicles occupied 26.16% of new vehicle in 1998, so the methodology II is used to compute the fuel consumption and the results are as following:

Diesel consumption of typical vehicle models: 2047834.3 L/100Km

Sales of typical vehicle: 148238

Average diesel economy of typical vehicle models: 13.81 L/100Km

Proportion of diesel vehicle in new vehicle in 1998: 26.16%

Total sales of diesel vehicle in 1998: 419414

Diesel consumption of new vehicle in 1998: 5792107.3 L/100Km

Total: 5068.09 tons/100Km

Gasoline consumption of typical vehicle model: 7336038.4 L/100Km

Sales of typical vehicle: 912652

Average gasoline economy of typical vehicle models: 8.038 L/100Km

Proportion of gasoline vehicle in new vehicle in 1998: 73.84%

Total production of gasoline vehicle in 1998: 1183852.4

Gasoline consumption of new vehicle in 1998: 9515805.2 L/100Km

Total: 6965.56 tons /100Km

Table 2-5 lists the computed results above

Table 2-5 Fuel consumption of new vehicles in 1998

	Gasoline (10^4 tons)	Diesel (10^4 tons)
Consumption	208.97	152.04

Note: the yearly average travel mileage is 30,000 kilometers

2.3.2 Fuel Consumption of Agriculture Vehicles in 1998

2.3.2.1 Production and Sales of Agriculture Vehicles in 1998

The total production of agriculture vehicle in 1998 was 2931183， which was 11.6% more than in 1997. The growth rate of four-wheel and three-wheel agriculture vehicles was 11.68% and 11.60% respectively. The ratio of production and sales of agriculture vehicles exceeded 96% in 1998, with 96.15% for four-wheel and 98.7% for three-wheel. More detailed information is present in Table 2-6.

Table2-6 Sales and Production of Agriculture Vehicles

	Production	Sales
Four-wheel vehicle	469414	451328
Three-wheel vehicle	2461769	2442730
Total	2931183	2894058

2.3.2.2 Fuel Consumption of Agriculture Vehicle

Currently, China is not very normative on management and statistic of agriculture vehicles, so only general data is available, which bring much difficulty to the computation. For evaluating fuel consumption of agriculture vehicle, certain kinds of typical vehicle model must be chosen to substitute other vehicle models, as Table 2-7 shows.

Table 2-7 Fuel Consumption of agriculture vehicles

	Sales	Average fuel consumption level L/100Km	Total fuel consumption L/100Km
Four-wheel	451328	6.5[1]	2933632
Three-wheel	2442730	2.8[2]	6839644
Total	2894058	3.38	9773276

[1] Refer to HB1605-5 flat head single row agriculture vehicles

[2] Refer to JL-153 three agriculture vehicles

The results are as following:

Total fuel consumption of agriculture vehicles: 9773276 L/100Km

Average fuel economy of agriculture vehicles: 3.38 L/100Km

Total fuel consumption: 8551.62 tons/100Km (diesel)

2.3.3 Fuel Consumption of Motorcycle in 1998

In 1998, the production and sales of motorcycle declined greatly in China, with the increasing rate of -12.5% and -9.8% respectively. The ratio of production and sales exceeded 100% and the storage decreased 12.7%. The motorcycle industries became more centralized, and the key enterprises had possessed certain production capacity, for example, there had been 13 motorcycle makers with production capacity of more than 200,000. The ratio of small discharge volume motorcycles (50 or 70mL) in the market decreased, and the sales of large motorcycles (250mL) declined most greatly, with a abate rate of 51%. Motorcycle of middle discharge volume took larger share of sales with 29.4% of 100mL, 30.15% of 125mL and 11.46% of 90mL, sum of which was up to 71%. Table 2-8 offers the detailed information about the production and sales of motorcycles.

Table 2-8 Production and Sales of motorcycle in 1998

Disp. (mL)		Production	Sales
Total		8789427	8857391
Two-wheel	≤50	1200430	1229084
	60	105401	105.86
	70	322724	324116
	80	211425	196011
	90	1007103	1064280
	100	2588268	2678326
	125	2650258	2617413
	150	115422	122968
	250	203165	137220
Three-wheel	50	20893	20813
	>50	326680	325286
	250	17831	16105
	750	19827	20683

Table 2-9 gives the fuel consumption of motorcycle at economical speed. For convenience, the max fuel consumption value of each motor type is chosen for computation and the results are available in Table 2-10.

Table 2-9 Fuel consumption of motorcycle at economical speed

Disp.		Fuel consumption at economical speed (100Km)			
		Four-stroke engine		Two-stroke engine	
		Two-wheel motorcycle	Two-wheel seater motorcycle	Two-wheel motorcycle	Two-wheel seater motorcycle
Two-wheel	≤50	/	1.4	1.5	1.6
	60	/	/	1.5	1.7
	70	1.2	1.7	/	/
	80	1.2	/	1.6	1.9
	90	1.3	1.9	1.6	1.9
	100	1.4	2.0	1.7	2.0
	125	1.7	2.2	2.0	2.3
	150	2.0	2.3	/	/
	250	2.1	2.5	2.4	/
Three-wheel		Four-stroke engine		Two-stroke engine	
	50	1.6		1.6	
	>50	2.0		2.5	
	250	/		3.0	
	750	5.0		/	

Table 2-10 Fuel Consumption of Motorcycle by Type

Disp. (mL)		Sales	Average fuel economy (L/100Km)	Fuel consumption (L/100Km)
Two-wheel	≤50	1229084	1.6	1966534.4
	60	105086	1.7	178646.2
	70	324116	1.7	550997.2
	80	196011	1.9	372420.9
	90	1064280	1.9	2022132
	100	2678326	2.0	5356652
	125	2617413	2.3	6020049.9
	150	122968	2.3	282826.4
	250	137220	2.5	343050
Three-wheel	50	20813	1.6	33300.8
	>50	325286	2.5	813215
	250	16105	3.0	48315
	750	20683	5.0	103415
Total		8857391		18091554.8

The results:

Fuel consumption of motorcycle: 18091554.8 L/100Km

Average fuel economy of motorcycle: 2.04 L/100Km

Total fuel consumtpion: 13243.018 tons/100Km (Gasoline)

2.3.4 Fuel Consumption of imported new vehicle in 1998

Table 2-11 gives the number of imported vehicle. For convenience, the labeled fuel economy of imported vehicles used the value of that of domestic vehicles. Table 2-12 lists the results

Table 2-11 Number of imported vehicle in 1998

Type	Number	Type	Number	Type	Number
Truck	4373	Coach & Bus	7424	Car	18016
Heavy (diesel)	1132	Large (diesel)	234	Compact (diesel)	4
Medium (diesel)	443	Medium (diesel)	138	Mini (gasoline)	17
Light (diesel)	163	Light (diesel)	2868	Subcompact (gasoline)	1033
Heavy (gasoline)	11	Large (gasoline)	757	Compact (gasoline)	15279
Medium (gasoline)	12	Medium (gasoline)	75	Intermediate (gasoline)	1207
Light (gasoline)	2610	Light (gasoline)	3352	Limousine (gasoline)	476
Total			40216		

Table 2-12 Fuel consumption of imported vehicles

	Number	Average fuel economy (L/100Km)	Fuel consumption (L/100Km)
Truck	4373		
Heavy-duty(Diesel)	1132	22.60	25583.2
Medium-duty(Diesel)	443	17.5	7752.5
Light-duty(Diesel)	163	11.5	1874.5
Heavy-duty(Gasoline)	11	/	0
Medium-duty(Gasoline)	12	25.1	301.2
Light-duty(Gasoline)	2610	12.7	33147
Coach & Bus	7424		0
Large(Diesel)	234	24.8	5803.2
Medium(Diesel)	138	19.1	2635.8
Light(Diesel)	2868	8.5	24378
Large(Gasoline)	757	24.8	18773.6
Medium(Gasoline)	75	28	2100
Light(Gasoline)	3352	8.5	28492
Passenger Cars	18016		0
Compact(Diesel)	4	/	0
Mini(Gasoline)	17	5	85
Subcompact(Gasoline)	1033	6.2	6404.6
Compact(Gasoline)	15279	8.0	122232
Intermediate(Gasoline)	1207	11.5[1]	13880.5
Limousine(Gasoline)	476	12.5[2]	5950
Total	Diesel: 68027.2		Gasoline: 231365.9

[1] refer to CA7460　　　　[2] refer to CA7200E

The results are:

Fuel economy of imported new diesel vehicles in 1998: 68027.25 L/100Km

Diesel consumption: 59.52 tons/100Km

Fuel economy of imported new gasoline vehicles in 1998: 231365.9 L/100Km

Gasoline consumption: 169.36 tons/100Km

2.3.5 The Results of fuel consumption of new vehicles

Table 2-13 summarizes the results above.

Table 2-13 Fuel consumption of new vehicles

	Diesel (tons/100Km)	Gasoline (tons/100Km)
Domestic vehicles	5068.09	6965.56
Agriculture vehicles	8551.62	0
Motorcycle vehicles	0	13243.018
Imported vehicles	59.52	169.36
Total	13679.23	20377.938
Fuel consumption (10^4 tons)	410.38	611.34

Note: annual average travel mileage is 30,000 km

2.4 Fuel consumption of In-use Vehicles

2.4.1 Situation of Diesel Vehicle Development in China

Recently, the development of diesel vehicles in China has speeded up. Before 1980, most vehicles in China used gasoline and only heavy duty trucks used diesel. In 1982, the production of diesel vehicles was about 5100, only 2.6% of the whole vehicle production of 196,000. In later 1980s, diesel vehicles got well developed in China, such as "**Jiangling**" in Jiangxi and "**Qingling**" in Chongqing, and the production of medium and heavy duty vehicles with diesel engines were also grew gradually. In 1990, diesel vehicles occupied 14.88% of the total vehicle production and the ratio was raised to 26.16% in 1998. The proportion of diesel vehicles in new produced vehicles, becomes larger and larger, especially in trucks, which had more than 50% of diesel vehicles in 1998.

2.4.2 Investigate Results and Analysis

2.4.2.1 Investigate Results

I Fuel economy of "JinLong" large coach

Model: **JinLong**

Number of samples: 21

Source of the samples: Jiyun Passenger Company in Changchun City, Jilin Province

Source of data: Report forms of the Company

Disposal method of data: take the average value of each type according to the total travel mileage and draw the figure 2-4 using data processing software ORIGIN5.0.

Analysis:

At the beginning, because the vehicles can't run with the economical speed, the fuel consumption is relative high. At the end of wearin period, the fuel economy begin to improve, and when the total travel mileage is up to 150,000 km, because the interior wear condition of vehicle reaches the optimal point, fuel consumption is the lowest. Then, as the increasing of travel mileage, the technical condition of vehicles begins to decline and fuel consumption begins to increase. When the vehicle have traveled 350,000 Km, the fuel consumption has increased 5% than that of optimal status and vehicles should be overhauled at that time. After the overhaul, the fuel consumption decreases greatly and trends to a stable level.

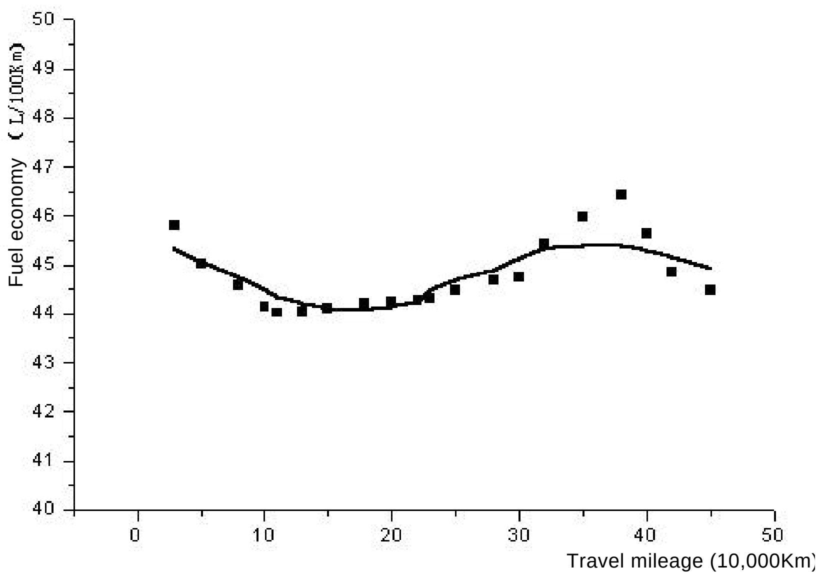


Figure 2-4 Life-cycle fuel consumption of JinLong larger coach

II Fuel Economy of “Jieda (common model)” car

Model: **Jieda** (common model)

Number of samples: 128

Source of the samples: Some large Taxi Companies and enterprises and in Changchun City, Jilin province

Disposal method of data: take the average value of each type according to the total travel mileage and draw the figure 2-5 using data processing software ORIGIN5.0.

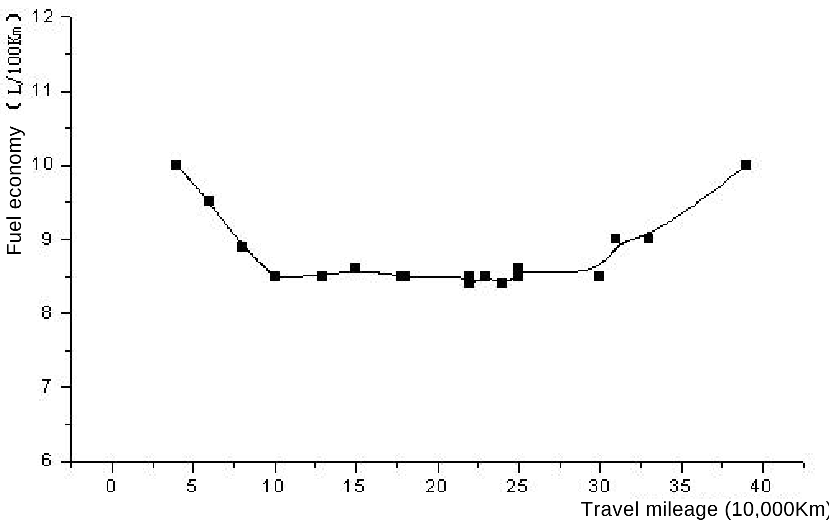


Figure 2-5 Life-cycle fuel consumption of Jieda cars

Analysis:

There are not so many changes of fuel economy in Jieda’s life. At the beginning, the fuel consumption is relative high. At the travel mileage of 70,000 km, the fuel economy begin to improve, and when the total travel mileage is up to 300,000 km fuel consumption begins to increase. The engines should be overhauled after traveling 350,000-400,000 km and after the overhaul, the fuel consumption trends to a stable level.

III Fuel Economy of 6090 Large Bus

Model: **6090** large bus

Number of samples: 31

Source of the samples: Public transmit Company of Changchun City, Jilin Province

Source of data: Bus drivers

Disposal method of data: take the average value of each type according to the total travel mileage and draw the figure 2-6 using data processing software ORIGIN5.0.

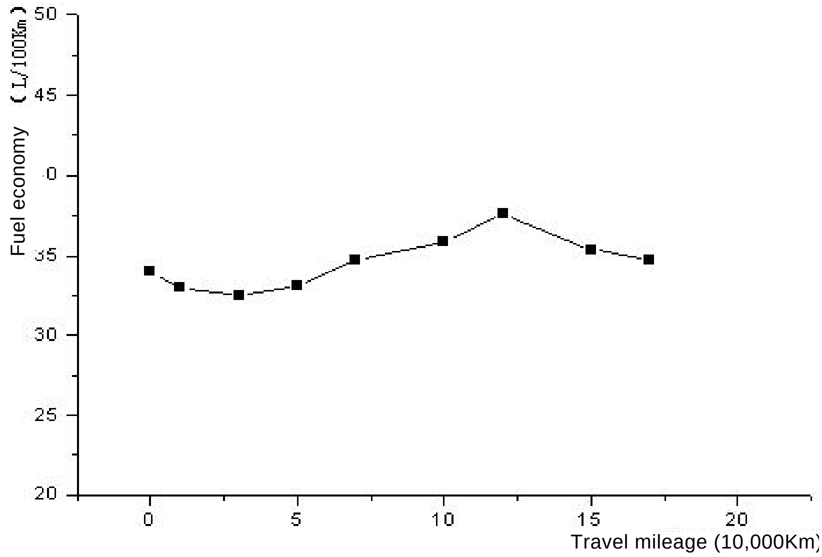


Figure 2-6 Life-cycle fuel consumption of 6090 Buses

Analysis:

At the beginning, because the vehicles can't run with the economical speed, the fuel consumption is relative high. At the end of wearin period, the fuel economy begin to improve, and when the total travel mileage is up to 40,000 km, because the interior wear condition of vehicle reaches the optimal point, fuel consumption is the lowest. Then, as the increasing of travel mileage, the technical condition of vehicles begins to decline and fuel consumption begins to increase. When the vehicle have traveled 110,000-130,000 Km, the fuel consumption has increased 20% than that of optimal status and vehicles should be overhauled at that time. After the overhaul, the fuel consumption decreases greatly and trends to a stable level.

VI Fuel economy of medium duty trucks

Model: **JieFang** flat head diesel truck

Number of samples: 38

Source of the samples: Jiyun Company of Changchun, Jilin Province, and Transit Company of Changchun Coach Manufacturer

Source of data: report forms of the companies

Disposal method of data: take the average value of each type according to the total travel mileage and draw the figure 2-7 using data processing software ORIGIN5.0.

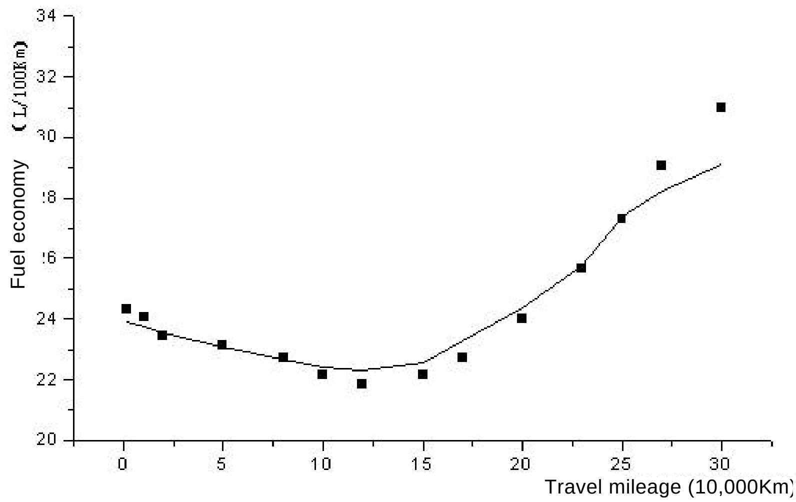


Figure 2-7 Life-cycle fuel consumption of 6-tons flat head diesel trucks

Analysis:

At the beginning, because the vehicles can't run with the economical speed, the fuel consumption is relative high. At the end of wearin period, the fuel economy begin to improve, and when the total travel mileage is up to 80,000-150,000 km, because the interior wear condition of vehicle reaches the optimal point, fuel consumption is the lowest. Then, as the increasing of travel mileage, the technical condition of vehicles begins to decline and fuel consumption begins to increase. When the vehicle have traveled 250,000-300,000 Km, the fuel consumption has increased 20% than that of optimal status and vehicles should be overhauled at that time. After the overhaul, the fuel consumption decreases greatly and trends to a stable level.

2.4.2.2 Analysis of Data

Table 2-14 summarizes the results above.

Table 2-14 shows that in the actual fuel consumption level in the operating period is much higher than the labeled value, so the actual fuel consumption of in-used vehicle should be readjusted. In this report, we apply the method of arithmetic average to compute the total fuel consumption of in-use vehicles in 1998.

Table 2-14 Summary of the data

Model	Labeled fuel consumption L/100Km	Actual fuel consumption			
		Minimum L/100Km	Change Ratio %	Maximum L/100Km	Change Ratio %
JiLong large coach	32[1]	44.1	37.8	45.4	41.9
Jieda car	6.9[2]	8.5	23	10	44.9
6090 large bus	27[3]	33	22	38	28.9
Jiefang 6-tons truck	18[4]	22.7	26.1	27	50

[1] Refer to the fuel consumption parameter of **JinLong**/XMQ6121 announced in 1998

[2] Refer to the fuel consumption parameter of **Jieda** announced in 1998

[3] Refer to the fuel consumption parameter of Guangzhou/GZK6874A announced in 1998

[4] Refer to fuel consumption parameter of CA1110PK2L7 announced in 1998

Table 2-15 gives the average fuel consumption level of in-use vehicles and shows that the average fuel consumption level is over 30% higher than labeled value.

Table 2-15 Average fuel consumption level of in-use vehicles

Model	L/100Km	Difference with labeled value (%)
JiLong large coach	44.75	39.84
Jieda car	9.25	34.06
6090 large bus	35.5	31.48
Jiefang 6-tons truck	24.85	38.06

2.4.3 Vehicle Population by type in 1998

Table 2-16 offers the fuel consumption level and average travel mileage of some vehicle types from relevant sections.

Table 2-16 Fuel consumption level and average travel mileage of some vehicle types

Type	Fuel consumption Level (L/100Km)	Average travel mileage (10^4Km)
Bus	34	6
Light omnibus	16	6
Taxi	6-8	8-10
Heavy duty truck	30	6

Vehicle sales of 1995-1998 were chosen to determine the ratio of each type in-use vehicles. Table 2-17 gives vehicle sales by type and sales share of each type of these four years. Figure 2-18, which describes the sales share of each vehicle type from 1995 to 1998, shows that the sales share did not change very much, except medium duty truck. So we assume that the proportion of each type in in-use vehicle is same as the average sales ratio of each vehicle type from 1995 to 1998. Table 2-18 shows the computation results.

Table 2-17 Vehicle sales in 1995-1998 (by type)

	1995		1996		1997		1998	
	Sales	Ratio	Sales	Ratio	Sales	Ratio	Sales	Ratio
Total	1441779	100%	1458666	100%	1565904	100%	1603054	100%
Truck	638372	44.28%	632547	43.36%	665884	42.52%	658051	41.05%
Heavy duty	23404	1.62%	23696	1.62%	30646	1.96%	36676	2.29%
Medium duty	205667	14.26%	175460	12.03%	188047	12.01%	187661	28.52%
Light duty	300201	20.82%	292888	20.08%	297515	19.00%	292469	18.24%
Mini duty	109100	7.57%	140503	9.63%	149676	9.56%	141245	8.81%
Bus & Coach	320061	22.20%	312036	21.39%	420419	26.85%	436719	27.24%
Large	3653	0.25%	3337	0.23%	4650	0.30%	5790	0.36%
Medium	22267	1.54%	18611	1.28%	16144	1.03%	16715	1.04%
Light	140575	9.75%	120727	8.28%	189157	12.08%	180166	11.24%
Mini	153337	10.64%	169216	11.60%	210468	13.44%	234048	14.60%
Car	322839	22.39%	386743	26.51%	479601	30.63%	508284	31.71%

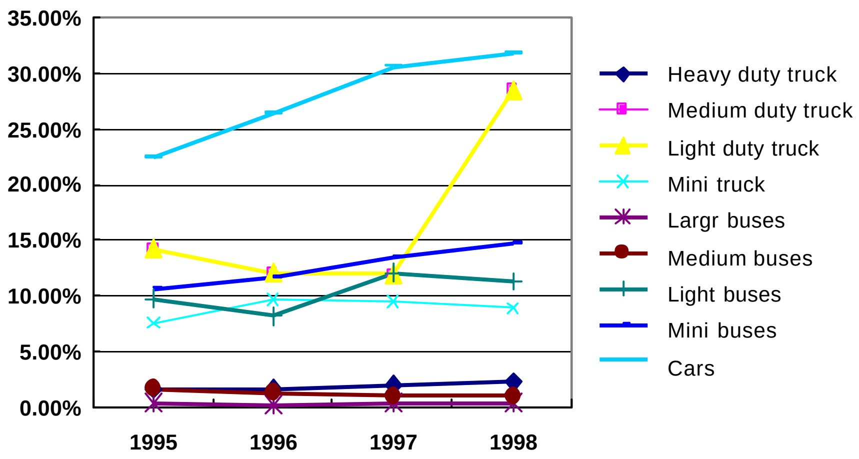


Figure 2-5 Sales ratio of each vehicle type in 1995-1998

Table 2-18 Computation results of in-use vehicle fuel consumption in 1998

	Ratio	Population by type (10^4)	Fuel consumption level* (L/100Km)	Fuel consumption (10^6L/100Km)
Total		1319.30		
Trucks	42.80%	564.69		
Heavy duty	1.87%	24.70	30.70*D	7.58
Medium duty	16.71%	220.39	23.78D	20.96
			34.10G	45.10
Light duty	19.54%	257.73	15.62D	8.05
			17.25G	35.57
Mini duty	8.89%	117.32	8.83G	10.36
Bus & Coach	24.42%	322.17		
Large	0.29%	3.76	33.69D	1.27
Medium	1.22%	16.13	25.95D	1.26
			38.04G	4.30
Light	10.34%	136.38	11.55G	15.75
Mini	12.57%	165.84	8.56G	14.20
cars	27.81%	366.90	6.4#	23.48

* represents the product of fuel consumption level of new vehicle and 1.3568

D represents Diesel

G represents Gasoline.

represents average value of compact car, subcompact car, and mini car.

The results is as following:

Diesel consumption of 100 Km traveling mileage: 3 9.12 $\times 10^6$ L/100Km

Gasoline consumption of 100 Km traveling mileage: 148.76 $\times 10^6$ L/100Km

The density of diesel is 0.875 Kg/L and gasoline is 0.732 Kg/L, then:

Diesel consumption is 342.3 tons/Km, gasoline consumption is 1089 tons/Km

Assume that the average yearly travel mileage of in-use vehicles is 30,000 Km (scenario 1) and 50,000 Km (scenario 2) respectively, then:

Diesel consumption is 10.269 million tons under scenario 1;

Diesel consumption is 17.115 million tons under scenario 2;

Gasoline consumption is 32.670 million tons under scenario 1;

Gasoline consumption is 54.450 million tons under scenario 2.

2.5 Compare of the Results

Table 2-19 compare the results computed above with the results published by relevant section and there is about 11% difference between them.

Table 2-19 compare of computed results and published values (million tons)

Gasoline			Diesel		
Published	Computed	Difference	Published	Computed	Difference
29.456	32.670	+10.9%	9.225	10.269	+11.3%
	54.450	+84.9%		17.115	+85.5%

Chapter 3 Vehicle Fuel Economy Programs Around The World

In the three major markets for light-duty vehicles in the developed world – those of the United States, Western Europe, and Japan – policies toward improving the fuel efficiency of these vehicles have evolved in sharply different directions. In the United States, from the mid 1970's to the mid 1980's, the major focus had been on the Corporate Average Fuel Economy (CAFE) program, whereby annual fuel economy standards were set which each manufacturer was required to comply with on average across the entire fleet of light duty vehicles. Separate CAFE requirements were put in place for passenger cars and light trucks. More recently, the focus of government actions has been on shared research and development (the Partnership for a New Generation of Vehicles) and on tax incentives for certain high-efficiency vehicles (proposed but not promulgated). In Europe, the European Car Manufacturer's Association (ACEA) has proposed, and the EU has accepted, a Voluntary Agreement pledging to reduce "per vehicle" greenhouse emissions by 25% by the year 2008. This implies a 33% improvement in new vehicle fleet fuel economy. And in Japan, the national government has established a series of weight-class fuel economy standards that require an approximately 23 percent improvement in the fuel economy of gasoline-fueled light-duty vehicles by 2010.

The purpose of this report is to summarize the US, European and Japanese programs.

3.1 The US Experience in Reducing Fuel Consumption

3.1.1 The CAFE Program

The United States has had a mandatory fuel efficiency program since 1975. The Energy Policy and Conservation Act, passed that year to come into effect in model year 1978, amended the Motor Vehicle Information and Cost Saving Act to require new passenger cars to get at least 27.5 miles per U.S. gallon (8.55 liters/100 km) by 1985, as measured by EPA test procedures.

Light-duty trucks, including jeeps and mini-vans had to meet a corporate fuel economy standard of 20.6 miles per gallon starting with their 1995 model year according to the National Highway Traffic Safety Administration.

In recent years, as fuel prices have dropped and the CAFE pressures to improve fuel efficiency have diminished, U.S. new-car fuel efficiency has begun to slip as illustrated below.

Vehicle manufacturers are required to test some percentage of all vehicles destined to be sold in the United States so that a fuel - consumption rating can be assigned to each product line. The test involves both city and highway driving cycles. From these figures, a sales-weighted average fuel-consumption figure is calculated for all the passenger cars produced by each manufacturer. Fuel efficiency (in mpg) calculated this way must exceed the Corporate Average Fuel Economy (CAFE) standard specified for the appropriate model year. Since the 1979 model year, the CAFE program, as it is called, has been expanded to cover light-duty trucks as well as passenger cars.

Table 3-1 US New-CAR Fuel Efficiency Standards (CAFE) (Miles/U.S. Gallon)

Model Year	Passenger cars	Light Trucks	
		2WD	4WD
1978	18.0	-	-
1979	19.0	17.2	15.8
1980	20.0	16.0	14.0
1981	22.0	16.7	15.0
1982	24.0	18.0	16.0
1983	26.0	19.5	17.5
1984	27.0	20.3	18.5
1985	27.5	19.7	18.9
1986	26.0	20.5	19.5
1987	26.0	21.0	19.5
1988	26.0	21.0	19.5
1989	26.5	21.5	19.0
1990	27.5	20.5	19.0
1991	27.5	20.7	19.1

Failure to meet the CAFE requirements can result in substantial financial penalties. For each vehicle produced, a manufacturer whose fleet-average fuel consumption does not meet the CAFE standard is fined $5 per vehicle for every 0.1 miles/U.S. gallon by which the standard is not met. These fines may be offset by credits accrued in other model years, however. Since 1983, the federal government has collected $164 million in CAFE fines.

Significantly, U.S. efficiency improvements began with the industrialized world's least-efficient car fleet. Only after the dramatic improvements observed to date are typical U.S. cars as generally efficient as those in the same weight class in other countries.

People who buy especially inefficient new cars do pay some financial penalties for the privilege. "Gas guzzler" taxes are levied on vehicles that do not achieve certain minimum fuel economy figures.

Besides the CAFE requirements, the federal program also provides consumers with information about the relative efficiency of new cars. The 'Gas Mileage Guide' published by EPA and the Department of Energy lists the city and highway fuel consumption test results of each vehicle model and is intended to provide information to new-car buyers. Also required on new cars are stickers indicating the vehicle fuel consumption as determined by EPA, an estimate of the annual fuel cost based on 15,000 miles of operation, and the range of fuel economy achieved by similar sized vehicles of other makes. The mpg estimates on these stickers have been adjusted by EPA to give a somewhat more realistic estimate of the on-the-road fuel consumption that the owner can expect under average driving conditions and to allow a comparison between different vehicle models.

3.1.2 The PNGV Program

The PNGV Program

The Big Three automakers and the U.S. government have been sharing high-tech information and manufacturing know-how since 1993 in an effort to serve mutually beneficial purposes. The program is called the Partnership for a New Generation of Vehicles (PNGV) and matches engineers from the auto industry with government researchers from national laboratories.

The goal is to create technology that will lead to a working model of a clean and efficient car by the year 2004 -- a car capable of getting 80 miles to the gallon while meeting Tier 2 emissions levels or better.

When this partnership was announced by President Clinton and the CEOs of Chrysler, Ford, and General Motors in September 1993, the participants recognized that the development of a new generation of vehicles with up to three times the fuel efficiency of conventional cars was a challenge requiring a national initiative. To improve the probability of achieving needed technology breakthroughs, a large number of promising technologies were initially identified for simultaneous research and development. A major milestone was to narrow the technology development efforts by the end of 1997 and focus resources on the most promising approaches.

In January 1998, the PNGV completed its selection of technologies considered to be the most promising for achieving the goals of the Partnership, and will now focus its research and technology development efforts in four key system areas: hybrid-electric vehicle drive, direct-injection engines, fuel cells, and lightweight materials.

I. Hybrid Electric Vehicle (HEV) Drive

Today, almost every vehicle in the world is powered solely by an internal combustion engine. Hybrid propulsion systems have two power sources on board a vehicle. One (such as a fuel cell, internal combustion engine, or gas turbine) converts fuel into useable energy. The second power source, an electric motor powered by an advanced energy storage device, lowers the demand placed on the first power source.

When the two HEV power sources are arranged in parallel, one or both can be used depending on the situation. The electric motor often can power the HEV alone in city driving or over flat terrain. When the hybrid is accelerating and climbing hills, the two power sources can work together for optimal performance. Another advantage is that the electric motor can operate as a generator to slow or stop the vehicle; this captures energy normally lost during braking and "regenerates" it into electricity for later use.

High-power batteries with either nickel metal hydride or lithium-ion technology are the most promising devices to store this energy for later use in powering the electric motor. Hybrids require advanced high-power batteries that are designed for repetitive discharge and recharge over 10,000 times a year as the HEV accelerates, climbs hills, and slows or stops using the brakes.

II. Direct-Injection Engines

PNGV researchers believe highly fuel efficient, direct-injection (DI) engines where the fuel is injected directly into each engine cylinder show the greatest promise for near-term hybrids. Because the DI engine works in concert with an HEVs electric motor, the engine can be smaller and turned off automatically when not needed, thus increasing mileage and reducing emissions.

Vehicles with today's internal combustion engines are very clean, emitting an average of 95 percent less hydrocarbons, carbon monoxide and oxides of nitrogen than vehicles of the mid-1960s. Nonetheless, PNGV researchers are aiming for even lower emissions from next generation vehicles. Important progress has been demonstrated, and the challenges that remain are being addressed from a full systems perspective, with additional research and development in advanced fuel injection, electronic controls and sensors that optimize engine efficiency, advanced catalysts, advanced emissions traps, and fuels.

Already-efficient DI engines can get better mileage when combustion is triggered by highly-compressing the air-fuel mixture so it self-ignites (i.e. compression-ignition), instead of using spark plugs (i.e. spark-ignition) at lower compression ratios. These compression-ignition, direct-injection (CIDI) engines become an especially attractive primary power source for HEVs when operated with either reformulated fuels (for example, low sulfur fuel now available in California and Sweden) that help catalytic converters work better at cleaning up pollutants, or new fuels (for example, dimethyl ether or "Fischer Tropsch" synthetic fuels made from natural gas) that produce almost no particulates.

However, the diesel technology unless cleaned up very significantly could present the dilemma of choosing between clean cities or more warming. The California Air Resources Board (ARB) has concluded that diesel exhaust is a toxic air contaminant under the State's air toxics identification program. To evaluate whether or not diesel exhaust causes cancer, the ARB reviewed all controlled animal and mutagenicity studies as well as studies of worker populations exposed to diesel exhaust.

The report analyzed over 30 human studies concerning lung cancer risk and workplace exposure to diesel exhaust. Workers who were exposed to diesel exhaust were consistently found to be more likely than others to develop lung cancer. The consistent results are unlikely to be due to chance, confounding, or bias, according to CARB.

The report concludes that a reasonable and likely explanation for the increased rates of lung cancer observed in the epidemiological studies is a causal association between diesel exhaust exposure and lung cancer.

III. Fuel Cells

Fuel cell technology is essentially just a battery, using an external supply of fluids as its energy source, and solids to separate those fluids, connected to an electric motor. Unlike a battery, however, a fuel cell does not run down or require recharging; it will operate as long as both fuel and oxidant (oxygen in air) are supplied to the electrodes and the electrodes remain separated by the electrolyte. The electrodes act as catalytic reaction sites where the fuel and oxidant are electrochemically transformed, producing D.C. power, water, and heat.

Since fuel cells are not limited by Carnot's theory of heat engines (as are all conventional internal combustion engines), their potential efficiency is much greater. Studies have demonstrated that fuel cells have the potential to approximately double or more vehicle fuel efficiency. At the same time they have the potential to substantially lower if not eliminate some of the conventional pollutants; CO and HC should be virtually eliminated. Further, since fuel cells operate at much lower temperatures than IC engines, NOX emissions should be very low.

Over the longer term, fuel cells could offer the auto industry near-zero emission vehicles with long range, good performance, and rapid refueling. Fuel cells generate electricity directly from a chemical reaction between hydrogen and oxygen, triggered by a catalyst. The required hydrogen can be either carried on the vehicle as a compressed gas, or extracted ("reformed") from a fuel, such as gasoline, methanol, ethanol or propane, carried on-board the vehicle. The electricity produced is used to power a traction motor that drives the wheels. Current research is focused on improving fuel cell size, lowering costs, and developing efficient, compact, and responsive on-board fuel reformers that would provide the needed hydrogen.

IV. Lightweight Materials

Tomorrow's vehicles will contain a mix of aluminum, steel, plastic, magnesium and composites (typically a strong, lightweight material comprised of fibers in a binding matrix, such as fiberglass). To make these materials affordable and durable, research is intensifying on vehicle manufacturing methods, structural concepts, design analysis tools, sheet-manufacturing processes, improved material strength, and recyclability.

Since 1975, the weight of a typical family sedan has dropped from 4,000 pounds to 3,300 pounds. To achieve the Partnerships up-to-80 mpg goal, researchers are working to reduce overall vehicle weight by yet another 40 percent to 2,000 pounds. To achieve this, researchers must reduce the mass of both the outer body and chassis by half, trim power train weight by 10 percent, and reduce the weight of interior components.

3.1.3 PNGV's Long Term Goal

PNGV's Long Term Goal

The Partnership's long-term goal is the development of technologies for new generation, mid-size family sedans that get up to 80 mpg; carry up to six passengers and 200 pounds of luggage; meet or exceed safety and emissions requirements; provide ample acceleration; are at least 80 percent recyclable; and provide range, comfort and utility similar to today's models.

The Partnership expects American consumers will buy these vehicles only if they cost no more to own and operate than today's models. Because U.S. gasoline prices are among the lowest in the world, few consumers are willing to pay more for advanced technologies even if they provide greatly increased fuel economy.

While the new concepts recently unveiled are impressive, significant additional technology breakthroughs and advancements will be required to achieve the PNGV goals. Chrysler, Ford and GM are all working on high-mileage concept vehicles to debut this year, to be followed by production prototypes in 2004. The government partners and their laboratories will continue to participate in high risk, cooperative research and development with the auto industry to advance critical enabling technologies for possible use in these vehicles. The research and commercial applications resulting from the ambitious PNGV time frame are stepping stones to the next technological breakthroughs that could yield even greater benefits for energy security, environment, and economic well-being.

Recent forecasts by the Energy Information Administration and others have projected that the fuel economy of the U.S. light-duty fleet will grow only modestly over the next 10 years without additional action. For example, EIA's Annual Energy Outlook 2000 projects, in its Reference Case, that new car fuel economy will grow from 28.2 mpg in 1998 to 31.4 mpg in 2010, or about 11 percent. The fuel economy of the new light-duty truck fleet is projected to grow from 20.6 mpg in 1998 to 21.6 mpg in 2010, or about 5 percent. Although such projections are notoriously unreliable (they have usually been too optimistic), they imply that, without further changes in national policy or unforeseen changes in energy prices or vehicle markets, in the future the U.S. light-duty vehicle fleet will fall considerably behind the Japanese and European fleets in fuel efficiency. To address this problem, the US Congress and the Administration recently reached agreement to carry out a major study under the auspices of the National Academy of Sciences in an effort to determine the most appropriate course of action in coming years.

3.2 Japanese Weight Class Standards

The Japanese government has established a set of fuel economy standards for gasoline and diesel-powered light duty passenger and freight vehicles, with fuel economy targets based on vehicle weight classes. Table 3-2 shows the vehicle targets for gasoline and diesel-powered passenger vehicles, as measured on the Japanese 10.15 driving cycle. The targets for gasoline-powered vehicles are to be met in 2010; 2005 is the target year for diesel-powered vehicles. The targets are to be met by each automaker for each weight class – that is, automakers cannot average across weight classes by balancing a less-than-target vehicle in one class with a better-than-target vehicle in another.

Table 3-2. apanese Weight Class Fuel Economy Standards for Passenger Vehicles

Gasoline-fueled passenger vehicles for 2010

Vehicle Wt	kg	～702	703-827	828-1015	1016-1265	1266-1515	1516-1765	1766-2015	2016-2265	2266～
	bl	～1548	1550-1824	1826-2238	2240-2789	2791-3341	3343-3892	3894-4443	4445-4994	4997～
F.E. Target	km/l	～21.2	18.8	17.9	16.0	13.0	10.5	8.9	7.8	6.4
	mpg	49.9	44.2	42.1	37.6	30.6	24.7	20.9	18.3	15.0

Diesel powered passenger vehicles for 2005

Vehicle Wt	kg	～1015	1016-1265	1266-1515	1516-1765	1766-2015	2016-2265	2266～
	lbs	～2238	2240-2789	2792-3341	3343-3892	3894-4443	4445-4994	4997
F.E. Target	km/l	18.9	16.2	13.2	11.9	10.8	9.8	8.7
	mpg	44.5	38.1	31.0	28.0	25.4	23.0	20.5

Assuming no change in vehicle mix, these targets imply a 22.8 percent improvement in gasoline passenger vehicle fuel economy (15.1 km/l in 2010 vs. 1995 level of 12.3 km/l), and a 14.0 percent improvement in diesel passenger vehicle fuel economy (11.6 km/l vs. 10 km/l) compared to the 1995 fleet. In other words, compliance with these standards will produce by 2010 and 2005, respectively, a Japanese gasoline-fueled light-duty passenger vehicle fleet of 35.5 mpg and a diesel fleet of 27.3 mpg as measured using the Japanese 10.15 driving cycle. As discussed later, the Japanese 10.15 driving cycle is substantially slower than the combined U.S. city/highway cycle, and the U.S. equivalent mpg for this fleet would be significantly higher.

The regulations call for civil penalties if the targets are not met, but these penalties are very small. Realistically, enforcement will come from pressure from the government and the auto companies' desire to avoid public embarrassment, not from the financial penalties.

The fuel economy targets were selected by identifying "best-in-class" fuel economies in each weight class and demanding that the average new vehicle meet that level in the target year. The Japanese call this the "top runner" method of selecting fuel economy targets. Theoretically, this method is not "technology forcing" in that the technology has already been identified. Practically speaking, however, the standards may prove to be technology forcing unless the "top runners" in each weight class fully match their competitors in other areas of performance and amenities.

The fuel economy regulations have additional requirements over-and-above the actual fuel economy targets. These are: For new vehicles, fuel economy and major efficiency technologies onboard must be recorded in catalogs and displayed at exhibits.

Government is charged with providing education and other incentives for vehicle users and manufacturers, making sure that fuel economy regulation proceeds in harmony with other regulations (especially new emission standards), reviewing manufacturers' efforts to improve fuel economy, and trying to harmonize this regulation with similar efforts in Europe and the United States.

Manufacturers are expected to develop new efficiency technologies, design vehicles of outstanding efficiency, and help educate the public.

The public is charged with selecting efficient vehicles and using them in an efficient manner.

3.3 European Commission/ACEA Voluntary Agreement on Vehicle Carbon Emissions

CO from passenger cars accounts for about half of CO emissions from Transport, and about 12 percent of total CO2 emissions in the European Union. Under a 'business as usual' scenario, CO2 emissions from cars are expected to increase by about 20 percent by this year and by about 36 percent by the year 2010 from 1990 levels. In one year, an average medium size car in the European Union emits some 3 tons of CO2. The road transport sector has stood out in recent years as one of the few sectors in the Union experiencing CO2 emissions growth.

In the UK, a government report noted that "fuel consumption is rising fastest in the road transport sector, and there has been no improvement in fuel efficiency over the last 20 years. Fuel use for road transport has increased by 90 percent since 1970, accounting for a quarter of total energy consumption".

In the face of these concerns, the European Automobile Manufacturers Association, ACEA, has entered into a Voluntary Agreement with the European Commission to reduce the CO2 emissions from new light-duty passenger vehicles, with firm fleetwide targets of 140 g CO2/km (~ 41 mpg for gasoline) by 2008, measured under the new European test cycle (Directive 93/116/EU). This represents about a 25 percent reduction from the 1995 average of 187 g/km (~30 mpg) on this cycle. As discussed later, the European cycle is likely to produce lower fuel economy ratings than the U.S. combined urban/highway cycle, so the "U.S. equivalent" mpg ratings5 of the year 2008 European fleet will likely be higher than 41 mpg if the targets are met.

Note that the 140 g CO2/km goal is a collective target, not a target for each individual company. The participants in the agreement –BMW, Fiat, Ford of Europe, GM Europe, DaimlerChrysler, Porsche, PSA Peugeot Citroen, Renault, Rolls-Royce, Volkswagen, and Volvo –have not publically defined individual objectives, but before signing the Agreement they discussed among themselves the likely tradeoffs that would have to be made to achieve the goal.

The Agreement applies to light passenger vehicles classified as M1 in European Council Directive 93/116/EEC, which includes vehicles with no more than 8 seats in addition to the driver. The Agreement includes a promise to introduce some models emitting 120g/km (~ 48 mpg) or less by 2000, and a nonbinding 2003 target range of 165-170g/km (~34-35 mpg). In addition, the commitment will be reviewed in 2003, with the aim of moving towards a fleet goal of 120g/km by 2012. Finally, ACEA agrees to monitor compliance with the Agreement jointly with the Commission.

In exchange for their commitment to meeting the 2008 CO2 emissions goal, the industry asked that a number of conditions be met:

Clean fuels availability. Because the industry believes that direct injected engines will play a key role in achieving the targets, the Agreement asks for the "full market availability" of clean fuels needed for this technology by 2005 – gasoline with 30 ppm sulfur content and less than 30% aromatics, diesel fuel at 30 ppm sulfur and Cetane number greater than or equal to 58.6

Protection against unfair competition. Non-ACEA members must commit to similar goals, and the European Community will agree to try to persuade other car manufacturing countries to embrace equivalent efforts. The latter is designed to protect ACEA members from suffering in world market competition for their European efforts. Both the Japanese Automobile Manufacturers Association (JAMA) and the Korean Automobile Manufacturers Association (KAMA) have agreed to a revised version of the ACEA targets – achievement of the 2008 target levels in 2009.

Regulatory cease fire. No new regulatory measures to limit fuel consumption or CO2 emissions.

Unhampered diffusion of technologies. The companies assume that the Commission will take no action that would hamper the diffusion of efficiency technologies, particularly direct injected gasoline and diesel engines. Presumably, this could include tighter emissions standards on NOx and particulates.

3.4 Fuel Economy Measurement/Driving cycles

Any examination of fuel economy achievement across national boundaries should account for differences in the way fuel economy is measured in the countries being analyzed. The precise way that fuel economy is measured can strongly influence the perceived fuel economy impact of alternative technologies. Also, to the extent that real world driving yields sharply different results from test data, actual driving patterns need to be examined to understand how the driving public may value alternative technologies.

In the United States, fuel economy measurement is accomplished with a single roller dynamometer using a harmonic average of two driving cycles, the Federal Urban Driving cycle

FUDS and the Federal Highway cycle HWY, with 55% of the driving assigned to FUDS. The formula for fuel economy FE is

$$1/FE = .55/FEFUDS + .45/FEHWY$$

This measurement produces fuel economy values that have been higher than those obtained in normal driving. EPA analyses conducted in 1984 concluded that the city values should be adjusted downwards by 10 percent and highway values down by 22 percent to obtain values that reasonably correspond to actual onroad fuel economy. EPA uses these adjustment factors when presenting fuel economy estimates to the public, e.g. on stickers attached to new cars. For the combined city/highway FE values, the appropriate adjustment factor is 15 percent.

Table 3-3 presents some important parameters of the U.S. driving cycles and compares them to the driving cycles used to measure European and Japanese fuel economy. In the table, values that are vehicle-specific (for example, maximum power) are derived from a simulation of a Ford Contour.

Table 3-3 Characteristics of U.S., European, and Japanese Emission Testing Cycles

	US	US	Europe	Japan
Cycle	FUDS*	HWY	NEDC	10.15
	urban	highway	mixed	urban
Type of driving	cold	cold	cold	hot
Start condition	1372	765	1180	680
Time, seconds	7.45	10.2	6.84	2.59
Distance, miles	0.164	0.164	0.109	0.082
Max acceleration, g	56.7	59.9	74.6	43.5
Max speed, mph	19.5	48.2	20.9	14.1
Avg speed, mph	31.7		33.3	18.9
Max power, kW**	5.1		4.8	3.8
Avg power, kW**				

*Actual test procedure ("FTP") repeats the first 505 seconds of the FUDS cycle, hot-started.
**Simulated Ford Contour (3000lb, 0.33 Cd, manual transmission, 0.0073 rolling resistance coefficient).

Source: Kenney, T.E., "Partitioning Emissions Tasks Across Engine and Aftertreatment Systems, SAE Paper 1999-01-3475, 1999.

A few values stand out. First, maximum acceleration and maximum power are relatively modest in all cycles. For example, maximum power for FUDS is 31.7 kW, less than half the power available from the vehicle's engine. This might tend to exaggerate somewhat the benefits of technologies designed to improve efficiency at low loads. Similarly, *average* power levels are extremely low, a very small fraction of maximum power available, on all cycles. Note, however, that to a certain extent this simply reflects the reality that engines in highway vehicles are always sized for extreme requirements many times in excess of average requirements. Although the cycles appear to be more gentle than actual onroad driving, average power levels would remain fairly low compared to maximum power even if the cycles were adjusted to account for actual (more aggressive) driving. These low average power values emphasize the value of technologies designed to improve engine efficiency at low load.

Second, average speeds are modest, about 20 mph on FUDS and less than 50 mph on HWY. Average speed is important because aerodynamic drag is a strong function of speed; power requirements vary with the 3^{rd} power of speed, and energy used/mile with the 2^{nd} power. In other words, the fuel used per mile to overcome aero drag is four times as high at 60 mph as it is at 30 mph. Improved aerodynamics will have little impact on the city cycle, but it will have an important effect on fuel economy on the highway cycle.

There is a significant potential for error in fuel economy measurement caused by underestimating average speeds on U.S. highways. Although congestion is growing in America's cities, average highway speeds have been climbing because of increases in speed limits (more accurately, these are largely adjustments *back* to levels allowed before national 55 mph maxima were established), more powerful and competent vehicles, and perhaps lower levels of enforcement of existing speed limits. Consequently, it seems likely that there is a growing divergence between HWY average speeds and actual onroad highway speeds. If the actual average speed on U.S. highways is 60 mph rather than 50, the fuel used to overcome aero drag will be 44 percent higher than estimated by the (about 50 mph) test.

Both the EU and Japanese cycles have average speeds much lower than HWY, implying that improvements in aerodynamic design will have little impact on *measured* fuel economy in either market. This probably will not translate into a lower effort to improve vehicle aerodynamics in European markets, however, and may not in the Japanese market either. European designs tend towards very high top speeds, perhaps as a bow to the German autobahn, and good aerodynamic design clearly is crucial to operating at such speeds. In the Japanese market, the image of high tech is important, so that sub-par aerodynamics may be unacceptable to many vehicle purchasers even if a low-drag design has little practical value in the vast majority of driving situations.

3.5 Potential Future Improvements in Fuel Efficiency

Some energy-intensity reductions are cost-effective for vehicle operators, because fuel savings will compensate for the additional cost of more energy-efficient vehicles. Several studies have indicated that these potential savings are not achieved for a variety of reasons, in particular their low importance for vehicle manufacturers and purchasers relative to other priorities, such as reliability, safety, and performance. Many vehicle users also budget for vehicle operation separately from vehicle purchase, especially where the latter depends on obtaining a loan, so that they do not trade off the vehicle price directly against operating costs. Although fuel savings may not justify the time, effort, and risk involved for the individual or corporate vehicle purchaser, they could be achieved through measures that minimize or bypass these barriers. In cars and other personal vehicles, savings that are cost-effective for users in 2020 might amount to 10 - 25% of projected energy use, with vehicle price increases in the range $500 - 1,500. Larger savings in energy are possible at higher cost, but these would not be as cost-effective.

The potential for cost-effective energy savings in commercial vehicles has been studied less than that in cars, and is estimated to be smaller - perhaps 10% for buses, trains, medium and heavy trucks, and aircraft - because commercial operators already have stronger incentives to use cost-effective technology.

Energy-intensity reductions are possible beyond the level that is cost-effective for users; however, vehicle design changes that offer large reductions in energy intensity also are likely to affect various aspects of vehicle performance. Achieving these changes would thus depend either on a shift in the priorities of vehicle manufacturers and purchasers, or on breakthroughs in technology performance and cost.

Changes in vehicle technology can require large investments in new designs, techniques, and production lines. These short-term costs can be minimized if energy-efficiency improvements are integrated into the normal product cycle of vehicle manufacturers. For cars and trucks, this means that there might be a 10-year delay between a shift in priorities or incentives in the vehicle market, and the full results of that shift being seen in all the vehicles being produced. For aircraft, the delay is longer because of the long service life of aircraft, and because new technology is only approved for general use after its safe performance has been demonstrated through years of testing.

Some fuel efficient technologies identified for cars are summarized below.

Table 3-4 Energy Efficiency Technology Matrix For Cars

	Fractional Fuel Efficiency Change	Incremental Cost(1990 $)	Incremental Cost/($/Unit Wt.)	Incremental Weight(Lbs.)	IncrementalWeight(Lbs./Unit Wt.)	Fractional Horsepower Change
Front Wheel Drive	0.060	160	0.00	0	-0.08	0
Unit Body	0.040	80	0.00	0	-0.05	0
Material Substitution II	0.033	0	0.30	0	-0.05	0
Material Substitution III	0.066	0	0.40	0	-0.10	0
Material Substitution IV	0.099	0	0.50	0	-0.15	0
Material Substitution V	0.132	0	0.75	0	-0.20	0
Drag Reduction II	0.023	32	0.00	0	0.00	0
Drag Reduction III	0.046	64	0.00	0	0.05	0
Drag Reduction IV	0.069	112	0.00	0	0.01	0
Drag Reduction V	0.092	176	0.00	0	0.02	0
TCLU	0.030	40	0.00	0	0.00	0
4-Speed Automatic	0.045	225	0.00	30	0.00	0.05
5-Speed Automatic	0.065	325	0.00	40	0.00	0.07
CVT	0.100	250	0.00	20	0.00	0.07
6-Speed Manual	0.020	100	0.00	30	0.00	0.05
Electronic Transmission I	0.005	20	0.00	5	0.00	0
Electronic Transmission II	0.090	60	0.00	5	0.00	0
Roller Cam	0.020	16	0.00	0	0.00	0
OHC 4	0.030	45	0.00	0	0.00	0.2
OHC 6	0.030	55	0.00	0	0.00	0.2
OHC 8	0.030	65	0.00	0	0.00	0.2
4C/4V	0.080	125	0.00	30	0.00	0.45
6C/4V	0.080	165	0.00	45	0.00	0.45
8C/4V	0.080	205	0.00	60	0.00	0.45
Cylinder Reduction	0.030	-100	0.00	-150	0.00	-0.1
4C/5V	0.100	300	0.00	45	0.00	0.55
Turbo	0.080	300	0.00	80	0.00	0.45
Engine Friction Reduction I	0.020	20	0.00	0	0.00	0
Engine Friction Reduction II	0.035	50	0.00	0	0.00	0
Engine Friction Reduction III	0.050	90	0.00	0	0.00	0
Engine Friction Reduction IV	0.065	120	0.00	0	0.00	0
VVT I	0.080	100	0.00	40	0.00	0.1
VVT II	0.100	130	0.00	40	0.00	0.15

	Fractional Fuel Efficiency Change	Incremental Cost(1990 $)	Incremental Cost/($/Unit Wt.)	Incremental Weight(Lbs.)	IncrementalWeight(Lbs./Unit Wt.)	Fractional Horsepower Change
Lean Burn	0.120	75	0.00	0	0.00	0
Two Stroke	0.150	0	0.00	-150	0.00	0
TBI	0.020	40	0.00	0	0.00	0.05
MPI	0.035	80	0.00	0	0.00	0.1
Air Pump	0.010	0	0.00	-10	0.00	0
DFS	0.015	15	0.00	0	0.00	0.1
Oil %w-30	0.005	2	0.00	0	0.00	0
Oil Synthetic	0.015	5	0.00	0	0.00	0
Tires I	0.010	5	0.00	0	0.00	0
Tires II	0.033	10	0.00	0	0.00	0
Tires III	0.048	15	0.00	0	0.00	0
Tires IV	0.053	20	0.00	0	0.00	0
ACC I	0.010	5	0.00	0	0.00	0
ACC II	0.017	13	0.00	0	0.00	0
EPS	0.015	40	0.00	0	0.00	0
4WD Improvements	0.030	100	0.00	0	-0.05	0
Air Bags	-0.010	300	0.00	35	0.00	0
Emissions Tier I	-0.010	150	0.00	10	0.00	0
Emissions Tier II	-0.010	300	0.00	20	0.00	0
ABS	-0.005	300	0.00	10	0.00	0
Side Impact	-0.005	100	0.00	20	0.00	0
Roof Crush	-0.003	100	0.00	5	0.00	0
Increased Size/Wt.	-0.033	0	0.00	0	0.05	0
Compression Ratio Increase	0.010	0	0.00	0	0.00	0.02
Idle Off	0.110	260	0.00	0	0.00	0
Optimized Manual Transmission	0.120	60	0.00	0	0.00	0
Variable Displacement	0.030	65	0.00	0	0.00	0
Electric Hybrid	0.660	1785	0.00	0	0.00	0

Source: Decision Analysis Corporation of Virginia, and Energy and Environmental Analysis, *NEMS Fuel Economy Model LDV High Technology Update, Final Documentation, Subtask, 9-2*, prepared for Energy Information Administration, .

3.6 Tax Incentives to Stimulate Efficient, Clean Vehicles

Advanced, fuel efficient technologies have no benefit, of course, unless they are brought successfully to the marketplace. Approaches such as CAFE mandate improvements in fuel efficiency. Similarly, California has taken the lead in stimulating the development and mandating the commercial introduction of advanced zero emissions technologies, many of which can also improve fuel efficiency and reduce CO_2 emissions. Another approach is to adopt tax policies which can encourage the purchase of efficient, clean vehicles. Two international programs which have successfully done so are summarized below.

3.6.1 German Tax Incentives For Clean Vehicles

In early 1997, the German government modified its vehicle taxes.

Table 3-5 Road tax rates in DM per 100 cm^3

		Present	01/07/1997	01/01/2001	01/01/2004	01/01/2005
Euro 3[0] Euro 4 3 liter car	Petrol		10.00	10.00	13.20	13.20
	Diesel		27.00	27.00	30.20	30.20
Euro 1	Petrol	13.20	12.00	12.00	14.40	14.40
	Diesel	37.10	29.00	29.00	31.40	31.40
Euro 2	Petrol	13.20	13.20	21.20	21.20	29.60
	Diesel	37.10	37.10	45.10	45.10	53.50
In Ozone alerts	Petrol	21.60	21.60	29.60	29.60	41.20
	Diesel	45.50	45.50	53.50	53.50	65.10
Cars not used in Ozone alerts	Petrol	13.20	33.20	41.20	41.20	49.60
	Diesel	37.10	57.10	65.10	65.10	73.50
Partially clean or without clean exhausts	Petrol*	18.80				
	Petrol**	21.60	41.60	49.60	49.60	49.60
	Diesel*	42.70				
	Diesel**	45.50	65.50	73.50	73.50	73.50

* .First registered before 1.1.86

**First registered after 1.1.86

3.6.2 Taxation of Vehicles and Fuels in Denmark

Passenger cars In the existing system the car owners have to pay an yearly tax based on the weight of the car. 7 different classes are defined. A typical vehicle in Denmark belongs to the group 801 - 1,100 kg with a yearly rate of Dkr. 2,260 for gasoline cars and Dkr 3,472 for diesel cars. From 1st July 1997 the yearly tax has been based on energy consumption measured according to directive 93/116 instead of weight. 24 classes are defined for both gasoline and diesel cars. Examples of selected classes (basis 1997) are given as Table 3-6 (the figures will be increased with inflation plus 1.5% every year):

Table 3-6 Fuel tax for some vehicle class

	Class	Km per liter (Km/L)	Yearly tax (Dkr)
Petrol	1	>20.0	200
	11	10.0－10.5	2200
	24	<4.5	7400
Diesel	1	>22.5	790
	11	10.2－11.3	3890
	24	<5.1	10130

It is estimated that the new system will give approximately the same income as the earlier one.

Gasoline Today the taxation of unleaded gasoline is fixed to Dkr. 3.32 pr liter (excluding 25% VAT). For leaded gasoline the figure is Dkr. 3.97 pr liter. As a result leaded gasoline has been removed from the market since March 1994. Since 1995 incentives (Dkr 0.03 pr liter) have been given to gasoline delivered from stations equipped with vapor recovery systems. From 1st of January 1998 differentiation will be introduced according to the content of benzene. The following figures have been decided in Table 3-7

Table 3-7 Fuel Tax According to he Benzene Content

Benzene (%)	<1	1－2	2－3	3－4	4－5
Differentiation (Dkr/L)	－0.04	－0.02	0.00	＋0.02	＋0.04

Light commercial vehicles In the new system incentives will be given to light commercial vehicles for which it can be demonstrated that they meet the proposed future EURO 3 (2000) or EURO 4 (2005) standards.

The Danish system operates with 4 classes based on gross vehicle weight. Examples on the reduction in the yearly taxes for class 1 and 4 are given in Table 3-8.

Table 3-8 Tax incentives in Damark

Class		EURO3（Dkr）	EURO4（Dkr）
Class I (<1000kg)	1998－2000	350	450
	2001	0	100
	2002－2005	0	100
Class IV (2500～2500kg)	1998－2000	1150	1600
	2001	1150	1600
	2002－2005	0	450

Chapter 4 Pilot Forecast of Fuel Consumptions in China

4.1 Forecast of the vehicle population in next five years

4.1.1 Methodology and Model

The various available forecast methodologies were widely used and the corresponding mathematical models were developed. Then the inapplicable models were washed out according to the model output, and the rest models were compared and distinguished by the feasibility and reliability of forecast results. The optimal scenario was obtained by the comprehensive analysis. The increase rate of the future vehicle market demand and the future vehicle quantity demanded were forecasted based on the historical data of the vehicle population and demand.

The forecast of vehicle population was calculated with time series extrapolation of passed years vehicle population and the elasticity coefficient of population and economic indicator.

The vehicle demand of base year was consist of the new demand and the renewed demand in which the new demand was equal to the base year population subtract the last year population and the renewed demand was equal to the last year population multiply the replacement coefficient. The calculate model is shown in Figer 4-1.

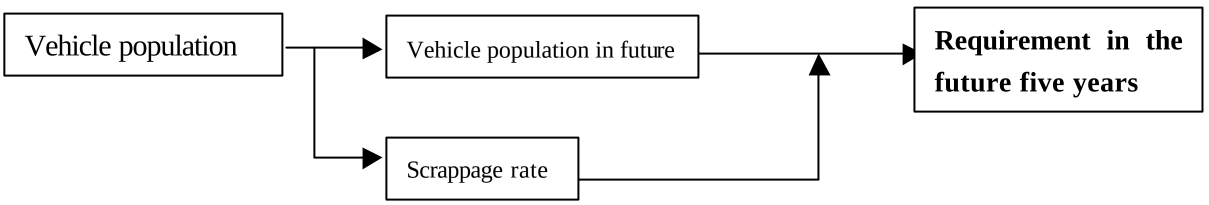


Figure 4-1 Model for Vehicle Population Requirement

4.1.2 Forecast of vehicle population from 2000 to 2005

Table 4-1 Forecast of vehicle population from 2000 to 2005(10^4)

	2000	2001	2002	2003	2004	2005
Total vehicle population	1640	1800	1965	2150	2355	2590
Truck	750	790	820	850	890	920
Bus	350	395	445	500	555	620
Car	540	615	700	800	910	1050

4.2 Forecast of fuel consumption in the next five years by vehicle type

4.2.1 Forecast of vehicle type composition in the next five years

The proportion of each sub type was shown in Figure 4-2.

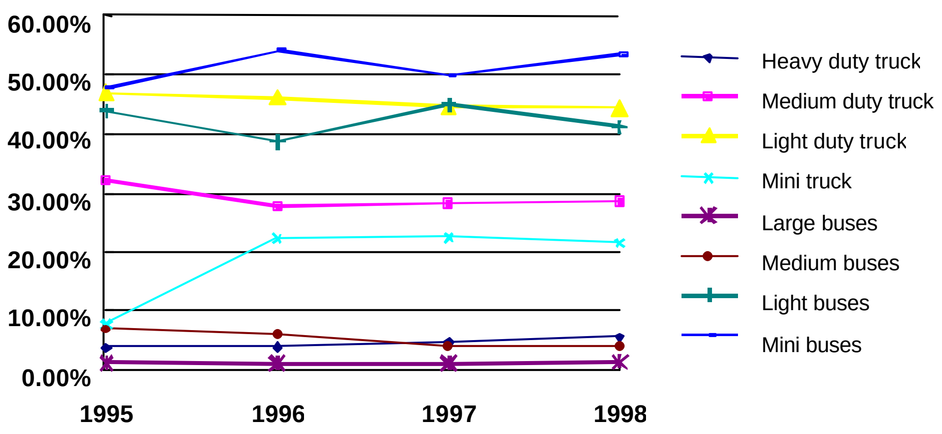


Figure 4-2 Proportion of each sub type in its main type (1995-1998)

As shown in Figure 4-2, the proportion of each sub type in its main type is almost stable. So the average proportion of those four years was reliable as shown in table 4-2.

Table 4-2 Average proportion of each sub type in its main type

Heavy duty truck	Medium duty truck	Light duty truck	Mini truck	Large buses	Medium buses	Light buses	Mini buses
4.87%	28.26%	44.97%	21.90%	1.21%	4.37%	41.55%	52.87%

4.2.2 Forecast of fuel consumption in the next five years by vehicle type

It is assumed that the fuel economy of in-use vehicles in the next five years would be rested on the level of 1998 due to the technic and policy environment influence. The forecast of fuel consumption in the next five years by vehicle type is shown in following tables from table 4-3 to table 4-7.

Table 4-3 Forecast of fuel consumption by vehicle type in 2001

Type	Fuel type	Population (104)	Fuel consumption (10^4 L/100Km)
Total		1800	
Truck		790	
Heavy duty truck	Diesel	38	1166.6
Medium duty truck	Diesel	89	2116.42
Light duty truck	Gasoline	134	4569.4
	Diesel	71	1109.02
	Gasoline	284	4899
Mini truck	Gasoline	173	1527.59
Bus		395	
Large buses	Diesel	5	168.45
Medium buses	Diesel	5	129.75
	Gasoline	12	456.48
Light buses	Gasoline	164	1894.2
Mini buses	Gasoline	209	1789.04
Car	Gasoline	615	3936

The calculated result is shown in following:

The diesel consumption of in-use vehicles in 2001 is 12.312 million tons.

The gasoline consumption of in-use vehicles in 2001 is 41.881 million tons.

Table 4-4 Forecast of fuel consumption by vehicle type in 2002

Type	Fuel type	Population (104)	Fuel consumption (10^4 L/100Km)
Total		1965	
Truck		820	
Heavy duty truck	Diesel	40	1228
Medium duty truc k	Diesel	93	2211.54
	Gasoline	139	4739.9
Light duty truck	Diesel	74	1155.88
	Gasoline	295	5088.75
Mini duty truck	Gasoline	180	1589.4
Bus		445	0
Large buses	Diesel	5	168.45
Medium buses	Diesel	6	155.7
	Gasoline	13	494.52
Light buses	Gasoline	185	2136.75
Mini buses	Gasoline	235	2011.6
Car	Gasoline	700	4480

The diesel consumption of in-use vehicles in 2002 is 12.9136 million tons.

The gasoline consumption of in-use vehicles in 2002 is 45.1079 million tons.

Table 4-5 Forecast of fuel consumption by vehicle type in 2003

Type	Fuel type	Population (104)	Fuel consumption (10^4 L/100Km)
Total		2150	
Truck		850	
Heavy duty truck	Diesel	41	1258.7
Medium duty truck	Diesel	96	2282.88
	Gasoline	144	4910.4
Light duty truck	Diesel	76	1187.12
	Gasoline	306	5278.5
Mini duty truck	Gasoline	186	1642.38
Bus			
Large buses	Diesel	6	202.14
Medium buses	Diesel	7	181.65
	Gasoline	15	570.6
Light buses	Gasoline	208	2402.4
Mini buses	Gasoline	264	2259.84
Car	Gasoline	800	5120

The diesel consumption of in-use vehicles in 2003 is 13.4203 million tons.

The gasoline consumption of in-use vehicles in 2003 is 48.7163 million tons.

Table 4-6 Forecast of fuel consumption by vehicle type in 2004

Type	Fuel type	Population (104)	Fuel consumption (10^4 L/100Km)
Total		2355	
Truck		890	
Heavy duty truck	Diesel	43	1320.1
Medium duty truck	Diesel	\101	2401.78
	Gasoline	151	5149.1
Light duty truck	Diesel	80	1249.6
	Gasoline	320	5520
Mini duty truck	Gasoline	195	1721.85
Bus			0
Large buses	Diesel	7	235.83
Medium buses	Diesel	7	181.65
	Gasoline	17	646.68
Light buses	Gasoline	231	2668.05
	Gasoline	293	2508.08
Car	Gasoline	910	5824

The diesel consumption of in-use vehicles in 2004 is 14.146 million tons.

The gasoline consumption of in-use vehicles in 2004 is 52.787 million tons.

Table 4-7 the forecast of fuel consumption by vehicle type in 2005

Type	Fuel type	Population (104)	Fuel consumption (10^4 L/100Km)
Total		2590	
Truck		920	
Heavy duty truck	Diesel	45	1381.5
Medium duty truck	Diesel	104	2473.12
	Gasoline	156	5319.6
Light duty truck	Diesel	83	1296.46
	Gasoline	331	5709.75
Mini duty truck	Gasoline	201	1774.83
Bus			
Large buses	Diesel	8	269.52
Medium buses	Diesel	8	207.6
	Gasoline	19	722.76
Light buses	Gasoline	258	2979.9
Mini buses	Gasoline	328	2807.68
Car	Gasoline	1050	6720

The diesel consumption of in-use vehicles in 2005 is 14.774 million tons.

The gasoline consumption of in-use vehicles in 2005 is 57.1718 million tons.

The summarized data is shown in Table 4-8 and Figure 4-3.

Table 4-8 Forecast of fuel consumption in the next five years by fuel type

	2001	2001	2003	2004	2005
Diesel	1231.2	1291.39	1342.03	1414.6	1477.4
Growth rate		4.83%	3.92%	5.41%	4.44%
Gasoline	4188.1	4510.79	4871.63	5278.7	5717.18
Growth rate		7.70%	8.00%	8.36%	8.31%

As shown in table 4-3, the increase of vehicle fuel consumption was slow in the next five years. The highest annual growth rate of gasoline consumption was 8.36%, while that of diesel consumption was 5.41%. The growth rate of gasoline consumption was higher than that of diesel consumption.

The forecast of fuel consumption in the next five years by vehicle type is shown in table 4-9.

As the table 4-9 shown, the increase rate of truck fuel consumption was around 5% while those of bus and car were higher than 10%. The primary fuel consumption was from medium duty truck, mini duty truck and car in the next five years due to the population dominance.

Figure 4-4 shows the trend of the fuel consumption by vehicle type in the future five years. The gasoline demands from cars would be rapidly increased, then medium duty gasoline truck, light duty gasoline truck, light gasoline bus and mini gasoline bus were arranged in turn. The increase rate of other types was low.

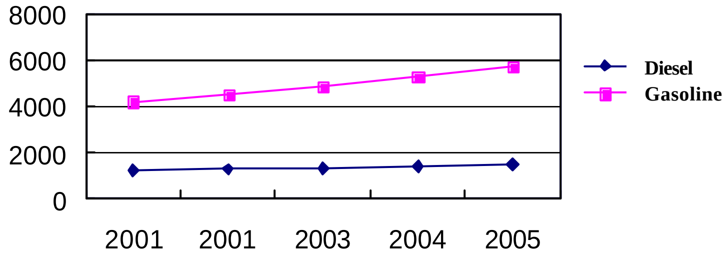


Figure 4-3 Fuel consumption by fuel type in the future five years

Table 4-9 The fuel consumption by vehicle type and fuel type in the future five years(10^4 tons)

Type	2001	2002	2003	2004	2005
Heavy duty truck (diesel)	306.23	322.35	330.41	346.53	362.64
Medium duty truck (diesel)	555.56	580.53	599.26	630.47	649.19
Medium duty truck (gasoline)	1003.44	1040.88	1078.32	1130.74	1168.18
Light duty truck (diesel)	291.12	303.42	311.62	328.02	340.32
Light duty truck (gasoline)	1075.82	1117.49	1159.16	1212.19	1253.86
Mini duty truck (gasoline)	335.46	349.03	360.67	378.12	389.75
Large bus (diesel)	44.22	44.22	53.06	61.91	70.75
Medium bus (diesel)	34.06	40.87	47.68	47.68	54.50
Medium bus (diesel)	100.24	108.60	125.30	142.01	158.72
Light bus (gasoline)	415.97	469.23	527.57	585.90	654.39
Mini bus (gasoline)	392.87	441.75	496.26	550.77	616.57
Car (gasoline)	864.35	983.81	1124.35	1278.95	1475.71

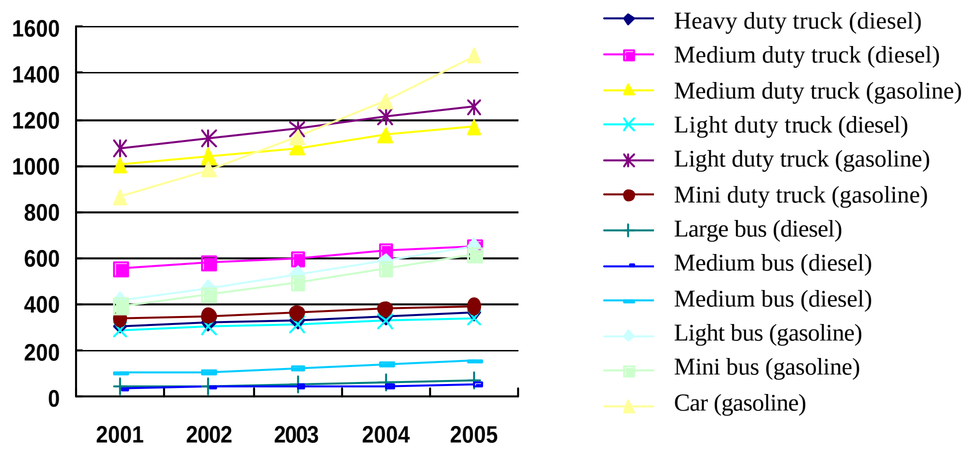


Figure 4-4 Fuel Consumption in the Future 5 Years

Chapter 5 Policy Recommendation on Fuel Economy

1. Encouraging to Increase Fuel Economy by Laws

China has promulgated the Energy Saving Law in 1997 and taken into effect in 1998. In 2002, China will promulgate the first Clean Production Law in the world. Increasing fuel economy is very important for energy saving, and it also can reduce the energy consumption and pollutant emission of the whole life cycle. So the government should encourage the fuel economy by laws and their implementation regulations.

2. Implementing the National Standard for Vehicle Fuel Economy Testing Methods

The vehicle fuel economy assessment system and fuel economy standards are based on the normalized vehicle fuel economy testing methods. According to the standards of developed countries and practical situations in China, the government should implement the national standard for vehicle fuel consumption, what is called Fuel Consumption Testing Methods for Cars and Light Duty Vehicles.

3. Implementing the National Standard for Fuel Economy

According to the experiences of developed countries, one of the most effective ways to improve fuel economy is to implement mandatory vehicular fuel consumption standards. Based on the statistical results of vehicle fuel efficiency in China, the vehicle fuel economy assessment system should be development as soon as possible. And the cost-effectiveness of the new technologies should be analyzed. Then the government should implement the appropriate fuel economy standards to limit the fuel consumption of various types of vehicles step by step.

4. Supporting Measures for Fuel Economy Standard

The government should investigate the various technologies of reducing fuel consumption and calculate their cost and effectiveness, then publish a technical manual to lead the automobile and oil refining industries. The government should implement a series of measures to encouraging fuel economy, such as the propaganda in automobile industry and demonstration in selected cities.

5. Founding the Fuel Economy Report System

The vehicle fuel economy report system should be set up. The vehicle producers and importers must report the fuel consumption of their cars and light duty vehicles by uniform testing methods. And the system should be a part of vehicle authentication.

6. Founding the Fuel Consumption Label System

The fuel consumption label system should be founded. All of new cars and light duty vehicles must label their fuel consumption at a staring place.

7. Founding the Actual Fuel Consumption Bulletin System

Based on the automobile industry development and existing management system, the appropriate actual fuel consumption bulletin system should be founded.