

Supplementary information

Table S1 Summary of vehicle specifications

Vehicle ID	Manufacturer	Model year	Emission standard	Curb weight (kg)	Fuel injection system	After-treatment device	Engine size (L)	Shift pattern	Maximum power (kw)	Energy efficiency standard	Test method	Start/stop system
#1	Toyota	2007	China 3	1550	PFI	TWC	2.4	AT ^{a)}	123	Stage 1	Dynamometer	None
#2	Volkswagen	2014	China 4	1550	GDI	TWC	2.0	AT	147	Stage 3	Dynamometer	None
#3	Honda	2015	China 5	1775	GDI	TWC	2.4	AT	137	Stage 3	Dynamometer	None
#4	Volvo	2011	China 4	1570	GDI	TWC	2.0	AT	149	Stage 2	On-road	None
#5	Bavarian Motor Works	2012	China 4	1565	PFI	TWC	2.5	AT	160	Stage 2	On-road	None
#6	Buick	2015	China 5	1705	GDI	TWC	2.4	AT	134	Stage 3	On-road	None
#7	Bavarian Motor Works	2013	China 4	1760	GDI	TWC	2.0	AT	160	Stage 3	On-road	None
#8	Honda	2016	China 5	1091	GDI	TWC	1.5	AT	86	Stage 4	On-road	None
#9	Cadillac	2016	China 5	1840	GDI	TWC	2.0	AT	193	Stage 4	On-road	None

Notes: a) AT: automatic transmission

Table S2 Comparison of three driving cycles in this study

Driving cycle	NEDC	WLTC	BARC
Cycle type	Steady-state	Transient state	Transient state
Duration	1180	1800	1398
Number of stops	12	7	9
Average speed (km/h)	33.6	46.5	26.0
Average speed except when stopped (km/h)	44.8	53.5	35.6
Maximum speed (km/h)	120.0	131.3	76.0
Maximum acceleration (m/s ²)	1.04	1.58	2.36
Minimum acceleration (m/s ²)	-1.39	-1.49	-1.94
Idling proportion	23.7	13.6	26.9
RPA (m/s ²) ^{a)}	0.111	0.152	0.177

Notes: a) RPA is the relative positive acceleration

Table S3 Definition of operating mode bins using the vehicle-specific power (VSP) and vehicle speed (v)

VSP (kW/ton)	V (km/h)			
	v < 1.6	1.6 ≤ v < 40	40 ≤ v < 80	v ≥ 80
VSP < -4		Bin 11	Bin 21	
-4 ≤ VSP < -2		Bin 12	Bin 22	
-2 ≤ VSP < 0		Bin 13	Bin 23	Bin 35
0 ≤ VSP < 2		Bin 14	Bin 24	
2 ≤ VSP < 4		Bin 15	Bin 25	
4 ≤ VSP < 6		Bin 16	Bin 26	Bin 36
6 ≤ VSP < 8	Bin 0	Bin 1	Bin 17	Bin 37
8 ≤ VSP < 10	Brake or decelerate	Idling	Bin 27	Bin 38
10 ≤ VSP < 12			Bin 28	
12 ≤ VSP < 14			Bin 29	
14 ≤ VSP < 16		Bin 18	Bin 2X	Bin 39
16 ≤ VSP < 20			Bin 2Y	Bin 3X
VSP ≥ 20				Bin 3Y

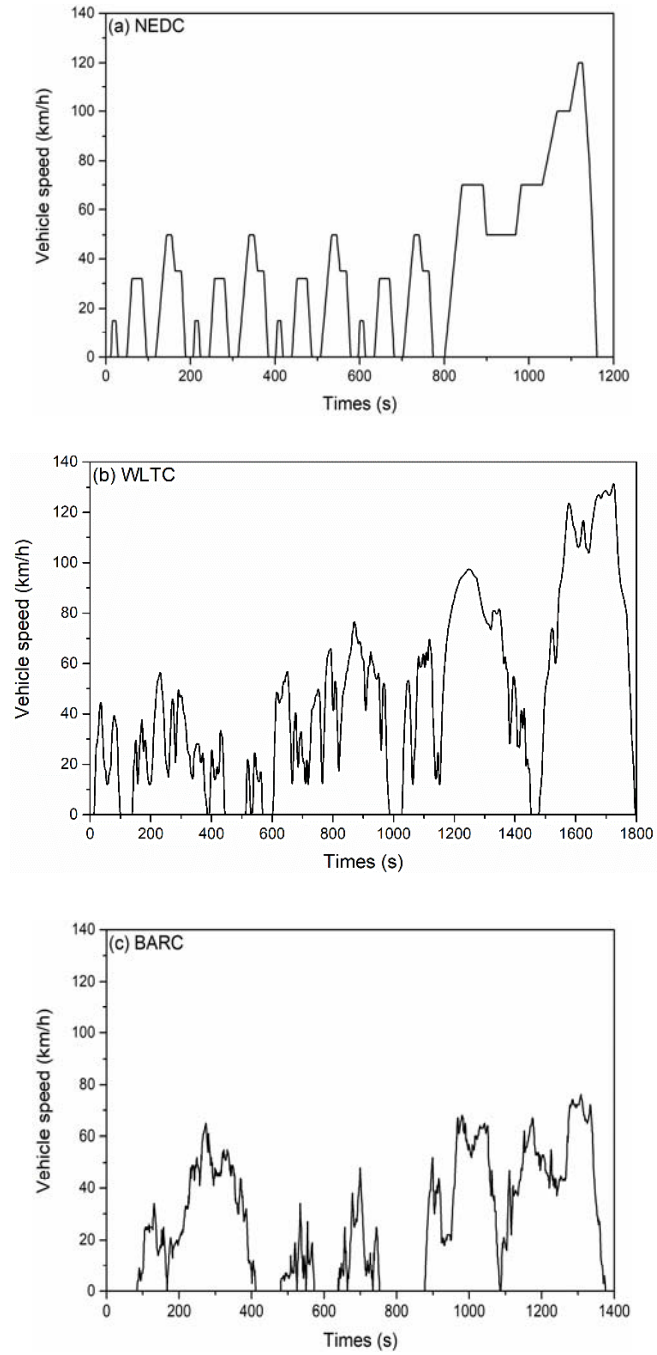


Fig. S1 The speed profiles of the (a) NEDC, (b) WLTC and (c) BARC

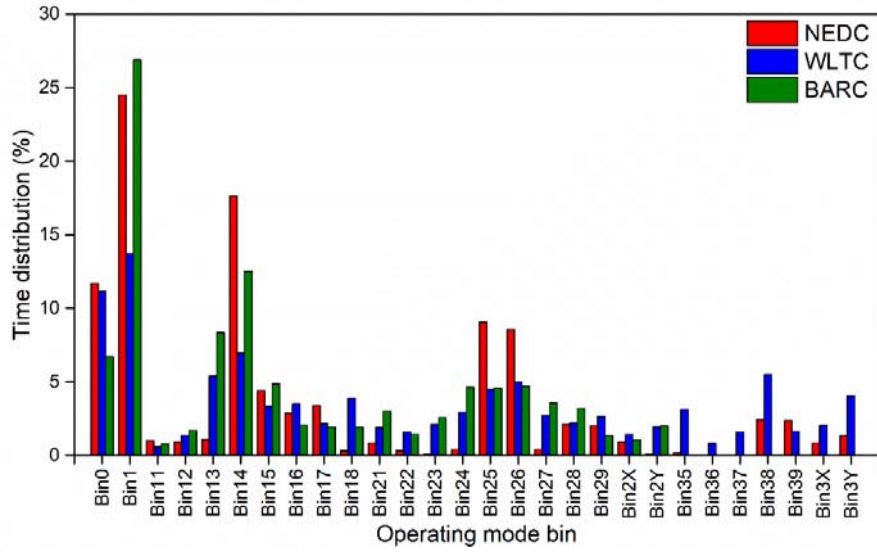


Fig. S2 Allocation of each operating mode bin to the total travel time for three typical traffic patterns

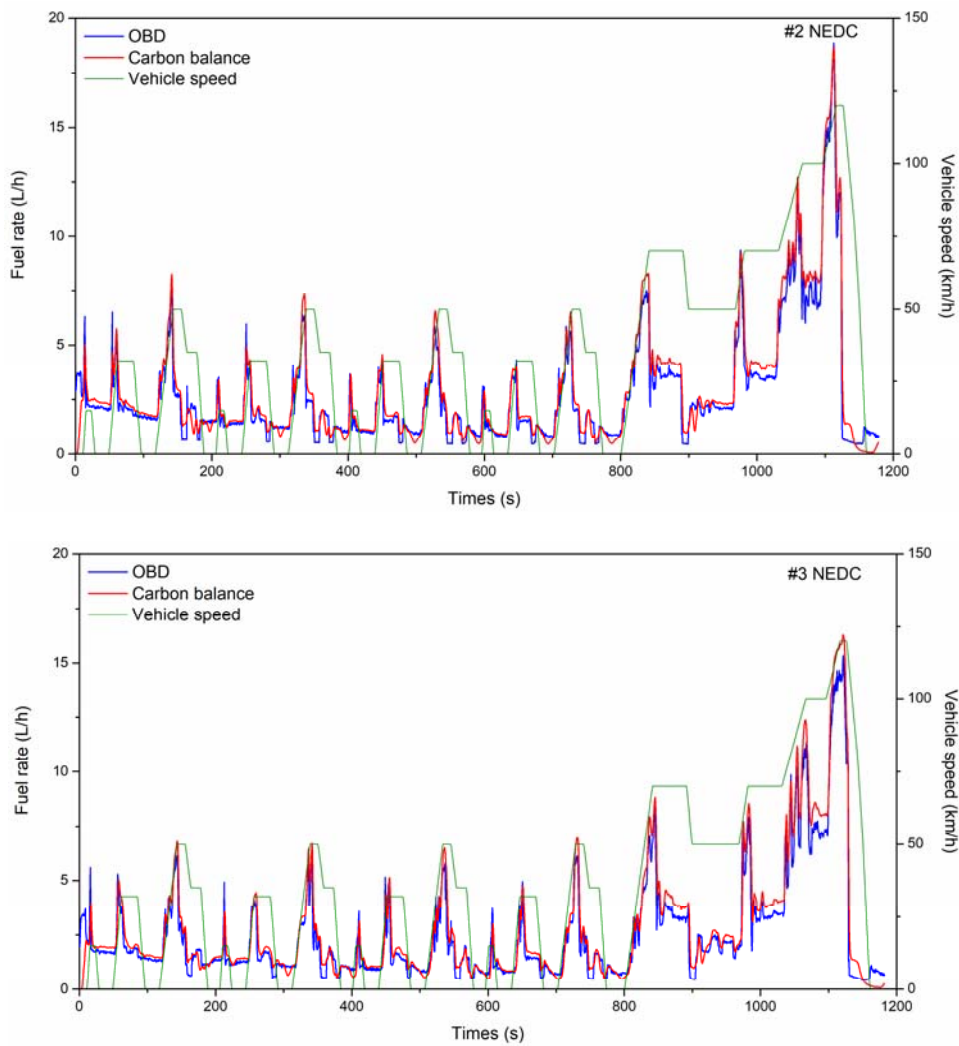


Fig. S3 Comparison of the OBD and carbon balance fuel rates for vehicles #2 and #3 based on NEDC conditions