HDV fuel efficiency regulation background and implementation to date

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Ministry of Land, Infrastructure, Transport and Tourism (MLIT)  
Japan
Today’s Contents

1. Background
2. Test procedure
3. Target Value and Improvement
4. Integrated Approach
1. Background

2. Test procedure

3. Target Value and Improvement

4. Integrated Approach
CO2 Emission from transport sector is 20% of total emission in Japan. Road transport emits 84% of transport emission.

CO2 Emission in Japan

- Industry: 388 m CO2 · ton (33.9%)
- Service/Office: 216 m CO2 · ton (18.8%)
- Private: 162 m CO2 · ton (14.1%)
- Others: 149 m CO2 · ton (13.0%)
- Total CO2 emission: 1,145 m CO2 · ton (2009 fiscal year)

Breakdown in Transport sector

- Passenger cars: 115 m CO2 · ton (50.2%)
- Commercial vehicles: 78 m CO2 · ton (34.1%)
- Breakdown:
  - Bus/coach: 4.2 m CO2 · ton (1.8%)
  - Taxi: 3.9 m CO2 · ton (1.7%)
  - Short sea: 11 m CO2 · ton (4.6%)
  - Aviation: 10 m CO2 · ton (4.3%)
  - Railway: 8 m CO2 · ton (3.3%)

※ Emission from electric generation and thermal generation are distributed to final demand sectors according to amount of consumption of each sector.
※Developed by MLIT referring to "Japanese GHG Inventory report"
Total CO2 emission increases by 13.3% compared to 1990 level. Transport sector has turned into decrease.

CO2 emission (m ton)

(reference: Japan's Ministry of Environment)

Since FY2001, emissions from the transportation sector have been on a downward trend.

**Improvement of mileage of passenger vehicles**
- Fuel Efficiency regulation
- Green Tax (Since FY2001)
  18.2mil./57.7mil. registered vehicles are GREEN

**Efficiency improvement of freight road transport**
- Deployment of larger-size trucks: 24-25t truck: 80,000 (FY02) → 160,000 (FY08)
- Shift of cargo from in-house distribution to freight carriers:
  freight carriers/total: 77.2% (FY97) → 87.4% (FY08)

CO2 emission in Transport sector

- Emissions from freight transport on road peaked out in FY1996
Japan has long history to execute FE regulation. Through this regulation, Japan’s average FE of automobile has been improving steadily.

<History of Top runner fuel efficiency regulation>

- **Passenger vehicle (Gasoline)**
  - Published: 1999
  - Target year: 2010

- **Passenger vehicle (Diesel)**
  - Published: 1999
  - Target year: 2005

- **Passenger vehicle (Gasoline and Diesel)**
  - Published: 2007
  - Target year: 2015

- **Passenger vehicle (Gasoline and Diesel)**
  - Published: 2015
  - Target year: 2020

**History of Fuel efficiency standard**

Japan has long history to execute FE regulation. Through this regulation, Japan’s average FE of automobile has been improving steadily.

- **History of Top runner fuel efficiency regulation**
  - **Published**:
    - Passenger vehicle (Gasoline): 1999
    - Passenger vehicle (Diesel): 1999
    - Passenger vehicle (Gasoline and Diesel): 2007
  - **Target year**:
    - 2010
    - 2005
    - 2015

**km/L**

- **50% Improvement for 20 years**
  - 2010 target
  - 2015 target

**Toward 2020**

- **FE regulation for HDV**
  - 2006
  - 2015
1. First, we establish an expert working group to start discussing a new regulation. Vehicle manufacturers provide fuel efficiency performance data with all the types of HDVs in the market, as well as their expectations on positive and negative factors.
2. We develop a draft proposal and submit it to the council body of our government.
3. The council consists of academics and stakeholders. It intensively discuss the submitted draft proposal. The Intermediate report of the council goes through public comments procedure and the result must be taken into consideration when it publish the final report.
4. The final draft should be completed by MLIT and METI based on report by the council.
5. The final regulation and test procedures are published after WTO/TBT notification procedure.
Top Runner Approach

- By target year, average fuel consumption must be higher than the best fuel efficiency in the base year.
- Standard should be high but reachable because target values are already achieved by actual vehicles in the base year.
- Particular types of cars such as HEVs and MT mounted cars are excluded from top runner.

\[ +\alpha : \text{positive factors} \]
\[ -\beta : \text{negative factors} \]

**Positive Factors:** Technological Improvement
**Negative Factors:** Exhaust Emission Regulations, etc. (trade-off relation with fuel economy)
1. Background

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Overview of Test procedure

○ FE of HDVs is measured by engine dynamometer, not using whole vehicle. FE map of an engine is measured by this instrument.

○ By using computer simulation with FE map and vehicle specification data, FE of HDV is calculated.

○ With computer simulation, we can save cost and time, because FE map data of an engine can be used for various vehicle with that engine.
"Heavy-duty Vehicle Mode"

- Urban Driving Mode = JE05 Mode

Interurban Driving Mode
= 80km/h Constant Speed Mode with Road Gradient

Evaluation of Fuel Efficiency by Simulation Method
Simulation Method Overview

Driving mode = \{ \text{Urban driving mode} \mid \text{Interurban driving mode} \}

Conversion program
- Determine gear-shift positions.
- Calculate engine speed and torque.

Vehicle specifications

Fuel efficiency map

Engine Operating Mode

Fuel consumption

Fuel efficiency

*Before simulation, perform operation tests to create a fuel efficiency map

Conversion Program Overview

Driving mode
Determine the shift lever position

Conversion program

The vehicle specifications (technical data)
- Engine related parameters
  - Full load engine torque
  - Idling engine speed
  - Maximum output engine speed
  - Maximum engine speed with load

- Drivetrain related parameters
  - Number of transmission gears
  - Transmission gear ratios
  - Final reduction gear ratio
  - Tire dynamic load radius

- Driving resistance parameters
  - Rolling resistance coefficient
  - Air resistance coefficient

- Vehicle weight related parameters
  - Complete vehicle kerb weight
  - Maximum load
  - Riding capacity

Engine operating mode
- Engine speed
- Engine torque

Speed
Time

Engine torque
Time (s)

Engine speed
Time (s)
“Simulation Method”
≠ Actual Engine Measurement Test by Driving Mode

✔ The method is based on real vehicle and engine specifications.

Engine related parameters
- Full load engine torque
- Idling engine speed
- Maximum output engine speed
- Maximum engine speed with load

Drivetrain related parameters
- Number of transmission gears
- Transmission gear ratios
- Final reduction gear ratio
- Tire dynamic load radius

✔ The method is an extension way of the emission test

- Low cost and high test efficiency
- Reproducibility of driving resistance
Simulation Method Flowchart and Equation

**Urban Driving Mode**
JE05 mode

- Engine Operating Mode
- \( E_u \): Fuel Efficiency

**Interurban Driving Mode**
80km/h constant speed mode with gradient

- Engine Operating Mode
- \( E_h \): Fuel Efficiency

\[
E = \frac{1}{\left( \alpha_u / E_u + \alpha_h / E_h \right)}
\]

- **E**: Heavy vehicle mode fuel efficiency (km/L)
- \( E_u \): Urban driving mode fuel efficiency (km/L)
- \( E_h \): Interurban driving mode fuel efficiency (km/L)
- \( \alpha_u \): Proportion of urban driving mode
- \( \alpha_h \): Proportion of interurban driving mode
\[ E = \frac{1}{\left( \alpha_u / E_u + \alpha_h / E_h \right)} \]

:::

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Ordinary bus</th>
<th>Route bus</th>
<th>Other than tractor</th>
<th>Tractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>GVW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over 14 t</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 t or less</td>
<td>0.9</td>
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<td>1.0</td>
<td>0.9</td>
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<tr>
<td>Over 20 t</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>20 t or less</td>
<td>0.9</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Over 20 t</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 t or less</td>
<td>0.1</td>
<td>0.3</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Other than tractor</td>
<td>0.1</td>
<td>0.3</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Tractor</td>
<td>0.1</td>
<td>0.3</td>
<td>0.2</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Passenger vehicles
(riding capacity: 11 persons or more)

Freight vehicles

Upper: \( \alpha_u \)
Lower: \( \alpha_h \)
1. Background

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3. Target Value and Improvement

4. Integrated Approach
### Target Standard Values: Passenger Vehicles

#### Ordinary Bus

<table>
<thead>
<tr>
<th>Vehicle Category</th>
<th>Gross Vehicle Weight Range (t)</th>
<th>Target Standard Values (km/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>3.5 &lt; &amp; ≤ 6</td>
<td>9.04</td>
</tr>
<tr>
<td>B2</td>
<td>6 &lt; &amp; ≤ 8</td>
<td>6.52</td>
</tr>
<tr>
<td>B3</td>
<td>8 &lt; &amp; ≤ 10</td>
<td>6.37</td>
</tr>
<tr>
<td>B4</td>
<td>10 &lt; &amp; ≤ 12</td>
<td>5.70</td>
</tr>
<tr>
<td>B5</td>
<td>12 &lt; &amp; ≤ 14</td>
<td>5.21</td>
</tr>
<tr>
<td>B6</td>
<td>14 &lt; &amp; ≤ 16</td>
<td>4.06</td>
</tr>
<tr>
<td>B7</td>
<td>16 &lt;</td>
<td>3.57</td>
</tr>
</tbody>
</table>

#### Route Bus

<table>
<thead>
<tr>
<th>Vehicle Category</th>
<th>Gross Vehicle Weight Range (t)</th>
<th>Target Standard Values (km/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BR1</td>
<td>6 &lt; &amp; ≤ 8</td>
<td>6.97</td>
</tr>
<tr>
<td>BR2</td>
<td>8 &lt; &amp; ≤ 10</td>
<td>6.30</td>
</tr>
<tr>
<td>BR3</td>
<td>10 &lt; &amp; ≤ 12</td>
<td>5.77</td>
</tr>
<tr>
<td>BR4</td>
<td>12 &lt; &amp; ≤ 14</td>
<td>5.14</td>
</tr>
<tr>
<td>BR5</td>
<td>14 &lt;</td>
<td>4.23</td>
</tr>
</tbody>
</table>
### Target Standard Values: Freight Vehicles

#### Other Than Tractor

<table>
<thead>
<tr>
<th>Vehicle Category</th>
<th>Gross Vehicle Weight Range (t)</th>
<th>Maximum Load Range (t)</th>
<th>Target Standard Values (km/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>3.5 &lt; &amp; ≤ 7.5</td>
<td>≤ 1.5</td>
<td>10.83</td>
</tr>
<tr>
<td>T2</td>
<td>1.5 &lt; &amp; ≤ 2</td>
<td>2 &lt; &amp; ≤ 3</td>
<td>10.35</td>
</tr>
<tr>
<td>T3</td>
<td>2 &lt; &amp; ≤ 3</td>
<td>3 &lt;</td>
<td>9.51</td>
</tr>
<tr>
<td>T4</td>
<td></td>
<td></td>
<td>8.12</td>
</tr>
<tr>
<td>T5</td>
<td>7.5 &lt; &amp; ≤ 8</td>
<td></td>
<td>7.24</td>
</tr>
<tr>
<td>T6</td>
<td>8 &lt; &amp; ≤ 10</td>
<td></td>
<td>6.52</td>
</tr>
<tr>
<td>T7</td>
<td>10 &lt; &amp; ≤ 12</td>
<td></td>
<td>6.00</td>
</tr>
<tr>
<td>T8</td>
<td>12 &lt; &amp; ≤ 14</td>
<td></td>
<td>5.69</td>
</tr>
<tr>
<td>T9</td>
<td>14 &lt; &amp; ≤ 16</td>
<td></td>
<td>4.97</td>
</tr>
<tr>
<td>T10</td>
<td>16 &lt; &amp; ≤ 20</td>
<td></td>
<td>4.15</td>
</tr>
<tr>
<td>T11</td>
<td>20 &lt;</td>
<td></td>
<td>4.04</td>
</tr>
</tbody>
</table>

#### Tractor

<table>
<thead>
<tr>
<th>Vehicle Category</th>
<th>Gross Vehicle Weight Range (t)</th>
<th>Target Standard Values (km/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>≤ 20</td>
<td>3.09</td>
</tr>
<tr>
<td>2</td>
<td>20 &lt;</td>
<td>2.01</td>
</tr>
</tbody>
</table>
Through the HDV FE standards, average fuel efficiency has been increasing to the target values.

However, in some categories, especially in buses, average fuel efficiency has not been improved well.
Through the HDV FE standards, average fuel efficiency has been increasing steadily to the target values.

However, in some categories, average fuel efficiency has not been improved well.
1. Background

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4. Integrated Approach
The key for success is the policy approach that integrates all the relevant measures. This approach designed and coordinated all the measures so that both maximized CO2 reduction and minimized social and economic cost can be achieved.

Breakdown of reduction potential in transport sector

- **Mobility Management/Public Transport**
  - Mobility shift to public transport
  - New transport infrastructure for railways
  - 18.6 m ton
  - 31%

- **Vehicle Technology and Driving Behavior**
  - Fuel Efficiency Standards (LDV/HDV)
  - Fiscal incentives for EFVs
  - Labeling
  - Eco-driving
  - 29.6 m ton
  - 49%

- **Efficient Logistics**
  - Deployment of larger trucks
  - Shift of cargo from in-house distribution to freight carriers:
  - 5.5 m ton
  - 9%

- **Better Flow of Traffic**
  - Elimination of bottlenecks, such as railroad crossing
  - ITS, Electric Toll Gate System
  - Flexible toll for highway
  - 3.8 m ton
  - 6%

- **Others**
  - 2.8 m ton
  - 5%

Source: MLIT
How to reduce CO2 emission?

Various factors are related to amount of CO2 emission from vehicles. (energy efficiency, traffic congestion, ...) It is not reasonable to focus only on improvement of vehicle performance.

**Integrated approach** has been introduced in Japan.

- Approaches from 3 viewpoints
  - vehicle performance
  - usage
  - infrastructure
<table>
<thead>
<tr>
<th>Term</th>
<th>Initial tax (Acquisition tax)</th>
<th>Annual tax (Auto tax/ Weight tax)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr. 2008 - Mar. 2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Next generation vehicles EV, PHEV, HV, CNG, Clean Diesels</td>
<td>Exempted</td>
<td>Exempted (weight tax)/ -50% (Auto tax)</td>
</tr>
<tr>
<td>Normal ICEs (passenger cars)</td>
<td>-75%</td>
<td>-75% (weight tax)/ -50% (Auto tax)</td>
</tr>
<tr>
<td>and +25% 2010 FE reg and +75% JP05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and +15% 2010 FE reg and +75% JP05</td>
<td>-50%</td>
<td>-50% (weight tax)/ -25% (Auto tax)</td>
</tr>
<tr>
<td>Normal ICEs (Heavy duty vehicles)</td>
<td>-75%</td>
<td>-75% (weight tax)</td>
</tr>
<tr>
<td>and +25% 2015 FE reg and JP09 level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and +50% 2015 FE reg and +10% JP05</td>
<td>-50%</td>
<td>-50% (weight tax)</td>
</tr>
</tbody>
</table>

High tax incentives are accelerating dissemination of fuel-efficient cars significantly.
By subsidies for bus and truck companies, the use of low-pollution vehicles is promoted and the air environment is improved.

<table>
<thead>
<tr>
<th>Subsidiary</th>
<th>Subsidiary rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNG truck and bus</td>
<td>1/3 of difference with normal vehicle price or 1/4 of vehicle main body price</td>
</tr>
<tr>
<td>Hybrid truck, bus and taxi</td>
<td></td>
</tr>
<tr>
<td>Electric vehicle (including PHV)</td>
<td>1/2 of difference with normal vehicle price or 1/4 of vehicle main body price</td>
</tr>
<tr>
<td>Remodeling of in-use vehicles to CNG vehicles or Electric vehicles</td>
<td>1/3 of remodeling cost</td>
</tr>
</tbody>
</table>
Eco-driving contributes to fuel efficiency and CO2 reduction by 10% in average.

- Campaigns, education, monitoring programs should play an important role, as well as in-car equipment to assist eco-driving.

**Eco-driving assist system/ Fuel consumption meter**

**National campaign ”10 tips for Eco-Driving”**

Education and monitoring program
A national project “Next generation EFV(HDV) project” has been implemented to develop next-generation low-pollution trucks and buses in cooperation with research institute, academics, manufactures. Verification running tests for improving their practicability are being conducted.

Developed Vehicle types:

- DME Vehicle
- Inductive power transferred hybrid vehicles
- Large CNG Vehicles
- LNG Vehicles
- FTD Vehicles
- Super Clean Diesel Engine
- Hydrogen Engine

Vehicle types under development:

- Electric/ Plug-in hybrid Trucks
- Next-Gen Biodiesel engines
- High performance electric route buses
Best use of new propulsion system and conventional vehicles

- **Intercity - Long distance**
  - Clean diesel vehicle
  - Alternate fuel trucks and buses
  - Super clean diesel trucks and buses

- **Suburb - Middle distance**
  - Fuel cell vehicles
  - CNG/LNG Trucks
  - Hybrid trucks

- **Urban areas**
  - Hybrid buses
  - Electric vehicles

- **Community**
  - Plug-in hybrid vehicles
  - Ultra fuel economy gasoline vehicles
  - Hybrid vehicles
  - Inductive Power Transfer (IPT) hybrid community buses
  - Inductive Power Transfer (IPT) hybrid community buses

- **Ultra small-sized mobility**

- ★: Infrastructure for Electric power supply is required.
- ★: Infrastructure for hydrogen and natural gas supply is required.
Future transport

Future of road transport should be realized through harmonized and simultaneous evolution of “vehicle technologies”, “people’s behavior” and “city planning/Infrastructure”.

- **Vehicle technologies**
  - EV/PHV are partly on sale.
  - EV/PHV will be disseminated in urban area.
  - Electric buses will prevail mainly around urban area.
  - EV/PHV will be popularly used thanks to technology innovation.

- **Behavior change**
  - Transport companies try to use “eco-drive”.
  - Eco-drive will be widely practiced.
  - Changes in the usage of vehicles are implied by the appearance of car-sharing or low-cost rental cars.

- **City planning, infrastructure**
  - Best transportation system will be developed in compact cities.
  - Facilities for EV/PHV will be completely established in all area.
  - Facilities for EV/PHV will be established in big cities.

Road transport today
- Diffusive structure of cities remains.
- Facilities for EV/PHV are not established.

Road transport in 2020
- Facilities for EV/PHV will be established in big cities.
- Advanced infrastructure will be developed by municipalities one after another.

Road transport in 2050
- Best transportation system will be developed in compact cities.
1. Fuel efficiency target standard values for heavy duty vehicles were set in JAPAN in 2006 for the first time in the world.

2. Average fuel efficiency has been improving from 2006 by introducing the target standard values.

3. In the test procedure, Japan has been using simulation method, because stand-alone engine test requires large resources (time, labor and money).

4. Japan has been taking Integrated approach to mitigate the Global Warming, not only the improvement of the vehicles, but also the usage of them and city planning.
Thank you for your attention