WHITE PAPER

DECEMBER 2016

LIGHT-COMMERCIAL VEHICLES IN INDIA, 2014-15

TECHNOLOGY ASSESSMENT AND INTERNATIONAL COMPARISONS

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ACKNOWLEDGEMENTS

The authors are grateful to R Velusamy, Shashikant Nikam (Mahindra &Mahindra) and Vignesh Annamalai (Vicky.in) for their assistance in securing data for the report, and Uwe Tietge for helping with database development.

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1. EXECUTIVE SUMMARY

This paper assesses the fleet characteristics and technology adoption of India's light-commercial vehicle (LCV) market during fiscal year (FY) 2014-15. The assessment focuses on the differences in fleet characteristics and technology adoption among LCV fleets in FY 2014-15 compared with FY 2011-12, as well as differences among manufacturers for FY 2014-15. Apart from light-commercial vehicles, this report includes a similar analysis for M2 vehicles (minivans and vans), which are not included in the definition of light-commercial vehicles in India. The report also analyzes and compares the fleet features and technologies among LCVs in Europe, Japan, and India for FY 2014-15.

The results of the analysis provide a baseline for light-commercial vehicle fleets as well as for the M2 category of vehicles in India. The LCV baseline can be used to develop a fuel consumption standard for India's LCV fleet, which is currently unregulated.

Table ES-1. LCV fleet characteristics in India, EU, and Japan

Fleet Characteristic	India		European Union (EU) FY 2014-15	Japan CY 2013-14
	FY 2011-12	FY 2014-15		
Engine Displacement (cc)	1,244	1,647	1,919	1,101
Curb Weight (kg)	1,047	1,299	1,752	1,067
CO_2 Emissions (g/km)	146.6	157.6	171	151 (NEDC Cycle); 150 (JC08 Cycle)
Diesel%	86%	89%	96%	6%
Compressed Natural Gas (CNG) %	10%	11%	0.6%	0%
Power (kW)	24	33	85	—
Footprint (m^2)	3.11	3.60	5.20	—
Automatic Transmission	0%	0%	4%	—

Table ES-1 compares the fleet characteristics of LCVs in India, the European Union (EU), and Japan. In EU and Japan, LCVs are categorized as N1 vehicles, similar to India. Our analysis shows that the LCV fleet in Japan has the lowest engine size, while the LCV fleet in the EU has the largest engine size. India's LCV fleet has an engine size midway between that of Japan and the EU's engine sizes in FY 2014-15 and closer to Japan's engine size in FY 2011-12.

The curb weight of India's LCV fleet in FY 2011-12 was almost the same as Japan's LCV fleet curb weight, but was higher in 2014-15. It would appear that the characteristics of India's LCV fleet are trending more toward those of the EU's LCV fleet.

Of the EU's LCV fleet, 96% was diesel powered, while 89% of India's LCV fleet was diesel powered. By contrast, only 6% of Japan's LCV fleet that was diesel powered.

The highest CO_2 emissions were from the EU fleet at 171 g/km, while the CO_2 emissions from Japan's LCV fleet were lowest at 151 g/km. India's LCV fleet had CO_2 emissions of 157.6 g/km, close to Japan's emissions. Figure ES-1 demonstrates the relationship between curb weight and CO_2 emissions for India, the EU-28, and Japan's LCV fleets plotted by manufacturer. The figure below also depicts the EU's LCV targets for 2017 and 2020.

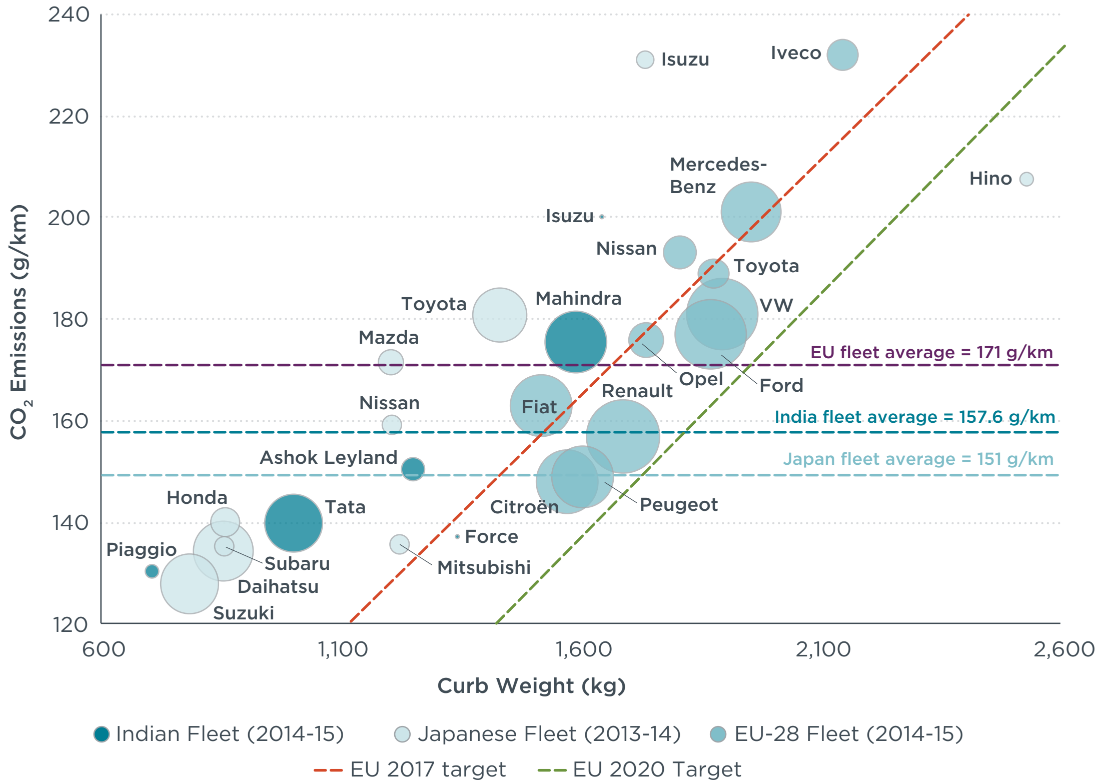

Figure ES-1. Curb weight vs. CO_2 emissions for India, EU-28 and Japan. Size of the circles represents market share.

Figure ES-1 shows that even though the EU's LCVs have higher fleet emissions on average, their fleet is also more efficient than those of Japan and India for the same weight categories. The comparison shows that India's LCV fleet has significant room for improvement, and EU LCV fuel consumption targets could be considered in the Indian context as well. India's first fuel-consumption standard, for passenger vehicles in category M1, will be implemented by the Ministry of Road Transport and Highways in collaboration with the Bureau of Energy Efficiency and will come into effect in April 2017 (MOP, 2015). The government should prioritize implementing a similar standard for LCVs.

A nearer term step that could be implemented more easily and within a lesser time frame would be including LCVs in the fuel-efficiency labeling program proposed by the Bureau of Energy Efficiency for passenger vehicles. Our analysis shows that the passenger vehicle fuel-efficiency labeling program could be made applicable to LCVs as well with no variation.

2. INTRODUCTION

2.1 OBJECTIVE

This paper outlines the status of fuel consumption and technology adoption in light-commercial vehicles (LCVs) in India for fiscal year (FY) 2014-15. The N1 vehicle segment in India is categorized as light-commercial vehicles. This project also analyzes the fleet characteristics and technology adoption of the M2 vehicle segment in India. The M2 segment of vehicles encompasses minivans and vans, which are not included in the definition of LCVs used in India. The idea behind including the M2 segment in this project is to provide a basis for further studies and to increase our knowledge of the M2 segment's vehicle market. The main objectives of this project are 1) to establish a baseline for both the N1 and M2 segments in India to help regulators develop an effective fuel consumption standard for these segments; 2) to compare the N1 and M2 fleets for FY 2011-12 and FY 2014-15; 3) to identify major LCV manufacturers and compare their performance in terms of technology adoption and fleet average fuel consumption; 4) to assess the performance of India's LCV fleet in comparison with the LCV fleets of the EU and Japan, taking the differences in curb weight and size of the vehicles into consideration; and 5) to suggest improvements to reduce the average fuel consumption of India's LCV fleet.

2.2 BACKGROUND

LCVs are used in India as last-mile connectivity for goods. LCVs are categorized as N1 vehicles, which are cargo vehicles with a gross vehicle weight (GVW) of less than 3,500 kg. The EU and Japan also define LCVs as N1 category vehicles fleet characteristics of LCVs from these regions are compared with those in India later in this report. M2 vehicles, passenger vehicles with more than nine seats and a GVW less than 5,000 kg are also analyzed in this report. There is currently no fuel consumption regulation for either of these vehicle segments in India.

LCVs have been bifurcated into two segments by the Society of Indian Automobile Manufacturers (SIAM), as shown in Table 1.

Table 1. SIAM's segmentation of LCVs

Segment	Description	Example	% of LCV market	Top Selling Model
N1 Mini truck	Cargo vehicles with GVW <2,000 kg		54%	Tata Ace
N1 Pickup truck	Cargo vehicles with 2,000kg<GVW<3,500kg		46%	Mahindra Bolero Camper

3. DATA SOURCES AND DATABASE CONSTRUCTION

This section explains the data sources and methodology used to construct the database. The following vehicle attributes and technical parameters were analyzed in the report:

- Curb weight
- CO_2 emissions and fuel consumption
- Engine displacement
- Fuel type
- Power
- Transmission type and gear count
- Fuel supply system
- Aspiration
- Valve configuration

Once the database was assembled, sales weighted averages for the above parameters were analyzed for both the N1 and M2 segments.

3.1 DATA SOURCE DESCRIPTION

The sales data used in this report for India was obtained from Segment Y, an independent international automotive data supplier (http://www.segmenty.com). The data, however, did not include sufficient description or details on vehicle specifications or fuel economy. Therefore, in constructing the database, the sales data were integrated with vehicle specifications and fuel economy information obtained from various sources. Most of the vehicle specifications such as engine displacement, aspiration, fuel injection, power output, dimensions, seating, etc., were obtained from a database acquired from www.Vicky.in by the ICCT. Other major sources include individual manufacturer websites and www.Truckaurbus.com. Since it is not mandatory for manufacturers to report fuel economy for LCVs in India, these values were obtained from different sources. Most of the fuel economy values were obtained from manufacturer websites and SIAM's 2014 fuel economy list. Segment Y's database for FY 2011-12 was used to acquire fuel economy values for LCVs that did not undergo many engine or curb weight modifications since 2011. The front track and rear track width, used to calculate the vehicle footprint[1], was estimated using the results of ICCT's "Analysis of passenger car dimensions in the European Union," 2010.

The sources for each specification and corresponding share percentage are listed below in Table 2.

1 Vehicle footprint is the product of distance between axles of the vehicle (wheelbase) and the distance between the centerline of the tires (average track width)

Table 2. Data sources

Category	Source	Share (%)
Sales	Segment Y	96%
	SIAM	4%
Fuel economy	Manufacturer website	51%
	SIAM	21%
	Segment Y (2011-12)	19%
	Other	9%
Curb weight	Manufacturer website	82%
	Truckaurbus.com	9%
	Vicky.in	9%
Engine displacement	Vicky.in	96%
	Manufacturer website	4%
No. of cylinders	Vicky.in	96%
	Manufacturer website	4%
Aspiration	Vicky.in	96%
	Manufacturer website	4%
Fuel injection	Vicky.in	96%
	Manufacturer website	4%
Emissions standard	Vicky.in	96%
	Manufacturer website	4%
Engine output	Vicky.in	96%
	Manufacturer website	4%
Price	Vicky.in	96%
	Truckaurbus.com	4%
Valve configuration	Manufacturer website	7%
	Owner's manual	5%
	Segment Y (2011-12)	14%
	Manufacturer presentations, car forums	74%
Transmission	Vicky.in	96%
	Manufacturer website	4%
Dimensions (L, W, Wheelbase)	Manufacturer website	8%
	Vicky.in	92%
Front track, rear track	Manufacturer website	30%
	Segment Y (2011-12)	2%

For international comparisons, the EU-28 LCV database compiled by ICCT was used (http://www.eupocketbook.com/). The data sources for Japan's LCV database included fuel consumption and vehicle specification data from the Japanese Ministry of Land, Infrastructure, Transport and Tourism's (MLIT) website and sales data from Polk Automotive (now IHS Inc.).

3.2 DATABASE CONSTRUCTION

Constructing each database primarily involved integrating the Segment Y sales data and the Vicky.in database on the basis of vehicle make and model matching. The matching was, however, not one-to-one since there were instances where a single vehicle model had multiple vehicle specifications. In the absence of additional information, this analysis assumes that sales are equally distributed over the variants matched to a given sales record in the database. The effect of this assumption is generally minor as the variation in fuel economy across model variants is small relative to the variation across models, but it does create some unavoidable uncertainty.

Constructing Japan's LCV database also involved a similar integration of sales data from POLK Automotive and vehicle specifications from MLIT's website (MLIT, 2016). An equal distribution of data was assumed across model variants with comparable fuel economy during Japan's LCV data integration as well.

4. FLEET CHARACTERISTICS AND TECHNOLOGY ADOPTION OF LCVS

In this section, the fleet characteristics and technology adoption of LCVs during FY 2011-12 and FY 2014-15 are analyzed and compared. Table 3 highlights the fleet characteristics for FY 2014-15 and FY 2011-12.[2]

Table 3. LCV Fleet characteristics for FY 2011-12 and FY 2014-15

Parameters	FY 2011-12	FY 2014-15
Price (INR)	3,28,137	4,30,848
Price (USD)	$5,048	$6,628
Displacement (cc)	1,244	1,647
Curb weight (kg)	1,047	1,299
Footprint (m²)	3.11	3.60
Power (kW)	24	33
Power-to weight ratio (kW/kg)	0.021	0.023
CO_2 Emissions (g/km)	146.6	157.6

4.1 FLEET CHARACTERISTICS FOR FY 2011-12 AND FY 2014-15

Table 3 compares the sales- weighted average fleet characteristics of LCVs in FY 2011-12 and FY 2014-15. The main findings from the analysis are:

- The engine size increased from 1.2 liters in FY 2011-12 to 1.6 liters in FY 2014-15.
- The average curb weight increased from 1,047 kg in FY 2011-12 to 1,299 kg in FY 2014-15.
- Average footprint increased from 3.11 m^2 in FY 2011-12 to 3.6 m^2 in FY 2014-15.
- Fleet average power increased from 24 kW in FY 2011-12 to 33 kW in FY 2014-15, while power-to- weight ratio rose from 0.021 kW/kg in FY 2011-12 to 0.023 kW/kg in FY 2014-15.
- Average CO_2 emissions increased from 146.6 g/km in FY 2011-12 to 157.6 g/km in FY 2014-15.

4.2 TECHNOLOGY ADOPTION COMPARISON BETWEEN FY 2011-12 AND FY 2014-15 FLEETS

Figure 1 shows the technology adoption of LCV fleets in FY 2011-12 and FY 2014-15. The findings of the analysis are:

- Fuel type remained almost constant in FY 2011-12 and FY 2014-15. The share of diesel powered and CNG vehicles is 89% and 11% respectively in FY 2014-15, and 86% and 10% respectively in FY 2011-12.[3]

2 All figures and tables in this paper correspond to N1 vehicles unless otherwise specified

3 Nearly 4% of new LCVs in 2011-12 were gasoline powered, mostly accounted by one model—Maruti Omni.

- The number of turbocharged LCVs in FY 2011-12 was 23% and rose to 56% in FY 2014-15.
- The number of LCVs with common-rail direct injection (CRDI) engines increased from 12% in FY 2011-12 to 31% in FY 2014-15, while the number of LCVs with indirect diesel injection (IDI) engines decreased from 49% in FY 2011-12 to 28% in FY 2014-15. The number of direct injection (DI) engines increased from 24% in FY 2011-12 to 31% in FY 2014-15. The number of sequential fuel injection (SFI) engines decreased by over half from 14% in FY 2011-12 to 6% in FY 2014-15, while the number of multi-port fuel injection (MPFI) engines increased from almost nil to 5% respectively.
- The number of LCVs with four valves/cylinders decreased from 7% in FY 2011-12 to 6% in FY 2014-15. LCVs with double overhead camshaft (DOHC) valve configuration also saw a similar decrease in number. The overhead valve (OHV) engine configuration decreased from 30% in FY 2011-12 to 11% in FY 2014-15, while the single overhead camshafts (SOHC) valve configuration increased from 63% in FY 2011-12 to 84% in FY 2014-15. Technologies such as variable valve lift (VVL) or variable valve timing (VVT) were not seen in LCVs for either year.
- The number of one-cylinder engines nearly decreased by half from 13% in FY 2011-12 to 6% in FY 2014-15 and two-cylinder engines decreased from 52% in FY 2011-12 to 38% in FY 2014-15. Three-cylinder engines marginally went up from 7% in 2011 to 8% in FY 2014-15. Four-cylinder engines also increased in number from 29% in FY 2011-12 to 49% in FY 2014-15.
- No LCVs had automatic transmission or dual clutch transmission (DCT) systems in 2011 or 2014. The number of LCVs with five-gear speeds increased from 18% in FY 2011-12 to 68% in FY 2014-15.
- The number of BS IV[4] type approved LCVs increased from 13% in FY 2011-12 to 31% in FY 2014-15.

Figure 2 shows the CO_2 emissions versus curb weight and Figure 3 shows the CO_2 emissions versus footprint for FY 2014-15 and FY 2011-12 fleet, both by manufacturer.

4 BS IV or Bharat stage IV standard is equivalent to Euro IV emissions standard

Figure 1. Technology adoption of LCVs in FY 2011-12 and FY 2014-15

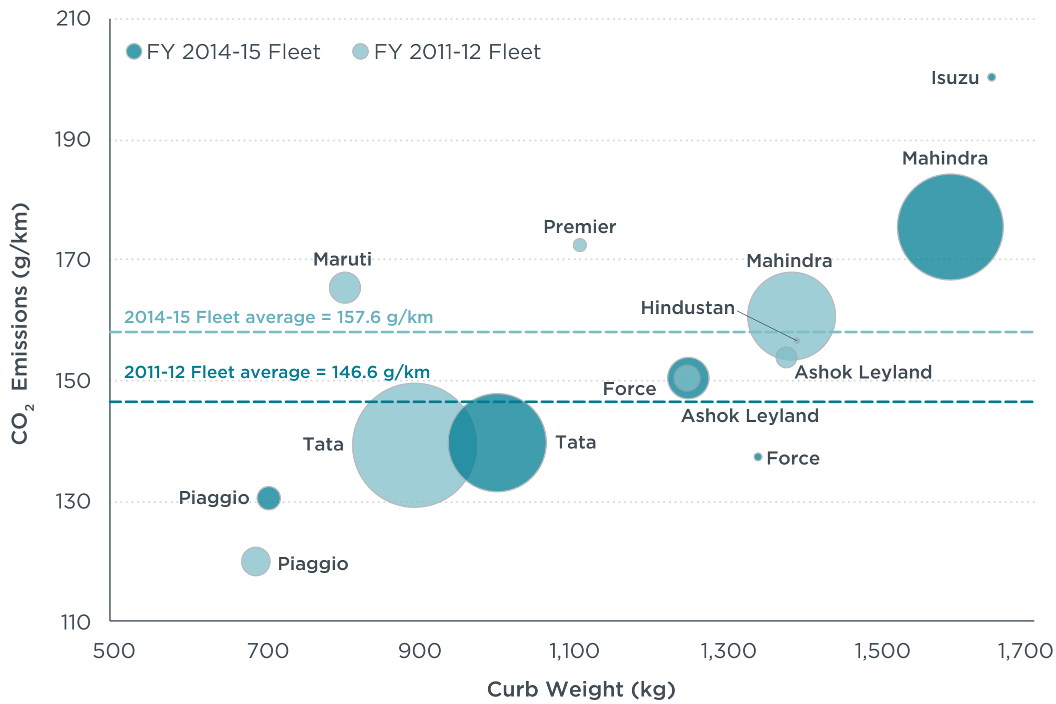

Figure 2. CO_2 emissions vs. curb weight for FY 2014-15 and FY 2011-12. Size of the circles represent market share.

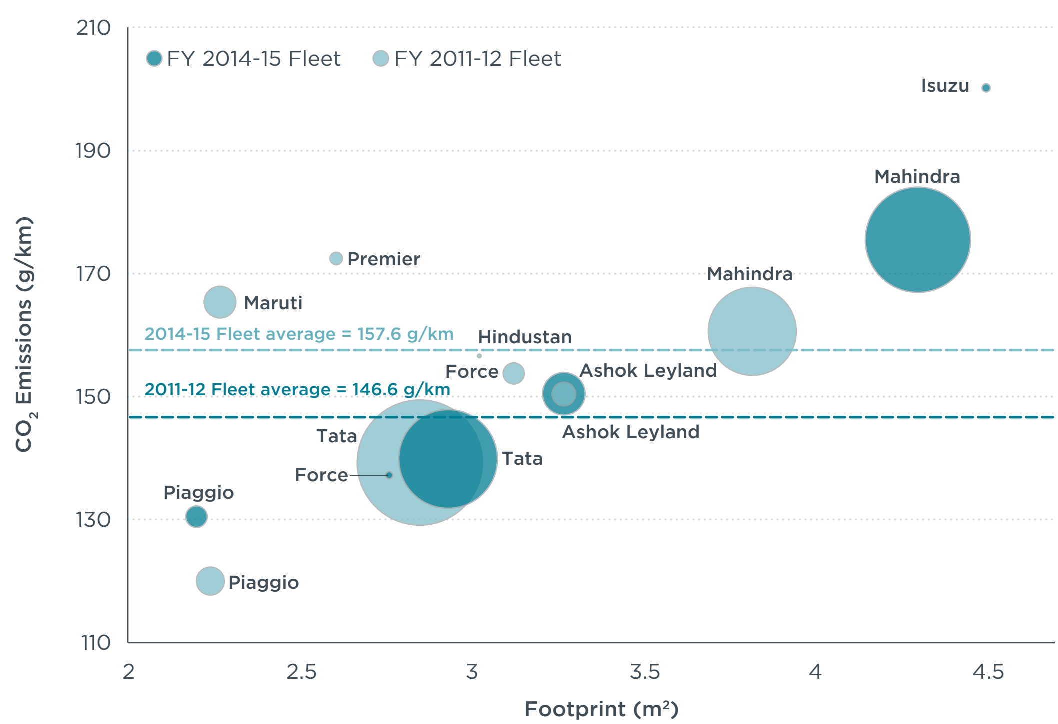

Figure 3. CO_2 emissions vs. footprint for FY 2014-15 and FY 2011-12. Size of the circles represent market share.

4.3 M2 FLEET CHARACTERISTICS AND TECHNOLOGY ADOPTION IN FY 2011-12 AND FY 2014-15

The fleet characteristics and technology adoption of M2 vehicles in the fiscal years 2011-12 and 2014-15 are analyzed in this subsection. Table 4 summarizes the fleet characteristics of both fiscal years.

The engine sizes are similar in FY 2011-12 and FY 2014-15. Average engine size was 2.5 liters in FY 2011-12 and 2.4 liters in FY 2014-15. The power-to-weight ratio decreased from 0.029 in 2011-12 to 0.028 in 2014-15.

The average curb weight increased from 1,909 kg in FY 2011-12 to 2,130 kg in FY 2014-15and and the average footprint from 4.73 m^2 to 5.29 m^2. Fleet average power increased slightly from 55 kW in FY 2011-12 to 58 kW in FY 2014-15.

CO_2 emissions in the FY 2011-12 fleet were 217.8 g/km, which increased to 231.2 g/km in FY 2014-15. In FY 2011-12, the fleet was 100% diesel powered, while in FY 2014-15 it decreased to 64% and the rest were CNG powered.

The number of turbocharged engines increased from 51% in FY 2011-12 to 86% in FY 2014-15. The share of vehicles with DOHC increased, from 1% to 6%, and so did the number of engines with four valves per cylinder. All M2 vehicles in FY 2011-12 and FY 2014-15 had four-cylinder engines. Similar to LCVs, M2 vehicles did not have VVL or VVT in either fiscal year.

CRDI became increasingly popular, from 1% in FY 2011-12 to 86% by FY 2014-15. The number of BS IV type M2 vehicles increased from 1% in 2011-12 to 41% in 2014-15.

Table 4. Fleet characteristics and technology adoption of M2 vehicles

Financial Year	2011-12	2014-15
Price (INR)	6,72,813	8,41,083
Price (USD)	$10,351	$12,940
Displacement (cc)	2,513	2,431
Curb weight (kg)	1,909	2,130
Footprint (m^2)	4.73	5.29
Power (kW)	55	58
Power-to weight ratio (kW/kg)	0.029	0.028
Fuel Type		
Diesel	100%	64%
Petrol	0%	36%
CNG	0%	0%
LPG	0%	0%
CO_2 Emissions (NEDC)		
Combined CO_2 Emissions	217.8	231.2
Transmission		
Manual	100%	100%
Automatic	0%	0%
Valve Configuration		
Dual overhead camshaft	1%	6%
Single overhead camshaft	48%	74%
Overhead valves	51%	20%
No. of Gears		
4	5%	0%
5	95%	100%
6 and above	0%	0%
No. of Cylinders		
One	0%	0%
Two	0%	0%
Three	0%	0%
Four	100%	100%
No. of Valves per Cylinder		
2	99%	94%
4	1%	6%
Fuel Supply		
Direct injection (Diesel)	99%	14%
Common-rail (Diesel)	1%	86%
Air Intake		
Naturally Aspirated	49%	14%
Turbocharger	51%	86%
Emissions Standard		
BS IV	1%	41%
BS III	99%	59%

Further, Figure 4 compares the M2 fleet curb weight with CO_2 emissions in FY 2011-12 and FY 2014-15 by manufacturer.

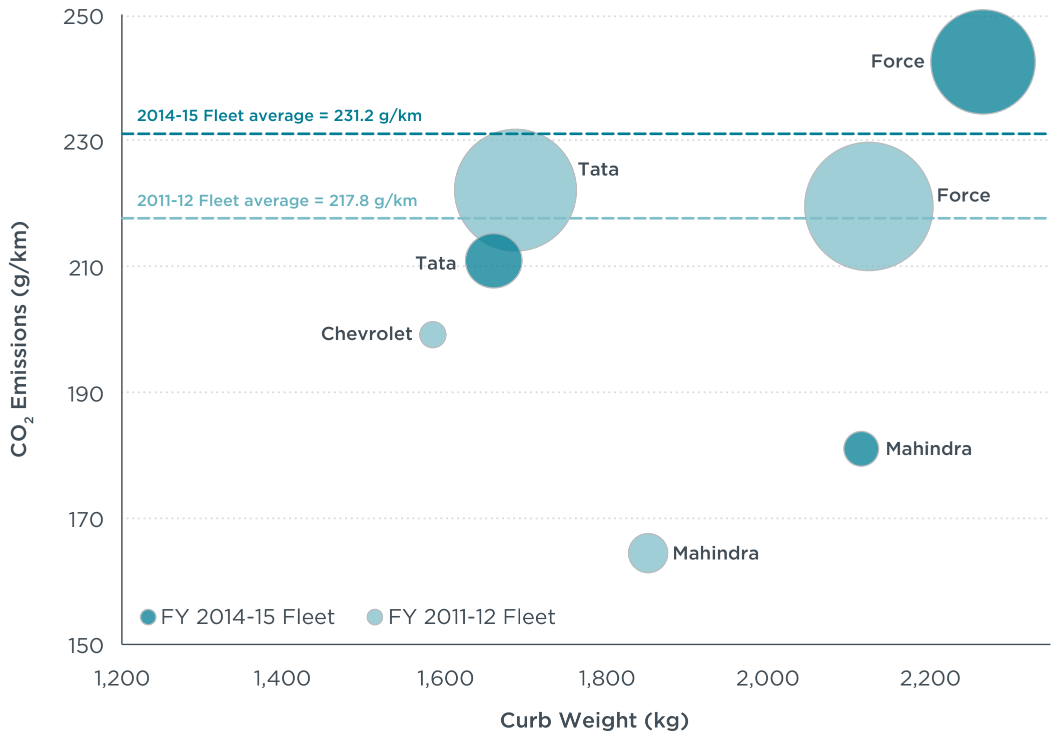

Figure 4. M2 category CO_2 emissions vs. curb weight, FY 2014-15 and FY 2011-12. Size of the circles represent market share.

5. FLEET CHARACTERISTICS AND TECHNOLOGY ADOPTION OF LCVS BY MANUFACTURER

This section analyzes the fuel consumption levels, fleet characteristics, and technology adoption of LCVs by manufacturer. This section also includes a similar analysis for the M2 vehicle category. The following manufacturers contributed to the LCV market share during FY 2014-15. All except Isuzu were domestic manufacturers.

- Ashok Leyland
- Force Motors
- Isuzu
- Mahindra and Mahindra
- Piaggio
- Tata Motors

Table 5. LCV Fleet characteristics by manufacturer for FY 2014-15

Manufacturer	Sales	Market Share	Curb Weight (kg)	CO_2 Emissions (g/km)	Engine Displacement (cc)	Power (kW)	Footprint (m^2)	Power/Weight (kW/kg)
Ashok Leyland	24,414	7.80%	1,250	150.4	1.478	43	3.27	0.034
Force	674	0.22%	1,341	137.2	1,923	29	2.76	0.021
Isuzu	912	0.29%	1,645	200.1	2,499	100	4.50	0.061
Mahindra	149,640	47.79%	1,591	175.4	2,294	45	4.30	0.027
Piaggio	6,229	1.99%	706	130.4	805	12	2.16	0.017
Tata	131,224	41.91%	1,002	140.0	974	18	2.93	0.016

5.1 LCV FLEET CHARACTERISTICS COMPARISON BY MANUFACTURER

This subsection compares the sales-weighted average fleet profile by manufacturer in terms of engine size, curb weight, power, engine displacement, power-to-weight ratio, CO_2 emissions, and vehicle size (footprint). Figure 5 compares fleet characteristics of LCV manufacturers. The summarized findings from the analysis are as follows:

- Tata Motors leads sales of mini trucks at 70% followed by Ashok Leyland, while Mahindra leads sales of pickup trucks.
- 89% of vehicles in the LCV fleet were diesel-powered while 11% were CNG-powered.
- Fleet average CO_2 emissions were 157.6 g/km for FY 2014-15. Isuzu sold the highest CO_2 emitting vehicles at 200 g/km followed by Mahindra at 175 g/km. Piaggio had the lowest average CO_2 emissions at 130 g/km followed by Force at 137 g/km.
- Isuzu had the largest engine size at 2.5 liters, followed by Mahindra at 2.3 liters. Piaggio and Tata had the lowest engine size at 800 cc and 1 liter.
- The average curb weight of the Indian LCV fleet was 1,299 kg for FY 2014-15. Isuzu had the heaviest curb weight vehicles at 1,645 kg followed by Mahindra at 1,590 kg. Piaggio had the lowest curb weight vehicles at 706 kg followed by Tata at 1,002 kg.
- The fleet average power for FY 2014-15 was 33 kW. At 100 kW power, Isuzu had the most powerful engine followed by Mahindra at 45 kW. Piaggio and Tata had the lowest power vehicles at 12 kW and 18 kW, respectively.

- The power-to-weight ratio for Isuzu was the highest at 0.0606 kW/kg followed by Ashok Leyland at 0.0340 kW/kg, while Tata and Piaggio had the lowest power-to-weight ratios of 0.0164 kW/kg and 0.0166 kW/kg, respectively.
- The fleet average footprint for FY 2014-15 was 3.6m². Isuzu had the highest average footprint at 4.5 m² followed by Mahindra at 4.3 m². Piaggio had the lowest average footprint at 2.2 m² followed by Force Motors at 2.7 m².

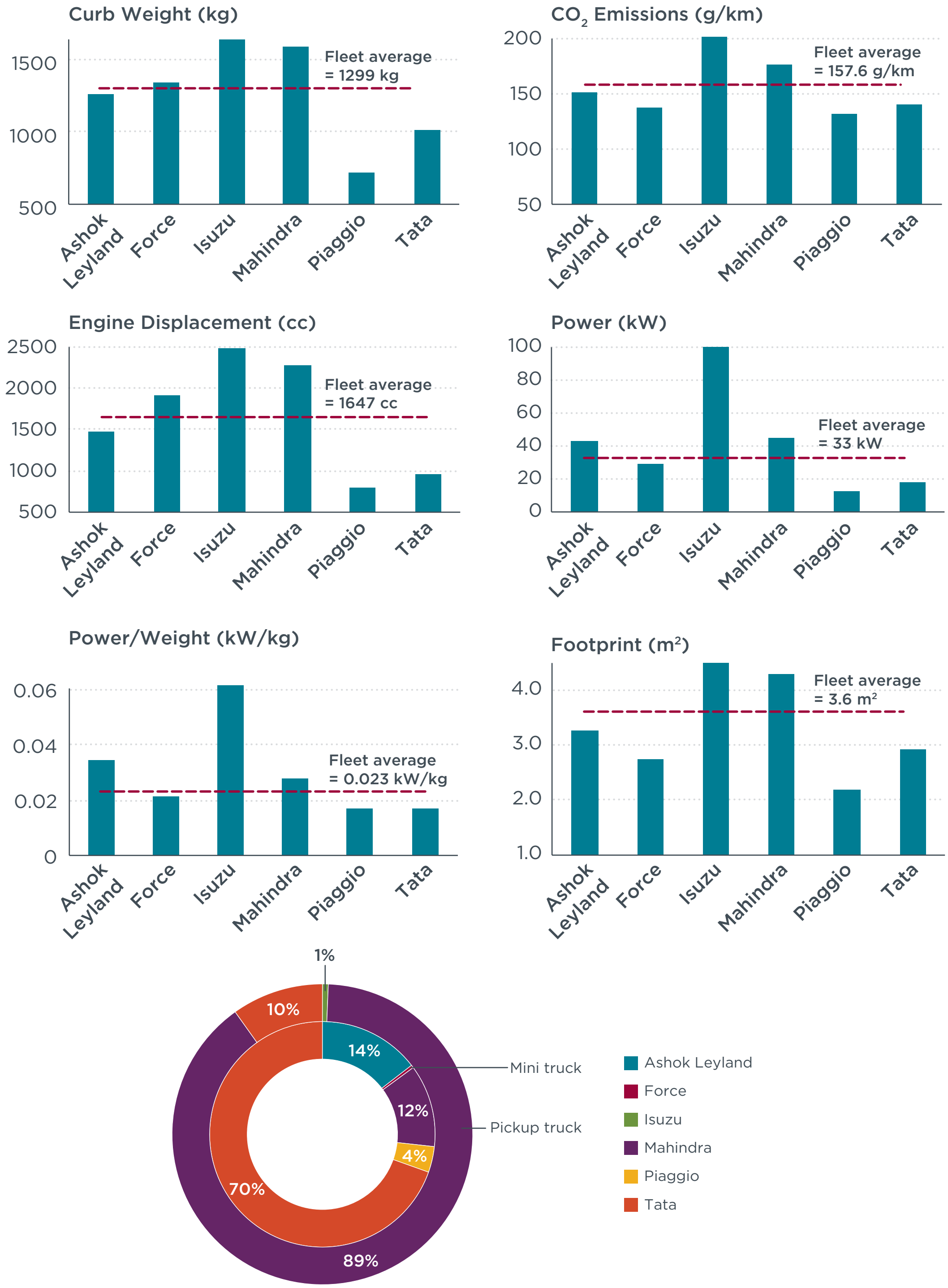

Figure 5. Fleet characteristics by manufacturer for FY 2014-15

5.2 LCV FLEET TECHNOLOGY ADOPTION COMPARISON BY MANUFACTURER

This subsection analyzes the adoption of specific technologies by manufacturers. Figure 6 depicts the technology adoption rate by manufacturers. The analysis found the following:

» Tata and Mahindra each sold 12% CNG models. All other manufacturers offered only diesel engines.

» Most manufacturers had vehicles with turbocharged engines; the exceptions were Force Motors and Piaggio. Ashok Leyland and Isuzu had all turbocharged engines while Tata and Mahindra had 86% and 16% turbocharged engines, respectively.

» Most manufacturers had the majority of the engines with either SOHC or OHV configuration with dual valves per cylinder. Isuzu was the only manufacturer with 100% DOHC engines and four valves per cylinder. Mahindra and Tata had 30% and 13% of vehicles with DOHC, respectively.

» Both Isuzu and Ashok Leyland had 100% CRDI engines. Tata, Force, and Piaggio had 65%, 2%, and 17% IDI engines, respectively. Mahindra had a mix of DI (41%) and CRDI (46%) engines.

» Force, Mahindra, and Tata had 2%, 2%, and 12% single-cylinder engines, respectively. Ashok Leyland only had three-cylinder engines. All Piaggio and 72% of Tata models had two-cylinder engines. Mahindra had 87% four-cylinder engines and all Isuzu models had four-cylinder engines.

» Five-speed gear models were more popular in FY 2014-15. Tata and Mahindra each had 30% and 50% with four-gear engine models, while all Force models had four-gear engines. None of the manufacturers had automatic or dual clutch transmission systems.

» Most manufacturers had BS-IV certified LCVs. All of the Piaggio and Force models were BS III certified, while only 20% of Tata and and 30% of Mahindra models were BS-III certified.

Figure 7 shows the curb weight versus CO_2 emissions and Figure 8 shows the footprint versus CO_2 emissions for the FY 2014-15 fleet, both by manufacturer.

Figure 6. Technology adoption of LCVs by manufacturer for FY 2014-15

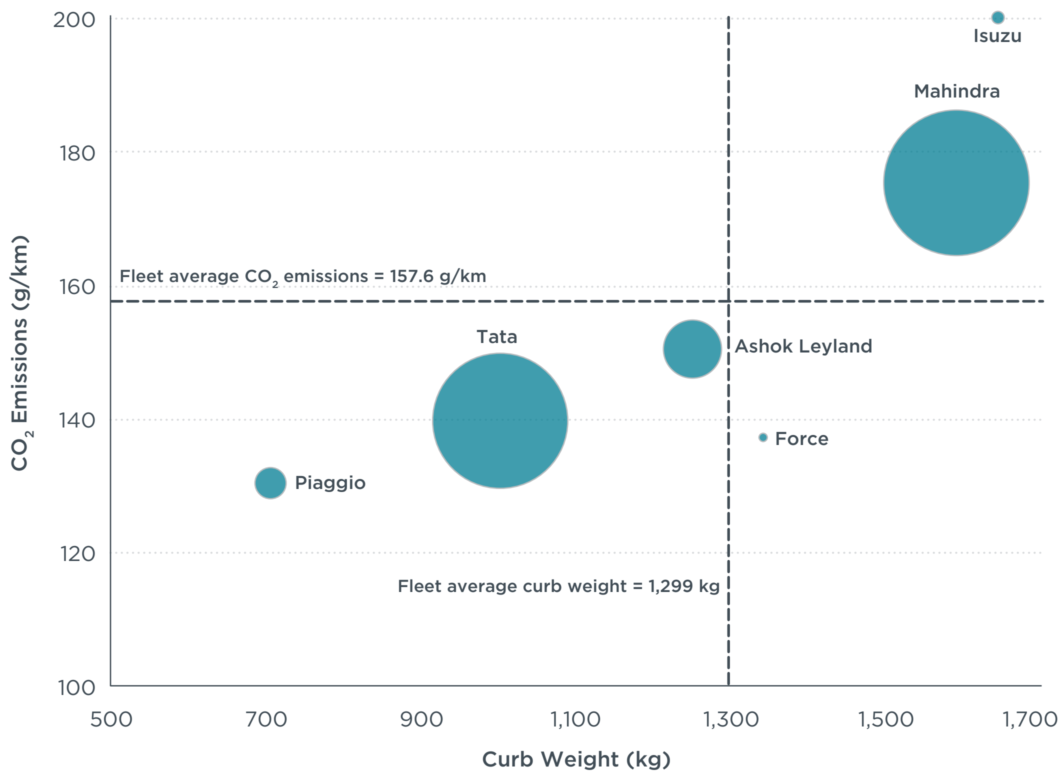

Figure 7. Curb weight vs. CO_2 emissions in FY 2014-15. Size of the circles represent market share.

As stated previously, LCV fuel consumption in India is currently unregulated**.** The EU has set a 2017 target of 175 g/km (for average curb weight equal to 1,706 kg) (EC, 2012) for LCVs. The EU has also set a 2020 target for LCVs stipulated at a target value of 147g/km CO_2 emissions (EC, 2014). Figure 9 shows FY 2011-12 and FY 2014-15 fleets by manufacturer alongside the EU 2017 and EU 2020 targets.

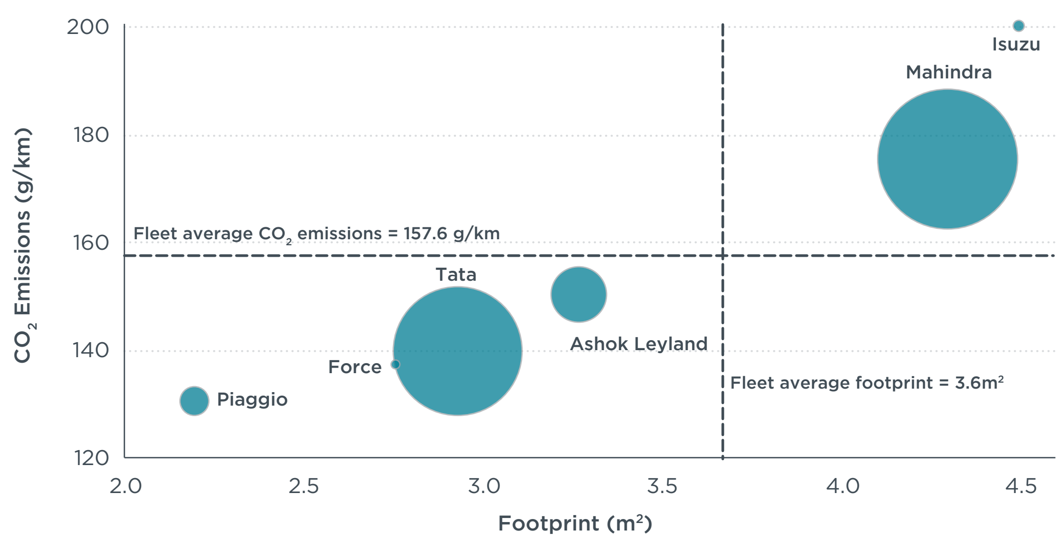

Figure 8. Footprint vs. CO_2 emissions in FY 2014-15. Size of the circles represent market share.

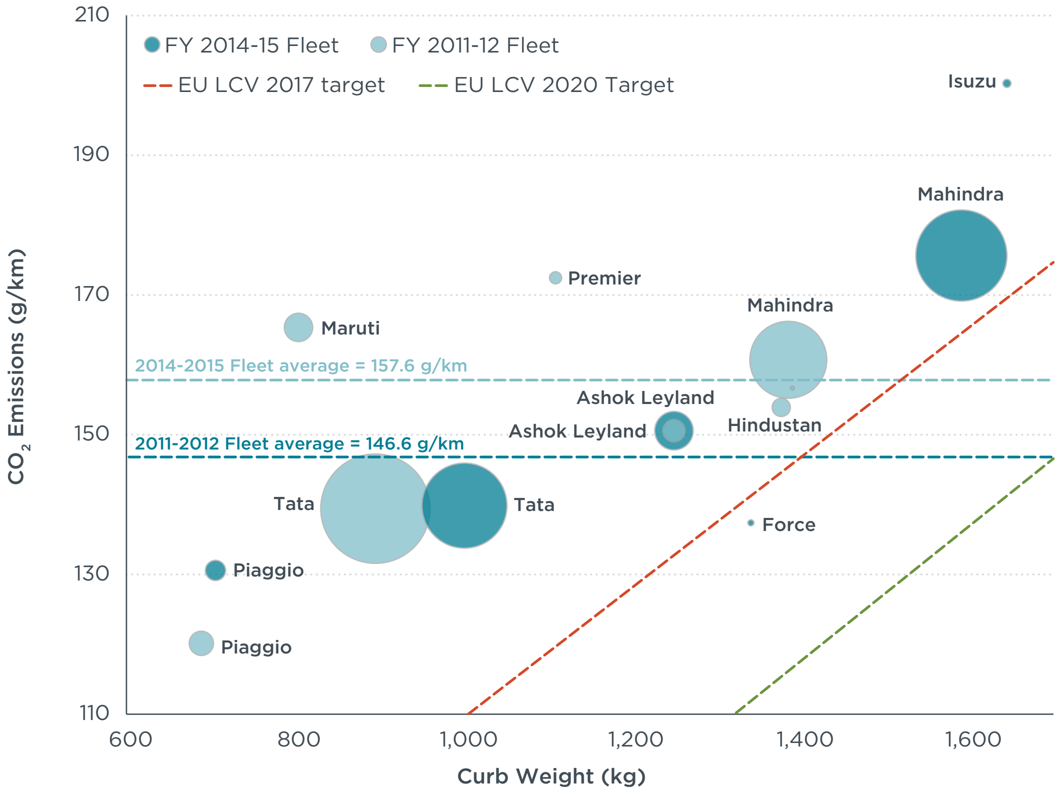

Figure 9. Curb weight vs. CO_2 emissions with EU LCV targets. Size of the circles represents market share.

If the EU LCV 2017 standard is implemented in India for LCVs, the percentage reductions required by manufacturers would be as shown in the table 6 below.

Table 6. Gap between LCV CO_2 emissions in India and EU LCV 2017 target

Manufacturer	Curb Weight (kg) in FY 2014-15	CO_2 Emissions (g/km) in FY 2014-15	EU 2017 Equivalent Target (g/km)	Reduction Required
Ashok Leyland	1,250	150.5	132.6	11.9%
Force	1,341	137.2	141.1	Target achieved
Isuzu	1,645	200.2	169.3	15.4%
Mahindra	1,591	175.5	164.3	6.4%
Piaggio	706	130.5	82.0	37.2%
Tata	1,002	139.9	109.5	21.7%
TOTAL	1,299	157.6	137.1	13.0%

5.3 FLEET CHARACTERISTICS OF M2 VEHICLES BY MANUFACTURER

In this subsection, the fleet characteristics of M2 vehicle segment are analyzed. Although M2 vehicles are not included in the LCV category, the analysis aims to provide insight into the M2 market segment and to serve as a basis for future studies on this sector specifically.

The major M2 vehicle manufacturers in FY 2014-15 were:

- Force
- Mahindra
- Tata

Table 7. Fleet characteristics of M2 vehicles by manufacturer for FY 2014-15

Manufacturer	Sales	Market Share	Curb Weight (kg)	CO_2 Emissions (g/km)	Engine Displacement (cc)	Power (kW)	Footprint (m^2)	Power/weight (kW/kg)
Force	13,286	71.7%	2,267	243	2,556	60	5.54	0.026
Mahindra	1,468	7.9%	2,115	181	2,523	52	4.99	0.025
Tata	3,790	20.4%	1,660	211	1,948	55	4.52	0.033
M2 Total	18,544	100%	2,131	231.2	2,432	58	5.29	0.028

Table 7 compares the fleet characteristics of M2 manufacturers. The findings were as follows:

- 80% of vehicles in the M2 fleet were diesel powered while the remainder were CNG powered
- Force had the largest average curb weight (2,267 kg), followed by Mahindra (2,115kg).
- Force had the largest engine size at 2.55 liters, followed by Mahindra at 2.52 liters.
- Force had the most powerful vehicles at 60 kW, followed by Tata at 55 kW.
- Force had the vehicles with the highest average footprint at 5.54 m^2, followed by Mahindra at almost 5 m^2.
- The CO_2 emissions of Force were the highest at 243 g/km; followed by Tata at 211 g/km. Mahindra had considerably lower CO_2 emissions than the other two, at 181 g/km.

5.4 TECHNOLOGY ADOPTION OF M2 VEHICLES IN INDIA

This subsection analyzes the level of technology adoption in M2 vehicles in India. Figure 10 shows the various technology adoption parameters by manufacturer.

The findings of the analysis are as follows:

- The majority of M2 vehicles were turbocharged in FY 2014-15. Force and Mahindra had all turbocharged vehicles, while only 33% of Tata vehicles were turbocharged.
- Overhead valves and SOHC were more popular in M2s. Only 8% of Force vehicles had DOHCs and four valves per cylinder, while the rest had overhead valves. Both Tata and Mahindra had two valves per cylinder engines, while Mahindra had all SOHC configurations, Tata had all OHV configurations.
- 14% Force Motors engines were CNG, while the rest were diesels. All Tata and Mahindra M2s had diesel engines.
- Tata had all direct injection (DI) engines, while Force had almost 82% with DI engines. Mahindra had all CRDI engines, while 8% of Force vehicles had CRDI engines.
- None of the M2s had automatic transmissions or DCT. All of them had five-speed gears.

» The majority of M2 vehicles were BS III certified. Of Force vehicles, 58% were BS IV certified, while the rest were BS III certified. All of Mahindra and Tata's M2 vehicles were BS III certified.

Figure 10. Technology adoption by M2 manufacturers in FY 2014-15

6. COMPARISON OF LCV FLEETS ACROSS COUNTRIES

This section analyzes the differences among LCV fleets in India, Japan, and Europe (EU-28). Japan and the EU, like India, refer to N1 category vehicles as light-commercial vehicles. Table 8 shows the comparison.

Table 8. LCV fleet characteristics for India, EU-28 and Japan

Fleet Characteristic	India		EU-28	Japan
	FY 2011-12	FY 2014-15	FY 2014-15	CY 2013-14
Engine Displacement (cc)	1,244	1,647	1,919	1,101
Curb Weight (kg)	1,047	1,299	1,752	1,067
CO_2 Emissions (g/km)	146.6	157.6	171	151 (NEDC Cycle); 150 (JC08 Cycle)
Diesel%	86%	89%	96%	6%
Compressed Natural Gas (CNG)%	10%	11%	0.6%	0%
Power (kW)	24	33	85	—
Footprint (m^2)	3.11	3.60	5.20	—
Automatic Transmission	0%	0%	4%	—

As presented in Table 8, 86% and 89% of India's LCVs were powered by diesel in FY 2011-12 and FY 2014-15, respectively. In the EU, 96% of LCVs were powered by diesel, while only 6% of Japan's LCVs were powered by diesel. The remainder, 94%, of Japan's LCVs was powered by gasoline.

The curb weight of India's LCVs was similar to Japan's LCV fleet curb weight in FY 2011-12, but the curb weight of India's fleet went up by 18% in FY 2014-15. On the other hand, the EU's LCVs had a heavier curb weight by almost 35% compared with India's LCV fleet in 2014-15 and by 67% in FY 2011-12.

Compared with India's LCV fleet, Japan's LCV fleet had a lower engine size (by 33% in FY 2014-15 and by 11% in FY 2011-12). On the other hand, the EU's LCVs had a larger engine size than India's LCVs by 67% in FY 2011-12 and by 34% in FY 2014-15. The lower average engine size and curb weight of Japan's LCV fleet can be credited to the popularity of Japan's Kei class vehicles, similar to mini trucks in India.

CO_2 emissions from Japan's vehicles are measured using the JC08 test cycle, while CO_2 emissions in India and the EU are measured using the new European driving cycle (NEDC). For the purposes of this study, the CO_2 emissions from the JC08 test cycle were converted to the NEDC test cycle using ICCT's conversion tool.[5] Similarities are seen across Japan and India's fleets in terms of CO_2 emissions. The difference was only 3% in FY 2011-12 and 4% in FY 2014-15. The EU's CO_2 emissions were higher than India's fleet by 16% and 9% in FY 2011-12 and FY 2014-2015, respectively. The lower CO_2 emissions in India compared with the EU can be attributed to the lower average curb weight and engine size of India's LCV fleet.

5 Conversion Tool and conversion tool methodology can be found at: http://www.theicct.org/info-tools/global-passenger-vehicle-standards

The EU's LCV fleet average power was significantly higher, by almost 157%, compared with India's fleet average in 2014-15. The EU footprint was also higher than India's LCV fleet by 44% in FY 2014-15. Looking at the transmission, 4% of the EU's LCV fleet had automatic transmissions while none of India's LCV fleet had automatic transmissions.

We were unable to obtain data on power, footprint, and transmission for Japan.

Figure 11 shows the fleet average CO_2 emissions of LCV manufacturers in India, Japan, and the EU-28. The figure also depicts the EU LCV CO_2 emissions targets for years 2017 and 2020. We can infer from the figure that although the EU's LCV fleet is heavier and more powerful, it is also more fuel efficient than the fleets in India and Japan.

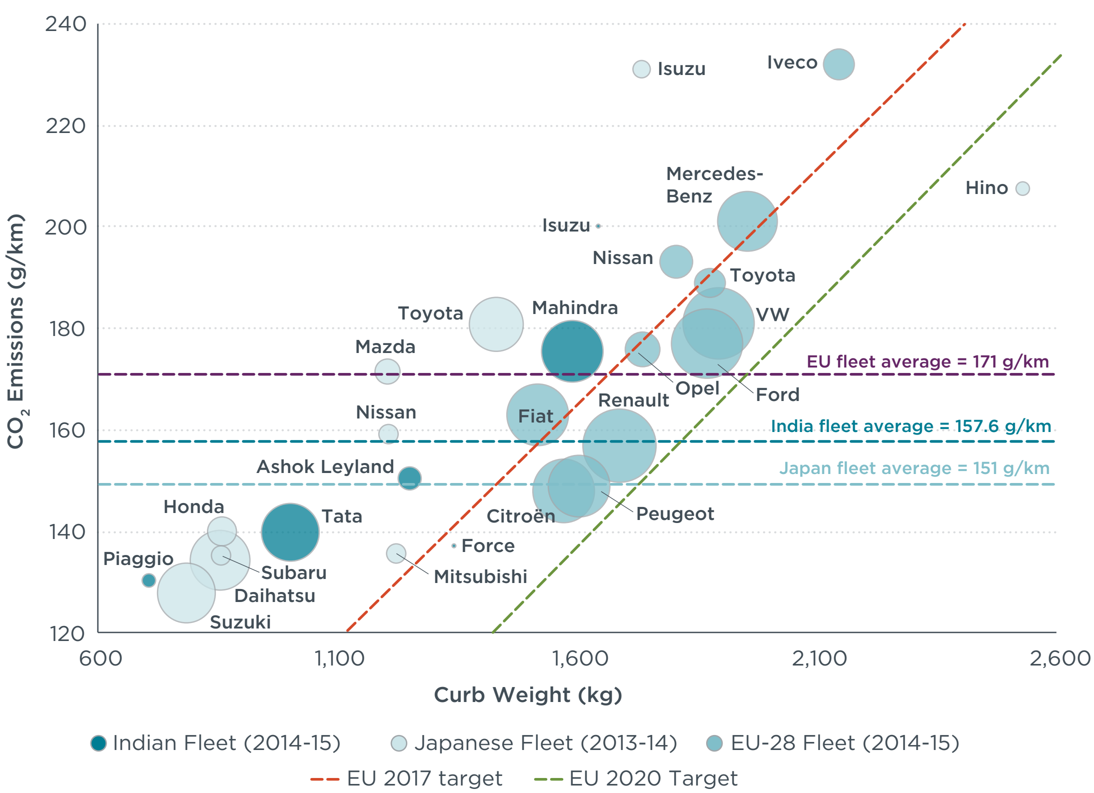

Figure 11. Curb weight vs. CO_2 emissions for India, EU-28, and Japan. Size of the circles represent market share.

7. FUTURE IMPROVEMENTS

From the analysis and comparison of the EU and Japan LCV fleets, we can conclude that India's LCV fleet has much room for improvement moving forward.

7.1 IMPROVEMENTS BASED ON BEST-IN-CLASS VEHICLES

Figures 12 and 13 above show improvements that can be made to the fleet based on best-in-class vehicles in each segment.

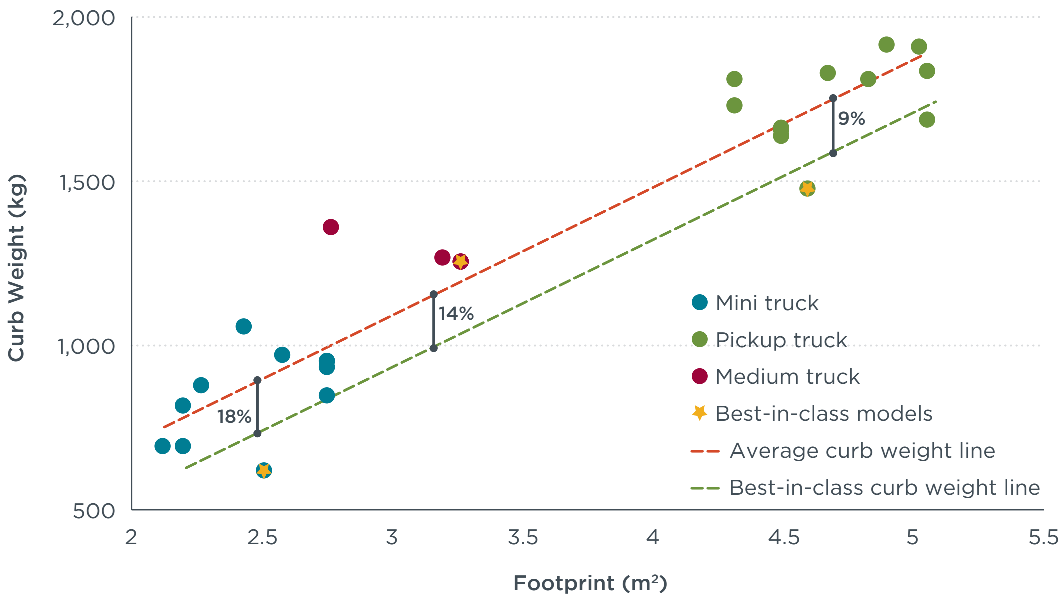

Figure 12. Footprint vs. curb weight regression for LCV models in FY 2014-15

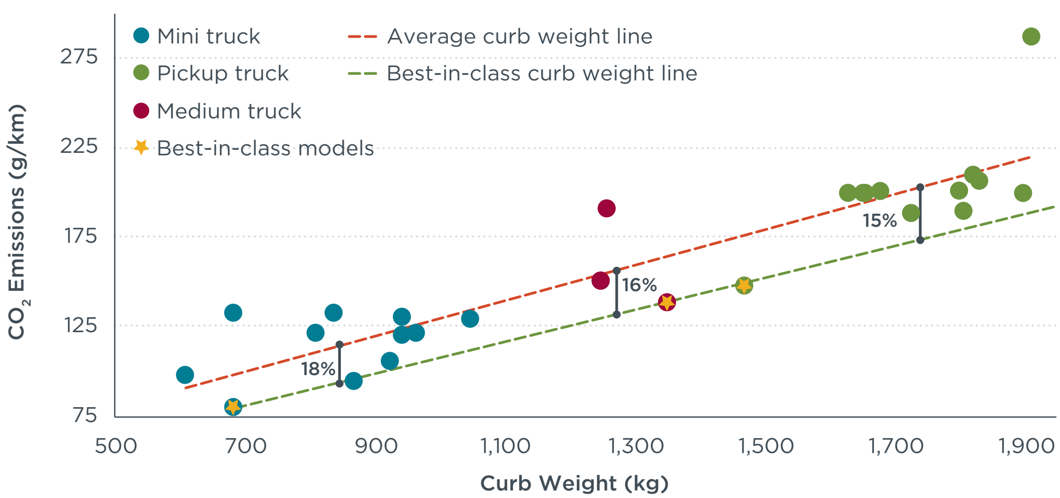

Figure 13. Curb weight vs. CO_2 emissions regression for LCV models in FY 2014-15

As mentioned before, SIAM categorizes N1 category vehicles (LCVs) as Mini trucks (GVW< 2,000 kg), and Pickup trucks (GVW >2,000 kg). Since the mini truck segment encompasses a wide range of engine sizes, we further divided the mini truck category into mini trucks and medium trucks. Mini trucks include all engine sizes below 1 liter, while medium trucks include all engine sizes between 1 liter and 1.5 liters. The pickup truck segment contains all LCVs with an engine size greater than 1.5 liters.

For Figure 12, we identified best-in-class vehicles based on the curb weight. The LCV with the lowest curb weight in each segment was assigned as the best-in-class vehicle in that segment. The green line represents regression of best-in-class vehicles, labeled as minimum curb weight line. The red line represents a regression of all LCV models, labeled as the average trend line. Using the regression lines, the analysis calculates the reduction in average curb weight of the segment if the curb weight of an average LCV model was equal to the best-in-class model for a particular LCV segment. The reduction is calculated at the average footprint of the segment. For mini trucks, the reduction in curb weight was 18% at the average footprint of 2.48 m^2. For medium trucks, the reduction was 14% at the average footprint of 3.15 m^2, and for pickup trucks, the reduction was 9% at the average footprint of 4.69 m^2. Therefore, the average reduction in curb weight for all LCV segments was 14%. A 14% reduction in curb weight would mean a 9% reduction in CO_2 emissions; in other words, the fleet average CO_2 emissions can come down to 145.2 g/km.

Figure 13 represents a similar analysis done on the basis of CO_2 emissions of LCV models. In each segment, an LCV model with the lowest CO_2 emissions was chosen as the best-in-class model. For each segment, at the average curb weight of the segment, we calculated the percentage difference between the best-in-class CO_2 emissions and average CO_2 emissions. For mini trucks, at the average curb weight of 848 kg, the difference was 18%. For medium trucks, at the average curb weight of 1,272 kg, the difference was 16%. For pickup trucks, the difference was 15% at the average curb weight of 1,740 kg. If average CO_2 emissions were to be brought in line with the best-in-class emissions, a 16% overall reduction in CO_2 emissions could occur; that means the CO_2 emissions would come down to 132 g/km. This reduction in CO_2 emissions could be achieved by introducing more fuel-efficient technologies to the LCV fleet. Figure 14 shows that matching the best-in-class CO_2 emissions would help achieve the EU's 2017 target.

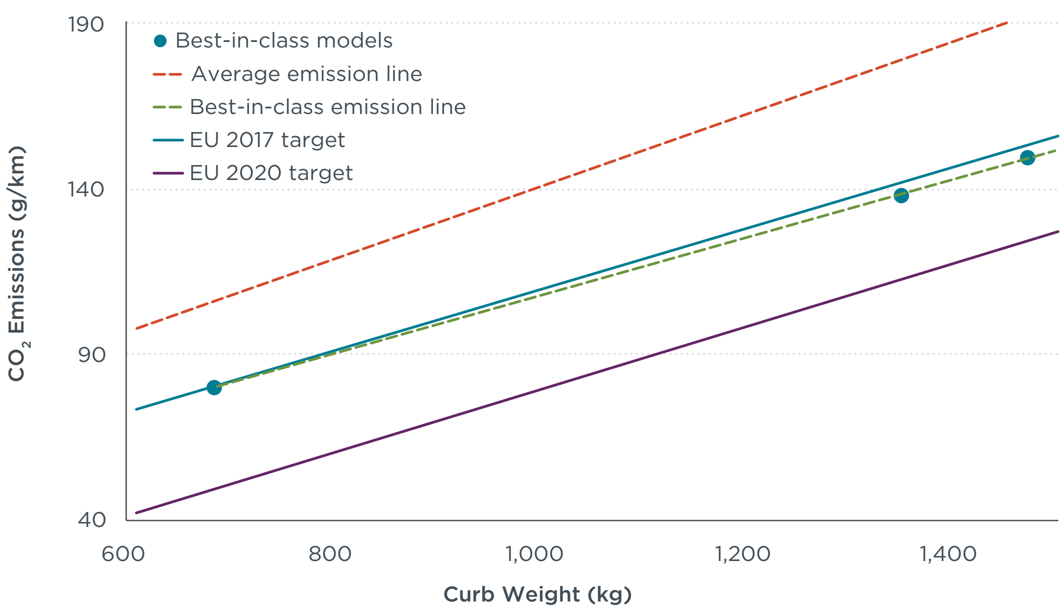

Figure 14 Comparison of best-in-class emission line and EU CO_2 LCV targets for 2017 and 2020

7.2 FUEL-ECONOMY LABELING FOR LCVS

The Bureau of Energy Efficiency (BEE) in India has designed a passenger vehicle fuel efficiency program. It entails a five star rating system based on the gasoline equivalent fuel consumption of the vehicle. The BEE formulated a star-rating band, shown in the table 9, which is calculated using the curb weight (W) of the vehicle in kilograms.

Table 9. BEE Star rating bands for passenger cars (M1 category)

Star Rating band	Gasoline Equivalent Fuel Consumption levels (l/100km)
1 Star	FC ≥ 0.00330xW+3.0034
2 Star	0.00330xW+3.0034 ≥ FC > 0.00264x W+3.0034
3 Star	0.00264xW+3.0034 ≥ FC > 0.00216 xW+3.0034
4 Star	0.00216xW+3.0034 ≥ FC>0.00168x W+3.0034
5 Star	FC ≤ 0.00168xW+3.0034

This fuel-economy labeling program currently does not include LCVs. For this analysis, the same star-rating band was applied to LCVs based on their gasoline equivalent fuel-efficiency values, then plotted in Figure 15. Under this scheme, 8.5% of the sales would get one star rating, whereas 10.1% of the vehicle sales would be assigned a five star rating. The percentage of vehicle sales receiving two, three and four stars would be 50.9%, 26.7%, and 3.8% respectively. This exercise suggests that including LCVs in the fuel-economy labeling program would be effective and easily executed within the existing program parameters.

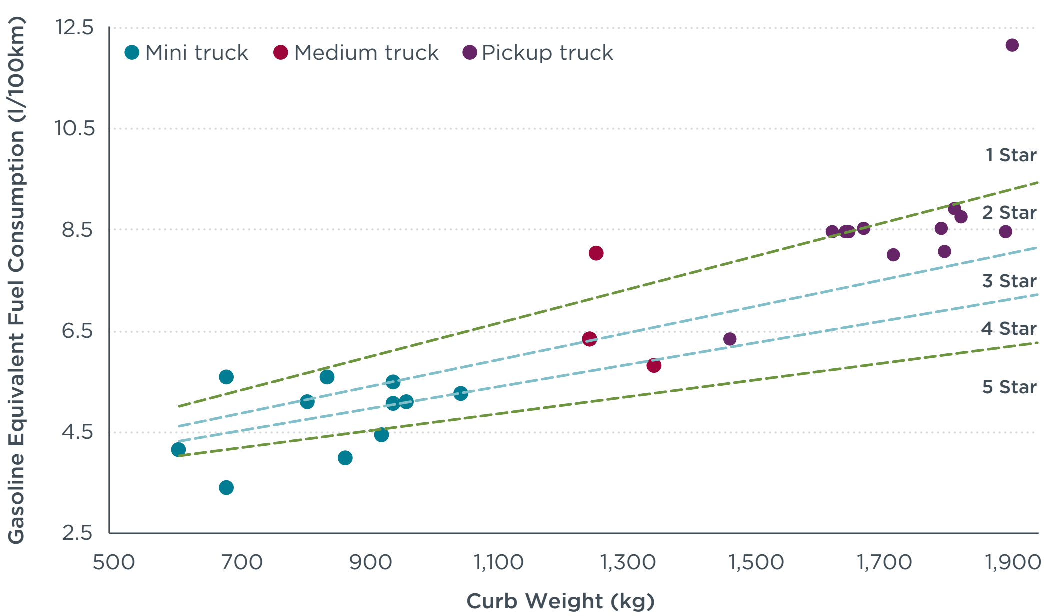

Figure 15. LCV fuel consumption labeling exercise

8. CONCLUSIONS AND RECOMMENDATIONS

- In FY 2014-15, India's LCV fleet was heavier and had a larger engine size and higher CO_2 emissions than in FY 2011-12.
- The fleet average CO_2 emissions for LCVs were 157.6 g/km in FY 2014-15. For the M2 category, the fleet average emissions were 238.1 g/km. Both values measured under the NEDC cycle.
- India's fleet characteristics in FY 2011-12 were similar to those of Japan, while in FY 2014-15, India's fleet characteristics were more similar to the EU's LCV fleet.
- The analysis found that there were no strong hybrids or mild hybrids in India in either FY 2011-12 or FY 2014-15. There are no electric LCVs in India yet, however, there are electric versions of Tata and Mahindra LCVs in the pipeline.
- Fuel-efficient technologies such as DOHC and automatic transmissions have very little to no penetration in India's LCV sector. VVL and VVT technologies are also non-existent in India's LCV market.
- The best-in-class vehicle analysis suggests that a 9% reduction in CO_2 emissions can be achieved by reducing the average curb weight of the fleet to the best-in-class vehicle curb weight.
- Reducing the fuel consumption of LCVs in each class to the level of their respective best-in-class vehicles can help reach the EU 2017 LCV fuel consumption target in India. This reduction can be accomplished by introducing more fuel-efficient technologies to the LCV segment. Thus, India should consider adopting a LCV fuel consumption standard on par with EU LCV CO_2 standard.
- The fuel-efficiency labeling program could be expanded to include LCVs. BEE's star-rating bands for passenger cars would be effective for measurement of LCVs, and could easily be implemented.

ANNEX

BEE	Bureau of Energy Efficiency
CNG	compressed natural gas
CO_2	carbon dioxide
CRDI	common-rail diesel injection
CY	calendar year
DCT	dual clutch transmission
DI	direct injection
DOHC	dual overhead camshaft
EU	European Union
FC	fuel consumption
FE	fuel efficiency
FY	fiscal year
GVW	gross vehicle weight
ICCT	International Council on Clean Transportation
IDI	indirect diesel injection
LCV	light commercial vehicle
MLIT	Ministry of Land, Infrastructure and Transport and Tourism
MPFI	multi-port fuel injection
NEDC	new European driving cycle
RWD	rear-wheel drive
SFI	sequential fuel injection
SIAM	Society of Indian Automobile Manufacturers
SOHC	single overhead camshaft
VVL	variable valve lift
VVT	variable valve timing

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