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## The Test method of the fuel economy on Heavy duty Hybrid vehicle in KOREA



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- ◆ **Object & present State**
- ◆ **Reason for amendment**
- ◆ **Main amendment**
- ◆ **Conclusions**

# Object & Regulation Fuel economy test method of HDH

## Object

The test method for the fuel economy of Heavy duty Hybrid Vehicle will be amended to urban driving fuel economy test method that **reflect real road speed pattern and feature of HDH**, which idle stop, regeneration function from constant speed test method.

## Regulation

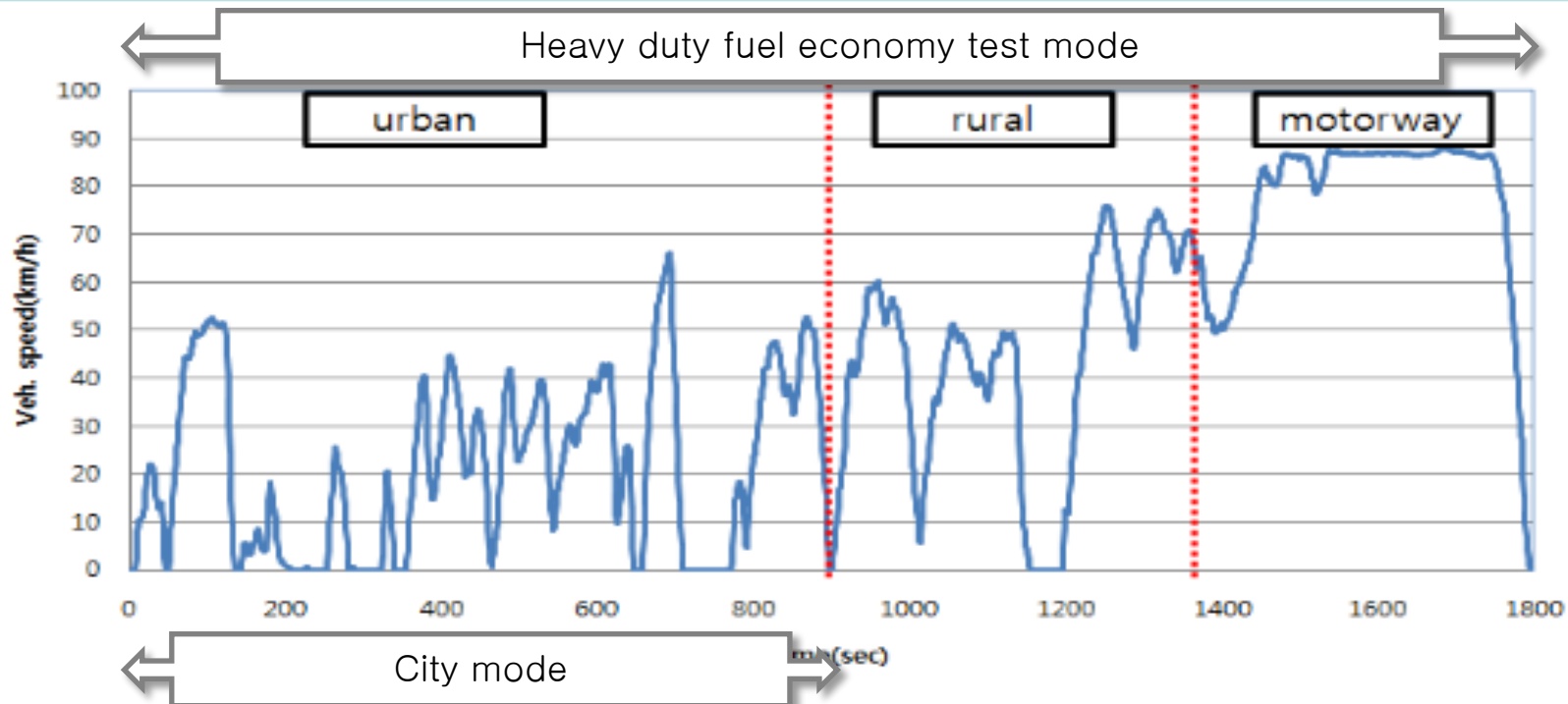
- 『Automobile Management Act』
  - Article 29 (Structure and Devices of Vehicle)
- 『Korea Motor Vehicle Safety Standard, KMVSS』
  - Article 111-4 (Fuel Economy)
- 『Korea Motor Vehicle Safety Standard Test Procedure』
  - Article 27 (Fuel Economy Test)
  - Test mode & method : **Constant speed(60km/h) & fuel flow measuring**

## Reason for Amendment

- Difficult to reflect the Real road fuel Economy
  - Real actual road speed pattern is transient, but constant speed test is steady.
  - Constant speed test can not reflect the actual road speed.
- Difficult to reflect the features of HDH
  - Hybrid vehicle contain the functions for improvement the fuel economy, idle stop and regeneration braking system.
  - Constant speed test can not reflect the feature of the functions.
- Difficult to measure the GHG of in-use vehicles
  - For reduction the GHG of in-use vehicle, it is necessary to measure the GHG of in-use vehicle in the real road speed patterns.
  - The development of test method reflected real actual road speed patterns is essential.

## Test Mode

- Test mode ; KHVC(WHVC), KHCC(WHVC\_urban, for city bus)
- Components : urban, rural, motorway
- Origin : WHVC mode of GRPE HDH



## Target Vehicle

- Classification : Bus(M2, M3), Truck(N2, N3) and tractor
- Weight : Over than 3.5ton of GVW
- Energy Source : Gasoline, Diesel, CNG, **Hybrid**, Hydrogen Fuel cell, Electric

## Test Method

- Measuring method ;
  - Combustion : Carbon Balance
  - Hybrid : Carbon Balance & Coulomb Counting
  - Hydrogen Fuelcell : Hydrogen mass, flow and pressure/temp. measure
  - Electric : Consumed Electric power measuring
- Cold/Hot weighing factor : 14%(Cold), 86%(Hot) or only Hot Condition
- Test loading weight : 100%(or 50%) of allowable loading weight
- Speed tolerance and M/A :  $\pm 2$ km/h, 3,000km(300km for electric vdhicle)
- C/H ratio : 2.06(Gasoline), 2.02(Diesel), 2.58(LPG), 4.09(Natural gas)



## Test Equipment

- Heavy duty Chassis dynamometer system
- Exhaust gas analyzer & CVS system
- Coulomb Counting system



## I.C vehicle

Fuel economy(km/ℓ) is calculated by carbon balance method using CO, HC & CO<sub>2</sub> measured by heavy duty chassis dynamometer and gas analysis system.

## Hybrid vehicle

The calculated Fuel economy(km/ℓ) by carbon balance method is compensated by accumulated current.

## Electric vehicle

Fuel economy(km/kWh) is calculated by total driving distance per full charging divided by power charging capacity for full charging.

## Fuel cell vehicle

Fuel economy(km/kg) is measured by mass measuring, flow measuring and pressure/temperature.



# Verification of Mode Fuel economy test method of HDH

## Statistical data

- The comparison interval average speed of WHVC mode and actual local road average speed
  - Average interval speed of Urban, rural and motorway are very similar.

Avg. speed(km/h)	Urban interval	Rural interval	Motorway interval	Total
WHVC	21.3	43.6	76.6	40.1
Actual road	21.0	42.1	76.4	39.5

### Urban interval(city bus)

	total	Capital area	Busan·ulsan area	Daegu area	Kwangju area	Daejeon area
Lines	578	281	75	74	51	97
Avg. speed (km/h)	21	22.6	20.4	20.1	19.9	21.6

### Rural interval

Γενεραλ Νατιοναλ Ροαδ	44.8
Περιοναλ Ροαδ βψ νατιοναλ αιδεδ	41.1
Περιοναλ Ροαδ	40.3

### Motorway interval

Μοτορ ωαψ	76.4
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source : 2010 National Transportation DB Center

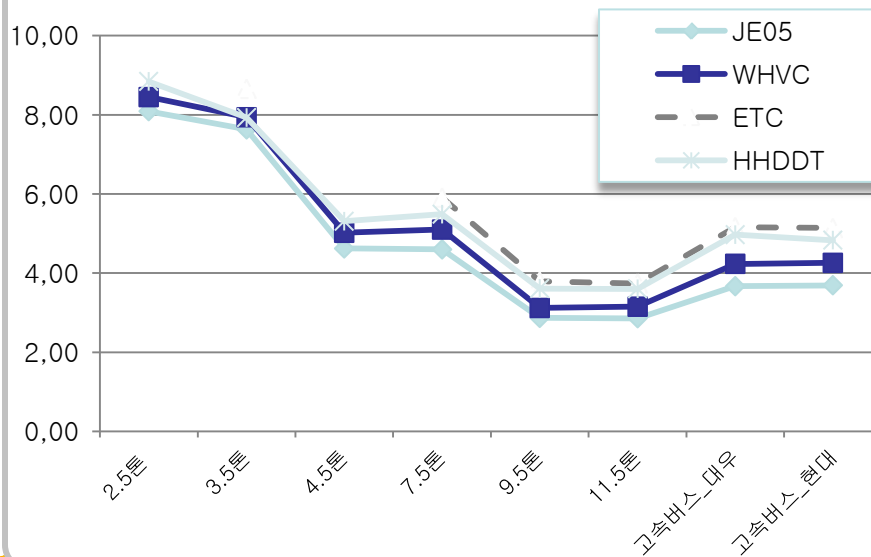
source : 2009 Kyunggi Transportation DB Center



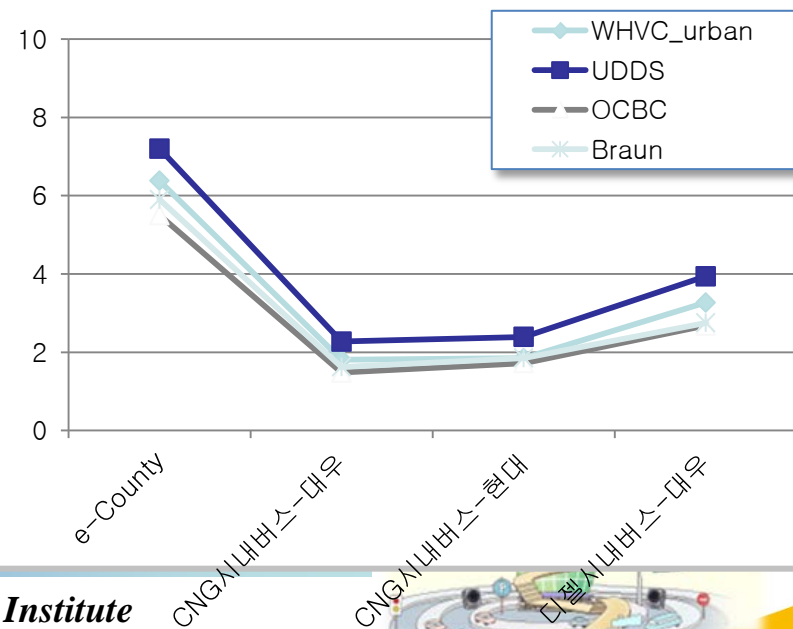
## Comparison with fuel economy test results by foreign modes

- The comparison of the fuel economy test results with foreign major modes and WHVC mode for middle and heavy duty vehicles, buses and trucks, the test results of WHVC mode are the middle line of foreign modes.
- Target vehicles : 6(trucks), 6(buses)
- Target test modes : 10(JE05,ETC, HHDT, WHVC,...)

Comparison of fuel economy with foreign modes(WHVC vs)

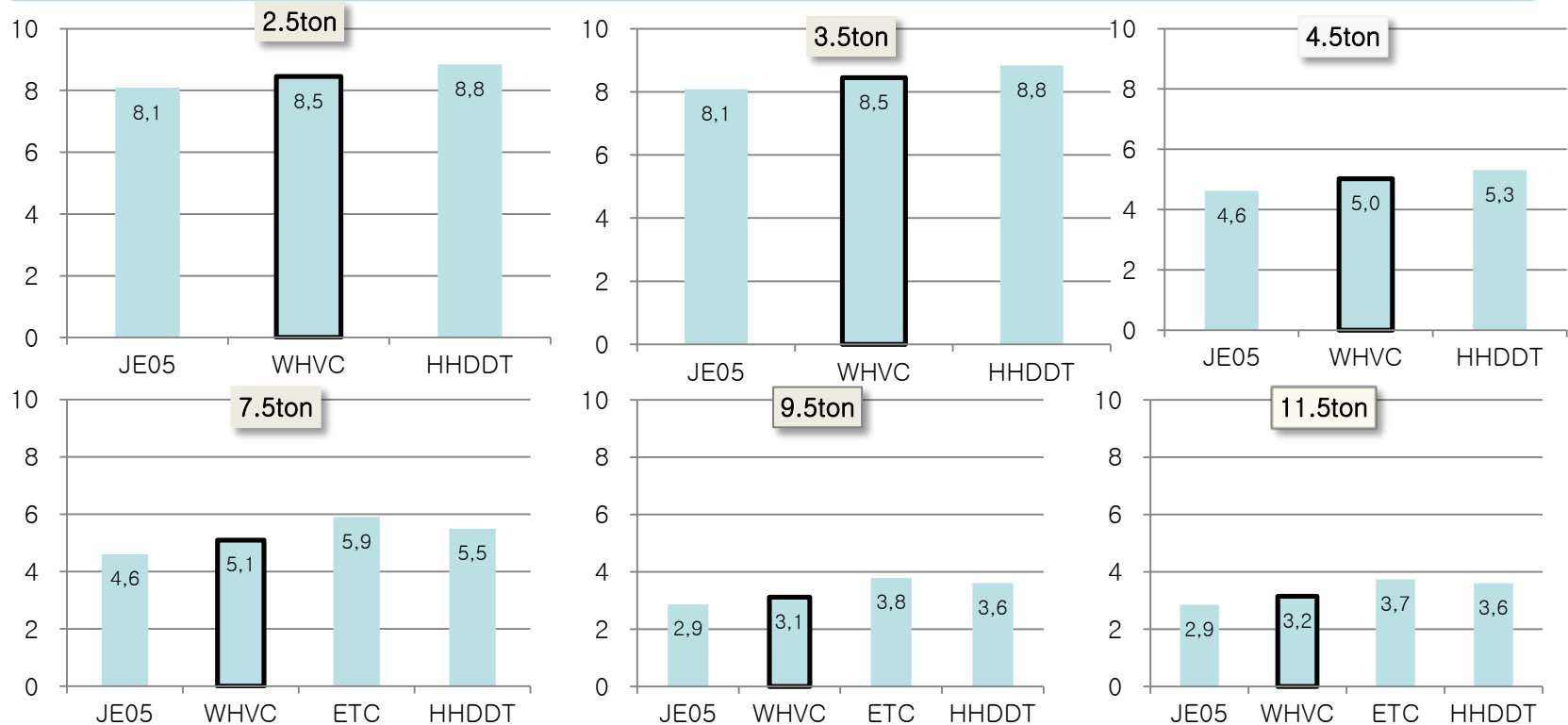


Comparison of fuel economy with foreign modes(WHVC\_urban vs)



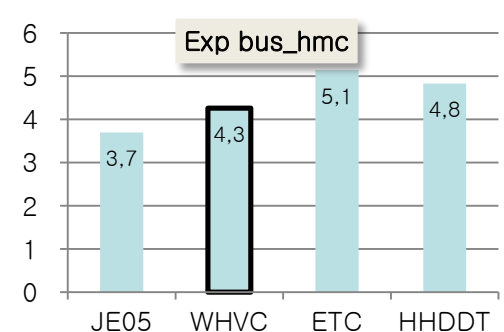
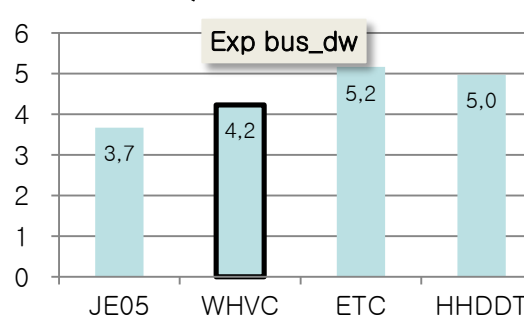
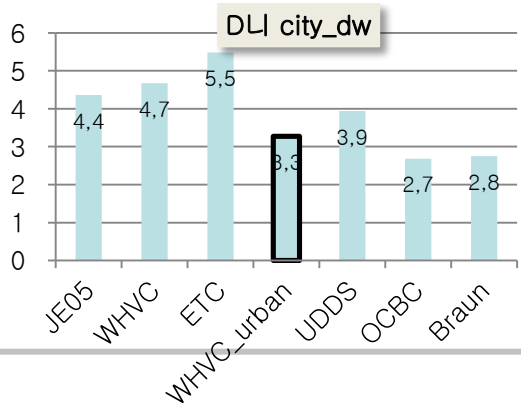
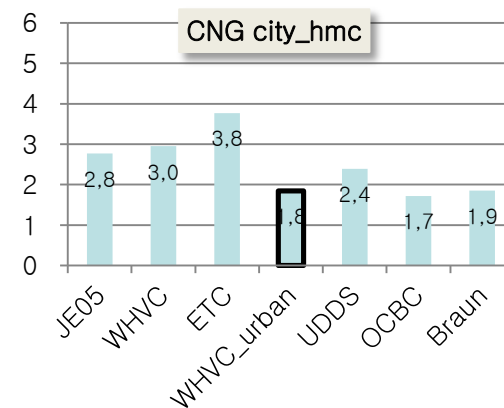
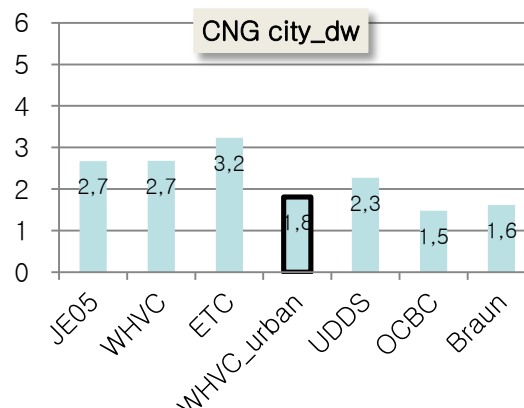
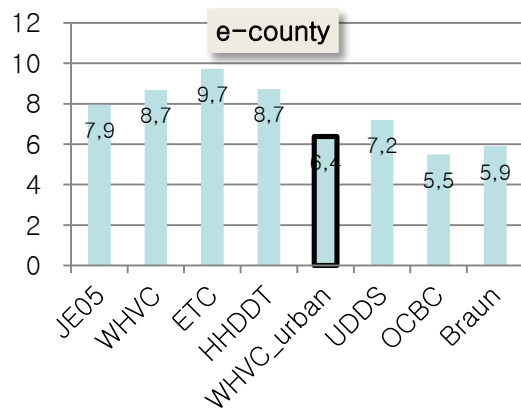
## Test results(trucks)

- The comparison of the fuel economy test results with foreign major modes and WHVC mode for middle and heavy duty vehicles, trucks, the test results of WHVC mode are the middle line of foreign modes.



## Test results(buses)

- The comparison of the fuel economy test results with foreign major modes and WHVC mode for middle and heavy duty vehicles, buses and trucks, the test results of WHVC mode are the middle line of foreign modes.

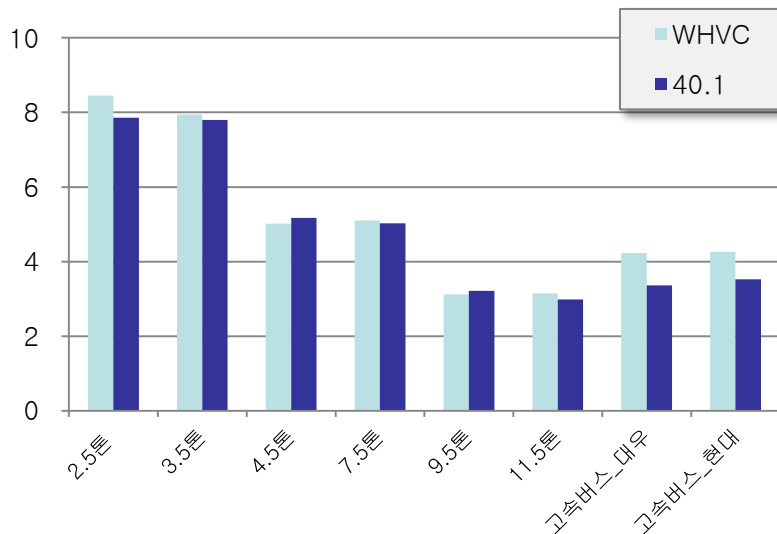


## Test result(avg. speed F/E vs)

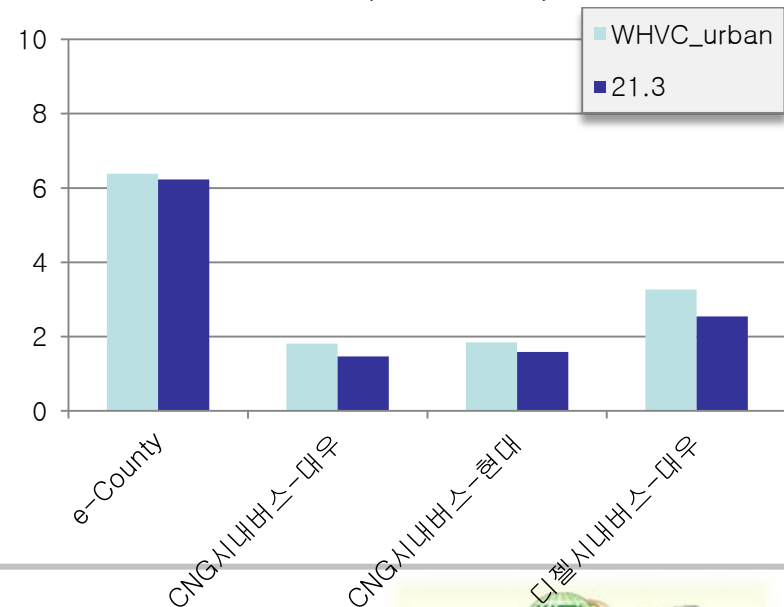
- Test vehicle : 6(trucks), 6(buses)
- The results of fuel economy are very similar
  - WHVC F/E vs avg. speed(40.1km/h) F/E, WHVC\_urban F/E vs avg. speed(21.3km/h)

\* Vehicle average speed test results obtained from the regression model that estimated from various speeds mode tests.

WHVC vs avg. speed  
mode(40.1km/h)



WHVC\_urban vs avg. speed  
mode(21.3km/h)



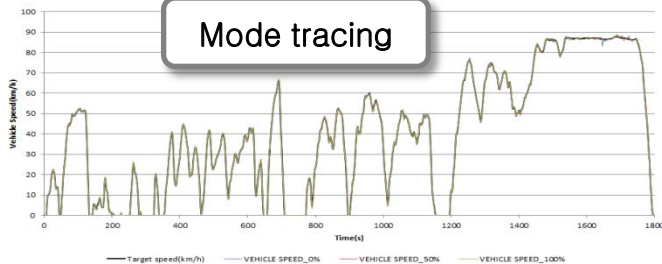
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## Test result of Electric buses

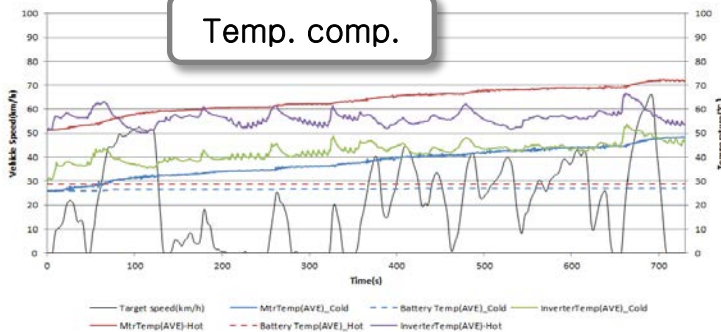
- Target vehicle : 2(Electric buses)
- Test mode : WHVC and WHVC\_urban
- Test method : mode tracing, temp. comparison, driving distance
- Result : tracing OK, , difference of temp., driving distance per full charging



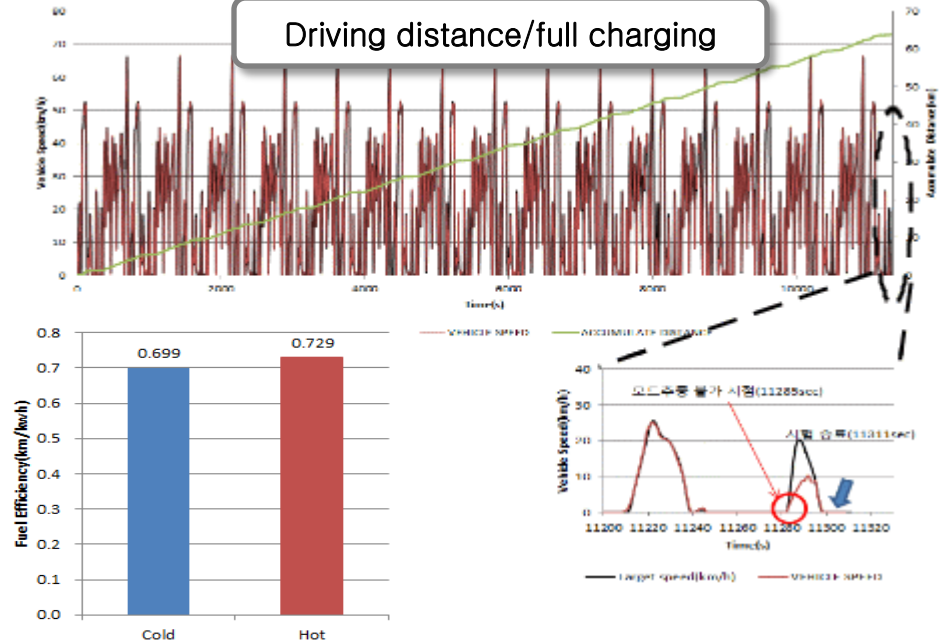
Mode tracing



Temp. comp.



Driving distance/full charging

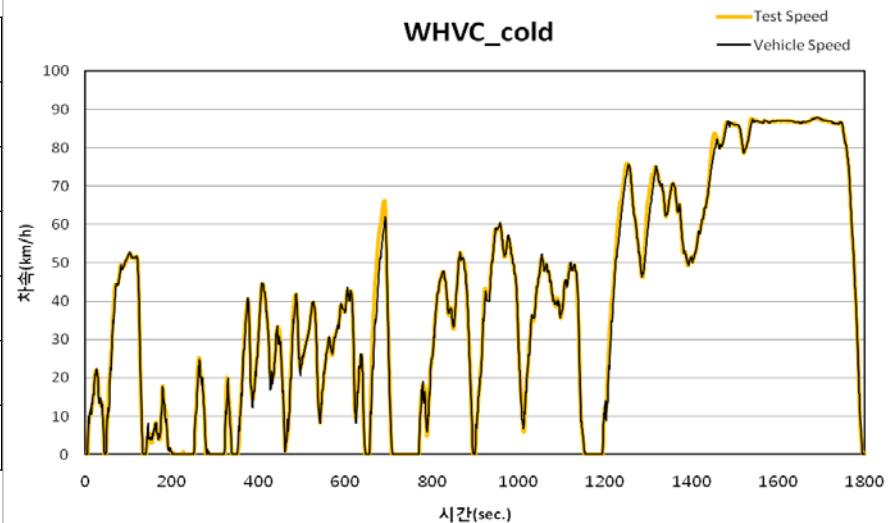




## Test Results

- WHVC mode is the complexed type of world wide road patterns.
- Mode tracing test achieved using 12 vehicles(combustion type) was good
- Mode tracing test of Hybrid vehicle was not good in some points
- Mode tracing test of electric/fuel cell vehicle was good
- Single energy source vehicle was good for the Mode tracing
- Hybrid vehicle will be developed to trace the WHVC mode

categories		quantities	mode tracing	
			WHVC	WHVC_urban
combustion	bus	5	◎	◎
	truck	7	◎	◎
Hybrid	bus	1	△	△
electric	bus	2	◎	◎
fuelcell	bus	1	◎	◎



## Summary

- Currently, the fuel economy method for heavy duty vehicle of KOREA is constant speed(60km/h).
- WHVC mode is the transient one reflected the actual road speed pattern and can reflect the feature of HDH. Also it can measure the GHG.
- 1st step : The fuel economy test will be achieved by Chassis dynamometer, Exhaust gas analyzer and the Coulomb counting system using WHVC test mode.
- 2<sup>nd</sup> step : After making up the HILS and Simulation method, Korea will adopt this method.

Thanks for your  
attention !

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