European Automobile Manufacturers Association

Phase specific calculation based on Japanese proposal (OIL#55)

ACEA EV Group

25.06.2014

ACEA WLTP E-Lab group
Conclusions based on the current state of play.

EU COM position:

► Does not need phase specific values for EVs (EV subgroup meeting in Vienna 25th and 26th March 2014). (Link)

ACEA position based on general issues (presentation from BMW):

► The approach does not work for vehicles with only one charge depleting cycle that is also the transition cycle. For ACEA it is no solution to drive consecutive each phase cycles instead because of higher test burden. (Link)

► Giving always the option to apply consecutive driven cycles needs a validation that makes sure that both methods lead to the same results. Otherwise an inconsistency can not be excluded. (Link)

► Driving the whole cycle in charge sustaining RCB-neutral does not mean that each phase RCB is also neutral. That leads definitely to wrong each phase charge sustaining values that make no sense to be communicated to the customer. (Link)

► The recommendation is to use separated values for charge depleting and charge sustaining mode for customer information and delete weighted each phase values. (Link)

ACEA position based on simulation results (presentation from Renault):

► Utility factor estimation for each phase is not coherent with global utility factor. (Link)

► Except the low phase, for all other phases the estimated EAER is higher than the combined EAER. This does not seem to be normal. (Link)

► Contrary to EAER the CO_2 value of combined cycle is much lower than the estimated value for each individual cycle. (Link)

► In the calculation the average CD CO_2 value from the real test (e.g. based on 3 real driven low phases) is assumed to be representative for the estimated number of cycles that would be driven in a single cycle test. (Link)

ACEA task was to think about required values:

► ACEA recommends to keep the GTR as it is. The additional $WLTC_{city}$ cycle that is included to determine an electric city range is enough.

N. Schütze, 25.03.14

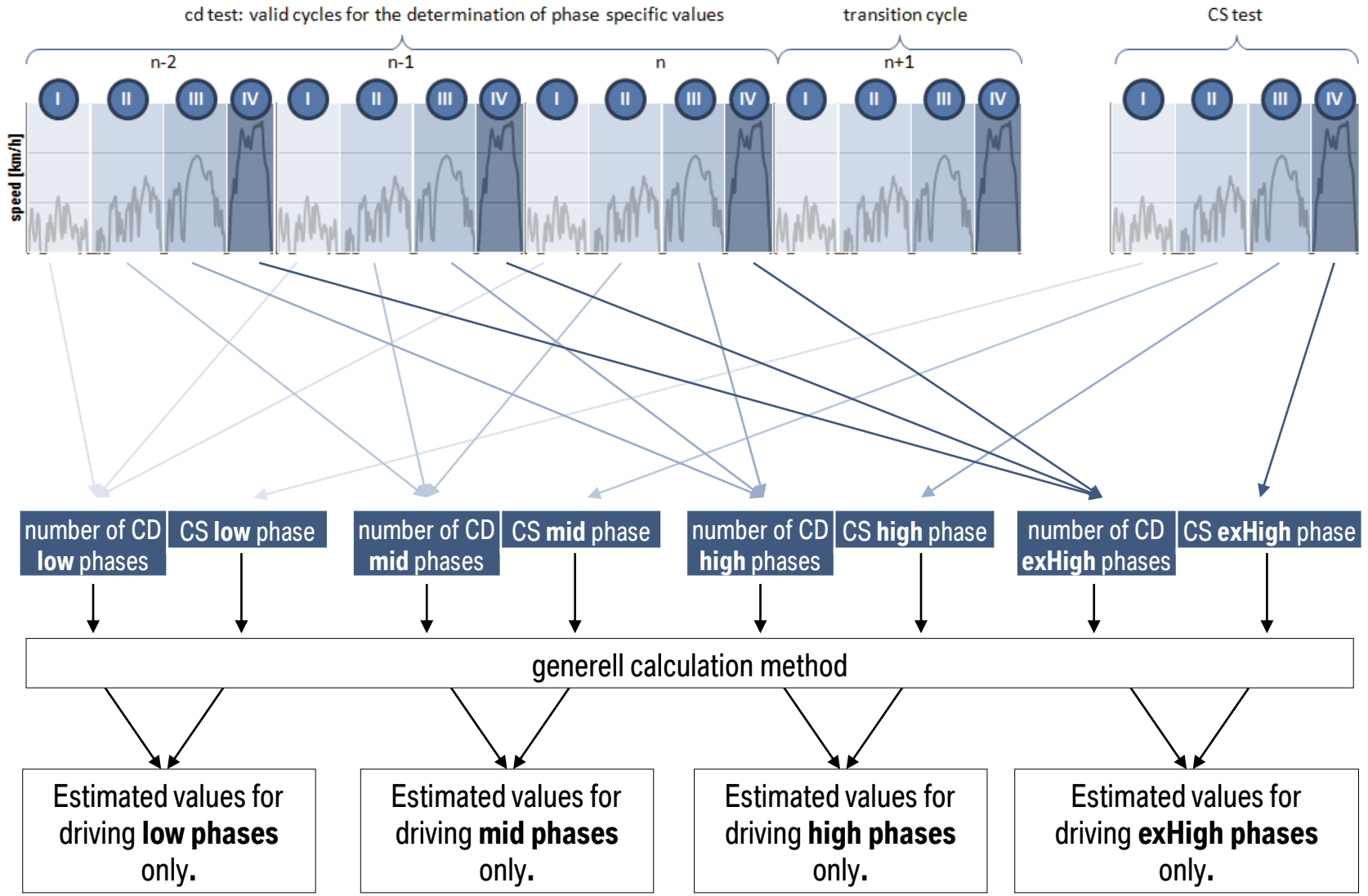
PHASE SPECIFIC CONSUMPTION FOR OVC-HEV BASED ON THE PROPOSAL FROM JAPAN (OIL#55).

BMW GROUP

Rolls-Royce Motor Cars Limited

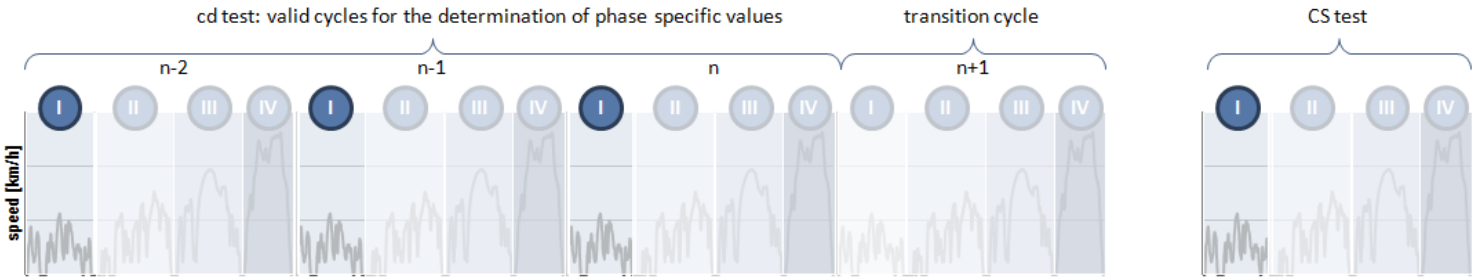
PHASE SPECIFIC CONSUMPTION FOR OVC-HEV.

JAPANESE APPROACH FOR PHASE SPECIFIC CONSUMPTIONS AND RANGES.



PHASE SPECIFIC CONSUMPTION FOR OVC-HEV.

CALCULATION OF ESTIMATED NUMBER OF DRIVEN CD PHASES.



virtual example:

$$C_{CD,Low} = \frac{\sum_{j=1}^{n} C_{CD,j,Low} \times D_{j,Low}}{\sum_{j=1}^{n} D_{j,Low}}$$

$$R_{CDa,Low} = \frac{C_{AC}}{C_{CD,Low}}$$

$$n_{Low} = \text{int}\left(\frac{R_{CDa,Low}}{D_{Low}}\right) + 1$$

number of low phase j	$C_{CD,j,Low}$ [Wh/km]	$C_{CD.Low}$ [Wh/km]	$R_{CDa,Low}$ [km]	n_{Low}
1	110	103,3	96,8 (assumed C_{AC} = 10 kWh)	32
2	100			
3	100			

R: ► The number of estimated phases that could be driven consecutively is the basis for all following phase specific calculations.

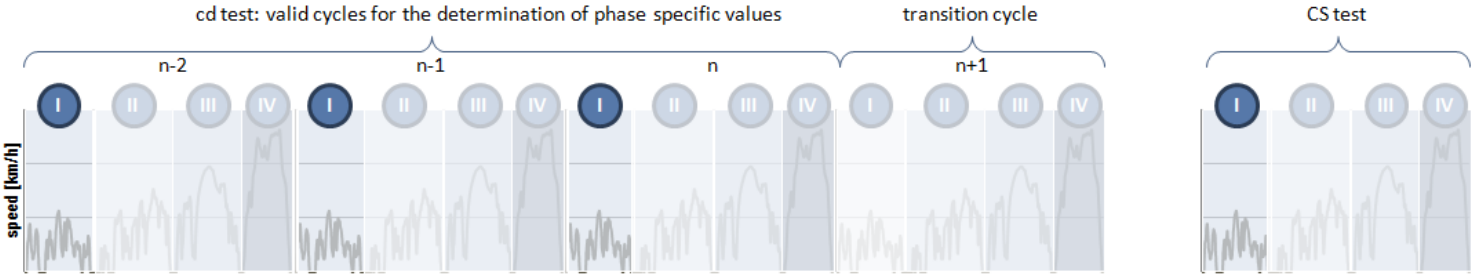
R: ► The approach can only be applied to vehicles that are able to drive the whole first cycle in charge depleting because the transition cycle has to be excluded for the determination of the electric consumption to calculate the estimated electric range for the specific phase.
Q: ► How to handle with vehicles that are able to drive a transition cycle only?

Japanese answer: Proposed calculation formula doesn't take care of such a vehicle. Thank you for your feedback. Need to consider the alternative method for those vehicles.
ACEA: In that case a proposal could be to drive each phase separately. → higher test burden for such kind of vehicles

Q: ► How big is the impact of the "cold start" conditions if only one cycle can be used because the second one is a transition cycle?
Japanese answer: It depends on the system, however, it has negative impact on performance value. It's OK for us to have an option to run the consecutive each phase test (L-L-L-L…, M-M-M-M…,) as an option.

PHASE SPECIFIC CONSUMPTION FOR OVC-HEV.

CALCULATION OF ESTIMATED ELECTRIC RANGES.



virtual example:

$$CO_{2,CDavg,Low} = \frac{\left(\sum_{j=1}^{n} CO_{2,CD,j,Low}\right)}{n}$$

$$EAER_{Low} = \frac{\left(CO_{2,CS,Low} - CO_{2,CDavg,Low}\right)}{CO_{2,CS,Low}} \cdot D_{Low} \cdot n_{Low}$$

$$R_{CDc,Low} = D_{Low} \cdot n_{Low}$$

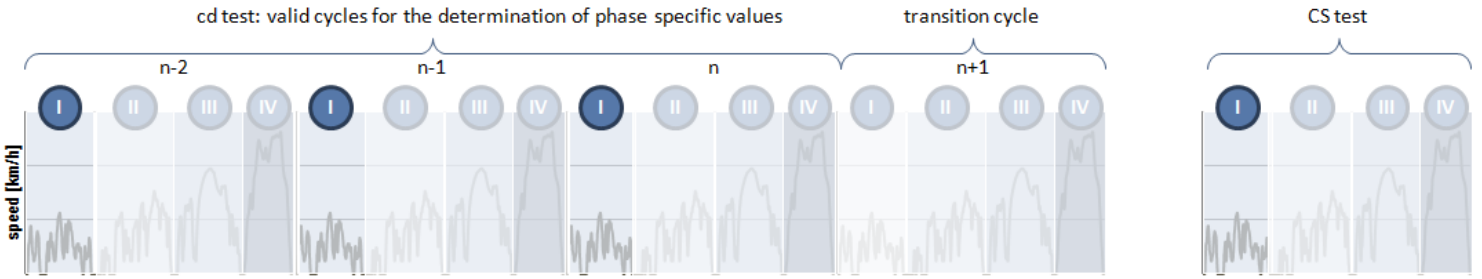
number of low phase j	$CO_{2,CD,j,Low}$ [g/km]	$CO_{2,CDavg,Low}$ [g/km]	n_{Low}	$CO_{2,CSavg,Low}$ [g/km]	$EAER_{Low}$ [km]	$R_{CDC,Low}$
1	0	0	32	100	99	99
2	0					
3	0					

R: ► The $CO_{2,CDavg,Low}$ will always be zero if there is no power-triggered engine start because the transition cycle is excluded. That means $EAER_m$ equals $R_{CDC,m}$!
Japanese statement: Not available.
ACEA: The calculation of RCDa is sufficient. The calculation of EAER and R_{CDC} has no additional value.

R: ► RCB-correction for each phase in charge sustaining is necessary! That is not required in the GTR now!
Japanese answer: If no correction is necessary for whole cycle, no correction is required for each phase as basis. It's OK to allow manufacturer to develop each phase correction factor.
ACEA: If the RCB correction is not required because the test is within the tolerance, the low and mid CO_2 will be lower and the high and extraHigh CO_2 will be higher than the value that would be determined by driving consecutive each phase cycles.
→First solution: Each phase measurement .→ Disadvantage of higher test burden. → Is not recommended by the ACEA.
→Second solution: An approach for each phase RCB-correction is to use the cycle energy. The energy demand over the whole cycle and the energy demand over each phase leads to an each phase percentage that can be used to calculate the each phase consumption by multiplication of each phase percentage and whole cycle consumption (nearly SOC neutral).

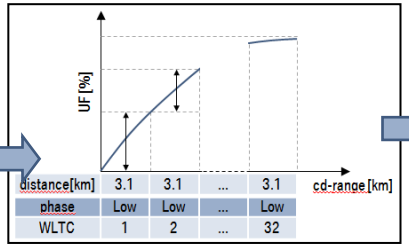
PHASE SPECIFIC CONSUMPTION FOR OVC-HEV.

CALCULATION OF ESTIMATED ELECTRIC CONSUMPTION.



virtual example:

number of low phase j	$C_{CD,j,Low}$ [Wh/km]	$C_{CD.Low}$ [Wh/km]	n_{Low}
1	110	103,3	32
2	100		
3	100		



$UF_{p,j,Low}$
9.6%
8.8%
...
0.4%

$$C_{weighted,Low} = \sum_{j=1}^{n_{Low}} \left(UF_{p,j,Low} \cdot C_{CD,Low} \right)$$

$C_{weighted,Low}$ [Wh/km]
96,4

R: ► Is it valid to use the same UF curve for the weighting of each phase consumptions or do we need more criteria concerning the analysis of databases to determine a UF curve for the low, mid, high and exHigh – phase (e.g. a filter that distinguishes between urban and non-urban drive)!

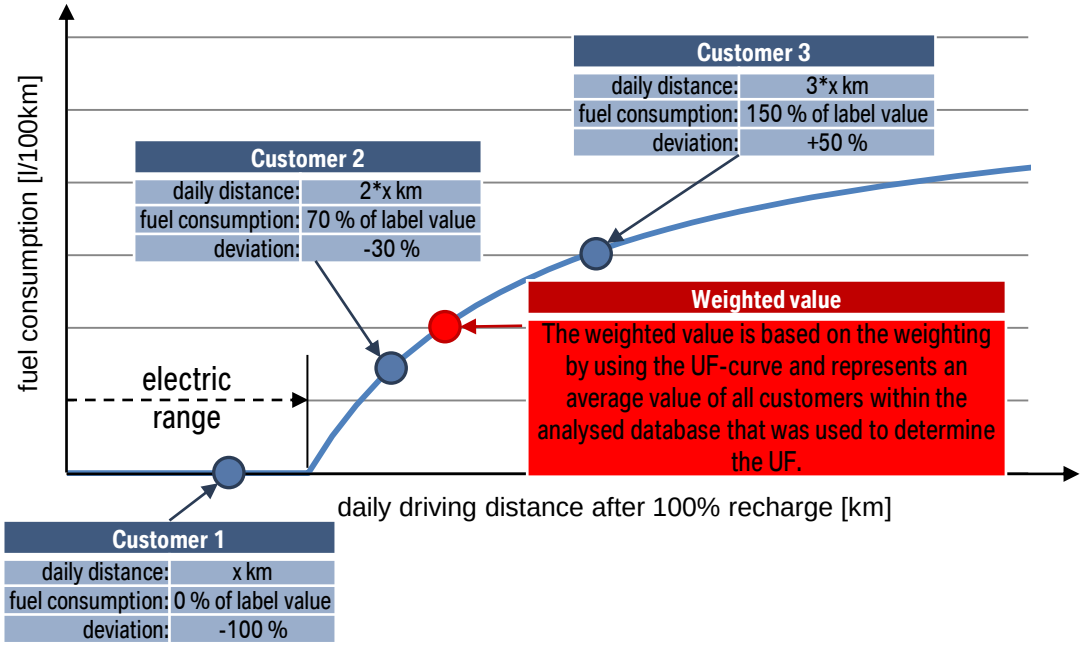
Japanese answer: We've made a decision to adopt regional UF for OVC-HEV calculation. Each region can adopt their own UF for also phase specific calculation. (JPN has only one UF and this UF is used for all kinds of calculation)

ACEA: UF-weighted values are only made for the calculation of average fleet values. Each individual customer consumption hardly depends on the average daily driven distance.

ACEA proposes to delete the calculation of weighted each phase values.

PHASE SPECIFIC CONSUMPTION FOR OVC-HEV.

WEIGHTED VALUES ARE **UNSUITABLE** FOR CUSTOMER INFORMATION; FOR WHOLE CYCLE VALUES AS WELL AS FOR EACH PHASE VALUES.



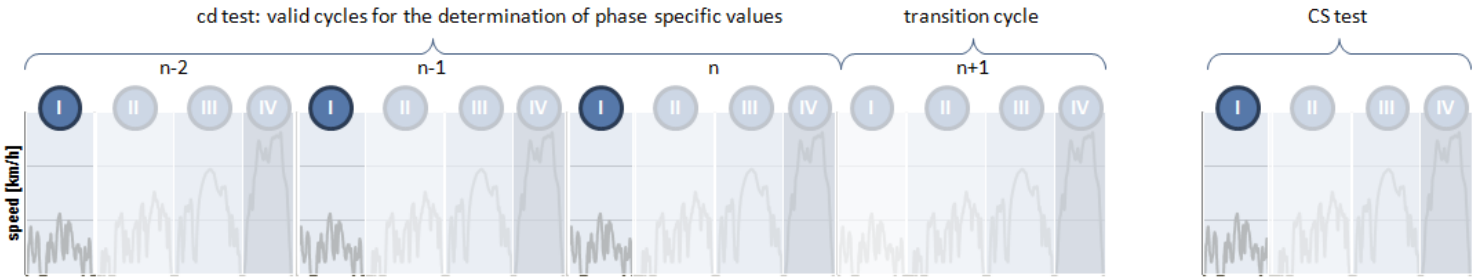
R: ► The figure shows the dependence from the daily driven distance of the customer concerning the fuel and electric consumption.

R: ► A weighted value is made to represent an average value for a fleet of vehicles, that can be used as a homologation value.

ACEA recommendation:
► Using of separated values for charge depleting and charge sustaining mode for customer information.

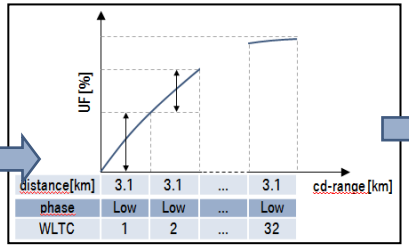
PHASE SPECIFIC CONSUMPTION FOR OVC-HEV.

CALCULATION OF ESTIMATED FUEL CONSUMPTION AND CO_2.



virtual example:

number of low phase j	$CO_{2,\,CD,\,j,\,Low}$ [g/km]	$CO_{2,\,CD,\,Low}$ [g/km]	n_{Low}
1	0	0	32
2	0		
3	0		



$UF_{p,\,j,\,Low}$
9.6%
8.8%
...
0.4%

$$CO_{2,weighted,Low} = \sum_{j=1}^{n_{low}} (UF_{p,j,Low} \cdot CO_{2,CD,Low}) + (1 - \sum_{j=1}^{n_{low}} UF_{p,j,Low}) \cdot CO_{2,CS,Low}$$

$CO_{2,\,weighted,\,Low}$ [g/km]
5 g/km

ACEA

► The recommendation from ACEA is to delete the calculation for the weighted each phase fuel consumption (as well as for the weighted electric consumption) because weighted values are not suitable for customer information (see slide 5 and 6).

PHASE SPECIFIC CONSUMPTION FOR OVC-HEV.
VALIDATION.

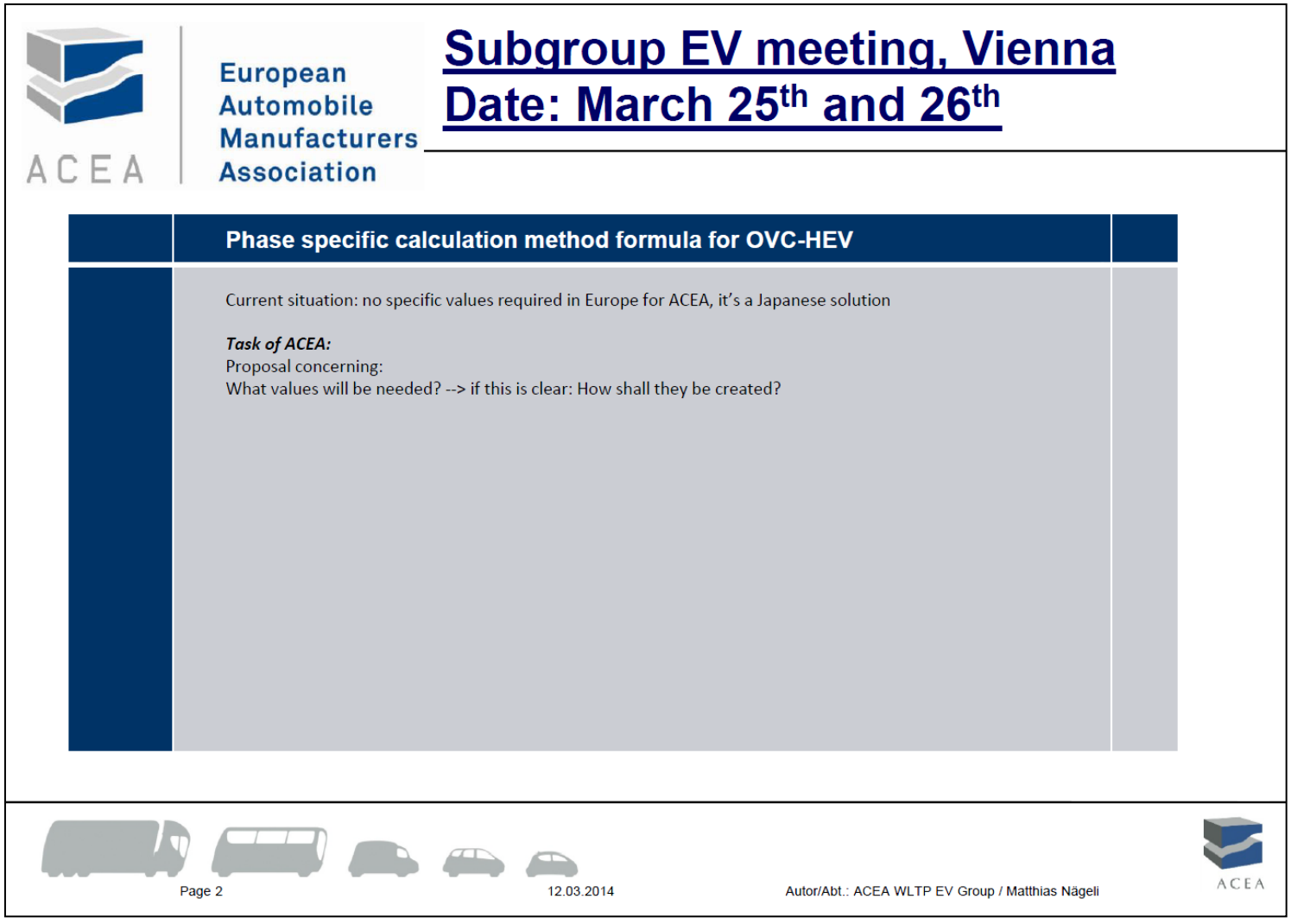
Q: ► How do the validation schemes/-results look like?

Japanese answer: A : We don't think the validation test is necessary. If this formula is not acceptable, we request to run each phase test to obtain each phase specific value.

ACEA
► In principle we can agree to a lot of proposed issues concerning the each phase calculation except for the issues we addressed on the slides before.

But ACEA also thinks:
► that a validation with randomly chosen vehicles is helpful in order to make sure that approach works for all possible OVC-HEV concepts.
► that it is more expedient to validate the approach now instead of creating a giant test burden by testing each vehicle by driving consecutive each phase test.

ACEA WLTP E-Lab group
Minutes from Vienna.



WLTP

PHEV test procedure : Phase based calculation

1 Phases based calculation: Calculations steps

Simulation:

- *We did a simulation with 3 CD cycle and one CS cycle*
- *Vehicle is able to follow the drive cycle*

Input:

- *CO_2 emission for each phase in CD mode*
- *CO_2 emission for each phase in CS mode*
- *Electric energy consumption for each phase in CD mode*
- *RCB of each phase*
- *Distance of each phase*

Calculation for each phase:

- *Step 1: Calculation of average electric energy consumption*
- *Step 2: Estimation of plug-in range (R_{cda}) for 'low' phase*
- *Step 3: Estimation of number of CD cycle*
- *Step 4: Estimation of RCDC*
- *Step 5: Estimation of EAER*
- *Step 6: Estimation of UF for each phase*
- *Step 7: Calculation of weighted CO_2 value for each phase*

2 Phases based calculation: Application for low phase

Low phase results:

Phase	distance	UF_i	E_{CD}	CO_2 CD	CO_2 CS	CO_2 CD avg	E_{CD} avg	R_{cda}	n	R_{cdc}	EAER	Wght CO_2
	km		Wh/km	g/km	g/km	g/km	Wh/km	km		km	km	g/km
Low CD1	3.1	0,09	101,9	0.0	-	0.00	111.7	66.1	22	68.1	68.1	24.9
Low CD2	3.1	0,04	113,1	0.0	-							
Low CD3	3.1	0,02	120,2	0.0	-							
Low CS	3.1	-	-	-	30.3							

$$R_{CDa,m} = \frac{C_{AC}}{C_{CD,m}}$$

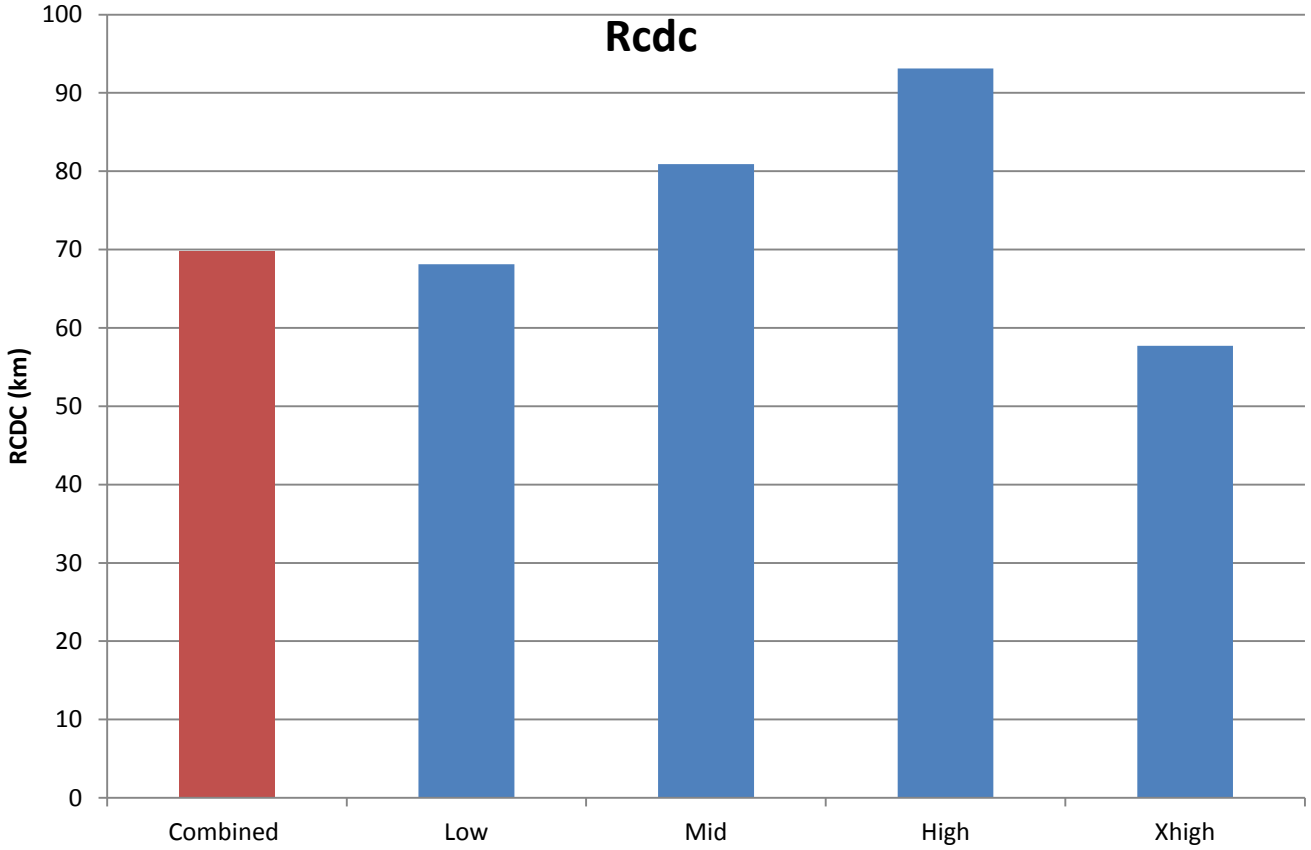
$$n_m = \text{int}\left(\frac{R_{CDa,m}}{D_m}\right) + 1$$

$$M_{CO2,Weighted,Low} = \sum_{j=1}^{n_m}(UF_{p,j,Low} \times M_{CO2,CD,Low}) + (1 - \sum_{j=1}^{n_m} UF_{p,j,Low}) \times M_{CO2,CS,Low}$$

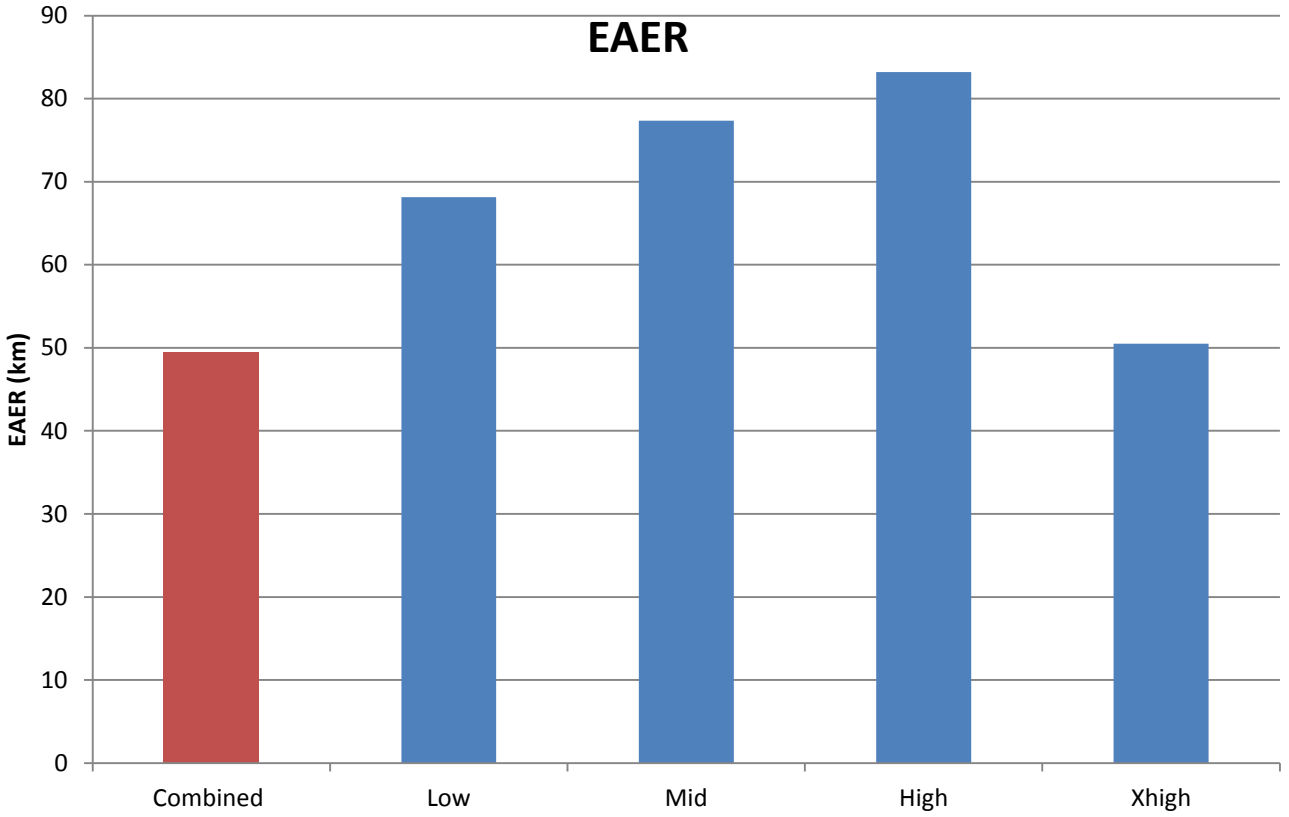
$$R_{CDc,m} = D_m \times n_m$$

$$EAER_m = \frac{(M_{CO2,CS,m} - M_{CO2,CDavg,m})}{M_{CO2,CS,m}} \times D_m \times n_m$$

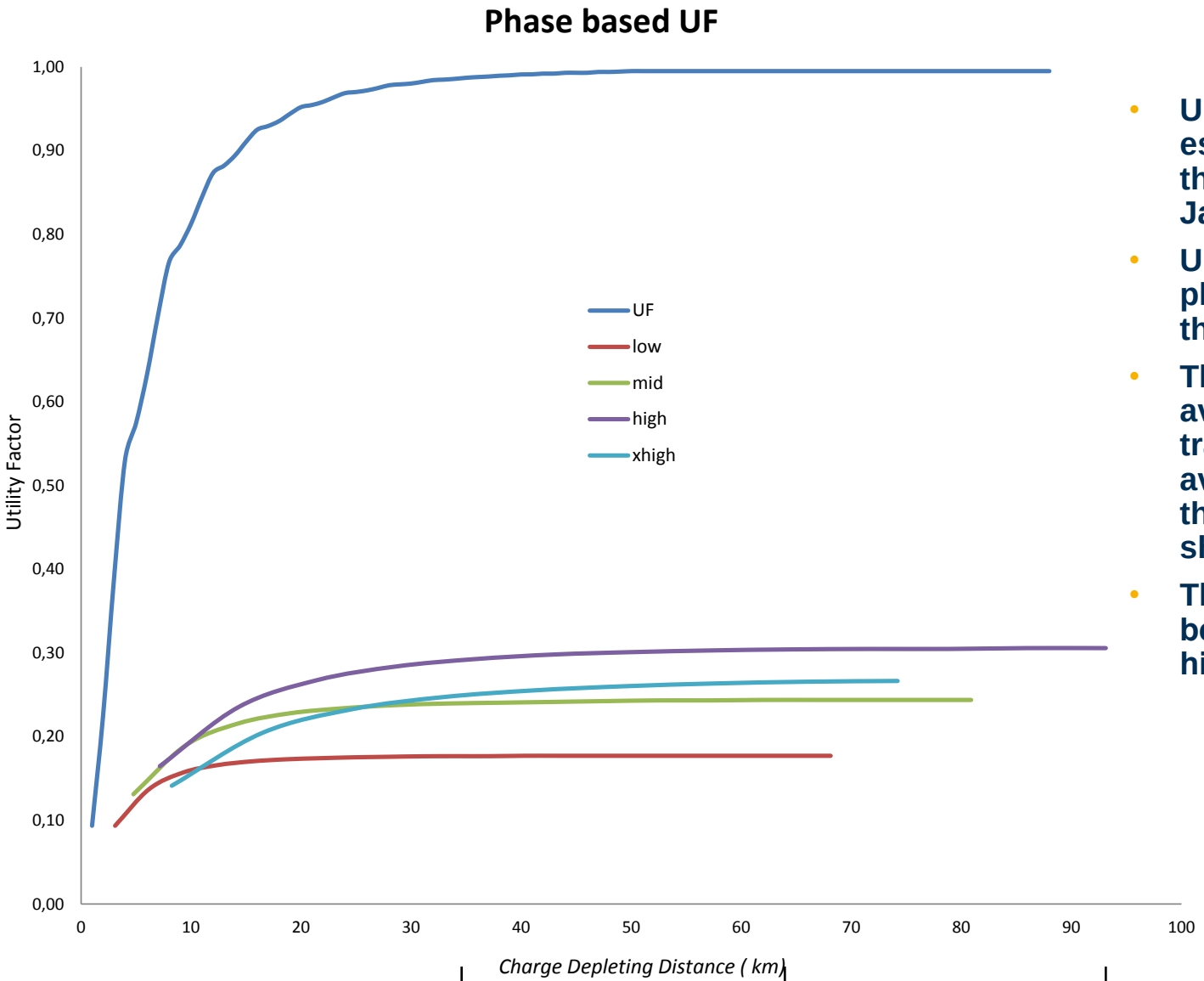
3 Phase based calculation: RCDC



3 Phase based calculation: EAER

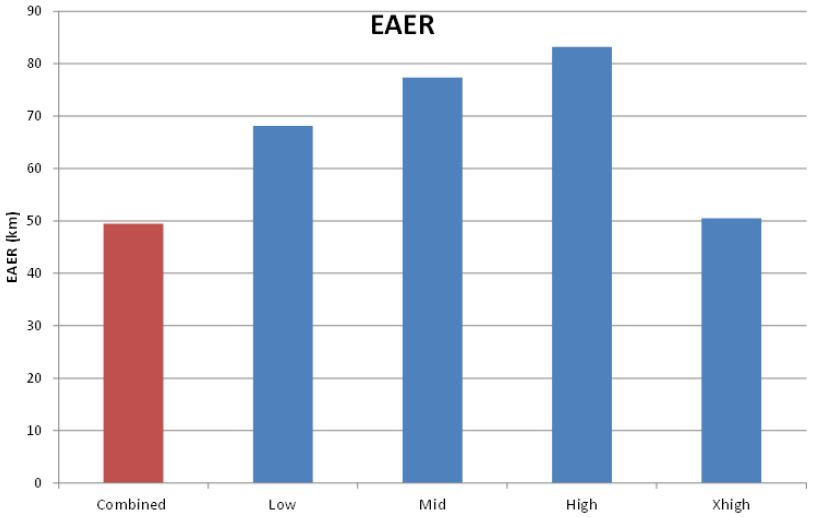


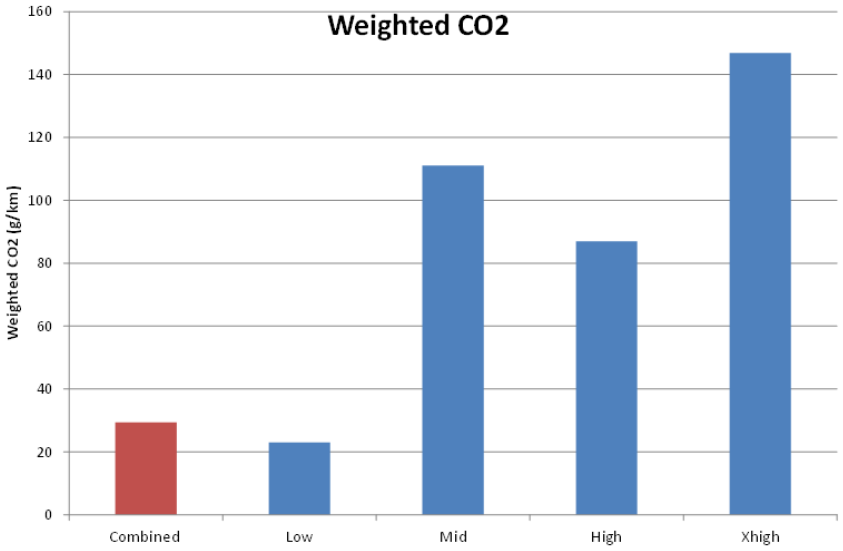
3 Phase based calculation: Utility factor estimation of each phase



- UF for each phase is estimated according to the method proposed by Japan.
- UF estimation for each phase is incoherent with the global utility factor.
- The UF depends on the average distance traveled but not on average speed. Hence the UF for each phase should not vary much.
- The high phase has better UF than the 'extra high' phase.

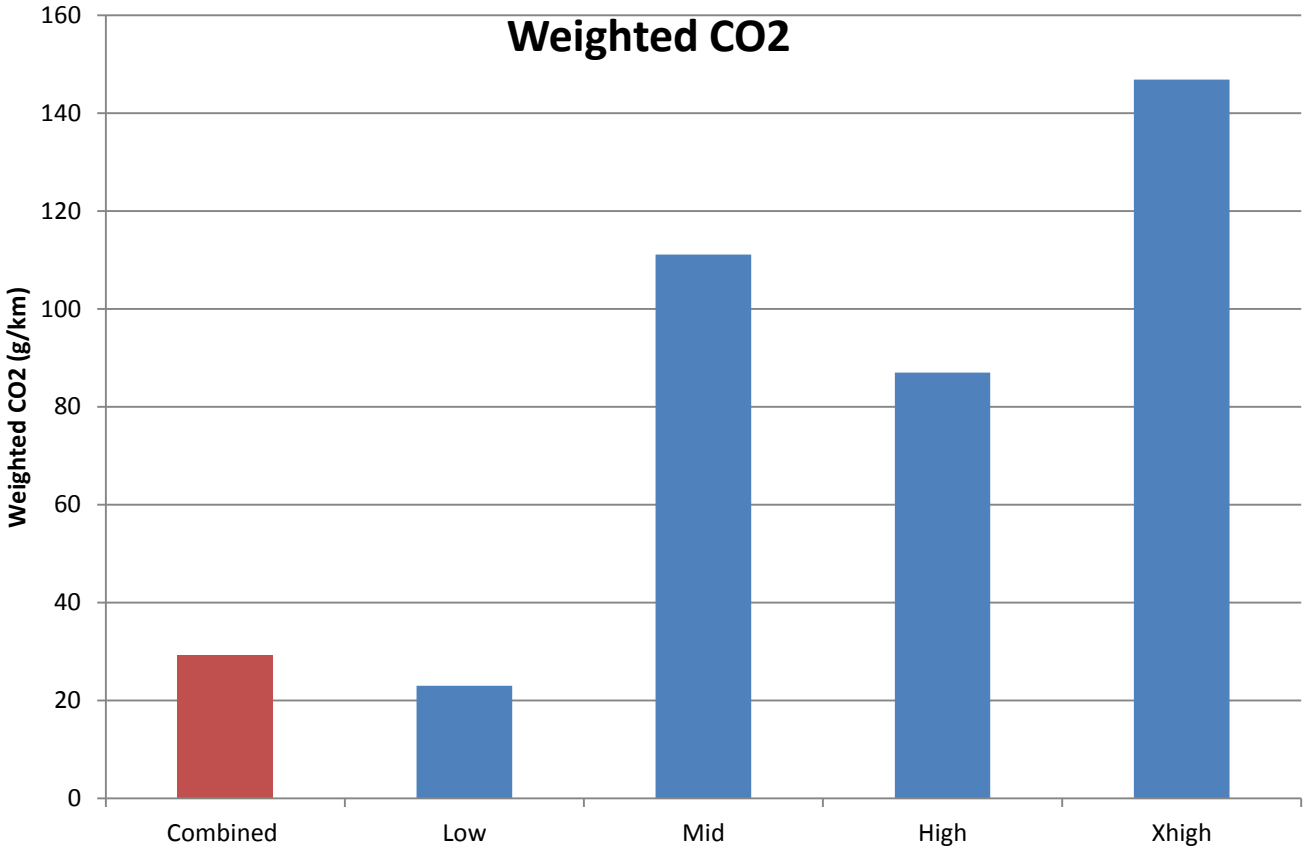
3 Phase based calculation: Utility factor estimation of each phase





Contrary to EAER the CO2 value of combined cycle is much lower than the estimated value for each individual cycle.

3 Phase based calculation: Weighted CO2 value



$$M_{CO2,Weighted,Low} = \sum_{j=1}^{n_m}(UF_{p,j,Low} \times M_{CO2,CD,Low}) + (1 - \sum_{j=1}^{n_m} UF_{p,j,Low}) \times M_{CO2,CS,Low}$$

In the calculation the average CD CO_2 value from the real test (e.g. based on 3 real driven low phases) is assumed to be representative for the estimated number of cycles that would be driven in a single cycle test.

4 Conclusion

- Utility factor estimation for each phase is not coherent with global utility factor.
- Except the low phase, for all other phases the estimated EAER is higher than the combined EAER. This does not seem to be normal.
- Contrary to EAER the CO_2 value of combined cycle is much lower than the estimated value for each individual cycle.
- In the calculation the average CD CO_2 value from the real test (e.g. based on 3 real driven low phases) is assumed to be representative for the estimated number of cycles that would be driven in a single cycle test.