Draft

EVE28-06e
Analysis of validation results of system power determination for HEVs
Japan
(28th EVE Meeting – 16-18th Oct. , 2018)

Partially quoted from EVE24-04e

Proposal for system power determination for HEVs

Japan

(24th EVE Meeting – 24-25th Oct. , 2017)

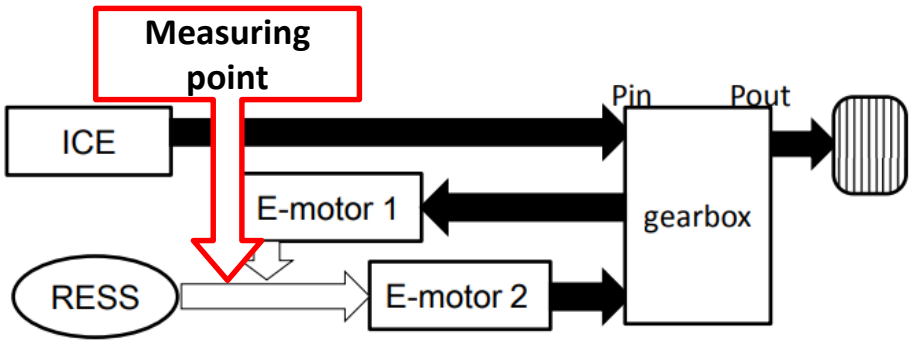
Background (Summary of the last session)

- In current situation, two candidate test procedures are there. The reflection of these procedures depends on actual test results which may be delivered during the validation program.

•TP1: REESS power based

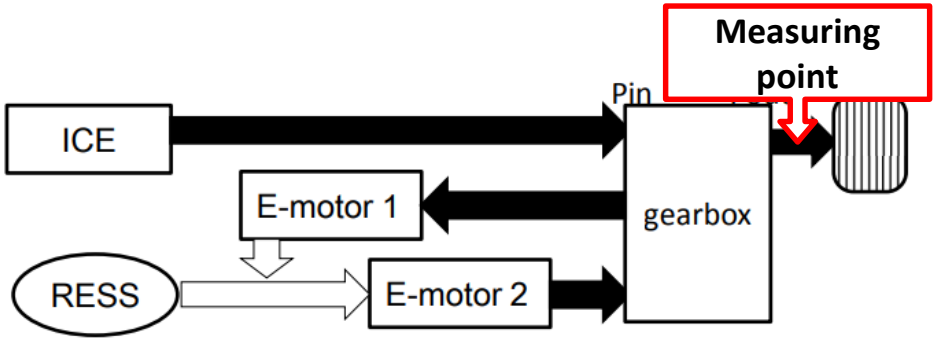
Transform efficiency of converter is considered.

Japan originally proposed TP1 for ISO.



•TP2: Gear box output axis power based

Transform efficiency of gear box is considered.



Calculation of System Power : TP1

Terms	Explanations	Discussion points
HEV system power	= ICE power [kW] + Converted RESS power [kW]	
ICE power [kW]	The test results of measurements according to ISO1585 are necessary. ICE power is based on the measured engine speed and intake manifold pressure in inlet system or fuel flow rate, it shall be determined by the engine dynamometer test specified in international standards and/or legal requirements. The engine dynamometer test fuel shall be the same as in 6.3(= vehicle test).	How EVE treat the reference of ISO 1585?/R83?
Converted RESS power [kW]	= (U_{RESS} [V]× I_{RESS} [A]/ 1000 −P_{DCDC}) x K P_{DCDC}= Power to DC/DC converter for 12V auxiliaries (1,0kW or measured value) [kW] K=Conversion factor from electrical power to mechanical power (0,85 or measured value).	

For JARI test, sampling frequency was 10Hz. Measured values were smoothed by the moving average for 1s.

Calculation of System Power : TP2

6.9.3.1 Calculation

The HEV system power at the wheels is calculated by multiplying individually the measured data of each drive shaft or wheel torque with the corresponding drive shaft or wheel speed to get the individual drive shaft or wheel power values and finally by the sum of each individual drive shaft or wheel power values according to the following formulas:

$$\textit{Drive shaft or wheel power } [kW] = (2\pi \times \text{drive shaft or wheel speed } [s^{-1}] \times \textit{drive shaft or wheel torque } [Nm])/1000$$

$$\textit{HEV system power at all axles or all wheels } [kW] = \textit{Sum of drive shaft or wheel power of each driven drive shaft or wheel } [kW]$$

Measured values

In order to calculate the HEV system power value comparable to the engine or electric machine power value at the engine or electric machine output shaft, the measured HEV system power value at wheels shall be corrected by the gearbox system efficiency factor $\eta_{gearbox}$ according to the following formula:

$$P_{HEV\ system}\ [kW] = \frac{P_{HEV\ system\ at\ wheels}\ [kW]}{\eta_{gearbox}}$$

Where

$P_{HEV\ system}$ is the HEV system power [kW]

$P_{HEV\ system\ at\ wheels}$ is the HEV system power at wheels [kW]

$\eta_{gearbox}$ is the gearbox system efficiency factor

JARI Test Vehicles

Specification of test vehicles		2015		2016
		Vehicle A	Vehicle B	Vehicle C
Vehicle	Length × width × height m	3.99×1.69×1.44	3.95×1.69×1.52	4.69×1.80×1.71
	Vehicle Weight kg	1080	1160	1820
	Gross vehicle weight kg	1355	1435	2095
	Test vehicle kg	1340	1360	1933
Engine	displacement L	1.496	1.496	1.998
	Maximum power kW	54	81	87
Motor	Maximum power kW	45	22	60/60
*HEV system	Maximum HEV system power kW	73	101	-

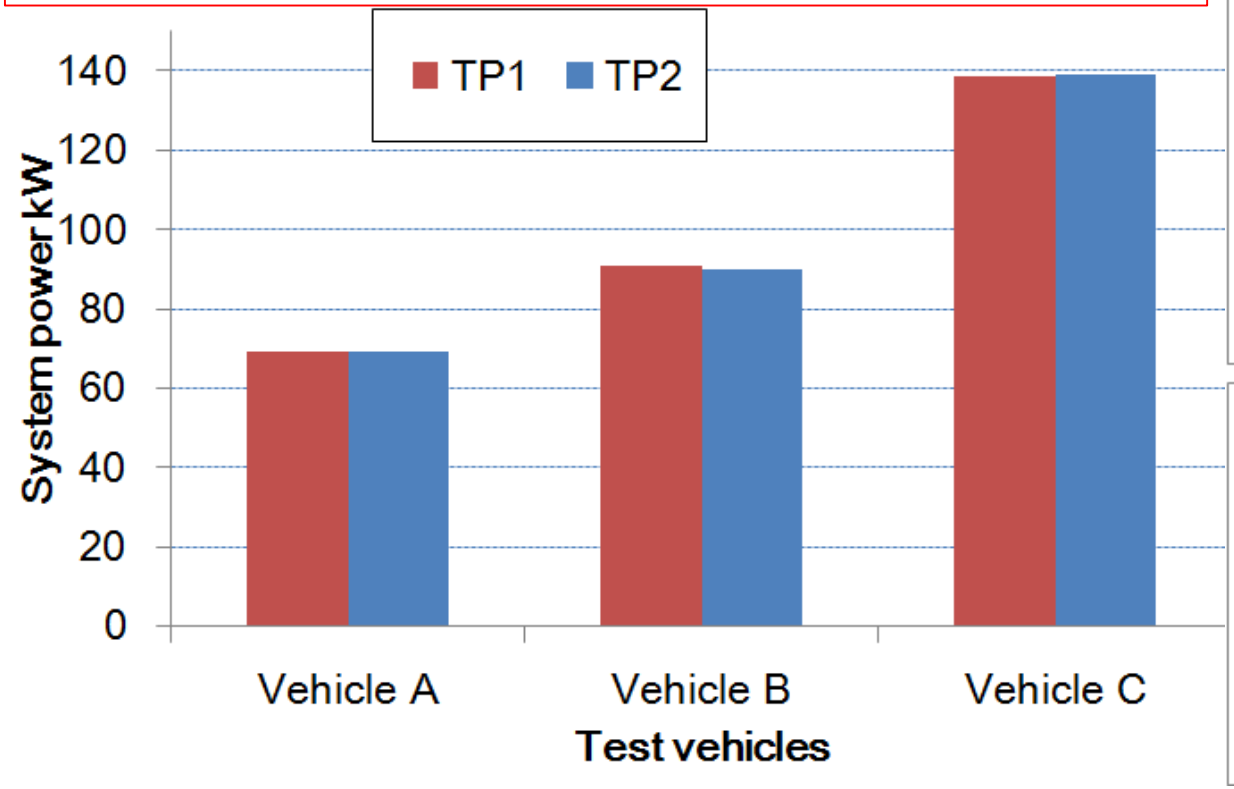
*HEV system : OEM's catalog information

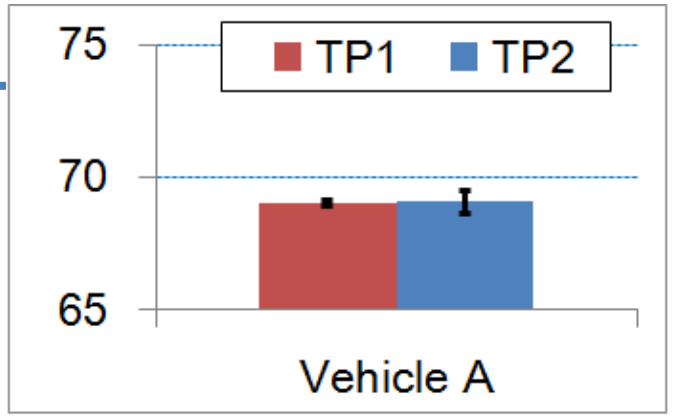
Fluctuation of Measured System Power between Chassis Dynamo and Hub Dynamo

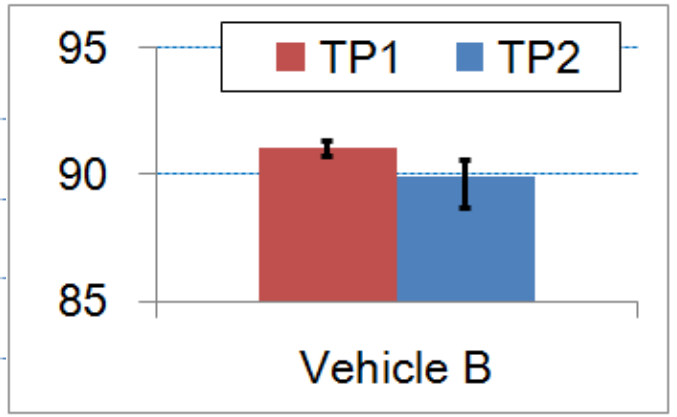
The error bar was delivered through 4 times repetition of the same test condition for each vehicle. The fluctuation of measured power with TP1 was smaller than that of TP2 non-depending on the type of vehicles.

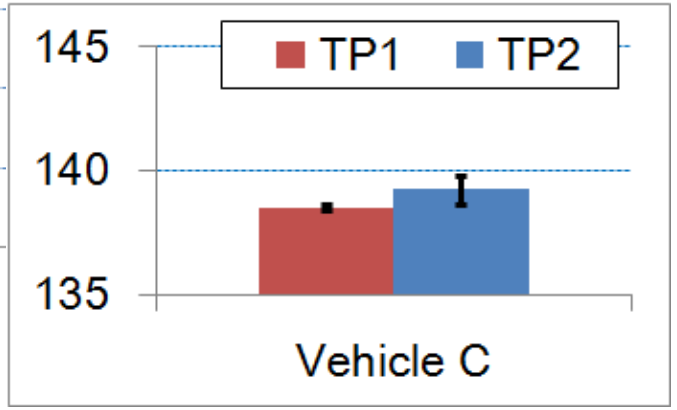
NOTICE:TP1 with Chassis Dynamo/TP2 with Hub Dynamo

Notice2: Chassis Dynamo with Six-component force meter





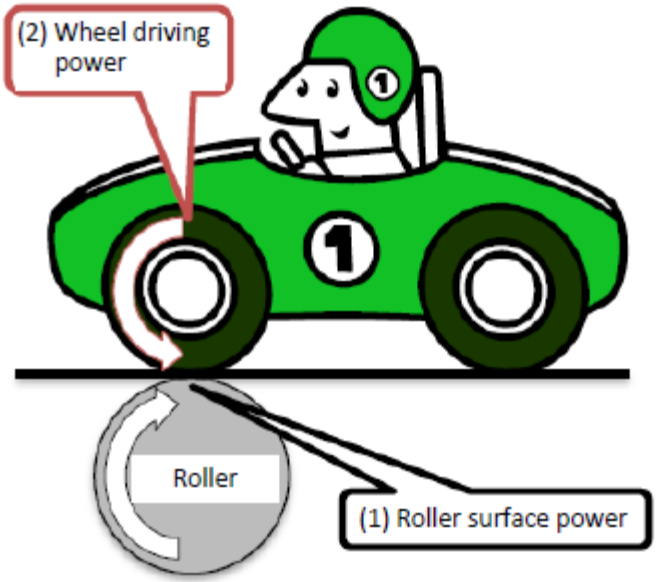




Measurement devices and calculation : TP2

Quoted fromEVE-26-10e

Chassis dynamometer (CD)



(1) Roller surface power (CD speed and CD driving force)
Power output = roller speed x roller surface driving force

(2) Wheel driving power output (six-component force meter)

JRC measured Roller surface Power

JARI measured both (1) and (2)

Axle-hub chassis dynamometer (CD)

(2) Wheel driving power output (six-component force meter)

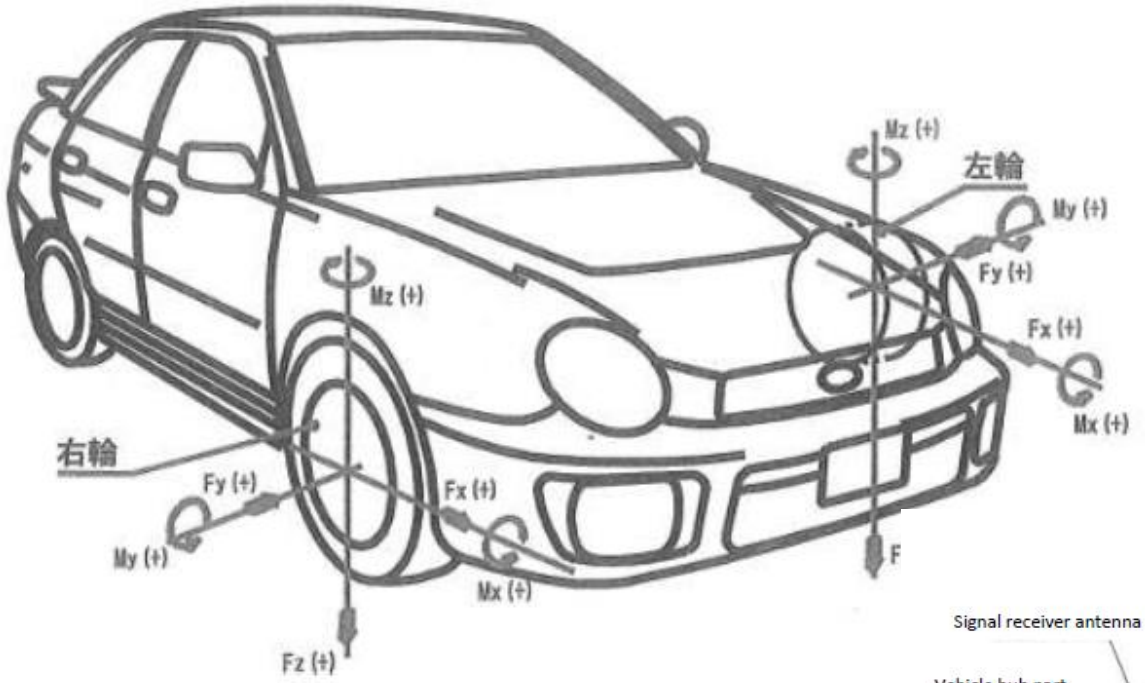
Testing vehicles A and B

Power output = right wheel rotating speed x right wheel driving torque
+ left wheel rotating speed x left wheel driving torque

Testing vehicle C

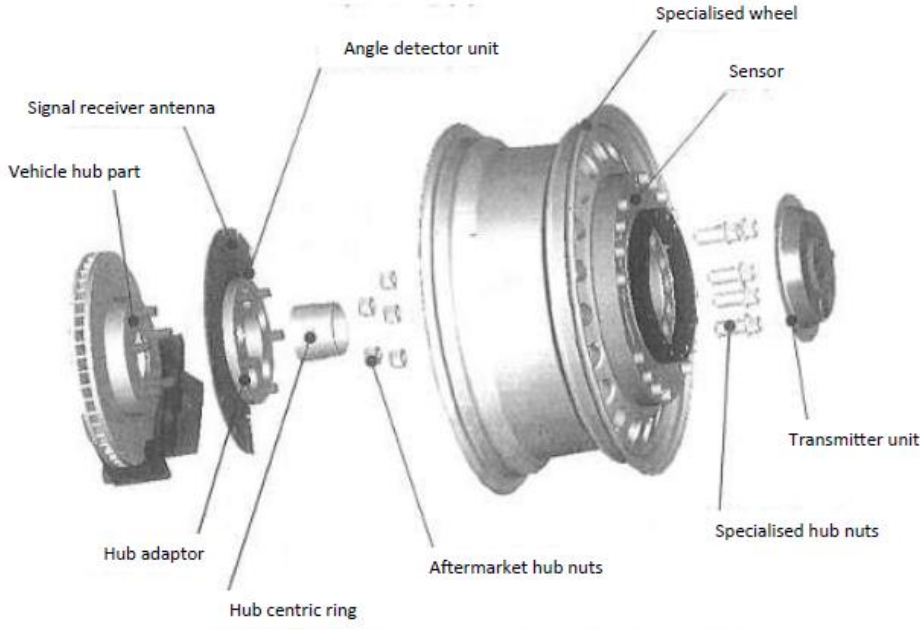
Power output: right front wheel rotating speed x right front wheel driving torque x 2
+ right rear wheel rotating speed x right rear wheel driving torque x 2

Six-component force meter



Three forces in three orthogonal directions (Fx,Fy,Fz)

Three moments around each axis (Mx,My,Mz)



Structure of Six-component force meter

JARI Test Report

Quoted fromEVE-26-10e

		Real road			Chassis dynamometer		
Tested vehicle		A	B	C	A	B	C
Road surface power output (real road)	Average measurement of HEV system power	58.1 kW	72.6 kW	131.6 kW	61.2 kW	84.8 kW	123.6 kW
	Power measured	Acceleration			Power output on chassis dynamometer		
Roller surface power output (chassis dynamometer)	Deviation	-0.7 – 1.4 kW (-1.2 – 2.4%)	-7.9 – 7.9 kW (-10.9 – 10.9%	-2.7 – 2.5 kW (-2.1 – 1.9%)	-0.4 – 0.7 kW (-0.7 – 1.1%)	-1.9 – 1.7 kW (-2.2 – 2.0%	-0.3 – 0.4 kW (-0.2 – 0.3%)
	Contributing factors to errors	Tire losses, testing environment, acceleration measurement			Tire losses		
Wheel-driving power	Error-alleviating measures	Wheel torque measurement; others issues are hard to deal with			Wheel torque measurement		
	Average measurement of HEV system power	62.8 kmW	73.3 kW	131.3 kW	63.9 kW	88.7 kW	137.0k W
	Power measured	Wheel-driving power			Wheel-driving power		
	Deviation	-0.3 – 0.3 kW (-0.5 – 0.5%)	-8.6 – 8.5 kW (-11.7 – 11.6%	-4.3 – 3.7 kW (-3.3 – 2.8%)	-0.8 – 0.5 kW (-1.3 – 0.8%)	-1.9 – 1.6 kW (-2.1 – 1.8%	-1.3 – 0.8 kW (-0.9 – 0.6%)

	A	B	C
Road surface power output	61.2	84.8	123.6
Wheel Driving power	63.9	88.7	137.0

Road surface power output is greatly affected by

1. Characteristic of tires

2. Vehicle restraint method

3. Others

Therefore ,

The variations or errors are large and Appropriate correction is necessary.

JARI test result

	A	B	C
Road surface power output	61.2	84.8	123.6
Wheel Driving power	63.9	88.7	137

In parallel HEV ,TP1 and TP2 are almost equivalent in principle,
The reason of "TP1 is always larger than TP2" is considered that the roller surface measurement value is not corrected by appropriate way.

GTR Draft open issue

6.4.1 : Required measurement devices

For TP2, measurement devices shall be used to measure REESS current and REESS voltage. Wheel torque and rotational speed measurement may be provided either by means of appropriate, calibrated measurement device(s) for torque and rotational speed of the gearbox output shaft(s) or the driven wheel(s), or by traction force and speed measured by the chassis dynamometer

If wheel torque and rotational speed measurement is provided by the chassis dynamometer, the accuracy of this measurement devices must fulfills the same requirements as for the shaft/wheel measurement devices. If so, it is necessary that the measured values for traction force and speed be transformed, by calculation, to the required values for torque and rotational speed at drive shaft or wheel, taking into account the specific data of the tires and the proportional vehicle weight at the wheels used during the test (e.g.: rolling friction losses, dynamic rolling radius).

Mr.Safortin commented that

Is rolling resistance coefficient commonly known for tires?
Or does this refer to another method?
Will we have this data for the validation program?
Discussed at 4th DG meeting. JAMA comments "VDA did not show an appropriate method at ISO meetings." Matthias to ask VDA for more details on how this is done.