Bad news

There will be no ICE-powered vehicles in future.

Good news

But that future with no ICE, is at least 20-30 years away.

Emission Control Technologies 2019 by ECMA

India Powertrain Outlook

Suraj Ghosh

Principal Analyst

Powertrain & Compliance Forecasts

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- Global Powertrain Outlook – Brief
- Regulations
  - BS VI
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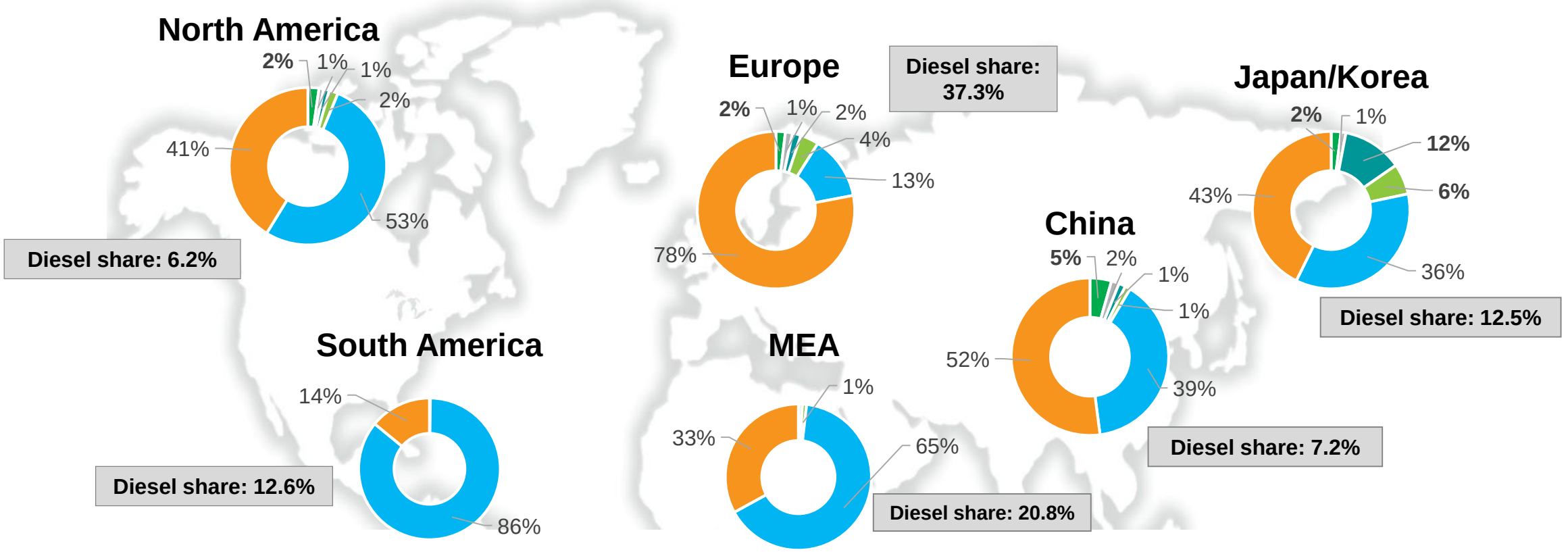
- Variables – Customer vs Carmaker
- Powertrain trend analysis
- Challenges & Opportunities
- Conclusion

Worldwide powertrain production
A global market with fragmented landscapes

IHS Markit 2019 global engine installation forecast by propulsion system, design, and fuel type



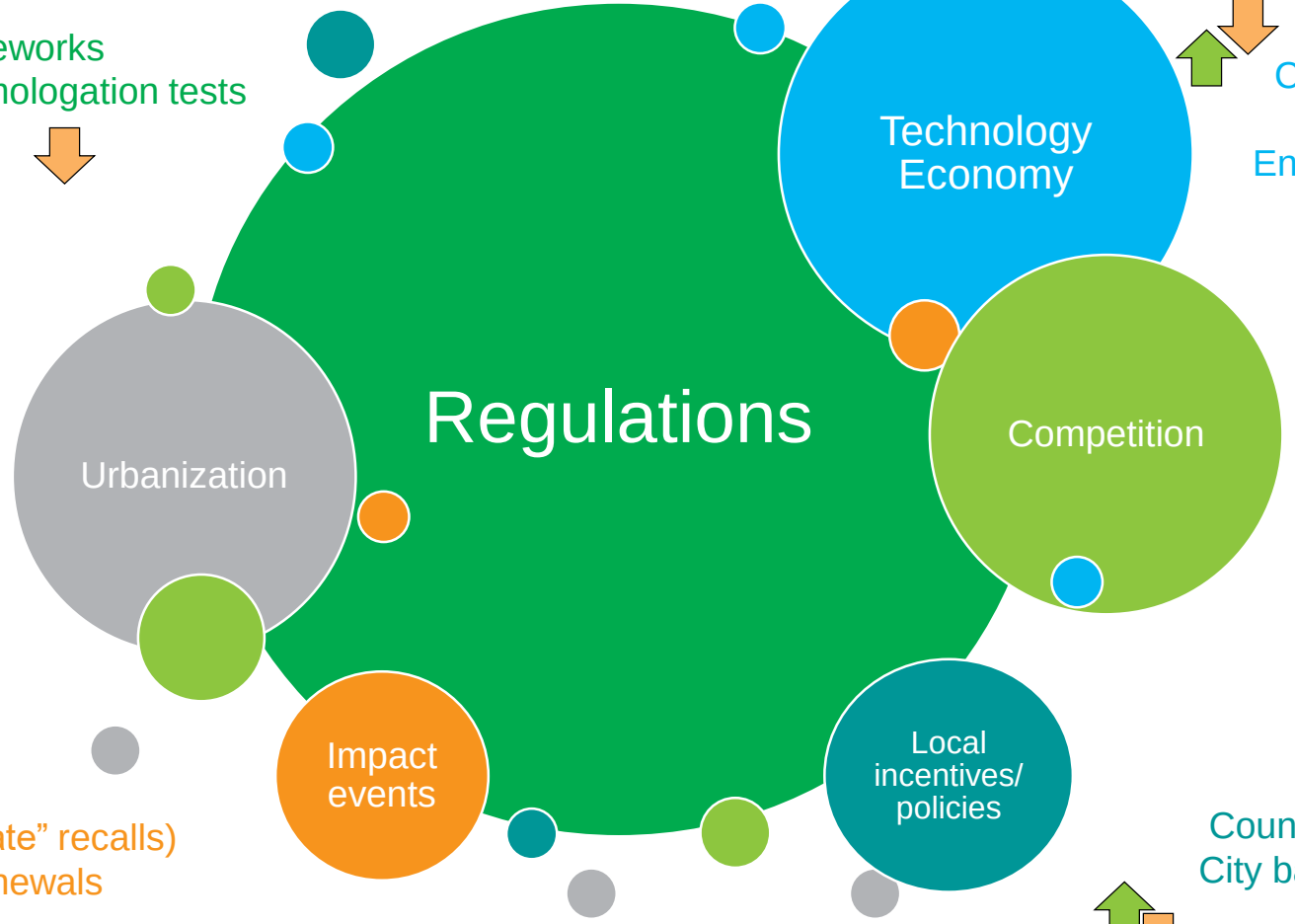
Source: IHS Markit Powertrain Production Forecast FEB19

Global market drivers: Multi-dimensional pressures and challenges

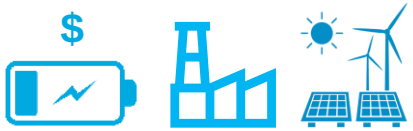
CO_2 regulatory frameworks
Emissions standards and homologation tests

Emissions-free areas
New mobility service providers
Charging infrastructure access

Industry challenges (“diesel-gate” recalls)
Disruptive government renewals



Cell production, capacity enhancement,
Technological breakthroughs
Energy network landscape (wind/PV/V2G)



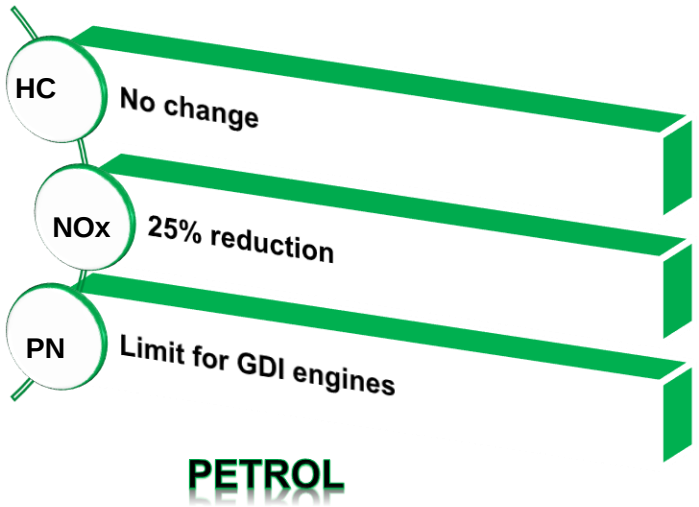
Current electrification race
Product portfolio competition

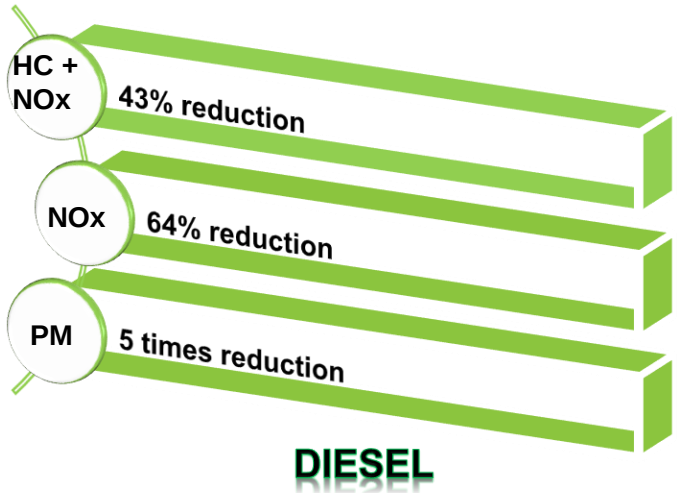
Countries/States or regions Incentives/fees
City bans, restricted areas, C40 Cities group

Regulations – BS6 & CAFE

Emission Norms Schedule

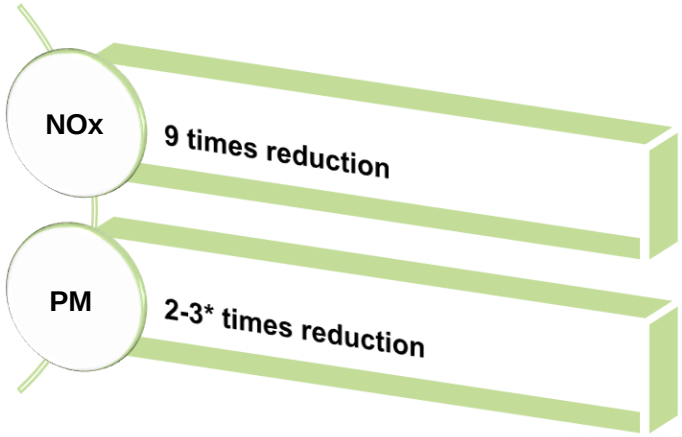
Region/Year	2010	2017	2020	2022	2023	2027
Select Cities	BS 4	BS 4	BS 6			BS 7
Rest of India	BS 3					
RDE			Observation phase		ISC	
Test Cycle			MIDC		WLTC	
CAFE			Phase 1		Phase 2	Phase 3
MHCV FE			Phase 1		Phase 2	Phase 3





LV

Pollutant limits



HDV

* Based on WHTC or WHSC

Standard Measures - Europe

	Euro 4	Euro 5	Euro 6
Gasoline	Base	• Combustion improvements over Euro 4 • Faster oxygen sensors • Catalyst improvements - oxygen storage capacity and better coatings	• No changes required for MPFI gasoline engines • Improvements to fuel injection timing or addition of a gasoline particle filter for gasoline direct injection (GDI) engines Diesel
Diesel	Base	• Combustion improvements over Euro 4 • Variable fuel injection timing for DPF regeneration • DOC + DPF • Some engines use lean NOX traps	• Increased fuel injection pressure • Smaller and medium-size engines (<2L) tend to use DOC+DPF and primarily LNT for NOX control • Larger cars (>2L) use DOC+DPF+SCR • Some manufacturers offer EGR-only NOX control (with no aftertreatment control), and DOC+DPF on medium and larger cars

- Our internal estimates indicate the following cost/unit incurred by OEMs in EU region:

	Tech (Assembly)	Cost/unit (€)
1	DOC	87
2	DPF	425
3	LNT	356
4	SCR	652

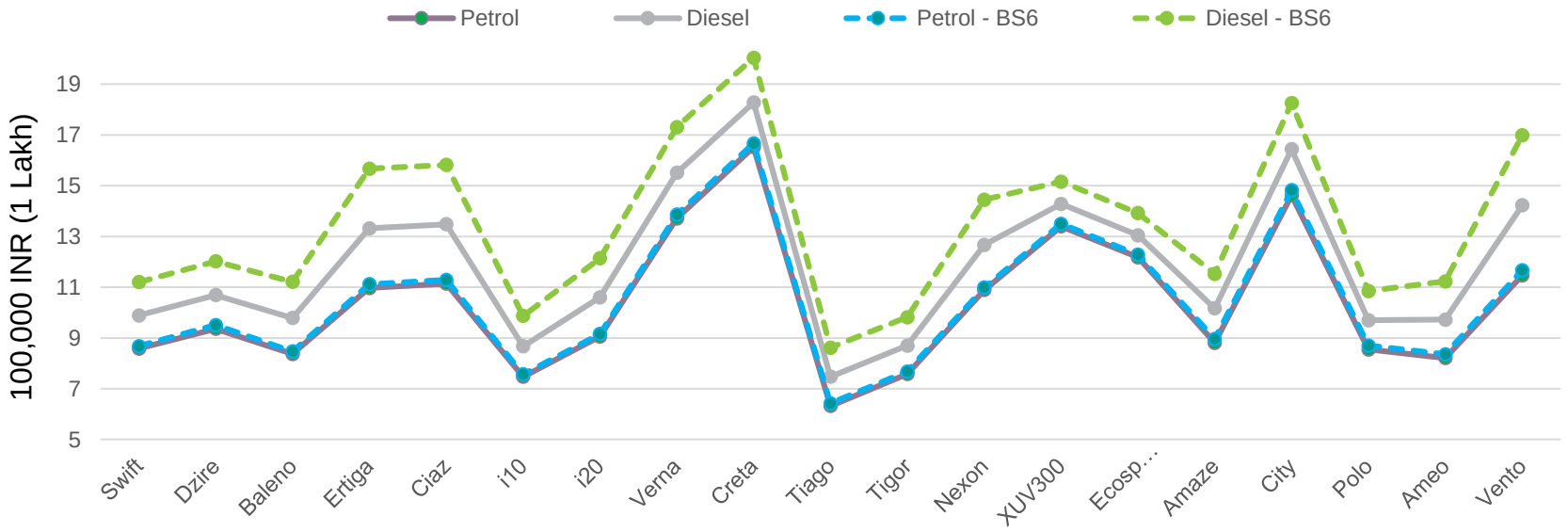
India:
Since India is skipping BS 5, the quantum of leap is wider but most technologies have evolved and matured with time, hence the incremental price impact is may be balanced.

Cost of BS 6 compliance - IHS Estimate based on internal research

₹10000~$145~¥16000

Engine Vol (liter)	PM Control	NOx Control	In-cylinder Measures	Incremental cost/engine (₹)
Petrol				
<1.2	Optimized cat/GPF*	None/EGR*	Low/Mild	**0 – 10k**
1.2 – 2.0	Optimized cat/GPF*	EGR	Mild	**5k – 15k**
>2.0	Optimized cat/GPF*	EGR	Mild	**10k – 20k**
Diesel				
<1.5	DPF+DOC	LNT	Mild	**45k – 67k**
1.5 – 2.0	DPF+DOC	LNT/SCR	Mild to Strong	**65k – 90k**
>2.0	DPF+DOC	SCR	Strong	**90k – 125k**

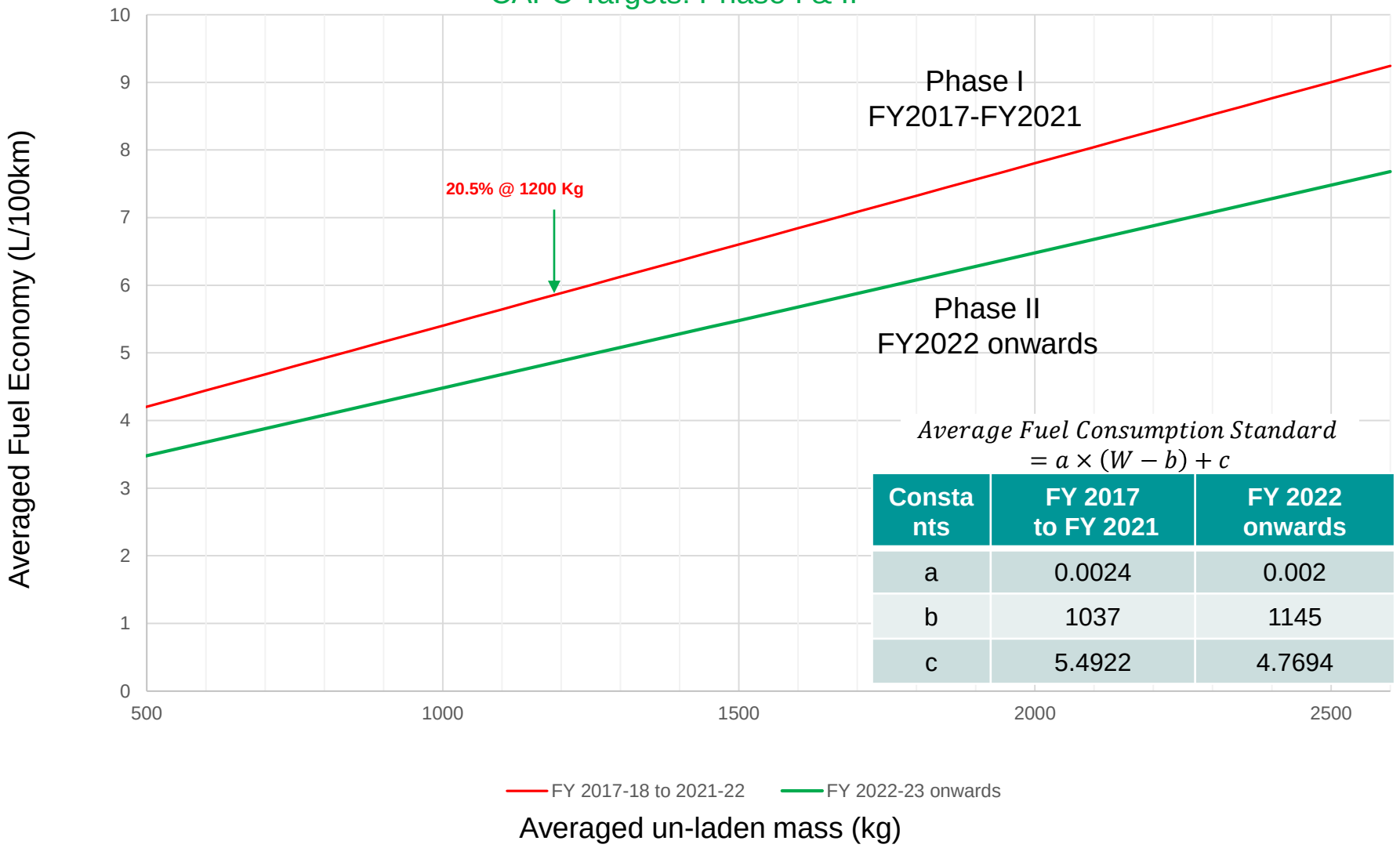
(Table based on an ICCT study, re-estimated and updated by IHS Markit)



* Required for GDI engines

CO2 Regulations

CAFC Targets: Phase I & II



$$Average\ Fuel\ Consumption\ Standard = a \times (W - b) + c$$

Constants	FY 2017 to FY 2021	FY 2022 onwards
a	0.0024	0.002
b	1037	1145
c	5.4922	4.7694

Fleet Target

Phase I (FY2017-2021)	Phase II (FY2022 onwards)
130 g/km	113 g/km

Resistance
- Air drag
- Rolling drag

Lightweight
- Body type
- Chassis
- Interior and exterior

In-cylinder
- Combustion engineering
- Intake technology
- Energy management
- Low friction
- Downsizing

Transmission
- Design
- Forward speed
- EVT

Electrification
- BEV
- PHEV
- FHEV
- MHEV

CO2 legislation

CO2 limit

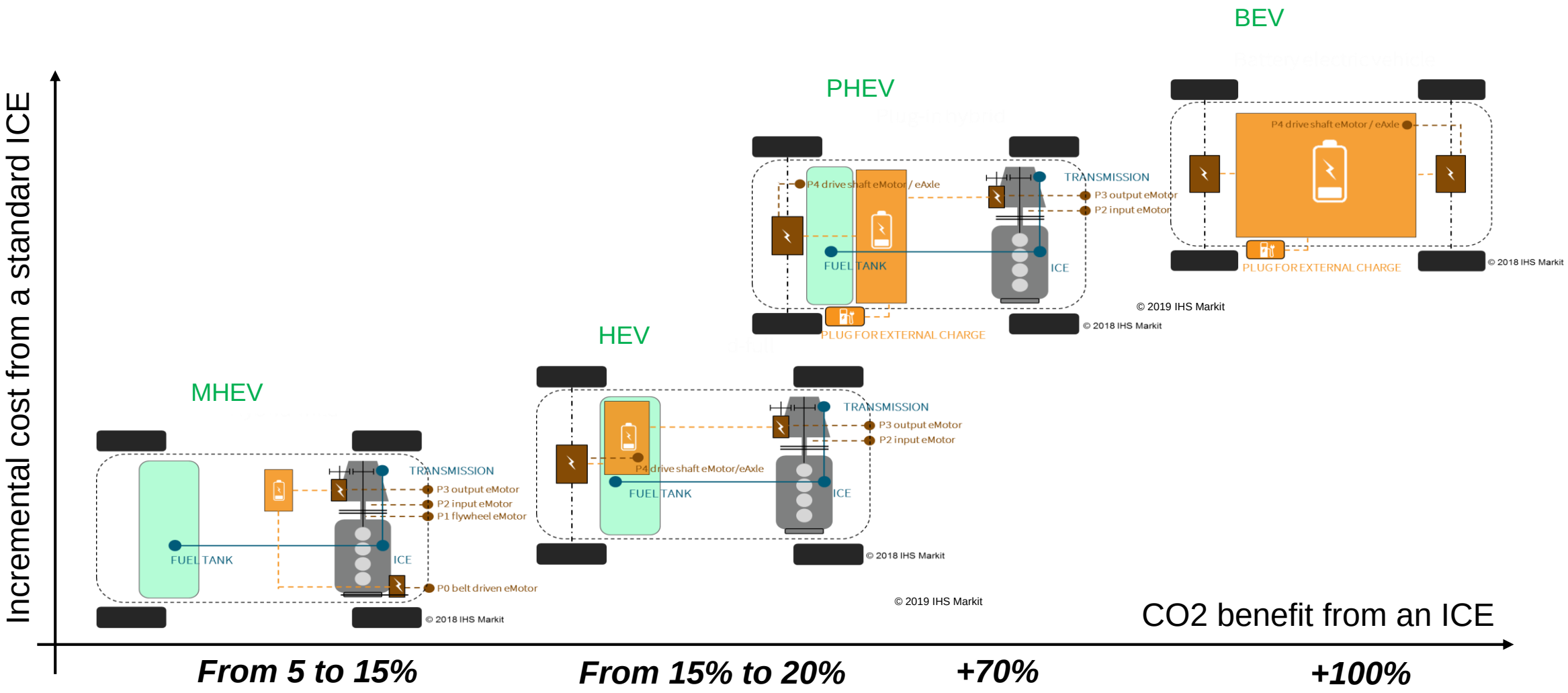
Test cycle

Procedure

Report

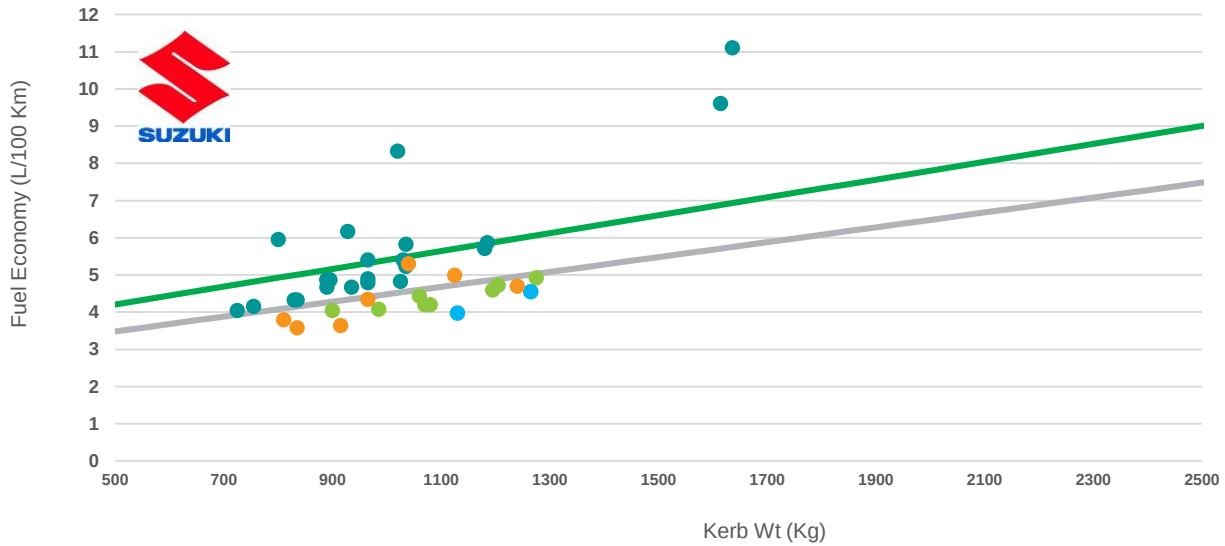
Compliance

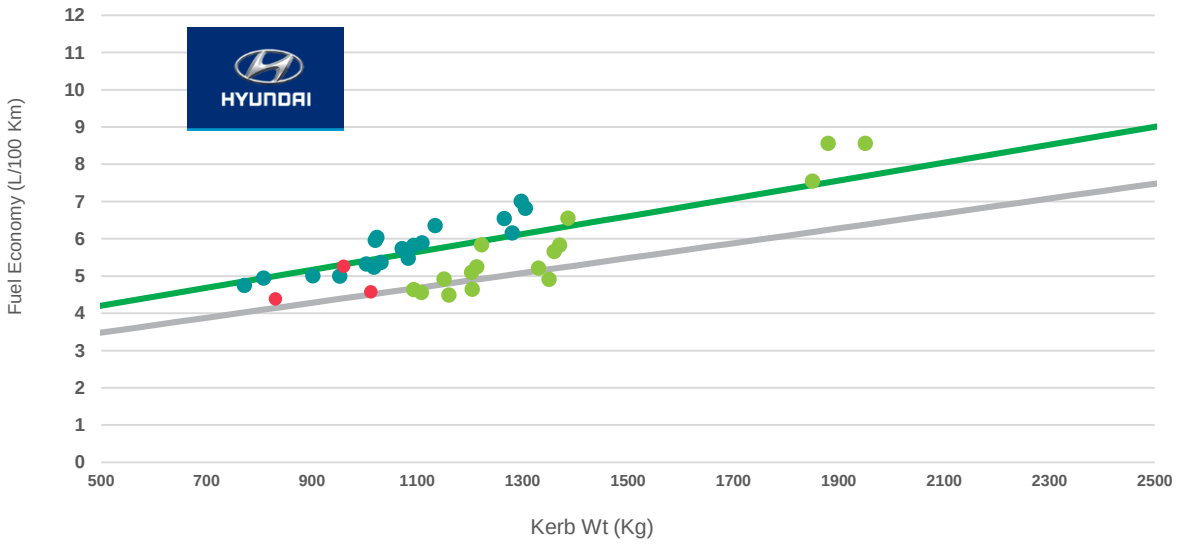
Electrification portfolio – From mild hybrid (P0 12V) to high-performance BEV

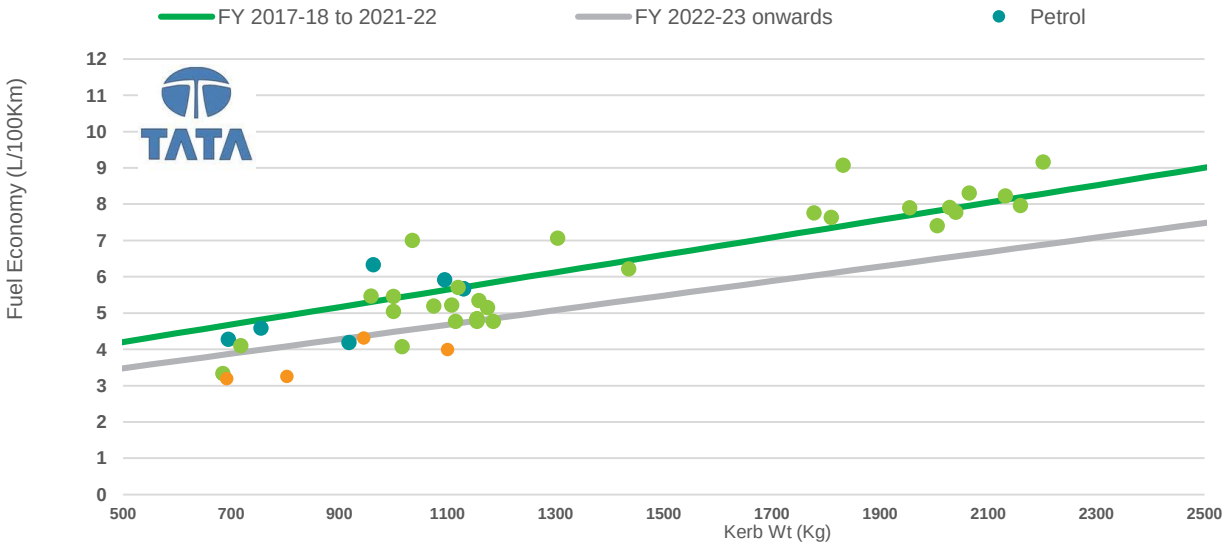


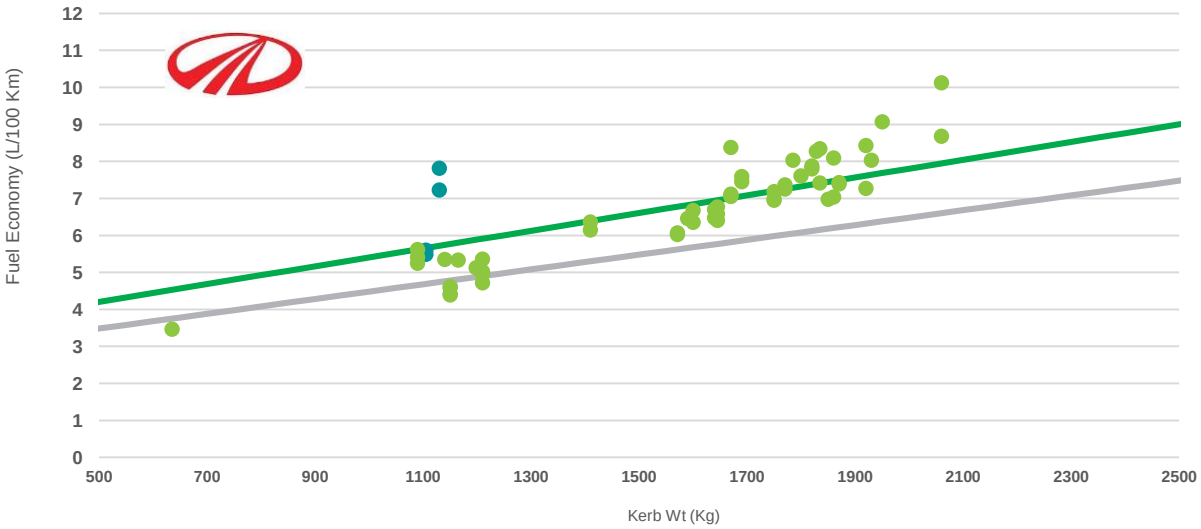
Key OEMs FE Map – FY2016-17

FE data source: SIAM FE data release, www.siamindia.com

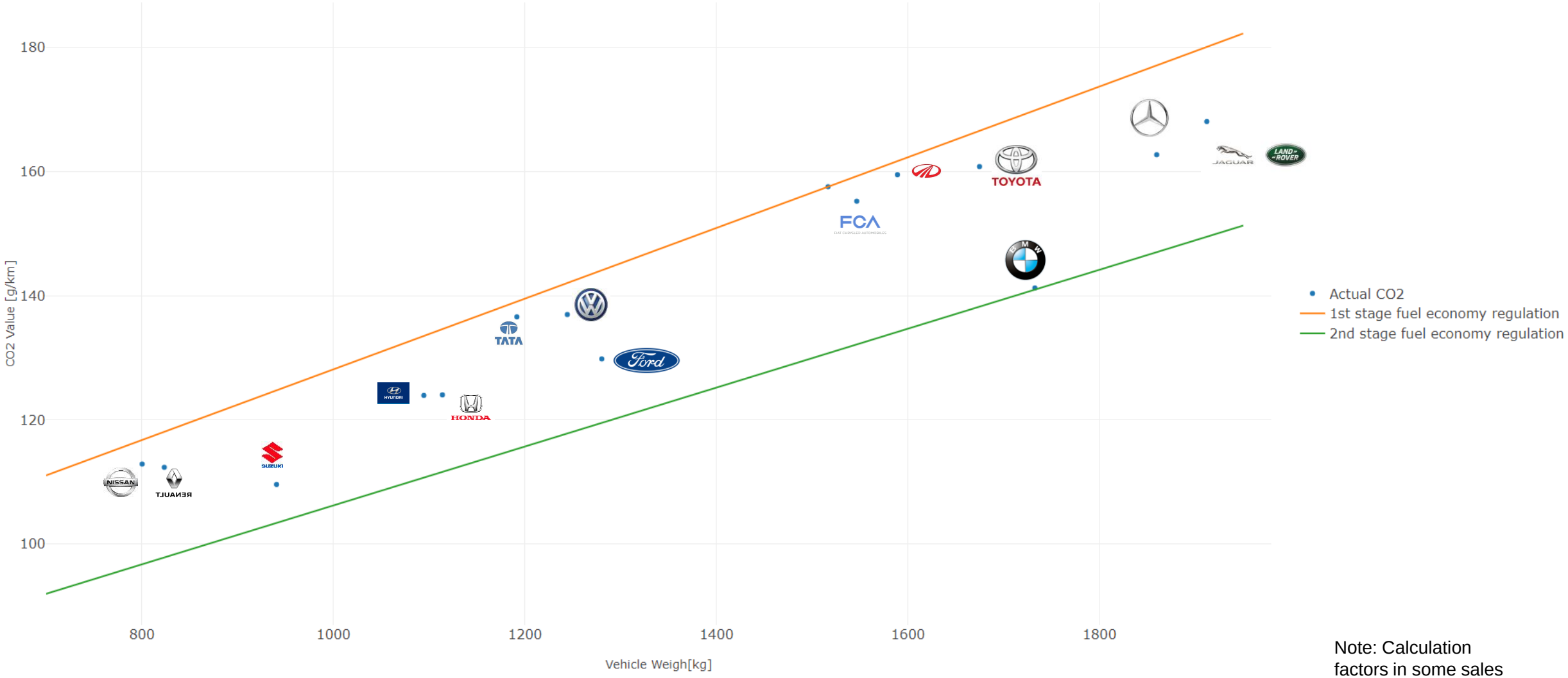








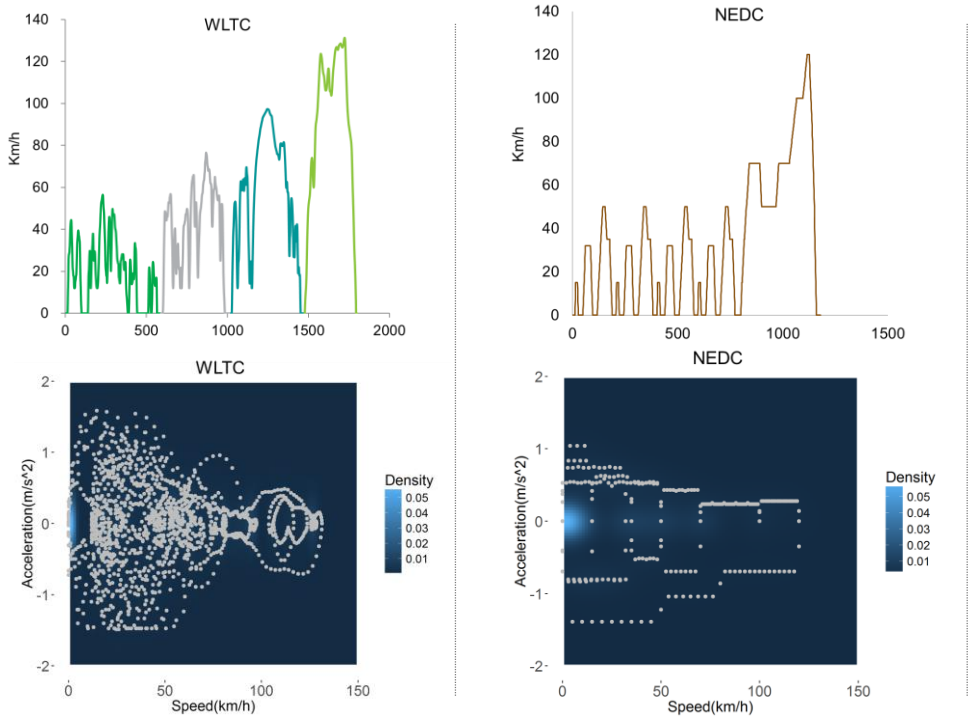
Actual FE Data – FY 2017-18

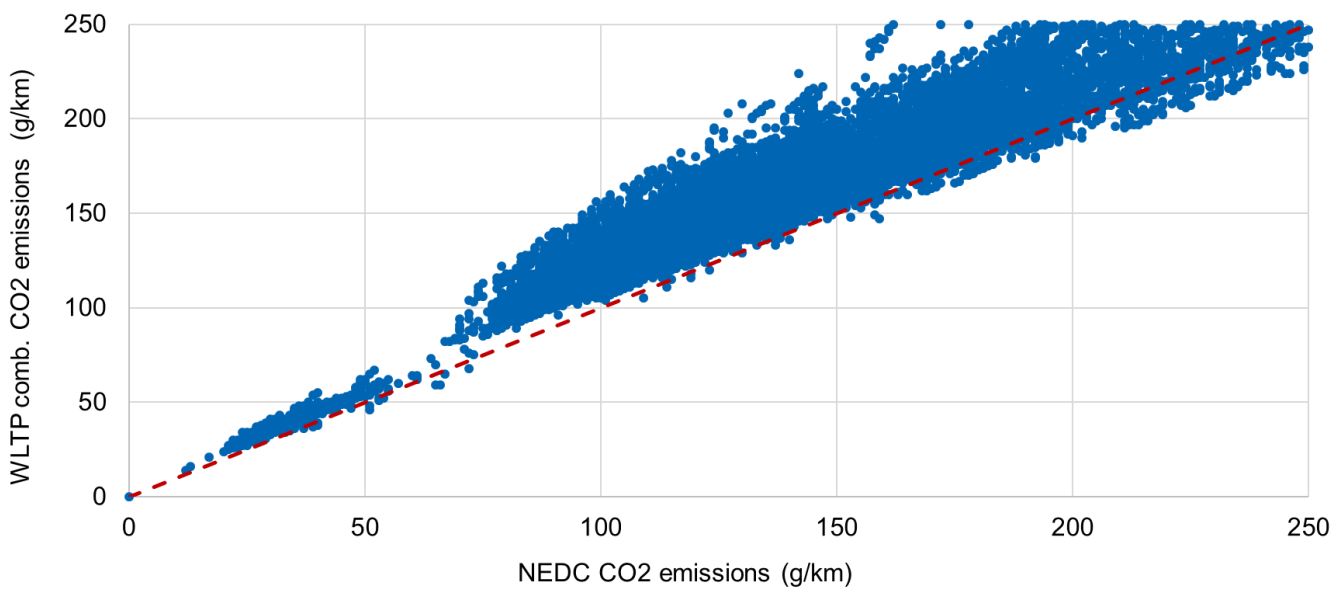


Note: Calculation factors in some sales number assumptions.

European homologation test cycle evolution

Impacts of the transition from NEDC to WLTC on the CO_2 road to target





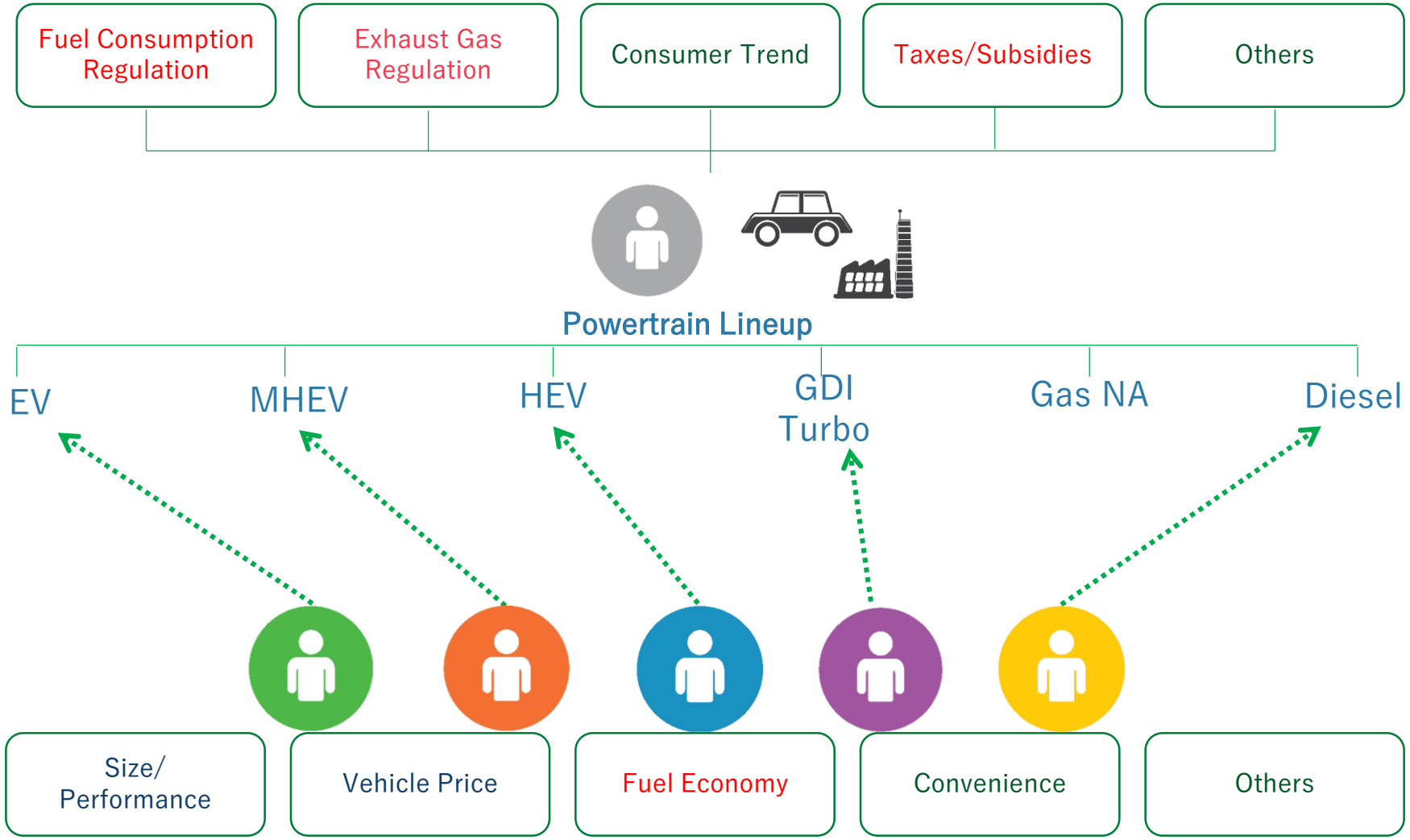
Notes: Test cycle comparison between NEDC and WLTP – Source IHS Markit

Source: IHS Markit VPaC EU

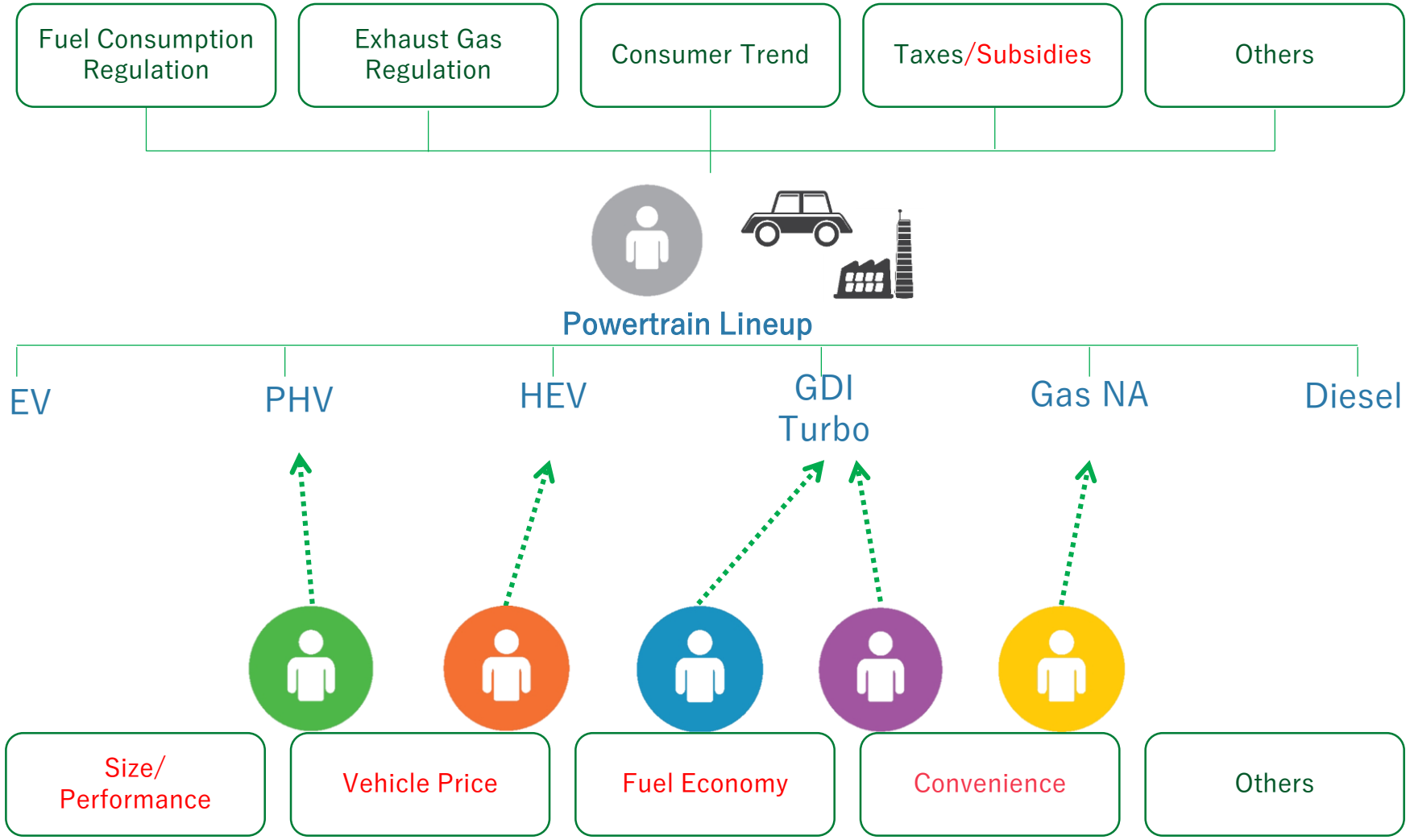
Simulation result comparison shows an estimated 20% average gap between WLTP CO_2 and current NEDC CO_2. This will make the OEMs' path to compliancy even harder.

Variables – Customer vs Carmaker

Variables – Mandated nature of requirements for **OEMs**



Variables – Open nature of requirements for **Customers**



Price Clusters – Influencing factors

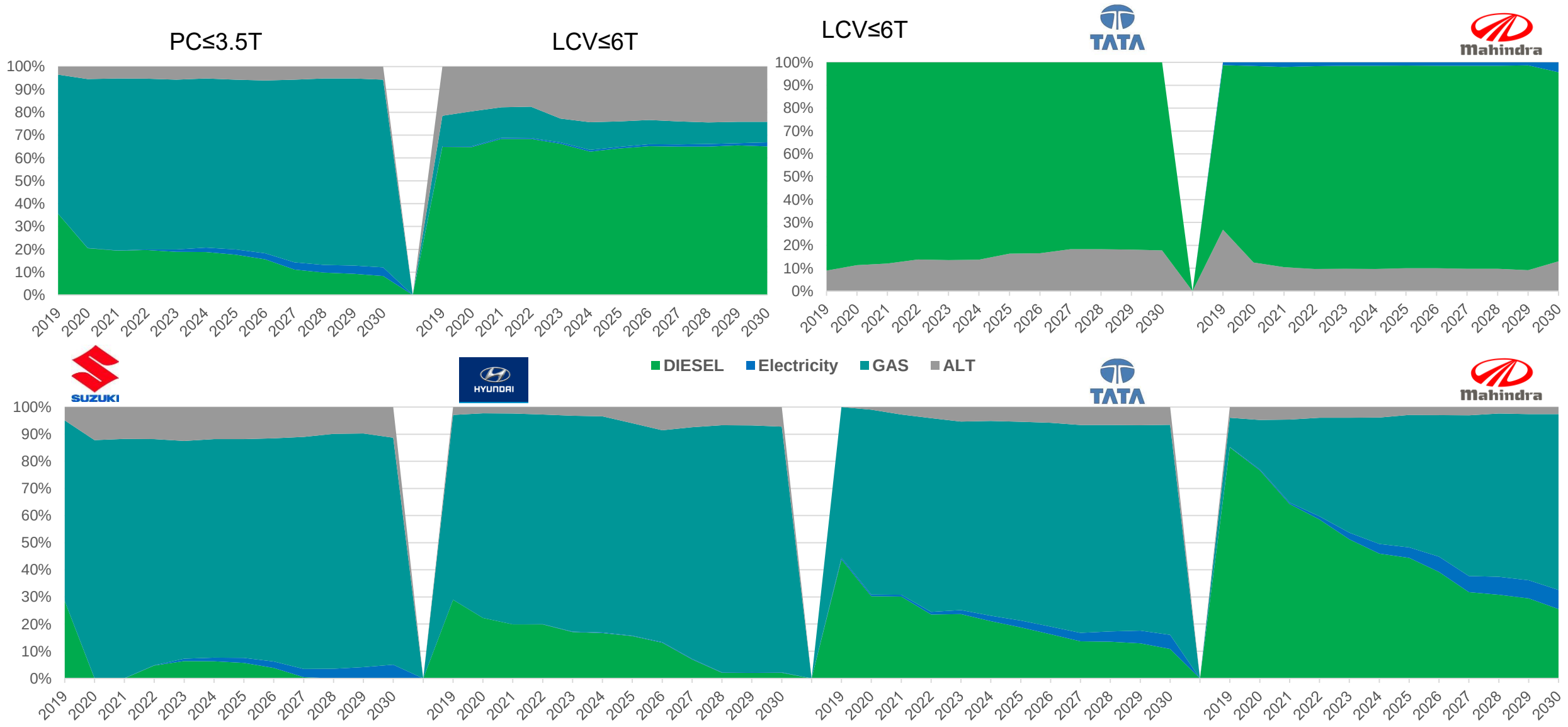
1 Importance 5

Price Class (₹)	TCO				Convenience/Technology/Safety								
	Initial Investment	Finance	Fuel economy	Maintenance cost	Power steering	Power window	Upholstery	Telematics	Performance	TM Design	NVH	Airbags	ABS
300000-500000													
500000-700000													
700000-900000													
900000-1.2mn													
1.2mn-1.5mn													
1.5mn-2mn													

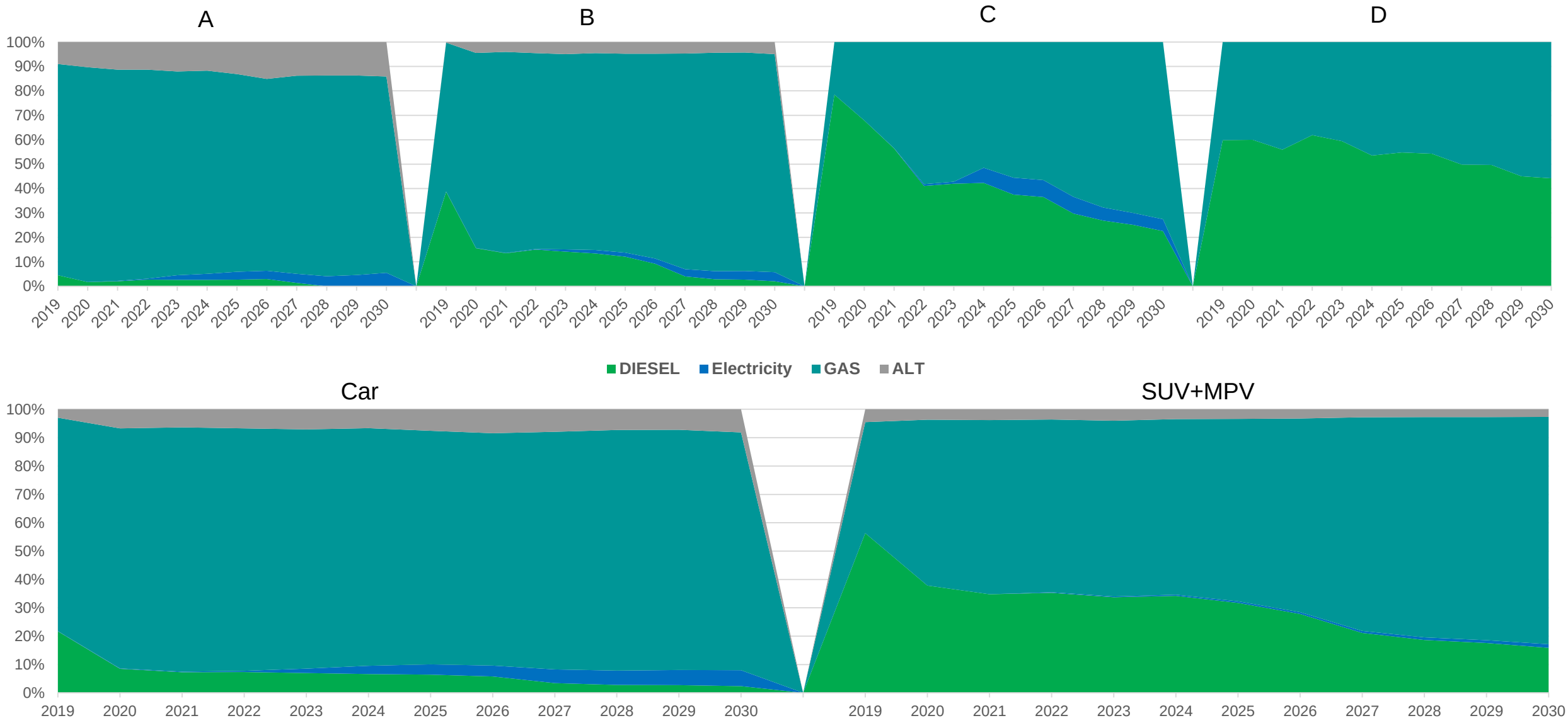
Source: IHSM internal research

Key Powertrain Trends

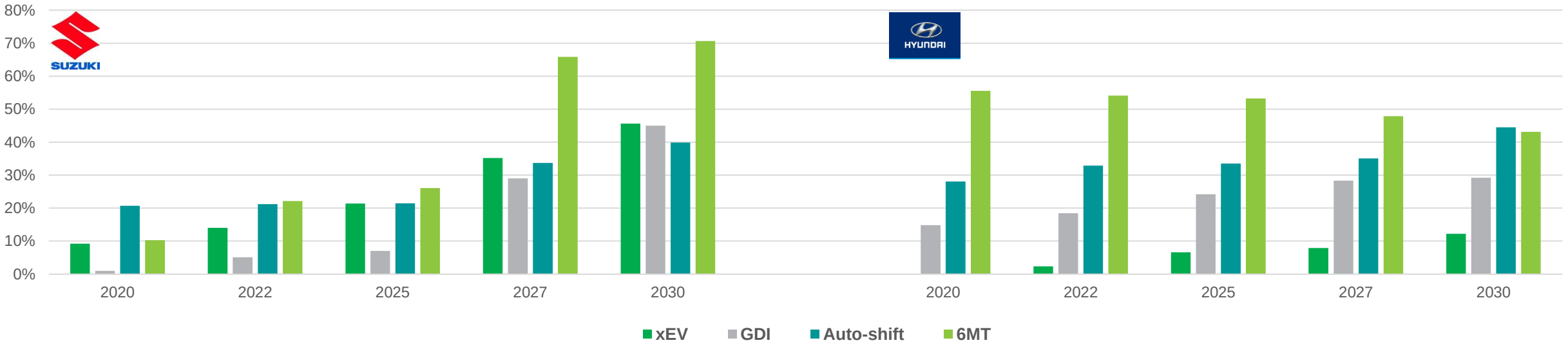
Diesel Share - OEMs

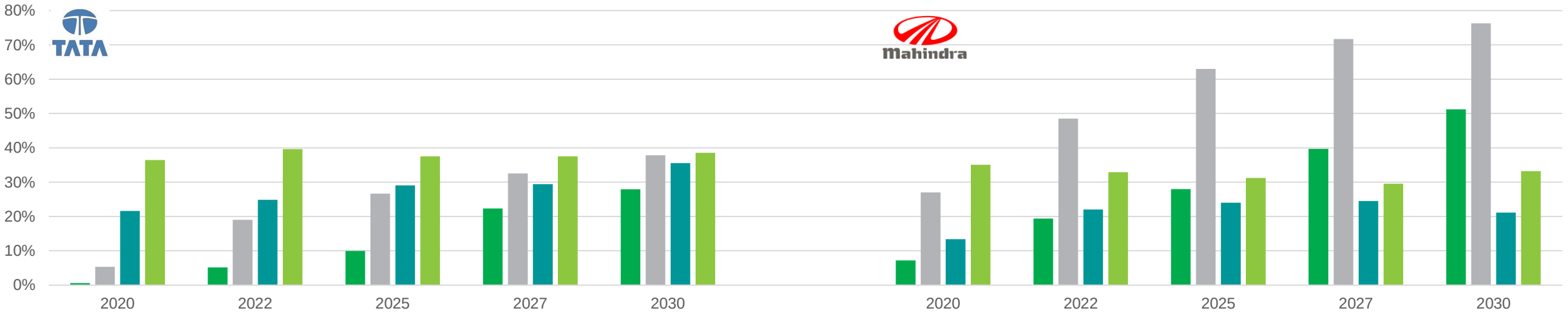


Diesel Share – Segments & Body-type (LVs)



Key Technologies - LVs





xEV = MHEV + HEV + PHEV + BEV

Challenges & Opportunities

Challenges & Opportunities

Government

- ***RDE implementation.***
- ***Shift to WLTC.***
- Urea supply for SCR tech.
- Certification and homologation.

Oil companies

- Supplying BS6 fuel across India on time.
- Huge investments (INR 80,000 crore ~ $11.5 bn).
- roduct mix prospects.

Opportunities

- Cleaner air
- Accessibility of advanced markets.
- Emission control tech manufacturers.

OEMs

- High compliance costs, hence higher vehicle prices.
- Risk of volume loss due to negative sentiments.
- Urea supply

- Uncertain business environment.
- Cost challenges.

RDE India

Driving condition	Speed (km/h)	Time	Remarks
Urban	V≤40	34% ± 10%	Time never <29%
Rural	40<V≤60	33% ± 10%	
Motorway	V>60	33% ± 10%	V≤90km/h

Challenges in Indian market

- Dense road traffic, extended idle: Critical for DPF Regeneration
- Extreme operating conditions: 0~5500m, -7ºC to 52ºC, Wide Humidity range.
- Low engine speed.
- Varying driving behavior and pattern.

Conformity Factor

- Will European estimations be followed?
- Phase I – 2.1 and Phase II – 1.4; then gradually moving to Phase III – RDE 1.0?

Validity of RDE Tests

- Start with power binning method or shift directly to moving average window (MAW) method?

In-Service Conformity

- The responsible authority for the ISC tests?

Conclusion

- Emission regulations continue to be the most significant driver of powertrain technologies.
  - > Transition to new Test cycle (WLTP) and stricter CO2 norms will become key drivers beyond 2025.
- Small car segments (A+, B and B+) would see rapid decline of diesel share post 2020.
- But, UV (SUVs, MUVs) segment would continue to be diesel-dominant in short- to mid-terms.
- LCVs/MHCVs will see rise in CNG but diesel will remain preferred fuel-type.
- Fleet segment could see more uptake of CNG vehicles, especially considering Maruti's aggressive CNG-push.

Thank you

IHS Markit Customer Care

CustomerCare@ihsmarkit.com
Americas: +1 800 IHS CARE (+1 800 447 2273)
Europe, Middle East, and Africa: +44 (0) 1344 328 300
Asia and the Pacific Rim: +604 291 3600

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