Final Report by
Heavy Vehicle Fuel Efficiency Standard Evaluation Group, Heavy Vehicle Standards Evaluation Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy

This subcommittee/evaluation group discussed various items necessary for heavy vehicle manufacturers and importers (hereafter referred to as "manufacturers") to evaluate the energy consumption efficiency (fuel efficiency) of heavy vehicles, and prepared the final report as shown below.

1. Target Scope (See Attachment 1)

Diesel fuelled freight vehicles and passenger vehicles (riding capacity of 11 persons or more) having a gross vehicle weight of 3.5 tons or larger, either type designated under the Road Trucking Vehicle Law (1951, Law No. 185) Article 75.1 (type designated vehicle), or those equipped with a CO and other substances emission preventive device under Article 75.2.1 of the same Law (vehicle equipped with a CO and other substances emission preventive device).

2. Items to be the standards for judgment by manufacturers

(1) Target fiscal year (See Attachment 2)

FY2015: this deadline was determined so that the manufacturers can be given enough time for development toward better fuel efficiency. During this period, they may have at least one or two opportunities for launching modified models with the fuel efficiency improved toward the target values.

(2) Energy consumption efficiency (fuel efficiency) measurement methods (See Attachment 3)

Energy consumption efficiency (fuel efficiency) evaluations shall use the simulation method with two different driving modes: urban driving mode (JE05 mode) and interurban driving mode (80 km/h constant speed mode with longitudinal grade) (combination of these two modes is referred to as "heavy vehicle mode").

Energy efficiency (fuel efficiency) is a weighted harmonic average of measurements in both driving modes ("urban driving mode fuel efficiency" and "interurban driving mode fuel efficiency" in kilometer per liter) obtained with the relevant factors shown in the following table. The efficiency is also a measured (examined) value by the Minister of Land, Infrastructure and Transportation in the course of designating vehicle type or CO and other substances emission preventive devices (hereafter, the efficiency is referred to as "heavy vehicle mode fuel efficiency").

In order to measure fuel efficiency, we shall define a standard vehicle type (plain body) for each vehicle category since heavy vehicle greatly vary each other in terms of design feature such as vehicle type. Also, for each category, besides driving resistance common for all manufacturers, final reduction gear ratio and tire's dynamic load radius of representative specifications shall be used in the measurement.

Table Driving Distance Proportion by Driving Mode

	Passenger vehicles (riding capacity : 11 persons or more)			Freight vehicles			
Vehicle type	Ordinary bus		Route bus	Other than tractor		Tractor	
GVW	14 tons or less	Over 14 tons		20 tons or less	Over 20 tons	20 tons or less	Over 20 tons

Drive proportion Upper: urban mode Lower: interurban mode	0.9 0.1	0.65 0.35	1.0 0.0	0.9 0.1	0.7 0.3	0.8 0.2	0.9 0.1

$E = 1/\{(\alpha u/Eu + \alpha h/Eh)$

Where,

- E : Heavy vehicle mode fuel efficiency (km/l)
- Eu : Urban driving mode fuel efficiency (km/l)
- Eh : Interurban driving mode fuel efficiency (km/l)
- αu : Proportion of urban driving mode
- αh : Proportion of interurban driving mode

(3) Target Standard Values (See Attachments 4, 5)

For heavy vehicles shipped in Japan in each of the target fiscal year and subsequent years, manufacturers shall ensure that weighted and averaged energy consumption efficiency (fuel efficiency) in (2) by their shipped units shall not be below the relevant standard target value for each of vehicle categories.

○Freight vehicles

<Other than tractor>

Category	Gross Vehicle Weight Range (t)	Maximum Load Range (t)	Target Standard Values（km/l）
1	3.5<&≦7.5	≦1.5	10.83
2		1.5<&≦2	10.35
3		2<&≦3	9.51
4		3<	8.12
5	7.5<&≦8		7.24
6	8<&≦10		6.52
7	10<&≦12		6.00
8	12<&≦14		5.69
9	14<&≦16		4.97
10	16<&≦20		4.15
11	20<		4.04

<Tractor>

Vehicle Category	Gross Vehicle Weight Range (t)	Target Standard Values（km/l）
1	≦20	3.09
2	20<	2.01

○Passenger vehicles (Riding capacity :11 persons or more)

<Route bus >

Vehicle Category	Gross Vehicle Weight Range (t)	Target Standard Values（km/l）
1	6<&≦8	6.97
2	8<&≦10	6.30
3	10<&≦12	5.77
4	12<&≦14	5.14
5	14<	4.23

<Ordinary bus>

Vehicle Category	Gross Vehicle Weight Range (t)	Target Standard Values（km/l）
1	3.5<&≦6	9.04
2	6<&≦8	6.52
3	8<&≦10	6.37
4	10<&≦12	5.70
5	12<&≦14	5.21
6	14<&≦16	4.06
7	16<	3.57

(Reference)

Given the target standard values are as above, assuming that the proportion of the number of shipped units for each vehicle category remains unchanged in the target fiscal year (FY2015) from FY2002, the improvement ratio of average fuel efficiency (weight-averaged fuel efficiency by the number of shipped units) from the actual values in FY2002 to the estimate values in FY2015 shall be calculated as shown below.

○Freight vehicles

	FY2002, actual values	FY2015, estimate values	Improvement ratio of fuel efficiency
Other than tractor	6.56(km/l)	7.36(km/l)	12.2%
Tractor	2.67(km/l)	2.93(km/l)	9.7%
Total	6.32(km/l)	7.09(km/l)	12.2%

○Passenger vehicles (Riding capacity :11 persons or more)

	FY2002, actual values	FY2015, estimated values	Improvement ratio of fuel efficiency
Route bus	4.51(km/l)	5.01(km/l)	11.1%
Ordinary bus	6.19(km/l)	6.98(km/l)	12.8%
Total	5.62(km/l)	6.30(km/l)	12.1%

(4) Display Items (See Attachment 6)

1] The following items shall be displayed.

a. vehicle name and type
b. Type, total displacement, maximum power and maximum torque of engine
c. Vehicle kerb weight
d. Transmission type, number of gears, and gear ratios
e. Fuel supply equipment type
f. Major measures to improve fuel efficiency
g. Energy consumption efficiency (fuel efficiency) (unit: km/l)
h. Manufacturer's name

2] Compliance items

(a) All the items specified in 1] shall be displayed in catalogs for the applicable heavy vehicles. In this case, the item g shall be displayed in such a manner that it stands out (e.g. by underlining, using a larger typeface, or changing the color of the characters).

(b) For heavy vehicles used for exhibition, all the items specified in 1] shall be displayed clearly in an easy-to-see place.

3] Others

To describe the item g, fuel efficiency in a driving mode relevant to city drive (hereafter referred to as "city driving mode") that is one of JE05 modes (hereafter referred to as "city driving mode fuel efficiency") or interurban drive mode fuel efficiency may be displayed in addition to the heavy vehicle mode fuel efficiency.

3. Proposal for energy-saving

(1) Actions of Government

1] For the purpose of spreading heavy vehicles which have excellent fuel efficiency, government supports, including efforts to spread awareness, shall be given to help the users and manufacturers take appropriate energy saving measures and efforts. Social conditions such as oil price shall also be factors that determine the details of the governmental supports.

2] To apply the judging standards, considerations shall be given to manufacturers' efforts for energy saving and emission control regulations, as well as other circumstances, so that these activities can proceed consistently with those required to achieve the target standard values.

3] As for reduction of driving resistance, one of fuel efficiency remedies, there is no methods available to evaluate it individually based on specification of each vehicle. Therefore, the present measurement methodology uses a fixed value of driving resistance for each of vehicle categories so that the target standard values are set without reflecting fuel efficiency improvement due to reduction of driving resistance. Also, the presently available fuel consumption simulation technologies are not applicable to AT and AMT (automated manual transmission) vehicles. Therefore, the fuel consumptions of these vehicles are calculated based on simulated fuel efficiency, assuming them as corresponding manual transmission vehicles with the same number of transmission gears and gear ratios. However, it is likely that reducing the driving resistance will lead to significant improvement in fuel efficiency, and innovative technologies available for AT and AMT vehicles will improve the fuel efficiency. Thus, efforts shall continue to find such evaluation methods that can reflect the reduction of driving resistance and improvement of fuel efficiency specific to AT/AMT transmission systems.

4] For heavy vehicles, depending on the technologies applied, there is normally a trade-off between improvement of fuel efficiency and reduction of exhaust gas emissions. When studying measures for improving fuel efficiency of heavy vehicles, it should be noted that these fuel efficiency targets have been determined in consideration of the 2009 exhaust gas emission control (the post new long-term control).

5] Energy-saving standards determined based on the Top Runner Program are very effective for promoting energy-saving. Take appropriate opportunities for presentation to spread these standards across the world.

(2) Actions of manufacturers

1] Technological developments to improve the fuel efficiency of heavy vehicles shall be promoted, and those with excellent fuel efficiency shall be developed.

2] To spread heavy vehicles that have excellent fuel efficiency, users shall be given appropriate information concerning the fuel saving advantages of these vehicles.

(3) Actions of users

Users are expected to select heavy vehicles with excellent fuel efficiency, and to make efforts to reduce fuel consumption through using the vehicles in an economical and efficient manner.

4. Challenges

For heavy vehicles, depending on the technologies applied, there is normally a trade-off between improvement of fuel efficiency and reduction of exhaust gas emissions. If necessary, these fuel efficiency standards shall be further studied in consideration of exhaust gas emissions reduction efforts along with the implementation of the 2009 exhaust gas emission control.

Once the methods which appropriately evaluate effects of reducing driving resistance and improving fuel efficiency in AT/AMT vehicles are developed, possibility of reflecting the effects in the evaluation standards shall be reviewed.

Attachment 1

Target Scope

Currently, heavy vehicles that are within the scope of these fuel efficiency standards based on the Law concerning the Rational Use of Energy (hereinafter referred to as the “Energy Conservation Law”) are diesel fuelled freight vehicles and passenger vehicles (riding capacity:11 persons or more) having a gross vehicle weight of 3.5 tons or larger; they are either type designated under the Road Trucking Vehicle Law (1951, Law No. 185) Article 75.1 (hereinafter referred to “type designated vehicle”) or equipped with a CO and other substances emission preventive device under Article 75.2.1 of the same Law (hereinafter referred to “designated vehicle equipped with a CO and other substances emission preventive device”).

Among vehicles having a gross vehicle weight of 3.5 tons or larger, those fuelled other than diesel oil, and those diesel fuelled but not “type designated” or “equipped with a CO and other substances emission preventive device” have been excluded from the scope, since the market of these vehicles is small, and there are some technical problems regarding measurement. However, while monitoring shipment volume of these vehicles, decisions shall be made to determine whether those categories of vehicles shall be included in the scope, and necessary studies shall be performed.

(*)Passenger vehicles (restricted to holding 10 persons or less) and freight vehicles with a gross vehicle weight of 2.5 tons or less (hereinafter referred to “passenger vehicles”) that have now been placed under the fuel efficiency control are under examination by the joint meeting of Automobile Standards Evaluation Subcommittee (under Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy) and Automobile Fuel Efficiency Standards Subcommittee (under Traffic Policy Council, Land Transportation Section) (hereinafter called the Passenger Vehicles and Other Vehicles Fuel Efficiency Standards Joint Evaluation Meeting) toward the next fuel efficiency standards that are planned to be established in early 2006.

(*)Freight vehicles with a gross vehicle weight over 2.5 tons but 3.5 tons or less and passenger vehicles with a gross vehicle weight of 3.5 tons or less (riding capacity: 11 persons or more) are now out of the scope of fuel efficiency standards. However, these categories of vehicles use the same exhaust gas emissions measuring methods as those applicable for other categories of passenger vehicles. Therefore, the Passenger Vehicles Fuel Efficiency Standards Joint Evaluation Meeting is investigating new fuel efficiency standards applicable for these vehicles in parallel with those for the other vehicles.

Attachment 2

Target Fiscal Year for Heavy Vehicles

Major improvements in fuel efficiency may occur when launching new models. New model launching cycles for heavy vehicles is said to be 5 to 10 years. Improvements in engines and drivetrains tend to occur when exhaust emissions reduction technologies are applied or modified to cope with exhaust gas emission control. However, since, depending on the types of fuel efficiency improving technologies applied, there may be a trade-off between exhaust gas emissions reduction technologies and fuel efficiency improving technologies, they may be implemented simultaneously. Considering this, there should be at least one or two cycles for launching new models, which can be an opportunity for applying or modifying fuel efficiency improvement measures, within the period up to the target year.

From the viewpoint of global warming countermeasures, it is desirable that heavy vehicles which have achieved the target standard values will have been significantly spread by the first commitment period (from 2008 to 2012) of the Kyoto Protocol.

Meanwhile, the 2009 exhaust gas emissions control (the post new long-term exhaust gas emissions control) is slated to be introduced in 2009 (2010 for some vehicles types). Heavy vehicle manufacturers are required to give first priority in addressing the control. Therefore, during the term up to 2009/2010, taking the trade-off described the above into consideration, it will be the task to suppress the decrease of fuel efficiency caused by the control. In other words, during this term, it may be difficult to achieve the required improvement in fuel efficiency.

Given the above, the target year for achieving the target standard values for heavy vehicles is set to FY2015, that is five years after the post new long-term exhaust gas emissions control, so that heavy vehicle manufacturers can have enough period for developing technologies for achieving the fuel efficiency goals.

Attachment 3

Energy Consumption Efficiency (Fuel Efficiency) Measurement Method for Heavy Vehicles

Depending on the types of fuel efficiency improvement technologies applied, there may be a trade-off between fuel efficiency improvement and exhaust gas emissions reduction. Therefore, these two aspects should be evaluated simultaneously under the same conditions. Moreover, to reduce burden to be born for the vehicle manufacturers, fuel efficiency measuring systems should be as common for measuring exhaust gas emissions as possible.

(For information only) Exhaust gas emissions measurement method available for heavy vehicles:

To measure exhaust gas emissions of a heavy vehicle, for reason of its heavier body and weight, engine-based measuring methods (using an engine dynamometer to evaluate the engine as a separate unit: stand-alone engine measurement) has been used in place of vehicle-based methods. For the new short-term control (since 2003), the 13-mode method has been employed for measuring exhaust gas emissions. For the new long-term control (since 2005), a new method based on the JE05 mode will be used.

This new method uses a conversion program to determine the engine revolution and torque according to the driving mode (JE05) with which an engine is operated. This conversion is calculated from transmission gear position which is set based on a certain rule as well as engine and vehicle specific parameters, so that the differences in revolution and torque among engines are reflected properly.

Assuming that exhaust gas emissions performance is evaluated appropriately, specifications (technical data) needed for the conversion have been standardized for each of gross vehicle weight categories and load categories in consideration of the fact that a single engine type is used for a large number of different vehicle types and in consideration of reducing burden for the manufacturers. The registration statuses (actual sales) of each category of vehicles are also a factor for determining the standardized specification (technical data) (which means that the standardized technical data are determined from weight-averaged actual data by the sales (registration) number of each category of vehicles).

1. Fuel efficiency measuring method

The following methods are considered to be available for heavy vehicles (See Table 1).

1] Vehicle-based actual measurement

2] Engine-based actual measurement

(i) Using the standardized specification (technical data) of vehicle

(ii) Using the actual specification (technical data) of vehicle

3] Stand-alone engine actual measurement with the assumed vehicle body

4] Simulation method (See Table 2 and Attachment 1)

Of these methods, Methods 1] and 3] are impractical, since a large number of different vehicle types may require the manufacturers to spend large resources (time, labor and money) for constructing the testing facility and performing measurements.

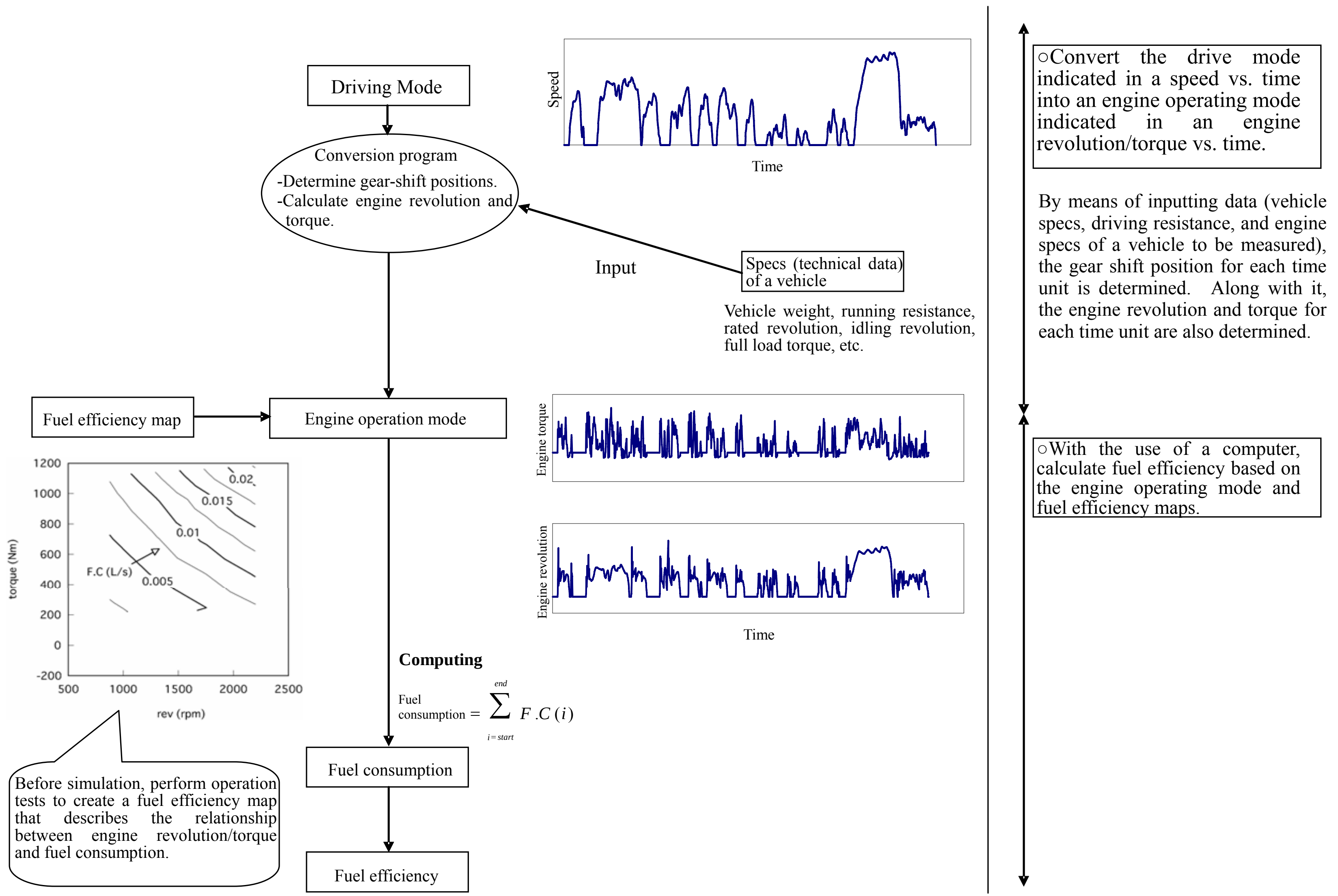
Method 2](i) (using standardized technical data including those for transmission) has been used for exhaust gas emissions measurement. However, for reason that the difference between the standardized data and the actual data may cause the evaluation to include larger errors than exhaust gas emissions evaluation, this method is also inappropriate (more detailed standardization would lead to the same problem as Method 2](ii) described next). Method 2](ii) is impractical for the same reason as for Methods 1] and 3]. Method 2] may produce some large measurement errors, since many of engine dynamometers currently possessed by manufacturers cannot control the torque within the torque range below zero, which cannot help but assume the fuel consumption is zero though some consumption occurs during actual driving.

Method 4] does not need additional testing facilities, and does not take long time for measurement though some work for preparing fuel efficiency maps occurs. Fuel efficiency maps may ease fuel consumption measurements even when performing them in multiple driving modes. The measurement errors are significantly smaller than those of vehicle-based actual measurement. This method can evaluate the effect of other factors than the engine, e.g. transmission, on the fuel efficiency.

Method 4], simulation, is more advantageous than other methods in terms of various factors such as testing facilities, labor and time resources, measuring accuracy, and factor-by-factor analysis. Therefore, this method shall be used in the evaluation.

Table 1 Heavy Vehicle Fuel Efficiency Measuring Methods

Table 2 Simulation Method Overview



Source: Japan Automobile Research Institute: Survey Report on Evaluation Methods for Heavy Vehicles, March 2003

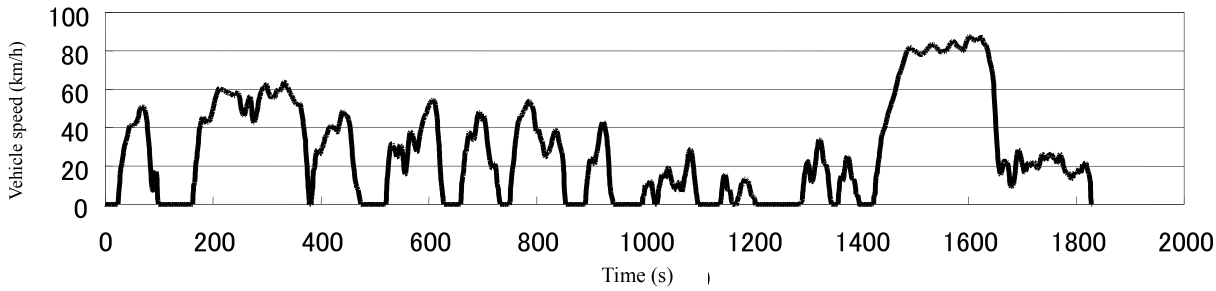
2. Drive modes

Many of heavy vehicles are used mainly for interurban travel (high-speed drive). To simulate actual usage as accurate as possible, fuel efficiency evaluations shall use a combined mode of urban drive and interurban drive modes based on the proportion of usage.

1] Urban drive mode

The exhaust gas emissions control (the new long-term control), effective since 2005, requires vehicles having a gross vehicle weight of greater than 3.5 tons to be tested in JE05 mode (a transient driving mode defined based on urban drive statistics). Therefore, fuel efficiency evaluations shall use the same principle of the driving mode.

Table 3 Urban Drive Mode



2] Interurban drive mode

Considering survey results on the interurban highway network and actual driving situation, the following conditions shall be applied to the interurban drive mode (See Attachment 2).

1) Travel Speed

From the facts that speed change during high-speed travel does not much affect the fuel consumption, the speed shall be considered constant. Taking the survey result on actual driving situation into consideration, a single speed of 80 km/h shall be applied irrespective of vehicle types.

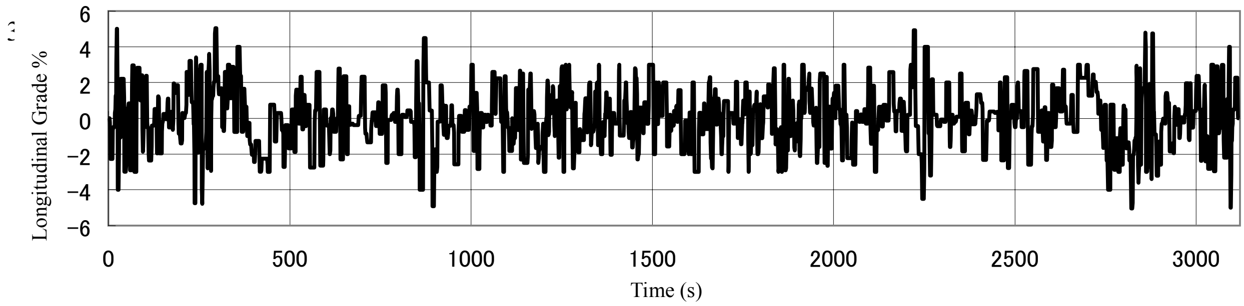
2) Longitudinal grade

Longitudinal grades greatly affect fuel efficiency. The grade distribution along of Tomei Expressway, an interurban expressway having the largest traffic throughout the country, shall be used as a representative road profile for simulation (See Table 4).

3) Load (riding) ratio

Based on survey results on actual driving situation and specified conditions for exhaust gas emissions measurement, the load ratio shall be 50% irrespective of vehicle types.

Table 4 Interurban Drive Mode



3] Proportion of the two modes

Based on survey results on actual driving situation and frequency of expressway use, the proportion of the urban and interurban drive modes shall be determined for each vehicle type as follows (GVW = Gross Vehicle Weight) (See Attachment 2).

Table Proportion of the Urban and Interurban Drive Modes

	Passenger vehicles (11 persons or more)			Freight vehicles			
Vehicle type	Ordinary bus		Route bus	Other than tractor		Tractor	
GVW	14 tons or less	Over 14 tons		20 tons or less	Over 20 tons	20 tons or less	Over 20 tons
Drive proportion Upper: Urban mode Lower: Interurban mode	0.9 0.1	0.65 0.35	1.0 0.0	0.9 0.1	0.7 0.3	0.8 0.2	0.9 0.1

3. Other notes

(1) AT and AMT vehicles

1] AT vehicle (equipped with torque converter)

The conversion program for the simulation method is intended for MT (manual transmission) vehicles. Similar programs (algorithms) for AT (automatic transmission) vehicles do not exist. There is no universal design of simulation method available for evaluating fuel efficiency applicable regardless of transmission types is available. Therefore, an alternative method shall be developed.

Normally, AT vehicles have worse fuel efficiency than MT vehicles. According to some test data, comparing an AT vehicle with a MT vehicle having the same number of gears and gear ratios, the former has a fuel efficiency ratio of about average 0.9 compared to the latter (specifically 0.91 for Urban drive mode and 0.96 for Interurban drive mode). Therefore, as a temporary method, calculate the fuel efficiency value of an MT vehicle which has the same number of gears and gear ratios as the AT vehicle under test, and then multiply it by the abovementioned fuel efficiency factor between AT and MT vehicles.

2] AMT (automated manual transmission) vehicle

AMT vehicles differ from manufacturer to manufacturer in terms of the transmission logic applied. However, they are approximately the same as the transmission logic by "excess drive force approach" in the fuel efficiency simulation method; and the fuel efficiency is not much different among them. Therefore, the fuel efficiency value of AMT vehicles shall be calculated assuming them as ordinary MT vehicles.

(2) Vehicles equipped with a post treatment device with forced regeneration control

Vehicles equipped with a post treatment device such as continuous regenerative DPF (diesel particle filter) have a different engine control that cannot be covered by the normal operation fuel efficiency map, since their operation includes activating the catalyst by injecting fuel, burning the particles on the surface of the filter, and regenerating the catalyst that has been stained with sulfur. And, the fuel consumption may increase compared to vehicles without such devices.

In this case, calculate the difference (change rate) in fuel efficiency between vehicles with and without the forced regeneration control, and then multiply fuel efficiency calculated using the fuel efficiency map for normal operation by the change rate to determine the fuel efficiency value of the vehicles.

4. Energy consumption efficiency (fuel efficiency) equation

Energy consumption efficiency (fuel efficiency) shall be calculated using the following equation.

$$E=1/\{\alpha u/Eu + \alpha h/Eh\}$$

Where,

E : Energy consumption efficiency (fuel efficiency) (km/l)

Eu : Urban drive mode energy consumption efficiency (fuel efficiency) (km/l)

Eh : Interurban drive mode energy consumption efficiency (fuel efficiency) (km/l)

αu : Proportion of urban drive

αh : Proportion of interurban drive

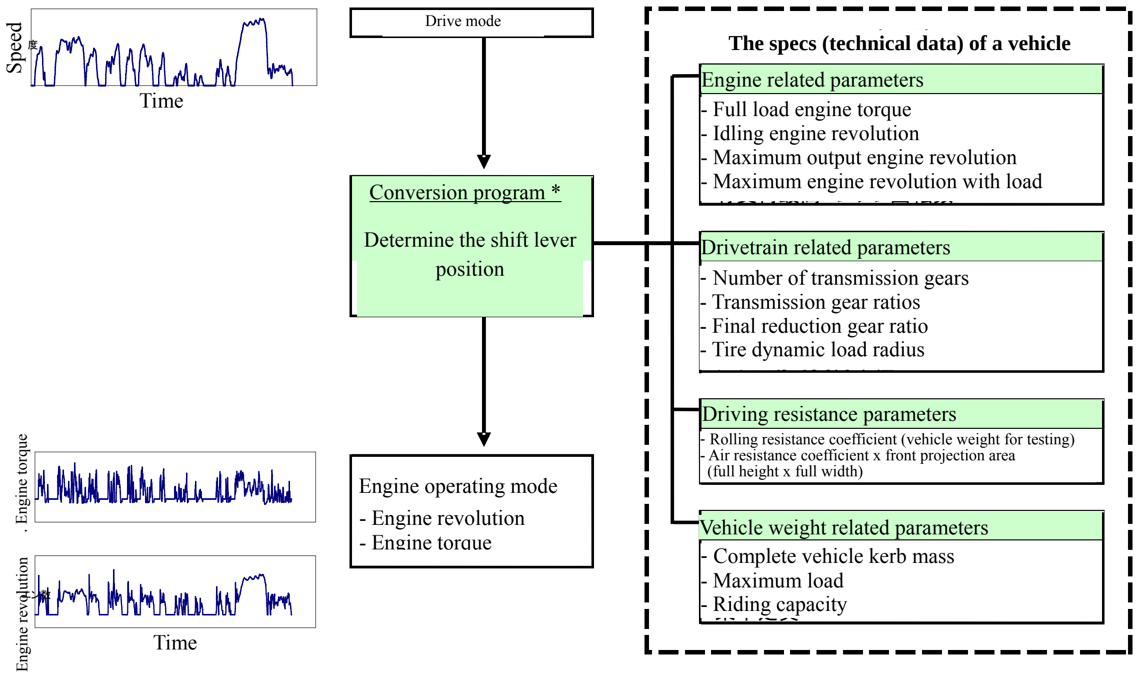
(Annex 1) Simulation Method

This method converts a given drive mode (travel speed vs. time) into an engine operating mode (engine revolution & torque vs. time) by inputting the specs (technical data) of a vehicle into a conversion program, and then calculates fuel efficiency under the drive mode using an actual-measurement based fuel efficiency map (representing the relationship between the engine revolution-torque combination and fuel efficiency for each engine).

(1) Conversion program

The conversion program intended for exhaust gas emissions evaluation (per Notice No. 2002-619 of the Ministry of Land, Infrastructure and Transport; see Attachment 41), as it is, shall be used for fuel efficiency evaluation.

Figure Conversion Program Overview



* Conversion program - algorithm

The following hypotheses regarding driver's operating behaviors are used for determining the position of the shift lever.

1] To accelerate, the driver moves the shift lever from lower to upper positions.

2] The driver selects an appropriate gear depending on the vehicle kerb mass, vehicle speed, acceleration, engine torque and revolution.

3] When changing gears, the driver may skip the next gear depending on mode type, vehicle kerb mass, engine performance, and gear ratios.

4] Ensure the follow-up characteristics of vehicle speed mode.

5] Once a gear position is changed, it is kept unchanged for the specified period (3 seconds; to avoid unnecessarily frequent shifting operation).

6] To accelerate from a slow speed or constant speed travel, the driver may shift gears to a lower position, if necessary.

7] To decelerate, the driver uses the brake, but does not shift the lever to a lower position, unless it's necessary.

(2) Specs (technical data) of vehicles

To measure fuel efficiency using the simulation method, the conversion program uses the following vehicle parameters.

Table Specification Setting - Overview

Parameter		Parameter setting	
1] Engine	Full load engine torque	For each engine type	**Actual value**
	Engine friction toque		
	Idling engine revolution		
	Maximum output engine revolution		
	Maximum engine revolution (with load)		
2] Drivetrain	Number of transmission gears	For each transmission type	**Actual value** * Fuel efficiency evaluation is required for each model of transmission system applied for certification
	Transmission gear ratios		
	Final reduction gear ratio	For each engine type; For each transmission type	**(Average) actual value** * The final reduction gear ratio and tire dynamic load radius should be those having an actual V1000 value closest to the highest gear V1000 value calculated as an arithmetic mean of all registered (applied for certification) vehicles within the same engine and transmission model.
	Tire dynamic load radius		
3] Driving resistance	Rolling resistance	For each fuel efficiency category applied to all manufacturers.	**Standard values (note 1)** * Unified value (*) for each fuel efficiency category available for all manufacturers. (*) This value can be calculated by entering the standard values of 4] shown below in the equation (note 2).
	Air resistance		
4] Vehicle's body form	Complete vehicle kerb weight	For each fuel efficiency category applied to all manufacturers.	**Standard values (note 1)** * Unified value for each fuel efficiency category available for all manufacturers. This value is a standard plain body value, taking the registration (selling) situation into consideration.
	Maximum load		
	Riding capacity		
	Full height		
	Full width		

(Note 1) Parameters for driving resistance and vehicle form

Heavy vehicles vary widely in terms of various features including the vehicle form. Moreover, there is no established method for evaluating the driving resistance individually based on their actual specifications. Therefore, a standard form (plain body) has been defined for each of fuel efficiency categories. The driving resistance common for all manufacturers shall be used.

(Note 2) Driving resistance approximation

The following equation has been used for exhaust gas emissions evaluations (the rolling resistance coefficient is a primary approximation determined with the vehicle kerb weight for testing; and the air resistance coefficient is a primary approximation determined with a function of [full height x full width] (front projection area)). This equation is used to determine driving resistance.

$$\mu_r = 0.00513 + \frac{17.6}{W}$$

$$\mu_a A = 0.00299 B \cdot H - 0.000832$$

μr: rolling resistance coefficient μa: air resistance coefficient A: front projection area

W: vehicle kerb weight for testing B: full width H: full height

* The vehicle kerb weight for testing is calculated as follows.

- Truck and tractor: Complete vehicle kerb weight + Maximum load/2 + 55 (human body weight of one person)
- Bus: Complete vehicle kerb weight + Riding capacity (number of passengers) x 55 (human body weight of one person)/2

* For the air resistance coefficient for bus, the above approximation is multiplied by a correction factor (0.680).

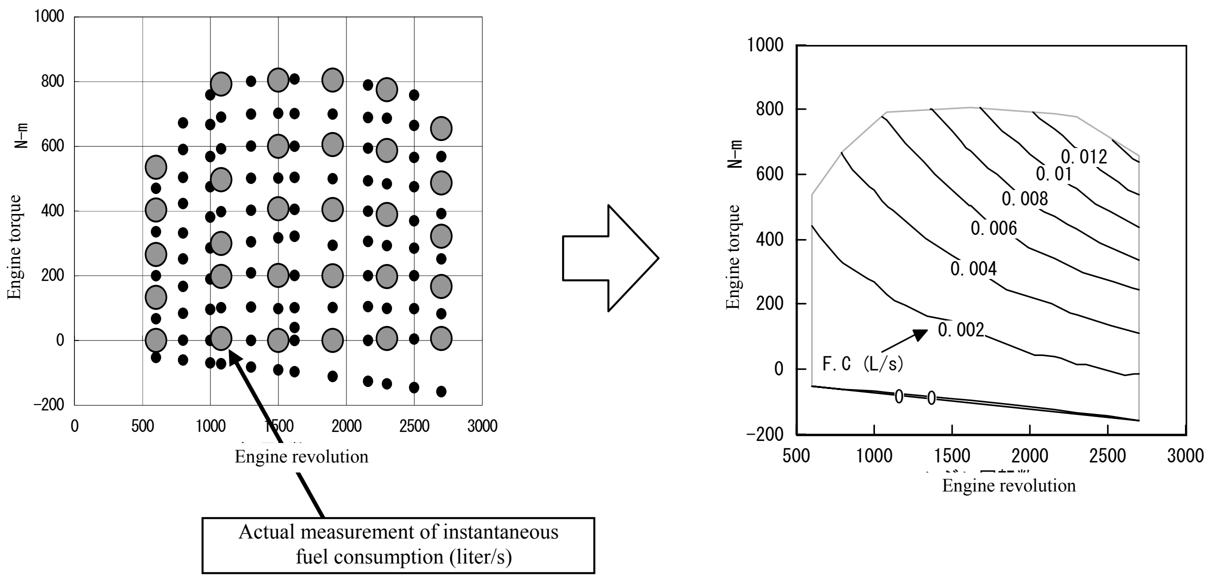
(3) Engine fuel efficiency map

The engine fuel efficiency map shows a relationship between the engine's revolution-torque and fuel consumption. The map shall be created for each model of engines.

For each combination of the engine's revolution (at least 6 points in the range between the lowest and highest revolutions) and torque (at least 5 points in the range between zero and full load torque), measure the instantaneous value of fuel consumption. Using an interpolation technique with the values at other given revolution-torque combinations, a fuel efficiency map can be created.

Figure Engine Fuel Efficiency Map – How to Create

For each combination of the engine's revolution (at least 6 points) and torque (at least 5 points), measure the instantaneous value of fuel consumption; and create a fuel efficiency map.



(4) Accuracy of the simulation method

To evaluate the accuracy of the simulation method, a comparison was made between a fuel efficiency estimated by using "fuel efficiency map" based on the simulation method and that obtained by the vehicle-based actual measurement (*).

To enable effective comparison, these two measurements were made by using the same vehicle speed and shift lever position; and the fuel efficiencies of them are compared.

(*) Based on the report of "the Survey on Heavy Vehicle Fuel Efficiency Evaluation Method", a governmental project under the Ministry of Land, Infrastructure and Transport (Japan Automobile Research Institute, March 2003)

1] How to evaluate the accuracy

First, measure the actual fuel consumption using the vehicle-based actual measurement method. Next, obtain the engine revolution and torque that correspond to the vehicle speed and shift lever position at the actual measurement. Then, with the engine revolution and torque, the fuel consumption was estimated from an engine fuel efficiency map. The map should be created based on the engine removed from the vehicle which was used in the vehicle-based actual measurement. Finally, compare the fuel efficiency obtained from the simulation method with that obtained from the actual measurement. Figure 1 shows the steps of the comparison.

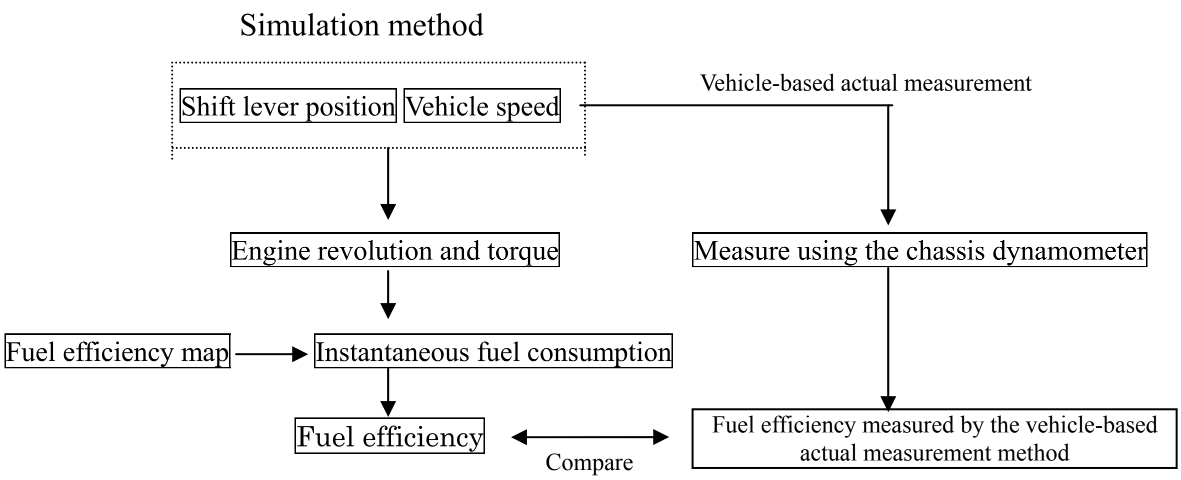


Figure 1 Steps to Evaluate the Accuracy of the Simulation Method

Engine revolution and torque were calculated using the following equation with the actual measurements of vehicle speed and shift lever position.

- Engine revolution

$$N_e = \frac{1000}{120\pi} \cdot \frac{i_m \cdot i_f}{r} \cdot V$$

Engine revolution

Where

N_e : engine revolution rpm

V : vehicle speed km/h

i_m : transmission gear ratio

i_f : final reduction gear ratio

r : tire dynamic load radius m

- Engine torque

$R \geq 0$

$$M = \frac{r}{\eta_m \eta_f i_m i_f} \cdot R$$

$R < 0$

$$M = \frac{r \cdot \eta_m \eta_f}{i_m i_f} \cdot R$$

However

$$R = \mu_r W + \frac{s}{100} W + \mu_a A V^2 + (W + \Delta W_1 + \Delta W_2) \frac{\alpha}{g}$$

Where,

M : engine torque $N-m$

R : driving resistance N

η_m : mechanical transmission efficiency of the transmission gear

η_f : mechanical transmission efficiency of the final reduction gear

μ_r : rolling resistance coefficient N/N

μ_a : air resistance coefficient $N/m^2/(km/h)^2$

s : longitudinal grade %

A : front projection area m^2

W : vehicle kerb weight for testing N

ΔW_1 : equivalent weight of the rotating parts such as an engine and flywheel N

ΔW_2 : equivalent weight of the rotating parts other than the engine N

α : vehicle acceleration m/s^2

g : acceleration by gravity

The equivalent weight of the rotating parts (such as the gears and tires) and the mechanical transmission efficiency are as follows according to other studies.

- Equivalent weight of rotating parts = (0.07 + 0.03 x transmission gear ratio^2) x vehicle kerb weight

  Note: the weight of the portion from the transmission output axle to tire is 7% of the vehicle kerb weight; and the portion from the engine to transmission gear input axle is 3% of the vehicle kerb weight.

- Mechanical transmission efficiency

  98% for gears directly coupled to the transmission; 95% for other types of transmissions

  95% for final reduction gear

2] Results

With the values of 4 different heavy vehicles shown in Table 1, a comparison study between the fuel efficiency by the vehicle-based actual measurement and the estimated fuel efficiency by the simulation was conducted. As shown in Figure 2, the error by the simulation to the actual measurement is found to be limited to about 0.4% irrespective of the types of heavy vehicles.

Table 1 Vehicles Under Test: Specifications

			A	B	C	D
Vehicle under test			A	B	C	D
Body	Overall length, mm		4690	11990	8490	7890
	Full width, mm		1695	2490	2260	2490
	Full height, mm		1990	2950	2500	2800
	Vehicle kerb weight, kg		2140	8590	3770	6640
	Riding capacity, person		2	3	2	2
	Maximum load, kg		2000	11250	3750	12000
	Gross vehicle weight, kg		4250	19950	7630	18750
Engine under test			a	b	c	d
Engine	Number of cylinders, and their configuration		In-line 4-cylinder	V-type 8-cylinder	In-line 6-cylinder	In-line 6-cylinder
	Type		DI, NA	DI, NA	DI, TI	DI, TI
	Compression ratio		18.4	17.3	17.5	16.0
	Total swept volume, cc		4104	21205	7127	10520
	Maximum output, PS/rpm		125/3200	400/2200	220/2700	300/2150
	Maximum torque, kgm/rpm		29.5/2000	142/1400	66.0/1700	110/1100
Transmission	Transmission gear ratio	1st gear	5.339	6.326	6.120	6.523
		2nd gear	2.792	4.139	3.948	4.159
		3rd gear	1.593	2.326	2.580	2.700
		4th gear	1.000	1.480	1.540	1.625
		5th gear	0.788	1.000	1.000	1.000
		6th gear	-	0.731	0.763	0.692
	Final reduction ratio		4.625	5.571	3.900	5.250

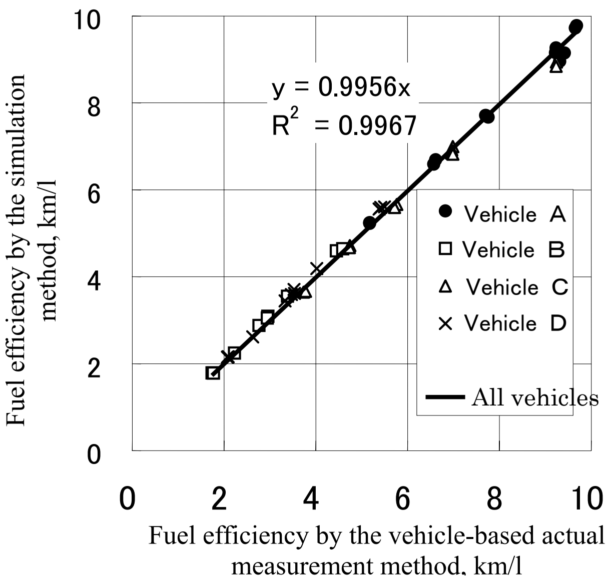


Figure 2 Accuracy of Fuel Efficiency Estimated by the Simulation Method
(Comparison in fuel efficiency between by the vehicle-based actual measurement method and by the simulation method)

(Annex 2)　Interurban Drive Mode Settings

(Sections 1 (1) and 2 are based on the report of “the Survey on Heavy Vehicle Fuel Efficiency Evaluation Method”, a governmental project under the Ministry of Land, Infrastructure and Transport (Japan Automobile Research Institute, March 2003); and sections 1(2), 3, 4 and 5 are based on the report of “the Study on Standardizing Heavy Vehicle Fuel Efficiency Measuring Method and Survey on Heavy Vehicle Fuel Efficiency Standards”, a governmental project under the same Ministry (Japan Automobile Research Institute, March 2004)).

1.　Travel speed settings

(1)　Effect of travel speed fluctuation on fuel efficiency

Before determining the travel speed profile in the interurban drive mode, an experimental test using five diesel engine driven trucks having a maximum load of 2 to 10 tons was made for investigating the effect of the travel speed fluctuation on the fuel efficiency (these trucks were half loaded during the test).

With respect to driving mode having a sinusoidal waveform (flat road) with average 80 km/h vehicle speed, change the amplitude of speed fluctuation in the range of 0 to 10 km/h, and investigate the effect.

The result is shown in Figure 1.　The speed fluctuation of ±10 km/h worsens the fuel efficiency by about 5%.　It implies that a large fluctuation in travel speed may affect the fuel efficiency.　However, many of drivers tend to keep the travel speed as constant as possible when driving on an expressway. So, such fluctuation of as large as ±10 km/h is unlikely.　Smaller fluctuation in driving speed less affects the fuel efficiency.

As a result, the interurban drive mode shall use a constant travel speed, without any consideration to speed fluctuation.

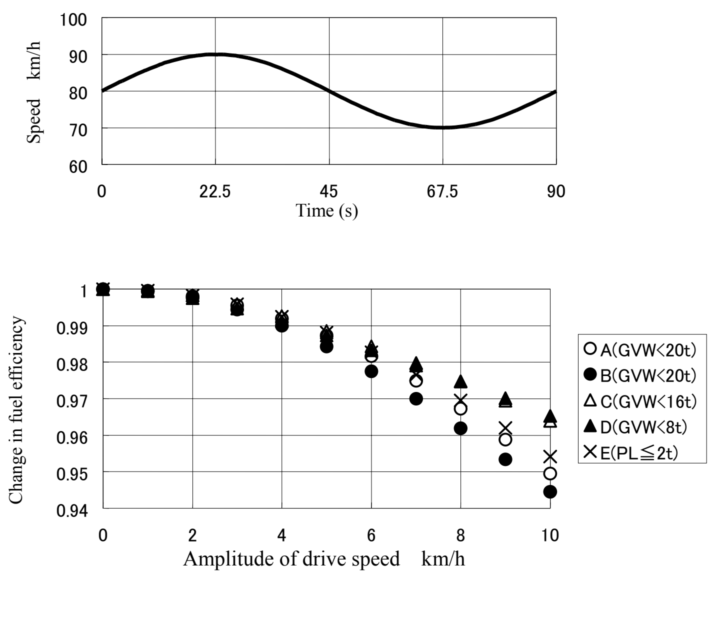


Figure 1　Effect of Travel Speed Fluctuation on Fuel Efficiency

(2) Setting travel speed (constant speed)

Before determining the travel speed (constant speed) in the interurban (expressway) drive mode, an inquiry was made for the owners of freight vehicles (trucks and tractors) with a gross vehicle weight (GVW) of 3.5 tons or larger and passenger vehicles (buses) having a riding capacity of 11 persons or more to survey the actual expressway travel speed (see an attachment for further details of the inquiry).

The travel speed was determined in consideration of the inquiry results and other factors (exhaust gas emissions measuring procedures, various regulations, etc.). (Following (3) and (4) are determined likewise).

1] Trucks

1) Average and standard deviation

Figure 2 shows the average and standard deviation values of expressway travel speed for each of GVW categories of "freight vehicles". Except tractors of less than GVW 20t that drive at less than 80 km/h, the vehicles in all other GVW categories fall in the travel speed range from 80 to 85 km/h.

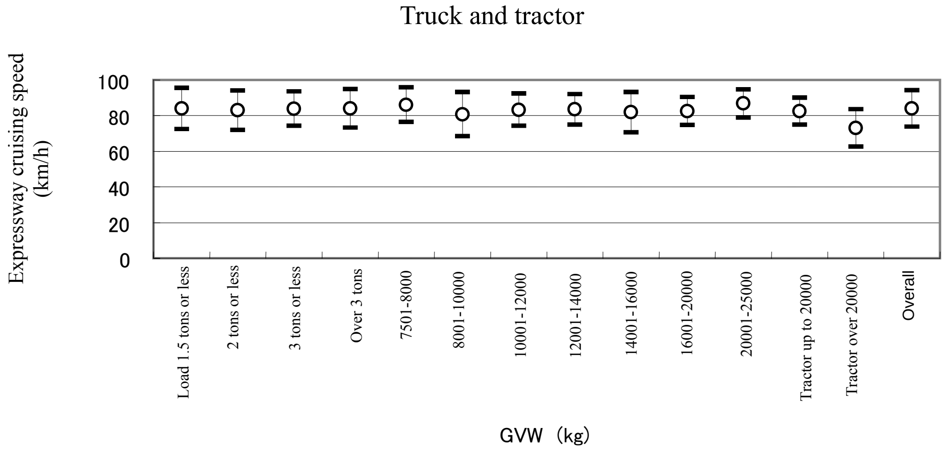


Figure 2 Expressway Travel speed of Trucks by GVW Category
(Average and Standard Deviation)

2) Setting travel speed

The Road Traffic Act specifies the maximum travel speed of expressway as follows.

GVW of 8 tons or larger, or maximum load of 5 tons or larger	80km/h
Other than the above	100km/h

Except tractors of less than GVW 20 tons, the average value of travel speed falls in the range of 80 to 85 km/h irrespective of GVW categories. Therefore, in consideration of the inquiry result and legal requirement for the maximum travel speed, it is reasonable to unify the travel speed to 80 km/h irrespective of GVW categories.

2] Bus

<Ordinary bus>

1) Average and standard deviation

Figure 3 shows the average and standard deviation values of expressway travel speed for each of GVW categories of "ordinary bus." The driving speed falls in the range of 80 to 85 km/h irrespective of GVW categories.

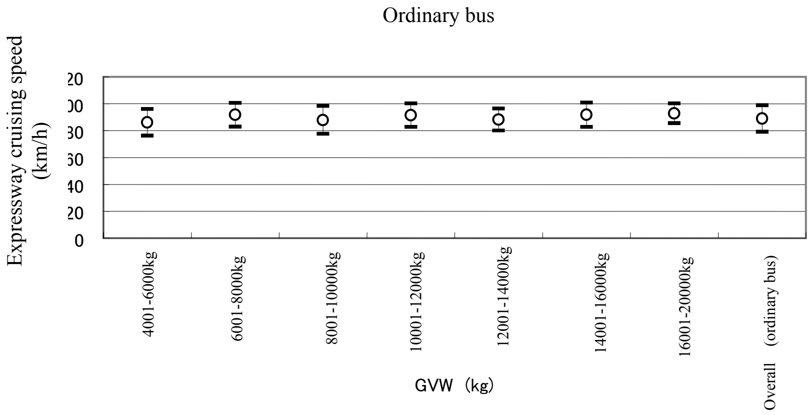


Figure 3 Expressway Travel speed of Ordinary Buses by GVW Category (Average and Standard Deviation)

2) Travel speed

The travel speed falls in the range of 80 to 85 km/h irrespective of GVW categories. Therefore, the speed shall be a single value common for all GVW categories. Possible candidates of the driving speed include 80 km/h, 85 km/h and 90 km/h. However, in consideration of the legal requirement for the maximum travel speed, it is reasonable to select 80 km/h also for ordinary bus as well as for freight vehicles.

< Route bus>

As mentioned later (See 4.), it is assumed that this category of bus does not use expressways. Therefore, the travel speed does not have to be specified.

2. Setting longitudinal grade

(1) Effect of longitudinal grade on fuel efficiency

As seen in expressways, interurban roadways are not always flat and have ascent and descent grades. This survey clarified the effect of longitudinal grades on fuel efficiency assuming driving at constant speed of 80 km/h.

The survey result is shown in Figure 4. A longitudinal grade of 1% worsens the fuel efficiency by about 30%. Longitudinal grades affect fuel efficiency very much.

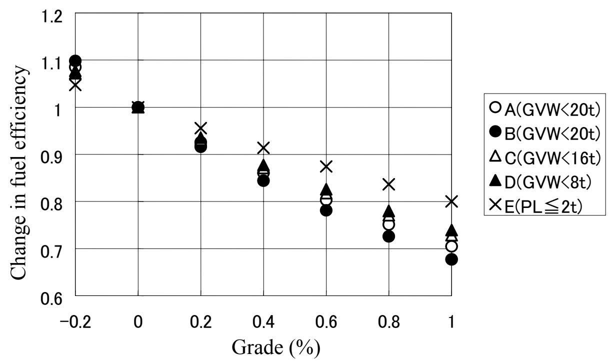


Figure 4 Effect of Longitudinal Grades on Fuel Efficiency

Next survey was to find causes of the effect of longitudinal grade on fuel efficiency.

The driving routes used for this survey were round trips of 1/10-scale Tomei Expressway and 1/10-scale Chuo Expressway (average 0% grade in both). Figures 5 and 6 show the grade profile of the Tomei and the Chuo Expressway respectively.

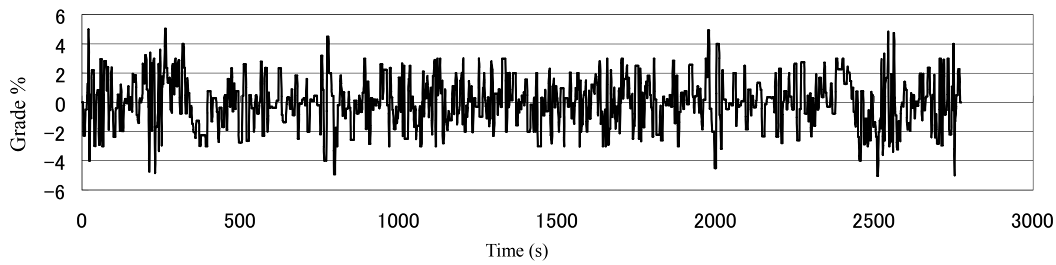


Figure 5 Longitudinal Grade Profile of Tomei Expressway

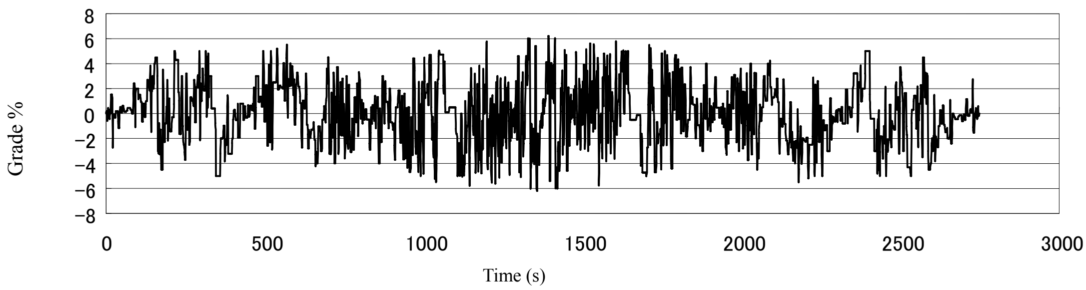


Figure 6 Longitudinal Grade Profile of Chuo Expressway

Figure 7 shows the fuel efficiency in the case of travel at constant speed of 90 km/h throughout the two routes. As shown in these figures, the fuel efficiency worsens by more than 2% for driving on the Tomei Expressway, and more than 5% for driving on the Chuo Expressway.

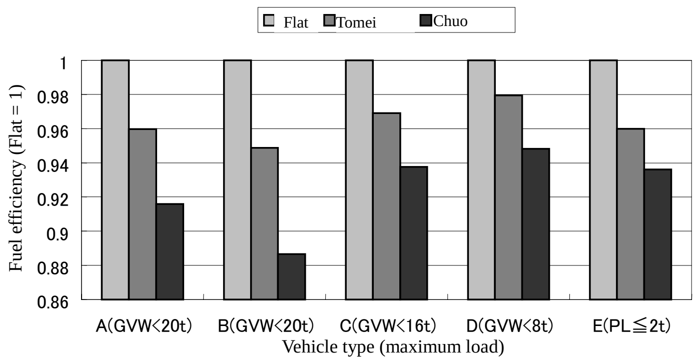
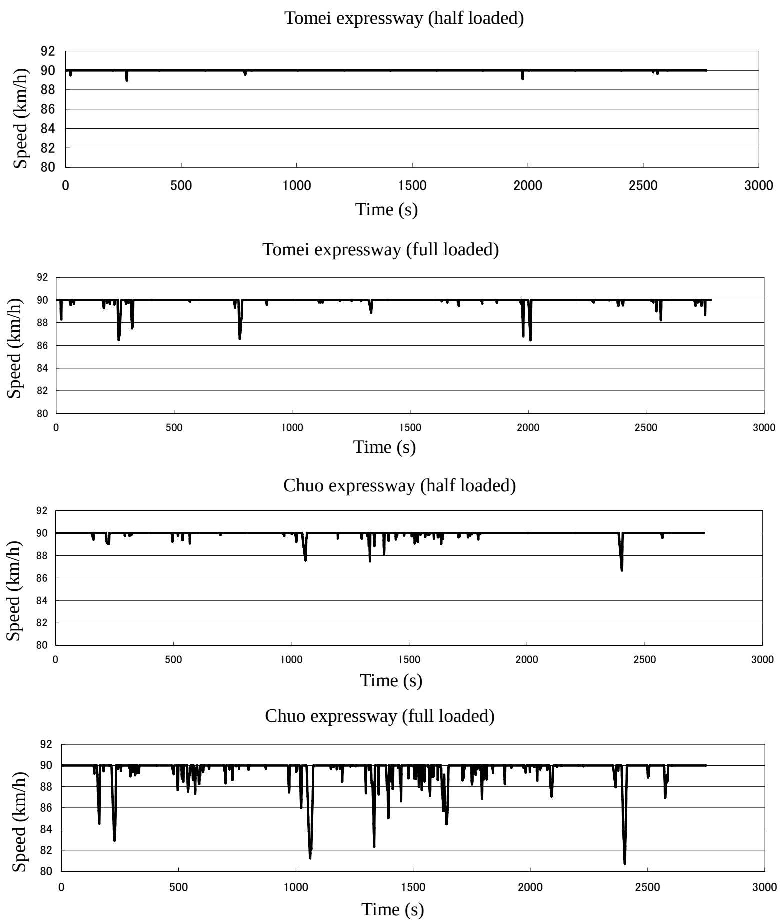


Figure 7 Fuel Efficiency During Drive on Expressway

Figure 8 shows examples of actual travel speed measured. With the presence of longitudinal grades, the travel speed varies because it is difficult to maintain the specified speed.



(Note) Full loaded: 100% of the maximum load
Half loaded: 50% of the maximum load

Figure 8 Examples of Vehicle Speed and Follow-up Characteristics During Drive on Expressway

To determine whether the worse fuel efficiency is a direct result of longitudinal grades or caused by the unsteady travel speed due to the presence of grades, calculations of fuel efficiency for driving at actual (non-steady) speeds on a flat expressway are shown in Figure 9.

There is almost no difference in fuel efficiency between at steady speed and unsteady speed (about 0.5% for fully loaded vehicle traveling on the Chuo expressway). It implies that the worse fuel efficiency is caused directly by the grades, not caused by the speed fluctuation.

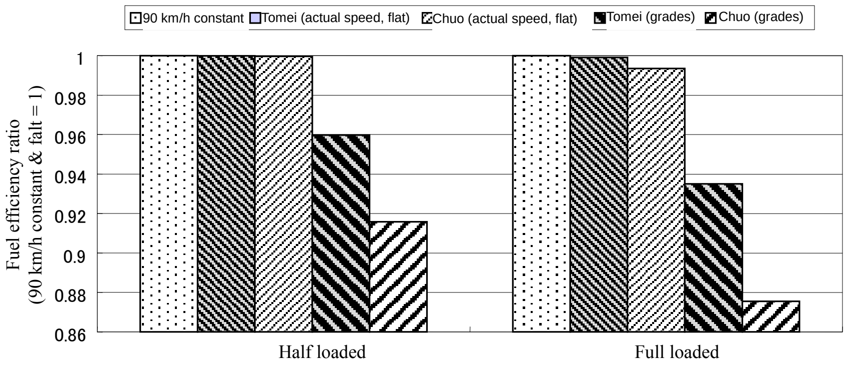


Figure 9 Causes of Worsen Fuel Efficiency

Therefore, the interurban driving mode shall include considerations on longitudinal grades of roads.

(2) Setting longitudinal grades

The grade profile of Tomei Expressway, accounting for the largest traffic ([number of vehicles] x km) among those in Japan, shall be used as the specific grade profile for Interurban driving mode (see Figure 10).

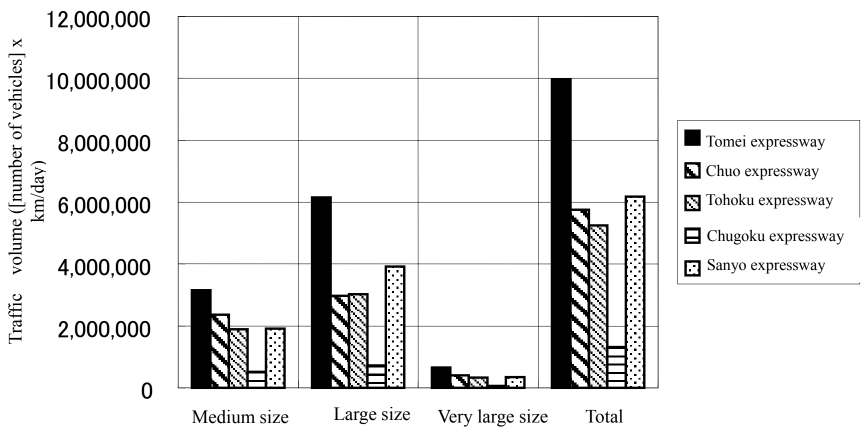


Figure 10 Traffic Volume of Major Expressways

3. Loading (riding) ratio

To determine the loading (riding) ratio being associated with the interurban drive mode (expressway drive mode), an inquiry was made for investigating the actual status of load (number of persons) of heavy vehicles operating on expressways (see an attachment for further details of the inquiry).

1] Truck

1) Average and standard deviation

Figure 11 shows the average and standard deviation values of the loading ratio of expressway transport trucks by GVW category. Trucks having a larger GVW have a larger loading ratio. The average value of loading ratio falls in the range of 40 to 60% irrespective of GVW categories.

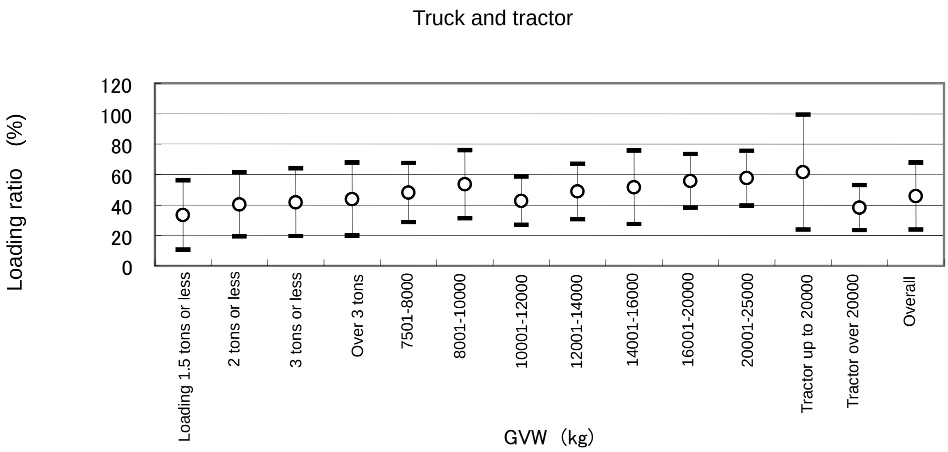


Figure 11 Truck Loading Ratio by GVW Category (Average and Standard Deviation)

1) Setting loading ratio

Exhaust gas emissions measurement use a loading ratio of 50%.

Although vehicles having a larger GVW have a larger loading ratio, its average value falls in the range of 40 to 60% irrespective of GVW categories, and the overall average is about 46%. Therefore, taking the loading ratio at the exhaust gas emissions measurement into consideration, a loading ratio of 50% (half loaded) shall be used.

2] Bus

<Ordinary bus>

1) Average and standard deviation

Figure 12 shows the average and standard deviation values of riding ratio of ordinary bus by GVW category. The average value of riding ratio falls in the range of 60 to 70% irrespective of GVW categories.

Figure 12 Riding Ratio of Ordinary Bus by GVW Category
(Average and Standard Deviation)

2) Setting riding ratio

Exhaust gas emissions measurement/evaluations use a riding ratio of 50%.

The riding ratio falls in the range of 60 to 70% irrespective of GVW categories. Therefore, the ratio shall be a single value common for all GVW categories. The average value for each of GVW categories falls in the range of 60 to 70%, and the overall average of ordinary bus is about 66%. Therefore, 65% is a possible candidate. However, 50% is believed to be reasonable in consideration of the fact that exhaust gas emissions measurement use this value, and that the loading factor for truck has been set to 50% as mentioned before.

<Route bus>

1) Average and standard deviation

Figure 13 shows the average and standard deviation values of riding ratio of route bus by GVW category. The average value of riding ratio of a GVW category of over 4t to below 6t is about 60%, while that of other GVW categories falls in the range of 30 to 40% (average of about 39%).

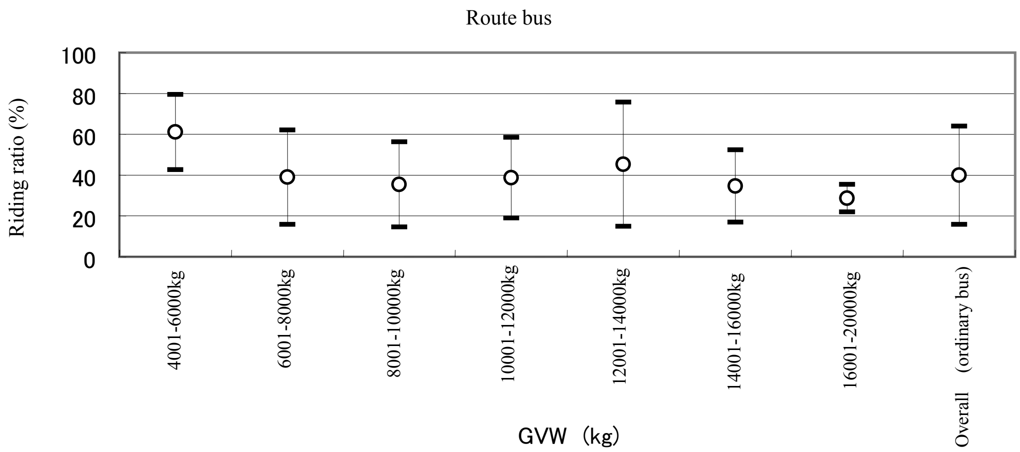


Figure 13 Riding Ratio of Route bus by GVW Category (Average and Standard Deviation)

2) Setting riding ratio

Exhaust gas emissions measurement use a riding ratio of 50%.

The riding ratio of a GVW category of 4 to 6 tons is higher than that of other GVW categories. So, a possible option is to set 60% for the former category and 40% for the others. However, 50% shall be used for route buses as well as ordinary buses, in consideration of the fact that exhaust gas emissions measurement use this value.

4. Setting the total proportion (of using expressways) in drive modes

To determine the total proportion (of using expressways) in the urban driving mode and interurban driving mode, an inquiry was made for investigating the actual status of expressway usage (see an attachment for further details of the inquiry).

1] Truck

1) Average and standard deviation

Figure 14 shows the average and standard deviation values of expressway usage ratio of trucks by GVW category. Trucks within a GVW category of over 20t to below 25t have an average expressway usage of about 30%; for tractors within a GVW category of 20 tons or less, it is about 20%. Trucks and tractors within other GVW categories have an average expressway usage of about 10%.

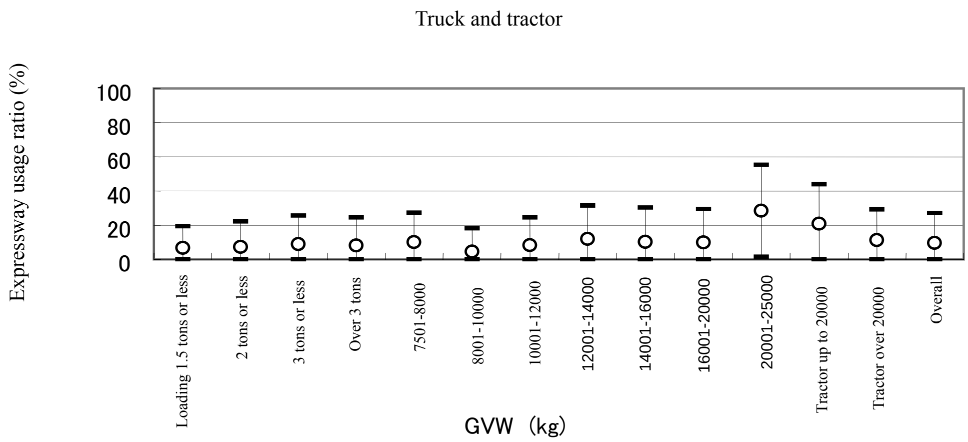


Figure 14 Expressway Usage Ratio of Trucks by GVW Category
(Average and Standard Deviation)

2) Setting expressway usage ratio

Both Trucks within a GVW category of over 20t to below 25t and tractors within a GVW category of 20 or less have higher expressway usage ratios. Therefore, it shall be defined separately for each of the four categories as shown below.

Truck:	GVW of 20 tons or less	10%
	GVW of over 20 tons to below 25 tons	30%
Tractor:	GVW of 20 tons or less	20%
	GVW of over 20 tons	10%

2] Bus

<Ordinary bus>

1) Average and standard deviation

Figure 15 shows the average and standard deviation values of expressway usage ratio of ordinary buses by GVW category. Though the average values vary widely depending on the GVW category, ordinary buses within a GVW category of 14 tons or less have an expressway usage ratio in the range of 10 to 30%; and those within a GVW category of over 14 tons have it in the range of 30 to 45%.

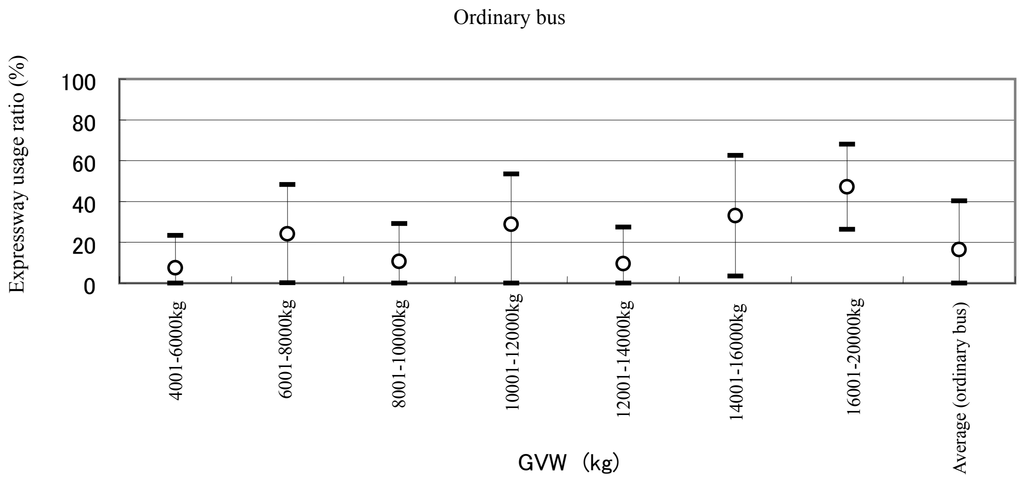


Figure 15 Expressway Usage Ratio of Ordinary Buses by GVW Category
(Average and Standard Deviation)

2) Setting expressway usage ratio

This value varies widely depending on GVW categories. This suggests the possibility to define the expressway usage ratio separately for each GVW category. However, in consideration of distinctive difference in the usage ratio between two groups of GVW categories (14 tons or less & over 14 tons), the expressway usage ratio shall be defined separately for each of the two groups as shown below.

GVW of 14 tons or less: 10%
GVW of over 14 tons: 35%

<Route bus >

1) Average and standard deviation

Figure 16 shows the average and standard deviation values of the expressway usage ratio of route buses by GVW category. The average value is less than 5% irrespective of GVW categories, with the maximum value of about 7% for GVW category of over 16t up to 20t.

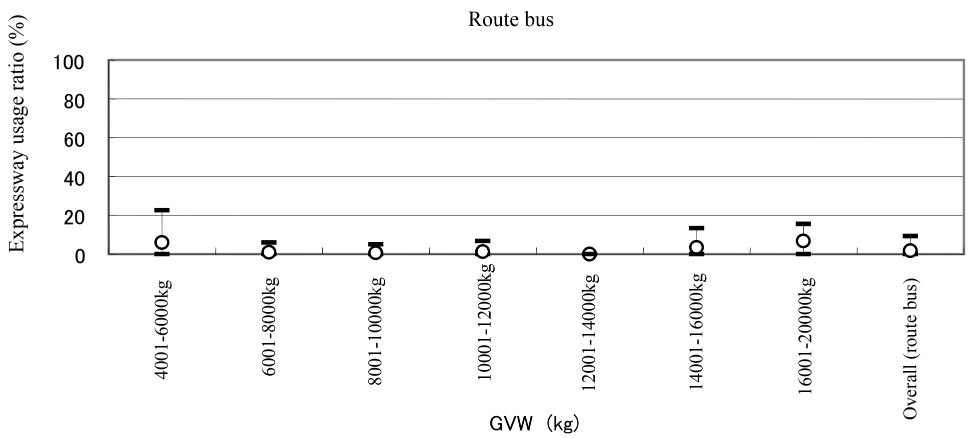


Figure 16 Expressway Usage Ratio of Route Bus by GVW Category
(Average and Standard Deviation)

2) Setting expressway usage ratio

For all GVW categories, the expressway usage ratio is as small as several percents. Therefore, it shall be considered zero irrespective of GVW categories.

(Attachment)

Questionnaire (Inquiry about Actual Driving Situation) - Overview

1] Area: throughout Japan

2] Target: trucks and buses of GVW 3.5 tons and above

3] The extracted number of targets: 28,600 (truck) and 7,268 (bus)
(For the numbers of targets by GVW category, see the next table.)

4] Means to deliver the questionnaire: by postal mail

5] Respondents: vehicle operation manager

6] Major question items: travel speed, loading weight, expressway usage ratio, etc.

7] Period: October through November 2003

8] Valid responses: 4,210 (14.7%) for truck and 2,006 (27.6%) for bus
(For the numbers of valid responses by GVW category, see the next table.)

9] Means to analyze the information collected:
- Aggregate the collected information by categories as shown in the next tables. Route buses and other buses ("ordinary bus") were separately analyzed.

Table　Number of Extraction and of Valid Responses

(Trucks)

		The extracted number of targets	Number of valid responses	Responses rate %	Nationwide population of trucks unit
Overall trucks		28,600	4,210	14.7	4,049,247
Small truck (3.5t＜GVW≦7.5t)	Load≦1.5t	3,705	504	13.6	279,806
	1.5t＜Load≦2t	6,719	845	12.6	1,636,450
	2t＜Load≦3t	2,885	402	13.9	272,514
	3t＜Load	858	106	12.4	89,857
Medium and large truck (7.5t＜GVW≦25t)	7.5＜GVW≦8t	3,855	481	12.5	949,512
	8t＜GVW≦10t	473	89	18.8	30,764
	10t＜GVW≦12t	331	63	19.0	21,175
	12t＜GVW≦14t	820	147	17.9	45,267
	14t＜GVW≦16t	481	75	15.6	29,207
	16t＜GVW≦20t	4,221	633	15.0	424,578
	20t＜GVW≦25t	2,955	615	20.8	177,154
Tractor [Classified by tractor head GVW]	GVW≦20t	946	193	20.4	70,727
	20t＜GVW	351	59	16.8	22,236

（Buses）

	The extracted number of targets	Number of valid responses	Responses rate %	Nationwide population of buses unit
Overall buses	7,268	2,006	27.6	215,509
4t＜GVW≦6t	2,762	711	25.7	94,556
6t＜GVW≦8t	1,377	343	24.9	16,580
8t＜GVW≦10t	1,292	396	30.7	23,442
10t＜GVW≦12t	475	163	34.3	7,642
12t＜GVW≦14t	296	87	29.4	20,031
14t＜GVW≦16t	717	198	27.6	46,998
16t＜GVW≦20t	347	107	30.8	6,221
20t＜GVW	2	1	50.0	39

Attachment 4

Classification of Heavy Vehicles

To define fuel efficiency categories, using the same categories as those for exhaust gas emissions measurement permits manufacturers to evaluate fuel efficiency under the same conditions, which may lead to effective environmental protections and reduce burden to be born for the manufacturers.

Basically, the classifications for exhaust gas emissions evaluations (i.e. vehicle categories based on the gross vehicle weight (GVW) and maximum load) shall be applied for fuel efficiency evaluations. Specifically, each type of heavy vehicles mentioned in the following sections 1 and 2 should be categorized by various factors considered to affect fuel efficiency (such as the vehicle structure, intended use, transmission type, GVW) and actual shipment volume.

1. Freight vehicles

(1) Classification by structure

Of the types of freight vehicles, tractors are different from others as they are intended to tow vehicles such as trailers. Because tractors have a distinct feature (towing) that other freight vehicles don't, the body strength of tractors is not the same as the others. Therefore, tractors shall be grouped separately from other types of freight vehicles ("tractors" and "other than tractors") for the purpose of fuel efficiency evaluation.

(2) Classification by transmission types (manual transmission (MT (AMT)) and other than manual transmission (AT))

Most of relevant vehicles use an MT. It is assumed that this trend will remain unchanged in future. For the purpose of measuring fuel efficiency, AT vehicles and MT vehicles are addressed essentially the same each other (to evaluate an AT vehicle, calculate fuel efficiency assuming that the vehicle as a corresponding MT vehicle with the same number of gears and gear ratios, and multiply it by a factor: see Attachment 3).

Therefore, no classification has to be made between MT and AT vehicles. Target standard values of fuel efficiency shall be determined based on MT vehicles; and then, for AT vehicles, it is adjusted according to the share of AT vehicles as opposed to the sales of MT vehicles in the target year (AT is a contributor for worsening the fuel efficiency).

(3) Classification by gross vehicle weight and maximum load

<Other than tractor>

These categories shall be defined so that fuel efficiency can be properly evaluated taking the difference of GVW into consideration. Another point for defining these categories is that the ratio of category range to the GVW shall not much vary each other.

<Tractor>

Tractor axle configurations are mainly 4x2 or 6x4. The 4x2 configuration is used mainly for tractor head GVW (= tractor mass + 5th-wheel load + riding capacity x 55 kg) of not greater than 20 tons, and 6x4 configuration is used mainly for tractor head GVW of greater than 20 ton. Therefore, it is reasonable to define two categories by tractor head GVW: "20t or below" and "over 20t".

As a result, freight vehicles are categorized as follows.

＜Other than tractor＞

NO	GVW range (t)	Maximum load range (t)
1	3.5<&≦7.5	≦1.5
2		1.5<&≦2
3		2<&≦3
4		3<
5	7.5<&≦8	—
6	8<&≦10	—
7	10<&≦12	—
8	12<&≦14	—
9	14<&≦16	—
10	16<&≦20	—
11	20<	—

＜Tractor＞

NO	(Tractor head) GVW range (t)
1	≦20
2	20<

2. Passenger vehicles (riding capacity :11 persons or more)

(1) Classification by intended use

Buses used for public transportation service on a fixed route other than expressway and those for other use (ordinary bus) are quite different in terms of use and driving conditions. Therefore, they should be separated as follows according to the classification defined by Article 22-3 (Seat belt etc.) of the Road Vehicle Security Standard.

(i) Route bus

Of passenger vehicles having a riding capacity of 11 persons or more, limited those used for offering regular public transport service on a fixed route other than expressways fall in this category.

(ii) Ordinary bus

Besides passenger vehicles having a riding capacity of 11 persons or more, excluding those in the category of "Route bus", "small" and "light" passenger cars fall in this category.

(2) Classification by transmission types (manual transmission (MT) and automatic transmission (AT))

Most of medium and large size relevant vehicles use an MT. It is assumed that this trend will remain unchanged in future. Therefore, target standard values of fuel efficiency shall be determined based on MT vehicles; and then, for AT vehicles, it is adjusted according to the share of AT vehicles as opposed to the sales of MT vehicles in the target year (AT vehicles are contributors for worsening fuel efficiency).

For small-size passenger cars, both MT and AT vehicles have large amount of shipment volume. It is assumed that this trend will remain unchanged in future. For the purpose of measuring fuel efficiency, AT vehicles and MT vehicles are addressed essentially the same each other. Therefore, as well as for freight vehicles, no classification has to be made between MT and AT vehicles. And target standard values of fuel efficiency shall be determined based on MT vehicles; and then, for AT vehicles, it is adjusted according to the share of AT vehicles as opposed to the sales of MT vehicles in the target year (AT is a contributor for worsening fuel efficiency).

(3) Classification by gross vehicle weight and maximum load

These categories shall be defined so that fuel efficiency can be properly evaluated taking the difference of GVW into consideration. Another point for defining these categories is that the ratio of category range to the GVW shall not much vary each other.

As a result, passenger vehicles (11 persons or more of riding capacity) are categorized as follows.

<Route bus >

NO	GVW range（ｔ）
1	6<&≦8
2	8<&≦10
3	10<&≦12
4	12<&≦14
5	14<

<Ordinary bus>

NO	GVW range（ｔ）
1	3.5<&≦6
2	6<&≦8
3	8<&≦10
4	10<&≦12
5	12<&≦14
6	14<&≦16
7	16<

<Standard specification for each category>

Standard parameter values for each of the vehicle categories defined in Sections 1 and 2 above (complete vehicle kerb weight, maximum load, riding capacity, full height and full width: setting unified values for each fuel efficiency category, which are common for all manufacturers, (which are also the standardized values in consideration of actual sales (the number of registered units))) are as follows.

Table　Standard Vehicle Specification

<Freight Vehicle>

(Other than tractor)

Category			Standard parameters				
NO	GVW range (t)	Maximum load range (t)	Complete vehicle kerb weight (kg)	Maximum load (kg)	Riding capacity (person)	Full height (m)	Full width (m)
1	3.5<&≦7.5	≦1.5	1,957	1,490	3	1.982	1.695
2		1.5<&≦2	2,356	2,000	3	2.099	1.751
3		2<&≦3	2,652	2,995	3	2.041	1.729
4		3<	2,979	3,749	3	2.363	2.161
5	7.5<&≦8	—	3,543	4,275	2	2.454	2.235
6	8<&≦10	—	3,659	5,789	2	2.625	2.239
7	10<&≦12	—	4,048	7,483	2	2.541	2.350
8	12<&≦14	—	4,516	7,992	2	2.572	2.379
9	14<&≦16	—	5,533	8,900	2	2.745	2.480
10	16<&≦20	—	8,688	11,089	2	3.049	2.490
11	20<	—	8,765	15,530	2	2.934	2.490

(Tractor)

Category		Standard parameters				
NO	(Tractor head) GVW range (t)	Complete vehicle kerb weight (kg)	Maximum load (kg)	Riding capacity (person)	Full height (m)	Full width (m)
1	≦20	10,525	24,000	2	2.927	2.490
2	20<	19,028	40,000	2	2.890	2.490

<Passenger Car (11 persons or more)>

(Route bus)

Category		Standard parameters			
NO	GVW range（t）	Complete vehicle kerb weight（kg）	Riding capacity (person)	Full height（m）	Full width（m）
1	6<&≦8	5,186	39	2.880	2.072
2	8<&≦10	6,672	46	2.947	2.301
3	10<&≦12	7,324	62	2.949	2.304
4	12<&≦14	8,654	77	2.969	2.385
5	14<	9,790	79	2.962	2.490

(Ordinary bus)

Category		Standard parameters			
NO	GVW range（t）	Complete vehicle kerb weight（kg）	Riding capacity (person)	Full height（m）	Full width（m）
1	3.5<&≦6	3,543	29	2.593	2.027
2	6<&≦8	5,622	29	3.019	2.197
3	8<&≦10	6,608	49	3.105	2.314
4	10<&≦12	8,022	58	3.160	2.399
5	12<&≦14	9,774	60	3.168	2.490
6	14<&≦16	12,110	62	3.320	2.490
7	16<	14,583	51	3.668	2.490

Attachment 5

Target Standard Values for Heavy Vehicle

According to the Energy Conservation Law, the target standard values of fuel efficiency shall be determined in consideration of possible improvements in fuel efficiency due to the subsequent technical development, effect of the current or planned exhaust gas emissions regulations on the fuel efficiency, and fuel properties, while focusing on the most fuel-efficient vehicles in the current market.

1. Policy for determining the target standard values

Among all commercially available heavy vehicles in each category in 2002, select the vehicle that has achieved the highest fuel efficiency as a basic. Then, target standard values shall be determined based on it, after evaluating fuel efficiency improvement due to technological development and effect of working around exhaust gas emission regulation on fuel efficiency within the period from 2002 (long-term control level) to 2015 (2009 exhaust gas emissions control level). Note, because Low PM4 ☆ Approved Vehicles (*) have partially been on the market since FY 2004, their fuel efficiency levels shall also be considered when determining the target standard value.

(*) Low PM4 ☆ Approved Vehicles: vehicles with lower PM emissions than the new short-term control value by more than 85%.

2. Technology improvements for fuel efficiency

Review the ongoing and planned R&D projects for improving the fuel efficiency of heavy vehicles, and estimate which technologies will have been available and how much fuel efficiency will have been improved by using such technologies as of the target year (2015). These identified technologies and expected improvement rate of fuel efficiency due to these technologies are shown below.

However, some of these new technologies may not be immediately available depending on the types of heavy vehicles. Expected diffusion rate of these technologies in future shall be taken into consideration when determining the target standard values.

(1) Improvement of engine

1] Thermal efficiency can be improved by means of:

4-valve & center nozzles (1.0 to 1.5%), direct injection (4.0 to 5.0%), fuel injection at higher pressure (200 MP equivalent) (2.0%), improved combustion chamber (0.5%), EGR (1.0 to 1.5%), higher supercharging (BMEP = 2.0 MPa or higher) (2.5 to 4.5%), improved supercharging efficiency (0.3 to 0.5%), variable supercharger (0.5%), intercooler (1.5 to 2.5%), turbo compound (0 to 1.5%), optimized entire engine control system (3.0%), etc.

2] Loss can be reduced by means of:

Lower friction (1.0 to 1.5%), lower idling revolution (0.5%) and lower loss of auxiliary equipment driving power (0.5 to 1.0%).

(2) Optimization of operating range of engine by means of:

Larger number of transmission gears (1.0 to 5.0%), tor-con (torque converter) AT (-9.0 to -4.0%), differential gear having a lower gear ratio (0.5 to 3.0%), direct coupling of the highest gear (0.5 to 3.0%)

(3) Others

Idling-stop (0 to 4.0%)

3. Evaluation of effect on fuel efficiency by working around exhaust gas emissions regulations

As for diesel engine driven heavy vehicles, estimate and evaluate adverse effects on fuel efficiency along with the introduction of technologies addressing exhaust gas emission, which is intended to reduce NOx and PM emission as well as which is necessary to comply with the 2009 exhaust gas emission regulation slated to take effect in 2009 or 2010. Specifically, the following exhaust gas emissions reduction technologies (and corresponding deterioration rates) have been taken into consideration.

(1) PM reduction technologies(▲ 2 to 3%)

1] Engine

Improved fuel injection system (higher injection pressure, etc.), and improved combustion chamber and intake system

2] Exhaust gas treatment technologies

Continuous regenerative DPF

(2) NOx reduction technologies (▲ 5 to 7%)

1] Engine

Improved EGR system (cooling and larger capacity), and improved fuel injection system (finer control of injection rate, etc.)

2] Exhaust gas treatment technologies

Occlusion type NOx reduction catalyst (LNT) and Urea-additive NOx reduction catalyst (SCR)

4. Effect of fuel properties on fuel efficiency

In the evaluation of improved fuel efficiency due to technological development and adverse effect on fuel efficiency due to exhaust gas emission regulations, it is supposed that the vehicles use commercially available diesel fuel containing sulfur of not greater than 10 ppm.

5. Setting target standard values of fuel efficiency

Based on the sections 1 through 4 above, the FY 2015 target standard values shall be defined as follows.

○Freight vehicle

<Other than tractor>

Category	GVW range (t)	Maximum load range (t)	Target standard values (km/l)
1	3.5<&≦7.5	≦1.5	10.83
2		1.5<&≦2	10.35
3		2<&≦3	9.51
4		3<	8.12
5	7.5<&≦8	−	7.24
6	8<&≦10	−	6.52
7	10<&≦12	−	6.00
8	12<&≦14	−	5.69
9	14<&≦16	−	4.97
10	16<&≦20	−	4.15
11	20<	−	4.04

<Tractor>

Category	GVW range (t)	Target standard values (km/l)
1	≦20	3.09
2	20<	2.01

○Passenger vehicles (riding capacity of 11 persons or more)

<Route bus >

Category	GVW range (t)	Target standard values of fuel efficiency (km/l)
1	6<&≦8	6.97
2	8<&≦10	6.30
3	10<&≦12	5.77
4	12<&≦14	5.14
5	14<	4.23

<Ordinary bus>

Category	GVW range (t)	Target standard values (km/l)
1	3.5<&≦6	9.04
2	6<&≦8	6.52
3	8<&≦10	6.37
4	10<&≦12	5.70
5	12<&≦14	5.21
6	14<&≦16	4.06
7	16<	3.57

<For information only>

With the target standard values given as above, assuming that the shipment rate of vehicles per category is the same in both FY2002 and the target year (FY2015), the fuel efficiency improvement rates (fuel efficiency weight-averaged by the shipment volume) when compared actual values in FY2002 to estimated values in FY2005 are shown in the following tables.

○Freight vehicle

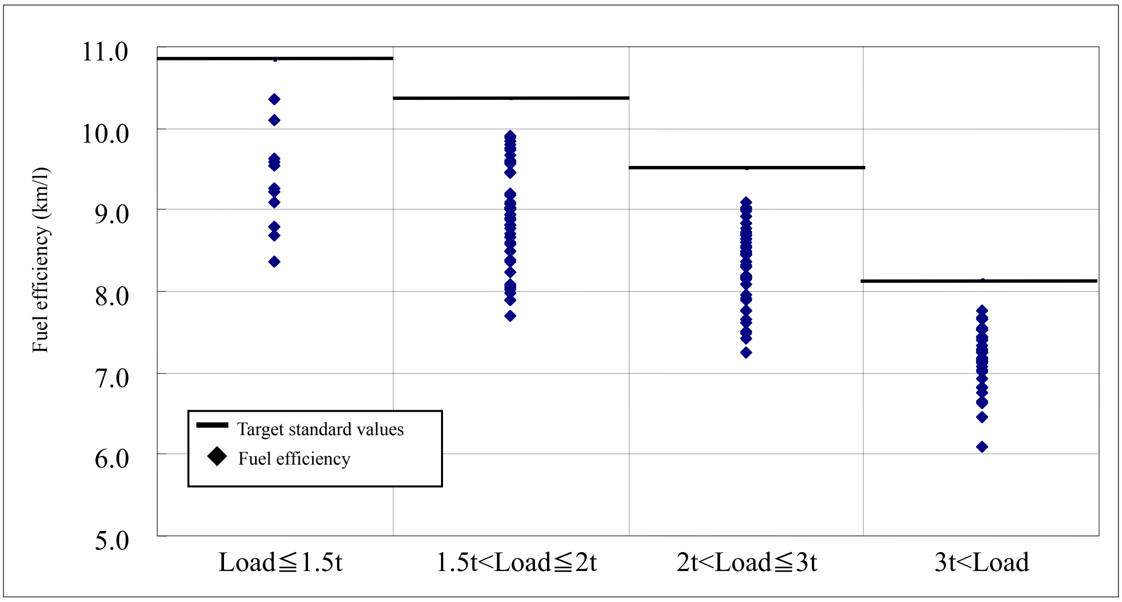
	2002 actual	2015 estimated	Fuel efficiency improvement rate
Other than tractor	6.56(km/l)	7.36(km/l)	12.2%
Tractor	2.67(km/l)	2.93(km/l)	9.7%
Total	6.32(km/l)	7.09(km/l)	12.2%

○Passenger vehicles (riding capacity of 11 persons or more)

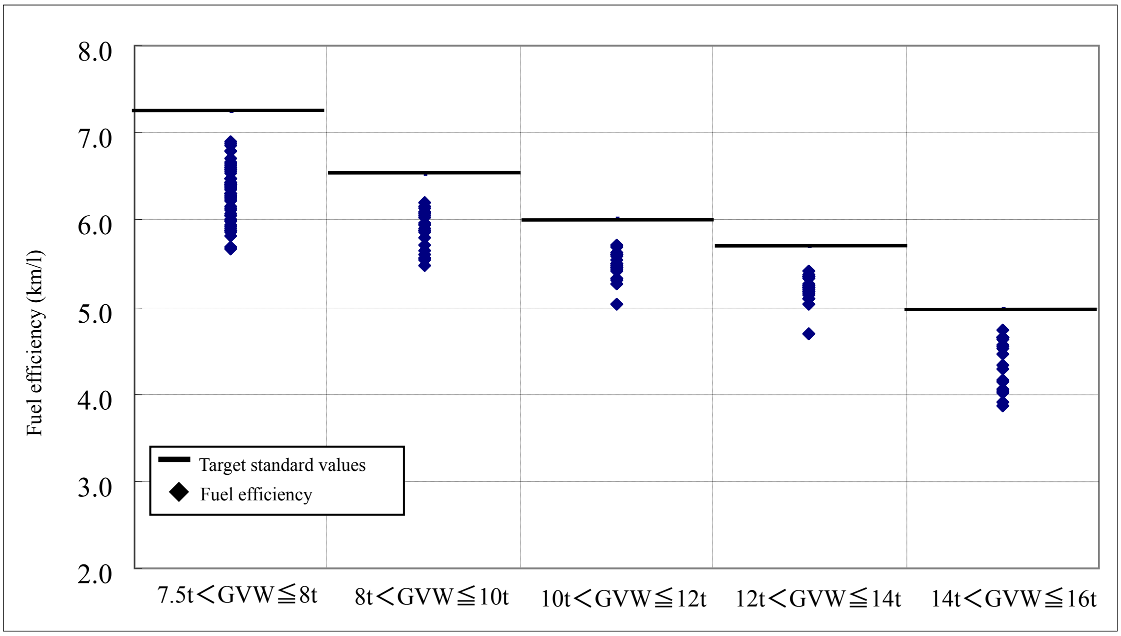
	2002 actual	2015 estimated	Fuel efficiency improvement rate
Route bus	4.51(km/l)	5.01(km/l)	11.1%
Ordinary bus	6.19(km/l)	6.98(km/l)	12.8%
Total	5.62(km/l)	6.30(km/l)	12.1%

(For information only) Actual fuel efficiency of heavy vehicles shipped in FY2002, and target standard values of fuel efficiency

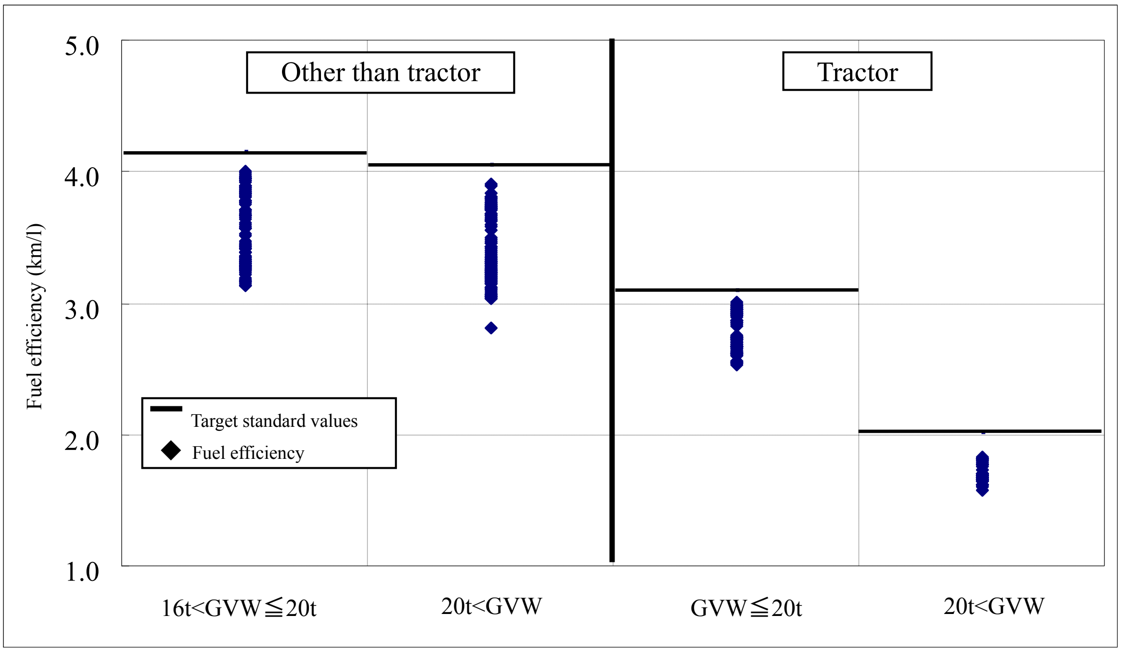
(1) Freight vehicle (other than tractor (GVW 3.5 to 7.5 tons))



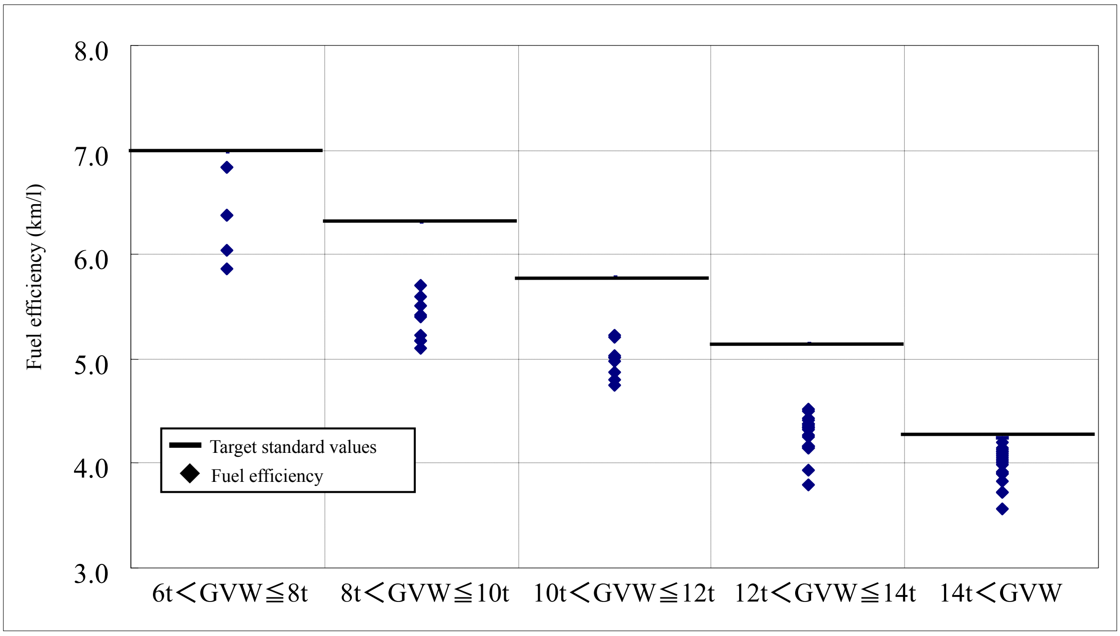
(2) Freight vehicle (other than tractor (GVW 7.5 to 16 tons))



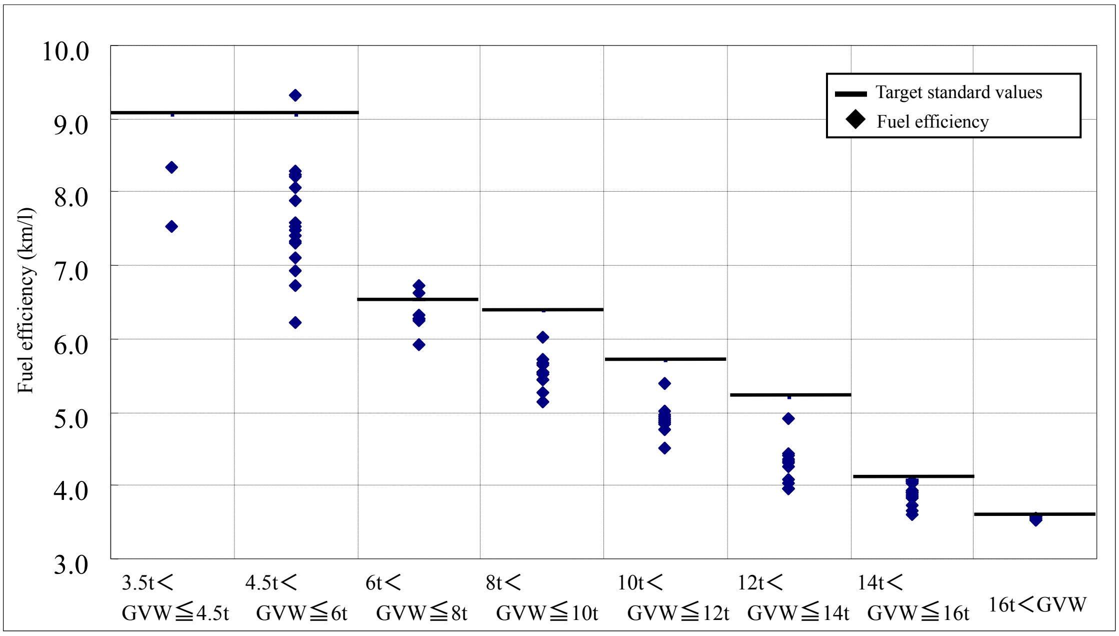
(3) Freight vehicle (other than tractor (GVW over 16 tons) and tractor)



(4) Passenger vehicles (riding capacity of 11 persons or more) (Route bus)



(5) Passenger vehicle (riding capacity of 11 persons or more) (Ordinary bus)



(Note) The target standard values shown above have been determined based on MT vehicles only. As for AT vehicles, these values are adjusted with fuel efficiency lowering factors in consideration of penetration of AT vehicles in the target year. Ordinary buses of 4.5t<GVW≦6t and 6t<GVW≦8t have lower target standard values than the 2002 Top Runner values (MT vehicle) since the penetration of AT vehicles is greater than those of other categories.

Attachment 6

Display Items

1. Items to be displayed

(1) Display items

Like other designated equipment under the Energy Conservation Law, the following items shall be displayed.

a. Vehicle name and type
b. Type, total displacement, maximum power and maximum torque of engine
c. Vehicle kerb weight
d. Transmission type, number of gears, and gear ratios
e. Fuel supply equipment type
f. Major measures for improving fuel efficiency
g. Energy consumption efficiency (fuel efficiency) (unit: km/l)
h. Manufacturer' name

(2) Display of fuel efficiency

1] Types of the fuel efficiency to be displayed.

As the item g. above, the heavy vehicle mode fuel efficiency shall be displayed.

* Heavy vehicle mode fuel efficiency (see Attachment 3)

This is a weight-averaged value of the fuel efficiency for driving in the urban drive (JE05) mode (Urban drive mode fuel efficiency) and that for driving in the interurban drive ("80 km/h constant speed & representative grade distribution") mode (Interurban drive mode fuel efficiency), by the factor set for each vehicle type in the following table.

Table Proportion of Drive Mode

	Passenger vehicles (riding capacity of 11persons or more)			Freight vehicles			
Vehicle type	Ordinary bus		Route bus	Other than tractor		Tractor	
GVW ragne	14 tons or less	Over 14tons		20 tons or less	Over 20 tons	20 tons or less	Over 20tons
Drive proportion Upper: urban mode Lower: interurban mode	0.9 0.1	0.65 0.35	1.0 0.0	0.9 0.1	0.7 0.3	0.8 0.2	0.9 0.1

2] Additional information to be displayed along with the fuel efficiency

1) Driving resistance

The fuel efficiency measuring method (simulation method) uses a unified driving resistance of a representative form (plain body) for each of fuel efficiency category, as a common "standard specification" for all manufacturers. Note: the driving resistance is one of the vehicle parameters needed for determining the engine revolution and torque in a conversion program.

Therefore, to prevent the consumers from misunderstanding the real meaning of the displayed value of fuel efficiency, its indication shall e.g. accompany a note "this fuel efficiency value was computed using the driving resistance of a standard form of vehicle body (plain body defined by complete vehicle kerb weight of X kg, maximum load of X kg (or riding capacity of X persons), full height of X m and full width of X m)."

2) Final reduction gear ratio and tire dynamic load radius

This fuel efficiency measuring method (simulation method) uses a final reduction gear ratio and tire dynamic load radius both of which have an actual V1000 value closest to the highest stage V1000 value calculated as an arithmetic mean of all vehicles (those filed for certification) that use the same engine and transmission.

Therefore, the indication of fuel efficiency shall e.g. accompany a note "this fuel efficiency is in case of the final reduction gear ratio of X and tire dynamic load radius of X m."

2. Compliance items

Like other designated equipment under the Energy Conservation Law, the following requirements shall be satisfied.

1] The display items specified by Section 1(1) above shall be indicated in the catalogs of the relevant heavy vehicles. In this case, the item g shall be indicated in such a manner that it stands out e.g. by underlining, using a large typeface, or changing the color of the characters.

2] To exhibit a heavy vehicle, all the items specified by Section 1(1) above shall be displayed clearly in an easy-to-see place.

3. Others

Vehicles under the category of "heavy vehicle" vary in terms of gross vehicle weight. Moreover, their intended use varies widely from "mainly for urban drive" to "mainly for expressway drive."

Therefore, to ensure that consumers are given more effective information, in addition to the heavy vehicle mode fuel efficiency, the following two types of fuel efficiency values may be displayed.

1) City drive mode fuel efficiency

This is the fuel efficiency in city drive mode (hereafter referred to as "city drive mode"), a type of modes defined in JEO5 referred as urban drive mode.

2) Interurban drive mode fuel efficiency

This is the fuel efficiency in a drive mode with constant speed of 80 km/h (on an expressway having a representative grade distribution), which is defined as interurban dive mode.

(Note) The target standard values are based on the "heavy vehicle mode fuel efficiency". Therefore, judgment on whether the target standards are achieved or not shall be evaluated with the weight averages of “heavy vehicle mode fuel efficiency” for each manufacturer and for each category (the abovementioned two optional fuel efficiency values will not be used for this evaluation).

Attachment 7

Heavy Vehicle Fuel Efficiency Standard Evaluation Group,

Heavy Vehicle Standards Evaluation Subcommittee,

Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy
History of Holding

1st Joint Meeting (September 2, 2004)
- Possibility of opening the discussions of the Automobile Standards Evaluation Subcommittee/Heavy Vehicle Fuel Efficiency Standards Evaluation Group to the public
- Overview of the present program regarding fuel efficiency standards
- Current status of heavy vehicles

2nd Joint Meeting (November 12, 2004)
- Range of target products
- Energy consumption efficiency and its measurement methods

3rd Joint Meeting (February 4, 2005)
- Energy consumption efficiency and its measurement methods
- Classifications for target standard value settings

4th Joint Meeting (June 27, 2005)
- Renaming the Joint Meeting
- Hearing from the automobile production and import trade organizations

5th Joint Meeting (September 6, 2005)
- Target fiscal year
- Approach to freight vehicles of GVW over 2.5t to 3.5t or less and passenger vehicles (riding capacity of 11 persons or more) of GVW 3.5 tons or less
- Fuel efficiency standard values
- Display items

6th Joint Meeting (September 22, 2005)
- Fuel efficiency standard values
- Interim report

Reception of public comments on the interim report (September 30, 2005)

7th Joint Meeting (November 10, 2005)
- Final report

Attachment 8

Heavy Vehicle Fuel Efficiency Standard Evaluation Group,
Heavy Vehicle Standards Evaluation Subcommittee,
Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy
List of Committee Members

Committee Chairman

Makoto Ikegami	Professor, Dept. of Engineering, Fukui University of Technology

Committee Members

Tsunemi Araki	Environmental Affairs Committee Member, Japan Trucking Association
Norimasa Ohtera	Managing Director, The Energy Conservation Center, Japan
Takeyuki Kamimoto	Professor, Future Science and Technology Joint Research Center, Tokai University
Risuke Kubochi (Kazutaka Obata up to the 3rd meeting)	Vice-Chairman, Japan Auto-Body Industries Association Inc.
Keizo Saito	Collaboration Coordinator, Collaboration Department, National Institute of Advanced Industrial Science and Technology (an Independent Administrative Institution)
Yasuhiro Daisho	Professor, School of Science and Engineering, Waseda University
Yoshiyasu Nao	Vice-Chairman and President, Japan Automobile Manufacturers Association, Inc.
Kazuo Nagai	Managing Director, Nihon Bus Association
Akira Noda	Director, National Traffic Safety and Environment Laboratory (an Independent Administrative Institution)
Yasuhiro Fukuma	Director, Japan Automobile Research Institute
Masatoshi Matsunami	President, Japan Automobile Federation
Masanobu Wada	Managing Director, Japan Automobile Importers Association