Examples of policy implemented and under development
JAPAN

Hisakazu Suzuki

National Traffic Safety and Environment Laboratory

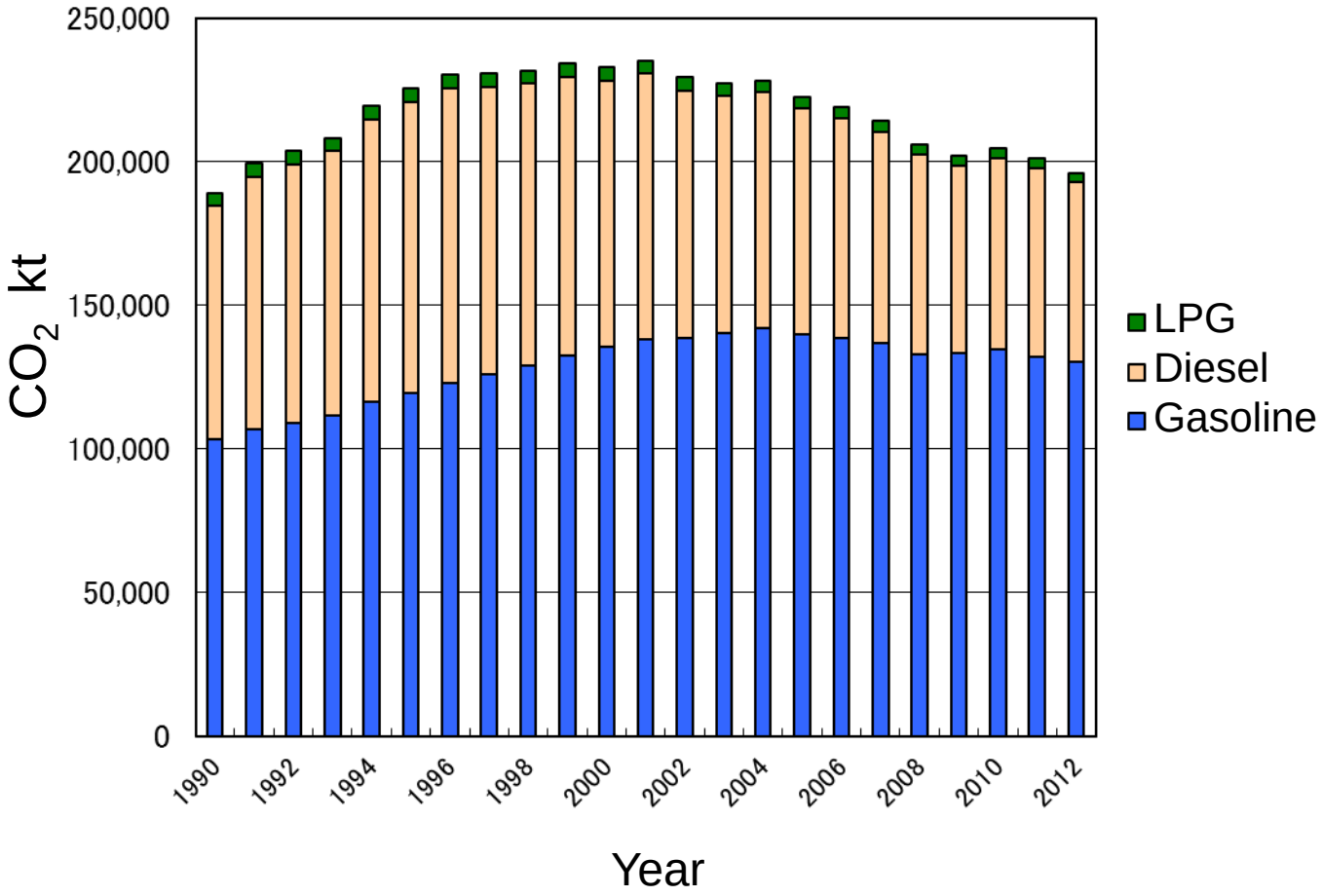
JAPAN

CONTENTS

1. Background - CO_2 emissions from vehicles
2. Overview of 2015 Fuel Consumption Regulation and Test Method
3. Characteristics of current test method
4. Next Step to move forward in 2015 FC Regulation for HDV

Total CO_2 emissions from Vehicles in Japan

Total CO_2 emissions from vehicles reduces slightly in the last 10 years



CO_2 emissions

Gasoline	66.5%
Diesel	31.8%
LPG	1.7%

About 1/3 of CO_2 were emitted from diesel vehicles.
The number of diesel vehicles is only less than 10% of total number.

Japan 2015 Fuel Consumption Regulation for HDV

- Started from 2006
- FC status in 2002 was set as the baseline.
- With technological advance and countermeasure for emission reduction, fuel economy is improved by an average of 12% by 2015.

Target value (averaged)

	Target year	Base year (2002) Fuel Economy	Target standard value (average)
Trucks	2015	6.32 km/L (415 g-CO2/km)	7.09 km/L (370 g-CO2/km) (12.2% improvement)
Buses	2015	5.62 km/L (466 g-CO2/km)	6.30 km/L (416 g-CO2/km) (12.1% improvement)

*Target standard values are set by categories of GVW.

2015 fuel economy targets for HDVs for each weight category

Other Than Tractor

Vehicle 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

FC Test Method - Simulation

Fuel consumption for HDV is calculated using Simulation method.
Preconditions for the calculation:

- **Calculation target is vehicle.**
  Not enough to improve only engine performance.
  Combination of engine and transmission is important.

- **Regulation Target is for vehicle manufactures.**
  Vehicles without loading platform ; Cab and chassis

- **To reduce workload, "small things" are neglected.**
  e.g. Rolling resistance (RC) is set to the constant value based on the weight, and air drug is set to the constant based on the frontal area.

- **Engine tests needs to create a fuel efficiency map by steady state operation.**

Simulation Method Overview

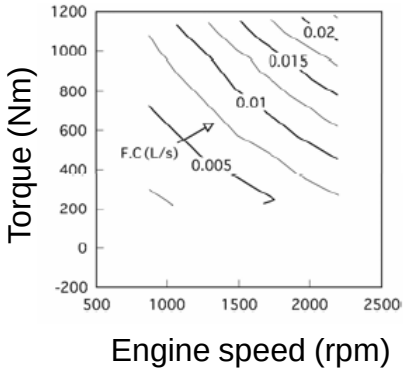
Driving cycle = Urban driving mode / Interurban driving mode

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

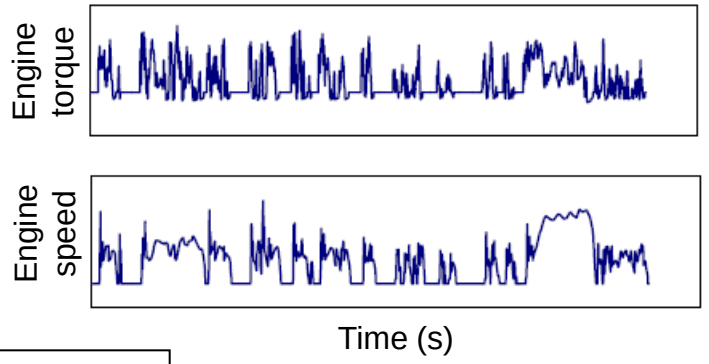
Vehicle specifications and maximum engine torque

Fuel efficiency map (tested)

Engine Operating Mode



Computing



Fuel consumption = $\sum_{i=start}^{end} F.C.(i)$

Fuel efficiency

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

Phase of conversion

Cycle based on Vehicle speed

↓

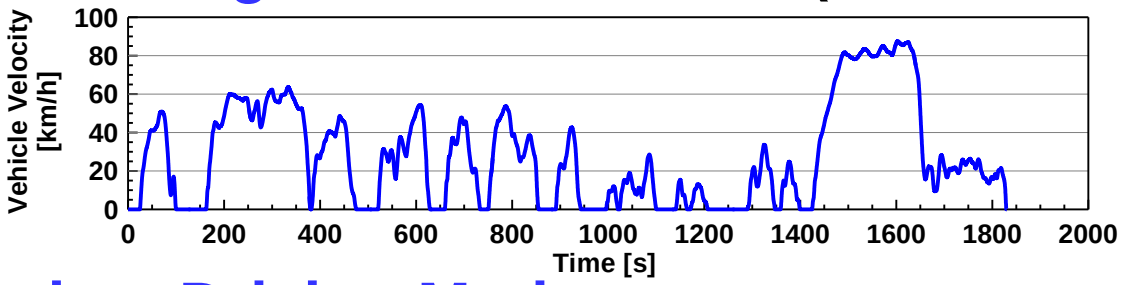
Cycle based on engine speed and engine torque

Phase of calculation of fuel efficiency

Driving cycles for FC evaluation

“HD Vehicle Mode”

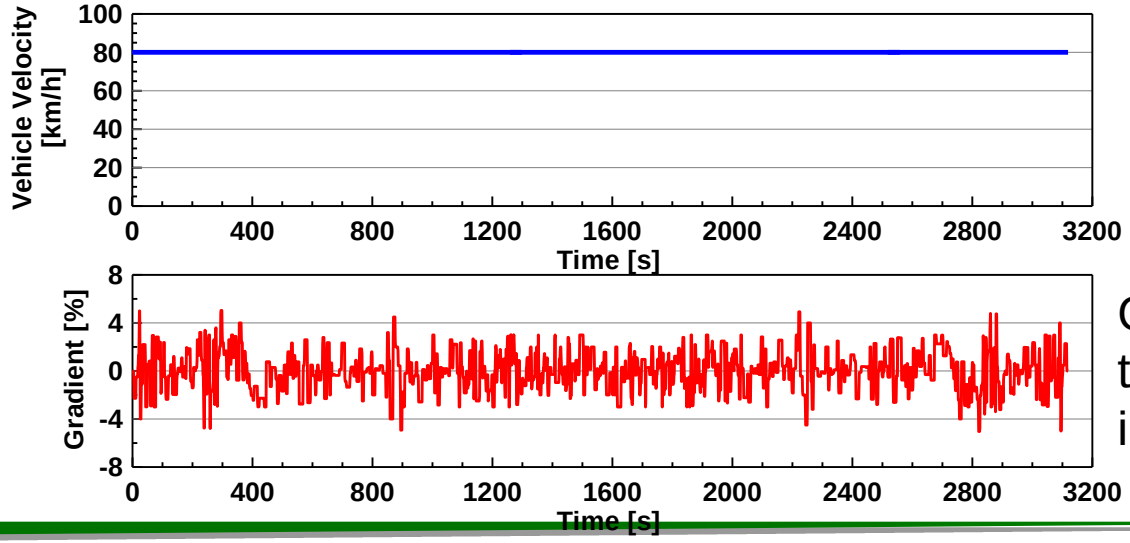
Urban Driving Mode = JE05 Mode (Emission Test cycle)



Ave. speed
27.3 km/h

Interurban Driving Mode

= 80km/h Constant Speed Mode with Road Gradient



Gradient according to major highways in Japan

Characteristics - Why are Air Drugs "small things" ?

- ✓ Air resistance in HD trucks greatly influences on fuel efficiency.
- ✓ Then, highly accurate measurement method of air resistance is often studied in many countries.
- ✓ But, the current Japanese test method uses the constant value calculated based on the frontal area.

50 years ago

WHY?

- ✓ Maximizing the loading space within the limited vehicle size is essential in Japanese market.
- ✓ Thus, cab-behind-engine trucks are not common anymore. They have now been replaced by cab-over type trucks.

All of trucks now are cab-over type

Trucks of same category in Japanese market

Comparing 4 major HD vehicle manufactures

Almost the same in;
Body shape,
Dimensions.

These minor differences are set aside in the current FC test method.

But, in the next regulation....

Hino

ISUZU

Mitsubishi Fuso

UD tracks

GVW 25t trucks
(the heaviest category other than trailer)

Characteristics – Representation of Transmission Effects

- In the simulation, combination between engine and transmission is important.
- Before 2005, 7 speed manual transmission (7MT) was mainly equipped in GVW 25t class HD tracks.
- 1 2 speed automated manual transmission (12AMT) become common now for the potential to improve FC.
- But the effects of 12AMT vary with engine or vehicle characteristics.

Maximum Torque Curve

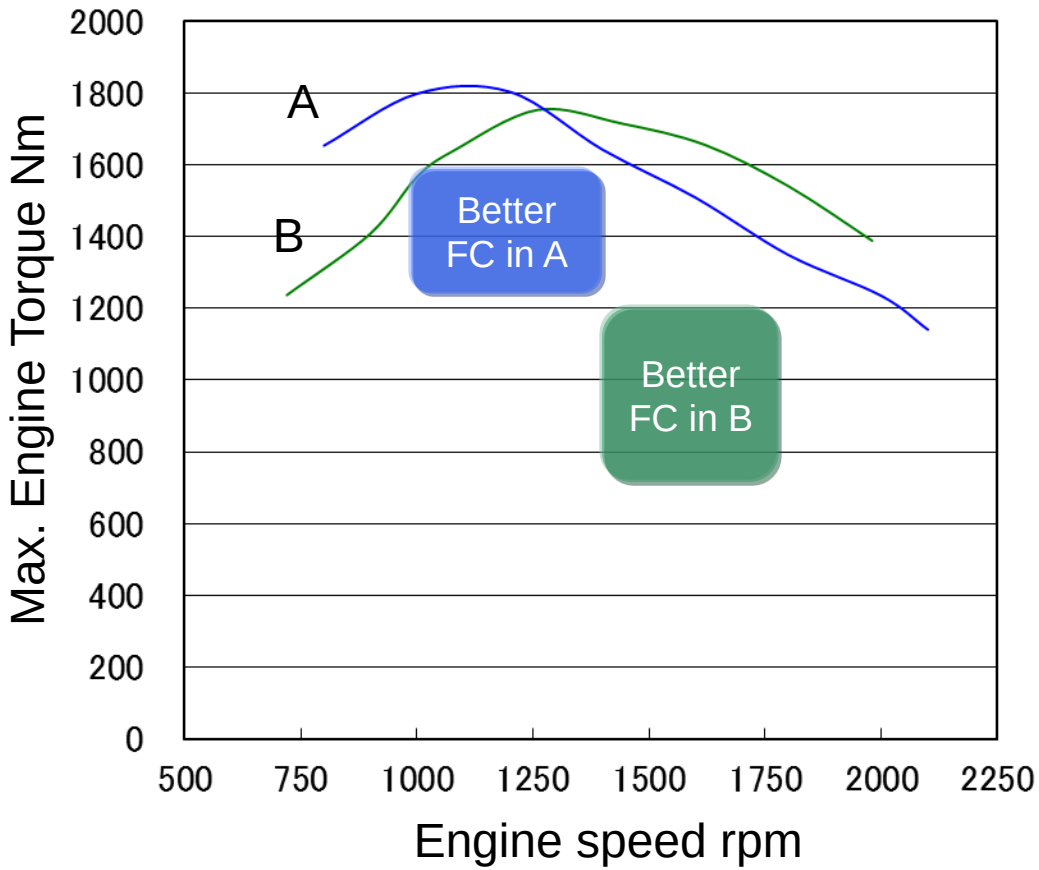
Maximum torque curve in 2 Engines in the same category

Engine A and B are ca. 13L displacement TCI engines for GVW 25t trucks.

The maximum torque and FC properties are different.

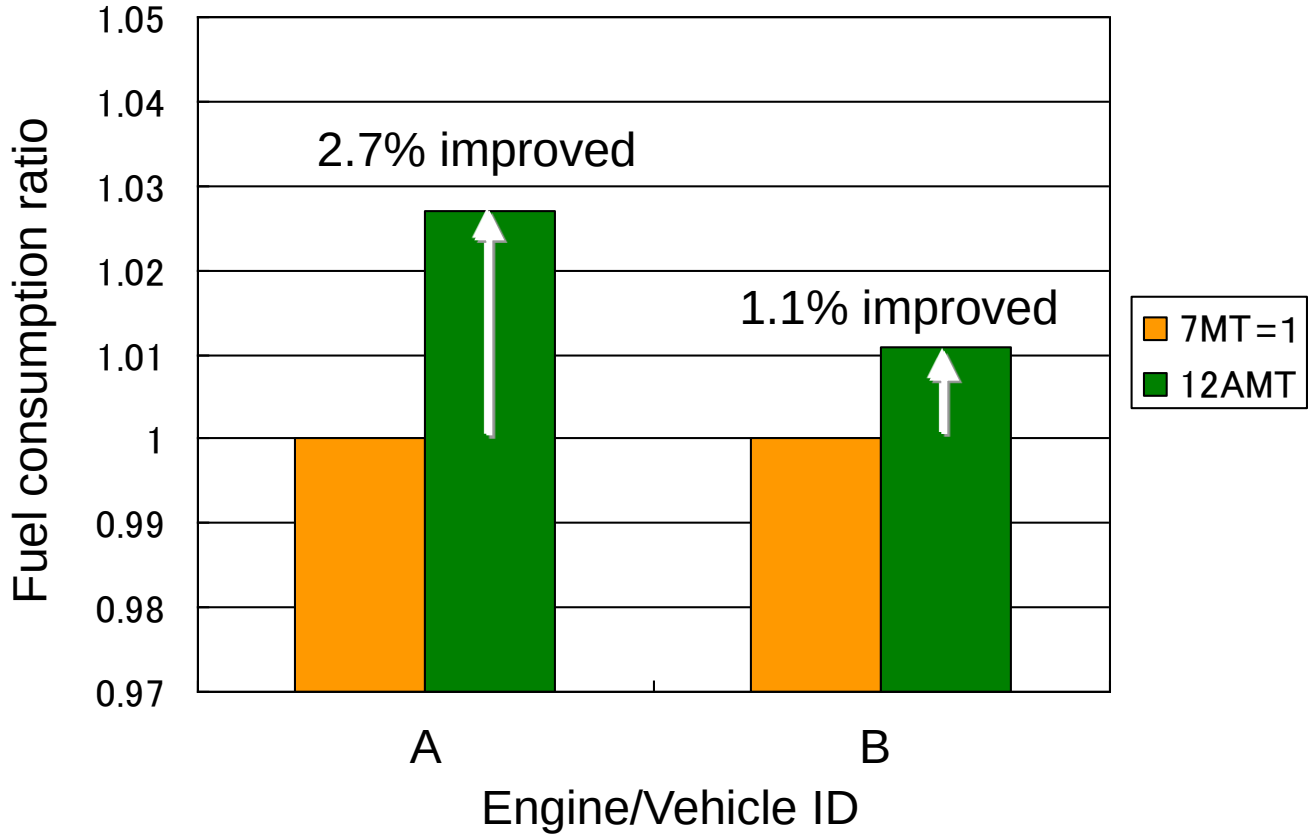
Engine A: better performance at lower engine speed

Engine B: better performance at higher engine speed



Assumption in Using 12-speed AMT

FC improvement replacing from 7MT to 12AMT was estimated by the simulation.
FC improved more in engine A, as 12AMT enables to keep engine speed lower.



Differences in Engine Operating State in Transient Operation

Simulation program:
The instant fuel consumption is calculated by a fuel consumption map based on steady state engine operation.

In the real world:
Vehicles are not always operated with steady state, due to delays of turbocharger and EGR performance when engine speed or torque changes.

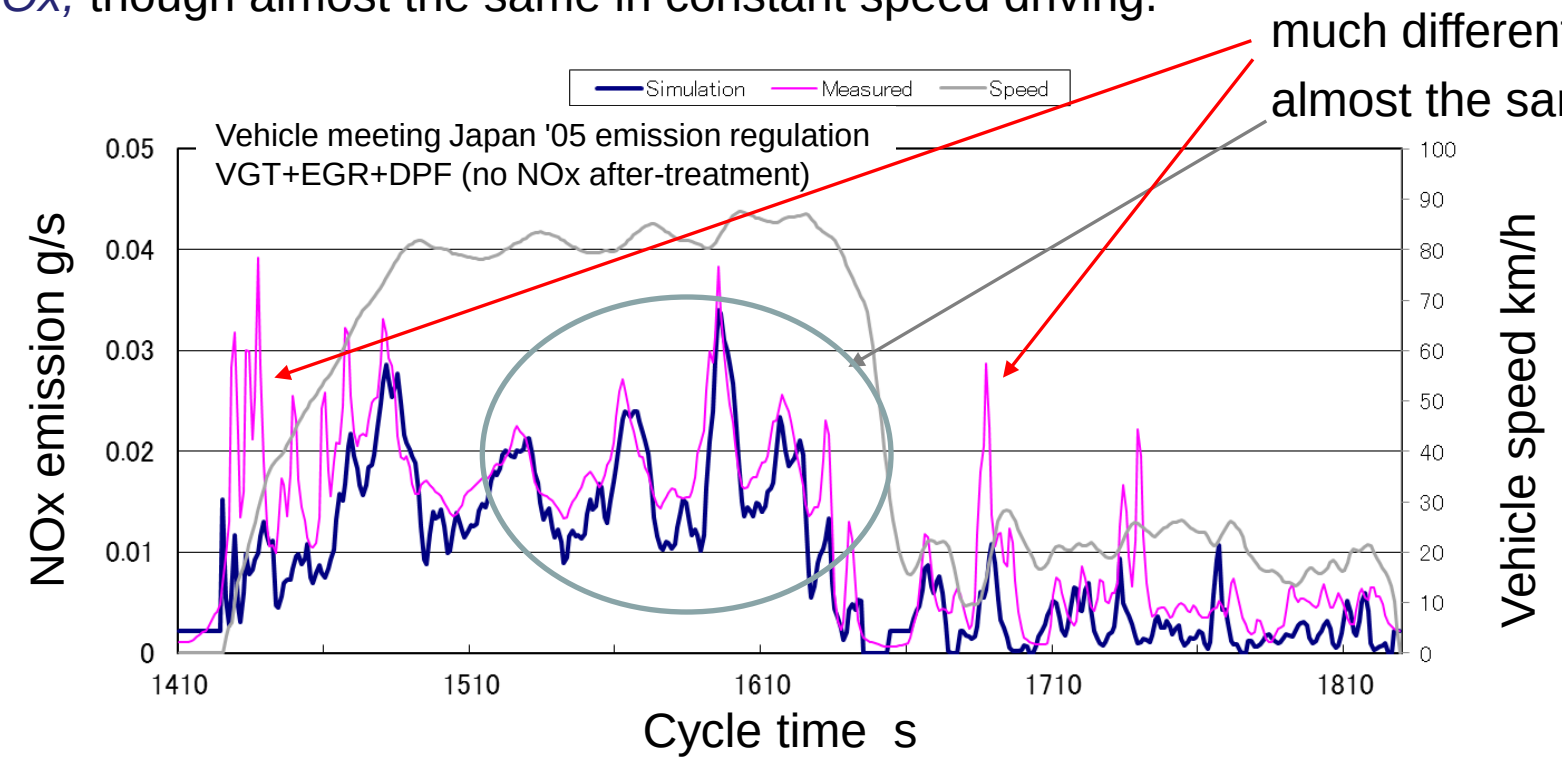
This difference is NOT seemed to have a decisive influence on fuel consumption.

BUT
The engine operation state is greatly different in each operation.
Example:
NOx emission trends were calculated by FC calculation program using "NOx emission map" acquired by steady state engine operation.

NOx Emission Trends in Transient Cycle

Comparison between *calculated NOx* and *measured NOx*:

NOx emission trends were calculated by FC calculation program using “NOx emission map.”
In acceleration phase, *measured NOx* was about 3 times as much as *calculated NOx,* though almost the same in constant speed driving.



Next Step to move forward in 2015 FC Regulation

- METI* and MLIT** are planning the next FC regulation following 2015 Regulation.
- Concrete schedule is not yet fixed, but discussion will commerce in the near future.
- Items on the agenda will include the review of the test method and the evaluation method.

METI* Ministry of Economy, Trade and Industry
MLIT* *Ministry of Land, Infrastructure, Transportation and Tourism

Items expected to be reviewed ← Personal opinion

・Air resistance and/or Rolling resistance
　－ Whether including the actual measurement values so as to reflect improvement efforts or not?

・Transient operation correction
　－ Will be introduced by degree of influence on fuel efficiency.?

・Data points in fuel efficiency map
　－ More testing points are applied to the test method in US and Europe.

Items to be Considered for Next FC Regulation

Most of emission reduction technologies tend to make FC worse.

So, the timing of introducing the next regulation and the schedule should be carefully considered.

Scheduled items in Japan:

- 2016 - Japanese next emission regulation
  NOx 0.4g/kWh in WHTC and WHSC
- 2018 - WWH-OBD
- 20?? - PEMS ? or PN ?

The last message

Thank you for your kind attention

If you have any question, please speak slooooowly.

Contact to :

Hisakazu Suzuki

suzuki@ntsel.go.jp