7 Supplementary materials

7.1 Supplementary Tables

Supplementary Table 1: Framework notation

Codes	Descriptions
	REGION (i)
CHN	China
IND	India
NAM	North America: US, Canada and Mexico
BRZ	Brazil
NAD	North Asia developed: Japan, South Korea and Taiwan
CIS	The Commonwealth of Independent States: Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Uzbekistan, Turkmenistan, Ukraine and Georgia
WEU	Western Europe: Austria, Belgium, Cyprus, France, Finland, Germany, Greece, Italy, Ireland, Luxembourg, Malta, Netherlands, Portugal, Spain, Slovenia, Denmark, Sweden, UK, Norway, and Switzerland
REU	Rest of Europe: Turkey and Baltic Nations
SEA	Southeast Asia: Philippine, Malaysia, Vietnam, Thailand, Singapore, Indonesia and other minor countries
OTH	Others: Africa, other C&S America, other sub-Indian continent, Oceania, other Middle East, and GCC countries
WTO	The world (Aggregate all regions)
	TYPE (j)
LDV	Vehicles weighting 0-6t in North America, and 0-3.5t for all other regions
HDV	Vehicles weighting over 6t in North America, and over 3.5t for all other regions. This category does not include passenger vehicles
BUS	Passenger vehicles over 6t. MiniBus (Bus below 6t) are counted as HDV. This is consistent with LMCA definition
	POWER (k)
ICE - PETROL	Internal combustion only / petrol powered
ICE - DIESEL	Internal combustion only / diesel powered
HEV	HEV (Mild hybrid electric vehicle + Full hybrid electric vehicle). Split between diesel and petrol where applicable.

PHEV	Plug in hybrid electric vehicle (including extended range EV (REEV)). Split between diesel and petrol where applicable.
BEV	Battery electric vehicle
FCEV	Fuel cell electric vehicle
PFCEV	Plug in fuel cell electric vehicle
	YEAR (t) (2015-2030)
	FUELS (f)
ELE	Electricity
PET	Petrol
DIE	Diesels
HYD	Hydrogen
	POWER SOURCES (s)
COA	Coa
GAS	Gas
OIL	Oil
	METALS (m)
CU	Copper
LI	Lithium
CO	Cobalt
NI	Nickel
MN	Manganese
CR	Chrome
FE	Steel
AL	Aluminium

Supplementary Table 2: Predefined roadmap for sale share by powertrains for LDV in China

Power train	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ICE PETROL	0.92	0.9	0.88	0.86	0.85	0.83	0.82	0.79	0.7	0.61	0.51	0.42	0.32
ICE DIESEL	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.0
HEV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.09	0.18	0.26	0.35	0.44
PHEV	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05
BEV	0.04	0.06	0.07	0.08	0.09	0.1	0.11	0.13	0.14	0.15	0.17	0.18	0.19
FCEV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PFCEV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Supplementary Table 3: Assumed fuel prices by regions (including taxes)

	BRZ	CHN	CIS	IND	NAD	NAM	REU	SEA	WEU
Diesel (2017) ($ /l)	0.89	0.78	0.57	0.81	0.57	0.7	1.23	0.7	1.28
Diesel (2030) ($/l)	1.04	0.85	0.62	0.88	0.62	0.83	1.28	0.81	1.28
Diesel (CAGR)	1.2%	0.7%	0.6%	0.6%	0.6%	1.3%	0.3%	1.1%	0%
Electric (2017) ($/kWh)	0.24	0.13	0.14	0.14	0.19	0.12	0.24	0.19	0.24
Electric (2030) ($/kWh)	0.3	0.17	0.18	0.18	0.25	0.15	0.3	0.25	0.3
Electric (CAGR)	1.7%	2.1%	2%	2%	2.1%	1.7%	1.7%	2.1%	1.7%
Hydrogen (2017) ($/kg)	12.06	12.06	12.45	12.45	8.59	12.45	12.06	12.45	12.45
Hydrogen (2030) ($/kg)	6.08	6.08	6.28	6.28	4.33	6.28	6.08	6.28	6.28
Hydrogen (CAGR)	-5.1%	-5.1%	-5.1%	-5.1%	-5.1%	-5.1%	-5.1%	-5.1%	-5.1%
Petrol (2017) ($/l)	1.07	0.84	0.61	0.95	1.06	0.67	1.27	0.92	1.41
Petrol (2030) ($/l)	1.16	0.9	0.64	1	1.12	0.8	1.28	0.99	1.37
Petrol (CAGR)	0.6%	0.5%	0.3%	0.4%	0.4%	1.3%	0.1%	0.5%	-0.2%

Sources: CRU internal reports and authors' own assumptions.

Supplementary Table 4: Vehicle representatives

Powertrain	NAD	NAM	WEU	CHN	IND	REU	CIS	SEA	BRZ
					LDV				
ICE - PETROL	Nissan Sylphy	Toyota Camry	Volkswagen Golf	VW Lavida	Maruti Suzuki Dzire	Fiat Eaga	-	Mazda 2	Volkswagen Brasília
ICE - DIESEL	modelled	Chevrolet Cruze	Volkswagen Golf	modelled	Maruti Suzuki Dzire	Volkswagen Golf GT	Hyundai Santa Fe	Mazda 2	Volkswagen Gol
HEV	Prius HEV	Toyota Camry Hybrid	Auris Hybrid	Toyota corolla	modelled	Auris Hybrid	Toyota Camry Hybrid	Prius HEV	Toyota Auris
PHEV	Prius PHEV	Chevrolet Volt	VW Golf GTE	BYD Qin	modelled	Volkswagen Golf GT	Outlander-Mitsubishi	Prius PHEV	Mitsubishi Outlander
BEV	Nissan Leaf	Tesla 3	VW e-Golf	BAIC EU260 EV	Mahindra eVerito D6	VW e-Golf	LADA Ellada	Nissan Leaf	BMW i3
FCEV	Toyota Mirai	Toyota Mirai	Toyota Mirai	modelled	Toyota Mirai	Toyota Mirai	Toyota Mirai	Toyota Mirai	Toyota Mirai
PFCEV	modelled	modelled	modelled	modelled	modelled	modelled	modelled	modelled	modelled
					HDV				
ICE - DIESEL	Hino 195	Freightliner M2 106	MAN TGM 18.280	Dongfeng KL	Tata LPD 1618	MAN TGM 18.280	Kamaz 53605	FUSO FN65FJ	Mercedes Benz 2426
BEV	Mercedes Urban eTruck (or modelled on Mercedes Urban eTruck)								
FCEV	Nikola One (or modelled on Nikola One)								
					BUS				
ICE - DIESEL	Mitsubishi Fuso-Aero Bus	New Flyer Xcelsior D40LF	MAN Lion's City A21	Yutong ZK6128HG	Tata Marcopolo	Solaris Urbino 12	LiAZ-5292	Volvo B8R	Mercedes Benz 2426
HEV	Selega R HIMR	New Flyer Xcelsior DE40LF	MAN Lion's City hybrid	Yutong ZK6126HGZ1	Tata hybrid bus	Solaris Urbino 12 Hybrid	LiAZ-5292XX	Volvo B5RLEH	
PHEV	-	-	-	Yutong H-12	-	-	-	-	-
BEV	BYD-K9	Flyer Xcelsior Charge	BYD K9	BYD K9	Tata electric bus	Solaris Urbino 12 Electric	LIAZ-6274	ByD K9	modelled
FCEV	FCHV-BUS2	New Flyer Xcelsior H40 FLR	Van Hool A330 FC Europa	Feichi-Ballard prototype	Tata fuel cell bus	Van Hool A330 FC Europa	modelled	FCHV-BUS2	modelled

Supplementary Table 5: Assumed lifespan of vehicles and batteries (year)

Type	Powertrain	Life	BRZ	CHN	CIS	IND	NAD	NAM	OTH	REU	SEA	WEU
LDV	BEV	Vehicle	10	8	12	12	10	9		11	10	10
		Battery	7	5	7	7	7	9		7	6	7
	FCEV	Vehicle	10	8	12	12	10	9		11	10	10
		Battery	10	5	10	5	10	9		10	10	10
	HEV	Vehicle	10	8	12	12	10	9		11	10	10
		Battery	7	5	7	7	7	9		7	6	7
	ICE DIESEL	Vehicle	10	8	12	12	10	9	10	11	10	10
		Battery	2	3	3	3	3	9	3	3	2	3
	ICE PETROL	Vehicle	10	8	12	12	10	9	10	11	10	10
		Battery	2	3	3	3	3	9	3	3	2	3
	PFCEV	Vehicle	10	8	12	12	10	9		11	10	10
		Battery	10	5	10	5	10	9		10	10	10
	PHEV	Vehicle	10	8	12	12	10	9		11	10	10
		Battery	7	5	7	7	7	9		7	6	7
HDV	BEV	Vehicle	15	13	17	15	13	15		13	14	12
		Battery	7	5	7	7	7	15		7	6	7
	FCEV	Vehicle	15	13	17	15	13	15		13	14	12
		Battery	10	5	10	5	10	15		10	10	10
	ICE DIESEL	Vehicle	15	13	17	15	13	15	14	13	14	12
		Battery	2	3	3	3	3	15	3	3	2	3
BUS	BEV	Vehicle	12	10	12	12	10	10		11	12	10
		Battery	7	5	7	7	7	9		7	6	7
	FCEV	Vehicle	12	10	12	12	10	10		11	12	10
		Battery	10	5	10	5	10	9		10	10	10
	HEV	Vehicle	12	10	12	12	10	10		11	12	10
		Battery	7	5	7	7	7	9		7	6	7
	ICE DIESEL	Vehicle	12	10	12	12	10	10	10	11	12	10
		Battery	2	3	3	3	3	9	3	3	2	3
	PHEV	Vehicle	12	10	12	12	10	10		11	12	10
		Battery	7	5	7	7	7	9		7	6	7

Sources: CRU internal reports and authors' own assumptions.

Supplementary Table 6: Assumed annual millage travelled (km)

Type	BRZ	CHN	CIS	IND	NAD	NAM	REU	SEA	WEU
LDV	12,983	19,400	16,882	12,200	12,356	21,687	12,276	14,853	13,788
HDV	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
BUS	53,226	55,000	60,000	52,500	51,499	53,226	55,200	50,000	51,658

Sources: CRU internal reports and authors' own assumptions.

Supplementary Table 7: Assumed Average Fuel Efficiency CAGR, 2015-2030

Powertrain	NAD	NAM	WEU	CHN	IND	REU	CIS	SEA	BRZ
					LDV				
ICE - PETROL	2.30%	3.00%	2.20%	2.20%	1.60%	2.20%	1.60%	1.70%	2.20%
ICE - DIESEL	2.00%	3.00%	2.20%	2.20%	1.50%	2.20%	1.50%	1.50%	2.20%
HEV	1.70%	2.40%	1.70%	2.20%	1.60%	1.70%	1.60%	1.70%	1.70%
PHEV	2.30%	3.00%	2.20%	2.20%	1.60%	2.20%	1.60%	1.70%	2.20%
BEV	1.50%	1.50%	1.50%	1.40%	1.50%	1.50%	1.50%	1.50%	1.50%
FCEV					1.70%				
PFCEV					1.70%				
					HDV				
ICE - DIESEL	0.90%	1.10%	1.60%	1.10%	2.90%	1.10%	1.10%	1.10%	1.10%
BEV					1.10%				
FCEV					1.20%				
					BUS				
ICE - DIESEL					1.00%				
HEV					1.00%				
PHEV	-	-	-	1.00%	-	-	-	-	-
BEV					1.20%				
FCEV					1.50%				

Supplementary Table 8: Assumed maintenance cost as a share of vehicle price (%)

Type	Powertrain	BRZ		CHN		CIS		IND		NAD		NAM		REU		SEA		WEU	
		2017	2030	2017	2030	2017	2030	2017	2030	2017	2030	2017	2030	2017	2030	2017	2030	2017	2030
LDV	BEV	6	13	4	10	8	16	7	17	9	16	6	11	10	17	7	14	5	9
	FCEV	4	9	3	6	5	11	5	9	4	9	4	8	5	10	4	9	3	6
	HEV	19	22	11	12	26	30	28	32	17	18	13	14	22	24	19	20	10	11
	ICE DIESEL	22	23	14	15	31	33	39	42	24	25	15	16	27	29	22	23	13	14
	ICE PETROL	26	27	16	17	37	39	41	44	27	29	17	18	31	33	26	27	13	14
	PFCEV	4	8	3	6	5	10	5	9	4	8	4	7	5	10	4	8	2	5
	PHEV	10	15	6	12	17	25	13	20	12	15	8	11	14	16	12	15	7	8
HDV	BEV	18	25	11	20	12	21	7	13	31	55	17	23	19	35	18	32	17	30
	FCEV	14	24	9	19	9	20	6	13	24	52	13	22	16	34	15	32	13	28
	ICE DIESEL	53	43	53	56	48	51	45	48	66	70	44	36	58	62	54	59	59	63
BUS	BEV	17	25	23	36	11	21	36	67	14	26	17	25	11	20	18	36	14	20
	FCEV	20	37	17	56	16	27	34	63	11	26	20	37	16	27	13	25	15	26
	HEV	26	28	56	60	23	30	84	157	23	24	26	28	20	22	19	20	17	19
	ICE DIESEL	53	56	109	116	75	80	318	339	51	55	53	56	50	54	62	66	37	40
	PHEV			50	64														

Supplementary Table 9: Assumed vehicle values at EOL (USD)

	HEV		PHEV	
	2017	2030	2017	2030
BRZ	22,234	20,706	14,823	13,913
CHN	15,162	14,235	11,884	11,157
CIS	14,550	10,948	7,365	6,915
IND	11,436	11,446	7,624	7,630
NAD	30,947	29,055	20,910	19,632
NAM	11,225	14,521	7,484	9,681
REU	29,538	26,032	17,475	16,407
SEA	20,821	19,549	9,664	9,073
WEU	50,831	45,466	35,389	33,226

Supplementary Table 10: Assumed Compliance Cost

Vehicle type	Powertrain	Region	Year		
			2017	2025	2030
LDV	ICE DIESEL	BRZ	-	131	128
		CHN	-	713	696
		IND	-	1,228	1,199
		NAM	64	62	60
		REU	246	237	231
		WEU	246	237	231
	ICE PETROL	BRZ	-	131	128
		CHN	-	66	64
		IND	-	246	240
		NAM	64	62	60
		SEA	-	56	55
HDV	ICE DIESEL	BRZ	-	1,733	1,570
		CHN	-	2,492	2,432
		CIS	-	1,733	1,570
		IND	-	2,244	2,189
		WEU	246	1,895	2,669
BUS	ICE DIESEL	BRZ	-	1,251	1,221
		CHN	-	5,464	5,331
		CIS	1,177	1,133	1,105
		IND	-	10,540	10,284
		REU	2,639	2,539	2,478

Supplementary Table 11: Assumed Annual Circulation Tax (ACT)

Power train	Region	2017	2025	2030
BEV	NAM	5,340	4,561	4,131
FCEV	NAM	5,340	4,561	4,131
HEV	NAM	5,340	4,561	4,131
ICE DIESEL	NAD	25,287	23,333	22,190
	NAM	5,340	4,561	4,131
ICE PETROL	NAD	25,287	23,333	22,190
	NAM	5,340	4,561	4,131
PFCEV	NAM	5,340	4,561	4,131
PHEV	NAM	5,340	4,561	4,131

Supplementary Table 12: Average metal intensities in batteries, kg/kWh (2015-2017)

Metal/Component	NCA	NMC (1:1:1)	NMC (5:3:2)	NMC (6:2:2)	NMC (8:1:1)	LMO	LFP	NiMH
Lithium /Cathode +electrolyte	0.12	0.18	0.14	0.15	0.12	0.13	0.12	
Cobalt /Cathode	0.14	0.41	0.22	0.20	0.10			0.17
Nickel /Cathode	0.77	0.4	0.55	0.61	0.78			4.15
Manganese /Cathode		0.38	0.31	0.19	0.09	1.77		
Aluminium/Cathode	0.02							
Copper/Current collector	0.51	0.77	0.70	0.70	0.70	0.91	0.82	0.40
Aluminium/Current collector	0.34	0.5	0.46	0.46	0.46	0.59	0.53	0.30
Steel casing/Pack	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Assumed changes in average metal intensities in batteries, 2015-2030								
Reduction in cathode active materials content (approximate)	0.15	0.05	0.15	0.15	0.15	0.05	0.15	0.05
Reduction in other metals content (approximate)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

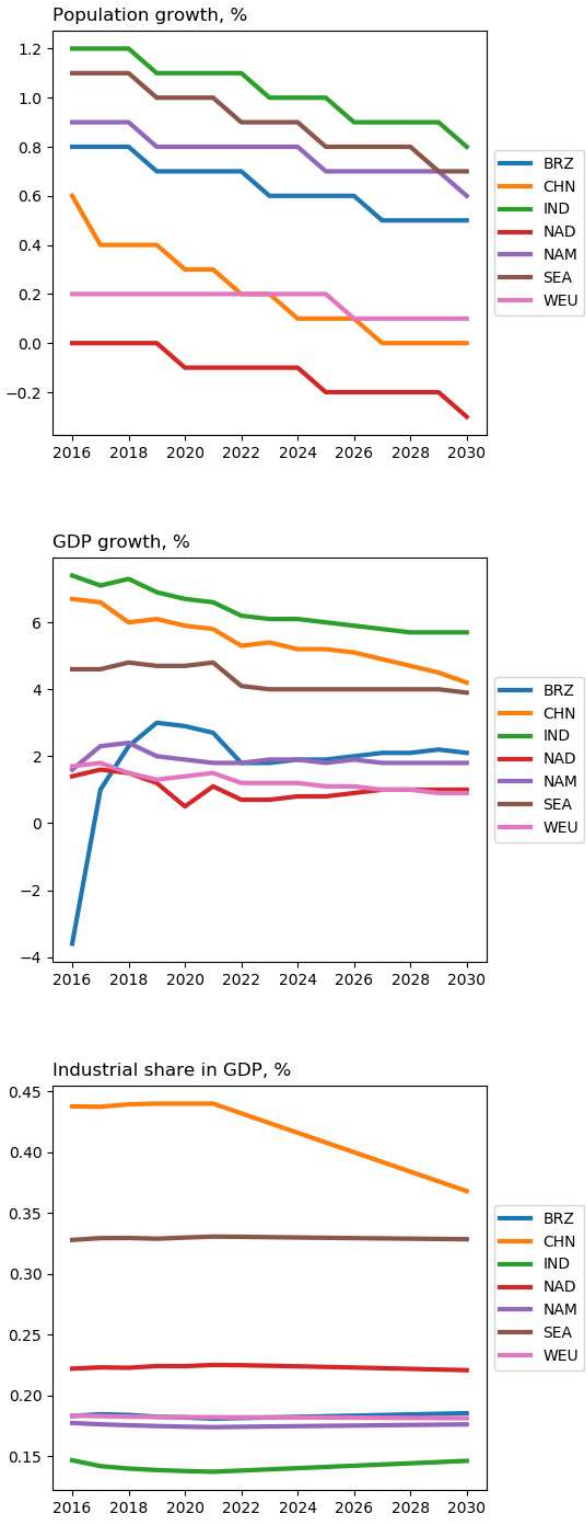
*Note: NiMH - average of NiMH (AB2) and NiMH (AB5).

Supplementary Table 13: Steel and aluminium content assumptions

Metal	Vehicle parts	Average intensity (2016), kg/unit		
		LDV	HDV	BUS
Aluminium in battery	Battery cathode (NCS) and in current collector (foil)	Up to 0.7 in NCA cathode 20 in Al current collector	80 in BEV	• 13 in HEV • 30 in FCEV
Aluminium ex. battery	Aluminium body parts body inner structure, radiator	150-159	100-120	600-900
Steel in battery	Battery casing	Up to 150 in Tesla	430 in BEV	• 50-75 in HEV • 125 in FCEV • 500-750 in BEV
Steel ex. battery	Body, frame, engine, chassis, exhaust system	600-800 in ICEs	4600	8,600-11,000
Copper in battery		• 0.6 in HEV • 10-12 in PHEV • 30-40 in BEV • 7 in PFCEV	120 in BEV	• 15-20 in HEV • 37 in PHEV • 150-250 in BEV • 40 in FCEV
Copper ex. battery		• 20 in ICE • 30 in HEV • 40-45 in PHEV • 48 in PFCEV	30 in ICE, BEV, FCEV, PFCEV	• 40 in ICE • 70 in HEV • 40-48 in BEV • 80 in PHEV, BEV, FCEV & FCEV

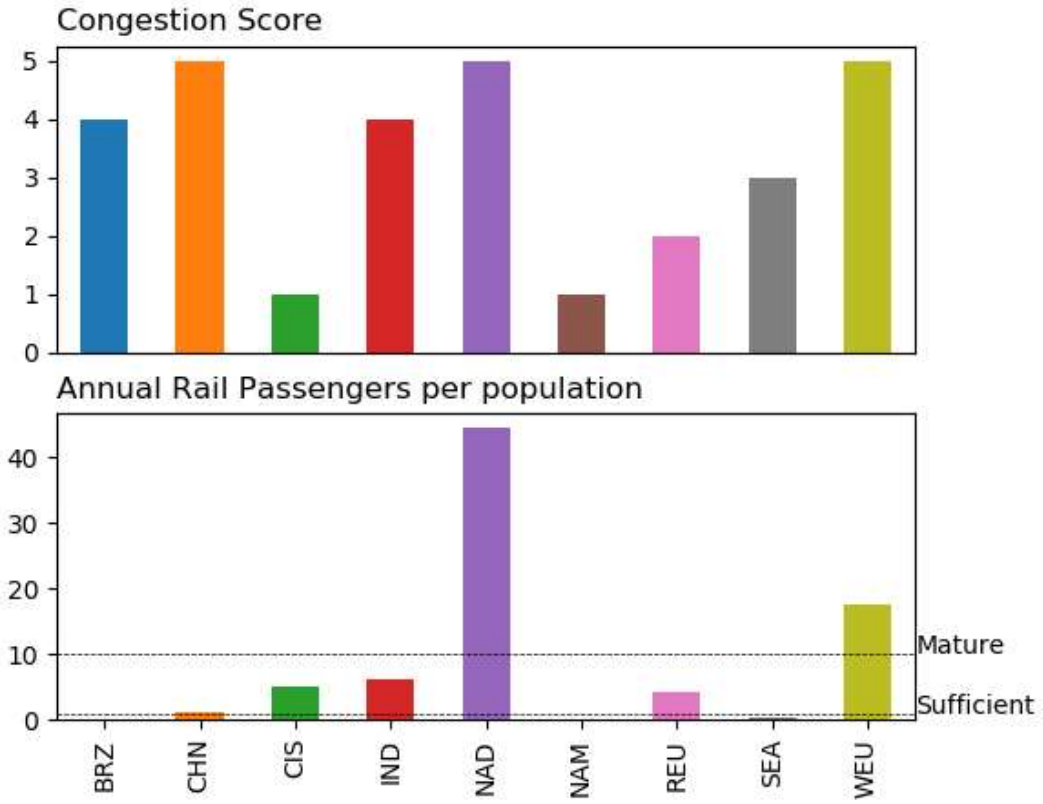
7.2 Supplementary Figures

Supplementary Figure 1: Assumptions on macro variables



Sources: Oxford Economics

Supplementary Figure 2: Infrastructure availability assessment



Supplementary Figure 3: Tailpipe Emissions Standard (Passenger Cars & LDV)

	2017	2018	2019	2020	2021	2022	2023	2024	2025
Europe	EU 6 / RDE Phase 1 / 130g/km CO2				RDE Phase 2 / 95g/km CO2			EU 7	
USA (EPA)	Tier 3 Phase in: NMOG + NOx, PM tightening								
USA (CARB)	LEV III Phase in: NMOG + NOx, PM tightening				LEV III: Full vehicle certification				
Japan	JP 09				JP 18				
S. Korea (Gasoline)	K-ULEV 70				LEV III / 97g/km CO2				
S. Korea (Diesel)	EU 6b		EU 6c/ RDE Phase 1		RDE Phase 2 / 97g/km CO2			EU 7	
China	China 4 (EU 4)		China 5 (EU 5)		China 6a		China 6b / RDE		
China (Beijing)	BJ6				China 6b				
India	BS4 (EU 4)				BS 6 (EU 6)		BS 6 / RDE		
Indonesia	EU2		EU 4						
Thailand	EU 4		EU 5					EU 6	