CO_2/FC correction for (N)OVC-HEV

Proposed update by ACEA EV for WLTP SG EV to give the option to avoid unnecessary testing without additional value (updated proposal after 05.03.2020 – revision 2)

Status: 08.03.2020

NOVC-HEV: CO_2/FC correction

Proposal ACEA EV for SG EV (status: March 6th)

- ACEA EV is supporting the approach of a generic worst case correction as for pure ICE vehicle due to
  - the high measurement effort nowadays without any additional value (as factor are similar/identical)
  - the procedure is not reproducible due to measurement inaccuracies caused by small REESS compared to absolute CO_2 values; therefore massively different corrections could be the consequence)
- It should be at the option of the manufacturer to use a generic worst case correction or to use a physically determined K_{CO2} factor
- Proposal: Use of the pure ICE vehicle approach but apply different generator efficiency depending in the case of REESS charging

➔ Generator efficiency "$n_{alternator}$ = 1" is "Worst case approach"

ACEA EV proposal to keep the generator efficiency of "0,67" for discharging case → "worst case" for discharging

ACEA EV proposal to add this generator efficiency of "1" for the charging case → worst case for charging

	Willans Factor	Generator efficiency with neg. REESS Balance (Discharging)	Generator efficiency with pos. REESS Balance (Charging)
Diesel (B7)	161 (unchanged)	0,67	1
Petrol (E10)	184 (unchanged)	0,67	1

Calculation of CO_2-Delta which need to be corrected:

$$\Delta M_{CO2,j} = 0{,}0036 \times \Delta E_{REESS,j} \times \frac{1}{\eta_{alternator}} \times Willans_{factor} \times \frac{1}{d_j}$$

➔ In case of charging: With $n_{alternator}$ = 1 → smallest pos. $\Delta M_{CO2,j}$

➔ In case of discharging: With $n_{alternator}$ = 0,67 → higher neg. $\Delta M_{CO2,j}$

Higher than with real life alternator efficiency

Calculation of corrected CO_2 value:

$$M_{CO2,c,3} = M_{CO2,c,2} - \Delta M_{CO2,j}$$

➔ With smallest pos. $\Delta M_{CO2,j}$ → highest $M_{CO2,c,3}$

➔ With higher neg. $\Delta M_{CO2,j}$ → higher $M_{CO2,c,3}$

Higher than with real life alternator efficiency

NOVC-HEV: CO_2/FC correction

Proposal ACEA EV for SG EV (added: March 4th)

Explanation why assuming a generator efficiency of 100% ($n_{alternator} = 1$) is the worst case in the context of CO_2/FC correction (charging)

Fuel energy used for vehicle propulsion and charging of the REESS

Fuel energy used for vehicle propulsion → $\Delta M_{CO2,c,2}$

Fuel energy converted to electric energy → REESS charging (Generator efficiency < 100%) → Positive $\Delta E_{REESS,j}$ (measured during Type 1 test, , electric energy going in the REESS)

$$|\Delta M_{CO2,j}| < |\Delta M_{CO2,j}|$$

Less correction with 100% generator efficiency

Back-calculation from $\Delta E_{REESS,j}$ to $\Delta M_{CO2,c,2}$ with the real life generator efficiency:

$$positive\ \Delta M_{CO2,j} = 0,0036 * \Delta E_{REESS,j} * \frac{1}{n_{alternator} = 0,9} * Willans_{factor} * \frac{1}{d_j}$$

$\Delta E_{REESS,j}$ to $\Delta M_{CO2,c,2}$ (Generator efficiency = 90%)

Back-calculation from $\Delta E_{REESS,j}$ to $\Delta M_{CO2,c,2}$ with proposed generator efficiency of 100% (which is not the reality but reflects the worst case regarding CO2 correction):

$$positive\ \Delta M_{CO2,j} = 0,0036 * \Delta E_{REESS,j} * \frac{1}{n_{alternator} = 1} * Willans_{factor} * \frac{1}{d_j}$$

$\Delta E_{REESS,j}$ to $\Delta M_{CO2,c,2}$ (Generator efficiency = 100%)

$$M_{CO2,c,3} = M_{CO2,c,2} - \Delta M_{CO2,j}$$

Smaller ΔM_{CO2} means higher corrected CO2 value
→ Worst Case

$$> M_{CO2,c,3} = M_{CO2,c,2} - \Delta M_{CO2,j}$$

Is the generic approach also the worst case compared to K_{CO2} derived by measurements?

→ Yes, because measurements reflect real life and therefore a generator efficiencies of less than 100% but more than 67%

NOVC-HEV: CO_2/FC correction

Proposal ACEA EV for SG EV (added: March 5th)

Explanation why assuming a generator efficiency of 67% ($n_{alternator}$ = 0,67) is non beneficial in the context of CO_2/FC correction (discharging)

Fuel energy used for vehicle propulsion, electric energy used for vehicle propulsion (REESS discharging)

Fuel energy used for vehicle propulsion → $\Delta M_{CO2,c,2}$

Fuel energy converted to electric energy → REESS charging (Generator efficiency = 90%)

$negative\ \Delta E_{REESS,j}$ (measured during Type 1 test, electric energy going out of the REESS)

$$|\Delta M_{CO2,j}| > |\Delta M_{CO2,j}|$$

More correction with 0,67% generator efficiency

Back-calculation from $\Delta E_{REESS,j}$ to $\Delta M_{CO2,c,2}$ with the real life generator efficiency:

$$\text{negative } \Delta M_{CO2,j} = 0,0036 * \Delta E_{REESS,j} * \frac{1}{n_{alternator} = 0,90} * Willans_{factor} * \frac{1}{d_j}$$

$\Delta E_{REESS,j}$ to $\Delta M_{CO2,c,2}$ (Generator efficiency = 90%)

Back-calculation from $\Delta E_{REESS,j}$ to $\Delta M_{CO2,c,2}$ with generator efficiency of 67% (already in regulation, which is not the real life generator efficiency, but an efficiency which is not to the benefit for the manufacturer):

$$\text{negative } \Delta M_{CO2,j} = 0,0036 * \Delta E_{REESS,j} * \frac{1}{n_{alternator} = 0,67} * Willans_{factor} * \frac{1}{d_j}$$

$\Delta E_{REESS,j}$ to $\Delta M_{CO2,c,2}$ (Generator efficiency = 67%)

$$M_{CO2,c,3} = M_{CO2,c,2} - (-\Delta M_{CO2,j})$$

Higher ΔM_{CO2} means higher corrected CO2 value
→ Worst Case

$$> \quad M_{CO2,c,3} = M_{CO2,c,2} - (-\Delta M_{CO2,j})$$

Is the generic approach also the worst case compared to K_{CO2} derived by measurements?

→ Yes, because measurements reflect real life and therefore a generator efficiencies of more than 67% but less 100%

(N)OVC-HEV: K_{CO2} correction factor family

Updated proposal ACEA EV for SG EV (status: February 26th)

K_{CO2} family for NOVC-HEVs and OVC-HEVs

Only OVC-HEVs and NOVC-HEVs that are identical with respect to the following characteristics may be part of the same K_{CO2} family at which K_{CO2} shall be determined with vehicle H of one of the included interpolation families:

a. Type of internal combustion engine: fuel type (or types in the case of flex-fuel or bi-fuel vehicles), combustion process, engine capacity, ~~full-load characteristics~~, engine technology, and charging system, and also other engine subsystems or characteristics that have a non-negligible influence on ~~CO2 mass emission~~ K_{CO2} under WLTP conditions;

b. Operation strategy of all ~~CO2 mass emission~~ K_{CO2} influencing components within the powertrain;

c. Transmission type (e.g. manual, automatic, CVT) and transmission model (e.g. torque rating, number of gears, number of clutches, etc.);

d. Type and number of electric machines: construction type (asynchronous/ synchronous, etc.), type of coolant (air, liquid) and any other characteristics having have a non-negligible influence on ~~CO2 mass emission and electric energy consumption~~ K_{CO2} under WLTP conditions;

e. Type of traction REESS (model, capacity, nominal voltage, nominal power, type of coolant (air, liquid));

f. Type of electric energy converter between the electric machine and traction REESS and between the traction REESS and low voltage power supply ~~and between the recharge-plug-in and traction REESS~~, and any other characteristics a non-negligible influence on ~~CO2 mass emission and electric energy consumption~~ K_{CO2} under WLTP conditions. ~~At the request of the manufacturer and with the approval of the approval authority, electric energy converters between recharge-plug-in and traction REESS with lower recharge losses may be included in the family;~~