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Fuel consumption from new passenger cars in India: Manufacturers' performance in fiscal year 2020–21

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Keywords: India CO_2 standards, corporate average fuel consumption, CO_2 compliance and enforcement, GHG emissions, fuel efficiency

Introduction

Passenger vehicles sold in India have been subjected to fuel consumption standards established by the Ministry of Power since fiscal year (FY) 2017–18.[1] Since then, the ICCT has evaluated how well manufacturers of new vehicles sold complied with the standards.[2] Building on that, this paper examines the fuel consumption of manufacturer groups for passenger vehicles sold in FY 2020–21 and evaluates their readiness to meet more stringent requirements that will take effect in FY 2022–23. We evaluate new passenger vehicle performance and identify basic vehicle specifications by fuel type and manufacturer group. This paper also considers the potential impact of flexibility mechanisms on manufacturers' compliance with the standards.[3]

Additionally, the paper makes a technology comparison between best-in-class vehicles in Europe and India. India had been closely tracing Europe in terms of carbon dioxide (CO_2) emissions for the past decade, but the gap widened in 2020, as Europe adopted stringent regulations for 2025 and 2030. European manufacturers are adopting more advanced technologies in conventional internal combustion engine vehicles and there has been increased penetration of battery electric vehicles and plug-in hybrids in the market.

1 Passenger vehicles are considered M1 category if seating capacity is not more than eight seats, in addition to the driver's seat, and the gross vehicle weight does not exceed 3.5 tons. The category includes hatchbacks, sedans, SUVs, and crossovers. Note that the fiscal year in India runs from April 1 to March 31 of the following year. Ministry of Power, "Fuel Efficiency Notification," April 23, 2015, https://beeindia.gov.in/sites/default/files/Fuel%20Efficiency%20Notification%20%2823April2015%29.pdf.

2 Zifei Yang, Compliance with *India's first fuel consumption standards for new passenger cars (FY 2017–2018)*, (ICCT: Washington, DC, 2018), https://theicct.org/publications/compliance-india-fuel-consumption-standards-pv; Ashok Deo and Zifei Yang, *Fuel consumption of new passenger cars in India: Manufacturers' performance in fiscal year 2018–19,* (ICCT: Washington, DC, 2020), https://theicct.org/publications/fuel-consumption-pv-india-052020; Ashok Deo, *Fuel consumption of new passenger cars in India: Manufacturers' performance in fiscal year 2019–20,* (ICCT: Washington, DC, 2021), https://theicct.org/publications/fuel-consumption-pv-india-apr2021.

3 Flexibility mechanisms under the fuel consumption standards in India are super credits for electric vehicles, plug-in hybrid electric vehicles, and strong hybrids, and off-cycle credits for technologies such as start-stop, regenerative braking, tire-pressure monitoring systems, and 6-speed transmission.

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Our analysis is based on FY 2020–21 sales data and vehicle characteristic information from Segment Y Automotive Intelligence Pvt. Ltd.[4] As was the case with the earlier papers, the fuel economy data was checked against data from the Society of Indian Automobile Manufacturers (SIAM) and updated where appropriate.[5] Our data covers 99.9% of new vehicle sales in FY 2020–21.

Background

India is the fifth-largest passenger vehicle market in the world by sales volume, and SIAM data shows annual sales in FY 2020–21 reached 2.7 million (Figure 1). Compared with FY 2019–20, passenger car sales in FY 2020–21 dropped by 2%.

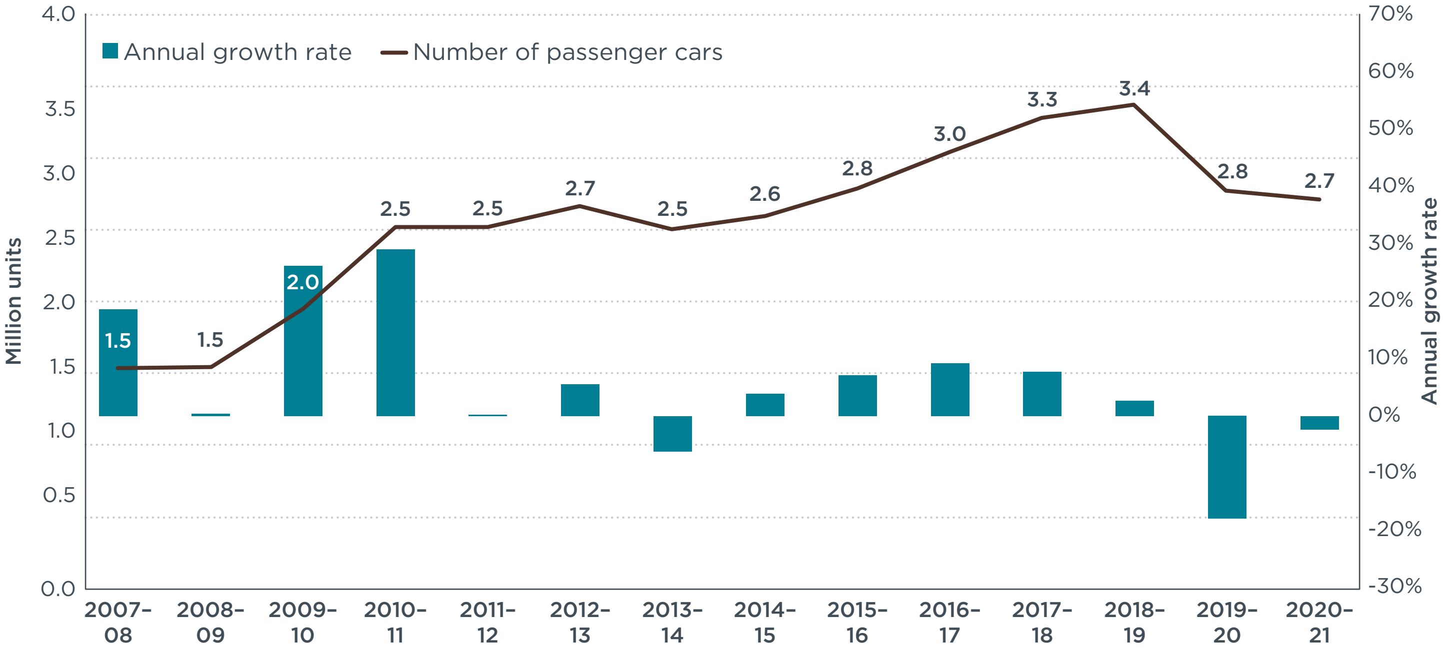

Figure 1. The trend of passenger car sales in India. Source: SIAM data.

In 2015, the Government of India established corporate average fuel consumption standards for passenger cars. They take effect in two phases: the first targets began in FY 2017–18 and the second are slated to begin in FY 2022–23. The standards are set in terms of gasoline-equivalent liters per 100 kilometers (L/100 km) and are adjusted based on vehicle curb weight.

In 2018, the Ministry of Road Transport and Highways (MoRTH)—the agency in charge of implementing the vehicle fuel consumption standards—finalized the document that describes how to determine the compliance of manufacturers with the fuel consumption standards.[6] In June 2021, the industry average curb weight for FY 2022–23 was revised from 1,145 kg to 1,081.83 kg. Since 2017, the industry average curb weight has been in the range of 1,095 kg to 1,065 kg (Figure 2). Therefore, the modification of the curb weight to 1,081.83 kg means the curb weight of passenger cars in FY 2022–23 will be

4 Segment Y Automotive Intelligence focuses on automotive markets in Asia. Annual data was purchased from Segment Y for FY 2006–07 through 2012–13, 2015–16, and 2017–18 through 2020–21.

5 The fuel economy of vehicles sold in fiscal 2020–21 is from SIAM, https://www.siam.in/uploads/filemanager/2344WFEDeclaration2019-20.pdf. For models that do not have SIAM fuel economy information, we collected information from voluntary reporting by manufacturers on manufacturers' website or advertising materials.

6 Ministry of Road Transport and Highways, "Administrative and Technical Procedure for Measurement and Monitoring [Average] Fuel Consumption in l/100 km of M1 Category Vehicles with GVW Not Exceeding 3500 kg," Amendment No. 7 to Doc. No.: MoRTH/CMVR/ TAP-115/116: Issue No.: 4, (2018), https://www.icat.in/pdf/Amendment_7_TAP_CAFE_23052018.pdf.

represented more realistically. All analysis in this paper was done with the revised curb weight of 1,081.83 kg for FY 2022–23.

The fuel consumption for compliance is measured as grams of CO_2 emissions per kilometer (g/km) during vehicle type approval. The factors to be used for converting consumption of different fuel types into gasoline-equivalent fuel consumption, and for converting from gasoline-equivalent fuel consumption to CO_2 emissions, are defined in the regulation.[7] Additionally, in a type-approval test, CO_2 is one of the emission parameters in the emissions report for all fuel types.

The CO_2 value provided by the manufacturer during type approval is called the declared value (DV).[8] The CO_2 value derived from the type-approval test should not exceed the DV by more than 4%. The accuracy of the DV is again checked during conformity of production (COP) tests. The CO_2 values used in our analysis are the DVs provided by the manufacturers.

The compliance document includes flexibility mechanisms that are intended to reduce compliance costs and promote innovative technologies that reduce CO_2 emissions. The flexibility mechanisms that would influence manufacturers' compliance with standards include off-cycle credits and super credits for battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and strong hybrid electric vehicles (HEVs).

Off-cycle credits aim to reward innovative technologies that produce real-world CO_2 savings beyond what is measured over a standardized test cycle during vehicle type approval. The compliance provisions allow manufacturers to use off-cycle credits for four technologies: regenerative braking, start-stop systems, tire-pressure monitoring systems (TPMS), and 6-speed or more transmissions. Note that TPMS is mandatory for safety under U.S. and EU regulations, but not in India. In India's standard, the CO_2 emissions values are multiplied by 0.98 for each off-cycle technology applied on a vehicle. Although manufacturers are also allowed to demonstrate the savings of technologies (1 g/km or more) other than the four on the list, the total CO_2 reduction due to the off-cycle credits of listed technologies or additional technologies cannot exceed 9 g/km.

Previous compliance reports published by the MoRTH showed that all car manufacturers met the fuel consumption standards for all years through FY 2019–20, when various flexibility mechanisms were taken into account.[9] This paper evaluates compliance for FY 2020–21 by referring to the fuel consumption standards and the rules for evaluating compliance by manufacturer groups. Fuel consumption standards and compliance are reported in terms of equivalent CO_2 emissions.

Historical fleet average CO_2 emissions

Our analysis shows that the sales-weighted, industry average CO_2 emissions for new passenger cars in India in FY 2020–21 was 121.3 g/km, including the flexibility mechanisms. The fleet average curb weight increased from 1,068 kg to 1,081 kg. The fleet target was 132.7 g/km, and it was met by a margin of 8.5%. Figure 2 shows the historical fleet average performance of CO_2 from FY 2006–07 to FY 2020–21.

7 Fuel types include gasoline, diesel, liquid petroleum gas, compressed natural gas, and electricity. Gasoline equivalent fuel consumption (liters/100 km) = 0.04217 (g/liter) × CO_2 emissions (g/km) CO_2 emissions (g/km) = 2371.35/ fuel economy (kmpl).

8 Ministry of Road Transport and Highways, "Administrative and Technical Procedure for Measurement and Monitoring [Average] Fuel Consumption."

9 Ministry of Road Transport and Highways, "Annual Fuel Consumption Compliance Report for M1 Category of Vehicles with GVW not Exceeding 3500 kg," https://morth.gov.in/sites/default/files/circulars_document/Annual%20Fuel%20Consumption%20report%20for%202019-20.pdf.

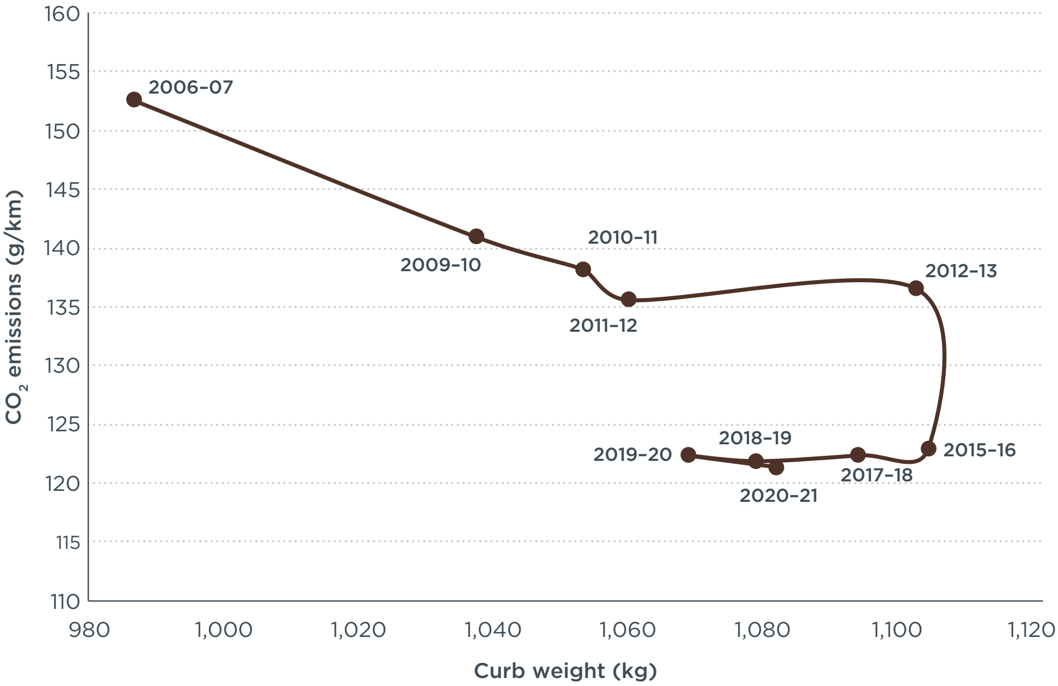

Figure 2. Trend of historical fleet average CO_2 performance with flexibility mechanisms and curb weight.

In the 10 years from FY 2009–10 to FY 2019–20, average CO_2 emissions decreased 1.4% a year, whereas average curb weight rose 0.5% annually. The three-year period between FY 2012–13 and FY 2015–16 saw the sharpest decline in CO_2 emissions, averaging reductions of 3.4% per year, along with the smallest increase in curb weight of 0.2% a year. From FY 2015–16 onward, the fleet average curb weight started dropping and reached 1,068 kg in 2019–20; it then slightly increased by 1.2% to 1,081 kg in FY 2020–21. This trend is mainly due to the decrease in the market share of diesel vehicles (Figure 3). In FY 2018–19 and FY 2019–20, the fleet average CO_2 emissions remained relatively flat, and they decreased by 0.8% in FY 2020–21.

Market and technology fleet specifications

Bharat Stage (BS) VI emission standards were implemented on April 1, 2020. This makes analyzing FY 2020–21 fleet characteristics particularly interesting, as BS VI requires diesel vehicles to contain advanced emission control technologies that increase the upfront cost. As a result, the market share of diesel vehicles declined from 30% in FY 2019–20 to 17.8% in FY 2020–21. Currently, only diesel engines 1,500 cc and larger have a sizeable market share. Most of the small car manufacturers that earlier had close to an equal mix of diesel and gasoline vehicles stopped selling diesel variants and developed turbocharged gasoline variants to take their place.

Figure 3 plots the recent trend of market share of annual new passenger vehicle sales by fuel type, and Figure 4 shows the share of turbocharged gasoline vehicles rose to 9.5%.

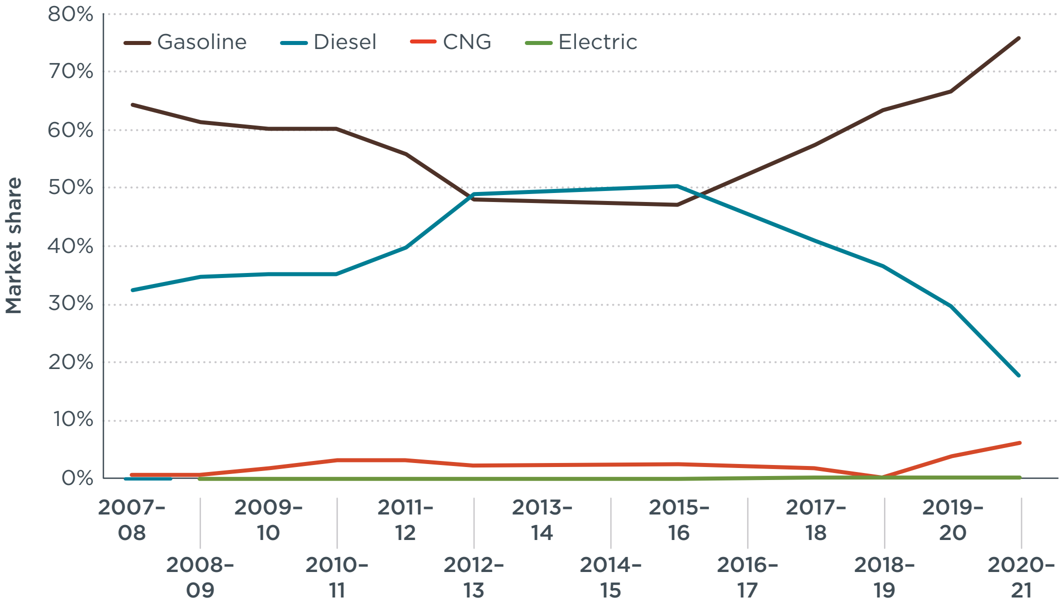

Figure 3. Trends of passenger vehicle sales in India by fuel type.

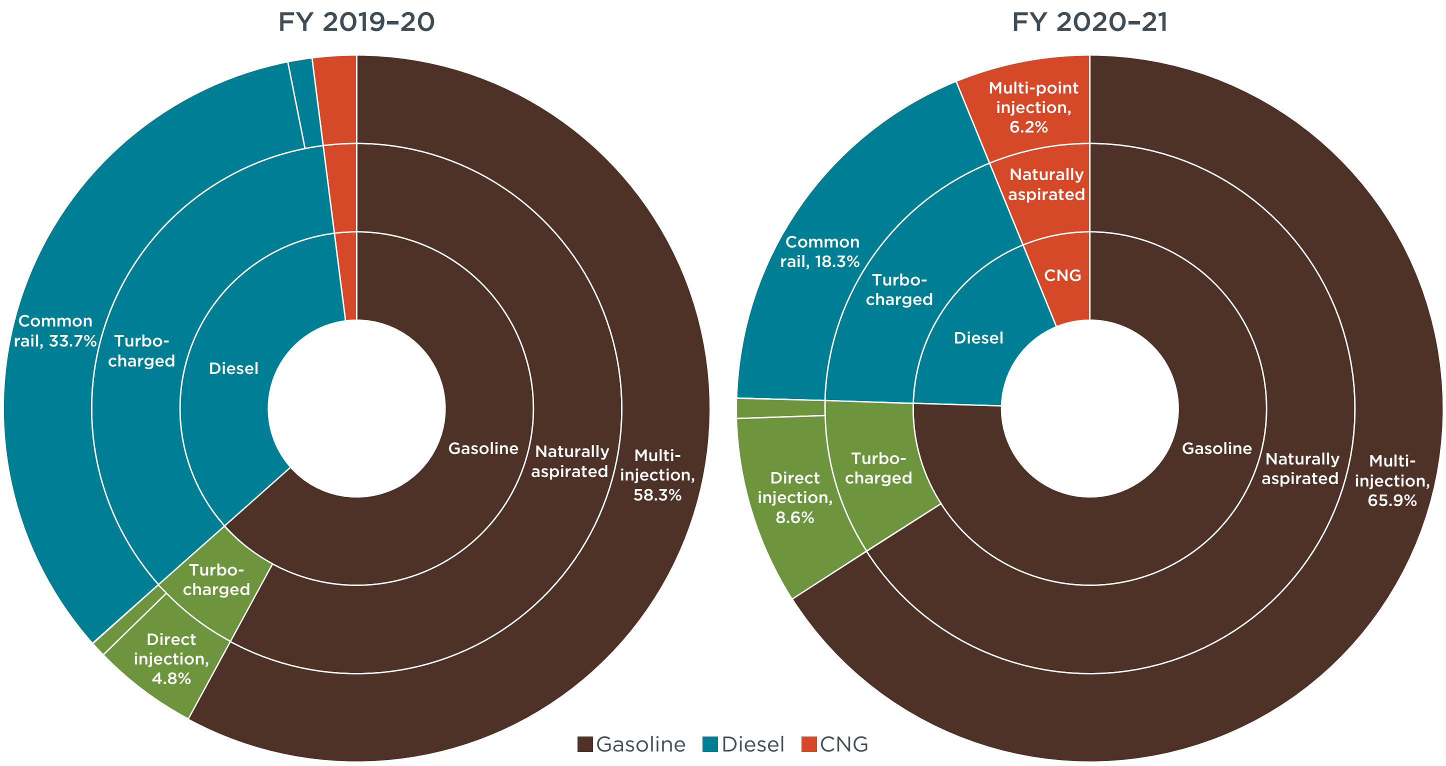

Figure 4. Comparison of gasoline and diesel fuel injection technologies in new vehicle sales in FY 2019–20 and FY 2020–21.

Figure 5 shows the market share of the top 15 passenger car manufactures in India in FY 2020–21. Maruti and Hyundai maintained the top two positions from the prior year with market shares of 47.2% and 17.2%, respectively. The top five manufacturers had 84.2% of the market, and thus they mostly govern industry trends in terms of new technologies and CO_2 emissions. Tata, which was fourth the prior year in terms of market share, improved its position to third place in FY 2020–21. Kia moved up to fourth position based on its sales of sport utility vehicles (SUVs).

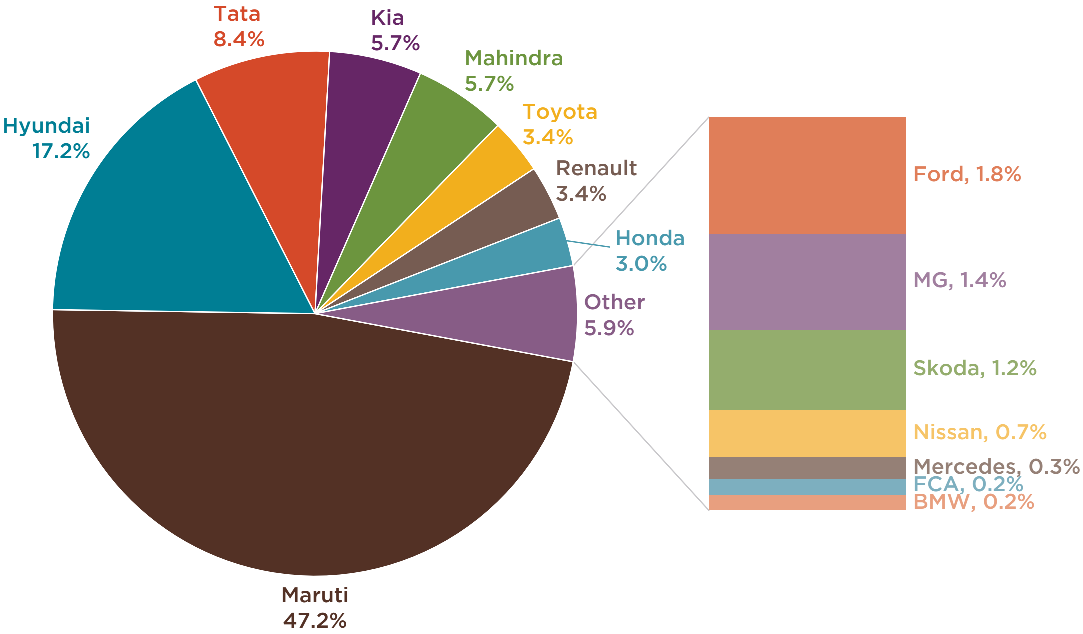

Figure 5. Market share of top manufacturers in FY 2020–21.

Manufacturers also developed turbocharged gasoline engines for the heavier SUVs, which were previously predominantly diesel. The gasoline variants are significantly better closing the gap with diesel in terms of fuel efficiency and engine torque. All the models in the diesel segment in FY 2020–21 use common rail technology.

Figure 6 plots the historical trend of curb weight and engine displacement of new vehicles sold by fuel type. The market share of electric vehicles in FY 2015–16 was 0.03%, and this increased to 0.2% in FY 2020–21. The market share of compressed natural gas (CNG) vehicles also increased during the same period, from 0.1% in FY 2015–16 to 6.2% in FY 2020–21. The decrease in the share of diesel vehicles sold impacted the average curb weight and average engine displacement of all major passenger car manufacturers, as the diesel fleet has always been heavier and more powerful than the gasoline fleet.

Figure 6. Trend of fleet average curb weight and engine displacement by fuel type.

Even though both diesel and gasoline vehicles are increasing in curb weight and engine displacement, the combined average weight has decreased slightly since FY 2015–16. In FY 2020–21, the average displacement for diesel vehicles was 1,731 cc, 45.7% higher than the average gasoline displacement of 1,188 cc, and the average curb weight of diesel vehicles was 1,526 kg, 35.7% higher than the gasoline average curb weight of 980 kg. As a result of the declining market share of diesel, in FY 2019–20, the fleet had an average curb weight of 1,068 kg; in FY 2020–21 it was higher by 1.2% at 1,081 kg, due to an increase in heavier SUVs and CNG vehicles. Average displacement for FY 2019–20 was 1,295 cc, and it decreased to 1,282 in FY 2020–21 due to reduced sales of diesel cars.

The average ratio of passenger cars to SUVs/vans was roughly 4:1 between FY 2006–07 and FY 2011–12. This ratio shifted suddenly by about 10% toward SUVs/vans in FY 2012–13. Then through FY 2019–20, the market share of SUVs hovered around 30%, and in FY 2020–21, the market share of SUVs increased to 36%, and the average ratio with passenger cars was 1:1.8.

Figure 7 illustrates these trends.

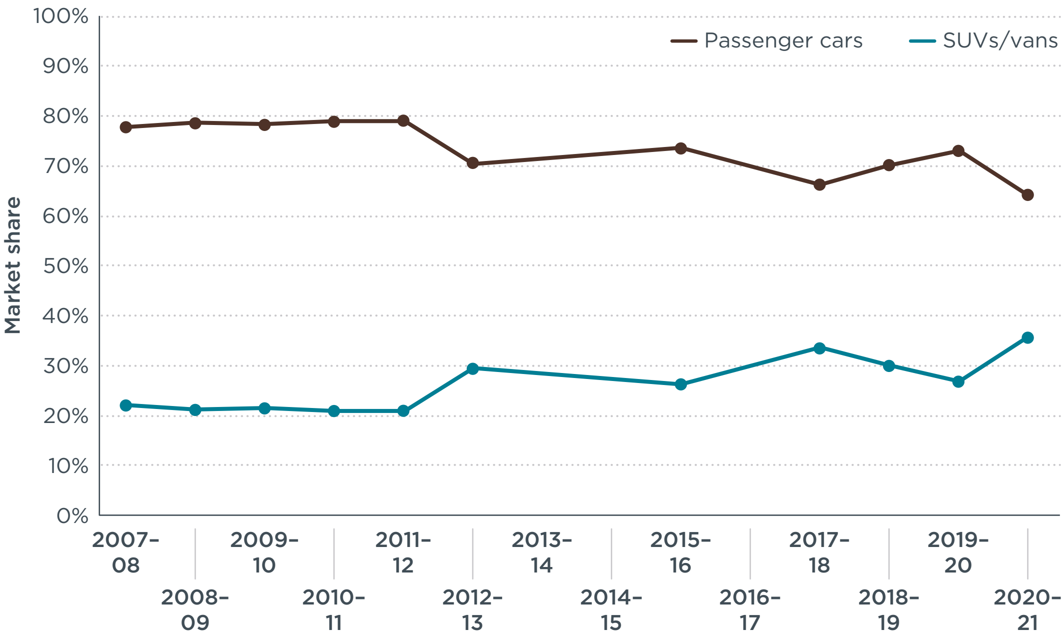

Figure 7. Trend of market share by vehicle type.

Figure 8 shows the fuel mix for all passenger car manufacturers in India. Skoda, Nissan, and Renault have 100% gasoline fleets and stopped selling diesel variants. For Force and Isuzu, their entire fleets are diesels, but their overall market share is much smaller. Maruti and Hyundai are the only brands that are aggressively promoting CNG cars. Maruti has largest share of 11.7% with CNG models like the WagonR, Alto, Celerio, S-Presso, Eeco, and Ertiga. Hyundai's 4% CNG market share puts it in second, and it sells models like the Aura, Santro, Xcent, and Grand i10 Nios.

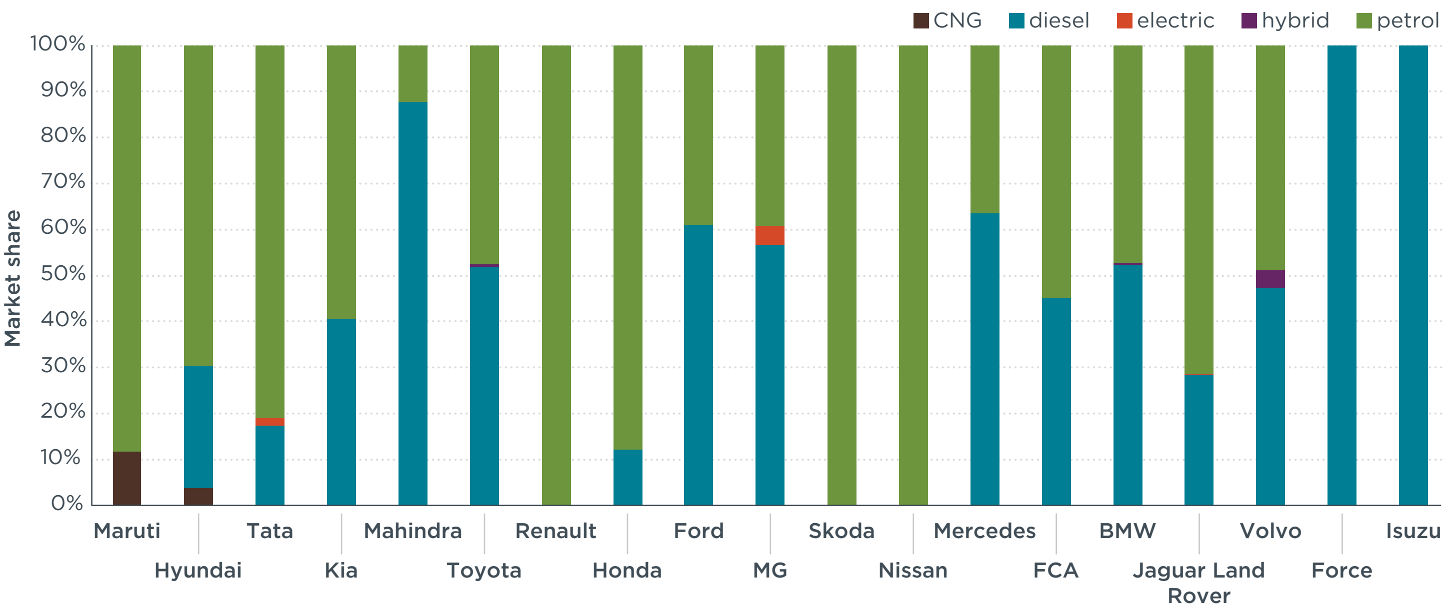

Figure 8. Market share of fuel types for manufacturers in FY 2020–21. Note that the hybrids shown in the chart are full hybrids.

Under its Mission Green Million strategy, Maruti Suzuki is promoting CNG and hybrid cars to offset the discontinuation of its diesel segment.[10] There are several factors that have led to the growth of CNG vehicle sales, and one is the noticeable growth in CNG refilling stations across India. Additionally, in FY 2020–21, diesel and gasoline prices increased continuously, and that shifted customers toward the cheaper CNG fuel alternative.

CO_2 compliance by manufacturer

Table 1 presents our estimates of the annual corporate average CO_2 performance and the average CO_2 target for all manufacturers. Note that the CO_2 target varies based on average curb weight. The table also details the market share of each corporate group.

According to the compliance standard, corporate group is defined as having a minimum of 51% direct shareholding in each manufacturing company by the group. This may be considered as one manufacturer for the purpose of complying with fuel consumption standards. Further, Segment Y data provides information on 6-speed transmissions, regenerative braking, start-stop, TPMS, electric variants, and hybrid vehicles.

The list of manufacturers is the same in FY 2020–21 as in FY 2019–20. Based on sales volumes in FY 2020–21, Jaguar Land Rover, Force Motors, Volvo, and Isuzu should all be categorized as small manufacturers. Small car manufacturers are considered compliant under the provisions that set the FY 2020–21 target for small volume manufacturers at actual performance.

Table 1. Market share, curb weight, and CO_2 performance including flexibility mechanisms for BEVs, PHEVs, and hybrids, for passenger cars in FY 2020–21.

	FY 2020–21							FY 2022–23				
Corporate group	Market share (%)	Curb weight (kg)	Target (g/km)	Performance w/o flexibility mechanism (g/km)	Performance with flexibility mechanism (g/km)	Exceedence (gap) without flexibility mechanisms (%)	Exceedence (gap) with flexibility mechanisms (%)	Target for 2022–23 standard using industry average weight of 1,145 kg (g/km)	Target for 2022–23 standard using industry average weight of 1,081.83 kg (g/km)	Gap without flexibility mechanisms (%)	Gap with flexibility mechanisms (%)	Small manufacturer
Maruti	47.2%	911	123.1	112.7	111.8	8.4%	9.1%	102.0	105.0	-7.3%	-6.5%	N
Hyundai	17.2%	1109	134.4	123.1	120.6	8.4%	10.3%	111.4	114.4	-7.6%	-5.4%	N
Tata	8.4%	1144	136.3	126.3	121.6	7.4%	10.8%	113.1	116.1	-8.8%	-4.7%	N
Kia	5.7%	1305	145.5	134.5	130.8	7.5%	10.1%	120.7	123.7	-8.8%	-5.8%	N
Mahindra	5.7%	1647	164.9	158.5	153.5	3.9%	7.0%	136.9	139.9	-13.3%	-9.7%	N
Toyota	3.4%	1481	155.5	151.8	148.5	2.4%	4.5%	129.0	132.0	-15.0%	-12.5%	N
Renault	3.4%	870	120.8	120.8	120.7	0.0%	0.1%	100.1	103.1	-17.2%	-17.1%	N
Honda	3.0%	1029	129.8	129.3	127.4	0.4%	1.8%	107.6	110.6	-16.9%	-15.2%	N
Ford	1.8%	1344	147.7	138.4	136.9	6.3%	7.3%	122.5	125.5	-10.3%	-9.1%	N
MG	1.4%	1718	169.0	156.4	141.4	7.4%	16.3%	140.3	143.3	-9.2%	1.3%	N
Skoda	1.2%	1176	138.2	136.4	133.5	1.3%	3.3%	114.6	117.6	-16.0%	-13.6%	N
Nissan	0.7%	914	123.3	122.5	121.6	0.7%	1.3%	102.2	105.2	-16.5%	-15.7%	N
Mercedes	0.3%	1929	181.0	172.0	163.1	5.0%	9.9%	150.3	153.3	-12.2%	-6.4%	N
FCA	0.2%	1544	159.1	161.5	156.9	-1.5%	1.4%	132.0	135.0	-19.7%	-16.2%	N
BMW	0.2%	1812	174.3	164.6	155.2	5.6%	11.0%	144.7	147.7	-11.4%	-5.1%	N
Jaguar Land Rover	0.1%	1852	176.6	180.9	172.2	-2.4%	2.5%	142.9	142.9	-26.6%	-20.5%	Y
Volvo	0.0%	1878	178.1	158.1	145.6	11.2%	18.2%	120.9	120.9	-30.9%	-20.5%	Y
Force	0.0%	2011	185.7	213.6	213.6	-15.0%	-15.0%	177.3	177.3	-20.5%	-20.5%	Y
Isuzu	0.0%	2010	185.6	215.3	215.3	-16.0%	-16.0%	178.7	178.7	-20.5%	-20.5%	Y
Total	**100.0%**	**1081**	**132.7**	**123.5**	**121.3**	**7.0%**	**8.6%**	**110.1**	**113.1**	**-9.2%**	**-7.3%**	**—**

Because the compliance targets are based on curb weight, and Maruti has a lighter-than-average fleet, it has to meet a more stringent target than the industry average target. In the table, we use the manufacturer sales-weighted average weight of FY 2020–21 to calculate the FY 2022–23 targets for each manufacturer. The FY 2022–23 CO_2 targets are based on recently revised industry-average curb weight of 1,081.83 kg. Assuming that the fleet average curb weight remains the same as FY 2020–21, the industry fleet

10 Maruti Suzuki, "About Mission Green Million," accessed July 2021, https://www.marutisuzuki.com/auto-expo-2020/mission-green-million.html.

average CO_2 target in FY 2022–23 will be 113.1 g/km. Therefore, the new passenger car fleet will need to reduce CO_2 emissions/fuel consumption by only 6.8% in the next two years, or about 3.5% annually.

Table 1 also includes the margins with respect to both the target for FY 2020–21 and the upcoming FY 2022–23 target. Among 15 manufacturers, MG and Volvo are already meeting the compliance targets for FY 2022–23. Meanwhile, FCA, Jaguar Land Rover, Force, Renault, and Isuzu are not complying with the FY 2020–21 targets before the application of flexibility mechanisms, and Force and Isuzu are also not complying with the targets after application of flexibility mechanisms. Recall, though, that Isuzu and Force do not need to meet compliance targets, as they qualify as small manufacturers with total sales of fewer than 5,000 units per year. Force and Isuzu are also identified as small car manufacturers in last year's MoRTH's compliance report. The FY 2022–23 targets for these small manufacturers will be 17% below their FY 2017–18 performance.

Renault, Skoda, Toyota, FCA, and Nissan are meeting their targets with less than a 5% margin when flexibility mechanisms are taken into account. The larger the margin with the current target, the more these manufacturers will have to improve to meet FY 2022–23 standards; many will have to reduce fuel consumption by another 14%–20% including flexibility mechanisms.

India's FY 2022–23 standards are much less stringent than the EU 2021 standards. Figure 9 compares the EU and India standards and presents a pictorial representation of the annual corporate performance of all Indian manufacturers as a function of average curb weight without flexibility mechanisms or super credits.

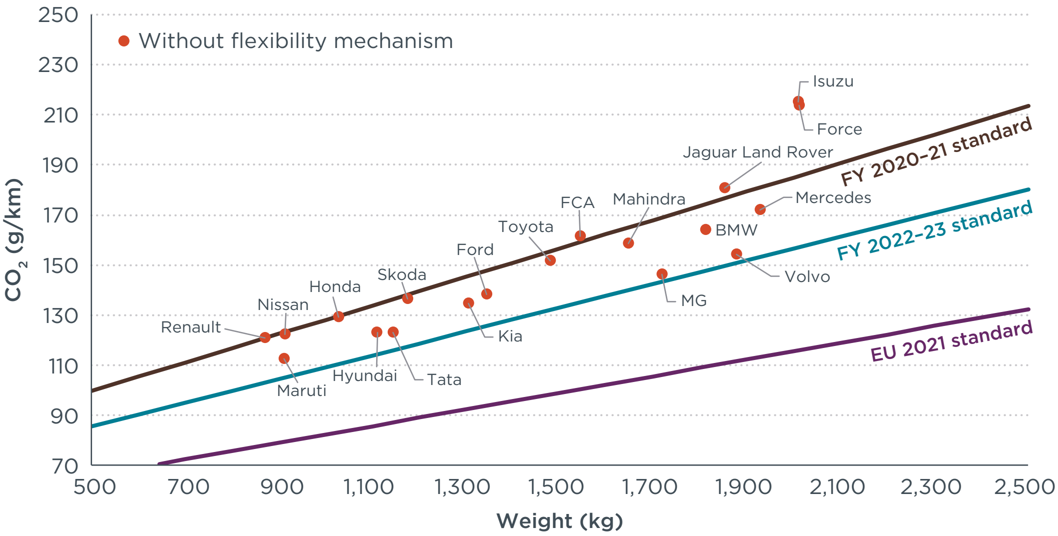

Figure 9. CO_2 performance of corporate group in FY 2020–21 without flexibility mechanisms.

Figure 10 gives a similar pictorial representation of corporate performance, this time including flexibility mechanisms. This chart shows that manufacturers like Jaguar Land Rover and FCA have clearly benefited from these flexibility mechanisms.

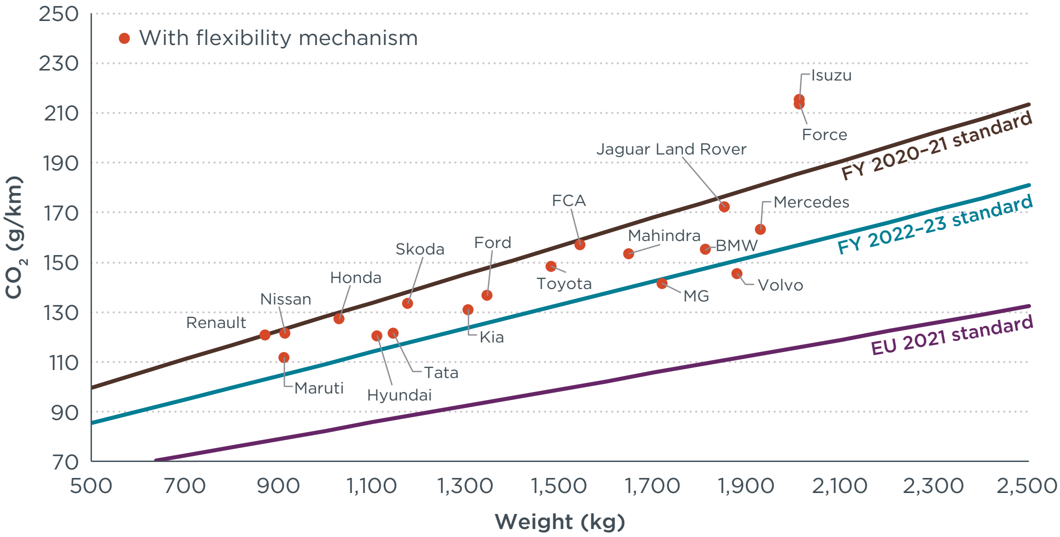

Figure 10. CO_2 performance of corporate groups in FY2020–21 with flexibility mechanisms.

Figure 11 compares CO_2 values of FY 2018–19, FY 2019–20, and FY 2020–21 for the top 12 manufacturers. Except for Renault and Nissan, all manufacturers improved their performance with respect to the previous year. MG is already meeting the FY 2022–23 standard, but Mahindra, Renault, Nissan, and Skoda have a wider gap to bridge in the coming years.

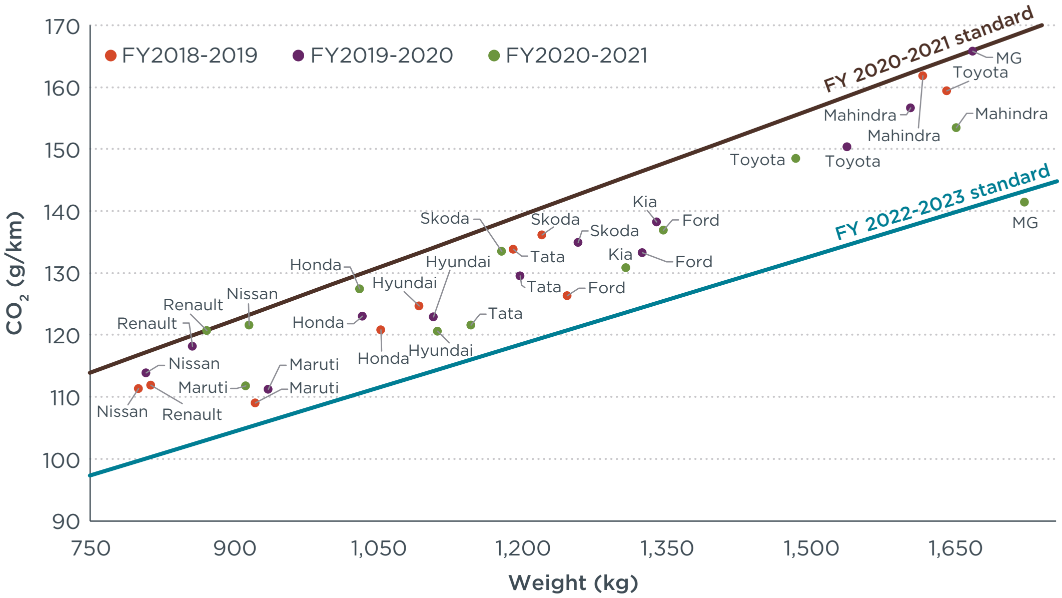

Figure 11. Fleet average CO_2 emissions of the top 10 manufacturers FY 2018–19, 2019–20, and 2020–21.

The impact of flexibility mechanisms

The maximum benefit of flexibility mechanisms—the off-cycle credits for technologies such as start-stop, TPMS, regenerative braking, and 6-speed transmission—is capped at 9 gCO_2/km per vehicle. The standards also allow super credits from sales of electric vehicles and hybrid vehicles. For the purpose of calculating the corporate average CO_2 performance, a manufacturer uses a volume derogation factor of 3 for BEVs, 2.5 for PHEVs, and 2 for strong HEVs. This means that a BEV counts as 3 vehicles, a PHEV as 2.5 vehicles, and a strong HEV as 2 vehicles when calculating fleet average CO_2 emissions. The fuel consumption of the electricity driving portion for BEVs and PHEVs is converted from electricity consumption based on an equation provided in the regulations.

Table 2 summarizes the impact of flexibility mechanisms in terms of CO_2 g/km and the average CO_2 emissions level with and without the flexibility mechanisms. Benefits achieved through the sale of electric and hybrid vehicles, and benefits achieved through the 6-speed, TPMS, regenerative braking, and start-stop technologies are listed under the overall impact of flexibility mechanisms. While BMW, Mercedes, and Volvo are fully using their flexibility mechanisms to 9 gCO_2, Renault, Nissan, and Maruti are using less than 1 gCO_2 of flexibility mechanisms.

Table 2. Effect of flexibility mechanisms on CO_2 emissions by corporate group in FY 2020–21.

Corporate group	Target (g/km)	Avg CO_2 w/o flexibility mechanism (g/km)	Impact of flexibility mechanisms (g/km)			With flexibility mechanisms (g/km)	Small manufacturer
			Supercredits	Off-cycle credits	Total		
Maruti	123.1	112.7	0.0	-0.9	-0.9	111.8	N
Hyundai	134.4	123.1	-0.1	-2.4	-2.5	120.6	N
Tata	136.3	126.3	-3.3	-1.5	-4.7	121.6	N
Kia	145.5	134.5	0.0	-3.7	-3.7	130.8	N
Mahindra	164.9	158.5	0.0	-5.0	-5.0	153.5	N
Toyota	155.5	151.8	-0.2	-3.0	-3.2	148.5	N
Renault	120.8	120.8	0.0	-0.1	-0.1	120.7	N
Honda	129.8	129.3	0.0	-1.9	-1.9	127.4	N
Ford	147.7	138.4	0.0	-1.5	-1.5	136.9	N
MG	169.0	156.4	-9.9	-5.1	-15.0	141.4	N
Skoda	138.2	136.4	0.0	-2.9	-2.9	133.5	N
Nissan	123.3	122.5	0.0	-0.8	-0.8	121.6	N
Mercedes	181.0	172.0	0.0	-8.9	-8.9	163.1	N
FCA	159.1	161.5	0.0	-4.6	-4.6	156.9	N
BMW	174.3	164.6	-0.4	-9.0	-9.4	155.2	N
Jaguar Land Rover	176.6	180.9	-0.3	-8.5	-8.7	172.2	Y
Volvo	178.1	158.1	-3.7	-8.8	-12.5	145.6	Y
Force	185.7	213.6	0.0	0.0	0.0	213.6	Y
Isuzu	185.6	215.3	0.0	0.0	0.0	215.3	Y
Total	**132.7**	**123.5**	**-0.4**	**-1.8**	**-2.2**	**121.3**	**—**

Because most of the mass-market manufacturers are not using the flexibility mechanisms in all of their vehicles, there remains a lot of potential to reduce the gap with the FY 2022–23 fleet average targets via more widespread use of them. Note, too, that the allowed off-cycle credits are cheaper in terms of cost when compared with expensive technologies that generate super credits, such as electric vehicles and strong hybrids. Manufacturers already equipped some percentage of their newly launched vehicles in FY 2020–21 with the technology and are likely to implement them in most of their models in the future. This means that manufacturers are likely to prefer to use the maximum off-cycle credits benefit of 9 gCO_2/km before shifting to other technologies.

Table 3 lists the market share of vehicles equipped with flexibility mechanisms by corporate group. As you can see, corporate groups that sell luxury or high-end vehicles are 100% equipped with most of the flexibility mechanisms. The share of flexibility mechanisms also increased from FY 2019–20 to FY 2020–21 in such vehicles, including those from Mercedes-Benz, BMW, and Jaguar. The trend for 6-speed transmission and start-stop is increasing in mass-market passenger cars, too.

Table 3. Comparison of vehicles equipped with flexibility mechanisms in FY 2019–20 and 2020–21.

Manufacturer	6-speed transmission (%)		Regenerative braking (%)		TPMS (%)		Start stop (%)	
	FY 2019–20	FY 2020–21	FY 2019–20	FY 2020–21	FY 2019–20	FY 2020–21	FY 2019–20	FY 2020–21
Mercedes	100.0	100.0	27.9	78.3	98.9	100.0	98.9	100.0
BMW	100.0	100.0	97.7	100.0	97.7	97.4	97.6	100.0
Jaguar	100.0	100.0	26.8	23.0	74.6	100.0	74.6	73.3
Volvo	100.0	100.0	52.3	100.0	74.0	100.0	66.7	100.0
MG	100.0	100.0	16.3	10.1	56.4	54.7	12.7	12.9
Kia	100.0	88.3	—	—	55.0	47.4	—	—
FCA	98.7	100.0	—	0.4	0.1	1.8	0.3	42.8
Toyota	49.1	29.9	8.7	14.3	2.0	1.0	46.0	54.4
Tata	46.3	39.1	2.8	1.7	0.4	5.3	13.4	10.3
Mahindra	45.8	60.5	8.0	0.5	12.9	18.6	46.5	84.4
Hyundai	45.2	53.8	0.2	—	1.5	41.2	—	—
Honda	37.4	48.7	—	—	—	24.7	0.5	—
Skoda	28.5	75.8	2.6	12.7	5.6	14.9	2.6	13.2
Nissan	16.4	13.9	—	—	—	14.0	—	3.0
Ford	14.7	15.5	—	—	10.9	15.2	18.9	12.3
Maruti	5.5	4.4	9.3	10.7	—	—	9.3	21.9
Renault	4.9	2.2	—	—	—	—	—	1.3
Force	—	—	—	—	—	—	—	—
Isuzu	—	—	—	—	—	—	—	—

Figure 12 shows the increase in usage of flexibility mechanisms for the entire fleet in FY 2020–21 when compared with FY 2019–20. TPMS showed the most growth across all manufacturers. Regenerative braking showed the least growth, likely because of its higher cost compared with the others.

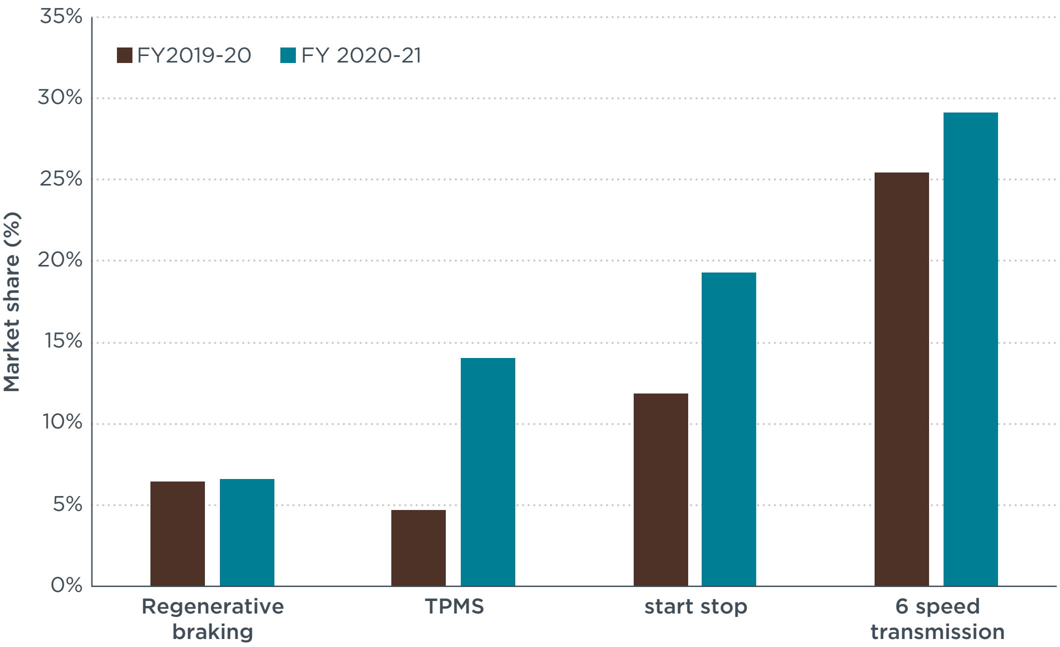

Figure 12. Comparison of flexibility mechanisms for FY 2019–20 and FY 2020–21.

Table 4 gives the market share of CNG, electric, PHEV, strong hybrid, 48V, and advanced micro-hybrid sales volumes for manufacturers in comparison with their total sales volume. Higher sales of advanced micro-hybrids and CNG vehicles shows increased market acceptance of low fuel consumption vehicles. India's EV market is still at nascent stage with less than 1% market share of electrics and PHEVs. There are many challenges currently. For one, as compared with conventional (ICE) vehicles, electrics in the same segment are more expensive. This is primarily because of the higher cost of the battery and other technologies used in the EVs, as these constitute a substantial portion of the overall vehicle cost. These extra costs also do not leave much avenue for including features usually available in vehicles of a similar price category.

However, the central government is prioritizing the shift toward EVs with schemes such as FAME II and Production Linked Incentive Scheme (PLI) for Advanced Cell Chemistry (ACC) battery manufacturing. This will support the EV supply chain, and with batteries made locally, the cost of electric vehicles is expected to drop. Manufacturers such as Tata are planning to launch more EV models, and that will help provide customers with a wide range of products.[11]

Table 4. Share of CNG, electric, strong hybrids, advanced micro-hybrid, 48V hybrid, and PHEV in total sales volume in FY 2020–21.

Manufacturer	CNG (%)	Advanced micro- hybrid (%)	48V hybrid (%)	Strong hybrid (%)	PHEV (%)	Electric (%)
Maruti	11.68	10.10	—	—	—	—
Hyundai	3.96	—	—	—	—	0.04
Tata	—	—	—	—	—	1.67
Mahindra	—	—	—	—	—	0.01
Toyota	—	—	—	0.61	—	—
MG	—	—	6.08	—	—	4.21
Mercedes	—	—	3.87	—	—	—
BMW	—	—	—	—	0.40	—
Jaguar Land Rover	—	—	—	—	—	0.09
Volvo	—	—	—	—	3.75	—

Table 5 gives the CO_2 reduction potential for each of the manufacturers when all four flexibility mechanism technologies are used in all the vehicles sold. Among the major manufacturers, Maruti can easily meet its FY 2022–23 target without using electric or hybrid vehicles. MG and Volvo are already meeting their FY 2022–23 targets with a small share of electric and hybrid vehicles. Tata and Hyundai will have to fully use the flexibility mechanisms and continue with the existing share of EVs sold in FY 2020–21.

The top three manufacturers can comfortably meet the FY 2022–23 CO_2 standard by simply using flexibility mechanisms. This shows that the FY 2022–23 targets are not stringent enough to drive the adoption of new technology, and there is room for the standards to be more stringent.

Table 5 also shows scenarios of CO_2 reduction with more penetration of electric and hybrid vehicles. The analysis uses a super credits factor for both electric and strong hybrid vehicles. Kia will need at least 1% and Mahindra at least 2% electric vehicle penetration to meet the target. Toyota would need either 3% electric or 10% of strong hybrids along with full use of all the flexibility mechanisms. Renault, Honda, and FCA will have to deploy more than 3% electric or 10% strong hybrids to meet their target. Note that we considered a 25% fuel consumption benefit for strong hybrids as compared with conventional vehicles.

11 "Tata Motors to launch 10 new EVs by 2025," *Business Today*, Updated June 29, 2021, https://www.businesstoday.in/auto/story/tata-motors-to-launch-10-new-evs-by-2025-299938-2021-06-29.

Table 5. CO_2 reduction potential with maximum use of flexibility mechanisms in FY 2020–21.

Manufacturer	Performance with flexibility mechanisms in FY 2020–21 (g/km)	Performance after using all flexibility mechanisms in all sales volume (g/km)	FY 2022–23 target (g/km)	Gap with FY 2022–23 target after using all flexibility mechanisms in all sales volume (g/km)	Scenario 1: CO_2 reduction with 1% EV (g/km)	Scenario 2: CO_2 reduction with 2% EV (g/km)	Scenario 3: CO_2 reduction with 3% EV (g/km)	Scenario 4: CO_2 reduction with 1% HEV (g/km)	Scenario 5: CO_2 reduction with 2% HEV (g/km)	Scenario 6: CO_2 reduction with 10% HEV (g/km)
Maruti	111.8	103.7	105.0	-1.3	2.5	5.0	7.4	0.6	1.1	5.6
Hyundai	120.6	113.9	114.4	-0.5	2.7	5.4	8.1	0.6	1.2	6.0
Tata	121.6	113.9	116.1	-2.1	2.7	5.4	8.1	0.6	1.2	6.1
Kia	130.8	125.4	123.7	1.7	3.0	5.9	8.9	0.7	1.3	6.5
Mahindra	153.5	149.5	139.9	9.6	3.5	7.0	10.5	0.8	1.5	7.7
Toyota	148.5	142.5	132.0	10.5	3.3	6.7	10.0	0.7	1.5	7.4
Renault	120.7	111.8	103.1	8.7	2.7	5.3	8.0	0.6	1.2	6.0
Honda	127.4	120.3	110.6	9.7	2.8	5.7	8.5	0.6	1.3	6.4
Ford	136.9	129.1	125.5	3.6	3.0	6.1	9.1	0.7	1.4	6.8
MG	141.4	137.4	143.3	-5.9	3.2	6.4	9.7	0.7	1.4	7.1
Skoda	133.5	127.7	117.6	10.1	3.0	6.0	9.0	0.7	1.3	6.7
Nissan	121.6	113.4	105.2	8.2	2.7	5.4	8.1	0.6	1.2	6.1
Mercedes	163.1	163.1	153.3	9.8	3.9	7.7	11.6	0.8	1.6	8.1
FCA	156.9	152.5	135.0	17.4	3.6	7.1	10.7	0.8	1.6	7.8
BMW	155.2	155.2	147.7	7.5	3.7	7.4	11.1	0.8	1.6	7.8
Jaguar Land Rover	172.2	172.2	142.9	29.3	4.0	8.0	12.1	0.9	1.7	8.6
Volvo	145.6	145.6	120.9	24.8	3.5	6.9	10.4	0.7	1.5	7.3
Force	213.6	204.6	177.3	27.3	4.9	9.7	14.6	1.1	2.1	10.7
Isuzu	215.3	206.3	178.7	27.6	4.9	9.8	14.7	1.1	2.2	10.8
Fleet average	**121.3**	**112.3**	**113.1**	**-0.8**	**2.7**	**5.4**	**8.1**	**0.6**	**1.2**	**6.1**

Technology baseline gap between India and Europe for 2020 new vehicles

Historically, Indian and European passenger cars had similar fleet average CO_2 emissions (Figure 13). European vehicles were generally heavier and more powerful but had better technologies that allowed the CO_2 emissions to be comparable with Indian vehicles. But now Europe has adopted more stringent standards for 2025 and 2030 lower by 15% and 55%, respectively. This has further increased the rapid diffusion of electric vehicles, alternative fuels, and advanced gasoline engine technology. Similar to India, the demand for diesel passenger cars is waning as manufacturers are shifting to gasoline engines to avoid the high cost of diesel emission control technology. Also, new gasoline technologies such as direct injection, turbocharging and downsizing, engine friction reduction, cooled exhaust gas recirculation (EGR), and variable valve timing (VVT) bridged the efficiency gap with diesel.

Development of technologies such as multi-stage variable geometry turbochargers, variable compression ratio, and Atkinson/Miller-cycle engines is further improving gasoline efficiency. Studies in Europe show that gasoline models like the VW Golf TSI are as efficient as diesel cars and deliver comparable performance at a much lower retail price.[12]

On the vehicle side, mass reduction, low rolling-resistance tires, and aerodynamic drag reduction are some of the technologies that have been adopted in Europe to reduce CO_2 emissions.

12 Peter Mock and Uwe Tietge, *Diesel car sales decline will have negligible impact on attainment of European CO_2 emission standards*, (ICCT: Washington, DC, 2018), https://theicct.org/sites/default/files/publications/ICCT_diesels-EU_20180315.pdf

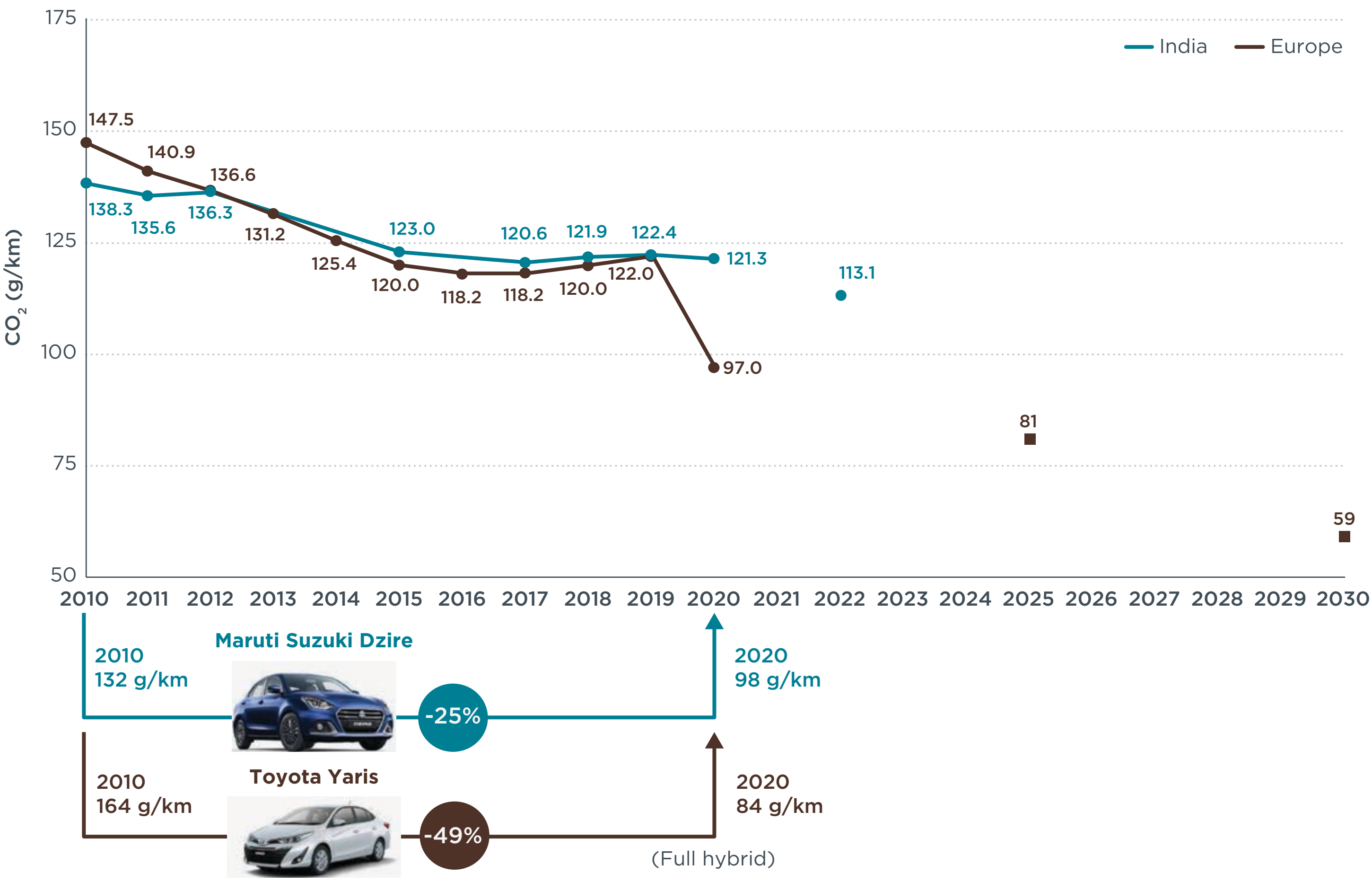

Figure 13. Comparison of fleet average CO_2 performance for the European Union (brown line) and India (blue line), with future fleet average targets (circles). Also, the best-in-class vehicles shown represent the level of CO_2 reduction achieved in a decade. CO_2 values from other vehicles in the fleet may vary. *Source:* The EU pocketbook was used for European fleet average CO_2 data.

HEV technology combines the ICE and an electric motor drivetrain. Most of the fuel energy lost during vehicle braking on a conventional vehicle is captured by the electric motor and stored in a lithium-ion battery. The recaptured energy, commonly called regenerative braking energy, is used to power the electrical system, shut off the engine during low-load operation, and assist the engine while accelerating. This improves the overall efficiency of the ICE, especially during low-speed operation.

For example, Toyota developed a sophisticated input power-split system for its hybrid vehicles. As shown in the example in Figure 13, the Yaris improved its CO_2 emissions by 49% from 2010 to 2020. However, the higher voltage electrical system, electric motor, and lithium-ion battery add cost. The new-generation 1.5-liter dedicated hybrid engine has been adopted by Toyota for the first time, and it achieves greater fuel efficiency by enhancing the efficiency of the entire system.

India's passenger car fleet is lighter than Europe's. This is largely driven by the lightweight vehicles sold by Maruti Suzuki. Other manufacturers, like Renault, Honda, and Nissan, have a relatively small market share, but their lighter models still contribute to the overall industry average curb weight.

Apart from lighter vehicle architectures, manufacturers like Hyundai and Maruti have implemented new engine technologies to reduce CO_2 emissions. Hyundai Motor India implemented new technologies in power trains like e-VGT, intelligent manual transmission, CVT, DCT, and turbocharger to reduce fuel consumption. Some of the engine-level technologies used by Maruti Suzuki are an all-aluminium engine, rocker-less camshafts, and a plastic intake manifold that gives better thermal management. Low-tension rings and low-friction lubricating oils reduce engine friction. Dual VVT, dual Injectors, higher compression ratio, and EGR cooling further helps in reducing fuel consumption.[13]

As shown in Figure 13, the Maruti Suzuki Dzire gasoline variant reduced CO_2 emissions by 25%, from 132 g/CO_2 in 2010 to 98 g/CO_2 in 2020. This was done simply by using incremental and cost-effective technologies. Dzire reduced its weight from 1,035 kg in 2010 to 890 kg in 2020 and implemented incremental technologies such as low-viscosity oils, aerodynamic improvement, and low-resistance tires.[14] The 14% weight reduction in 10 years contributed to an approximately 9% reduction in CO_2 emissions. Currently, Dzire is using an advanced Dualjet engine K12N with dual VVT technology and first-in-segment idle start-stop technology. Dzire does not have hybrid technology, yet, but its CO_2 is comparable to most of the mild hybrids available in Europe. The inclusion of incremental technologies is therefore an effective measure to reduce a vehicle's CO_2 emissions.

Table 6 shows the comparison of fleet average CO_2 and penetration of hybrid and electric vehicle technologies from 2017 onward. In 2020, Europe witnessed a phenomenal increase in sales of PHEV and BEV, from 3% in 2019 to 10.6% in 2020, and high-voltage full hybrids and 48V mild hybrids, from 5.4% of new sales in 2019 to 12.4% in 2020.[15] These market share increases were primarily to meet the stricter target of 95 g/km (in New European Driving Cycle terms). The sales of these vehicles are likely to increase to meet the even stricter norms of 2025 and 2030.

Table 6. Comparison of curb weight, CO_2 emissions, and percentage of hybrids and PHEVs and BEVs in Europe and India.

Europe					India				
Year	Curb weight (kg)	CO_2 (g/km)	Hybrid (%)	PHEV+BEV (%)	Year	Curb weight (kg)	CO_2 (g/km)	Hybrid (%)	PHEV+BEV (%)
2017	1395	118	2.7	1.4	2017-18	1064	120.6	0.0	0.01
2018	1397	120	3.7	2.0	2018-19	1078	121.9	0.01	0.06
2019	1415	122	5.4	3.0	2019-20	1068	122.4	0.03	0.1
2020[a]	NA	97	12.4	10.6	2020-21[b]	1081	121.3	0.13	0.2

[a] New passenger car registrations are for calendar year January 1–December 31.
[b] New passenger car registrations are for fiscal year April 1–March 31.
Data source for new passenger car registrations in Europe is EU pocketbook, and data for India are analyzed through passenger car sales data from Segment Y.

Both premium car manufacturers like Jaguar Land Rover and Audi and mainstream manufacturers such as Lancia, Subaru, Mazda, and Suzuki have already equipped more than 30% of their fleet with mild hybrids in 2020.[16] As a result, the mild hybrid market share in Europe jumped from 2.1% in 2019 to 8.2% in 2020. FCA also announced that 40% of its fleet would have mild hybrids by 2022, from zero in 2019. This shows acceptance of mild hybrids as one of the most viable and cost-effective solutions for meeting CO_2 targets in Europe.

Because India has less stringent CO_2 requirements and a more cost-sensitive market compared with Europe, Indian manufacturers have historically relied on technologies with low cost-to-benefit ratios. Now, though, concerns about energy security and high fuel prices are leading to the development of alternative fuel and low-cost hybrid

13 Maruti Suzuki, "Performance and Fuel Efficiency," Technology, accessed July 2021, https://www.marutisuzuki.com/corporate/technology/engine.

14 Ashok Deo, "Every Manufacturer's 'Dzire' for Meeting PV Fuel Consumption Standards in India," International Council on Clean Transportation, November 20, 2020, https://theicct.org/blog/staff/dzire-pv-fuel-consumption-standards-india-nov2020.

15 John German, Jan Dornoff, Ashok Deo, *Technology Brief: Mild-hybrid vehicles – a technology trend for reducing CO_2 emissions*, (ICCT: Washington, DC, forthcoming).

16 Ibid.

vehicles in India. Manufacturers such as Maruti Suzuki and Hyundai have increased their portfolio of CNG powered vehicles to 11.7% and 4.0%, respectively, in FY 2020–21.

Maruti Suzuki has also developed an advanced micro-hybrid system as a cost-effective technology for vehicles like the Baleno, Brezza, S-Cross, Ciaz, and XL6. This technology uses a conventional, lead-acid battery for cold cranking the engine and a small lithium-ion battery to absorb recuperation energy during braking. The absorbed energy is later provided into the electrical system or used during torque assist, and this results in larger CO_2 benefits than from a micro-hybrid. Introduction of 48V mild hybrid systems will play a crucial role for cost-sensitive markets like India, as it offers the potential of providing most of the benefits of strong hybrids at a fraction of the cost.

Figure 14 summarizes and compares the market share of BEVs, PHEVs, full hybrids, and mild hybrids in Europe and India for 2020.

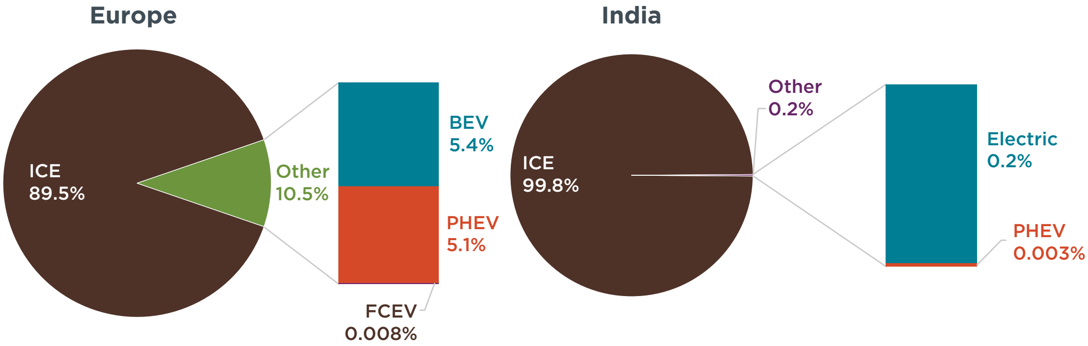

Figure 14. Comparison between the market share of new technologies in Europe and India.
Source: Dataforce.

Conventional technology comparison between Europe and India

While data regarding the market share of hybrids and plug-in vehicles are available in Europe and India, as illustrated in Figure 15, comparable market share data are not available for the technologies used to improve efficiency of conventional power trains. As a substitute, this section compares the top-selling car in Europe, the VW Golf, and the top seller in India, the Maruti Suzuki Dzire. Both are mid-segment cars in their regions. The Dzire is smaller than the Golf and considerably lighter, as it is designed to take advantage of a lower tax structure in India for vehicles less than 4 meters long. In Europe, there are no such tax-based incentives, and the mid-segment vehicles are longer than 4 meters.

The technology on the Toyota Yaris hybrid in Europe is also analyzed, as 49% of Yaris sales in Europe are the hybrid version, and there is no comparable vehicle sold in India. The comparisons demonstrate that there is considerable technology already widely available in Europe that could be easily adapted to vehicles in India.

VW Golf

The VW Golf in Europe includes derivatives: the GTI (gasoline), GTD (diesel), and GTE (plug-in hybrid). With a rising market share of gasoline engines and increasingly stringent CO_2 standards, VW has been consistently improving the fuel efficiency of its gasoline variants. It uses engine-level technologies such as optimized combustion process and vehicle-level technologies such as lightweight materials, low-resistance tires, and aerodynamic improvements.[17] These incremental technologies reduced the gasoline fuel consumption to a level comparable with diesel engines at a significantly cheaper cost than for a diesel.

Volkswagen developed the new 1.5 TSI ACT BlueMotion engine, with an output of 96 kW / 130 PS, and it is currently powering more than 45 Volkswagen, Audi, SEAT, and ŠKODA models, including mild, full, and plug-in hybrid drive systems. The combined fuel consumption of the Golf 1.5 L TSI ACT BlueMotion on the NEDC cycle is 110 gCO2/km.[18] Along with commonly used turbocharging and gasoline direct injection, the engine also uses technologies such as the Miller cycle, variable geometry turbocharger, cylinder deactivation, and advanced start-stop technology.

The cylinder deactivation system is called Active Cylinder Management (ACT), which deactivates the two inner cylinders at low power demands. The cylinder deactivation functionality is within an engine speed range of 1,400 to 4,000 rpm and at vehicle speeds of up to 130 km/h. To further reduce fuel consumption, the engine decouples from the dual clutch gearbox during coasting conditions and is switched off. The 12V, compact, lithium-ion battery system that is part of the advanced start-stop system powers all of the safety systems in the car when the engine is inactive.

The Miller cycle enables higher compression and when added to turbocharging, it leads to efficiency improvement of approximately 10%.[19] Increased compression ratio of 12.5:1 and variable geometry turbochargers (VGT) provide an increase in efficiency and torque across all engine speeds, particularly at low engine RPMs. The 1.0 L TSI version of the engine includes additional technologies to reduce fuel consumption, such as an electric wastegate actuator, an intake manifold with integrated intercooler, and an exhaust manifold integrated into the cylinder head.[20]

Maruti Suzuki Dzire

Maruti Suzuki's K-Series gasoline engines are known for their low fuel consumption in India. The BS VI compliant 1.2L K12N Dualjet gasoline engine in the Dzire has a peak power of 66 kW and maximum torque of 113 Nm, and is measured at 98.3 gCO2/km on the standardized test cycle. Although this is virtually the same as the Golf 1.0L, the Dzire is 325 kg or 27% lighter, indicating that Golf engines have much higher levels of technology and efficiency. The Dzire's fuel efficiency above other vehicles in India is achieved from technologies such as higher compression ratio (12.0:1), Dualjet engine, and dual VVT technology that improve the thermal efficiency and produce better low-end torque, in addition to reducing fuel consumption. However, it is clear from the comparison in Table 7 that the Golf includes many technologies not implemented in the Dzire.

17 VW groups strategy for future programs, accessed in August 2021: https://www.volkswagen-newsroom.com/en/press-releases/fuel-efficient-micro-hybrid-for-the-golf-new-130-ps-petrol-engine-is-as-efficient-as-a-diesel-1997

18 "Fuel-Efficient Micro-Hybrid for the Golf New 130 PS Petrol Engine is as Efficient as a Diesel," Volkswagen, March 19, 2018, https://www.volkswagen-newsroom.com/en/press-releases/fuel-efficient-micro-hybrid-for-the-golf-new-130-ps-petrol-engine-is-as-efficient-as-a-diesel-1997.

19 Ibid.

20 "International Engine of the Year 2018: The Innovative 1.0 TSI in the New Ip! GTI Wins the Award in Its Category," Volkswagen, June 05, 2018, https://www.volkswagen-newsroom.com/en/press-releases/224.

Table 7. Comparison between engine specifications of VW Golf and Maruti Suzuki's Dzire. Source: VW and Maruti Suzuki.

Parameters	Golf		Dzire
Fuel type	Gasoline	Gasoline	Gasoline
Footprint (m²)	4.9	4.9	3.7
Curb weight (kg)	1300	1205	880
Engine displacement (cc)	1498	999	1197
Number of cylinders	4	3	4
Power (kW)	96	85	66
Torque (Nm)	200	200	113
Power to weight ratio (kW/kg)	0.073	0.071	0.075
Gearbox	AMT	Manual	AMT
Max speed (km/h)	210	200	170
CO_2 (g/km)	110	99	98.3
Non-Engine Technologies			
Idle start-stop	Yes	—	Yes
Coasting start-stop	Yes	—	—
Micro-hybrid (advanced start-stop)	Yes	—	—
Engine technologies			
Compression ratio	12.5:1	12.5:1	12.0:1
Offset crankshaft	—	—	Yes
Dual VVT	Yes	Yes	Yes
GDI	Yes	Yes	
Cooled EGR	Yes	Yes	Yes
Turbocharged	Yes	Yes	—
Variable geometry turbocharger	Yes	—	—
Miller cycle	Yes	—	—
Electric wastegate actuator	—	Yes	—
Active cylinder management	Yes	—	—
Intercooler integrated with intake	—	Yes	—

Toyota Yaris hybrid

Toyota has been constantly improving its hybrid technology for more than 20 years. It began with the Toyota Prius in 1997, and the latest fourth-generation Toyota Yaris hybrid was launched in 2020. The 1.5 L Hybrid Dynamic Force engine in the Yaris is a three-cylinder Atkinson cycle gasoline engine with VVT and reduced internal friction. It also has 15% more power output and higher low end torque. The 40% brake thermal efficiency is similar to typical diesel engines.[21] The hybrid transaxle is redesigned with a dual axis structure, resulting in a low-loss geartrain with 9% smaller overall dimensions. The new lithium-ion hybrid batteries are 27% lighter than the earlier nickel-metal hydride batteries, and they provide an increase in output that enables quicker vehicle acceleration and improved efficiency.

As a result, the Yaris hybrid achieves 84 gCO_2/km on the official test cycles. Note that this is not a niche vehicle. More than 200,000 Yaris vehicles were sold in recent years in Europe, ranking 13th in total sales by nameplate, and 49% of them sold in 2019 have the

21 "New Toyota Yaris—Designed for Urban Life," Toyota Europe, October 16, 2019, https://newsroom.toyota.eu/new-toyota-yaris--designed-for-urban-life/.

hybrid system. Even though there are no comparable vehicles sold in India, this is already mainstream technology in Europe.

Summary

As India moves toward more stringent FY 2022–23 fuel consumption standards for new passenger vehicles, our analysis of Segment Y data shows the fleet average CO_2 emissions for FY 2020–21 was 121.3 g/km. Assuming similar industry average weight going forward, the compliance target for FY 2022–23 will be 113.1 g/km. This means that to bridge the gap of 6.8% from 121.3 to 113.1 g/km in 2 years, the industry needs to reduce fuel consumption by approximately 3.5% each year. However, the actual, real-world decrease will almost certainly be lower, as manufacturers are likely to expand their use of super credits and flexibility mechanisms.

Based on the significant progress that manufacturers have already made toward compliance with FY 2022–23 standards and the relative leniency of the standards compared with those in Europe, MoRTH should start to develop significantly more stringent post-FY 2022–23 CO_2 emission standards.

Table 6, above, compared the CO_2 performance in Europe and India from 2017 to 2020. CO_2 performance from 2017 to 2019 is similar in both regions, even though average vehicle weight in India is far lower; this means that India already trailed Europe in efficiency technology adoption. In addition, Europe adopted stricter norms beginning in 2020 and this has been the major driver behind the dramatic reduction in CO_2 emissions in 2020 and further increases in efficiency technology in Europe, including increases in sales of electric vehicles and hybrids.

As illustrated by the comparison of the Golf with the Dzire and the technology on the Yaris hybrid, improved technologies are widely available in other regions and could be added to vehicles in India with minimal new investment. If India wants to pursue electrification in passenger cars, then it should update its fuel consumption standards with a focus on setting 2025 and 2030 standards on par with EU targets.

Corporate groups that sell luxury or high-end vehicles, including BMW, Volvo, Mercedes, and Jaguar, currently benefit more from flexibility mechanisms than other groups. Some mass market manufacturers like MG have already met their FY 2022–23 CO_2 targets owing to higher sales of electric vehicles and making use of the flexibility mechanisms. Because 29.1% of the FY 2020–21 passenger cars sold in India were equipped with 6-speed or more transmissions, regulators should consider not granting CO_2 credits for this technology any longer, as the provision is intended to promote innovation and new technology adoption.

Moreover, the impact of super credits is minimal for the FY 2020–21 fleet, but its impact could grow rapidly as the market share of BEVs, PHEVs, and strong hybrids goes up. Based on the analysis of Maruti, Tata, MG, and Hyundai, sales of advanced micro-hybrid, electric, and CNG vehicles will help manufacturers meet their compliance targets. The evolution of gasoline technology also means that the same standards can be met at lower cost with gasoline engines rather than diesel engines. As the impact of the flexibility mechanisms grows, MoRTH should also publish detailed compliance information to allow for a thorough understanding of the impact that each individual technology is having on the overall fleet compliance. This could also help in analyzing whether the particular technology has reached a wide penetration in the market and could therefore be removed from the benefit list.

Appendix

Manufacturers	Referred name
BMW India Pvt. Ltd.	BMW
FCA India Automobiles Pvt. Ltd.	FCA
Force Motors Ltd.	Force Motors
Ford India Pvt. Ltd.	Ford
General Motors India & CSIPL	General Motors
Hindustan Motor Finance Corporation Ltd.	HMFCL
Honda Cars India Ltd.	Honda
Hyundai Motor India Ltd.	Hyundai
Isuzu Motors India Pvt. Ltd.	Isuzu
Jaguar Land Rover	Jaguar
Corporate Group - Mahindra & Mahindra Ltd. (Mahindra & Mahindra Ltd & Mahindra Electric Mobility Ltd.)	Mahindra
Maruti Suzuki India Ltd.	Maruti
Mercedes-Benz India Pvt Ltd.	Mercedes
Nissan Motor India Private Ltd.	Nissan
Renault India Private Ltd.	Renault
Tata Motors Ltd.	Tata
Toyota Kirloskar Motor Pvt. Ltd.	Toyota
Skoda Auto Volkswagen India Private Ltd.	Skoda
Volvo Auto India Pvt. Ltd.	Volvo
MG Motor India Pvt. Ltd.	MG