DTP – Definition Test Procedure

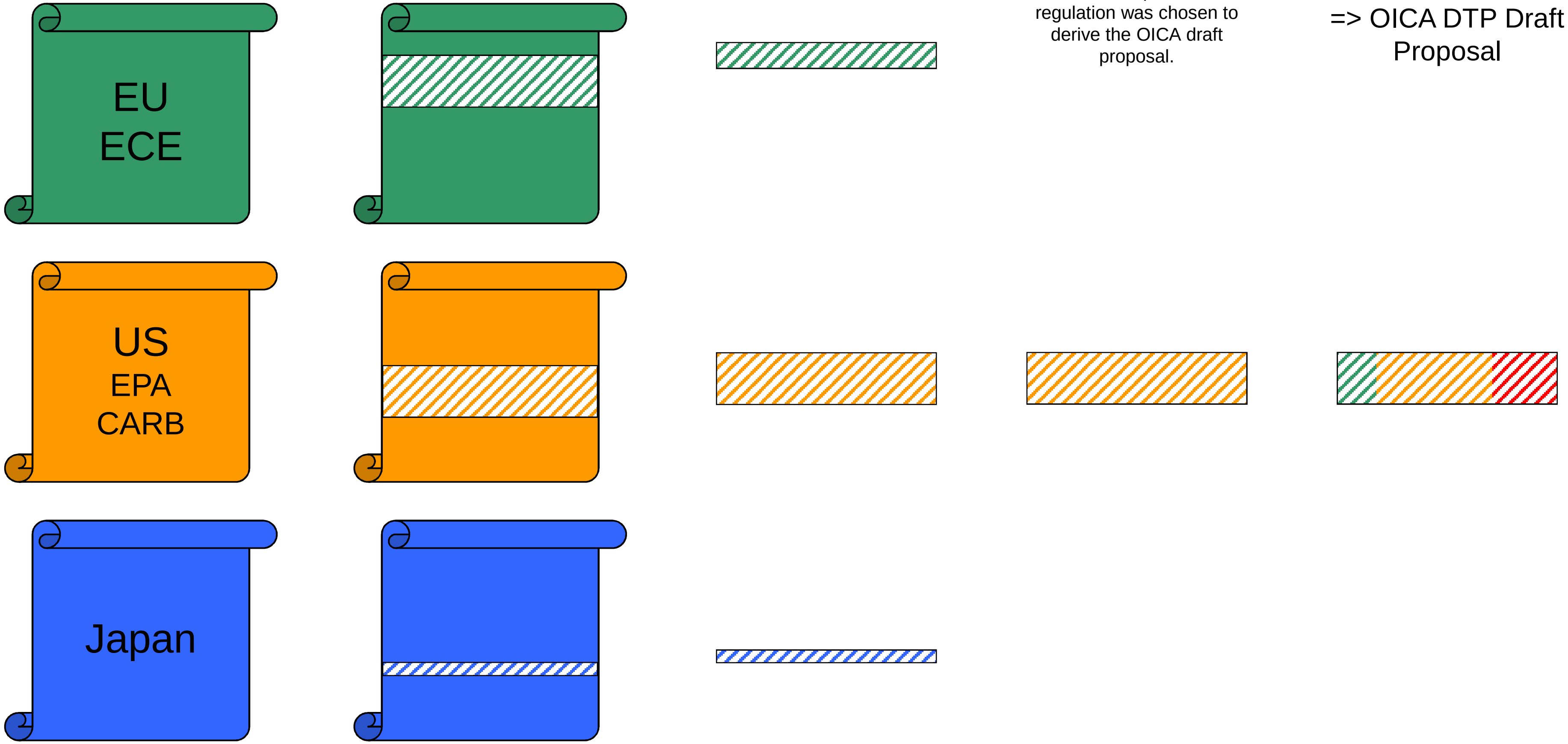
Preliminary Draft Proposal

Documents and Regulations

- **US-EPA (2000 pages +)**
  - Code of Federal Regulation 40 – Part 86 Control of Emissions form New and In-Use Highway Vehicles and Engines (includes §1065 for heavy duty procedure for PM)
  - Compliance Guidance Letters
  - Advisory Circulars
  - SAE- und ASTM-standards
  - NHTSA CAFE
  - EPA Greenhouse Gas
- **US California (1000 pages +)**
  - California Low-Emission Vehicle Regulations and Test Procedures (LEV II)
  - Formal Regulatory Documents for LEV II Regulation.
  - LEV III
  - CARB Greenhouse Gas
  - Manufacturer Advisory Correspondence
  - SAE-standards
- **Europa (app. 500 pages)**
  - ECE R-83
  - ECE-R-85
  - ECE R-101
  - ECE-R 24
  - EC 692 / 2008
- **Japan (app. 400 pages)**
  - Automobile Type Approval Handbook for Japanese Certification and included documents

Approach to develop the OICA DTP draft proposal

Data basis	1. step	2. step	3. step	final step
Regulations	Identification of relevant contents	Comparison of contents	Make a decision In this example the US regulation was chosen to derive the OICA draft proposal.	Modification of contents => OICA DTP Draft Proposal



Assumptions / basic principles for the proposal

- Focus on issues with high impact on CO_2 and emissions
- Physically reasonable results
- Tolerances adapted to technical progress
- Adapted to new cycle
- New vehicle technologies to be considered

- Experts from the industry are still studying the topics covered by the document, so further integrations/modifications will be provided in future.

Table of contents

Road Load Determination

General: Procedure is similar regulated in the US, EC/ECE and Japan Regulation. India follows EC/ECE.

Possible solution **: Use of ISO 10521-1 with amendments**

- Offers different methods for road load determination (use of 2).
- Ambient conditions are somewhat stricter than ECE.
- Choice of tires to be determined.
- Wind allowance on test track should be constrained.
- Provisions for new technologies and new WLTP cycle to be amended.

Road Load Determination

Provisions for new technologies (BEV, HEV, PHEV)

- Vehicle coast down method:
  - Transmission in neutral or disconnect power supply
  - Considering of effective mass of all rotating components incl. electric machines
  - Appropriate adjustments to avoid parasitic drags (e.g. brakes, electric machines)

- Alternatively using of torque measurement method

Inertia Classes for Light Duty Vehicles

- **Situation:** Actual Regulations have inertia classes, however the weight definition and ranges are different.
  - US: 1000 to 5500 lbs curb weight, steps125-250-500 lbs.
  - ECE: 1000 to 5000 lbs rf mass, steps 125-250 lbs.
  - Japan: 1000 to unspec., steps 125-250-500 lbs.
- **Open Points:**
  - Inertia Classes 500 – [5500 lbs], steps and upper limit, definition of weight to be defined.
  - Harmonized reference vehicle weight: Unladen mass plus 25 kg.
  - Unladen mass: Vehicle in running order, fuel tank 100 %
- Justification: Refined inertia classes enable more accurate CO_2-Values. Effect of down-weighting would be better represented.

Mileage of homologation vehicles

	Min.	Max.
• EU:	3K km (ECE-R83)	15K km (80/1268/EEC)
• USA:	2K resp. 4K miles (§86.096-26) 3,2K km resp. 6,4K km	6,2 K miles (§600.006-89) 10K km
• Japan:	3K km (7−1−3−7)	15K km (13-1-102)

- **Draft Proposal**
  combustion engine: min.: 3K km max.: 15K km
  [electric vehicles: min.::3K km]

Select Shift / Multi - Mode

- **General:**

  The procedure which takes care of the different technical equipment of the vehicles such as transmission modes and select buttons (e.g. off road button, extended e-drive button, ..) is regulated very similar in the US, ECE and Japan regulation.

- **Corresponding regulations:**

  US: CISD-2009-19

  EC/ECE: 70/220/EEC, R83, R101

  Japan: TRIAS 5-9-2007

Select Shift / Multi - Mode

- **Strategy/ Premises of proposal:**
  - Testing results should represent the usage of the customer during the predominant usage of the car
  - To consider new technologies

- **Draft Proposal:** Use of EC/ECE regulation
  - The testing should be performed only in the default driving mode regarding the transmission possibilities.
  - The default mode is the mode the vehicle starts with. All buttons must be deactivated with a new key ignition event on.
  - Other modes could be certified on request of the manufacture.
  - Emissions standards must be fulfilled in all modes.

Vehicle Dyno Mode

- **Situation:**

  Due to new technical features and technical equipment of the test vehicles, the test car must be prepared in a way, that the test vehicle can be driven properly and representative on a dyno (e.g. 2 WD dyno) and the operation can take place under safe conditions for the operator.

  Therefore the hardware must be adopted (e.g. drive shaft) and the ABS/PSM system must be deactivated.

- **Corresponding regulation:**

  Topic is not addressed in the regulations

- **Strategy/ Premises of proposal:**

  - Safe operation of the test vehicle

  - easy handling/preparation of the test vehicle

Vehicle Dyno Mode

- **Draft Proposal:**

The vehicle dyno mode should be activated by using
a manufacturer recommendation (e.g. using vehicle
steering buttons in a special „pressing order“ or by using
the manufacturer work shop tester).
The procedure must be very simple and safe for the user.
Description of the dyno mode setting and the effects (eg turns off ABS…) should be clearly recorded in the vehicle test setup.

2 WD / 4 WD testing requirements

- **Situation:**

  The regulation which describes how a test vehicle has to be tested on a dyno is very similar in the US/ECE/ Japan regulation.

- **Corresponding regulations:**

  US: Part 86 (86.135-90(i), 86.159-08(b)(8), 86.160-00(b)(8)

  ECE: 70/220/EEC, R83, R101

  Japan: TRIAS 60, TRIAS 24

Strategy/ Premises of proposal:

- \- definition of an appropriate/cost efficient testing procedure

2 WD / 4WD testing requirements

- **Draft Proposal: US regulation part 86**

In addition:

Ensure the possibility to test a 4 WD vehicle on a 2 WD dyno in the current regulation.

Electrical Accessories

- **Situation:**

  New technologies required by regulations, like daytime running lamps must be considered during testing.

- **Corresponding regulations:**

  - US: Part 86 (86.230-11, 86.135-94,86.160-00(c)(6)

  - EC/ECE: 70/220/EEC, R83, R101

  - Japan: TRIAS 60, TRIAS 24

- **Strategy/ Premises of proposal:**

  - The proposal should define a relevant list of electrical accessories, already considered by current regulations and deemed important for the good running conditions of the vehicles.

  - An harmonised approach is necessary and must still be solved.

Tire Pressure

- **Situation:**

  The regulations which define the correct tire pressure which has to be used on a dyno are very similar in the US/ECE/Japan regulation

- **Corresponding regulations:**

  - US: Part 86 (86.230-11, 86.135-94,86.160-00(c)(6)

  - ECE: 70/220/EEC, R83, R101

  - Japan: TRIAS 60, TRIAS 24

- **Strategy/ Premises of proposal:**

  To address/ define the same procedure of how to inflate the tires.

Tire Pressure

- **Draft Proposal: Basis is the EC/ECE regulation**

Modification:

The manufacturer recommended tire pressure should be used.

The pressure can be inflated up to 50 %.

For the road load determination the manufacturer recommended tire pressure is used.
Higher pressure tire on the dyno is used to minimize the deformation caused by the curvature of the dyno surface. The setting/checking of the dyno load is made with identical tire pressure.

Veh.Precon, Load Adjustment & Procedure

- General: Procedures are similarly regulated in the US, ECE and Japan Regulation
  - US: 40CFR part 86
  - ECE: R83/R101.
  - EC 70/220 and 692/2008 (refers to ECE R83)
  - Japan: Trias 5-9-2007

Veh.Precon, Load Adjustment & Procedure

- Strategy/Premises of proposal:
  - Physically reasonable results
  - Adapted to new cycle
  - New technologies to be considered

- **Draft Proposal: Use combined approach**

  Use existing procedures and streamline elements by physically reasonable approaches

Dyno Load Adjustment & Preconditioning

- Warm-up in Base Cycle
  (use correct inertia, estimated dyno load data)

- Load Adjustment for adjusted speed range (20 – 130) via:
  – Coast down
  – Torque

- Tolerances coast down times: ≤ 20 km/h: +/- 10%, Others: +/- 5%
- Alternative approach: used fixed load parameters

- Fuel Drain & Refill if required – no further drains&refills (canister loading actions) within overall exhaust emission/fuel economy test procedure
- Precon: at least 1 Base Cycle or more, as requested by the car manufacturer

Vehicle Soak

- Temperature soak area: (25 ± [2])℃
  Tolerance should be adapted to technical feasibility of the labs.
- 9 – 36 hrs natural soak with engine compartment closed

  or

- minimum 6 hrs accelerated cool down with open bonnet, appropriate use of cooling fan
  criterion for stabilization: oil temperature within ± 2°C of ambient temperature or with proof of technical service of oil temperature of representative engine group after 9 hrs (t.b.d.)
- HV battery: soak according to standard vehicle procedure
- HV Battery treatment according to ECE R 101

Vehicle Cooling during Test

- Variable speed fan
  - Proportional to roller speed within operating range of 10km/h to at least 50 km/h
  - Tolerance average fan speed vs roller speed: +/- 10km/h or +/-15%, whichever is larger
  - minimum outlet area: 0.2 m^2
  - minimum width: 0.8 m
  - Position: approx. 30cm of vehicle, adjust height and literal to meet vehicle air inlet position (grille position)
  - to be operated with engine compartment closed
  - additional fans on manufacturer‘s request if required for typical vehicle operation

Test Cycle Operation

- Test (25 ± 2)℃, abs. humidity 5.5 …12 g/kg
- Driving Cycle Tolerances: ± 1s and ± 2 mph draft proposal to be consolidated after official definition of the new basic cycle
- Following cycle curve with minimum deviation
- Smooth operation (avoid excessive acceleration/decelerations)
- Manual Transmission:
  - follow shift indicator light (SIL) of vehicle if available,
  - else:
    - shift according to shift pattern derived from rated engine speed (A/C72A)
    - shift according to fixed shifting points else.
- Semi-automatic transmission: use Manual Transmission procedure, or shift according to manufacturer‘s recommendation on special request, resp.

Precon for following tests

- for Base cycle: precondition with
  - base cycle
    (no load check / quick check after test cycle)

- for Supplemental cycles: precondition with
  - Base cycle
  - Any section of base cycle
  - Supplemental cycle

Calculations

- General: The exhaust emission calculation is in main topics quite similar regulated in the US, ECE and Japan regulation. The fuel consumption calculation is different.

  - US: CFR40 §86.144-94 and §86.145-82
  - EC/ECE: Reg. R83 (Emission); R101 fuel consumption
  - Japan: Trias 5-9-2007

Calculations

- **Situation:**

  All Regulations use the same method to determine the emission mass and fuel consumption (CVS-System and carbon balance) with slightly different parts in the equations.

- **Draft Proposal:**

  Follow calculations ECE R 83 (new) and ECE R101 based on the standard conditions US and Japan

  (20℃ and 1013mbar)

Calculations

- Exhaust emission
  - Given exhaust component density
  - Negative mass emissions set to zero for each phase (CVS-System)
  - General formula for dilution factor (DF) for each reference fuel

$$DF = \frac{X}{C_{CO2} + \left(C_{HC} + C_{CO}\right) \times 10^{-4}}$$

where:

C = concentration diluted exhaust component

$$X = 100 \frac{x}{x + \frac{y}{2} + 3{,}76\left(x + \frac{y}{4} - \frac{z}{2}\right)}$$

where:

Fuel components as $C_xH_yO_z$

Calculations

Summary of using EC/ECE Regulation:

exhaust emission:

- Applicable to every known fuel type
- General formula for dilution factor (DF) for each reference fuel
- Including NO_x humidity correction factor
- Including particle matter and number
- The standard condition 20 °C reflects close to the test procedure temperature

fuel consumption:

- Applicable to every possible carbon based fuel type

Emission measurement - sampling

prefer CVS concept over BMD or raw exhaust measurement

- CVS compatible with all vehicle types, fully applicable to electrified powertrains (no sampling shut off needed when ICE is stopped, no data connection between vehicle and sampling system required)
- CVS allows precise flow measurement due to static conditions, all other methods need to determine raw exhaust flow (pulsation, etc.)
- dilution and pneumatic integration offer best signal-to-noise ratio (required at very low emission levels)
- require remote mixing tee or short transfer lines to minimize aqueous condensation
  (especially when sampling particulates from gasoline engines)
- allow alternative tunnel design if turbulent flow and Reynolds number at the sample point is maintained

(CVS = Constant Volume Sampling; BMD = Bag Mini Diluter)

Emission measurement – gas analyzers

- use existing analyzer specifications
- determine THC for diesel vehicles from bag samples, quit heated FID
- allow use of NDUV method for NOx determination
- allow use of alternative analytical methods, if specifications are met and equivalency proven (e.g. photoacoustic detectors, diode lasers)

(FID = Flame Ionisation Detector; NDUV = Non Dispersive Ultra Violet)

Emission measurement - particulate emission

Particulate mass

use of PM method as described in ECE R83, i.e.

- aim at optimized net filter load, no secondary dilution
- no backup filter
- keep sampling temperature at <52℃ (filter face)
- 1µg balance, buoyancy correction
- weighing room specification 22℃ ± 1°C, rel. humidity 45% ± 8%

alternative

Particulate number

use of PN method as described in ECE R83

- no sampling during regeneration

  large interferences by water, hydrocarbons and possibly other compounds that cannot be removed completely in evaporation tube

Emission measurement – additional equipment

- specification for 4x4 chassis dynamometers added (acc. EPA), quality of force and speed control important to simulate road conditions without creating losses in 4x4 powertrains
- allow use of twin-roller (permanently coupled) and single-roller configurations (d>= 500mm)

Emission measurement – data quality

- limit total system verification of CVS to ± 2%
- keep exhaust analysis procedure (zero/span/zero etc.)
- use calibration and span gas specifications of CFR part 86
- use pure gas specifications of ECE R83
- gases must be traceable to national standards
- use reference filter criteria as in ECE R83 (± 5µg to avg.)

Bench ageing

General:

- Bench ageing is a procedure for time lapsed ageing of exhaust systems to determine the deterioration factors (saving time).

- Bench ageing for gasoline vehicles uses same procedure in EC/ECE and US.
- Bench ageing for diesel currently defined in EC/ECE.
- Definition of durability run requirements: WLTP phase II

Bench ageing

Details:

- EC/ECE 692/2008 Annex 7 and US Federal Part 86.1823-08 have identical content.
- Full useful life has to be simulated (for EC: 160.000 km, for US: 120.000 miles = 192.000 km)
- US: only for positive ignition, EC also for compression ignition
- Different bench cycles for gasoline and diesel engines
- Perform at least 2 emission tests with:
  - new, stabilized exhaust system (3K to 10K km)
  - aged system (after ageing procedure).

  Determination of deterioration factors

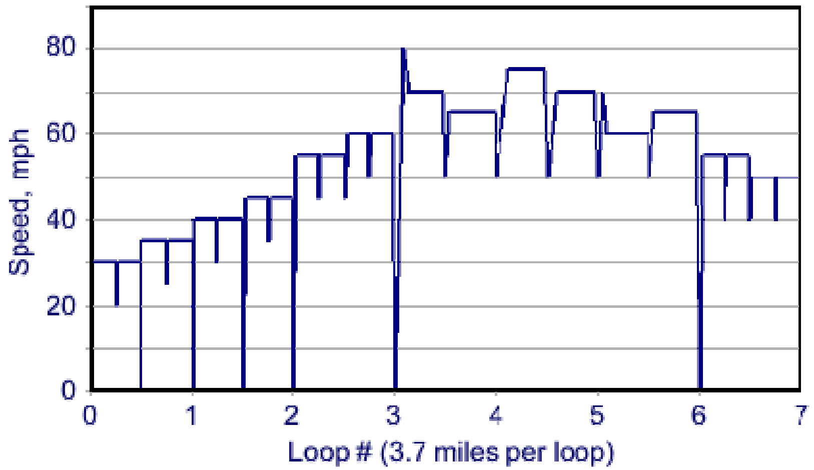
  (additive or multiplicative)

Bench ageing Gasoline (1/2)

Standard Road Cycle (SRC):

- Whole vehicle measurement
- Measure catalyst temperature at hottest catalyst
- Catalyst temperature must be measured during 2 SRCs

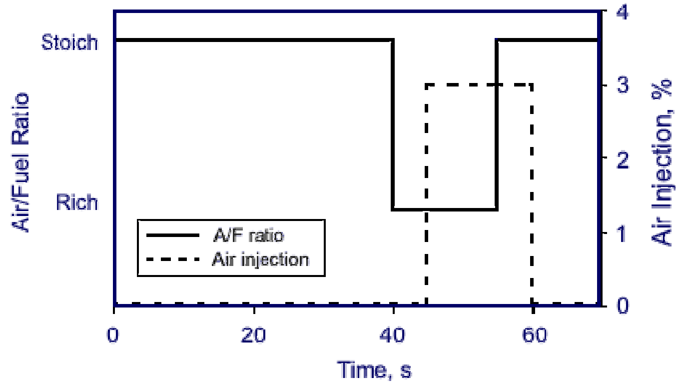
  Tabulate temperature histogram with temperature bins no larger than 25 °C



Bench ageing Gasoline (2/2)

Standard Bench Cycle (SBC):

- Measurement on engine bench
- Catalyst temperature must be measured at least 20 min
  Tabulate temperature histogram with temperature bins no larger than 10 ℃
- Calculation of bench ageing time
- Time lapsed ageing of exhaust system on engine bench



Bench ageing Diesel (1/2)

- **Standard Road Cycle (SRC):**
- Whole vehicle measurement

  Measurement of regeneration- / desulphurisation interval, duration, engine map points (load, rev., temp.) and loading of DPF.

  As an alternative intervals from Ki determination may be used.

Bench ageing - Diesel (2/2)

Standard Diesel Bench Cycle (SDBC)

- Measurement on engine bench
- Simulation of the SRC (equivalent operating points) on engine bench (usage of a stationary engine bench is possible)
- Rapid loading of DPF / NOx storage catalyst with modified engine settings.
- Equivalent number of regenerations and temperature during regeneration (120.000 miles or 160.000 km).
- Regeneration has to be performed with standard engine settings

Bench ageing

- **Draft Proposal**
- Adoption of the existing bench ageing procedures for gasoline and diesel engines for WLTP.
- Use of additive or multiplicative deterioration factors.

K_i factors

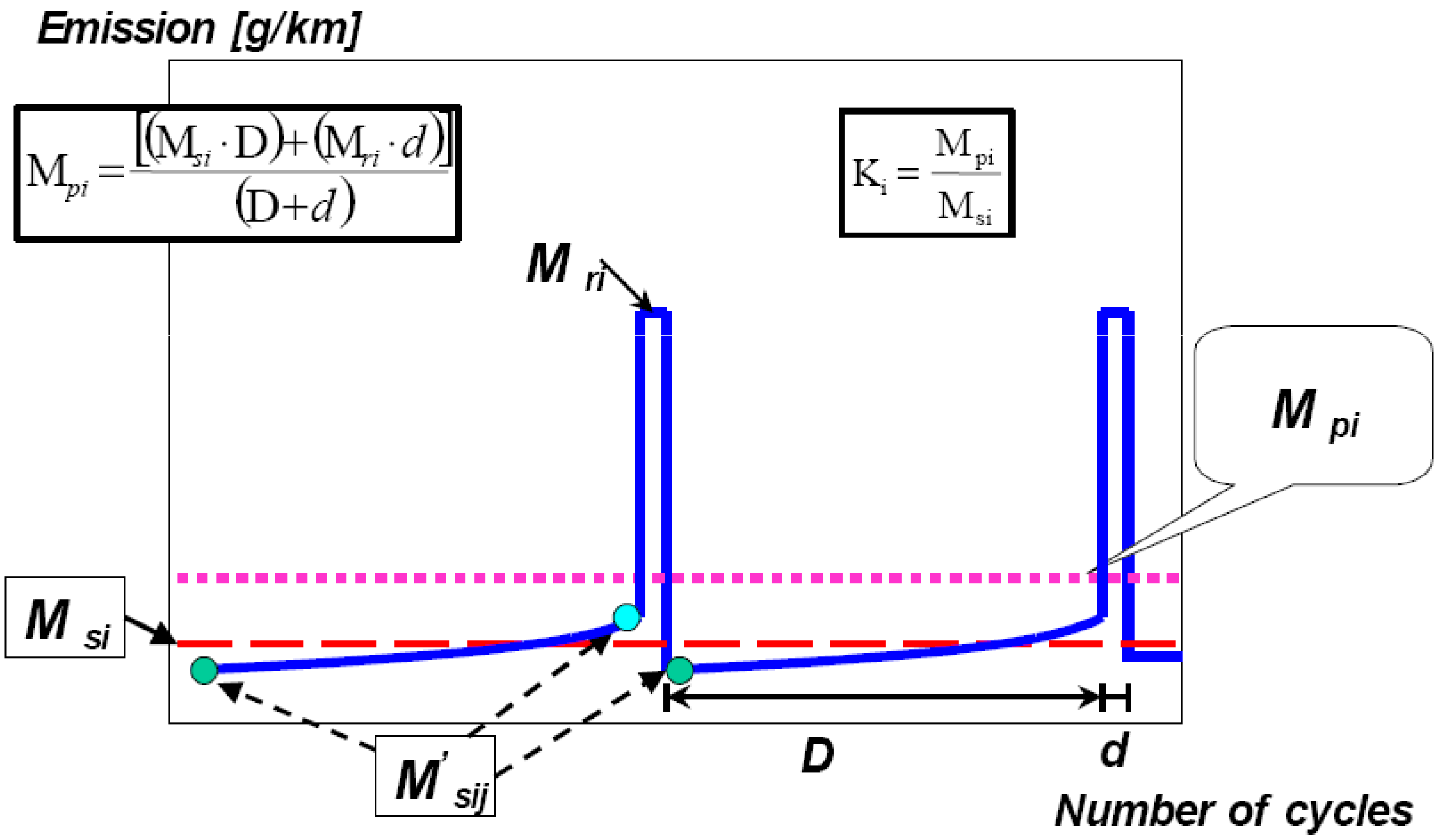
Comparison of K_i Factor Determination:

	ECE-R83	USA (AAF)
Conventional emission tests	**3** - Empty filter - Full filter - Empty filter (after regeneration) → mean value determination	-
Regeneration test	**YES**	**YES**
Calculation approach:	Emissions of the regeneration are set in proportion to the standard emissions	Emissions of the regeneration are "broken down" to one test cycle
K_i-Factor:	Multiplicative value	Additive value
Remark:	Conceptions using large limit value gap (low normal emissions) are unreasonably opposed by the multiplicative approach.	Additive factor in both new and old condition. Emission level during regeneration is deterioration-stable!
	no aged vehicle is needed	Only one test point
	4 test points	aged vehicle is needed (30K miles)

Proposal: Use of additive or multiplicative application.

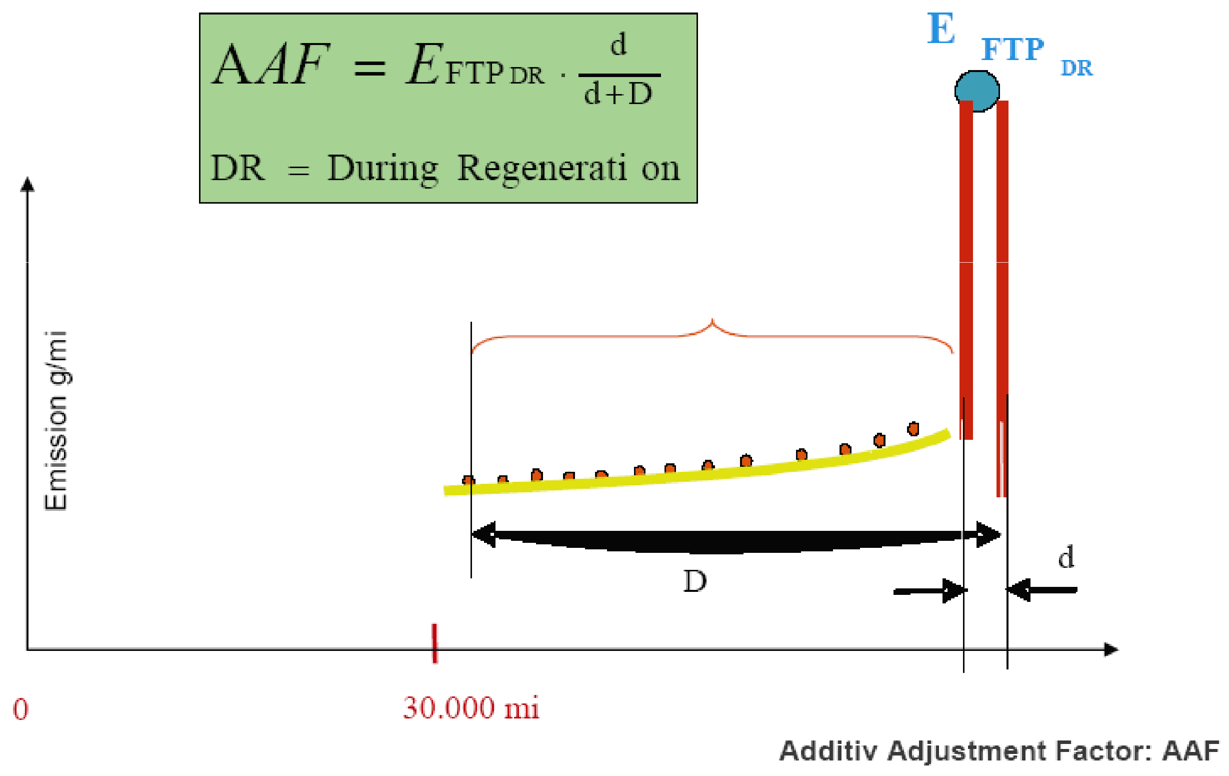
K_i factors

Determination of K_i-Factor in the EU:



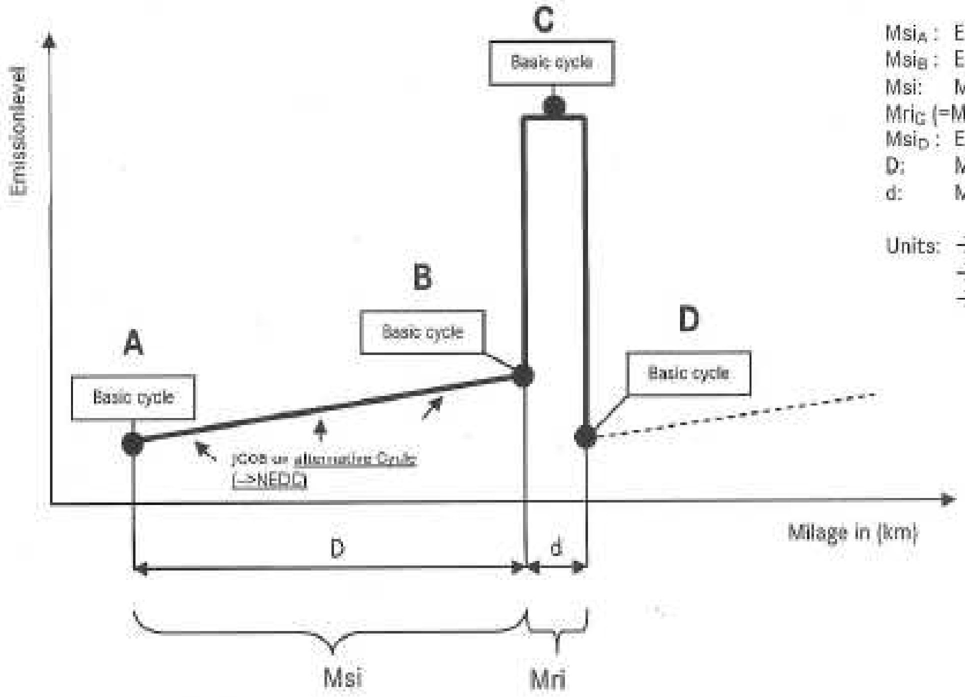
K_i factors

Determination of K_i-Factor in the USA:



Ki factors

Determination of K_i-Factor in Japan:



Msi_A : Emissions, measured in the Basic Cycle: DPF empty; No Regeneration
Msi_B : Emissions, measured in the Basic Cycle: DPF full; No Regeneration (before Reg.)
Msi: Mean of Msi_A and Msi_B (Msi= [Msi_A+ Msi_B] / 2 → Emissions while normal operation
Mri_C (=Mri): Emissions, measured in the Basic Cycle: DPF full→empty; While Regeneration
Msi_D : Emissions, measured in the Basic Cycle: DPF empty; After Regeneration
D: Milage needed for the loading of the DPF (from empty to full)
d: Milage needed for the Regeneration of the DPF (from full to empty)

Units: → Msi_A, Msi_B, Mri_C, Msi_D in (g/km)
→ D, d in (km)
→ KI in (g/km)

Calculation of corrected Emissions:

1.) Normal Operation: Msi

$Msi = (Msi_A + Msi_B) / 2$

2.) Operation while Regeneration: Mri

→ $Mri = Mri_C$

3.) Calculation of KI: Mpi

$Mpi = (Msi * D + Mri * d) / (D + d)$

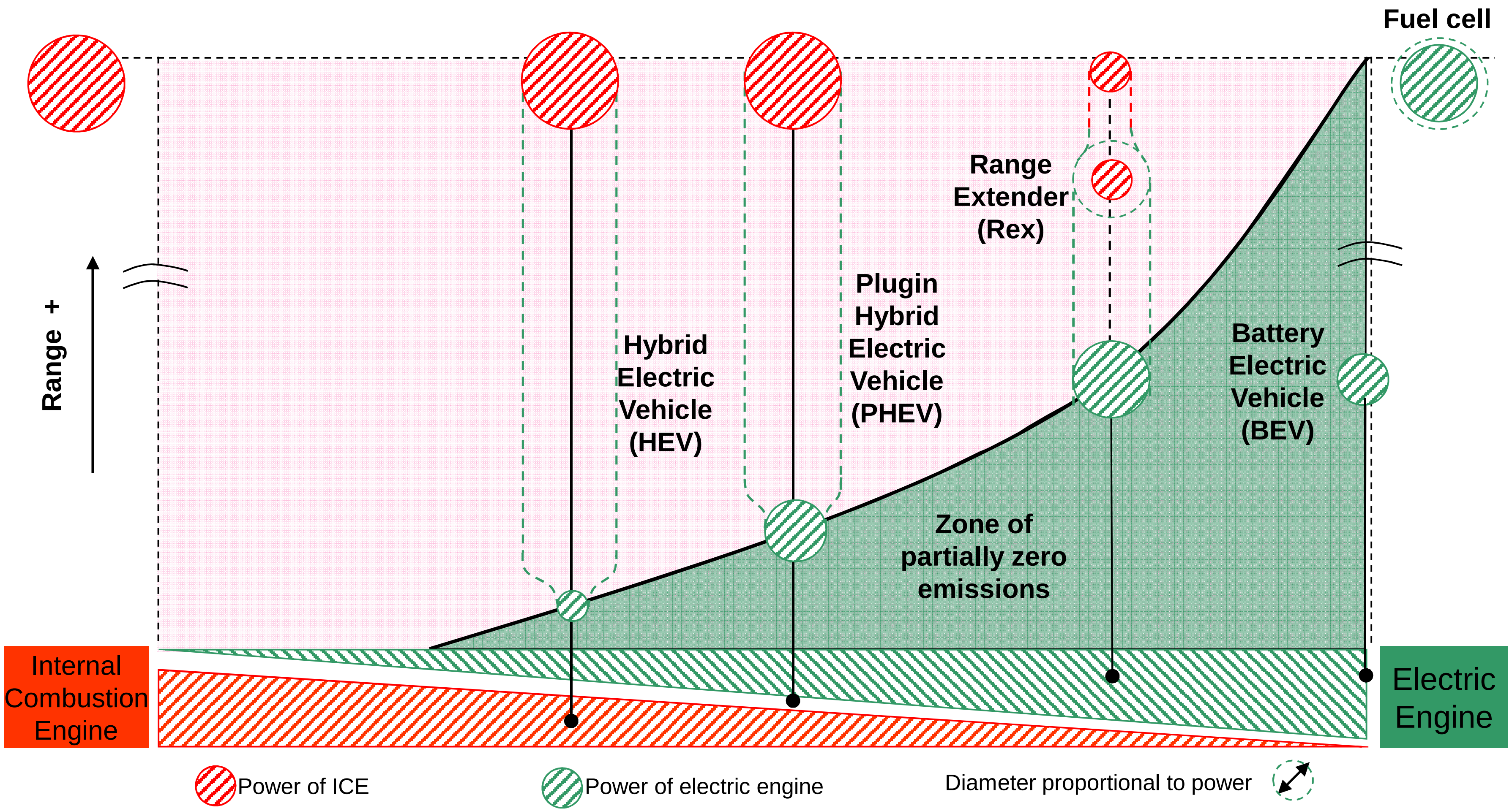
→ $KI = Mpi - Msi_D$

4.) Calculation of corrected Emissions:

→ $Emission_{Corr} = Emission_{measured} + KI_{Emission}$

Emission: CO, NOx, NMHC, PM, THC

Landscape Of Powertrain Configurations

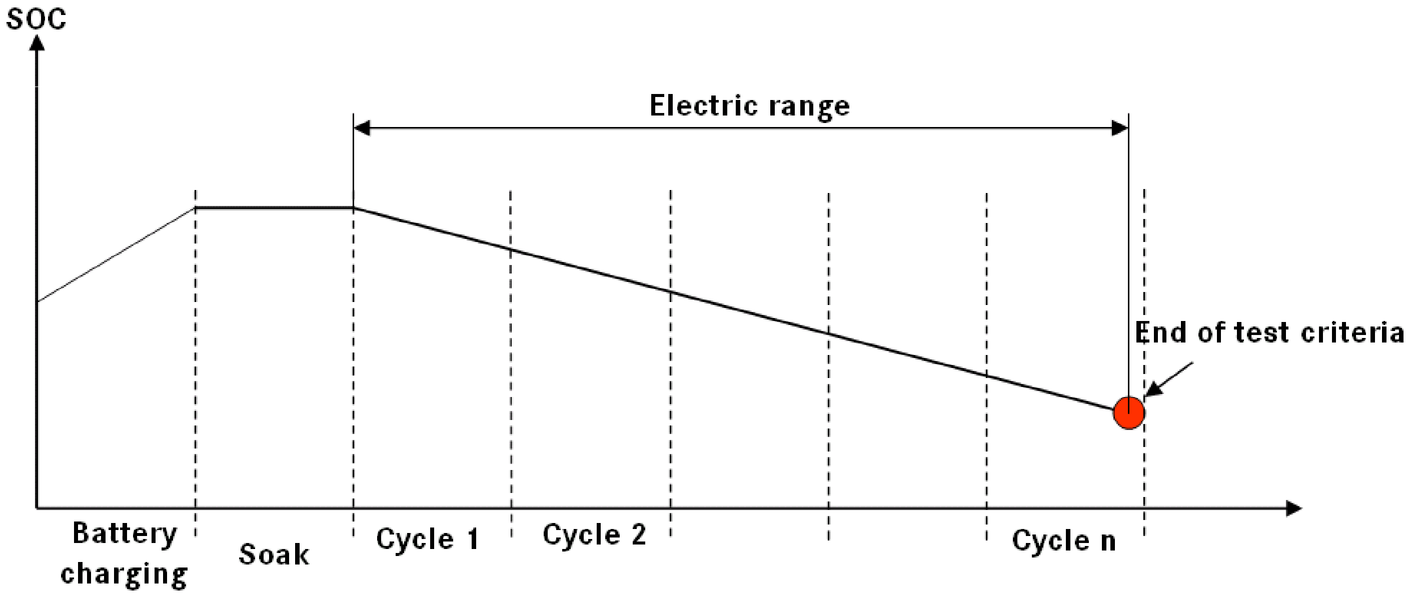


Test Procedure For Battery Electric Vehicles

Determination of the electric range

No difference between the EU, US and Japanese regulation:

- Full charge of the battery and soak
- Repeated driving of cycles until end of test criteria is reached



Test Procedure For Battery Electric Vehicles

- End of test criteria
- US: **Vehicles with a maximum speed equal or greater than the maximum speed in the cycle:**

  - violation of speed and time tolerances or the manufacturer determines to stop testing due to safety reasons

  Vehicles with a maximum speed less than the maximum speed in the cycle:

  - if the vehicle speed falls below 95% of the initially (first cycle) achieved maximum speed or the manufacturer determines to stop testing due to safety reasons

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- EU: Vehicle is not able to meet the target curve up to 50 km/h (city cycle) or on board instrumentation indicates to stop the vehicle

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- Japan: Vehicle is not able to meet the target curve for continuously more than 4 seconds or onboard instrumentation indicates to stop the vehicle

Draft Proposal: Determination the electrical range for the parts of the test cycle and use of US citeria

Test Procedure For Battery Electric Vehicles

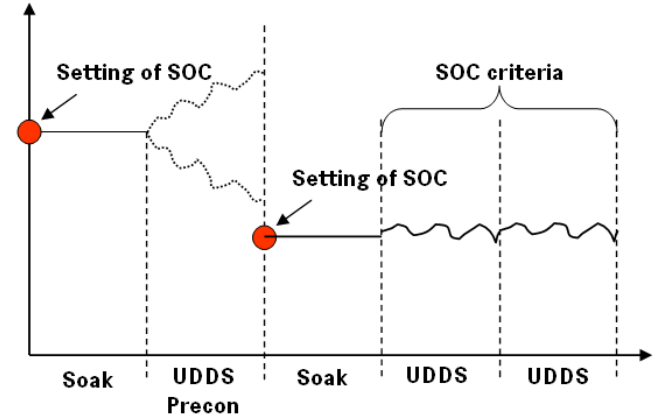
Calculation of the energy consumption

- **No difference between the EU, US and Japanese regulation:**
  - Full charge of the battery after the test sequence
  - Calculation of energy consumption in Wh/km or Wh/mi

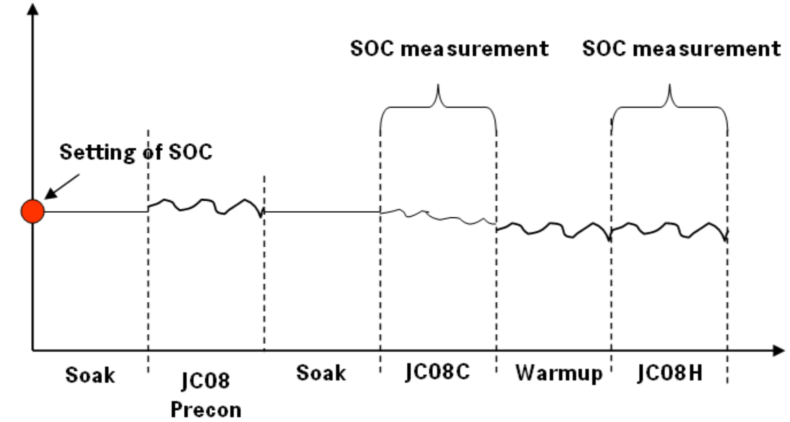
$$EnergyConsumption = \frac{Total\_charge\_energy}{ElectricRange}$$ [Wh/mi] or Wh/km]

Test Procedure For Hybrid Electric Vehicles

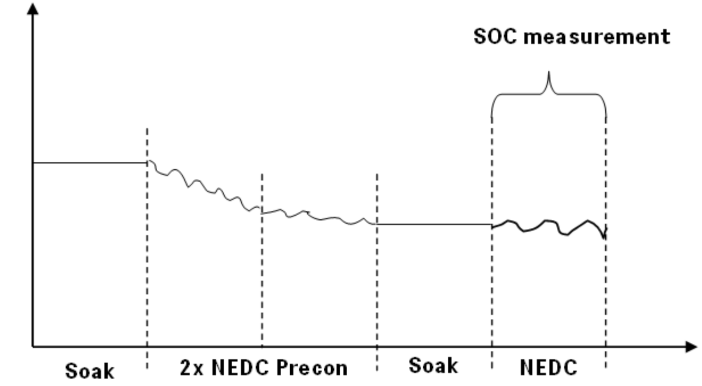
US



Japan



EU



Differences before emission test:

-setting of SOC in US and Japan regulation

-Number of preconditioning cycles (EU: min 2 NEDC; US and Japan 1 cycle)

Setting of SOC before preconditioning in order to minimize preconditioning cycles.

Test Procedure For Hybrid Electric Vehicles

US:

SOC criteria ±1% fuel energy used

$$(\text{Amp-hr}_{final})_{max} = (\text{Amp-hr}_{initial}) + 0.01 * \left(\frac{NHV_{fuel} * m_{fuel}}{V_{system} * K_1} \right)$$

$$(\text{Amp-hr}_{final})_{min} = (\text{Amp-hr}_{initial}) - 0.01 * \left(\frac{NHV_{fuel} * m_{fuel}}{V_{system} * K_1} \right)$$

EU and Japan:

SOC criteria EU ±1%, Japan ±2% fuel energy used

If SOC criteria is not met, emission results are corrected:

The fuel consumption C_0 at $\Delta E_{batt} = 0$ is determined by the following equation:

$$C_0 = C - K_{fuel} \cdot Q \qquad \text{(l/100 km)}$$

where:

C : fuel consumption measured during test (l/100 km)

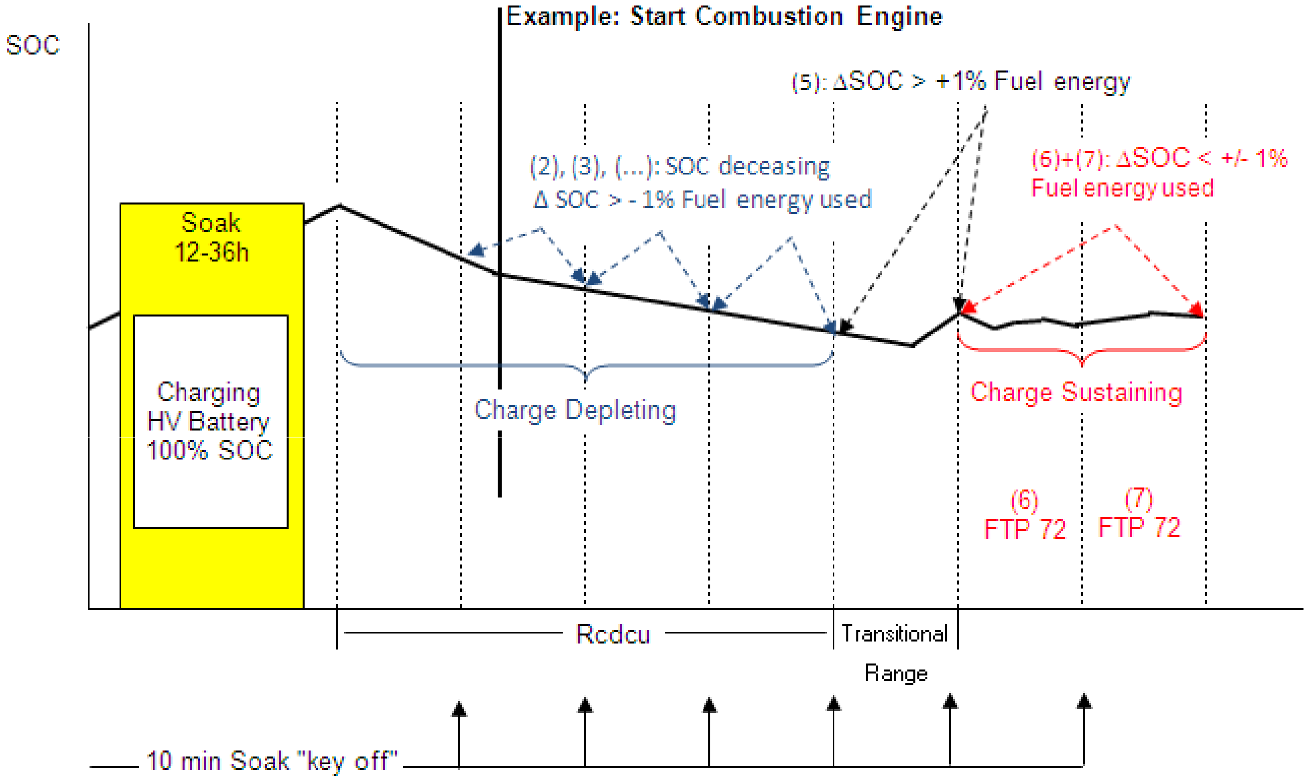
Q : electricity balance measured during test (Ah)

EU and Japanese regulation give the most flexibility for driving strategies and minimizes test burden in the emission labs.

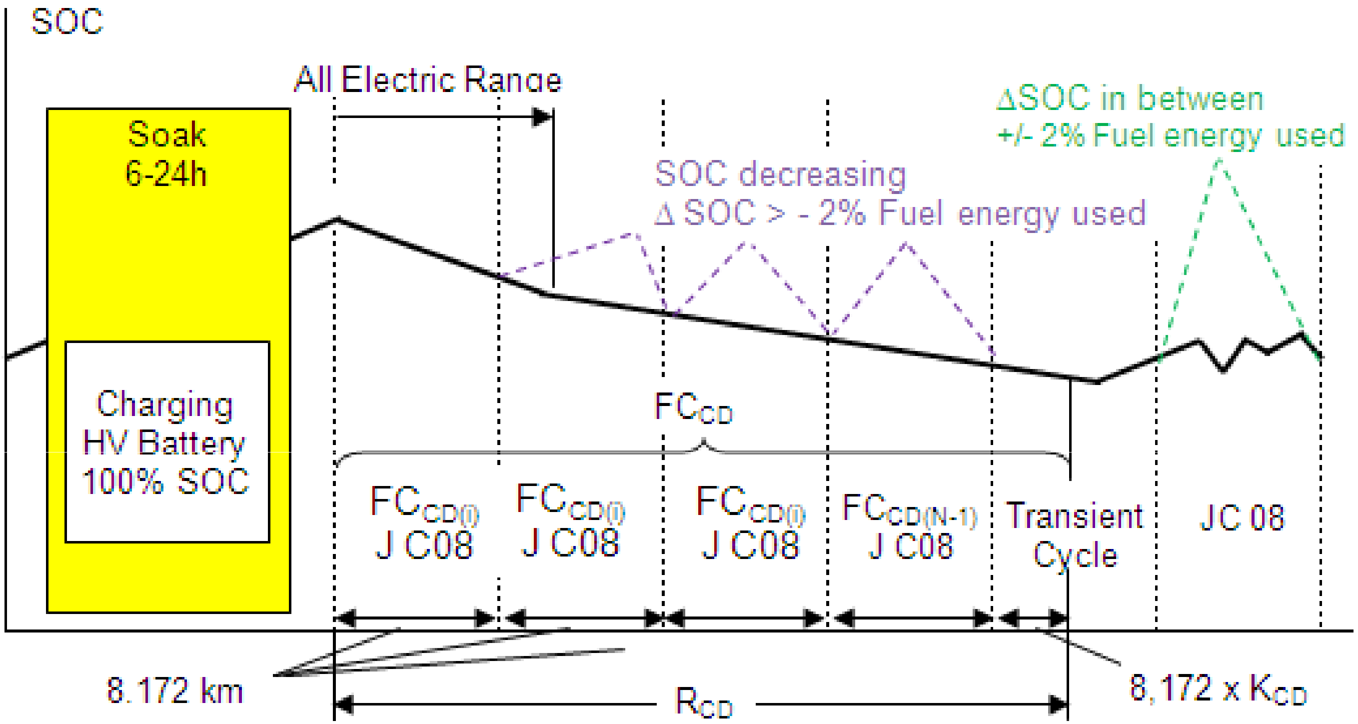
No other emissions than CO_2 should be corrected by the correction factor.

PHEV

Charge Depleting Test US



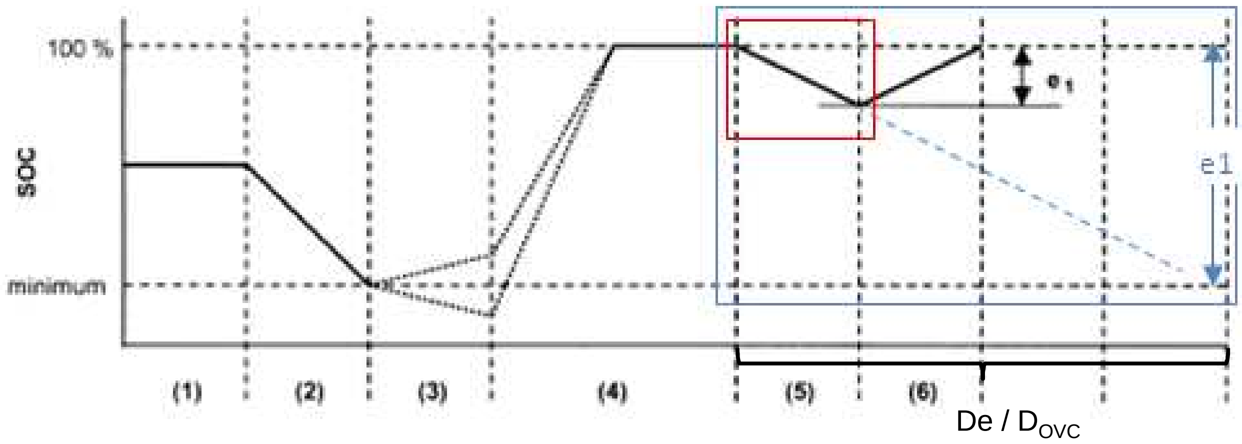
A series of charge depleting UDDS followed by a 10 minute key-off hot soak period is performed until charge sustaining operation is achieved for two consecutive UDDS.



A series of charge depleting JC08 is driven until charge sustaining operation is achieved for one JC08. In case of a transient cycle that does neither meet the SOC criteria for a charge depleting not for a charge sustaining mode, the transient cycle is divided in a depleting and sustaining part.

PHEV

Charge Depleting Test ECE



(1) initial state of charge of the electrical energy/power storage device
(2) discharge according to paragraph 3.2.1. or 4.2.2. of this annex
(3) vehicle conditioning according to paragraph 3.2.2.1./3.2.2.2. or 4.2.3.1./4.2.3.2. of this annex
(4) charge during soak according to paragraph 3.2.2.3. and 3.2.2.4. or 4.2.3.3. and 4.2.3.4. of annex
(5) test according to paragraph 3.2.3. or 4.2.4. of this annex
(6) charging according to paragraph 3.2.4. or 4.2.5. of this annex

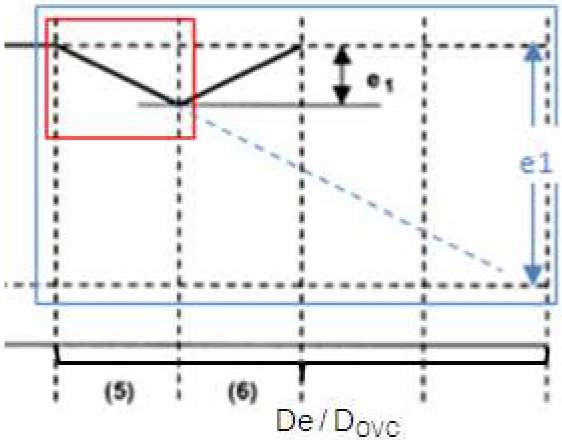
Option 1: 1 x NEDC
Following the preconditioning and battery charge to SOCmax one NEDC is performed.

Option 2: n x NEDC
Following the preconditioning and battery charge to SOCmax a number of repeat cycles is performed until battery minimum SOC is reached.

PHEV

Charge Depleting Test

ECE Option 1 where just one test cycle is driven is the preferred route for PHEV concepts that are focused on a high electrification. In this case a series of electrical driven test cycles would give no useful additional information as the electric energy consumption will be the same in all cycles.

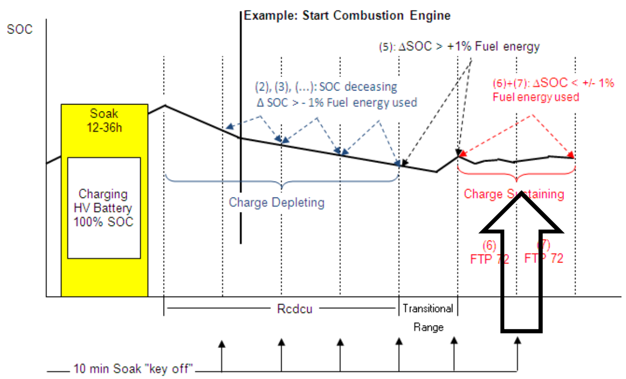


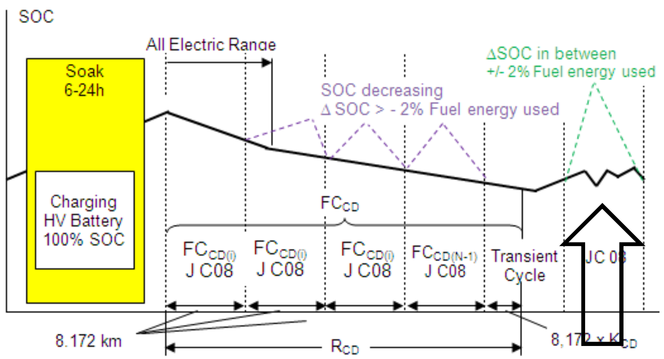
ECE Option 2 is based on the same principle than the US and Japan regulation that requires to drive the whole charge depleting range, one test after the other, until charge sustaining operation is reached. This approach is the preferred route for PHEV concepts which continuously change between combustion traction and electric traction in order to choose the most efficient energy use for any driving condition.

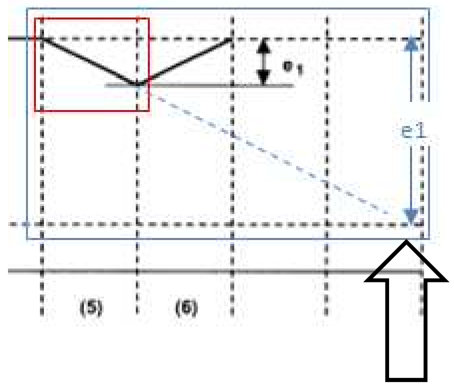
Draft Proposal: The ECE concept, consisting of two options to test the charge depleting mode, should be adopted as a WLTP approach. Depending on the PHEV concept used, this leaves the option to perform an short and effective test procedure for concepts that focus on a high pure electric range.

PHEV

Depleting Test, End of Test Criteria







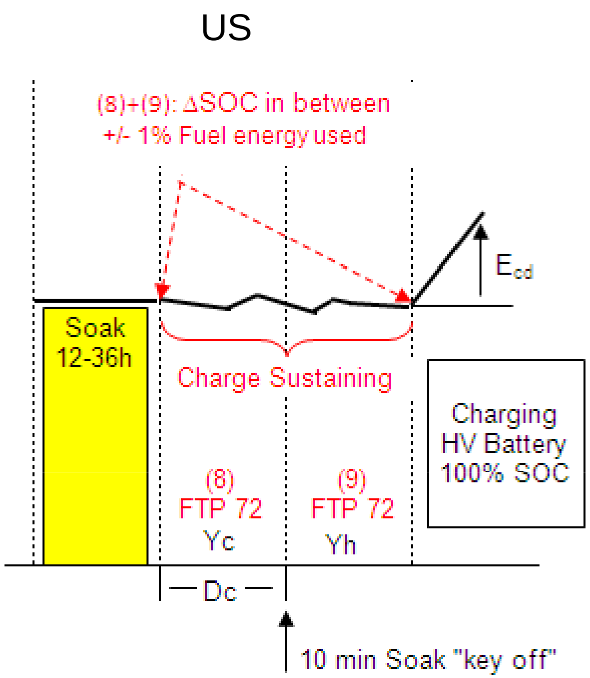
SOC tolerance US: Sustaining is defined by +/- 1% fuel energy used
SOC tolerance Japan: Sustaining is defined by +/- 2% fuel energy used
SOC tolerance ECE (Option 2): Sustaining is defined by < 3% discharge **(nominal battery capacity)**

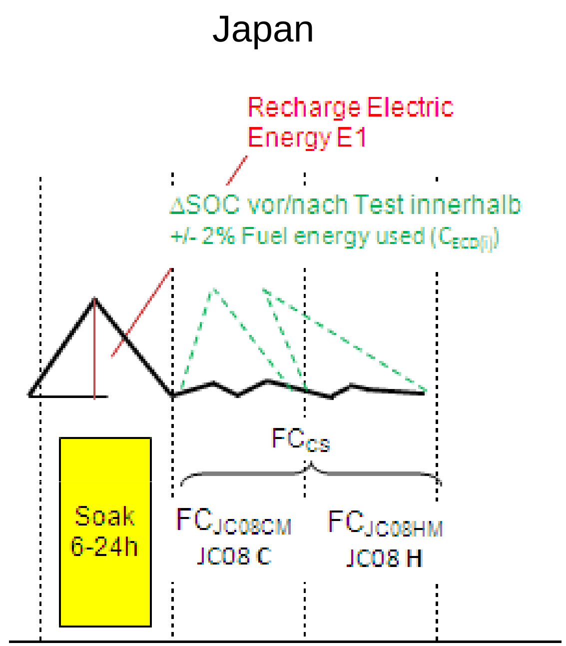
A definition of the SOC tolerance based on the mass of fuel consumed does not work for PHEV concepts focused on the electric drive performance. This concepts use a high electric storage capacity and a high electric drive performance combined with a small combustion engine used to extend the electric range. In this case the amount of consumed fuel translates into a very small SOC percentage tolerance. This means that it would be hard to meet the condition for the sustaining mode, several tests would have to be repeated just to reach the SOC criterion.

Draft Proposal: **The ECE definition (< 3% discharge) is to be preferred as it considers various concepts of electrification and sets the SOC tolerance in dependence from its battery nominal capacity.**

PHEV

Charge Sustaining Test



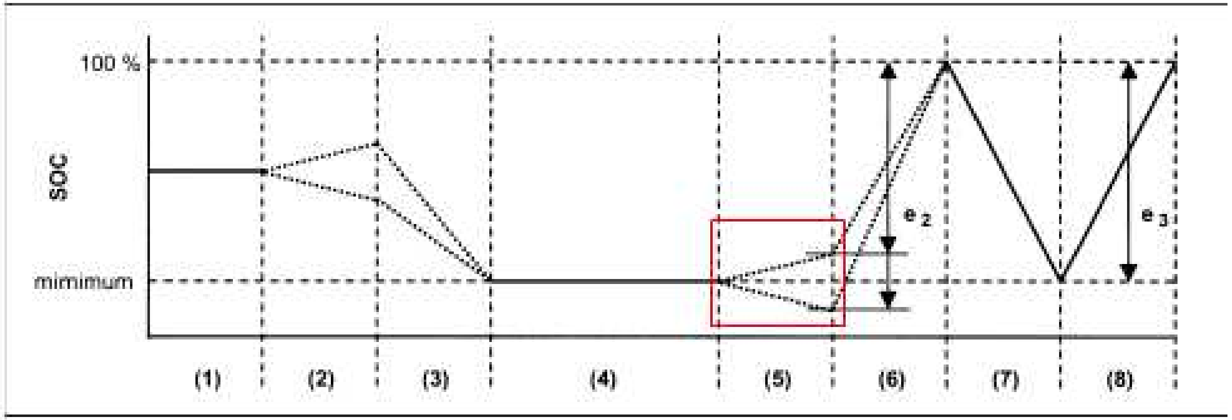


The US regulation requires the test consisting of 2 x FTP 72 on a SOC neutral basis which leads to significant restrictions in the development of the propulsion strategy.

The Japanese Regulation is based on a SOC neutral Sustaining Test as well but allows a correction of emissions if the tolerance is not met.

PHEV

Charge Sustaining Test ECE



(1) initial state of charge
(2) vehicle conditioning according to paragraph 3.3.1.1. or 4.3.1.1. (optional) of this annex
(3) discharge according to paragraph 3.3.1.1. or 4.3.1.1. of this annex
(4) soak according to paragraph 3.3.1.2. or 4.3.1.2. of this annex
(5) test according to paragraph 3.3.2. or 4.3.2. of this annex
(6) charging according to paragraph 3.3.3. or 4.3.3. of this annex
(7) discharging according to paragraph 3.3.4. or 4.3.4. of this annex
(8) charging according to paragraph 3.3.5. or 4.3.5. of this annex

e4 [Wh] = e2 - e3

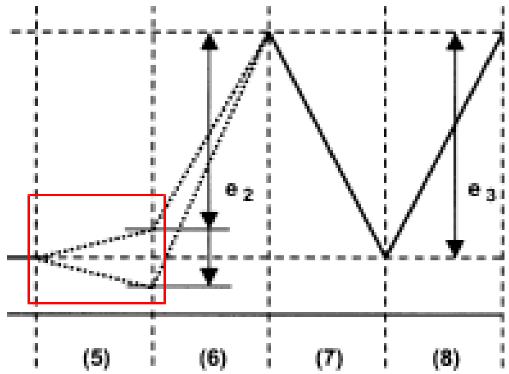
Differing from the US / Japan Regulation, the ECE Regulation does not require to perform the Charge Sustaining Test on a SOC neutral basis. Battery SOC (SOC min) results out of the preconditioning procedure. The calculation of the electric energy consumption takes into account the various end SOC (e2) after performing one NEDC (e4 = e2 - e3).

PHEV

Charge Sustaining Test, SOC Tolerance

US, Japan Regulation:
The rationale for defining a SOC tolerance is to treat PHEVs and HEVs in the same way when tested in the charge sustaining operation mode. This works for PHEV concepts using a component design comparable to HEVs which are mainly driven by the combustion engine, but does not account for PHEV concepts using a high electric drive performance combined with a small combustion engine. For this concepts a SOC tolerance based on the amount of consumed fuel translates to a very low percentage SOC tolerance.

Draft Proposal: **Following the ECE test procedure there is no requirement to run the charge sustaining test on a SOC neutral basis. Both conditions increasing or decreasing the SOC over the test are reflected by the formula calculating the electric energy consumption (e4 = e2 - e3). This leaves Maximum flexibility to develop strategies for the propulsion Concept and accounts for the whole variation of PHEV concepts.**



PHEV

Calculation Scheme

All regulation concepts are based on a formula that weights the CO2 Emission and electric energy consumption of the two operation modes charge depleting and charge sustaining in dependence of the utility factor UF.
The UF is a function of the charge depleting range.

$CO2 = UF \times CO2\ Charge\ Depleting + (1-UF) \times CO2\ Charge\ Sustaining$

⇩

UF *Definition US*: $UF = 1 - \exp\{-[C1 \cdot (x/norm\_dist) + C2 \cdot (x/norm\_dist)^2 + \ldots + C9 \cdot (x/norm\_dist)^9]\}$

UF *Definition Japan*: $UF(R_{CD}) = 1 - \exp(29.1 \times (R_{CD}/400)^6 - 98.9 \times (R_{CD}/400)^5 + 134 \times (R_{CD}/400)^4 - 89.5 \times (R_{CD}/400)^3 + 32.5 \times (R_{CD}/400)^2 - 11.8 \times (R_{CD}/400))$

UF *Definition ECE*:

Option 1 (1 x NEDC) used for the depleting test:
$M = (De \times CO2\ Depl. + 25 \times CO2\ Sust.) / (25 + De)$

De = Pure Electric Range

Option 2 (n x NEDC) is used for the depleting test:
$M = (D_{ovc} \times CO2\ Depl. + 25 \times CO2\ Sust.) / (25 + D_{ovc})$

D_{OVC} = Off Vehicle Charge Range

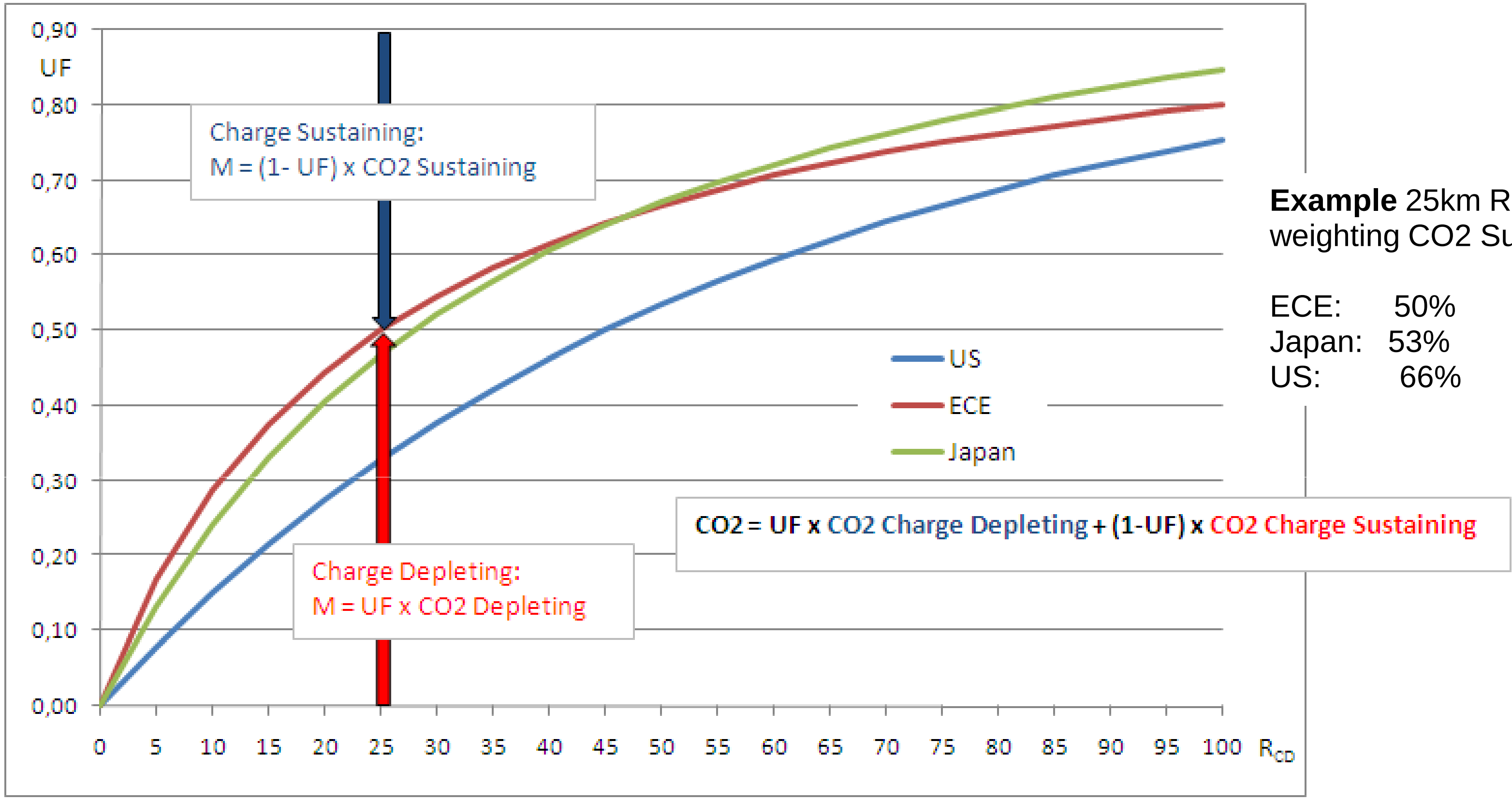
Derivation UF:
$UF_{ECE} = (1 - 25/(25 + De))$

Definition Charge Depleting Range :

US (norm_dist), Japan (R_{CD}) = Distance from CD mode to CS mode
ECE, Depleting Test Option1 (De)= Pure Electric Range
ECE, Depleting Test Option2 (D_{OVC})= Distance from CD mode to CS mode

PHEV, Draft Proposal

Utility Factor

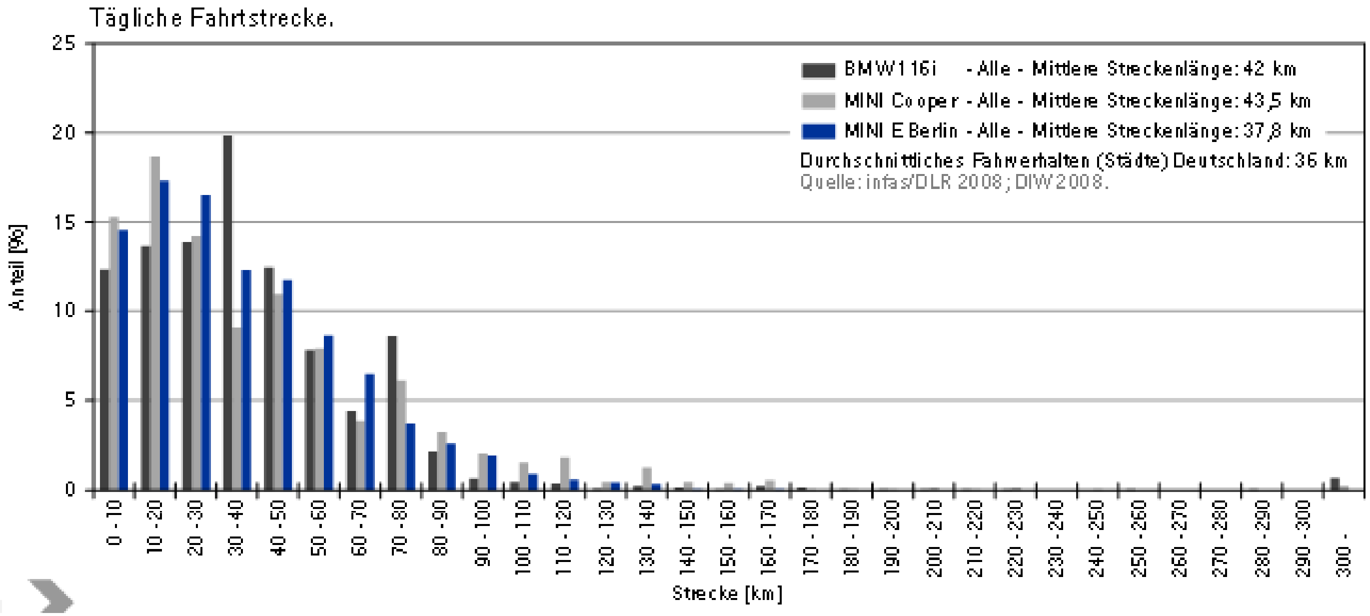


Example 25km R_{CD}, weighting CO2 Sustaining:

ECE: 50%
Japan: 53%
US: 66%

The US and Japanese utility factor curves are based on actual usage data, the ECE formula is based on an average trip length of 25 km.

PHEV, Draft Proposal
Utility Factor



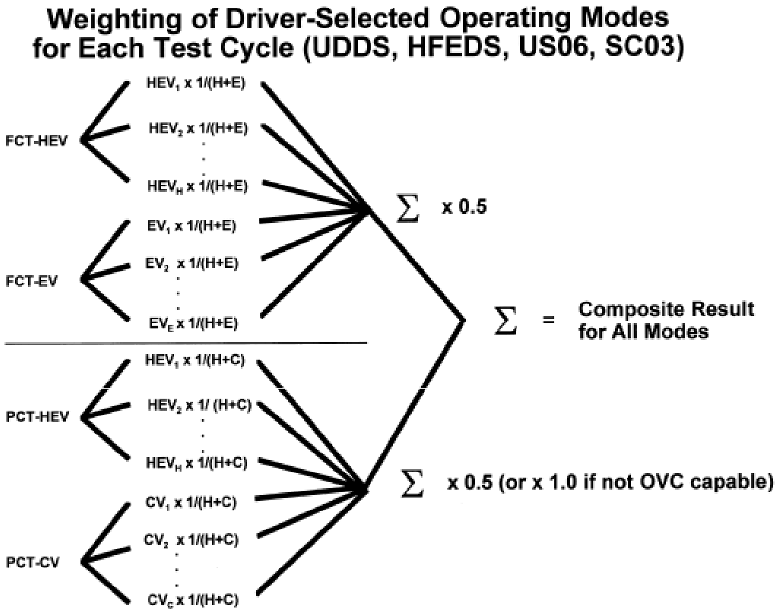
Draft Proposal: the ECE / Japan UF curve is to be preferred as it represents a driving behaviour focused on city driving which is representative for PHEVs and HEVS as shown by the MINI-E survey. The US utility factor curve, other than ECE and Japan was based on the current driving behaviour of conventional vehicles consisting of city urban and highway driving but does not take into consideration the special usage characteristic of PHEV concepts which are mainly attractive for customers with a high amount of city driving.

Beside a discussion on actual usage data the ECE / Japan curve, especially in typical city ranges of 0-50 km, gives a stronger incentive to raise the electric range of PHEV concepts. This aspect should be taken into consideration as well when defining a UF curve.
Country specific UF parameters should be avoided.

PHEV, Draft Proposal

Driver Selected Operation Modes

SAE J1711



ECE

Hybrid-modes / Battery state of charge	Pure electric; Hybrid	Pure fuel consuming; Hybrid	Pure electric; Pure fuel consuming; Hybrid	Hybrid mode n(*); ...; Hybrid mode m(*)
	Switch in position	Switch in position	Switch in position	Switch in position
Condition A Fully charged	Hybrid	Hybrid	Hybrid	Most electric hybrid mode (**)
Condition B Min. state of charge	Hybrid	Fuel consuming	Fuel consuming	Most fuel consuming mode (***)

Draft Proposal: **Definition of two options.**
Option 1: Depleting test in the most electric mode, sustaining test in most fuel consuming mode. (acc. to ECE)
Option 2: Depleting test in all modes, sustaining test in all modes, weighting of all modes. (acc. to SAE J1711)

Certifying a REx As BEV

- Could an Advanced Technology Range Extender (AT-Rex) be an BEV?
- Requirements
  - **Technical description**

    Serial powertrain concept only (internal combustion engine only for charging the battery)
  - **Restrictions**

    Manual activation of combustion engine not possible (no switch for operation mode selection)

Thank you for your attention!

Further question or comments

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