Introduction to System Power Concept and its Application

Dongseok CHOI / Ph.D.

KATRI (*Korea Automobile Testing and Research Institute*)

Republic of Korea

Contents

Background

Problems>

- Increased Electric Fraction of HEVs due to fuel economy
- Representative power for HEVs, PHEVs and EVs with in-wheel motors
- Vehicle classification and vehicle occupation tax

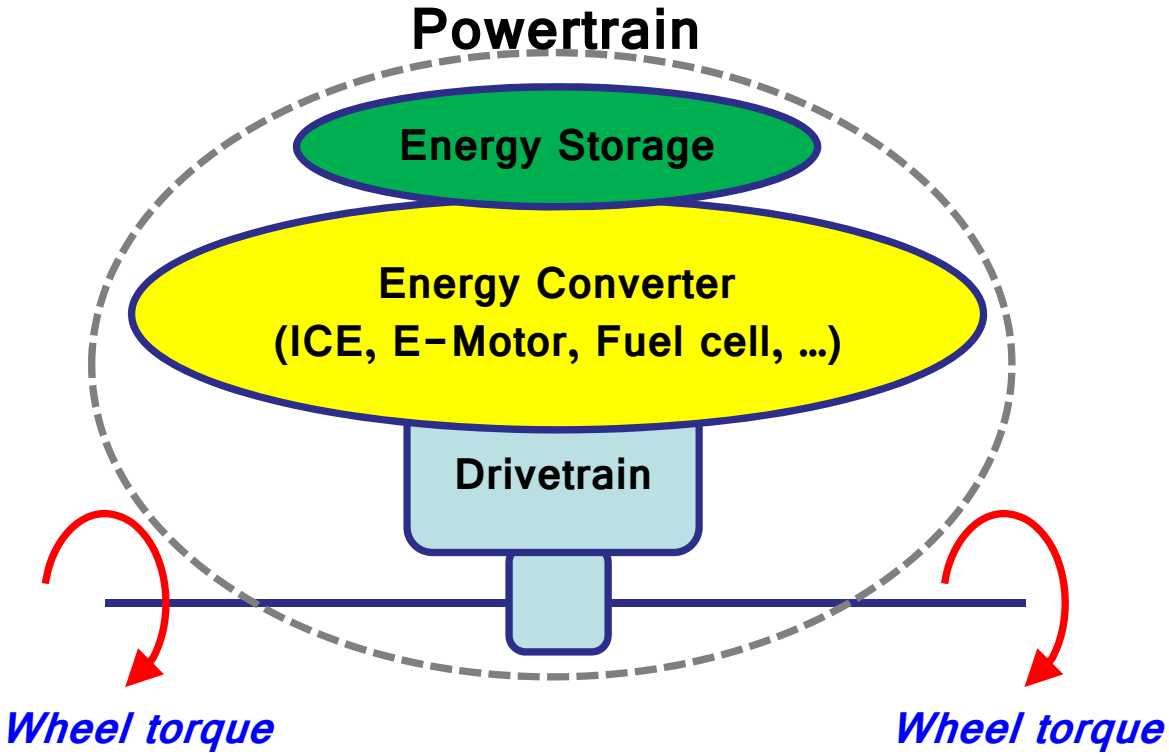
Suggested solution>

- Concept of system power

Background – concept of system power

"What is the system power? "

Power of the powertrain in a vehicle, not including the tire effect

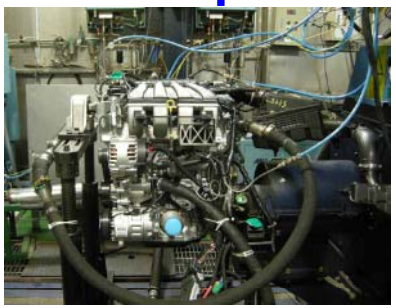


$$P = F \times V$$
$$= (T_w / R_{tire}) \times V$$

Background

"How to measure the representative power of HEVs? "

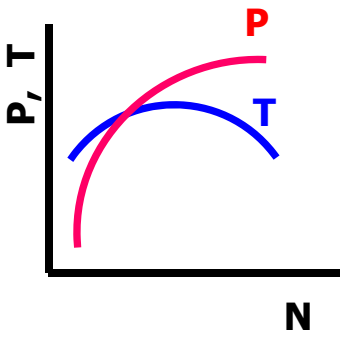
HEVs

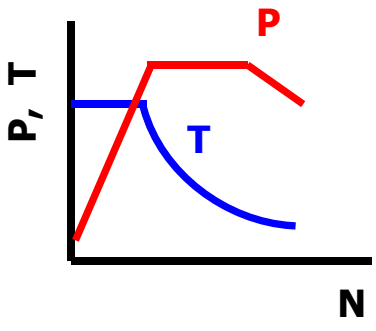


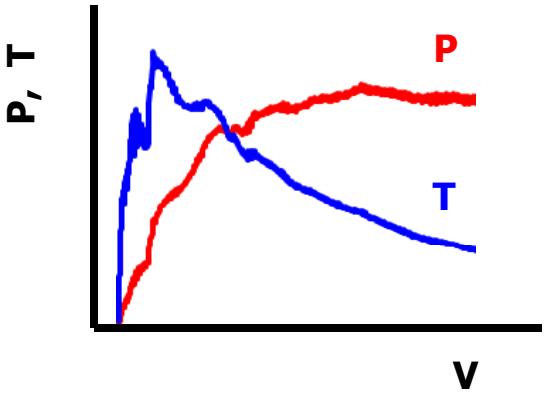
ICE

E-Motor

" System power "



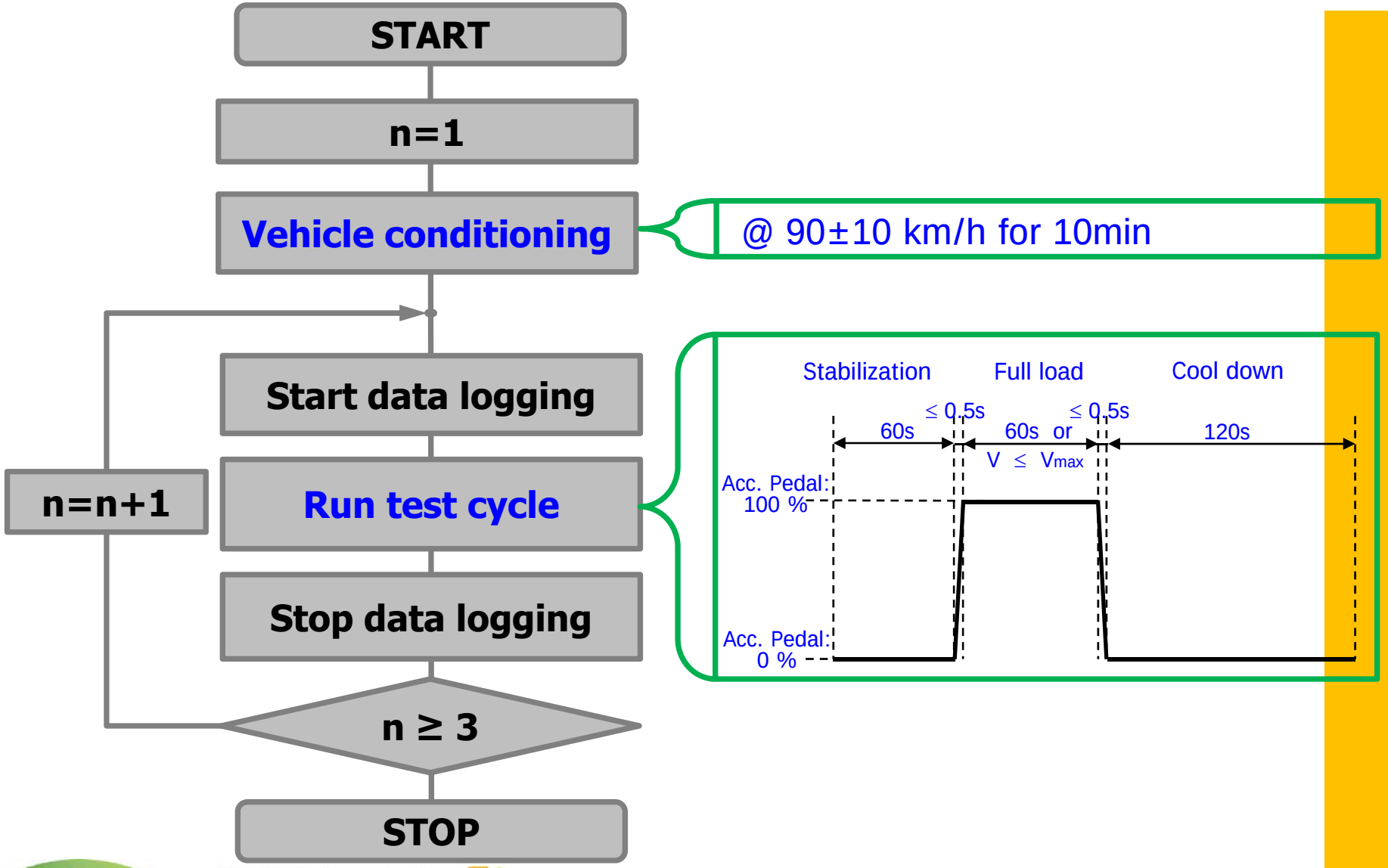




P : power T : torque N : speed

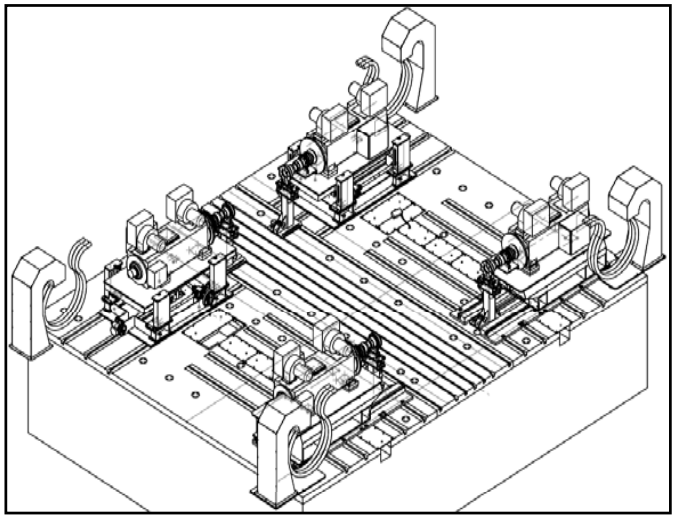
V : vehicle speed

Test Procedure



Powertrain test bed

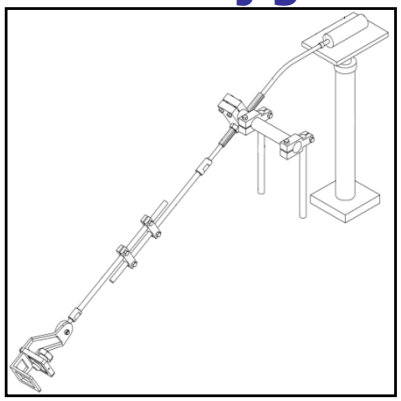
❖ Test bed



Dynamometer spec.

- Max power : 290 kW @1100 ~ 3000 rpm
- Max torque : 2500 Nm @ ~ 1100 rpm
  (40% overload : 3500 Nm)
- Wheel base : 1.8 ~ 3.8 m
- Thread : 1.2 ~ 2.2 m

❖ Control jig for acceleration pedal



Test vehicles

❖ **Specification of powertrain for test vehicles**

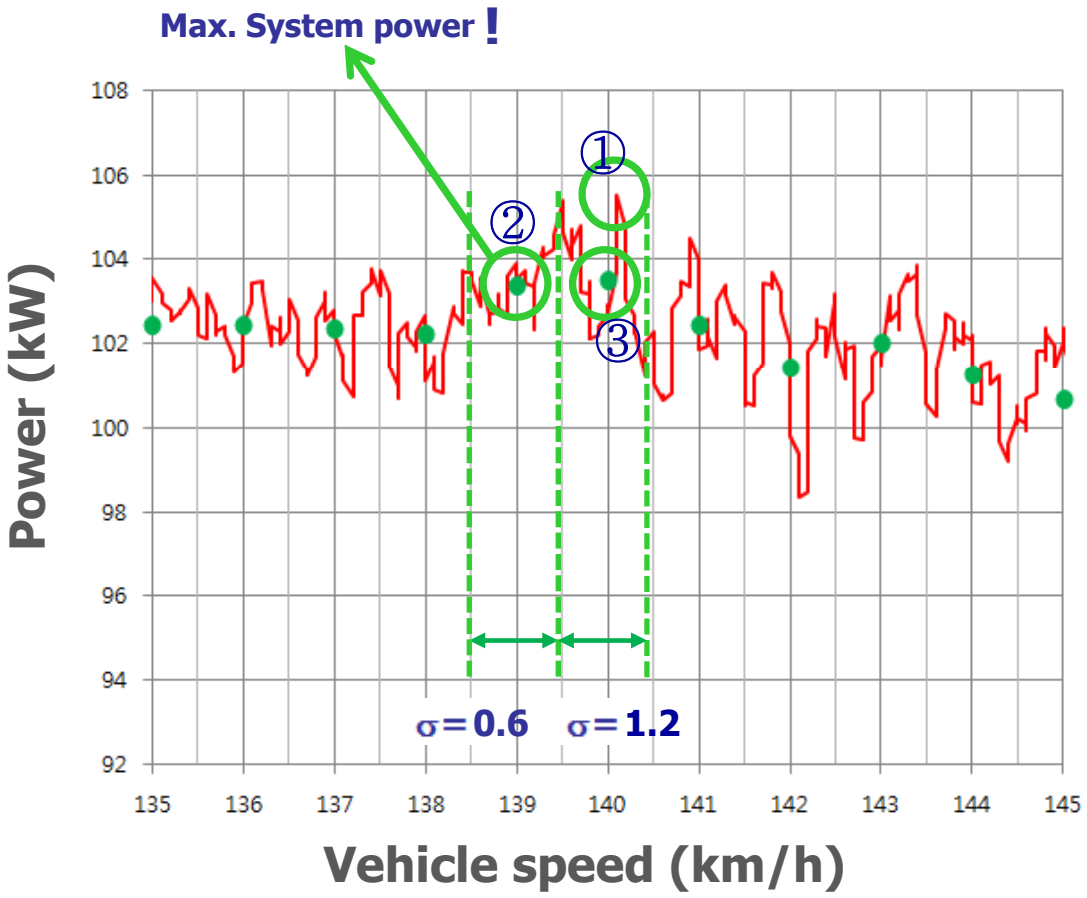
Items / Test Vehicles	Power		Drivetrain Type	Electric Fraction (EF) [%]
	ICE [kW]	E-Motor [kW]		
HEV 1	133.2	15	AT	10
HEV 2	110.4	30	AT	21
HEV 3	55.9	50	e-CVT	47
HEV 4	72.9	60	e-CVT	45
EV	-	70	RG	100

➢ $EF = \frac{\text{Motor power}}{(\text{ICE power} + \text{Motor power})} \times 100$

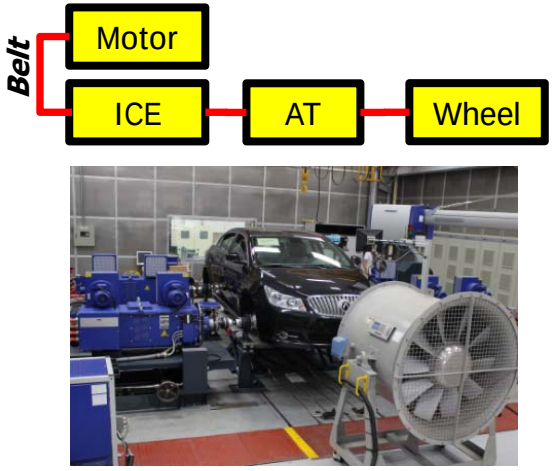
➢ RG : Reduction Gear

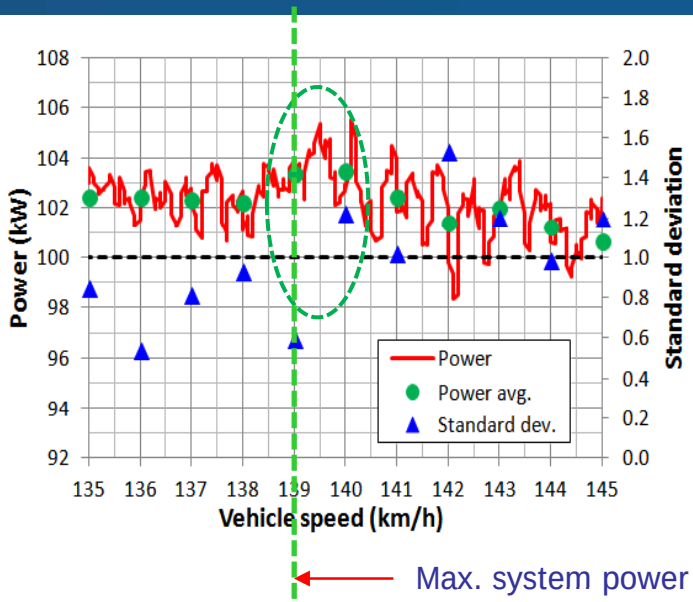
Determination of max system power

- How to determine max system power?

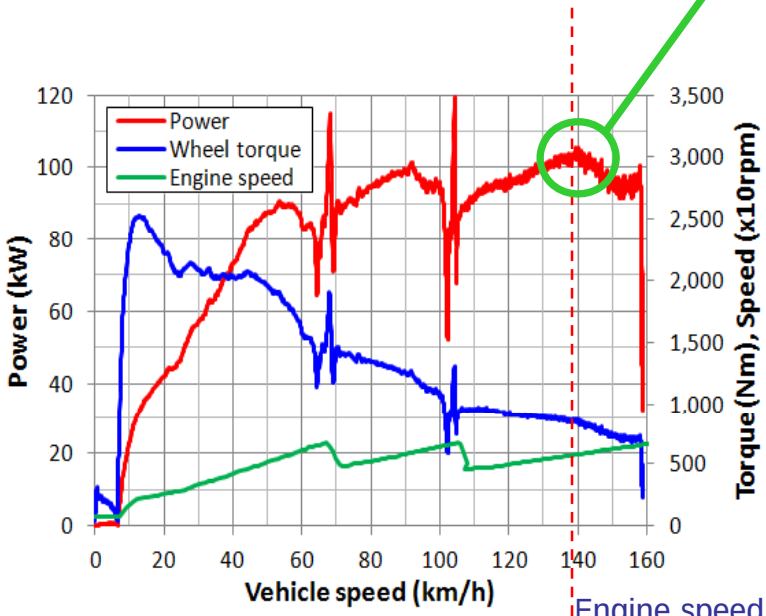


Test result of HEV 1 (EF=10%)





Max. system power : **103.4 kW**

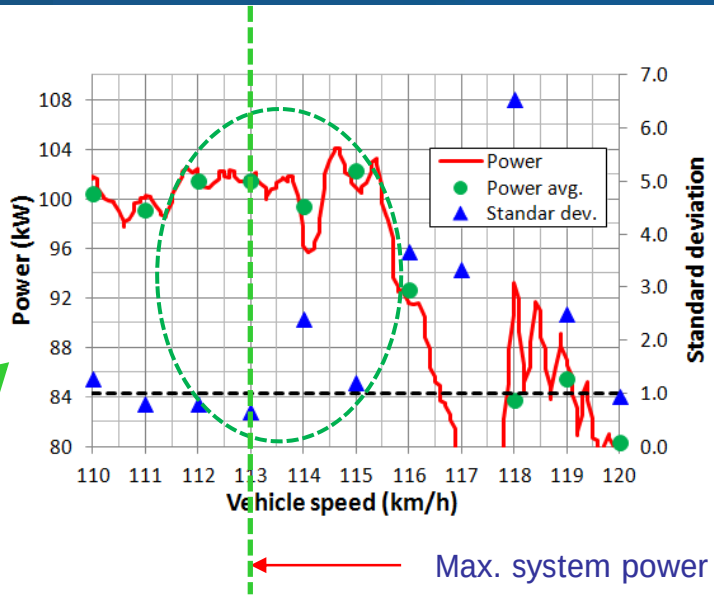


Engine speed : 5721 rpm
Vehicle speed : 139 km/h

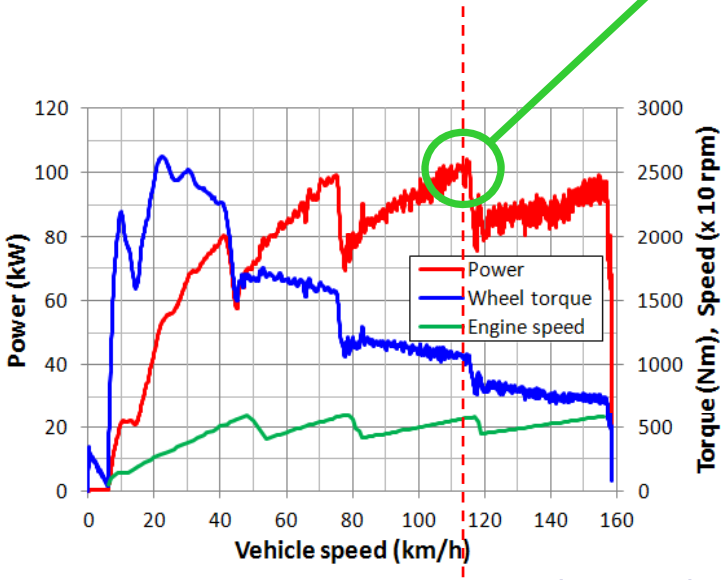
Test No.	Max sys. Power (kW)	Difference (%)	Vehicle speed (km/h)
1	103.4	1.3	139
2	97.9	-4.1	144
3	105.0	2.8	139
Avg.	**102.1**	-	**141**

Test result of HEV 2 (EF=21%)

ICE — Clutch — Motor — AT — Wheel



Max. system power : **101.5 kW**

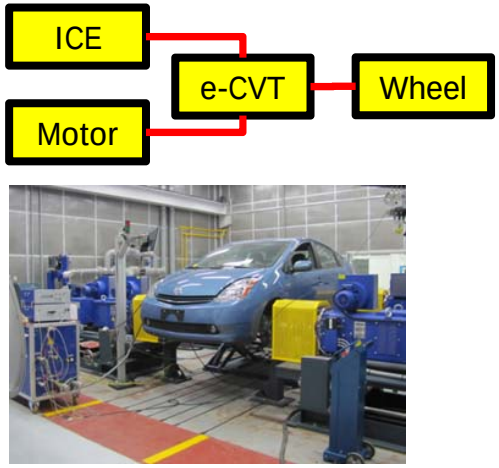


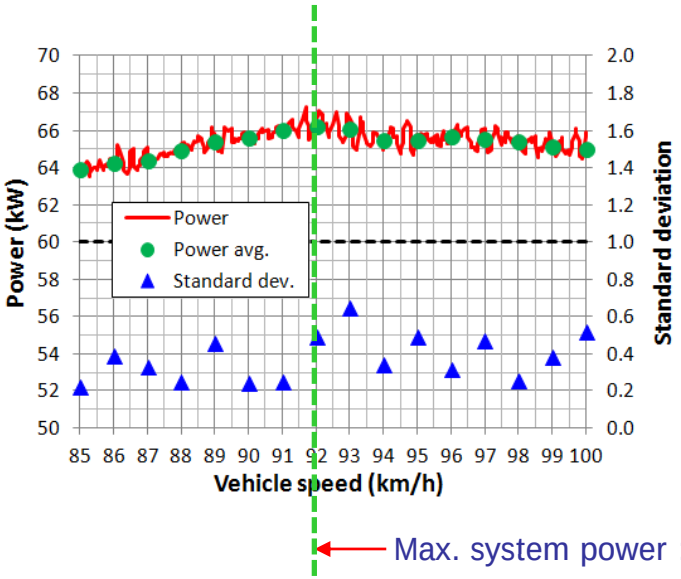
Test No.	Max sys. Power (kW)	Difference (%)	Vehicle speed (km/h)
1	105.1	3.5	113
2	98.1	-3.4	113
3	101.5	-0.1	113
Avg.	**101.6**	-	**113**

Engine speed : 5577 rpm

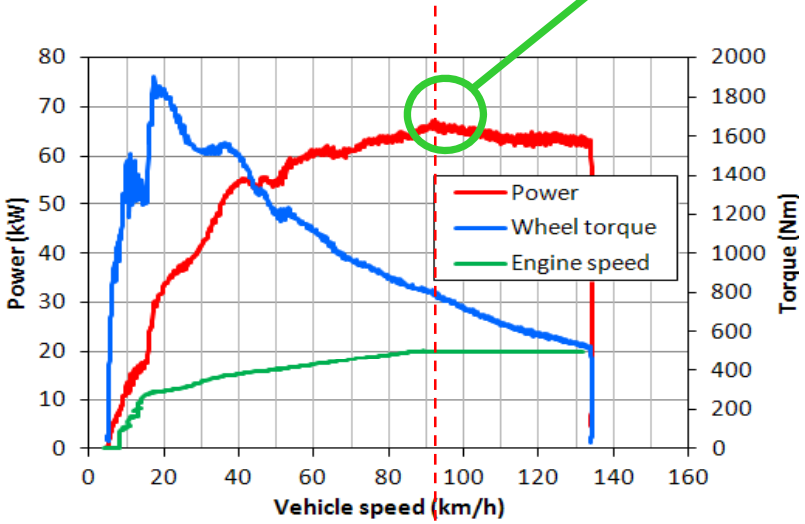
Vehicle speed : 113 km/h

Test result of HEV 3 (EF=47%)





Max. system power : 66.3 kW

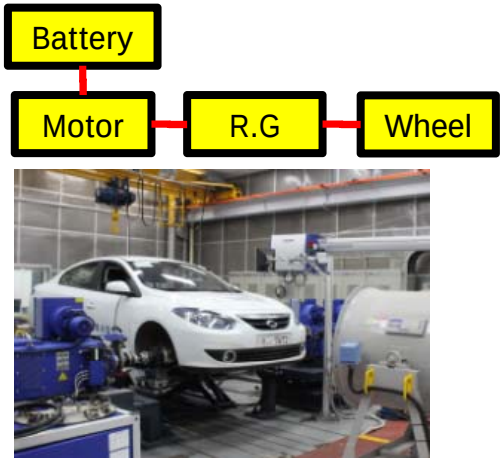


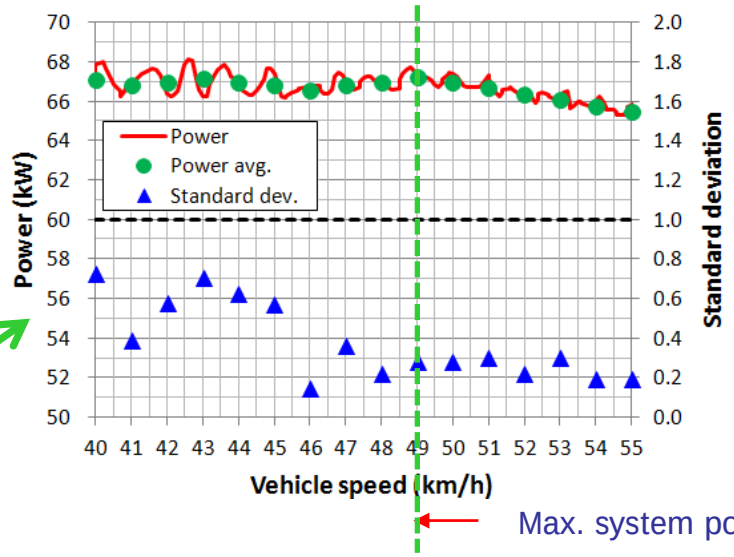
Vehicle speed : 92 km/h

Engine speed : 5000 rpm

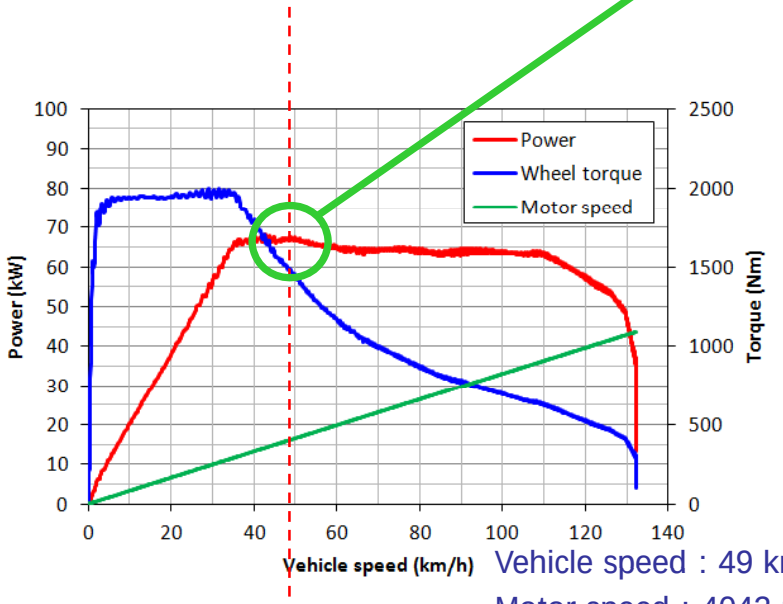
Test No.	Max sys. Power (kW)	Difference (%)	Vehicle speed (km/h)
1	69.0	1.3	91
2	69.0	1.3	93
3	66.3	-2.6	92
Avg.	**68.1**	-	**92**

Test result of EV (EF=100%)





Max. system power : **67.3 kW**



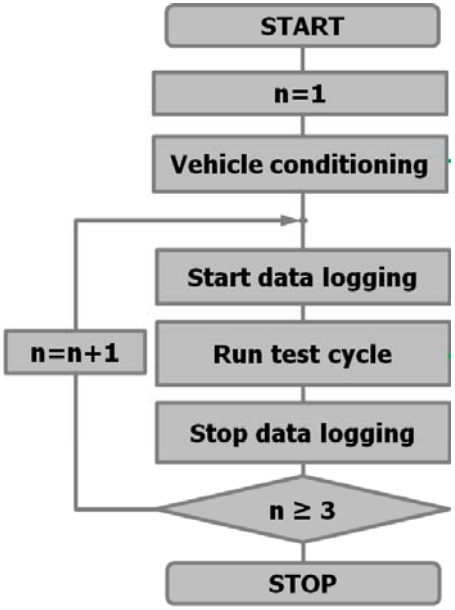
Vehicle speed : 49 km/h

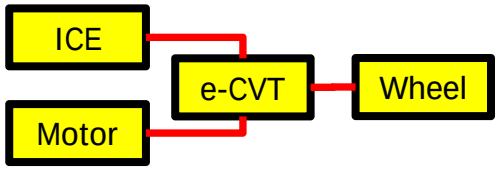
Motor speed : 4042 rpm

Test No.	Max sys. Power (kW)	Difference (%)	Vehicle speed (km/h)
1	67.3	-2.0	49
2	70.1	2.9	42
3	68.7	0.9	50
Avg.	**68.7**	-	**47**

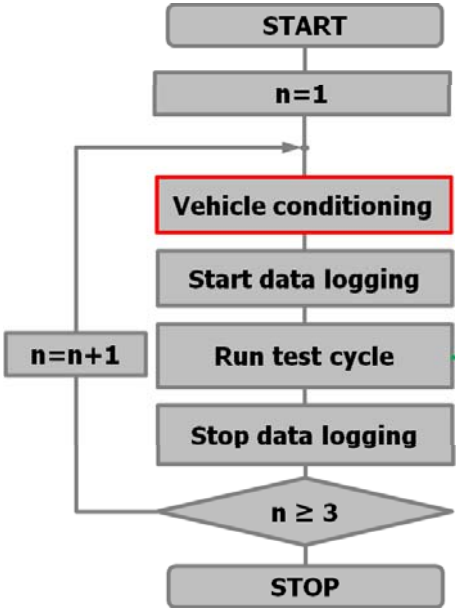
Test result of HEV 4 (EF=45%)

<Test procedure>





<Improved test procedure>



Test No.	Max sys. Power (kW)	Difference (%)	Vehicle speed (km/h)
1	70.2	-2.9	131
2	73.7	1.9	131
3	73.1	1.1	125
Avg.	**72.3**	-	**129**

Test No.	Max sys. Power (kW)	Difference (%)	Vehicle speed (km/h)
1	74.1	-0.1	139
2	74.1	-0.1	137
3	74.4	0.3	140
Avg.	**74.2**	-	**139**

Conclusions and future work

❖ Conclusions

- **System power** means **the power is measured at the end side of the powertrain without a tire.**
- For the determination of max system power, the criterion was the **one sigma.**
- The test procedure for system power measurement was proposed and the test result by the improved one had a good **repeatability within ±1 percent**.

❖ Future work

- To validate the test procedure for various types of vehicles such as plug-in hybrid vehicles and electric vehicles with in-wheel motors

Thank you!

dsechoi@ts2020.kr

http://eng.ts2020.kr/katri/katri_01.jsp