

# Input for HEV power determination From Japan

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EVE teleconference

February 13, 2019

# Background on the measurement problem

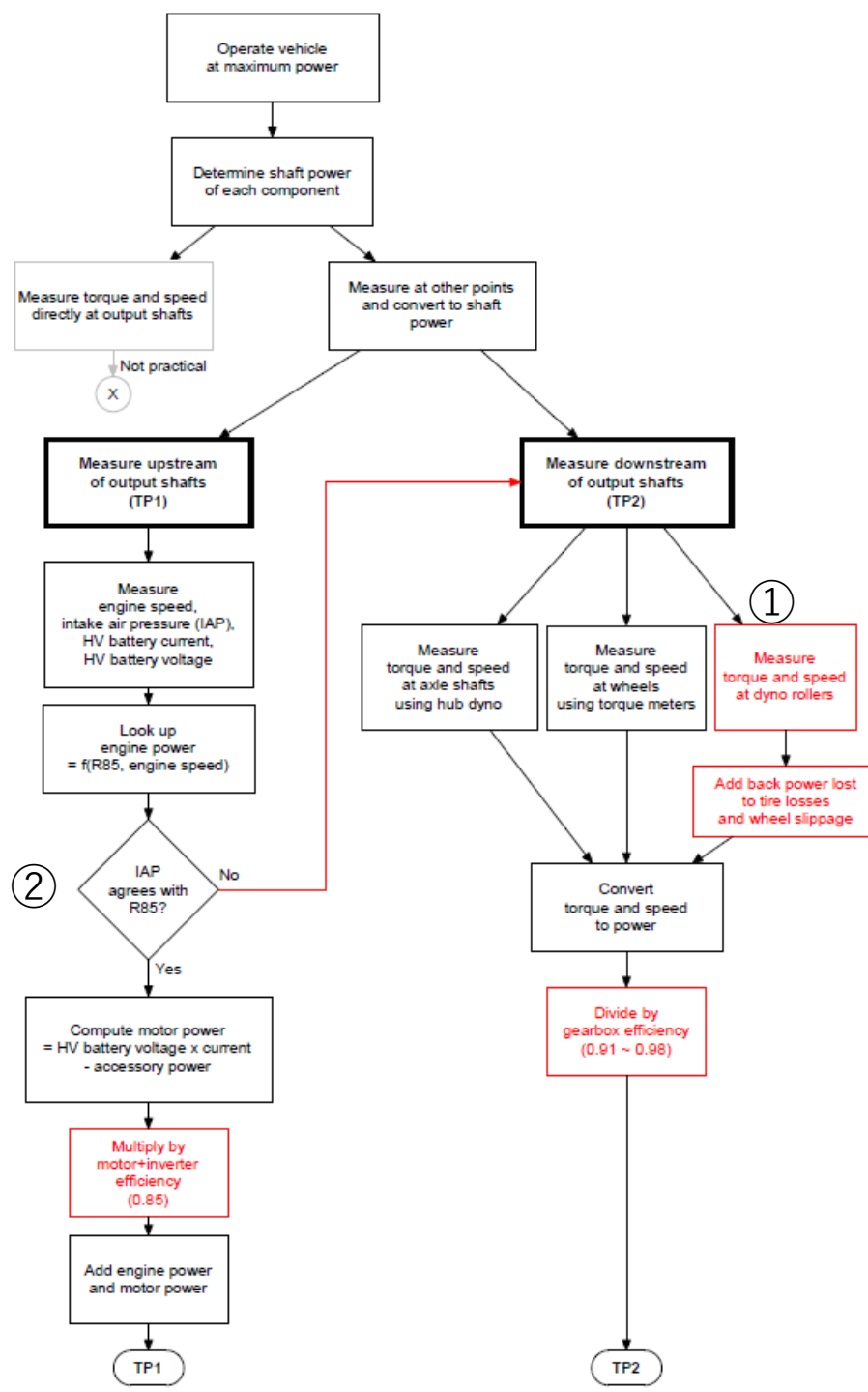
- For comparability with ICE, hybrid vehicle power is to be measured at a similar point in the powertrain: the engine output shaft
  - Not at the wheels
  - Not at the battery
- But with a hybrid vehicle that has more than one power source, max power on test stand is not necessarily same as on vehicle
  - Depends on how motor and engine power are combined during maximum acceleration
  - Battery may limit power instead of motor
- Therefore, we cannot rely on component rated power
- The power must be measured while in operation on the vehicle

Fully Agreed

# Background on the measurement problem

- To measure power on the vehicle:
  1. Need way to repeatably elicit maximum power of the vehicle
    - We do this by max acceleration at a fixed speed of the dyno
    - Seems reliable so far (except for some JRC tests)
  2. Need way to measure the power from each component
    - (a) Measure torque and speed at the output shafts
      - Invasive, costly, may be impractical or impossible
      - Not suitable for type approval situation
    - (b) Measure at more convenient points, and convert to shaft power
      - (b1) Measure upstream of the output shafts (TP1)
      - (b2) Measure downstream of the output shafts (TP2)

Fully Agreed



Comments

- ①. Since “torque-meters shall be mandatory” were agreed, this path can be eliminated.
- ②. In order to avoid misunderstanding, Please quote on flow chart exactly from GTR draft
  - 1)conduct ISO 1585:1992 under the same conditions
  - 2)ask the vehicle manufacturer
  - 3) conduct TP2

Quoted from 6.9.2 Calculation for TP1

The engine dynamometer test to obtain the ICE power can be conducted under the conditions specified in ISO 1585:1992 using the above-measured engine speed, intake manifold pressure in inlet system and fuel flow rate if the confirmation of air fuel ratio according to ISO 1585:1992 is necessary. If the intake manifold pressure or fuel flow rate deviates significantly from ISO 1585:1992, conduct ISO 1585:1992 under the conditions using the above-measured engine speed and intake manifold pressure in inlet system or fuel flow rate, ask the vehicle manufacturer, or conduct TP2.

# Observations

- In theory, both TP1 and TP2 should deliver the same results
- However, for this to be true, the respective K factors must be accurate
- The default K factors are rarely accurate for any specific vehicle (only coincidentally)
- Without accurate K factor for both TP1 and TP2, we should not expect the two results to be the same for any specific vehicle
- If the results are not the same, cherry picking becomes possible

Fully Agreed

# Possible directions

- A. Accept the variation as is
- B. Tighten up the causes of the variation
  - A. Provide more specific default K factors
  - B. Limit TP2 measurement options
- C. Eliminate default K factors and require verified K from manufacturer
- D. Allow default K, but for “provisional” ratings only
- E. Limit GTR to only TP1 or only TP2
- F. Delegate the decision to the legislation that references the procedure (next slide)
- G. Others?

## **Japan supports direction C.**

However, in order to make it possible for the Manufacturer or a third party to propose or verify the K factors ,

GTR needs description of the measuring methods (Inverter motor efficiency, gearbox efficiency)

### Examples for gearbox system efficiency factor (includes gearbox and differential) at maximum hybrid system power.

In the following tables, one can find for specific hybrid vehicles, representing the series hybrid vehicle configuration (Table 1), the parallel hybrid vehicle configuration (Table 2) or the power split hybrid vehicle configuration (Table 3) the dedicated gearbox system efficiency factor at maximum hybrid system power and at normal operating temperature, necessary to calculate the maximum HEV system power based on the measured maximum HEV system power at axle / wheel.

This listed gearbox system efficiency factor based on a comparable hybrid vehicle shall be used only, if the gearbox system efficiency factor for the type of tested hybrid vehicle is not available from the OEM.

PH 15	AWD	Front: Hybrid via 6-speed dual clutch transmission with integrated EM Rear: Electric via single-speed transmission	Front: <b>0,97</b>  Rear: <b>0,98</b>	PHEV Disconnecting clutch between ICE & EM at front drive
PH 16	RWD	9-speed automatic transmission	<b>0,95</b> <sup>*2</sup>	PHEV Automatic transmission with integrated EM and converter lockup clutch
PH 17	FWD	CVT with starting clutch	<b>0,95</b> <sup>*2</sup>	Full Hybrid EM fitted directly between ICE and transmission
<b>Average gearbox system efficiency factor</b>			<b>Front: 0,96</b> <b>Rear: 0,97</b>	

\*1 at max. power at high gears and normal operating temperature

\*2 estimated, to be confirmed by vehicle manufacturer

### Information about Gearbox efficiency measurement

This document was quoted from the Proposal of German delegation towards ISO/WD 20762. It seemed me that PH15 was measured by German OEM based upon certain test procedure. I believe German delegation can provide the measuring method.



# Delegate to the referencing legislation?

- Draft the GTR more or less as currently defined. Drafting task becomes a codification of the ISO procedure (aligned to WLTP)
- Acknowledge in the GTR that TP1 and TP2 may deliver different results
  - Depending on accuracy of the K factors
  - Depending on TP2 measurement options
  - Designate calculations that utilize default K as “provisional” rating
  - Designate calculations that utilize measured K as “reference” rating
- Recommend that the referencing legislation specify how to navigate the uncertainty, appropriate to the specific aim of the legislation
- For example, GTR 15 could specify (options):
  - A. Perform provisional TP1 and TP2, and take the larger (or average?) of the two
  - B. Perform reference TP1 and TP2, and take the larger (or average?) of the two
  - C. Perform provisional TP1, unless R85 does not validate, then perform provisional TP2
  - D. etc
- Legislation for taxation or consumer information could specify differently

## Japan's comment

- 1. Oppose to conduct two tests of TP1 and TP2 as MUST. (Due to increase of work load such as COP etc. )**
- 2. Support TP1 on the premise that all CPs have the engine certification test method such as R85,SAE\*\*\*\*.....**
- 3. NOT deny TP2, But the measuring method of gearbox efficiency have to be prepared.**

# 2. Summary Matrix

## Concerns from the Validation results

As a kind of certification test , fairness, reproducibility and ease should be prioritized.

	TP1	TP2	TP1/2 common ?	Measure/Resolution	
<b>Common</b>					
1. Default Values (K-factors, Inverter-Motor efficiency ,gearbox efficiency,)	<p>default K :Inverter-Motor efficiency value overcorrected downward the caluculated HEV power (See Document -02) (See EPA report)</p>	<p>default K: gearbox efficiency value overcorrected downward the caluculated HEV power (See Document-01) (See KATRI report)</p>	NO	<p>Eliminate default K factors and require verified K from manufacturer</p> <p>Describe the concrete measurement method of K factors that can be verified by a third party in the GTR.</p> <p>K-factor:Inverter-Motor efficiency is able to be mesured same condition as UNR85,IEC 60785? ISO21782,SAE2907.</p> <p>Standard for K factor:gearbox efficiency is not availabe.</p> <p>Measuring method of Gearbox efficiency has to be developed ASAP.</p>	Open
2.Chassis dynamometer	<p>fixed speed mode is only necessary. Operator should be getting used to control.</p>	<p>it is desirable to use hub dyno. or to attach a torque sensor on the axle. Otherwise,it is necessary to correct the slip effect of the tire etc. (See Document-01)</p>	NO	<p>it is necessary for TP2 measurement to use hub dyno. or to attach a torque sensor on the axle.</p>	Agreed

	TP1	TP2	TP1/2 common ?	Measure/Resolution	
3.Certification result of ICE	Dedicated US model does not have UN85 data. (See EPA report)		NO	Add the SAE method number that can be verified by a third party in the GTR . Certification are not required by US authority, Ice performance can be evaluated by the SAE test method.SAE1349	Agreeable
4. Multi- Motor system	Each motor system may have different <b>K-factor</b>		No	Prepare K-factor for each motor system if necessary	Agreeable
5.4WD system		Each axle may have diiferent <b>gear box efficiency</b>	No	Prepare gearbox efficienvy for each axle if necessary	Agreeable
6.Chassis dynamometer	Absorption power of the chassis dynamometer is lower than maximum hybrid power.	Absorption power of the chassis dynamometer is lower than maximum hybrid power.	YES	5.1 Test instrumentation 5.1.1 Chassis dynamometer The power absorption capacity of the chassis dynamometer in fixed speed control mode shall be sufficient for the maximum power of the vehicle. Due to the short duration of maximum power under the test procedure (approximately 10 seconds), a short duration power rating of the chassis dynamometer may be applicable to this requirement with approval of the responsible authority.  <b>If the maxmum power of the vehicle is far higher</b>	New & Open

	TP1	TP2	TP1/2 common ?	Measure/Resolution
<b>Hybrid system dependent</b>				
<b>Parallel hybrid</b>				
Automatic shift only (No manual mode switch)	Reproducibility of maximum power operation condition (See Document-03)	Reproducibility of maximum power operation condition (See Document-03)	YES	Provide the information from OEM, 1)maximum power operation condition 2)UP and Down shift Control 3)accelerator pedal modulation mastery of test drivers. Try & Error
With manual mode				
<b>Series hybrid</b>	No Validation test	No validation test		
e-Power type (ENG nearly = MOT)				
REX (ENG<<MOT)	It is anticipated that Engine will not operate at the maximum power operation condition. 1) CD mode; TP1(CD)= measured RESS * K-factor 2) CS mode; TP1(CS)= ICE + measured RESS * K-factor maximum power= TP1(CD)		No	

Open

	TP1	TP2	TP1/2 common ?	Measure/Resolution	
<b>Power split hybrid</b>		<b>Definition of gearbox efficiency (See document-01)</b>	NO	<b>Define and decide the efficiency for each system with OEM cooperation</b>	Open
Single Power split (Prius)	Confirmation of maximum power operation condition	Confirmation of maximum power operation condition		Provide the information from OEM, 1) maximum power operation condition	Agreeable
multi Power split (Volt / Malibu)	Confirmation of maximum power operation condition	Confirmation of maximum power operation condition <i>(See document-04)</i>	YES	Provide the information from OEM, 1) maximum power operation condition	Agreeable
Power split with Transmission (LS500h)	Confirmation of maximum power operation condition	Confirmation of maximum power operation condition <i>(See document-04)</i>	YES	Provide the information from OEM, 1) maximum power operation condition	Agreeable
PHEV Application (Volt / outlander)	Confirmation of maximum power operation condition	Confirmation of maximum power operation condition <i>(See document-04)</i>	YES	Provide the information from OEM, 1) maximum power operation condition	Agreeable