EVE In-Vehicle Battery Durability

Reflection on the discussion in EVE 37 on day 1

(indicator discussion – range vs. UBE)

Prepared by Matthias N.

EVE In Vehicle Battery Durability (Input for 37th IWG EVE)

Situation on range required as durability indicator

	UBE (or ∑Delta E)	Range
Part A	OK	OK (but higher tolerance required)
Part B	OK	Challenging, normalization required → Adding not necessary complexity

A lower range can have several reasons:

- Deteriorated battery (means less available energy)
- Higher energy consumption of the vehicle (e.g. electric machine has an increased consumption)
- Customer behavior (e.g. aggressive driving, entertainment, heating, air conditioning)

Concern raised during the previous IWG EVE meetings on UBE as durability metric:

- UBE is covering all effects coming from the deteriorated battery
- UBE is not covering effects coming from other parts in the power train, but range does

ACEA and ALLIANCE position:

- The scope of the GTR is in-vehicle-battery-durability
- “In-Vehicle” means that the measurement should be done in the vehicle and no component test
- The focus should be on the battery and not on non-battery related parameters

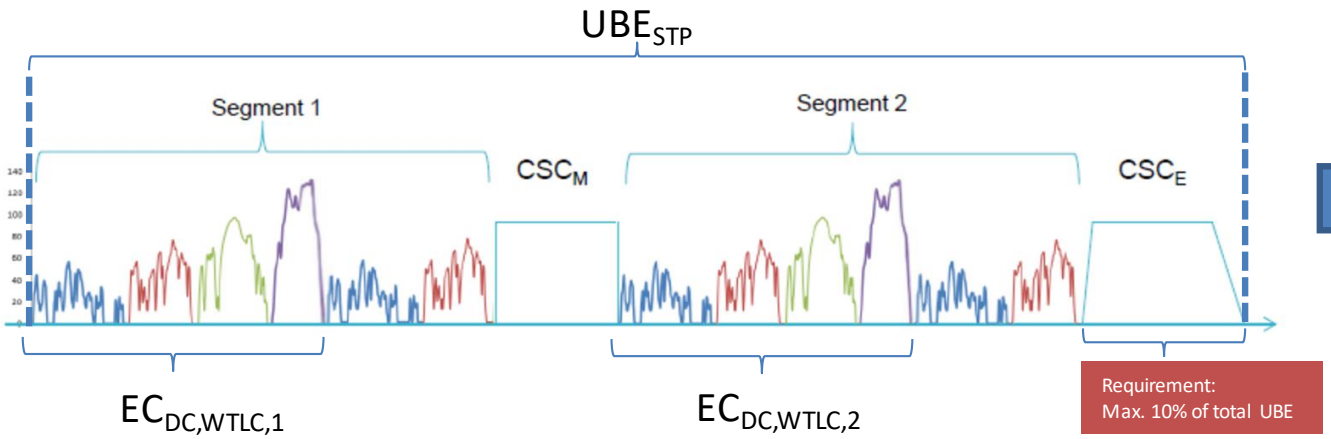
Position EU-Com and US:

- Yes, the scope is in-vehicle-battery-durability
- But “in-vehicle” means: also the effects coming from other parts in the vehicle

EVE In Vehicle Battery Durability (Input for 37th IWG EVE)

PEV: Range calculation and UBE determination with Shortened Test Procedure (TA/ISC)

Shortened test procedure in EU-WLTP and JPN (MCT in US has same set up but different cycles)
→ Procedure performed during TA and ISC



Range calculation :

$$PER_{WLTC} = \frac{UBE_{STP}}{EC_{DC,WLTC}}$$

Important: $EC_{DC,WLTC}$ is a weighted value → Weighting $EC_{DCWLTC,1/2}$ of segment 1 and segment 2

➔ Range = f (available UBE, vehicle energy consumption, driving behavior, auxiliary devices)
➔ UBE = f (available UBE)

EVE In Vehicle Battery Durability (Input for 37th IWG EVE)

PEV: Challenges with range based indicator and benefits with UBE based indicator

Important points in the context of the real world range:

→ Range based indicator need to compensate the red factors and have solution for the blue factor

Range = f (available UBE, vehicle energy consumption, driving behavior, activated auxiliary devices)

➔ Vehicle energy consumption in the procedure is a weighted value which reflects a representative steady-state energy consumption (the bigger the battery, the less the less recuperation at the beginning will be considered)

➔ Effects from higher/lower energy consumption coming from driving behavior and activated auxiliary devices need to be eliminated

Conclusion:

A range based indicator needs to compensate the red factors and to find a solution for the blue factor

If a range based indicator compensates the red factors and has a solution for the blue factor, there would be the following way forward:

- Driving the procedure with the given cycle (in TA and ISC) → no compensation for the indicator
- Driving in the real world → compensation/solution required for the indicator

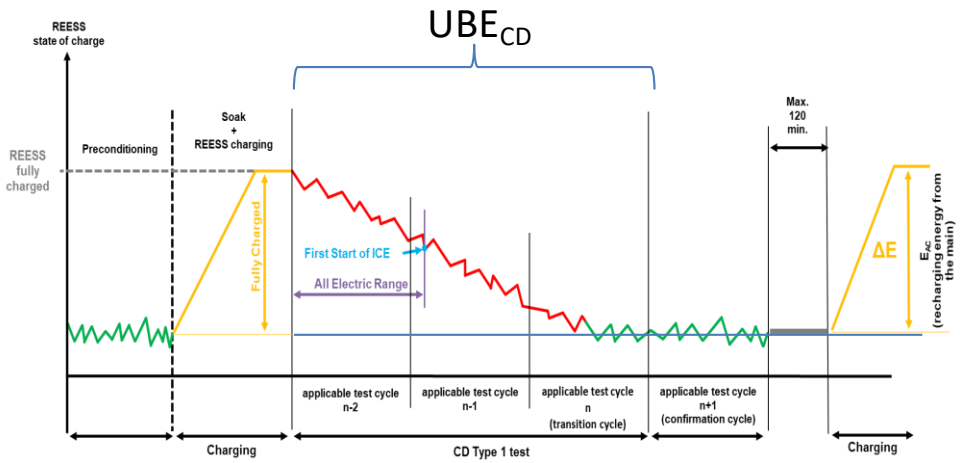
Benefit UBE:

As UBE independent from that, no compensation required at all

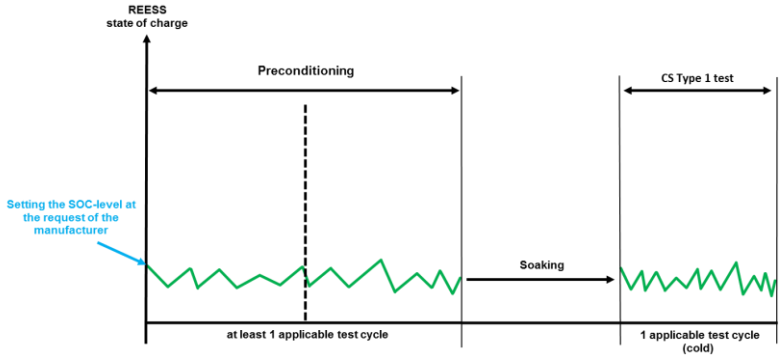
EVE In Vehicle Battery Durability (Input for 37th IWG EVE)

OVC-HEV: Range calculation and UBE determination with CD-Test and CS-Test

OVC-HEV Charge-Depleting Test Procedure
(FCT in US has same set up but different cycles)
→ Procedure performed during TA and ISC



OVC-HEV Charge-Sustaining Test Procedure
(CST in US has same set up but different cycles)
→ Procedure performed during TA and ISC



$$\text{AER} = \text{determined when the combustion engine starts consuming fuel}$$

$$\text{EAER} = \left(1 - \frac{M_{CO2,CD,avg}}{M_{CO2,CS}}\right) \times R_{CDC}$$

➔ Range_AER = f (first engine start) → only CD-test required during ISC
➔ Range_EAER = f ($M_{CO2,CD,avg}$, $M_{CO2,CS}$, R_{CDC}) → both CD-test and CS-test are required
➔ UBE = f (available UBE) → only CD-test required during ISC

EVE In Vehicle Battery Durability (Input for 37th IWG EVE)

OVC-HEV: Challenges with range based indicator and benefits with UBE based indicator

Important points in the context of the real world range:

→ Range based indicator need to compensate the red factors

Range_AER = f (first engine start)

➔ Effects from higher/lower energy consumption coming from driving behavior and activated auxiliary devices need to be eliminated ➔ Challenging/adding complexity/possible (?)

Range_EAER = f ($M_{CO2,CD,avg}$, $M_{CO2,CS}$, R_{CDC})

➔ Effects from higher/lower energy consumption coming from driving behavior and activated auxiliary devices need to be eliminated ➔ Challenging/adding complexity/possible (?)

Conclusion:

If a range based indicator compensates the red factors, there would be the following way forward:

- Driving the procedure with the given cycle (in TA and ISC) → no compensation for the indicator
- Driving in the real world → compensation of the factors above required for the indicator

Due to the two power trains and their interacting, it is a huge (maybe impossible) challenge/task regarding the range values AER and EAER → are AER or EAER the appropriate range values?

Benefit UBE:

As UBE independent from that, no compensation required at all

EVE In Vehicle Battery Durability (Input for 37th IWG EVE)

PEV and OVC-HEV: Summary slide UBE and range indicator discussion

- A range based indicator would cover the concerns from stake holders regarding an increased electric consumption as reason for the deteriorated range
- Influence of provided test data show that the influence of the increased electric consumption on range is negligible compared to the effect coming from the deteriorated battery (less UBE)
- As range is depending on a lot more parameters than UBE, the indicator for range need to compensate the higher energy consumption coming from driving behavior and auxiliary devices
- A range based indicator should only cover effects on range coming from the battery (less UBE) and an increased energy consumption from any component in the power train (higher EC)
- In TA test and ISC test, increased energy consumption (influenced by the driver) plays no role as defined procedure and cycle; while in the real world (Part B), these factors play a big role; when comparing with MPR, these factor should be compensated
- Regarding OVC-HEVs and the interaction of the two powertrains, the range based indicator (regardless if it is AER or EAER) is a huge (maybe impossible) challenge and task
  → Question: Are AER and EAER the appropriate range values?
- Having two indicators, one for UBE and one for range:
  Do both need to meet defined MPR? What if only one of these two indicators does not meet MPR?