Low T effect on vehicle emissions

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European Commission

	T C °	Cycle	Road-Load	Vehicles	Pollutants
	−7.0 ±3	UDC	Determined at -7 C or 10% reduction of coast-down time	P.I. including hybrids + information regarding NOx after-treatment for C.I.	HC, CO
	−7.0 ±3	UDC	"	"	THC, CO
	−7.0 ±1.7	FTP	Performing coast-down tests and calculating road-load coefficients	Otto-cycle and diesel including multi-fueled, alternative fueled, hybrid electric, and zero emission vehicles	NMHC, CO, CO_2 *
	−6.7	CVS-75	"	Gasoline + information regarding NOx after-treatment for C.I.	CO
	−7.0 ±3	Low+ Medium of WLTC	Determined at -7 C or 10% reduction of coast-down time	P.I.; C.I.; hybrids	THC, CO, NOx

* CO_2 is analysed and results used for the determination of the vehicle fuel economy. Cold temperature standards apply for CO and NMHC emissions.

Issues that needed to be revised

- **Cycle**
- **Criteria pollutants**
- **Applicability**

  Are emissions from diesel vehicles and OVC-HEV affected by low T?

  Should they be tested under the Type 6 test?

The procedure should be:

- **Fuel independent**

  positive ignition (petrol, ethanol flex-fuel, CNG and LPG) and compression ignition vehicles

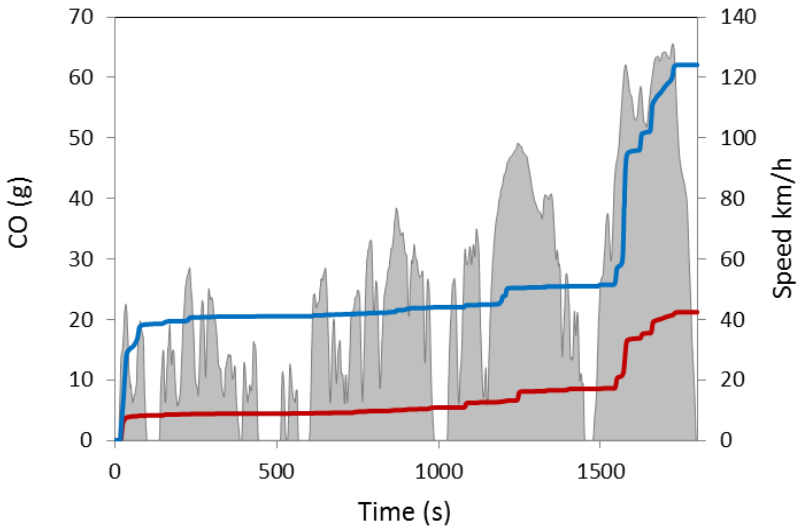
- **Technology independent**

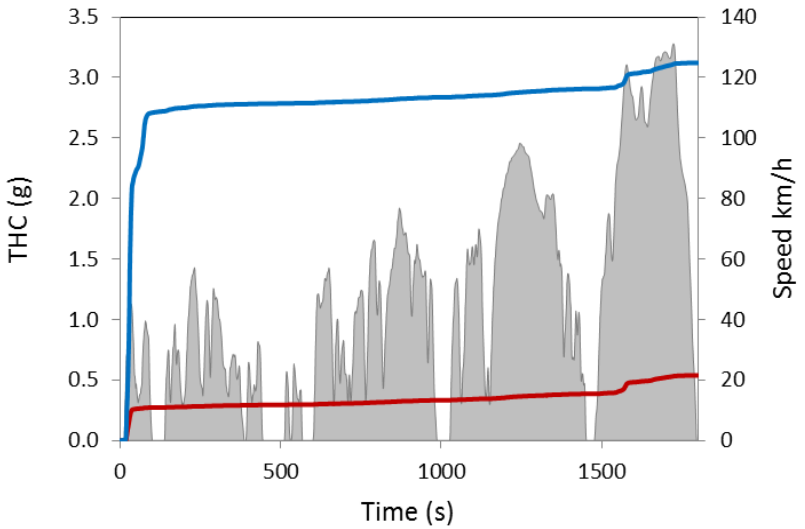
  NOVC-HEV, OVC-HEV, conventional vehicles (CI, PFI, GDI, etc)

  no distinction related to after-treatment used

CO and THC emissions

Positive ignition vehicle (Euro 6b)





Higher emissions at low temperature

High emissions during extra-high phase

Impact of cold temperature on Euro 6 passenger car emissions. Env. Pol. 234, 318-329. 2018

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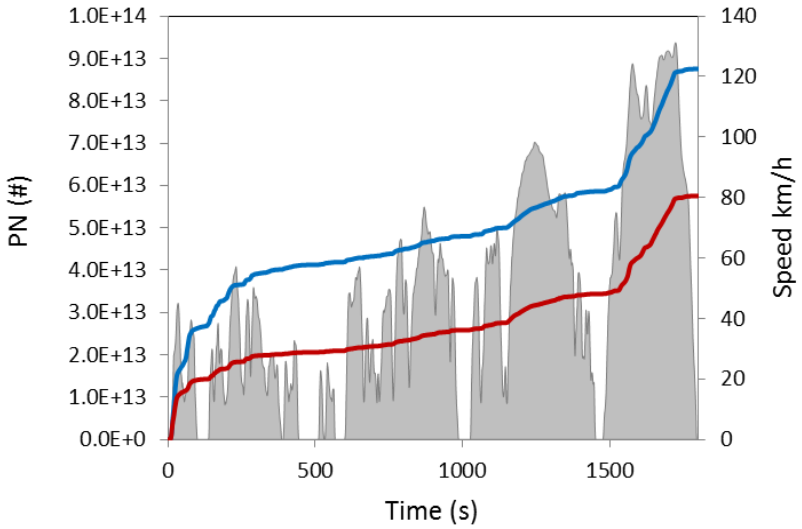
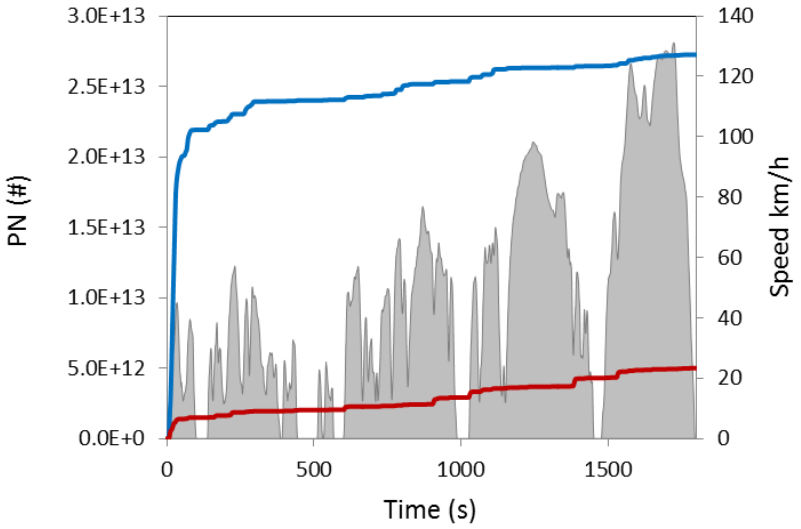
Solid Particle Number emissions

GV-GDI (Euro6b)



GV-PFI (Euro6b)



Also PFI present high PN emissions at Low T

PN emissions during the whole cycle

Impact of cold temperature on Euro 6 passenger car emissions. Env. Pol. 234, 318-329. 2018

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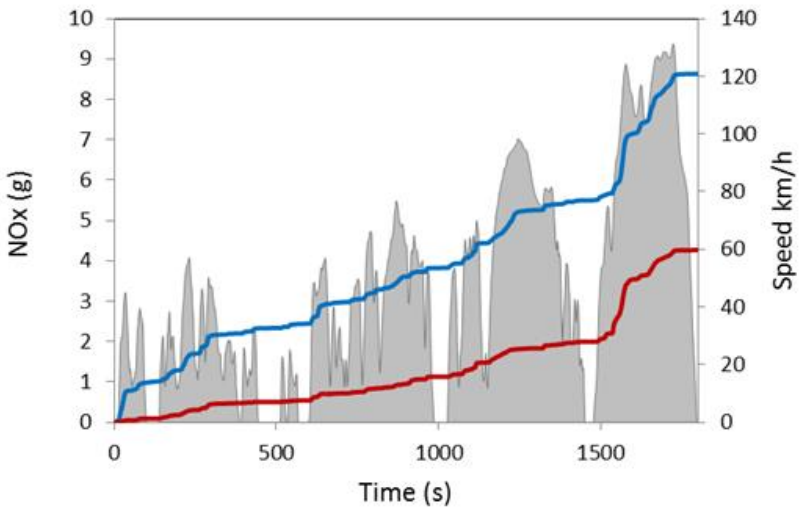
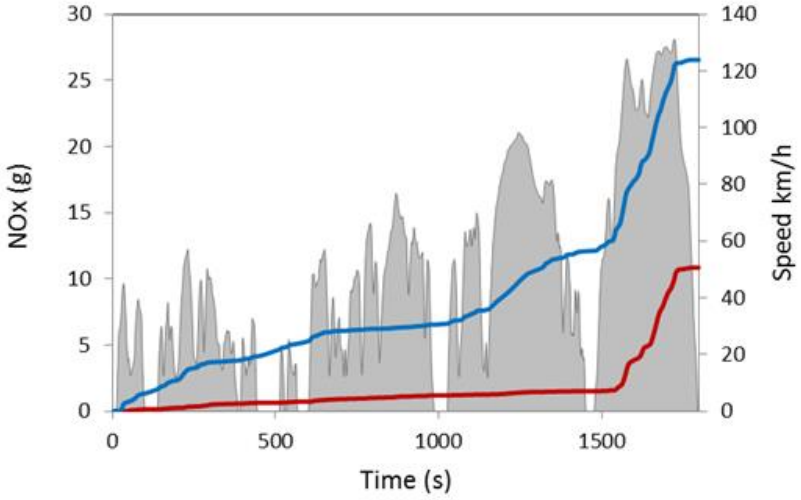
NOx emissions from diesel vehicles

DV-LNT (Euro6b)



DV-SCR (Euro6a)



NOx emissions higher at low temperature

Emissions during the whole cycle

Impact of cold temperature on Euro 6 passenger car emissions. Env. Pol. 234, 318-329. 2018

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Summary

- large amount of emissions are produced during all 4 phases WLTC

  To be able to properly assess their emissions at low temperature, vehicles should be tested over the entire WLTC

- Compression ignition vehicles were negatively affected by low ambient temperatures.

  They should also be tested at low temperature

- NOx, PN and CO_2 emissions increased at low ambient temperature

  These pollutants should be considered in the low temperature test

DG-GROW and DG-ENV request:

- Pollutant emissions measurement at low ambient temperature

Vehicles:	PI, CI, NOVC-HEV and OVC-HEV
Temperature:	-7 ° C
Procedure:	Type 1-like procedure as described in GTR-15
Cycle:	WLTC (4 phases)
Pollutants:	THC, NMHC, CH_4, CO, NOx, PN (and CO_2)
R/L:	Determined at -7 ° C or 10% reduction of coast-down time
Auxiliary devices:	heating, defrost and lights ON


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Low T effect on OVC-HEV emissions

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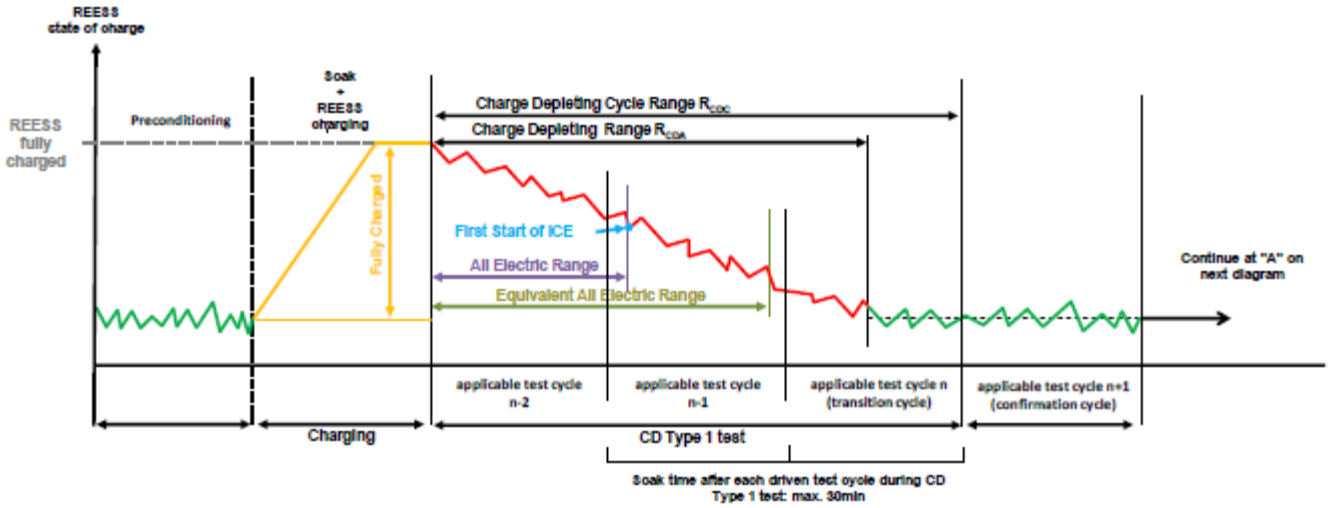
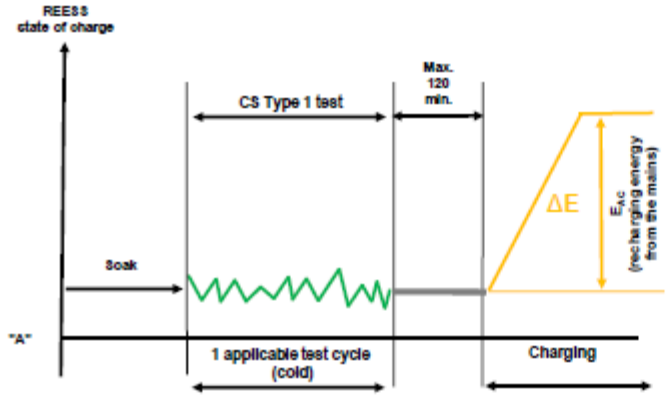
Could Type 1 test-like procedure be used?

OVC-HEVs, charge-depleting type 1 test with subsequent charge-sustaining Type 1 test





Experimental approach

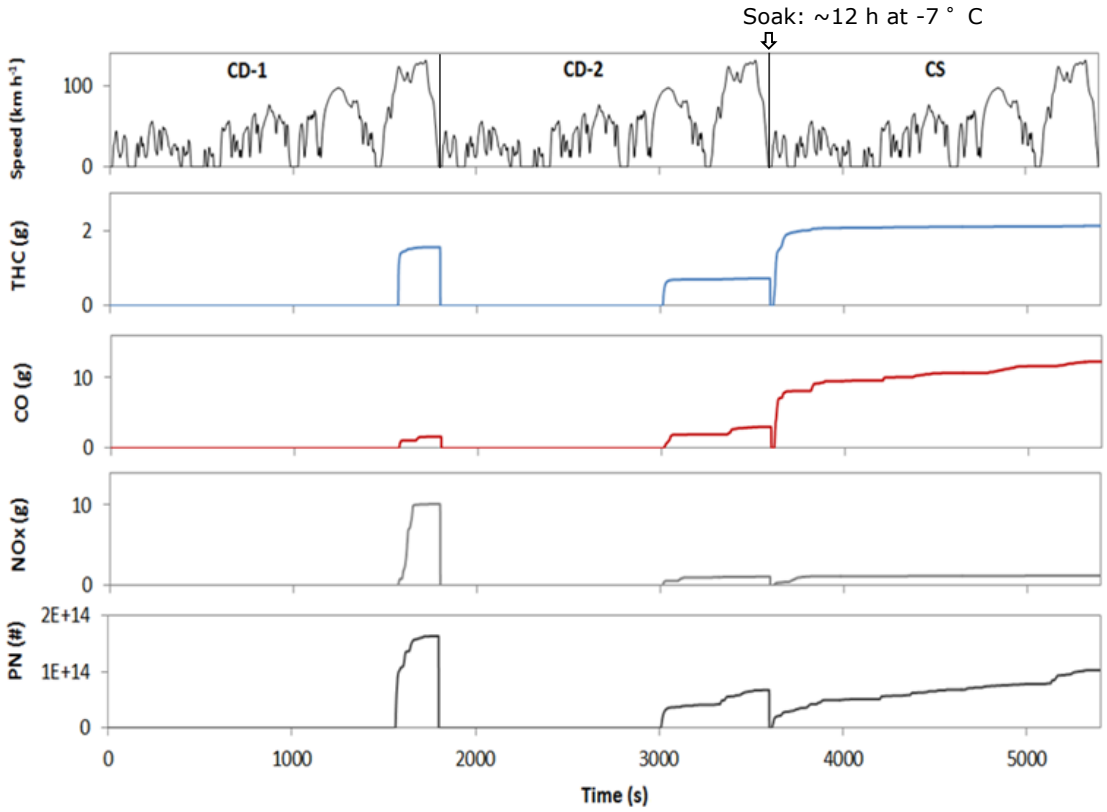
- Two OVC-HEV were tested
- Tested following Type 1 procedure at 23 ° C but also at -7 ° C
- Road load at -7 ° C as described in Type 6 Reg. 83 (i.e. 10% reduction of coast-down time)
- A/C set at 21 ° C as described in U.S. 1066.710 for cold temperature testing

Tested vehicles

	OVC-HEV1	OVC-HEV2
ICE	Spark Ignition Turbocharged	Spark Ignition
ICE Displacement (l.)	1.4	0.65
E-Motor Maximum output power (kW)	75	125
Maximum output torque (Nm)	330	75
Battery Type	Li-Ion	Li-Ion
Capacity (Ah)	25	60
Nominal voltage (V)	345	360
Nominal capacity (kWh)	8.7	21.8
Emission category	Euro 6	BEVx

OVC-HEV1 cumulative emissions

Test at -7 ° C



Total emissions during CD can be higher than during CS test

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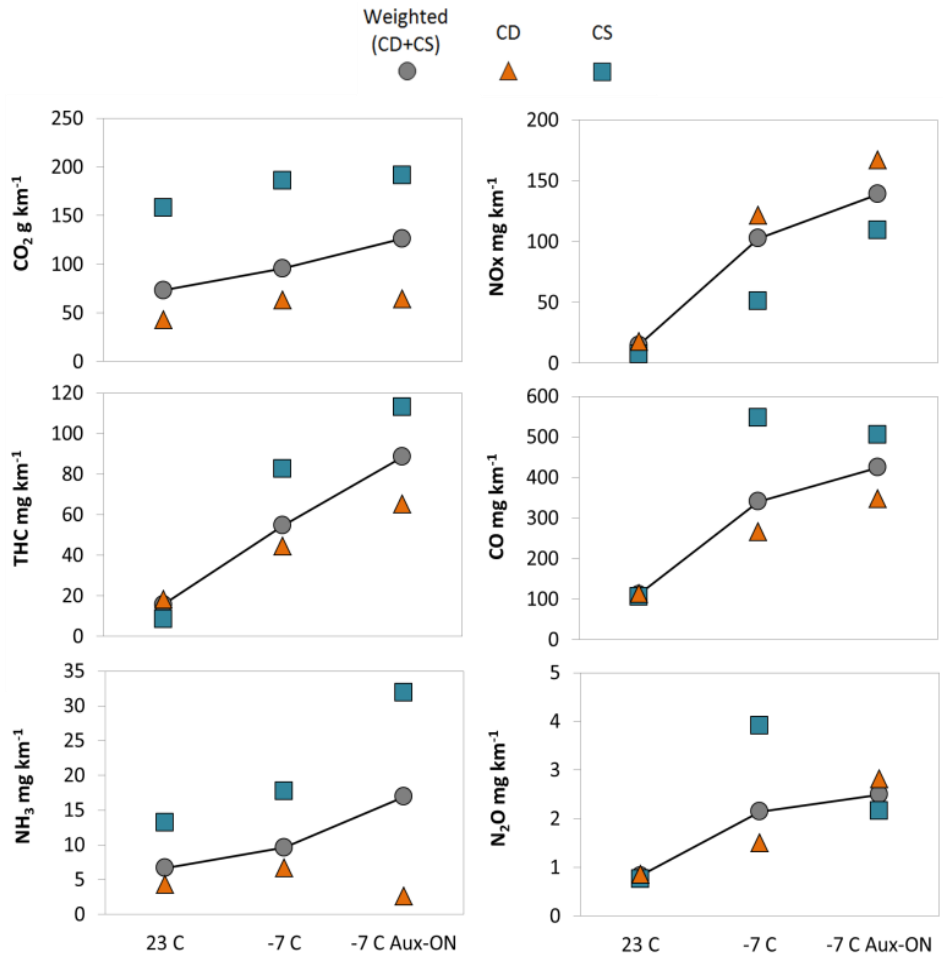
Does low ambient T or the use of auxiliary systems affect OVC-HEV emissions?



Higher emissions at lower T

CO_2: 30% higher

NOx: 7 times higher

THC: 4 times higher

CO: 3 times higher

NH_3: 1.4 times higher

N_2O: 2.6 times higher

Effect of low ambient temperature on emissions and electric range of plug-in hybrid electric vehicles. Ene. Pol.

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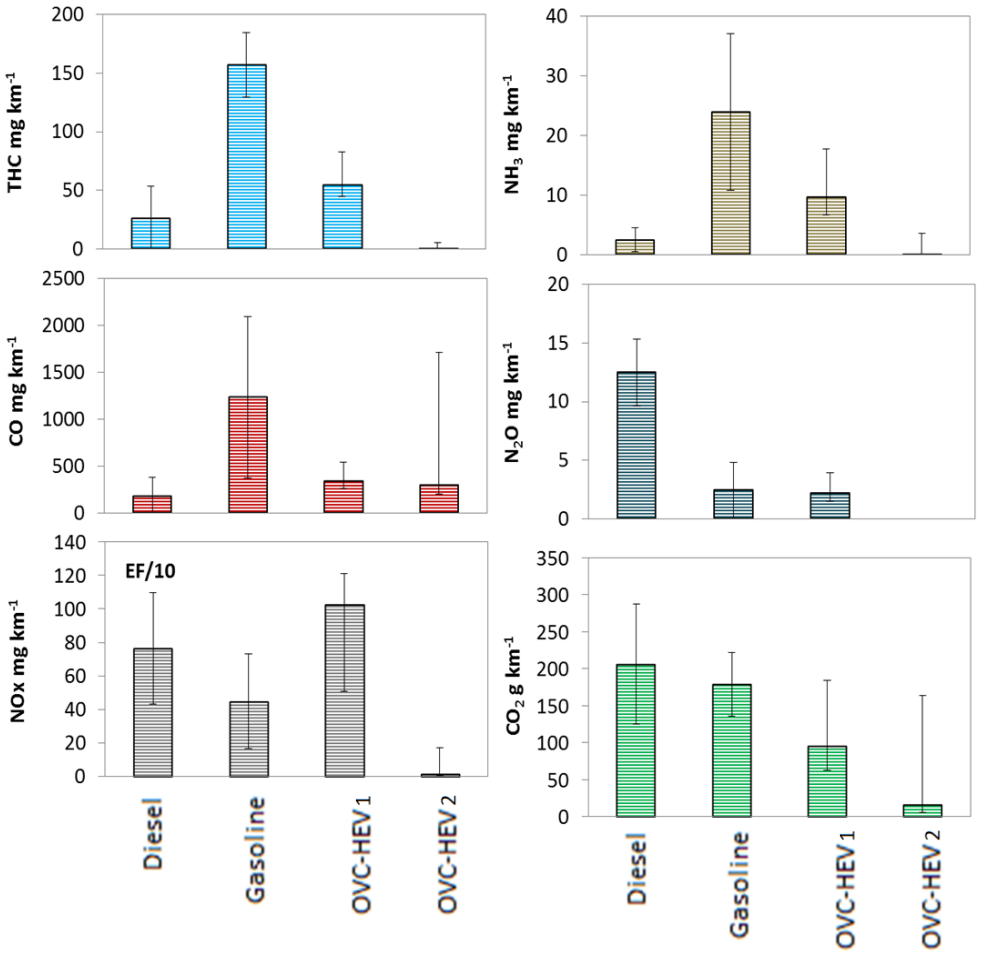
Compared to conventional vehicles

-7 ° C



- OVC-HEV1 emissions are comparable to conventional Euro 6 gasoline LDV
- OVC-HEV1 NOx emissions are higher than the worst gasoline LDV studied
- OVC-HEV2 emissions low with the exception of CO

Effect of low ambient temperature on emissions and electric range of plug-in hybrid electric vehicles. Ene. Pol.

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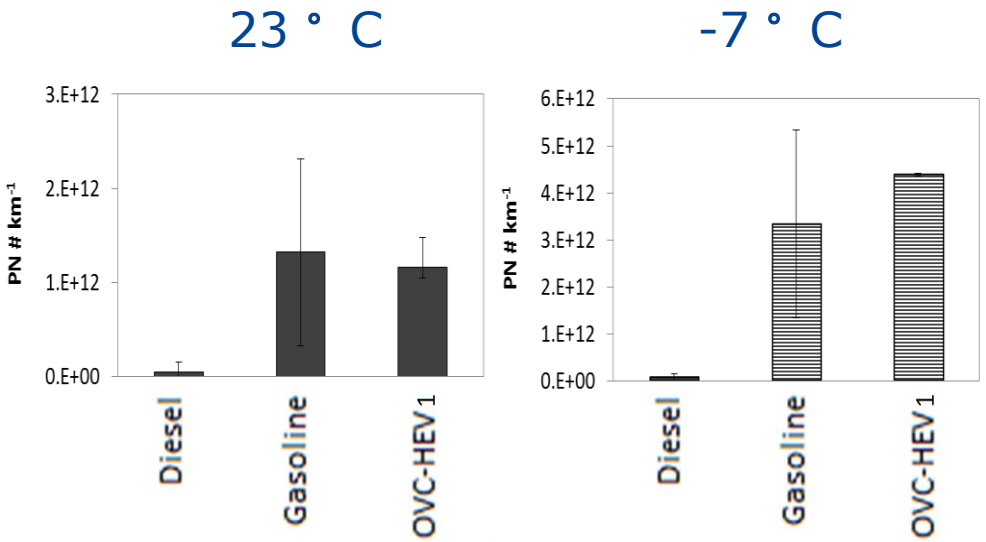
PN emissions compared to conventional vehicles



PN emissions from OVC-HEV1 were comparable to those measured from conventional Euro 6 gasoline vehicles at 23 ° C and -7 ° C

Effect of low ambient temperature on emissions and electric range of plug-in hybrid electric vehicles. Ene. Pol.

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Issues that need to be addressed for OVC-HEV

- Are emissions affected at cold temperature? **Yes**
- Is CS test enough to fully address OVC-HEV emissions? **No, CD test also needed**
- Is there a negative impact on emissions if heating system is used? **Yes**
- Is it possible to follow Type 1 procedure for OVC-HEVs at -7 C? **Yes**

DG-GROW and DG-ENV request:

- Pollutant emissions measurement at low ambient temperature

Vehicles:	P.I., C.I., NOVC-HEV and OVC-HEV
Temperature:	-7 ° C
Procedure:	Type 1-like procedure as described in GTR-15 (i.e., cold start for ICE and NOVC-HEV and CD+CS for OVC-HEV)
Cycle:	WLTC (4 phases)
Pollutants:	THC, NMHC, CH_4, CO, NOx, PN and CO_2
R/L:	Determined at -7 ° C or 10% reduction of coast-down time
Auxiliary devices:	heating, defrost and lights ON

Looking forward

Vehicle category / sequences		ICE	NOVC-HEV OVC-HEV(CS)	NOVC-FCHV OVC-FCHV(CS)	OVC-HEV (CD)	OVC-FCHV(CD)	PEV
Vehicle setting ✓		same setting as 23℃					
Test conditions	Test mass ✓	same setting as 23℃					
	R/L ✓	【apply compensation factor per ambient temperature】 1 : same as R83、2 : air density only, 3 : others 【apply compensation factor per altitude】 1 : air density only、2 : others 【apply compensation factor per auxiliary devices】 1 : in operation during test (switch position need to be defined) 、2 : increase R/L (how much?)					
R/L derivation	coast down test	practically impossible to measure R/L under the specific conditions (compensate R/L under standard conditions)					
	Dyno. setting ✓	1 : conduct R/L set under specific conditions 2 : conpensate dynamometer set value @23℃					
Pre-setting	REESS	NA			need to stabilize REESS temperature *		
Pre-conditioning	Test environment	【Temp】1. allow @ 23℃, 2. mandate @ specific temp. 【Altitude】 mandate @ specific altitude (stabilize emission control strategy)					
Soak	Soak environment	【Temp】 mandate @ specific temp. (allow forced cool down ?) 【Altitude】 allow @ see level					
	duration	1. check engine coolant & oil temp (except FCHV and PEV) 2. duration check only					
	REESS charge	NA			same condition as vehicle soak how to ensure the REESS temperature including warm-up strategy *		

◊***Source: Summary presented by Japan March 2017- f2f meeting LowT TF***

Looking forward

Vehicle category / sequences		ICE	NOVC-HEV OVC-HEV(CS)	NOVC-FCHV OVC-FCHV(CS)	OVC-HEV (CD)	OVC-FCHV(CD)	PEV
Testing	cycle ✓	harmonized cycle (L + M + H)					harmonized cycle (allow shorten procedure) ✖
	HVAC	operation* (setting of manual : start operation at XX sec with maximum @ hot max position, then change to minimum at YY sec)					
	REESS charge	NA			same condition as vehicle soak how to ensure the REESS temperature including warm-up strategy *		
Data processing	DF (deterioration factor)	Pollutants : same as R83 (no DF is applied) CO2/FC/Range/EC : apply same logic as 23℃ scenario (under the discussion)					
	SOC factor	NA	allow use same factor derived @23℃. As an option, accept specific factor derived @ specific temp.		NA		
	UF				use same UF as defined in gtr		NA

◊***Source: Summary presented by Japan March 2017- f2f meeting LowT TF***

Points to be addressed

sequences \ Vehicle category		ICE	NOVC-HEV OVC-HEV(CS)	NOVC-FCHV OVC-FCHV(CS)	OVC-HEV (CD)	OVC-FCHV(CD)	PEV
Pre-setting	REESS	NA			need to stabilize REESS temperature *		
Pre-conditioning	Test environment	【Temp】1. allow @ 23℃, 2. mandate @ specific temp. 【Altitude】 mandate @ specific altitude (stabilize emission control strategy)					
Soak	Soak environment	【Temp】 mandate @ specific temp. (allow forced cool down ?) 【Altitude】 allow @ see level					
	duration	1. check engine coolant & oil temp (except FCHV and PEV) 2. duration check only					
	REESS charge	NA			same condition as vehicle soak how to ensure the REESS temperature including warm-up strategy *		
Testing	HVAC	operation* (setting of manual : start operation at XX sec with maximum @ hot max position, then change to minimum at YY sec)					
	REESS charge	NA			same condition as vehicle soak how to ensure the REESS temperature including warm-up strategy *		

Low T effect on vehicle performance

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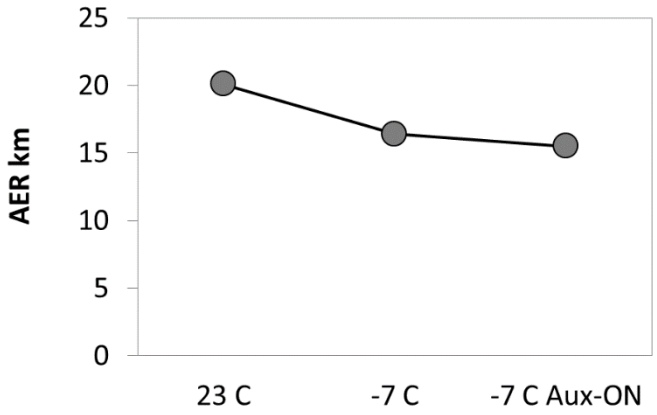
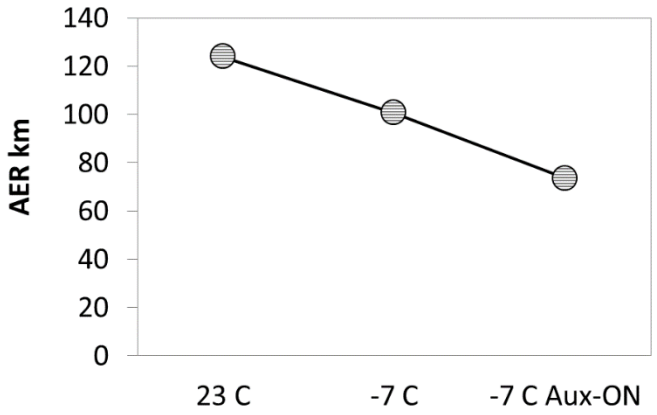
Electric range

OVC-HEV1



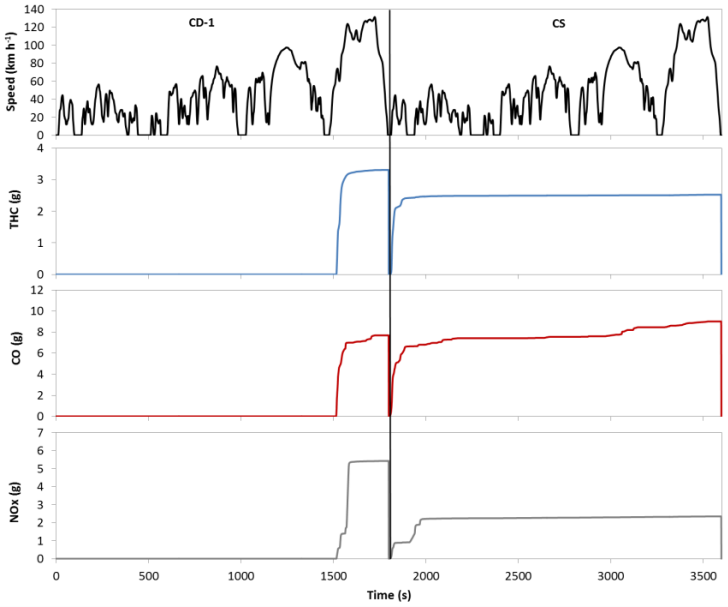
OVC-HEV2



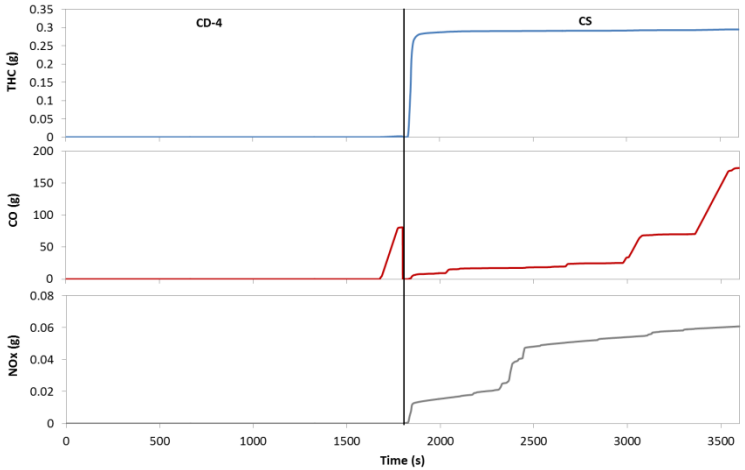
AER decreased 18% (OVC-HEV) and 19% (BEVx) at -7 C

AER decreased 23% and 41% at -7 C with heating-ON

OVC-HEV



BEVx



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