Japan Comments for Battery Durability GTR EVE38

8-9.October.2020

1．SOH_Capacity and SOH_Range

Previous Japanese comment at EVE 34 (See P.3)

1. Both range and capacity methods should be prepared for SOH verification.
2. If the degradation of electric consumption is considered to be negligibly small, SOH_range and SOH_capacity can be considered to be the same value.
3. After confirming the degradation of electric consumption is negligibly small, Range can be calculated by the electric consumption at certification test and UBE measured by ECU.

<Understanding of Japan>

From the discussion at EVE 37, the Electric Energy Consumption during driving in the general market is measured by the ECU,then the ECU will convert this EC to the EC at WLTC within the accuracy that the OEM can technically do, and the EV range is also obtained from the UBE measured by the ECU. The SOH _ range is calculated by comparing this value with the range value described in the CoC.

<Possible problem>

ECU conversion from the EC during actual driving to the EC during WLTC can have large variations/errors and it could be difficulty to guarantee its accuracy.(See P.4&5)

<Proposals>

Therefore, the following proposals are made:

It is allowed to use the electric energy consumption from certification for the SOH_range ECU calculation, if it can be proven that the degradation of other electric components than the battery is negligibly small.

Or,

Despite the considerable development challenges/ innacuracies, conversion from actual driving EC to WLTP EC for the SOH _ range ECU calculation will be conducted . For the time being, the SOH _ range would only be used for information collection, and the regulation compliance would only be checked by SOH _ capacity.

[PROPOSAL] State of Health monitor (SOH)

Quoted from EVE34-15e

1) Definition of SOH :

The **capacity estimation value in the ECU** should be used in phase 1 of GTR

2) Methods of verification

These TWO methods should be prepared.

<EV range method >

SOH = Current EV Range/EV Range in CoC @ WLTP

<Capacity method* >

SOH = Current EAC / EAC in Certification Test report of WLTP

where, the denominator (EAC)is the value of the test report at the time of authentication.

i) For third-party evaluations or verification , make test report values available for them.

or ii) Add EAC to CoC, if necessary

***Need for Capacity Method**

It is desirable to prepare a verification method in consideration of the **development of HDV** with larger difference of Electric consumption depending on the vehicle type and **Re-use of the In-vehicle battery** to other purposes.

If the degradation of the electric consumption is considered to be negligible small, EV Range method and capacity method can be considered to produce the same results. [evidence in P.11]

[for information] Basic formula of SOH in ECU

SOH in ECU = Current Estimated Usable Capacity/Cert. Vehicle Usable Capacity(fixed value)

EV Range(in ECU)= Usable capacity in ECU / Electric consumption (fixed value).

The effect of Electric consumption degradation is negligible smal.

The following procedures may be necessary for conversion from actual driving EC to WLTP EC

1. EC calculation at the certification;

∑ (Voltage * Current) / distance (kWh/km)

“EC “ considers the electric efficiency of different operating points in the certification mode.

2. Example of EC conversion ;From EC at actual costumer driving to EC at the certification cycle/mode.

*Note: There have been no implementation of this method in the past, and the following is **only a theoretical study, more problems are expected in implementing it in practice**.*

< Procedure>

1) Definition of the “calculation cells” for the drive force/ veh speed operating area during certification (mapping), and allocation of operating time to each cell. The smaller cells, the more accurate, but the software resource is greatly increased.

Example: 25 cells by mapping every 20 km of vehicle speed and every 1000 N of driving force

⬇

100 cells by mapping every 10 km of vehicle speed and every 500 N of driving force

2) The operating time during certification in each cell defines the weighting factor to be applied for that cell.

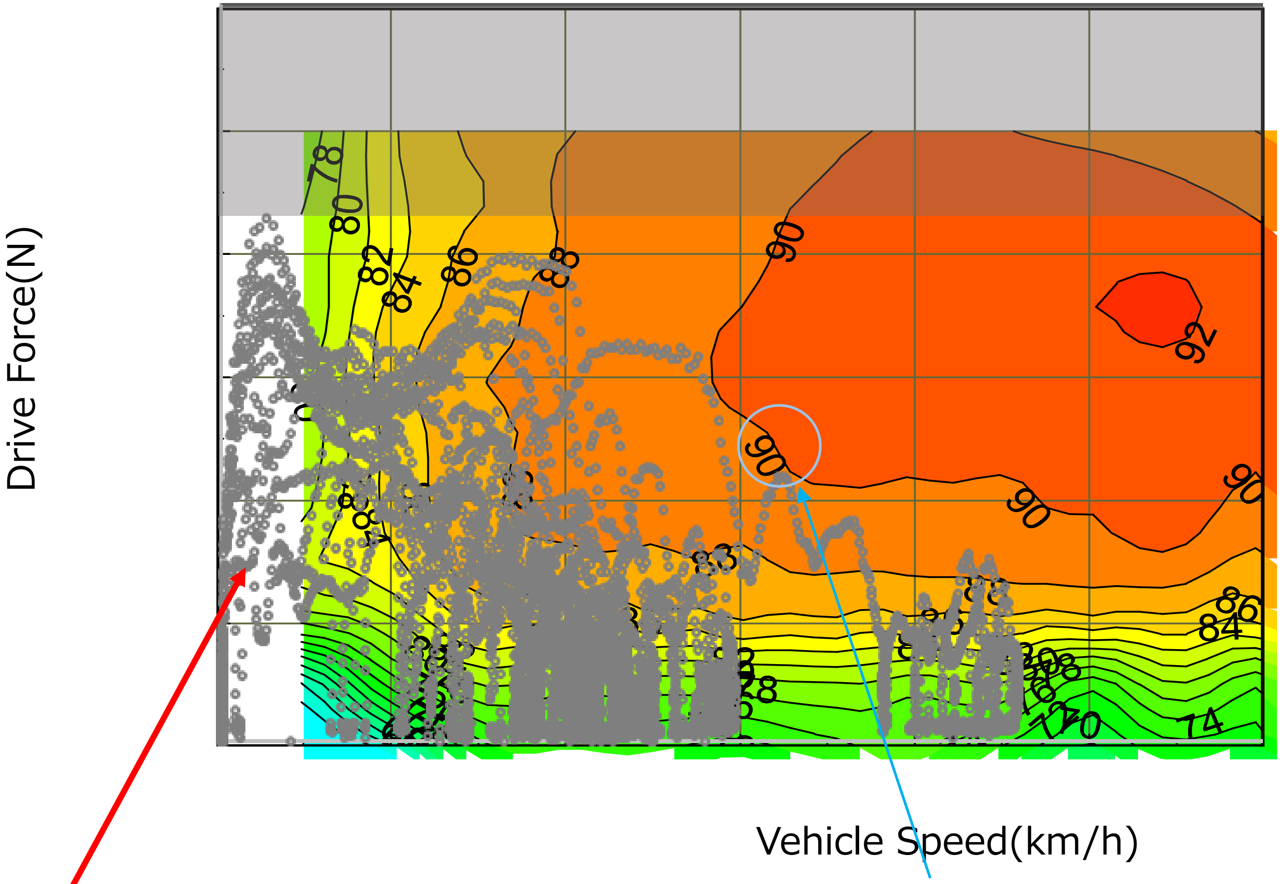
Example: If 10% of certification cycle time happens in that cell, a 0.1 weighting factor is applied to the actual driving EC on that cell: EC _ cell x 0.1.

3) Measurement of ∑ (Voltage * Current) and time for each unit mileage (for example, 100 meters.). (kWh/km)

Note: operating area might be too broad at every 1 km

The cell is determined from the average vehicle speed and the load during 100 m travel, the measured EC value is input to that cell.

Operating point during FTP and Power train efficiency



Powertrain efficiency: Motor output / Inverter input (%) (Voltage x Current)

・: FTP operating point by second (Vehicle speed and Driving force)

4) If there is any electric power used other than driving, it is subtracted from the EC of the cell. :Air conditioners and heaters are not used at certification.

5) When more than a certain amount of data is input to all cells used during certification, the weighting average process is performed to translate from actual driving EC to equivalent certification EC.

Cert. equivalent EC = ∑ EC _ Each Cell x Influence factor_ Each Cell

At least the following errors may not be negligible

1. Variation of current-voltage sensor and distance measurement error (tire diameter, etc.)

2. Error due to difference in efficiency distribution in the same cell caused by averaging processing every 100 m.

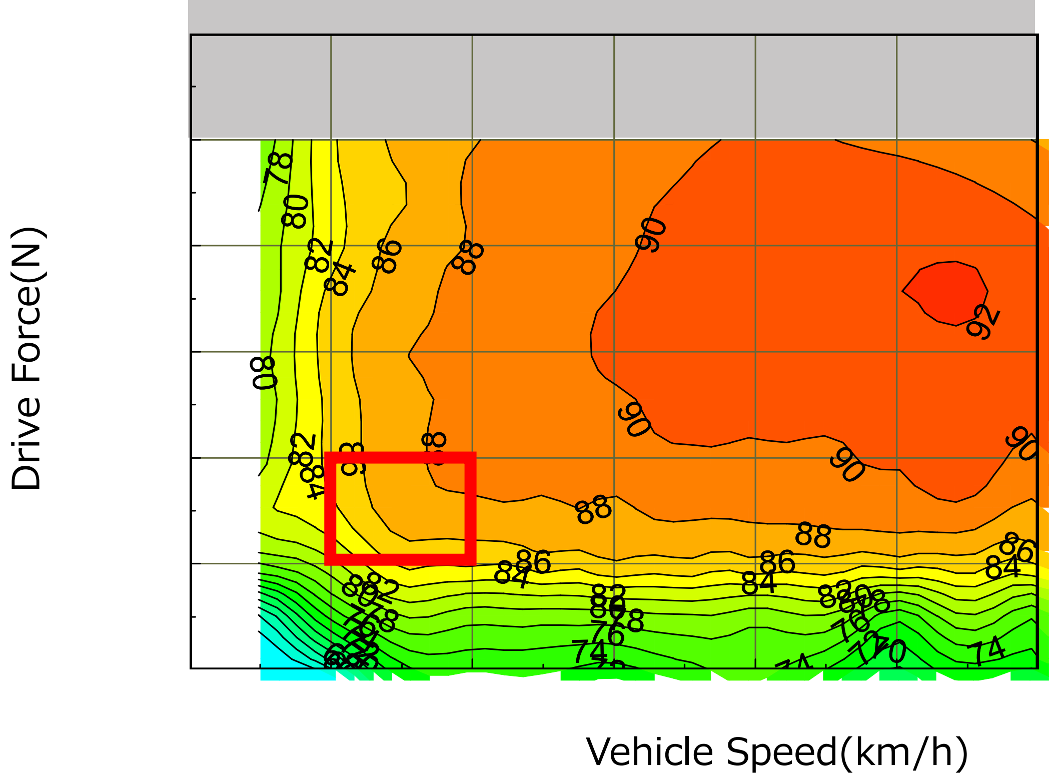
   Example:

   In the right figure, the power train efficiency in the cell in the red frame is distributed from 80% to 88%.
   *Efficiency is very different between 20 km * 1000 N (80%) and 40 km * 2000 N (88%) in the same cell.*
   so the EC error will vary depending on driving conditions.

   Finer cell granularity increases accuracy but increases ECU resources.

3. Power estimation errors of air conditioners, heaters, DCDC converters, etc. other than the driving load.

4. The Certification is conducted at 23 ~ 25˚C, but temperature in real driving varies in a wider range.
   And temperature correction, especially battery temperature correction, is considered to be a source of error because it is difficult to make an accurate compensation.



２．SOH indicator display

・SOH_capacity must be displayed on the dashboard. or the infotainment system.
・SOH _range_wltp does not need to be displayed on the dashboard. But via OBD port or OTA.
・The range information (How long can customer drive under the current driving conditions?) can be provided as per OEM choice.

< Comment>

The SOH _ capacity monitor needs to be accessible by the user.

The dashboard display space is limited and should be prioritised for information that requires visual confirmation constantly, such as speed, Warning lights, etc. which is not the case for SOH _ It is appropriate that the capacity durability monitor is displayed on demand from users e.g. via the infotainment system.

3. MPR

<Concerns>

1. MPRs(Range and Capacity) are set for NOVC-HEV.
2. MPRs should be determined reasonably, after having considered several factors(ex. User needs, battery diversity).
3. When the same battery pack is installed in the same vehicle model planned to be sold in many different countries, it may be difficult to comply with the regulation if each CP will select different MPR.
4. MPR for SOH_range (Compare to Label Value) may vary by region (e.g. between U.S. 5 cycles and WLTP)

< Comment>

1.The EV range and capacity of NOVC-HEVs are not measured at the certification, and therefore not in the scope of this GTR

2.Extremely severe MPR could hinder EV penetration or deployment due to too high battery specifications.
Therefore, keeping CP's flexibility, we propose a matrix defining the relation between the number of years, the distance and MPR , which can be included in the GTR, and each CP could select one MPR based on preferred number of years and distance. Details will be shown at the slide No.8 and 9.

3.the MPR for the range and capacity are set separately. Do you need a conversion table that clarifies the degree of influence of the range when the capacity decreases?
Simulation verification may be needed:
20% reduction in capacity is 20% range reduction between WLTP in Europe/Japan and 5 cycles in the U.S.?

MPR_Matrix concept proposal

The MPR is not determined uniformly, and the CP can select which frame of the matrix shown below.
Note)Color coding is an example of how easy it is to correlate the degree of battery degradation with the number of years of warranty. Details on how to select each value and frame are discussed at the IWG.

Examples

MPR	@3years 50,000㎞	@5years 80,000㎞	@8years 120,000㎞	@10years 160,000㎞
80%－				
70-80%				
60-70%				
50-60%				
40-50%				
-40%				

→ higher
→ harder
specification
market penetration
lower ←
easier ←

Background of the MPR _ Matrix Proposal

1)We agree with the need to define what is a substandard battery.
On the other hand, if the GTR is to be considered by CPs, it is appropriate to give a range of choices rather than single number representing all batteries, based on the following factors.

- **There are various types of Evs fulfilling different user needs.**
- The battery technology is in the process of development, and the usage conditions (Climate, charging infrastructure, etc.) of EV (battery) are not unified at present.
  It is necessary to consider the future diversity of batteries in terms of materials, shapes, and systems, as well as the market.
- There are a variety of EV deployment strategies in each region to determine the category of EV to be used.

2)The assumption of how to utilize the previous page matrix is as follows.

- The validity of the selected MPR value should be agreed among all CPs and participants (not necessarily accept all the numbers proposed).
- Thresholds for substandard battery that should not be placed on the market will be defined and decided uniformly on the matrix (red frame) at EVE.

4 ISC_Part_A

Frequency of verifications

The manufacturer shall complete the procedure for in-use verification at least every two years for the lifetime of each vehicle type and report all values to the authorities. The authorities may decide to proceed with their own verification of either Part A, Part B or both at a frequency and magnitude based on risk assessment.

< Comment> We'd like to confirm that the rationale for implementation should be confirmed at least every two years for the lifetime of each vehicle type.
From now on, PEV and OVC-HEV are expected to increase, which would impose an excessive burden.

PART A: Verification of SOH monitor

The range/capacity shall be tested according to the original method used to define it in the legislation. The measured values divided by the originally defined (or declared) range/capacity is defined as the "measured SOH_i" where i stands for range or capacity. The measured SOHi shall remain within z% (tbd) of the value r ead by the SOH monitor for capacity and range.

An adequate number of vehicles (3-10 vehicles) shall be selected for testing after a survey (see annex 1) containing information designed to ensure that the vehicle has been used and maintained according to good practice. The following statistics shall be used to take a decision on the accuracy of the monitor.

Statistics:

A vehicle test shall be considered a fail (f) when the measured SOH is larger or smaller than the SOH monitor ± z%.

A vehicle test shall be considered a pass (p) when the measured SOH is within ± z% of the SOH monitor value.

4 ISC_Part_A

<comment>
We propose the following definitions;
1.the denominator of SOH _ capacity (UBE at certification),
2.UBE of OVC-HEV, and 3. EAER (numerator of the SOH _ range).

<<New definition>>

1. UBE_base : UBE_base = UBE_measured * **PER (or EAER)_declared** / PER (or EAER)_measured

2. UBE for OVC-HEV ; $UBE_{OVC-HEV} = \sum_{j=1}^{n+1} \Delta E_{REESS,j}$

n+1 : confirmation cycle
energy balance during confirmation cycle needs to be considered

Modified from submission comments

3. EAER : GTR#15 Annex 8 para. 4.4.4.1. shall be modified as follows

$$EAER = \left(\frac{M_{CO2,CS,measured} - M_{CO2,CD,measured} \cancel{\frac{M_{CO2,CD,declared}}{M_{CO2,CD,ave}}}}{M_{CO2,CS,measured}}\right) \times R_{CDC}$$

Purpose of changing EAER: Prevention of step difference due to UF

EAER (As described in the CoC) at certification does not change, only the numerator definition at ISC _ Part _ A

CO2 test results for CD **without UF**

CO2 declaration value for CD **with UF**

CO2 test results for CD **with UF**

4.4.4.1. Determination of cycle-specific equivalent all-electric range

The cycle-specific equivalent all-electric range shall be calculated using the following equation:

$$EAER = \left(\frac{M_{CO2,CS,declared} - M_{CO2,CD,avg} \times \frac{M_{CO2,CD,declared}}{M_{CO2,CD,ave}}}{M_{CO2,CS,declared}} \right) \times R_{CDC}$$

where:

EAER is the cycle-specific equivalent all-electric range, km;

$M_{CO2,CS,declared}$ is the declared charge-sustaining CO_2 mass emission according to Table A8/5, step No. 7, g/km;

$M_{CO2,CD,avg}$ is the arithmetic average charge-depleting CO_2 mass emission according to the equation below, g/km;

$M_{CO2,CD,declared}$ is the declared charge-depleting CO_2 mass emission according to Table A8/8, step no. 14, g/km;

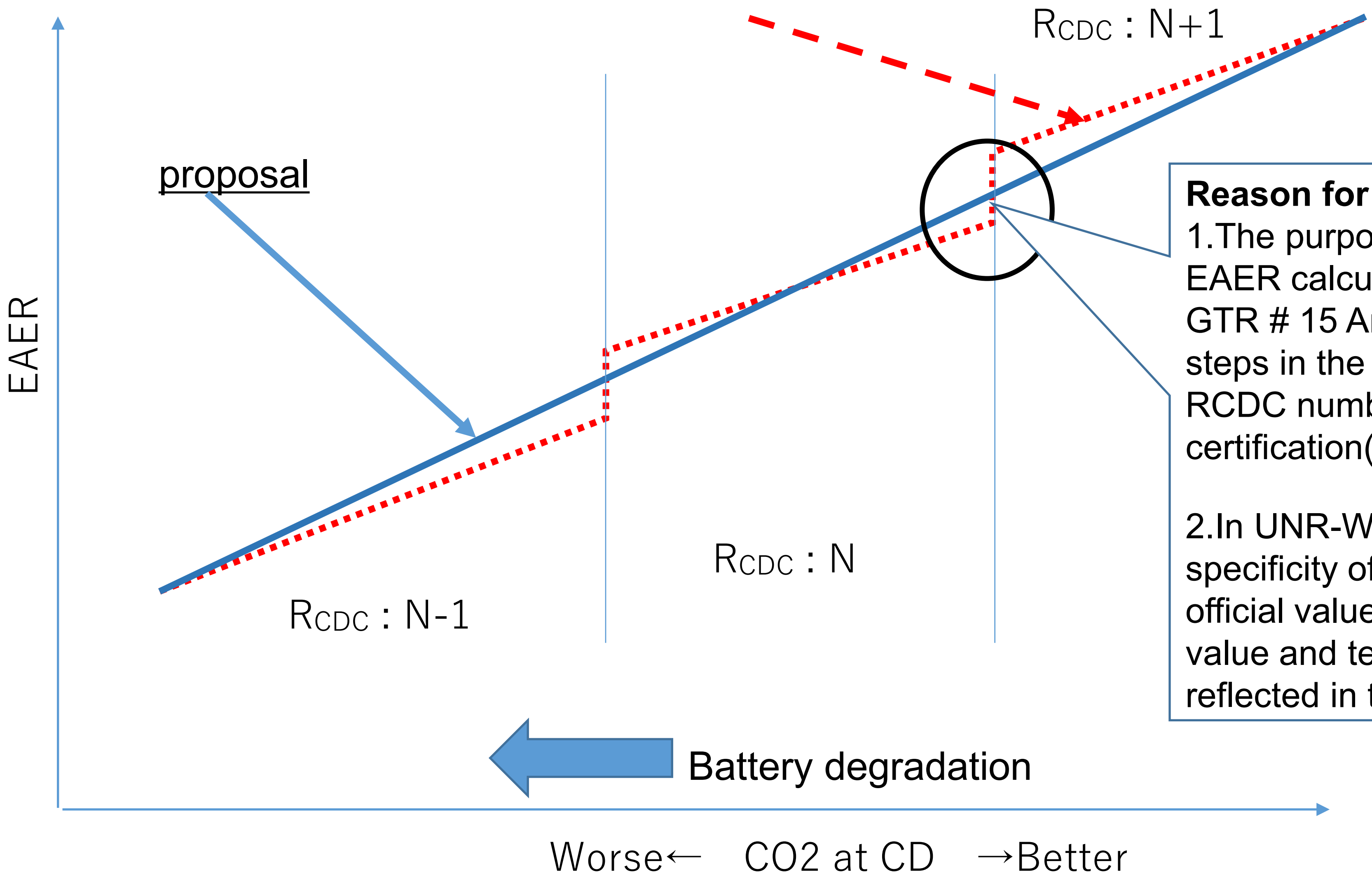
$M_{CO2,CD,ave}$ is the average charge-depleting CO_2 mass emission according to Table A8/8, step no. 13, g/km;

R_{CDC} is the charge-depleting cycle range according to paragraph 4.4.2. of this annex, km;

and

$$M_{CO2,CD,avg} = \frac{\sum_{j=1}^{k}(M_{CO2,CD,j} \times d_j)}{\sum_{j=1}^{k} d_j}$$

Definition at GTR#15 Annex 8 para. 4.4.4.1



Reason for the change

1.The purpose of this proposal is to return the EAER calculation to the formula adopted up to GTR # 15 Amed # 5 and eliminate inappropriate steps in the EAER value due to changes in the RCDC number caused by the specific formula at certification(formula that should be used).

2.In UNR-WLTP (and GTR # 15 Amend # 6), the specificity of the certification test (Determining the official value from the manufacturer's declared value and test results) is taken into account and is reflected in the calculation formula.

EAER (As described in the CoC) at certification does not change, only the numerator definition at ISC _ Part _ A

4 ISC_Part_A

Statistics:

A vehicle test shall be considered a fail (f) when the measured SOH is larger or smaller than the SOH monitor ± z%.

A vehicle test shall be considered a pass (p) when the measured SOH is within ± z% of the SOH monitor value.

<Comment>

Both the SOH _ range and the SOH _ capacity have the same criteria ; Z%,
But they should have different criteria based on the size of the variation.
Z_ SOH _ range. > Z_SOH_capacity.
As a rule, it is allowed to declare a lower range value than the test certification test results
In this case, the SOH shows less degradation.
Therefore, an appropriate Z value should be discussed including the factors that shift the distribution, for example, whether the declaration difference should be considered to be expanded.

<proposal>
Both UBE and EAC require definition of certification value* as well as EV range
***) declared or adjustment factor**

SOH based on certified vehicle range: 72.4 km (P.5)

	1 N=1	2 N=2	average
SOH_Eac	94.1	94.1	**94.1**
SOH_Range_cert.	100.9	98.8	99.9
SOH_Range_meas.	95	93.1	**94.1**

If the definitions set together, there is a good correlation.
SOH_range varies more than SOH_Eac

From the JARI results

1. The declared value of 68.2 km is lower than the certification test result (72.4 km)
2. Compared to the SOH_capacity using the measured value as the denominator, the SOH _ range shifts to the better side.

If the capacity adopts the declared value (lower number), the SOH_capacity is also shifted to the better side.

Note;
SOH _ range = Range_measured / Range_declared@TA
SOH_capacity = Capacity_measured / Capacity_measured@TA

Appendix

weighting factor

The distribution of vehicle speed and Drive Force in the certification test indicates the percentage of operating time in each Cell.
For example, the cell 22 was 10% of the time.
Therefore, the contribution of electric consumption on the Cell 22 during the WLTC operation was set at 10% in the market operation.