

# **Engine-Base Emissions Regulation using HILS for Commercial Hybrid Vehicles**

JASIC

# Regulation of Emissions from Commercial Vehicles--- Needs for Engine-Base

- Compared to passenger cars, heavy commercial vehicles have much wider variety of configurations. In addition, different engines, transmissions, gear ratios, tyres and equipments are selected based on each user's needs.
- Separate engine performance standards are an important part of a successful regulatory program for commercial vehicles. This is beneficial not only for emissions certification, but also for the whole engine and vehicle development process.
- In the current Japanese exhaust emission regulatory framework, both engine dynamo testing and chassis dynamo testing are available, and none of Japanese heavy-duty manufacturer request chassis approach.

# Regulation of Emissions from Commercial Vehicles--- Needs for Engine-Base (continued)

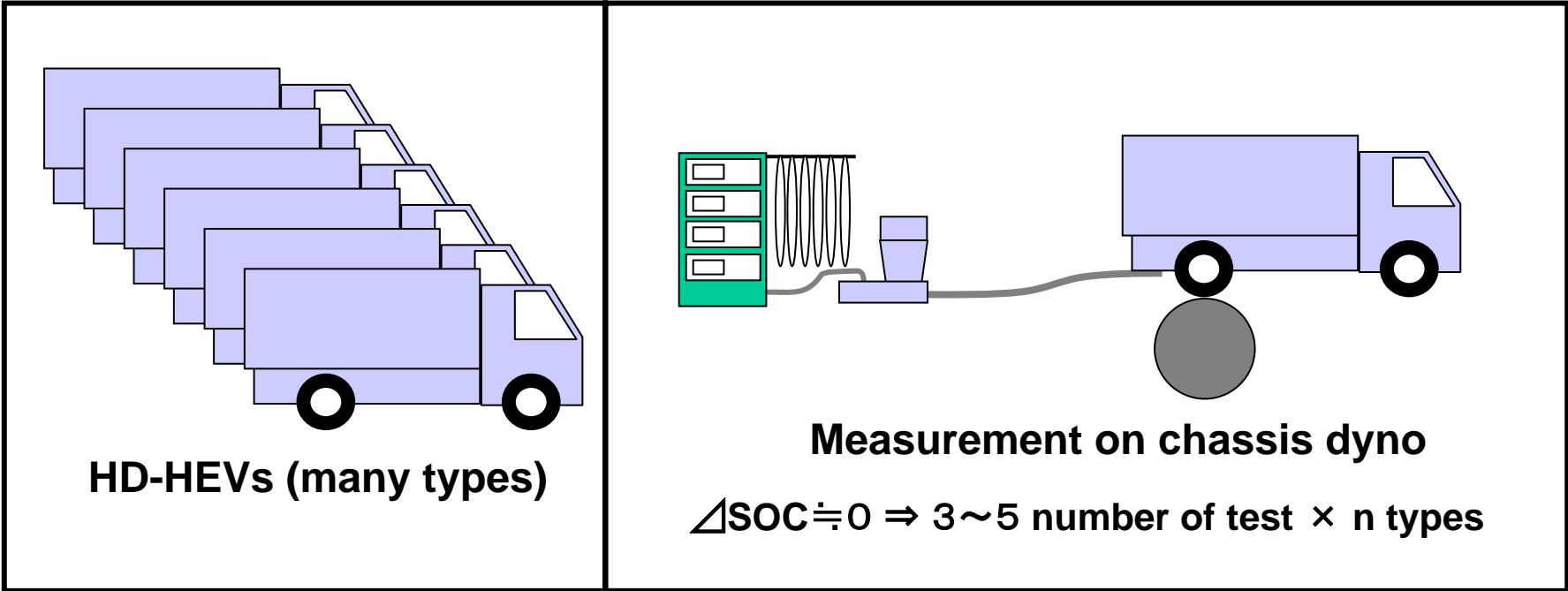
- WHTC adopt “micro-transient” engine operation, and includes frequent small accelerations and decelerations.
- The operation can be obtained only through pre-programming of electronically controlled engine dynamometer operation. In the case of chassis dynamo testing with driver’s manual operation, the accuracy of micro-transient operation will not be acquired.
- Dynamometer-based certification of engines using micro-transient test cycle has proven to be successful in achieving the desired reductions of criteria emissions output for a wide range of vehicles and applications in Japan. In principle, the engine should be the regulated entity for heavy commercial vehicle emissions performance regulation.

# Japanese hybrid commercial engine emissions certification using HILS

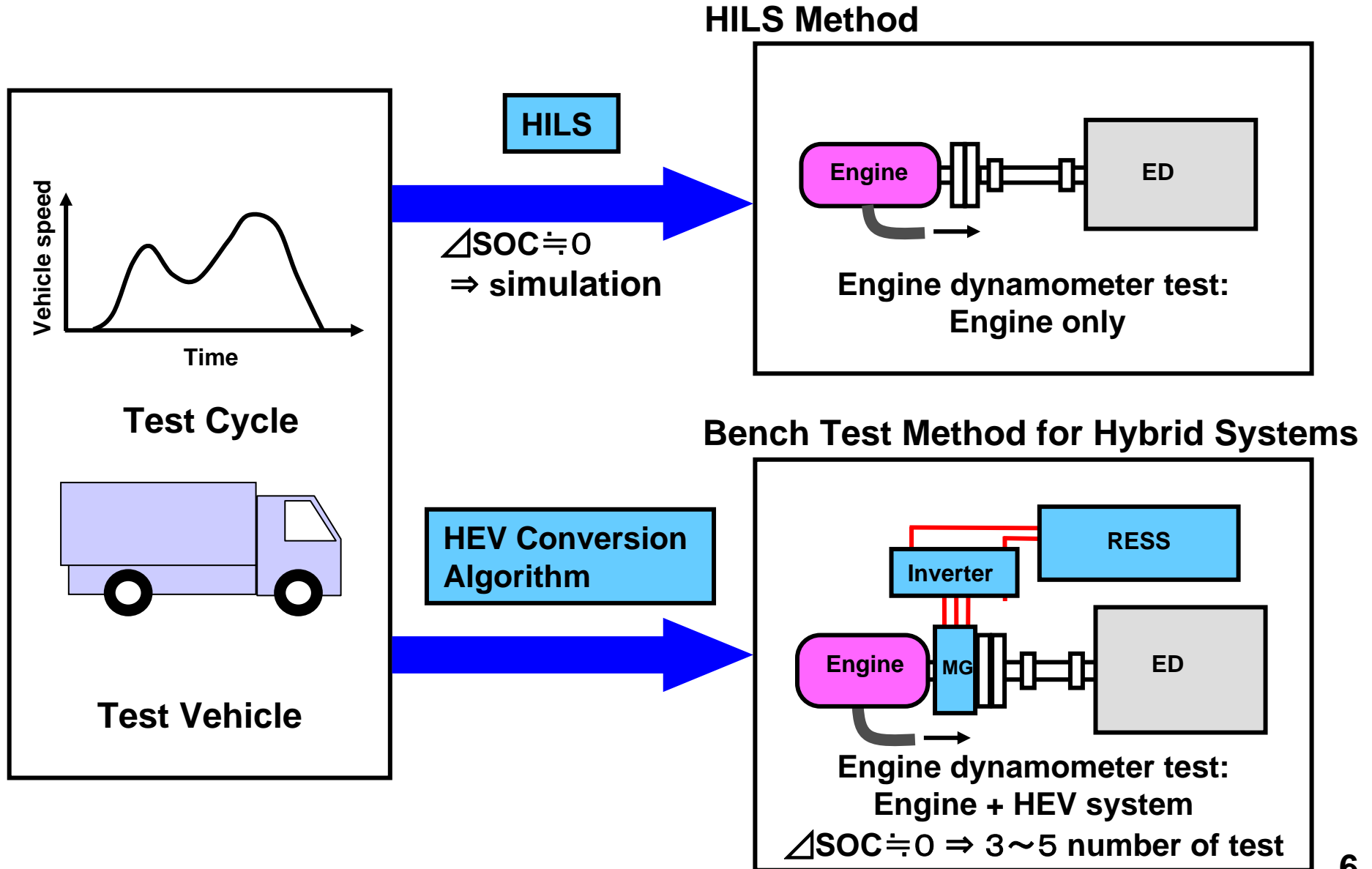
- Japan introduced engine-base certification procedure for commercial hybrid vehicles by applying HILS. Criteria emissions output are measured by engine only, the operation is simulated by HILS.
- Performances of the engine and the hybrid components are measured and certified as a set.
- The accuracy of simulated interactions between engine and hybrid components is certified by comparing measured and simulated results. Total fuel consumption etc. are the criteria for determining the accuracy.
- For the measurement, so-called “system in bench method” ,chassis dynamo testing or actual driving on test course are applied.

# Comparison of Chassis Dyno, HILS and Bench Test Methods

## Chassis Dyno Method



# Comparison of Chassis Dyno, HILS and Bench Test Methods (continued)



# Comparison of Chassis Dyno, HILS and Bench Test Methods (continued)

- ◆ Examination accuracy  
Chassis dyno  $\geq$  Bench test  $\geq$  HILS
- ◆ Certification efficiency  
Chassis dyno  $<$  Bench test  $<$  HILS

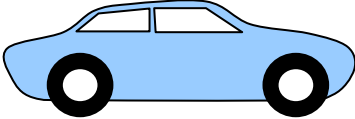
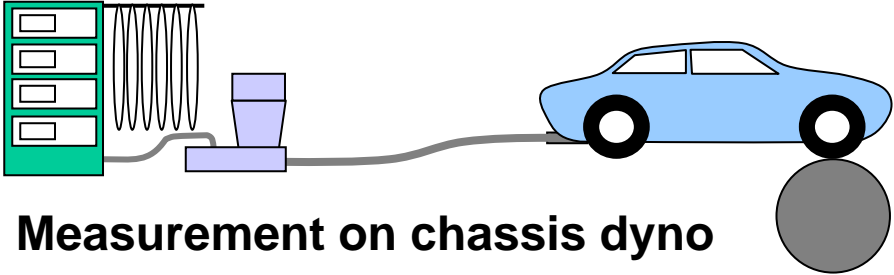
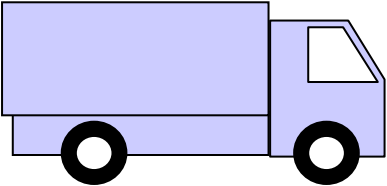
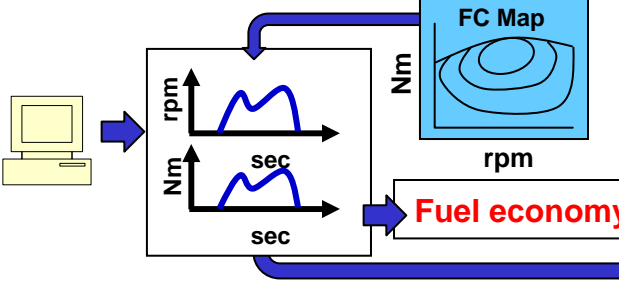
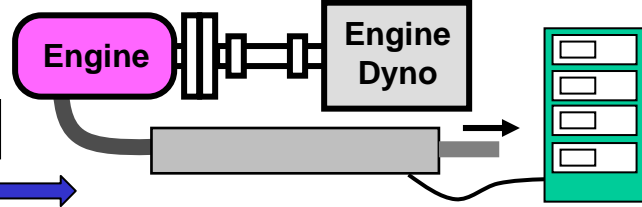
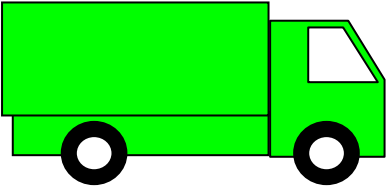
**The examination accuracy of HILS method can be put in the tolerance.**

**The maximum advantage of the HILS method is a time and cost efficiency improvements of the certification.**

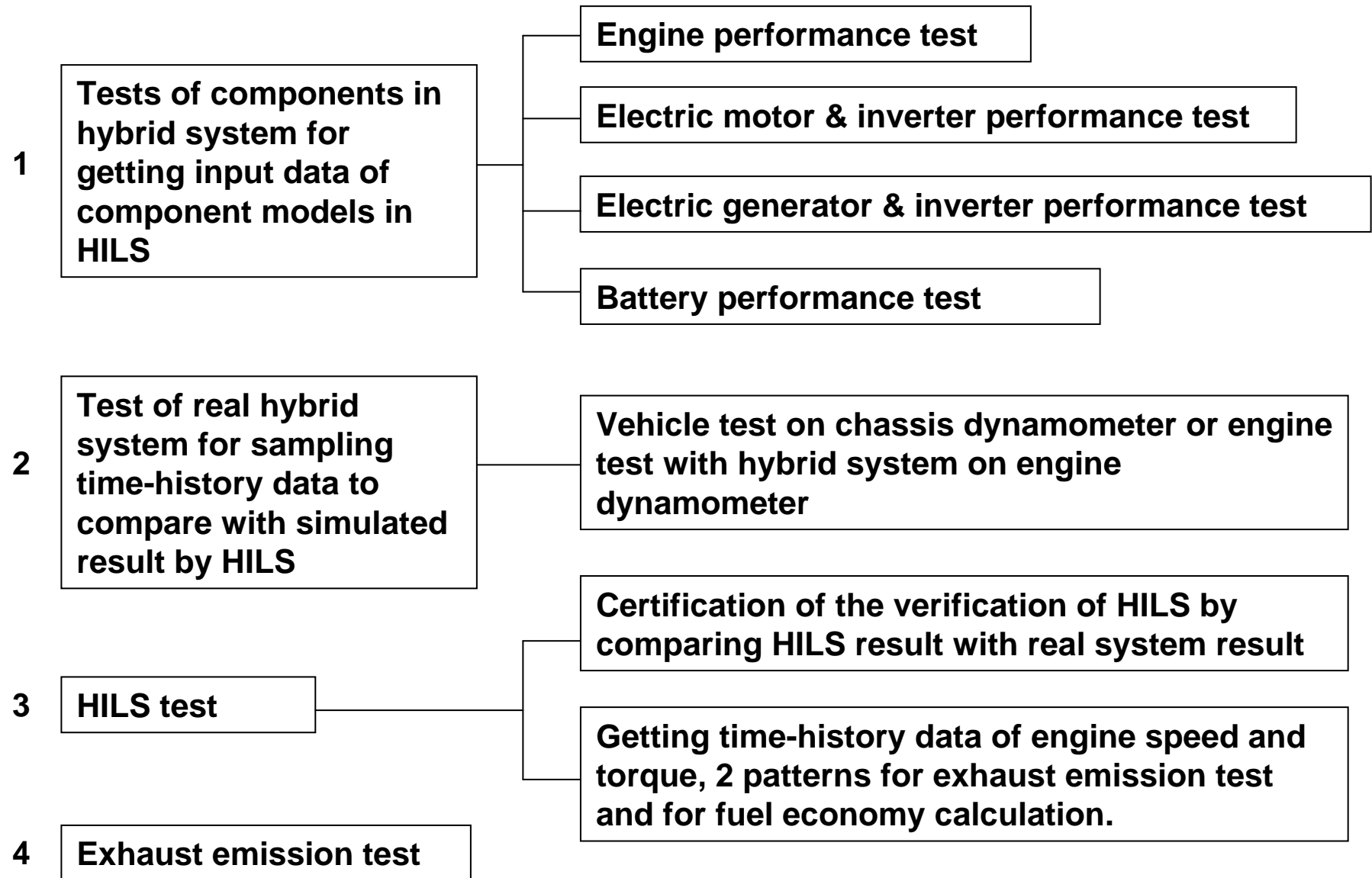
# Appendix



# Why HILS Method?

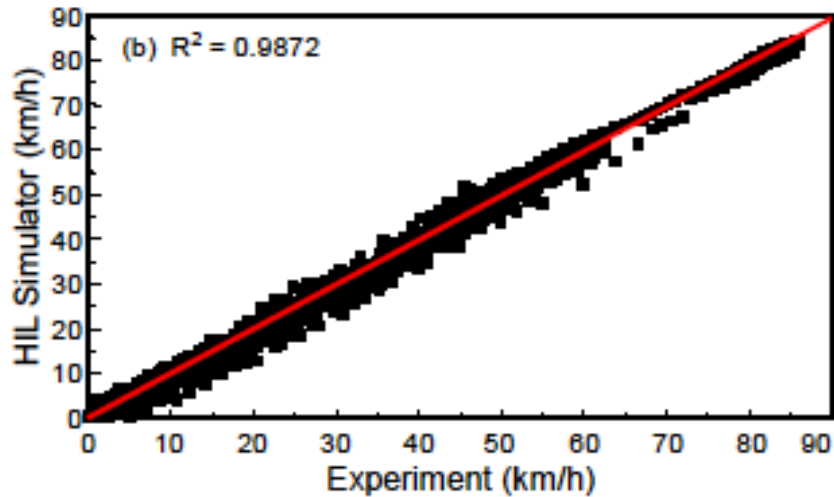
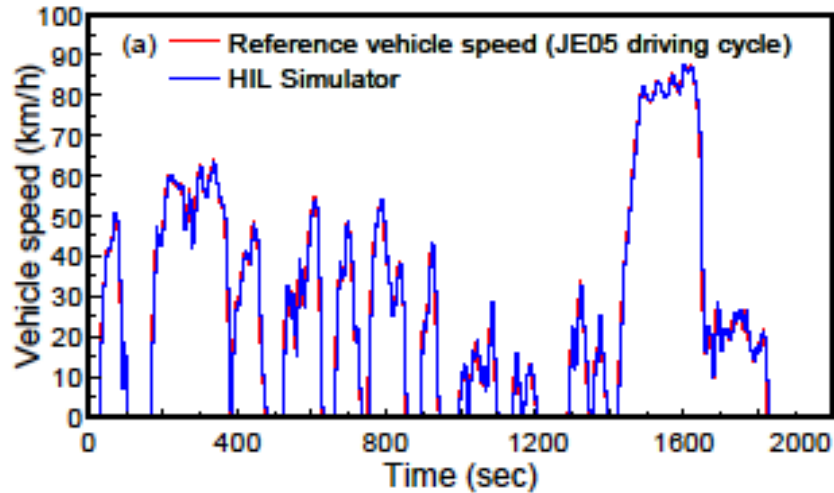
Vehicle type	Fuel economy	Exhaust emissions
 <p>LDVs (not many types)</p>	 <p>Measurement on chassis dyno</p>	
 <p>HD-CVs (many types)</p>	 <p>Simulation with FC map</p>	<p>Exhaust emissions are tested on engine dyno in the world.</p>  <p>Measurement with an engine unit</p>
 <p>HD-HEVs</p>	<p>Although there aren't many HD-HEVs at the moment, but many types of HD-HEVs (Ex. 4WD, In-wheel motor, multi wheels) will appear in the future.</p> <p>Therefore the <b>easy and efficient</b> test method using simulation is demanded (<b>HILS method is preferable</b>).</p>	

# Flow-chart of certification-test

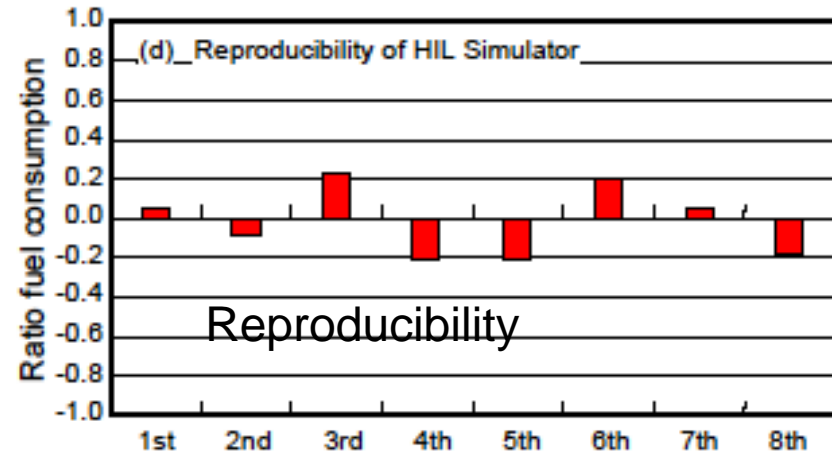
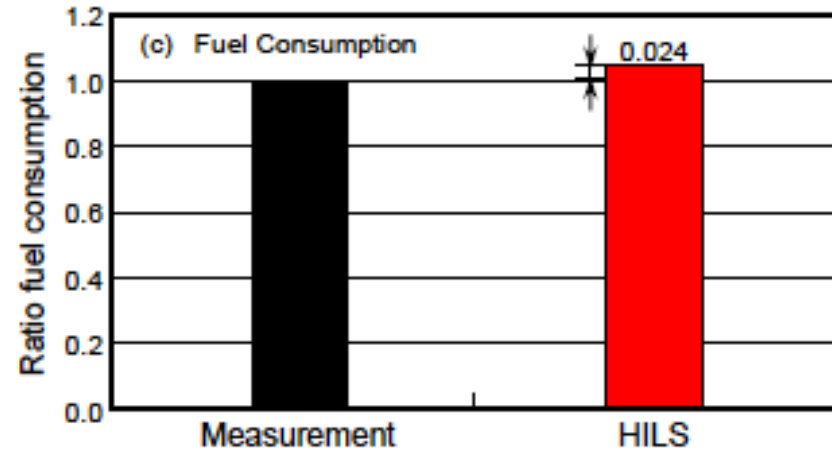


# Correlation Between test course driving and HILS for pre-transmission parallel hybrid architectures

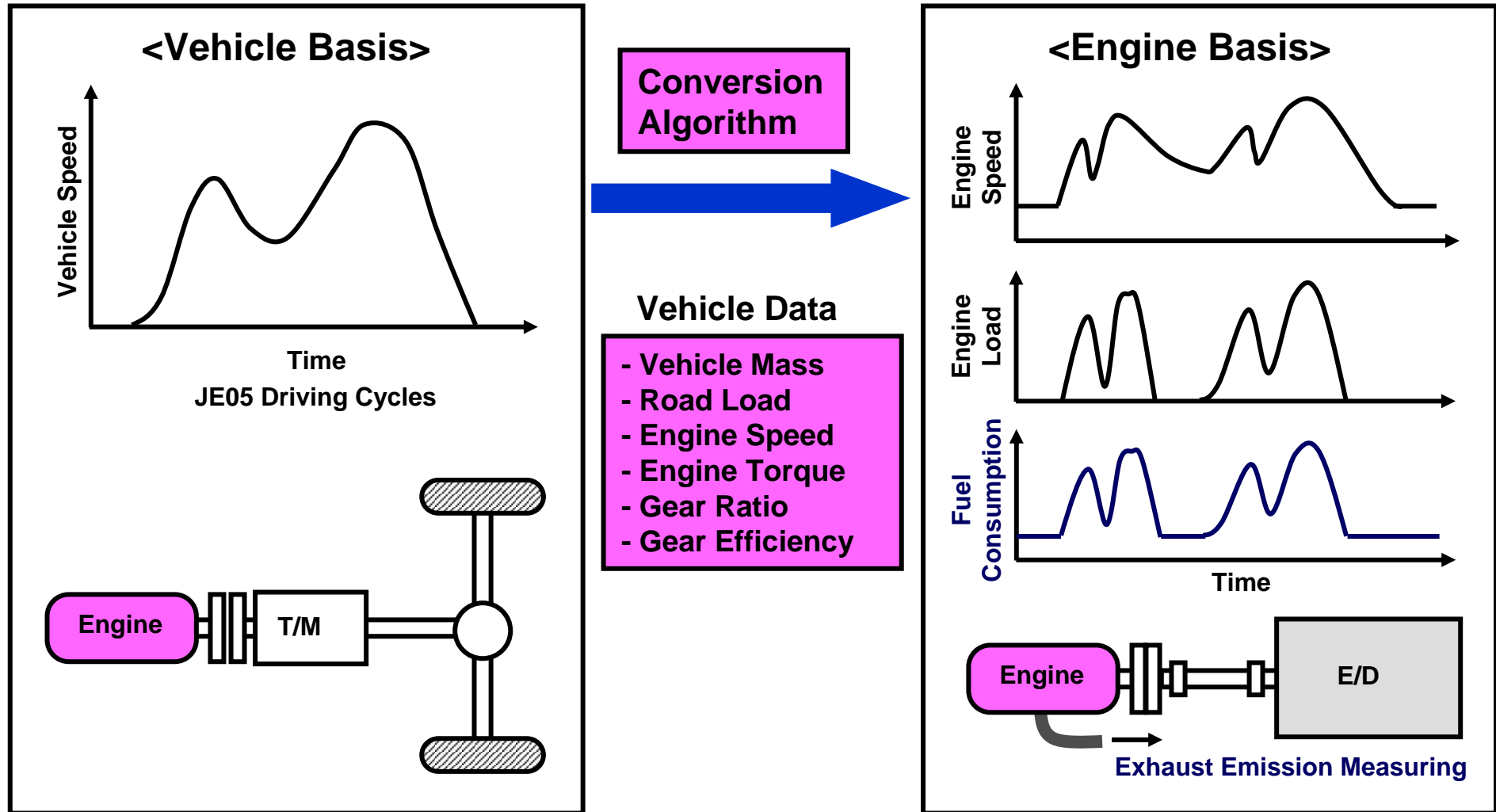
## Reference Vehicle Speed and HILS Simulation Speed



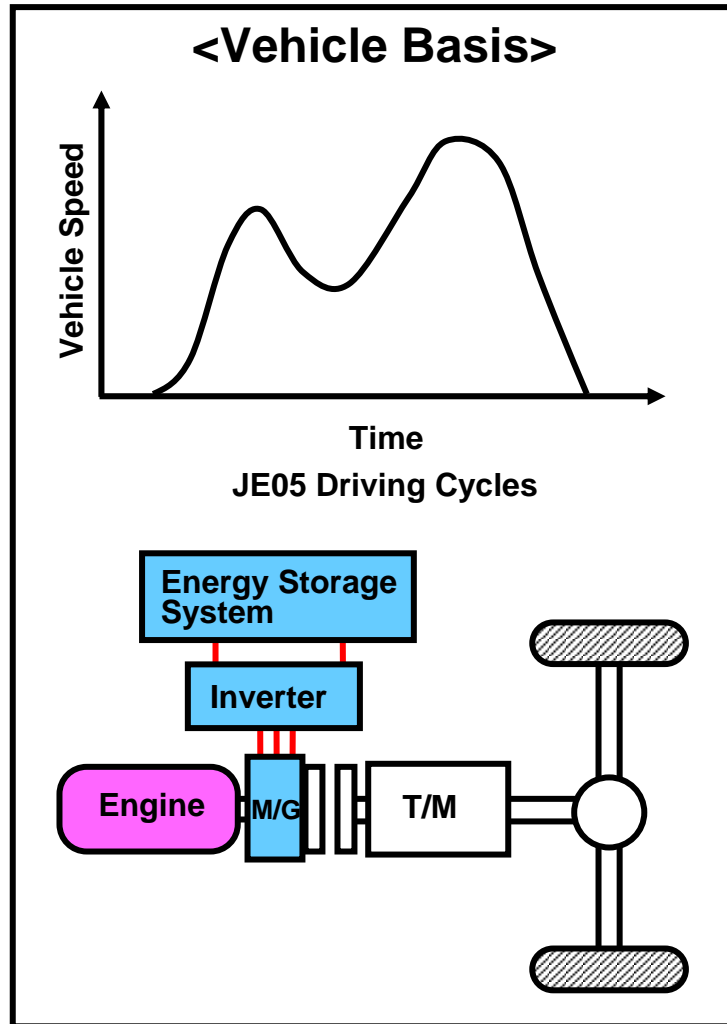
## FC



# Simulation Method for HD Conventional Vehicles



# Bench Test Method for Heavy-Duty HEVs



## HEV Conversion Algorithm



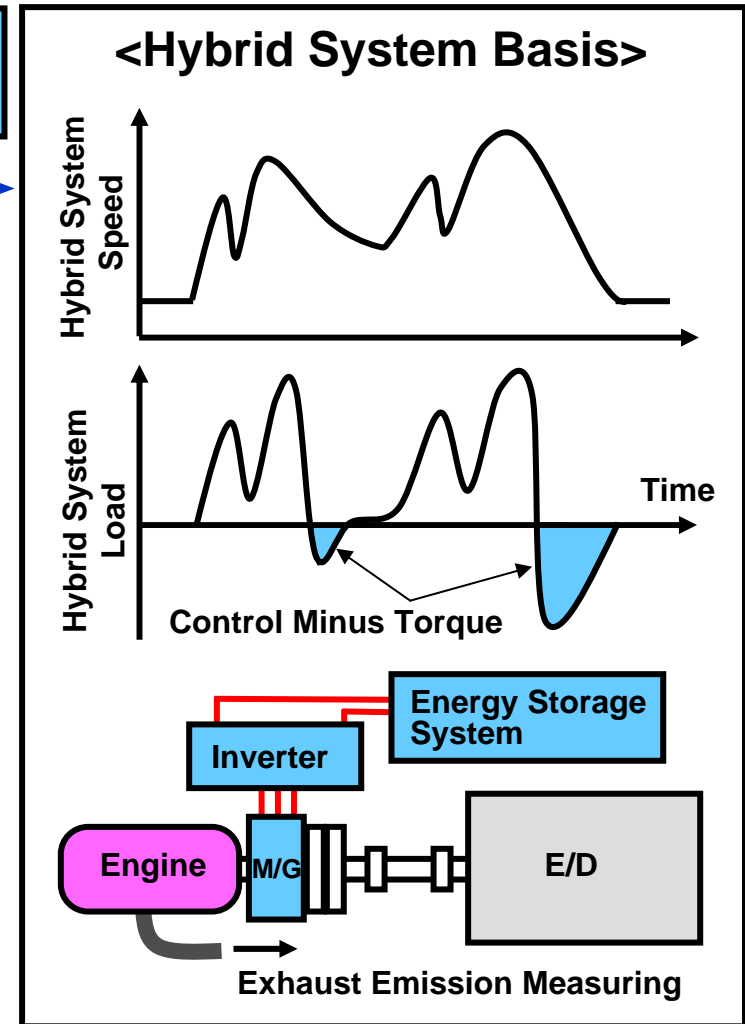
### Input Items

(1) Same Items with Conventional Vehicles

- Vehicle Mass
- Road Load
- Engine Speed
- Engine Torque
- Gear Ratio
- Gear Efficiency

(2) Special Items

Max. Regeneration Torque or Ratio of Regenerative Brake/ Mechanical Brake



# HILS Method for Heavy-Duty HEVs

