Fuel economy standard and test procedure for HD vehicles in JAPAN

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JAPAN

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→ not only overview but also some data from our research

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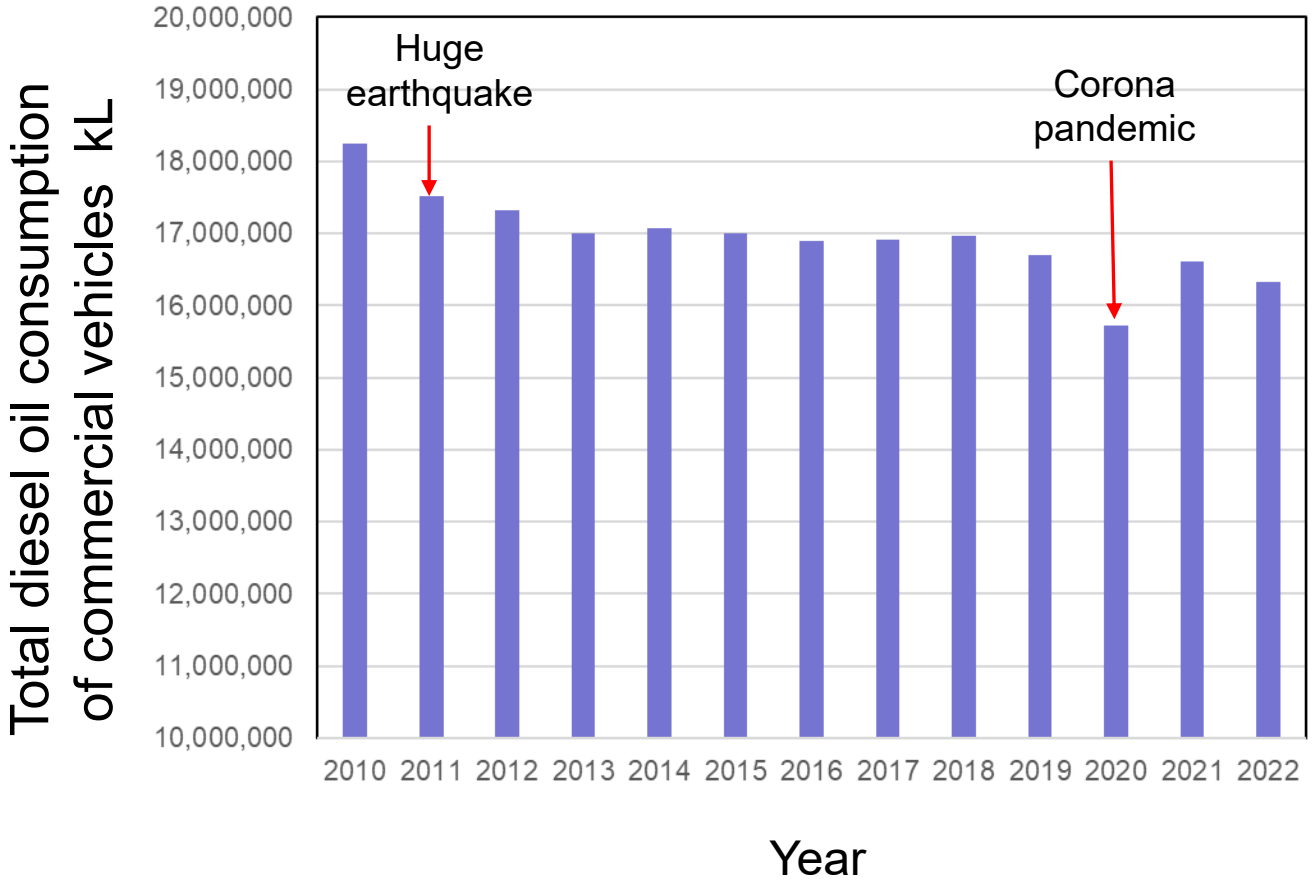
Total fuel consumption of commercial vehicles in Japan

Total fuel consumption of diesel commercial vehicles reduces slightly



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History of Developing Fuel Efficiency Standard

2004	Start to consider the fuel efficiency standard for heavy duty vehicles at a council held by MLIT and Agency for Natural Resources and Energy (NTSEL has been participating in it as an expert member)
2006	Development of the standard ・Target year : 2015 *= Called JH15* ・Aim to improve fuel efficiency by 12.2% from 2002 ・Test method : Simulation ・Combining JE05 mode (simulated urban area) and High-way mode
2010	Add the test method of Idle stop and AT
2017	Development of the new standard ・Target year : 2025 *= Called JH25* ・Strengthen regulation by 13.5% compared to 2015 standard ・Amend the test method - running resistance and engine map measurement method
2022	Add the test method for PHEV, EV and FCV

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Target value of JH25 fuel efficiency standard

Target value (averaged)

	Target year 2015 (JH15)	Target Year 2025 (JH25)	Improvement ratio*
Tracks	7.09 km/L	7.63 km/L	13.4%
Buses	6.30 km/L	6.52 km/L	14.3%

* Improvement ratio cannot be calculated from above target values as follow reasons:
1. The test method of 2015 standard and 2025 are different
2. The number of vehicles in each weight categories is different

2025 fuel economy targets for each weight category

◆ Trucks and Tractor

Category				2025 Standard value
Truck	T1	3.5t<GVW<=7.5t	PL<=1.5t	13.45
	T2		1.5t<PL<=2t	11.93
	T3		2t<PL<=3t	10.59
	T4		3t<PL	9.91
	T5	7.5<GVW<=8t		8.39
	T6	8t<GVW<=10t		7.46
	T7	10t<GVW<=12t		7.44
	T8	12t<GVW<=14t		6.42
	T9	14t<GVW<=16t		5.89
	T10	16t<GVW<=20t		4.88
	T11	20t<GVW<=25t		4.42 *
Tractor	TT1	GVW<=20t		3.31
	TT2	20t<GVW		2.32

◆ Buses

Category			2025 Standard Value
Route Bus	BR1	3.5<GVW<=8t	7.15
	BR2	8t<GVW<=10t	6.30
	BR3	10t<GVW<=12t	5.80
	BR4	12t<GVW<=14t	5.27
	BR5	14t<GVW	4.52
Tour Bus	B1	3.5t<GVW<=6t	9.54
	B2	6t<GVW<=8t	7.73
	B3	8t<GVW<=10t	6.37
	B4	10t<GVW<=12t	6.06
	B5	12t<GVW<=14t	5.29
	B6	14t<GVW<=16t	5.28
	B7	16t<GVW	5.14

* one of the major category in Japanese market. Vehicles used in the validation test showed later fall into this category.

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FC Test Method - Simulation

Fuel consumption for HDV is calculated using Simulation method.
Basic concept:

- **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 other than T11 category
  (Van body for T11 category)

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

Simulation Method Overview

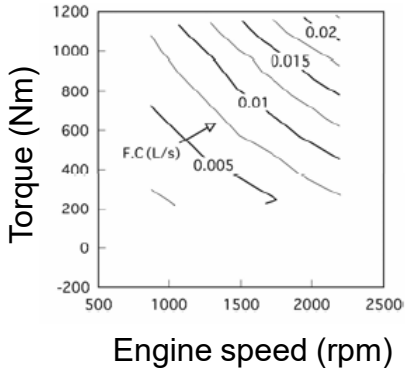
Driving cycle = { Urban driving mode; Interurban driving mode }

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

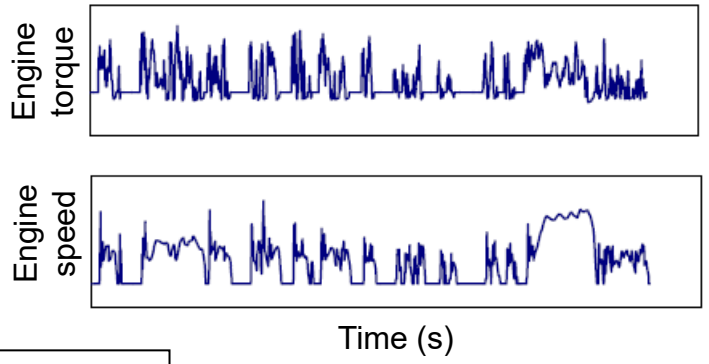
Vehicle specifications and maximum engine torque

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

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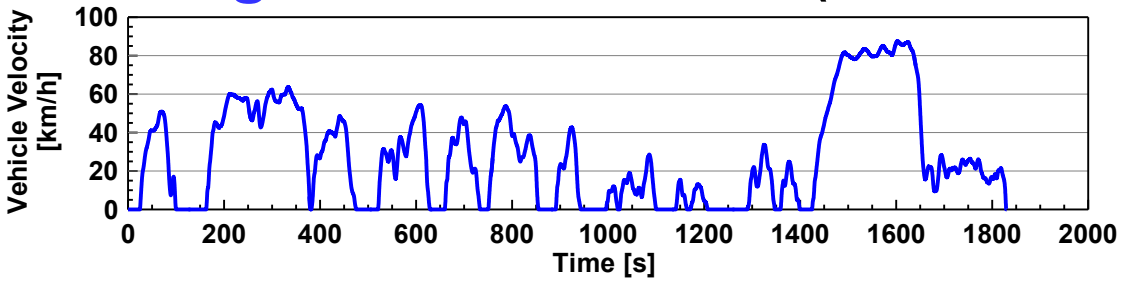
Cycle based on engine speed and engine torque

Phase of calculation of fuel efficiency

Driving cycles for FE evaluation

“HD Vehicle Mode”

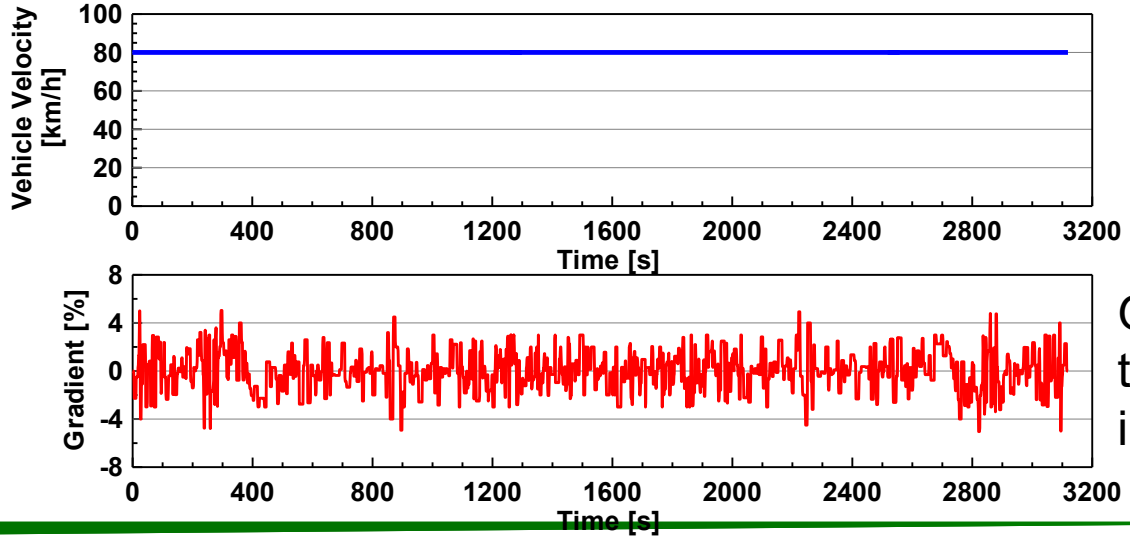
- **Urban Driving Mode = JE05 Mode (former Emission Test cycle)**



Ave. speed
27.3 km/h

- **Interurban Driving Mode**

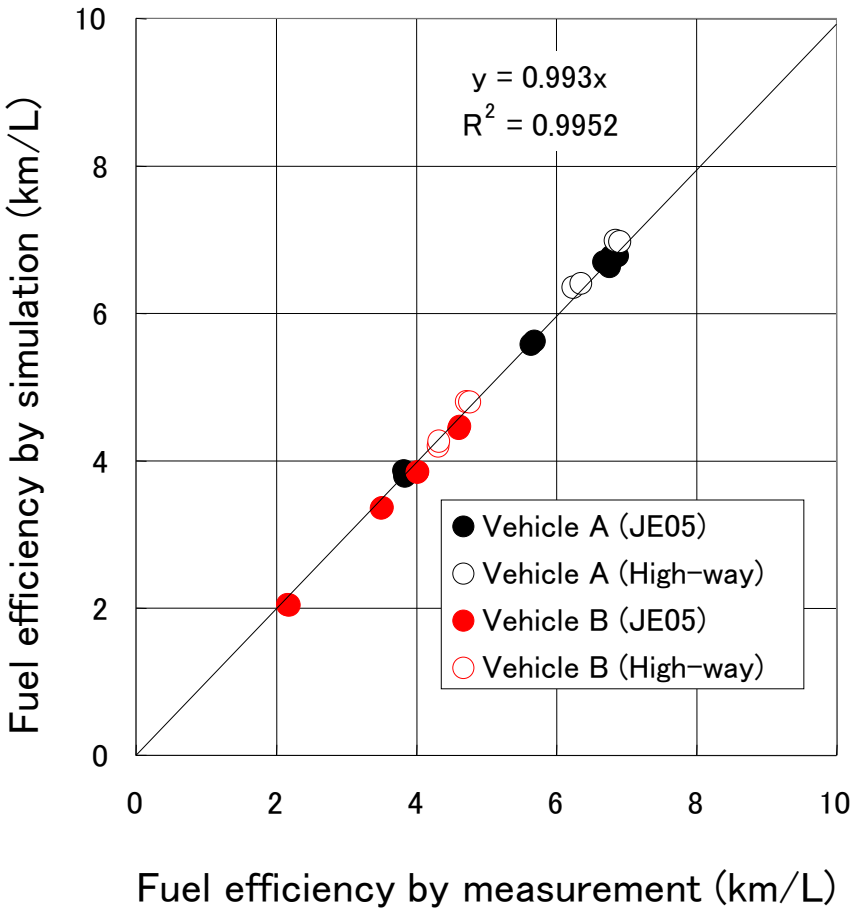
= 80km/h Constant Speed Mode with Road Gradient



Gradient according to major highways in Japan

Accuracy of the simulation

- The simulation method adopted as the heavy duty vehicle fuel efficiency measurement method in Japan has a comparatively small error from the measurement on the vehicle base.



Updated Items for JH25

Item	Amendment from 2025 standard
Aero drag *New*	Introduction of aerodynamic resistance coefficient of individual car
Tire rolling resistance *New*	Reflecting tire rolling resistance coefficient
Shift Logic	Update shift point
Rotational inertial mass	Equivalent rotating mass inertial mass review
Standard vehicle specifications	Update the standard vehicle specifications
Transient compensation *New*	Introduction of transient compensation coefficient
Fuel consumption map measurement	Increase measuring point
Weighting factor (High-way ratio and Payload ratio)	Update high-way ratio and payload ratio

Characteristics – Representation of Transmission Effects

- In the simulation, combination between powertrain and drivetrain is important.

- Before 2010, 7 speed manual transmission (7MT) was mainly equipped in GVW 25t class HD tracks.
- 12 speed automated manual transmission (12AMT) become common now for the potential to improve FE.
- But the effects of 12AMT vary with engine or vehicle characteristics.

Investigation using real engines

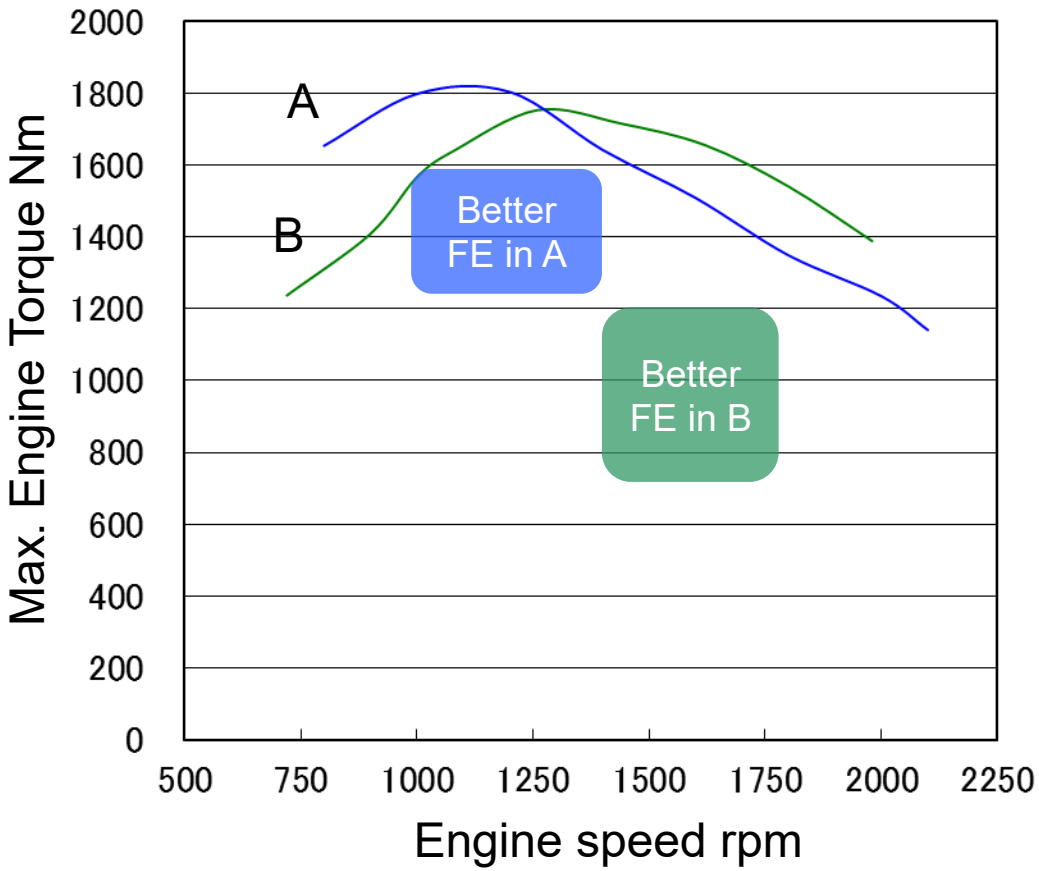
Maximum torque curve in 2 Engines in the same category

Engine A and B are 13L TCI engines for GVW 25t trucks (=T11 category).

The maximum torque and FE properties are different.

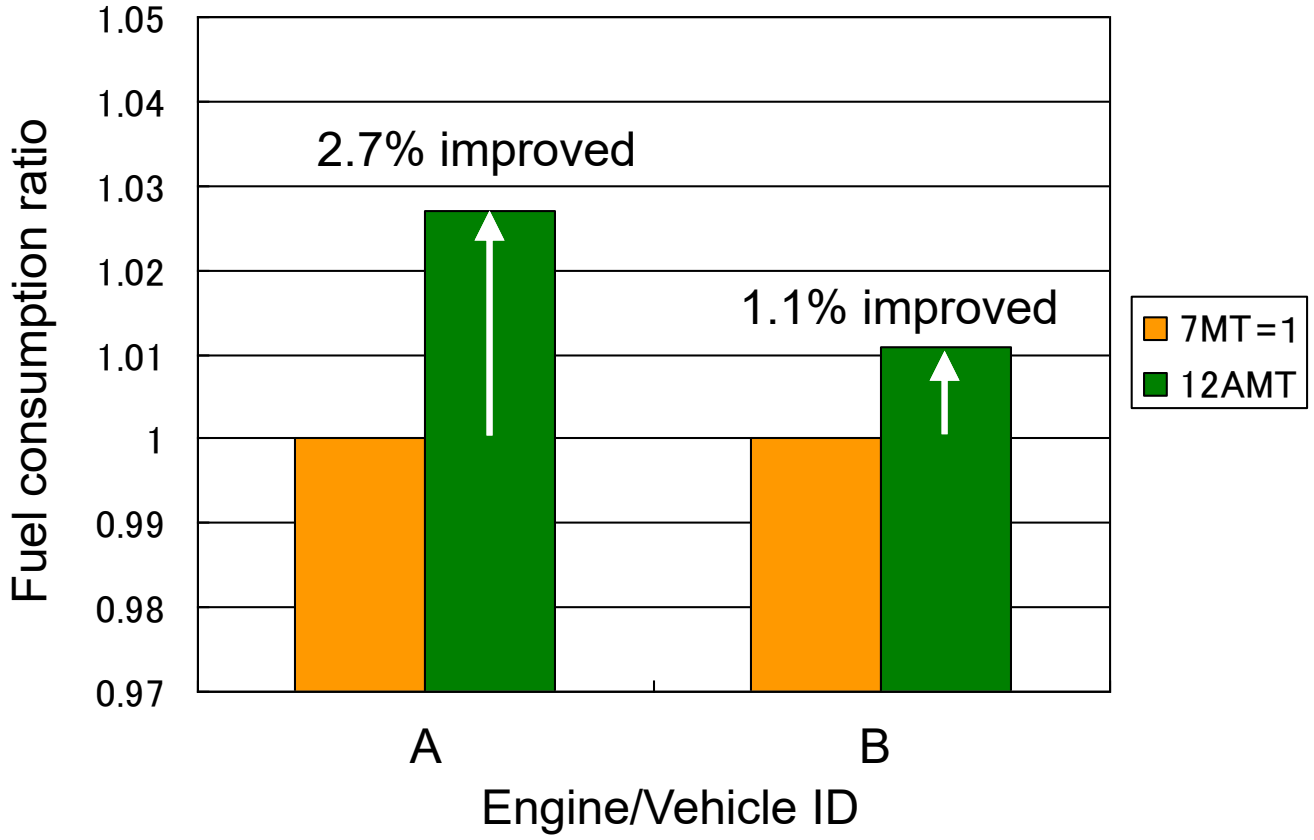
Engine A: better performance at lower engine speed

Engine B: better performance at higher engine speed



Assumption in Using 12-speed AMT

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



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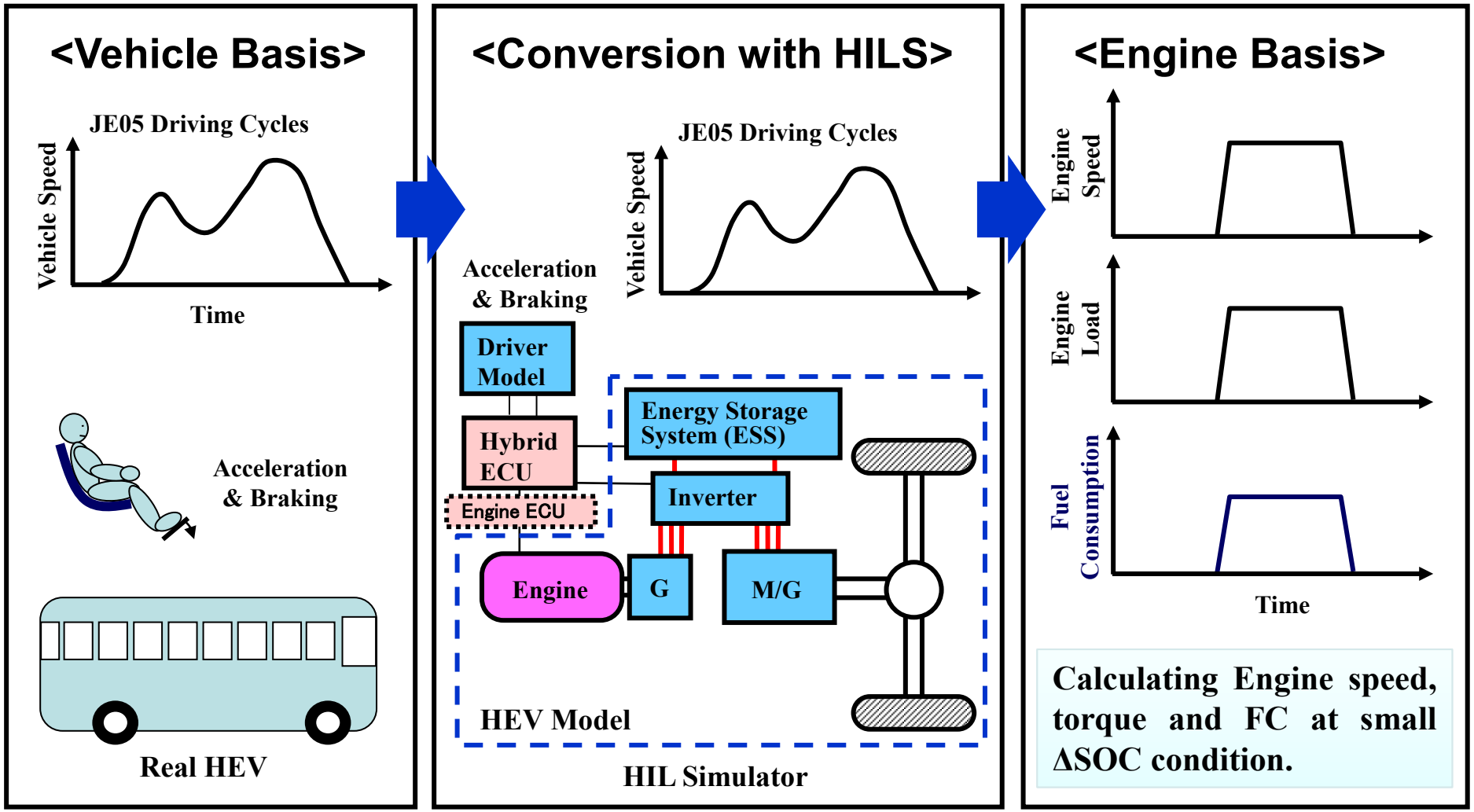
FE measurement for HD HEV

In vehicles of conventional engine, the engine speed and torque condition can be calculated by the vehicle specification and driving pattern of the test cycle.

But in hybrid vehicles, the engine is sometimes assisted by electric motor(s), power demand for the vehicle is not always corresponded to the actual engine output.

In order to resolve this issue, HILS (Hardware in the Loop Simulator) method and system bench (power pack) method based on GTR4 are introduced.

HILS Method for Fuel Economy measurement



Fuel Consumption of Commercial HD HEV

Most of HEVs are small sized trucks or route buses.

Example of route bus:

Bus with conventional diesel engine

Approved FE value

4.25km/L

1st generation HEV had low regeneration efficiency and same FE level as existing vehicles. The later model of HEV was improved.

HEV bus

1st generation in '06

4.25km/L

2nd generation in '11

4.60km/L

Validation survey of FE of HD HEV in Real World

FE comparison between diesel and hybrid buses of a route bus company in the center of Tokyo (yearly average)

Type	Fuel consumption km/L		# of the vehicles
	Certification value	Real world	
Conventional	4.25	2.18	102
HEV 1st gen.	4.25	2.25	100
HEV 2nd gen.	4.60	2.55	20

FE in real world is significantly worse than approved value.
2 reasons: Average vehicle speed is lower than JE05, and air conditioner is always operated.
In real world, 1st generation HEV had the same level of FC as existing vehicles, but in 2nd generation FC was improved up to near approved value's difference.

FE measurement with HILS method has good correlation with FE in real world. HILS is appropriate for FE evaluation.

The latest update; PHEV, EV and FCV test method

- ✓ PHEV, EV and FCV test method was added in 2022
- ✓ Basic concepts of those are based on GTR4 that contains test method of battery, motor or other electrical equipment
- ✓ Some of new roles such as hydrogen measurement for FCV are introduced

NTSEL is investigating the accuracy of massflow based hydrogen measurement.

Start date of application

	EV	PHEV	FCV
New cars	2025/4		2028/1
Continued production cars	2027/4		2030/1

The last message

Thank you for your kind attention

If you have any question, please speak slooooowly.

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