Reference 1

General Resources Energy Investigation Committee, Energy Savings Standards Section, Automobile Standards Judging Subcommittee

LPG Car Fuel Efficiency Standards Evaluation Group Final Report

This subcommittee and evaluation group convened discussions of items necessary to evaluate standards of LPG (liquid petroleum gas) car manufacturers and importers (hereinafter manufacturers) concerning energy consumption efficiency (fuel efficiency) of LPG cars. The final report is as below.

1. Target Scope (see Attachment 1)

LPG passenger cars that have received type designation under the Road Transport and Motor Vehicle Law (1951, Law No. 185) Article 75.1.

2. Prerequisite items, etc. for judgment standards of manufacturers, etc.

(1) Target fiscal year (see Attachment 2)

FY2010

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

Values shall be indicated in kilometers driven per one liter of fuel in the 10-15 Japanese test mode with values (inspection values) measured by the Minister of the Ministry of Land, Infrastructure and Transport for the type designation of cars.

(3) Classifications and Target Standard Values (see Attachments 4, 5)

For passenger cars shipped in Japan in the target year, LPG passenger car manufacturers, etc. shall not fall below the standard target values for energy consumption efficiency (fuel efficiency) measured by (2) and weighted and averaged by shipped units in each classification in the following table.

Classification (Vehicle Curb Weight) (kg)	-703	703 -827	828 -1,015	1,016 -1,265	1,266 -1,515	1,516 -1,765	1,766 -2,015	2,016 -2,265	2,266-
Target Standard Value (km/l)	15.9	14.1	13.5	12.0	9.8	7.9	6.7	5.9	4.8

(Reference)

The target standard values are set as above, and assuming the ratio of shipped units is the same for FY2010 as it was for FY2001, the improvement ratio of fuel efficiency is anticipated to increase from FY2001 actual performance values to 11.4%. However, if compared with FY1995, the standard fiscal year used for comparison concerning improvements in fuel efficiency standards for cars in broad outlines of global warming, the fuel efficiency improvement ratio is anticipated to be 10.1%.

(4) Indication items

①The items to be indicated are as below.

a. Car name and type
b. Engine type and displacement
c. Vehicle curb weight
d. Transmission type and number of speeds
e. Fuel supply equipment type
f. Main measures to improve main fuel efficiency
g. Energy consumption efficiency (use unit km/l and indicate to one decimal point)
h. Manufacturer name or abbreviation

②Compliance items

(a) The items for indication specified in ① are to be noted in catalogs concerning applicable LPG passenger cars. In this case, items carrying g. will be indicated in such a manner as to stand out such as by underlining, using a large typeface or changing the color of the characters.

(b) For LPG passenger cars presented for exhibition, the items for indication specified in ① shall be displayed clearly in an easy-to-see place.

<u>3. Comments, etc. concerning energy saving</u>

(1) Initiatives Government

① Efforts shall be undertaken by government support and spreading awareness, for example, to promote initiatives to increase the understanding of users and improve fuel efficiency improvements of manufacturers, etc. for the purpose of spreading LPG passenger cars, which have excellent fuel efficiency.

② Concerning putting judging standards into practice, considerations shall be made for energy saving efforts and emissions regulations measures of manufacturers, etc. and other circumstances as well to promote activities consistently so that their activities can lead to achieving the target standard values.

(2) Initiatives of manufacturers, etc.

① Technological developments to improve the fuel efficiency of LPG passenger cars shall be promoted and passenger cars with excellent fuel efficiency will be developed.

② To aim for the spread of LPG passenger cars that have excellent fuel efficiency, efforts will be made in providing appropriate information that is helpful to users so that they can select a LPG passenger car with excellent fuel efficiency; this includes evaluating the introduction of “energy saving labels”.

(3) User initiatives

Efforts will be made on selecting LPG passenger cars with excellent fuel efficiency, and on aiming for greater energy savings through appropriate and efficient use of LPG passenger cars themselves.

4. Details, etc. of evaluations

(1) Details of convening subcommittee/evaluation group (see Attachment 6)
(2) List of members (see Attachment 7)

Attachment 1

Thinking behind Necessary Scope

Passenger cars that have received type designation based on the Road Transport and Motor Vehicle Law

Currently, gasoline and diesel cars that are the target of fuel efficiency standards based on the Law concerning the Rational Use of Energy (hereinafter the Energy Saving Law) are passenger cars and freight vehicles with a curb weight of 2.5 tons or less that have received type designation based on Article 75.1 of the Road Transport and Motor Vehicle Law. Therefore, the target scope of LPG cars as well is those that have received type designation under the Road Transport and Motor Vehicle Law.

However, for LPG cars, at the current time there are no freight vehicles that have received type designation, so at this time only passenger cars are the target. As for freight vehicles though, evaluations will be made when they receive type designation in the future. (Incidentally, the gross units shipped in FY2001 of LPG cars (passenger cars and freight vehicles) was about 38,000 units, of which about 34,000 units had type designation, approximately 90% of the overall total.)

Furthermore, concerning modified cars, careful evaluations will be made in the future on their handling including clarifying responsibility and other issues in the Energy Saving Law concerning the party making the modifications.

Attachment 2

Thinking behind the Target Year

The target year for the achievement of target standard values shall be FY2010.

From the viewpoint of global warming countermeasures, it is essential that LPG cars which have achieved the target standard values be fully disseminated by the first commitment period (from 2008 to 2012) in the Kyoto Protocol, and it is desirable that the target standards be achieved as a short a time span as possible.

On the other hand, in the same way as with gasoline passenger cars, major improvements to the fuel efficiency of LPG cars and launching new models (with new engines, adopting new body structures, etc) are normal, and the new model cycle for LPG cars tends to be longer than regular passenger cars given that LPG cars are used mostly as taxis. Therefore, so that there is at least one opportunity for new models until the target year, it is necessary to consider setting it longer than the four to five years of the new model cycle for regular passenger cars.

Given the above, the target year for achievement of target standard values for LPG cars is set for FY2010.

Attachment 3

Thinking behind the Energy Consumption Efficiency (Fuel Efficiency) Measurement Method

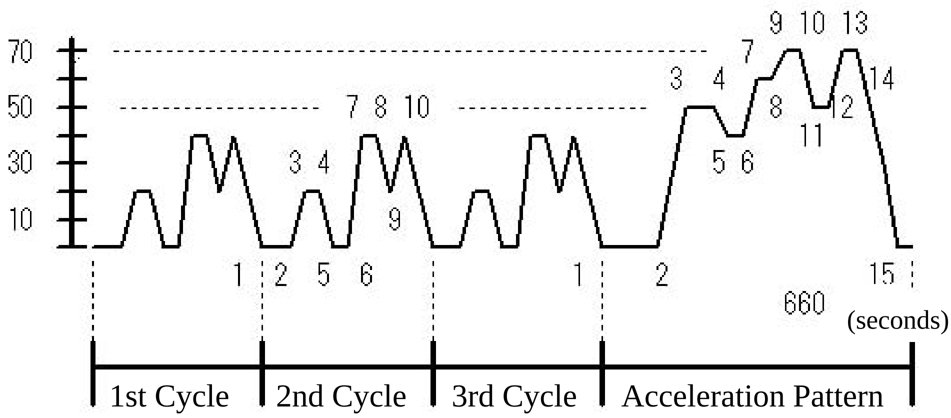
The 10-15 Japanese test mode shall be the measurement method.

The 10-15 Japanese test mode specified in the Road Transport and Motor Vehicle Safety Standards (1951 Ministry of Transport Law 67) Article 31.2, reflects metropolitan driving conditions such as traffic and metropolitan highway facilities based on driving performance studies in major metropolitan areas in Japan. This mode is currently being adopted to measure emissions of LPG cars.

The Japanese 10-15 mode is also currently used in measuring the energy consumption efficiency (fuel efficiency) of gasoline and diesel cars that are the target of the Energy Savings Law.

Given the above, the Japanese 10-15 mode has been adopted for energy consumption efficiency of LPG cars. Furthermore, the energy consumption efficiency (fuel efficiency) of LPG cars is a value indicated in kilometers of driving distance per one liter of fuel when driven in the 10-15 test mode, and the value (inspection value) measured by the Minister of the Ministry of Land, Infrastructure and Transport per car with type designation is appropriate.

Outline Schematic of the Japanese 10-15 Mode Cycle Based on Specifications of Article 31 of the Road Transport and Motor Vehicle Safety Standards



No. in Diagram	Acceleration	Time (seconds)
1	Idling	20
2	Acceleration 0→20 km/h	7
3	Fixed acceleration 20 km/h	15
4	Deceleration 20→0 km/h	7
5	Idling	16
6	Acceleration 0→40 km/h	14
7	Fixed acceleration 40 km/h	15
8	Deceleration 40→20	10
9	Fixed acceleration 20 km/h Acceleration 20→40	2 12
10	Deceleration 40→20 Deceleration 20→0 km/h	10 7

[City Area Pattern]

No. in Diagram	Acceleration	Time (seconds)
1	Idling	65
2	Acceleration 0→50 km/h	18
3	Fixed acceleration 50 km/h	12
4	Deceleration 50→40 km/h	4
5	Fixed acceleration 40 km/h	4
6	Acceleration 40→60 km/h	16
7	Fixed acceleration 60 km/h	10
8	Acceleration 60→70 km/h	11
9	Fixed acceleration 70 km/h	10
10	Deceleration 70→50 km/h	10
11	Fixed acceleration 50 km/h	4
12	Acceleration 50→70 km/h	22
13	Fixed acceleration 70 km/h	5
14	Deceleration 70→30 km/h Deceleration 30→0 km/h	20 10
15	Idling	10

[Acceleration Pattern]

Note: Japanese 10-15 Mode Test: Reflects driving conditions on Japanese roads and the car is driven along the mode on a chassis dynamometer, which measures emissions. Four cycles are measured with one cycle in the 15 mode added to the 10 mode.

Attachment 4

Thinking behind Classification for the Purpose of Setting Target Standards

Classification will be set according to emissions and common equivalent inertia weight.

(1) Emissions and vehicle curb weight are interrelated, so it is appropriate that the index for classification settings of target standard values is vehicle curb weight.

(2) For emission measurements, implemented in type designation inspections based on the Road Transport and Motor Vehicle Law Article 75, a car is driven on a chassis dynamometer using equivalent inertia weight, and measured by having it drive on top. By using it for emissions measurements and common classifications, evaluations of emissions and fuel efficiency can be done at the same time to engage in effective environmental measures. Combined with this, by measuring emissions and fuel efficiency at the same time, it is also possible to aim at easing the burden of manufacturers, etc.

(3) Classifications are set by emissions measurements and common equivalent inertia weight for gasoline and diesel cars that are already the target of energy consumption efficiency (fuel efficiency) standards based on the Energy Savings Law.

Given the above, classifications for the purpose of setting target standard values for LPG cars will be classified by emissions measurements and common equivalent inertial weight.

Relationships between Vehicle Curb Weight, Test Vehicle Curb Weight and Equivalent Curb Weight

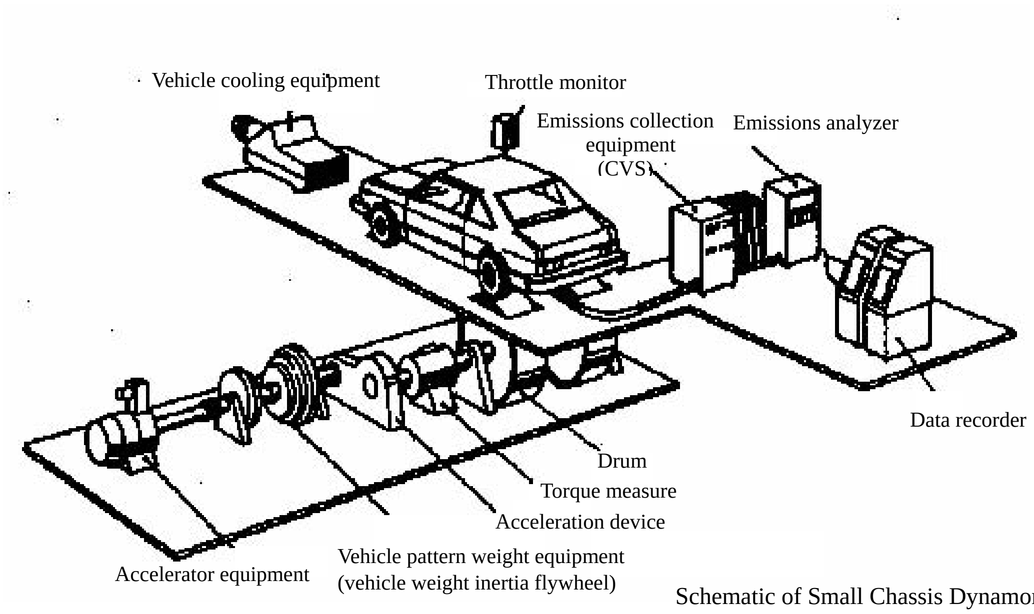
Vehicle Curb Weight (kg)	Test Vehicle Curb Weight (kg)	Equivalent Inertia Weight Standard Values (kg)
- 452	- 562	500
453- 577	563- 687	625
578- 702	688- 812	750
703- 827	813- 937	875
828- 1,015	938-1,125	1,000
1,016-1,265	1,126-1,375	1,250
1,266-1,515	1,376-1,625	1,500
1,516-1,765	1,626-1,875	1,750
1,766-2,015	1,876-2,125	2,000
2,016-2,265	2,126-2,375	2,250
2,266-2,515	2,376-2,625	2,500
2,516-2,765	2,626-2,875	2,750
2,766-3,140	2,876-3,250	3,000
less than 500kg skipped	less than 500kg skipped	less than 500kg skipped

Test Vehicle Curb Weight＝Vehicle Curb Weight (kg)＋110 (kg)

(Reference) Equivalent Inertia Weight

When measuring emissions in the test facility, a chassis dynamometer is used to recreate actual road conditions, but to recreate the inertia of the car's curb weight, a flywheel is used. The flywheel used is set to the various kinds of curb weights depending on the range of the curb weight of the vehicle being tested. The set flywheel weight is called the equivalent inertia weight.

Use is based on regulations in Attachment 24 gasoline car 10-15 Japanese test mode emissions measurement technology standards in the "Concerning Enactment of Technology Standards as part of the partial revision of the Road Transport and Vehicle Safety Standards" (former Ministry of Transport Automobile Agency (Automobiles No. 899.2, Oct. 1, 1983)



Schematic of Small Chassis Dynamometer

Attachment 5

Thinking behind Setting Target Standard Values

(1) For the target standard values of LPG passenger cars in the 1,266-1,515kg (equivalent inertia weight of 1,500kg) class of type designated cars, the focus is on currently commercially available passenger cars with the best fuel efficiency (top-runner cars), taking into consideration such items as improvements in fuel efficiency through technology improvements, effects on fuel efficiency by emissions regulations and fuel characteristics.

(2) When setting the target standard values, no classification is made for automatic transmission cars (AT cars) and manual transmission cars (MT cars); the policy is to use the fuel efficiency of AT cars as the base, and considering the launch ratio in the target year of MT cars, that is thought to be a cause for improvement in the target standard values.

(3) For non-type designated cars and other curb weight classifications, the base target standard value classification will be the curb weight of 1,266-1,516, in consideration of that being the target standard value for gasoline passenger cars.

Target Standard Values for LPG passenger cars

Classification (curb weight)	-702	703 -827	828 -1015	1016 -1265	1266 -1515	1516 -1765	1766 -2015	2016 -2265	2266-
Target standard value (km/l)	15.9	14.1	13.5	12.0	9.8	7.9	6.7	5.9	4.8

1. Concerning target standard value settings in type designated car classifications

Currently, LPG car models receiving type designation are only passenger cars with a curb weight classification of 1,266-1,515kg (equivalent inertia weight of 1,500kg), and as the target standard values in the applicable classifications are based on the “top-runner system” approach, it was decided upon to focus on currently commercially available passenger cars with the best fuel efficiency, taking into consideration such items as improvements in fuel efficiency through technology improvements, effects on fuel efficiency by emissions regulations and fuel characteristics.

(1) Primary factors in fuel efficiency improvements

Given expectations for technologies considered when setting standards for gasoline passenger cars and their fuel efficiency improvement ratio, a hearing was held with manufacturers, etc. concerning characteristics and related issues of LPG passenger cars, the set fuel efficiency improvement technology and fuel efficiency improvement ratio for LPG passenger cars was set as below. However, for these technologies, though they are not immediately applicable to all models, they are in combination with forecasts of future deployment ratios for target standard value settings.

	Fuel efficiency improvement ratio (%)	Deployment ratio (%)	Reflection in target standard values (%)	Calculation approach, etc.
Primary factors in fuel efficiency improvements			**8.8**	
①Engine improvements			5.4	
Switch to 4-valve/combustion chamber improvements	1.5	100	1.5	Given estimates of fuel efficiency improvements when establishing target standard values for gasoline cars, highest estimated values applicable for current LPG cars adopted.
Variable-valve timing	0.5	100	0.5	Some technology already deployed in LPG cars; highest values adopted on that assumption.
Electronic control fuel injection equipment	2.0	100	2.0	Given estimates of fuel efficiency improvement when establishing target standard values for gasoline cars, highest values adopted for AT LPG cars.
Idle revolution reduction	1.5	90	1.4	The highest values estimated in current LPG cars are adopted. The deployment ratio is set given that there is technology not compatible with idling-stop equipment
② Air-resistance reduction	0.5	100	0.5	For gasoline cars, a max. fuel efficiency improvement is possible, however with use restrictions of LPG cars to taxis, 0.5% is adopted.
③Engine loss, etc. reduction			1.0	
Improve AT	0.5	100	0.5	Some technology already deployed in current top-runner cars, highest value adopted on that assumption.
Switch to high-gear	1.0	50	0.5	Current LPG cars differential ratio assumed to be one rank lower and improvement ratio set. However, since even if applicable technology is deployed, about half the cars will have no fuel efficiency benefits, so deployment ratio is set at 50%.
④ Other improvement technologies			0.9	
Idling-stop equipment	9.0	10	0.9	Fuel efficiency improvement ratio is an actual measurement value. Equipment deployment ratio in LPG cars is currently under 1%. By FY2010, deployment is expected to be around 10% at most.

⑤ Fuel efficiency improvements by launching MT cars	10.0	10	1.0	Given expected spread of MT cars noted below in 2., the ratio is set at around 10% at the highest by 2010.
Primary factors in degraded fuel efficiency			**-3.0**	
①Measures for new long-term emissions regulations	-2.5	100	-2.5	Portion of technology already deployed in current top-runner cars to bring down fuel efficiency, and lowest values adopted on that assumption.
②Safety measures	-0.5	100	-0.5	Considering pedestrian protection regulations expected in the future and degraded fuel efficiency from off-set front collision regulation measures, lowest values adopted on that assumption.
Total			**5.8**	

While these have been adopted as primary factors for improving fuel efficiency when establishing target standard values for gasoline passenger cars, the technologies not adopted for establishing standards of LPG passenger cars are listed below.

1) Due to the boiling point of LPG being close to normal temperature and difficulty in securely maintaining a liquid or gaseous state given the fuel's characteristics, it is complicated to create a safe composite mixture in the combustion chamber for various conditions given the fuel characteristics. Therefore, direct injection engines are not anticipated to be applicable for LPG engines.
2) For reducing friction, independent fuel efficiency improvements upon adopting 4-valve or variable-valve timing are not expected.
3) As for adopting the use of lightweight materials in the chassis, taking the example of seeking durability and reliability of 500,000km for a taxi, which is several times more than for ordinary gasoline passenger cars, achieving the same certain level of durability and reliability at the 50,000km level with lightweight alloys and resin materials is not anticipated, and from economy in costs as well, application to LPG passenger cars is difficult.
4) As for adopting a chassis lightweight drive structure, securing durability and reliability on the 500,000km level are not anticipated and since the equipment requires even more maintenance than normal taxis, the possibility for acceptance by users is low. Furthermore, if one considers that current taxis have no need for front-wheel, forward-drive setups and other reasons, application to LPG cars is difficult.
5) As for adopting low skid low resistance tires, for the long driving distances of LPG passenger cars, an essential element on which the most focus is on is costs and securing durability in terms of strength and wear, but improvements in material quality and composition that aim for low-skid low resistance to support taxi durability and reliability are difficult.
6) AT lockup region expansion (flex-lockup system used in gasoline passenger cars) is difficult to apply to LPG passenger cars since securing durability at the 500,000km level of the lockup clutch is not anticipated.
7) Use of a continuously variable transmission (CVT) is difficult to apply to LPG cars since securing durability at the 500,000km level from the point of the durability of the metal belt is not anticipated.
8) As for the use of electric power steering, newly structured electric power steering that enables applicability for cars other than light cars is not anticipated to secure durability and reliability at the 500,000km level and is difficult to apply to LPG cars.
9) As for A/F feedback three-way catalytic converters, electronic ignition equipment, high compression ratios and OHCs, these are technologies already being adopted in top-runner cars among current LPG passenger cars and are not included as primary factors for fuel efficiency improvements in LPG passenger cars in the future.

(2)Primary factors in effects on fuel efficiency

1) Measures for emissions regulations

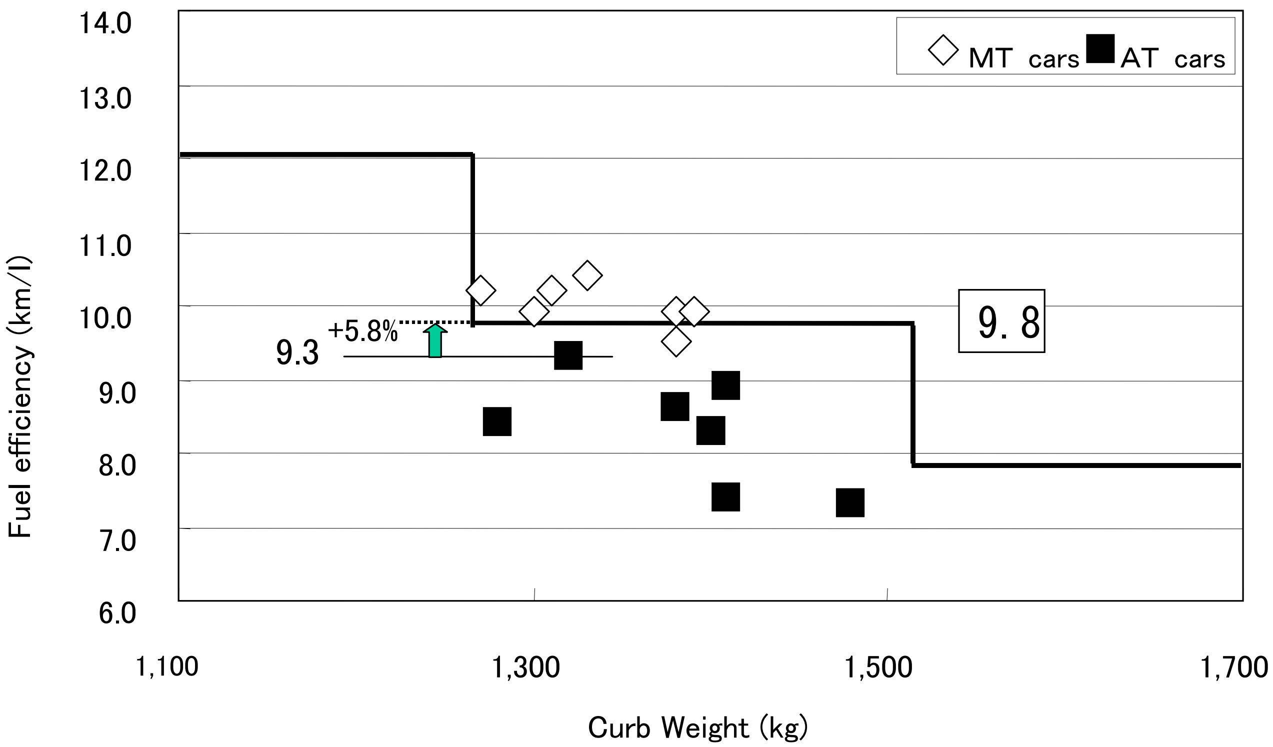
In order to respond to emissions regulations anticipated by 2005 (new long-term emissions regulations), degraded combustion arising from readapting ignition periods to reduce NOx as well as rises in exhaust back pressure due to catalyst improvements (volume increases, etc.,) are considered to have effects on worsening fuel efficiency.

2) Responses to safety regulations

Combustion is considered to degrade given weight increases due to responses to pedestrian protection regulations and off-set front collision regulations expected in the future.

Given the above, the target standard value is 9.8km/l for passenger cars with a curb weight classification of 1,266-1,515kg (equivalent inertia weight 1,500kg)

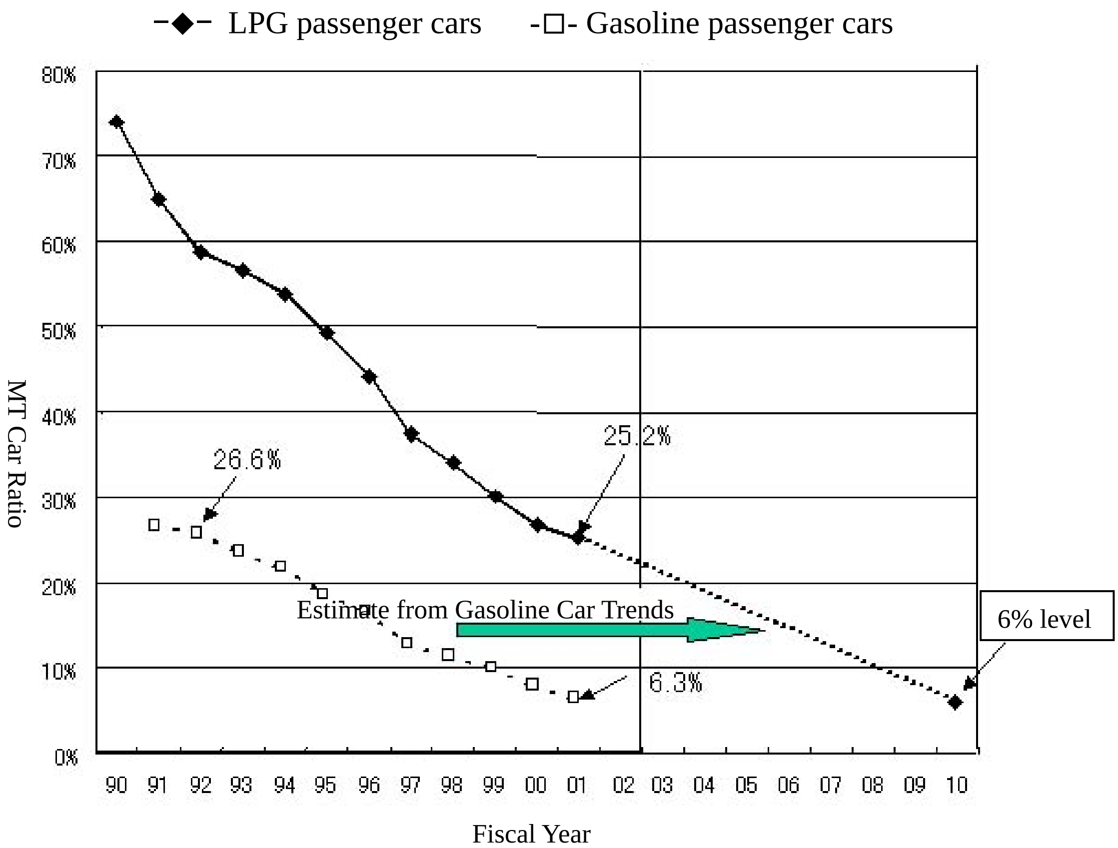
Target Standard Values in the Curb Weight 1,266-1515kg Classification



2. Handling of AT and MT cars

In the future, the ratio of MT cars among LPG passenger cars can be expected to decrease, therefore the target standard values of LPG passenger cars have not been classified into AT and MT cars. The energy consumption efficiency (fuel efficiency) of AT cars serves as the base and given consideration of the deployment ratio of MT cars in the target year, considerations were made as improvement reasons of standard target values.

Forecast of MT Ratio of LPG passenger cars



3. Target standard value settings in classifications not existing in type designated cars

Among classifications not existing in currently type designated cars, the target standard values that are set for classifications not existing in current type designated cars are appropriate for type designated cars considered to have a relatively high possibility of existing.

Furthermore, concerning basic composition and fuel efficiency improvement technologies, etc. of LPG passenger cars, the fuel used is different, but since it is generally similar to that used in gasoline passenger cars, the target standard values of curb weight classifications of LPG passenger cars in which type designated cars do not currently exist, and the calculations from target standard values of gasoline passenger cars of the same curb weight classification are appropriate. As the following equation specifically shows, the target standard value classification of the curb weight 1266-1515kg of which type designated LPG passenger cars exist is calculated from the ratio of standard target value of gasoline passenger cars in the same curb weight classification (curb weight 1266-1515kg) with the calorific values in LPG.

$$\text{Each classification's target standard value} = A \times \frac{9.8 \text{ (Target standard value of LPG passenger cars with curb weight of 1266-1515kg)}}{10.2 \text{ (target standard value of gasoline passenger cars with curb weight of 1266-1515kg converted to calorific value of LPG)}}$$

However, A: target standard value of gasoline passenger cars in each classification is value converted to calorific value of LPG.

The results below are the settings of target standard values for LPG passenger cars.

LPG Passenger Cars Target Standard Values

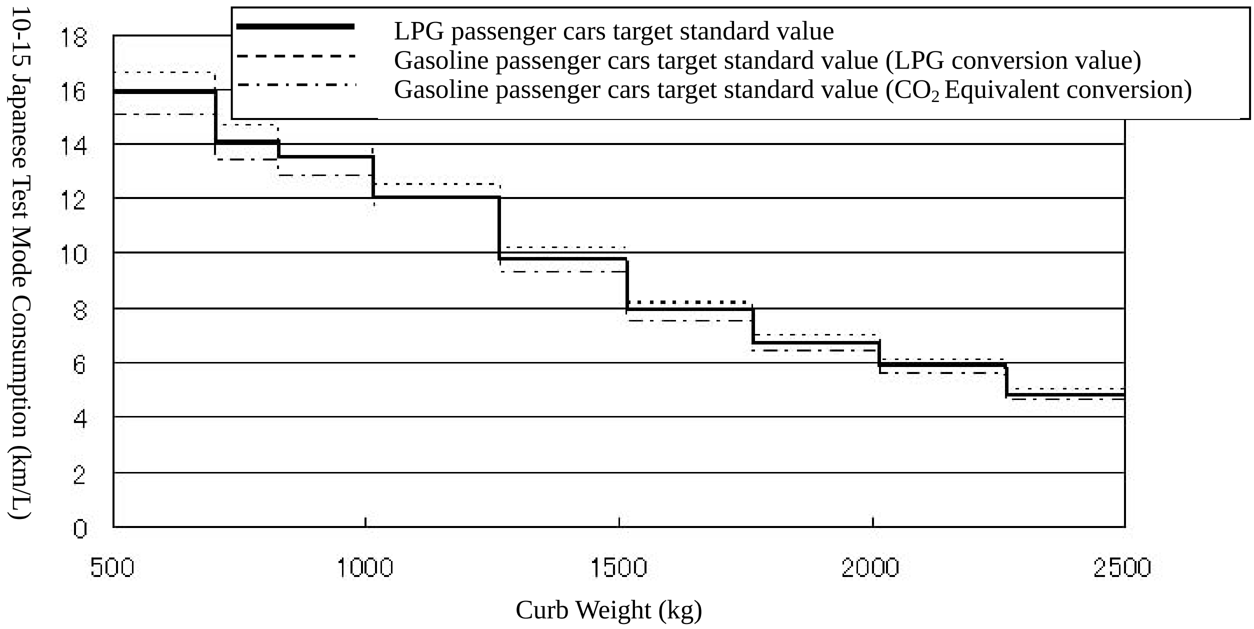
Classification (Curb weight kg)	-702	703 -827	828 -1015	1016 -1265	1266 -1515	1516 -1765	1766 -2015	2016 -2265	2266-
Target standard value (km/l)	15.9	14.1	13.5	12.0	9.8	7.9	6.7	5.9	4.8
Emission of CO2 per 1 km driving (g-CO2/km)	104	118	123	138	169	210	247	281	345

(Reference) Gasoline Passenger Cars Target Standard Values

Classification (curb weight kg)	-702	703 -827	828 -1015	1016 -1265	1266 -1515	1516 -1765	1766 -2015	2016 -2265	2266-
Target standard value (km/l)	21.2	18.8	17.9	16.0	13.0	10.5	8.9	7.8	6.4
LPG calorific value conversion (km/l)	16.6	14.7	14.0	12.5	10.2	8.2	7.0	6.1	5.0
CO_2 equivalent conversion (km/l)	15.1	13.4	12.8	11.4	9.3	7.5	6.4	5.6	4.6
Emission of CO2 per 1 km driving (g-CO2/km)	109	123	130	145	179	221	261	298	363

1. LPG calorific value conversion=0.782 x Gasoline passenger car target standard value
2. CO_2 equivalent conversion=0.714 x Gasoline passenger car target standard value

LPG Passenger Car Target Standard Value and Gasoline Passenger Car Standard Conversion Values



(Reference 1)

Trial Calculations concerning Improvements in Energy Consumption Efficiency (Fuel Efficiency)

Combined with the introduction of LPG passenger car target standard values, the energy consumption ratio (fuel efficiency) improvement ratio calculated from actual values in FY2001 and estimated values of 2010 is as below.

FY2001 Actual Results Values	FY2010 Estimated Values	Improvement Ratio
8.8km/l	9.8km/l	11.4%

However, as a prerequisite, the number of units and composition shipped in FY2010 is set as the same as FY2001. When actual performance values (8.9km/l) in FY1995, the standard fiscal year used for comparison concerning improvements in fuel efficiency standards for cars in broad outlines of global warming, are compared using the same method as FY2010 estimated values, the fuel efficiency improvement ratio is calculated to be 10.1%.

(Reference 2)

Technology Trends of LPG Cars and Current Trends in Energy Saving Technology and Predictions for the Future

1. Technology Trends

LPG cars were introduced in a form that historically improved on gasoline cars. Initially, among taxis to which LPG cars were introduced, LPG from the fuel cylinder was vaporized via a vaporizer, but a system was later adopted that supplied fuel to the engine via a mixer attached as a substitute to the vaporizer. After that, combined with the strengthening of emissions regulations, fine control of fuel supply by electronic control in order to adopt three-way catalytic converters was sought, and a switch was made to a mixer system with feedback control.

In the future, for the purpose of extremely fine control of the air-fuel ratio to respond to even stronger emissions regulations and to improve filling efficiency and fuel efficiency, trends are heading toward development and deployment of electronic control fuel injection equipment (multi-point injection; MPI). Because cars are outside the target of regulations since the High Pressure Gas Safety Law was revised in 1999, it is expected that rather than vaporizing injection systems, systems that inject pressurized liquid will become mainstream. In this way, the same kind of MPI systems already widely adopted in gasoline cars can be used, and they are expected to contribute to even greater fuel efficiency and reductions in emissions.

2. Current State of Energy Saving Technology and Future Prospects

As responsive measures to improving energy usage or efficiency to improve fuel, efficiency the following are given:

- Improves energy efficiency
- Reduced driving resistance (reduced air resistance, etc.)
- Reduced drive loss (improved transmission efficiency, etc.)
- Promotion of lightweight chassis

However, regarding structure and equipment of LPG cars, it is expected that in the future as well aims will be made for stronger safety standards to prevent accidents and reduce injuries when accidents happen. For the prevention of air pollution and reduction of roadside noise, stronger pollution prevention regulations concerning car emissions and noise are expected to be successively adopted. The technologies that will respond to these measures together with increases in the curb weight and energy consumption, etc, it is difficult to balance engine combustion technology related directly to improving fuel efficiency.

Therefore, concerning LPG car fuel efficiency measures and improvements, it is necessary to consider enabling the appropriate adoption of necessary technology for securing car safety and preventing pollution, etc.

(1) Primary factors for improvements in fuel efficiency through engine improvements

The primary factors for fuel efficiency in the engine are as follows.

1) Reduction of pump loss

When the fuel-air mixture is pumped in the intake stroke to the engine, a heavy load of work is done (pump loss). Valid methods to reduce this pump loss include optimization of the intake/exhaust valve opening and closing times of the variable valve timing mechanism.

2) Improvement of thermal efficiency

Improvements of the engine's thermal efficiency through higher compression ratios, improvements in combustion and so on. Changing to four valves, improving combustion chamber types and the like are being adopted to improve combustion.

(2) Main technologies to improve fuel efficiency

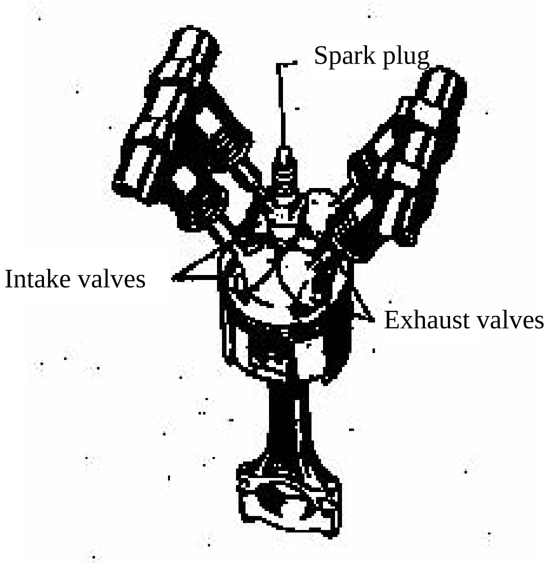
1) Valve control system

(a)Changing to four valves/combustion chamber improvements

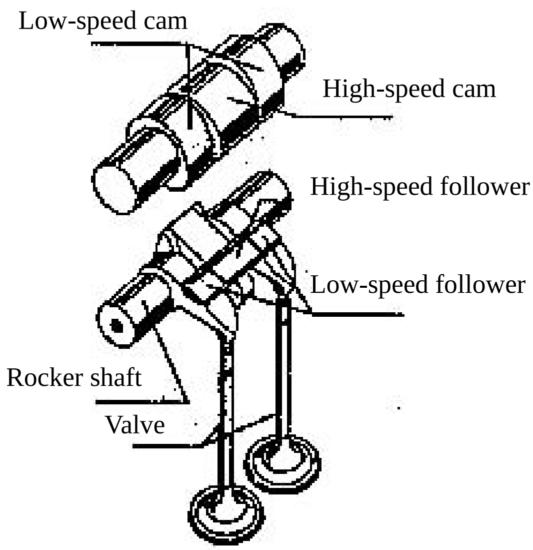
Changing to four valves increase the intake values to two and exhaust valves to two. By expanding the path for the fuel-air mixture and emissions, the volumetric efficiency is increased and pumping loss decreased. Along with these improvements, the central position of the ignition in the combustion chamber leads to combustion improvements. At the same time, by improving the shape of the combustion chamber and so on, combustion is sped up, thermal efficiency increased, and knocking controlled, securing optimal ignition periods.

(b)Variable valve timing

A system that controls the most suitable opening and closing timing depending on various driving conditions by varying the opening and closing timing of the intake and exhaust valves. While the high-speed revolution region receives high output, the low/mid revolution raises the torque in combination with the gear ratio, increasing fuel efficiency. The EGR (exhaust gas recirculation) volume is increased, pumping loss reduced and fuel efficiency increased.

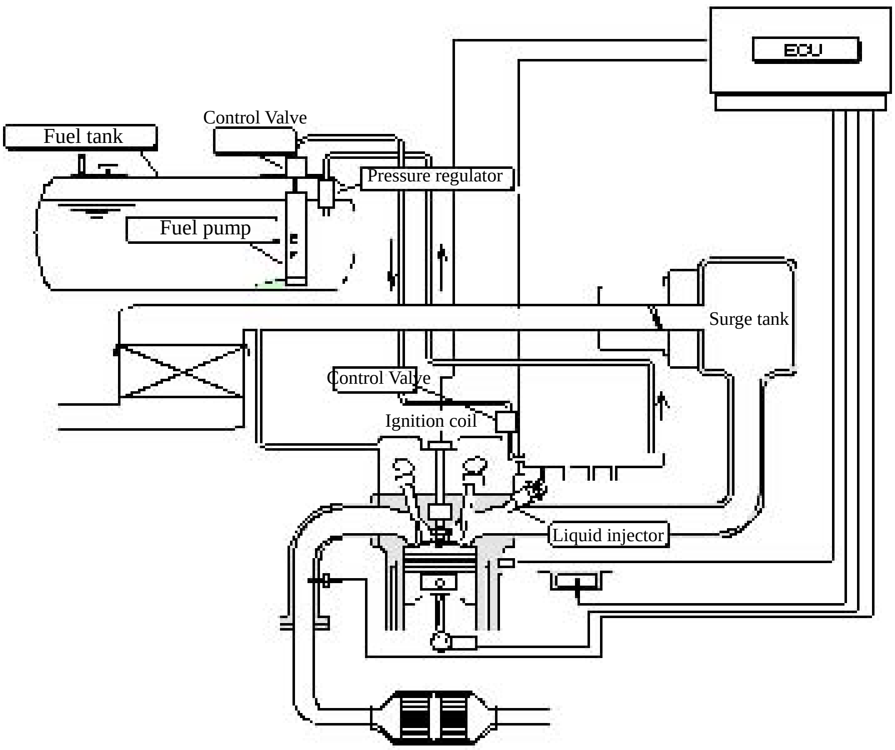


●Four valve combustion chamber



2) Electronic control fuel injection equipment (MPI)

System that injects fuel in liquid and gaseous states to each valve, enabling precise fuel control. Improvements in fuel efficiency can be aimed for by output improvements through increasing filling efficiency, expansion of fuel-cut region when decelerating, and improvements in distribution properties of fuel among the valves.



LPG Electronic Fuel Injection System (liquid injection)

3) Reducing idling revolutions

Technology exists to reduce the fuel consumption amount by reducing the number of revolutions during idling, and it is necessary to have combustion improvements, precise fuel control and vibration measures and so on in order to secure safe revolutions.

4) Reducing air resistance

Air resistance can be reduced by making improvements to the body shape.

5) AT Improvements (including electronic technologies)

Regarding AT, improving the efficiency of the torque converter (transmission equipment that uses fluids to convert torque), best shift control through using electronic control and expansion of the lockup region increases fuel efficiency.

6) Switching to high-gear

In aiming to improve engine output, fuel efficiency can be improved by reducing engine friction through lowering the gear ratio of the differential and reducing the number engine revolutions used. However, there are also models that have optimal points in the relationship with the engine's optimal fuel efficiency region and driving performance, and have no fuel efficiency improvement effects

7) Idling Stop Equipment

System to stop engine idling automatically when vehicle is stopped and restart it automatically when it starts moving. With it actual driving fuel efficiency improvements can be aimed for.

(3) Primary factors requiring attention when establishing target standard values

1) Measures for emissions regulations

Effects on fuel efficiency are inevitable from combustion degrading from readapting ignition times to reduce NOx and catalyst improvements (increase in volume, etc.) in order to respond to emission regulations (new-long term emissions regulations) expected by 2005. Furthermore, in the case of being used as taxis, since they drive long distances above endurance distances (80,000km), it is necessary to fully consider catalyst reliability and durability in response to these measures.

2) Responses to safety regulations

Curb weight increases to respond to pedestrian protection regulations and offset frontal collision regulations will result in effects on fuel efficiency.

(4) Technology adopted for the reason of improving fuel efficiency when establishing target standard values for gasoline passenger cars that cannot be anticipated to be a primary factor in improvements in fuel efficiency in LPG passenger cars

1) Direct injection engine

Engine that directly injects fuel into the cylinders. Uses an even leaner fuel-air mixture by stratifying the mixture and combusting it to improve fuel efficiency performance. It uses an extremely rarefied region with a mixture up to 40-50:1.

2) Reducing friction

Technology that reduces sliding portions in friction loss such as pistons, cranks, valves, etc, in aiming to improve fuel efficiency. While methods can be considered to reduce piston ring tension and sliding areas, it has effects on durability and other area. Meanwhile, if four valves or variable-valve timing technology and the like are adopted, since it increases friction, this is not anticipated as having fuel efficiency effects alone.

3) Adoption of lightweight materials in body

Fuel efficiency is improved by adopting lightweight materials such as lightweight alloys, resin materials and so on, lightening the overall vehicle weight.

4) Adoption of chassis lightweight drive structure

Using a front engine, front drive (FF) structure eliminates the need for a propeller shaft throughout the body, leading to improved fuel efficiency.

5) Adoption of low rolling resistance tires

Reducing the tires' rolling resistance coefficient through improved materials and composition reduces driving resistance and aims to increase fuel efficiency.

6) Expansion of AT Lockup Region

Expands the flex lockup region by having the lockup clutch affected by a minute slip (flex lockup) by precise control in the transmission equipped with a lockup clutch for direct connection as necessary with torque converter the purpose of avoiding slipping loss and input/output axle, and aims to increase fuel efficiency.

7) Adoption of Continuously Variable Transmission(CVT)

Automatic transmission that enables the active use of the best fuel regions in the engine without stages together with reducing slip loss by the belt drive. The optimum gear ratio is set according to driving conditions, and improvements in the fuel efficiency ratio can aimed for.

8) Adoption of Electric Power Steering

Originally, engine movement was always controlled with oil pumps, but with the use of electronics, control is possible so that energy is used only as necessary, improving fuel efficiency.

9) A/F Feedback Three-way Catalytic Converter

A system to detect the oxygen density level in the valve using an O_2 sensor and control the fuel volume and precisely control the theoretical air-fuel ratio with that feedback.

10) Electronic Ignition Equipment

Setting that enables optimum ignition timing according to driving conditions, improving fuel efficiency. Even among electronic ignition equipment, knock control systems detect the occurrence of knocking and control ignition timing, enabling driving with higher compression ratios and optimum ignition timing.

11) High Compression Ratio

The theoretical thermal efficiency ratio is improved by raising the compression ratio. Meanwhile, since it prevents abnormal combustion such as knocking, it is necessary to have combustion chamber improvements and use high-octane fuel.

12) Switch to OHC

Structure that positions the cam shaft over the cylinder heads, opening and closing the valves. Compared to the original OHV system with the original camshaft position on the cylinder block, it is possible to aim for high revolutions and high output, therefore improving fuel efficiency by low exhaust volumes in the same output.

Attachment 6

General Resources Energy Investigation Committee, Energy Savings Standards Section, Automobile Standards Judging Subcommittee
LPG Car Fuel Efficiency Standards Evaluation Group Interim Report
Session Details

1st Subcommittee/Evaluation Meeting (September 10, 2002)

- Setup of subcommittee
- Basic approaches concerning establishment of judgment standards and revisions
- Current status of LPG cars
- Target scope

2nd Subcommittee/Evaluation Group (November 12, 2002)

- Target scope
- Energy consumption efficiency and its measurement methods
- Classifications for target standard value settings
- Target standard values and target fiscal year

3rd Subcommittee/Evaluation Group (December 11, 2002)

- Target standard values
- Disclosure
- Interim Report

Invitation for public comment on the interim report (December 25, 2002).

4th Subcommittee/Evaluation Group (February 18, 2003)

- Final Report

Attachment 7

General Resources Energy Investigation Committee, Energy Savings Standards Section,
Automobile Standards Judging Subcommittee
LPG Car Fuel Efficiency Standards Evaluation Group
List of Committee Members

Committee Chairman	
Makoto Ikegami	Professor, Dept. of Engineering, Fukui University of Technology
Committee Members	
Norimasa Ohtera	Managing Director, The Energy Conservation Center, Japan
Matsuo Odaka	Environment Energy Section Chief, National Traffic Safety and Environment Laboratory (an Independent Administrative Institution)
Takeyuki Kamemoto	Professor, Department of Engineering, Tokai University
Hirofumi Kitamura	Committee Chairman, Vehicle Materials Committee, National Passenger Automobiles Association
Kazutaka Obata	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)
Narimasa Suzuki	Director, Japan Trucking Association
Takao Suzuki	Vice Chairman and Managing Director, Japan Automobile Manufacturers Association, Inc.
Yasuhiro Daisho	Professor, Science and Engineering, Waseda University
Yasuhiro Fukuma	Director, Japan Automobile Research Institute
Masatoshi Matsunami	Executive Director, Japan Automobile Federation
Shun Wakiyama	Executive Director, Japan Automobile Importers Association