THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Market analysis of heavy-duty vehicles in India for fiscal year 2017–18

Authors: Ben Sharpe and Bharadwaj Sathiamoorthy
Date: November 2019
Keywords: efficiency, fuel economy, regulatory design, VECTO

Introduction

In India, the process of formally establishing fuel-efficiency standards for heavy-duty vehicles (HDVs) started in July 2014, when the Ministry of Petroleum and Natural Gas created a steering committee to guide the regulatory development process. The HDV standards were subsequently finalized in August 2017 and went into effect for commercial vehicles with gross vehicle weight (GVW) more than 12 tonnes on April 1, 2018. Then, in July 2019, fuel-efficiency standards for light- and medium-duty commercial vehicles weighing between 3.5 and 12 tonnes were finalized.

The regulations for both sets of on-road commercial vehicles are based on meeting minimum performance requirements during constant speed fuel consumption (CSFC) testing. However, going forward, several stakeholders—including government officials—have expressed the desire to move to simulation-based standards to be more aligned with trends in other major markets. The Vehicle Energy Consumption Calculation Tool (VECTO) is a simulation model that was developed by the European Commission to facilitate the measurement of HDV fuel consumption and CO_2 emissions. Regulators in India are in the process of creating an India-specific version of VECTO for use in subsequent fuel efficiency regulations—the Bharat Energy Efficiency Tool (BEET).

Information about the market for new HDVs in India is needed to craft effective, regionally focused regulations, including BEET. To help, this paper is a follow-up to a previous ICCT market study for fiscal year (FY) 2013–14 (Sharpe, 2015) and examines FY 2017–18 data for commercial truck and bus sales in India.[1] The next section breaks down the new commercial vehicle sales market by vehicle segment, weight category, and manufacturer, and details the changes since FY 2013–14. Subsequently, we examine the size and power rating distributions of commercial vehicle engines. Finally, we use this information to analyze the options for an HDV segmentation system as India transitions to a regulatory program centered around BEET.

1 The fiscal year for the Government of India runs from April 1 to March 31.

India's HDV sales market

The sales market data referenced in this paper is for India's 2017–18 fiscal year and was acquired from Segment Y Automotive Intelligence. In fiscal year 2017–18, total domestic sales of commercial vehicles greater than 3.5 tonnes, which are "HDVs" in this paper, was nearly 460,000. Between FY 2013–14 and FY 2017–18, sales have increased by a factor of 1.7 (Sharpe, 2015).

BREAKDOWNS BY MANUFACTURER MARKET SHARE AND GROSS VEHICLE WEIGHT

Figures 1 and 2 summarize manufacturers' market shares for HDV sales in India. Figure 1 shows all HDV sales, and Tata Motors is the clear market leader with 45%. Tata's share of the market is nearly twice as large as its nearest competitor, Ashok Leyland, which sold roughly one-fourth of the vehicles in FY 2017–18. The gap between the two competitors has been significantly reduced since FY 2013–14, when Tata Motors' share of the market was nearly three times as large as Ashok Leyland's share. VE Commercial Vehicles (VECV), a joint venture between the Volvo Group and Eicher Motors, is the only remaining company with a double-digit share of the market at 12%; this is a drop of two percentage points since FY 2013–14. The next largest market shares are held

Acknowledgments: This work is funded by Lawrence Berkeley National Laboratory. The critical reviews of Anup Bandivadekar and Oscar Delgado of the ICCT were very valuable.

by Force, Mahindra, and Bharat Benz (Daimler India), which each represent roughly 4%–5% of sales. The three manufactures that make up the "other" category are SML Isuzu, MAN, and the Volvo Group.

In Figure 2, the inner and outer rings represent market share breakdowns for buses and trucks, respectively. When breaking out sales by these broad vehicle categories, the top three manufacturer rankings for trucks match the ranking for overall sales, and Tata, Ashok Leyland, and VECV are the best-selling manufacturers. Meanwhile, Force ranks ahead of Ashok Leyland and VECV as second highest in bus sales.

Rather than by manufacturer, Figure 3 summarizes the market shares of new HDVs in terms of gross vehicle weight rating (GVWR), which is the maximum recommended operating mass of a vehicle, as specified by the manufacturer. This figure plots the cumulative market share as a function of vehicle GVWR for both trucks and buses. The vertical or near-vertical collections of data points in the chart reflect concentrations of vehicle sales at that particular GVWR value. For example, for trucks, there are high concentrations of sales at 25, 37, 12, and 16 tonnes, and the percent of total truck sales at each of these points is approximately 20%, 10%, 10%, and 5%, respectively. India's Ministry of Road Transport and Highways (MoRTH) specifies a maximum GVWR of 25 tonnes and 12 tonnes for three-axle and two-axle rigid trucks, respectively, and this could be contributing to the skewed concentration at these weights. For trucks less than 12 tonnes, there are no distinct spikes in market share at any given GVWR value, and the distribution of sales is relatively smooth. For buses, the most well-defined vertical segments of concentrated market share are at 16 tonnes (16% of sales) and 3.8 tonnes (13% of sales). Between 4 and 16 tonnes, there are no individual GVWR values that are more than about 8% of total bus sales.

Figure 4 breaks down each manufacturer's sales portfolio by vehicle type (i.e., truck or bus) and GVWR. Tata, Ashok Leyland, and VECV have the most diversity in their sales mix, and each offer products in each of the seven vehicle class/weight categories. The top five highest-selling manufacturers all offer vehicles in at least five of the eight vehicle categories, while the three lowest volume manufacturers have sales limited to two or three of the categories.

Figure 5 shows the shift in market shares among manufacturers by total sales when compared with FY 2013–14. Force Motors gained significant market share since FY 2013–14. Total sales in 2017–18 were 455,731, nearly double what they were in 2013–14 (279,468). Figure 6 shows further breakdown of market share by bus and truck segments, and Tata had the largest market share in both categories in both FY 2013–14 and 2017–18. Between 2014 and 2018, Ashok

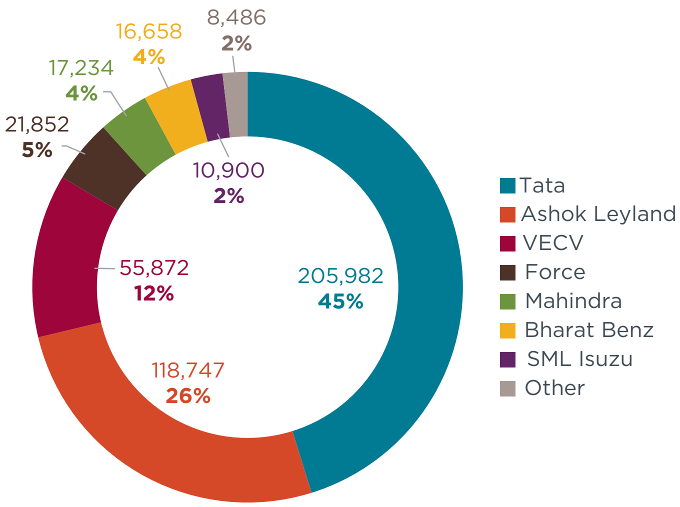

Figure 1. Manufacturers' market shares for new HDV sales

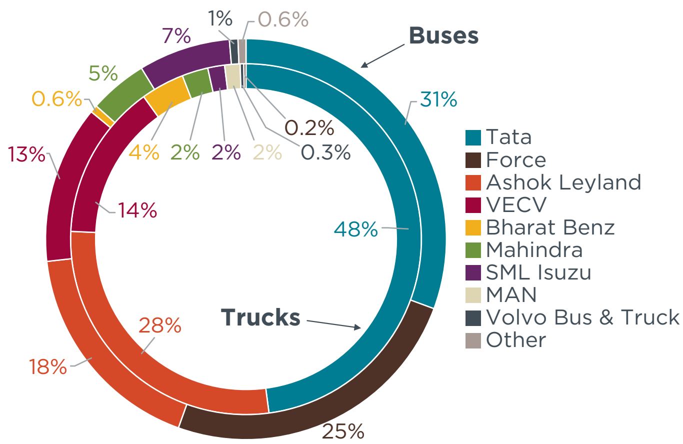

Figure 2. Manufacturers' market shares for new truck and bus sales

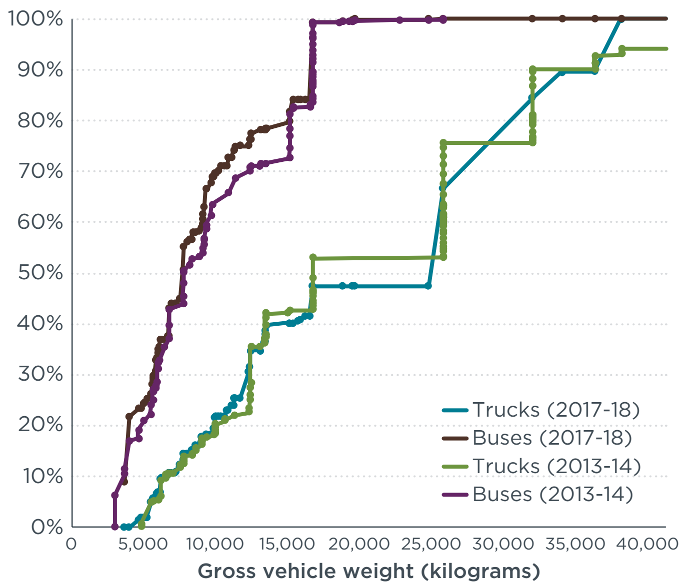

Figure 3. Cumulative market shares of trucks and buses as a function of GVWR

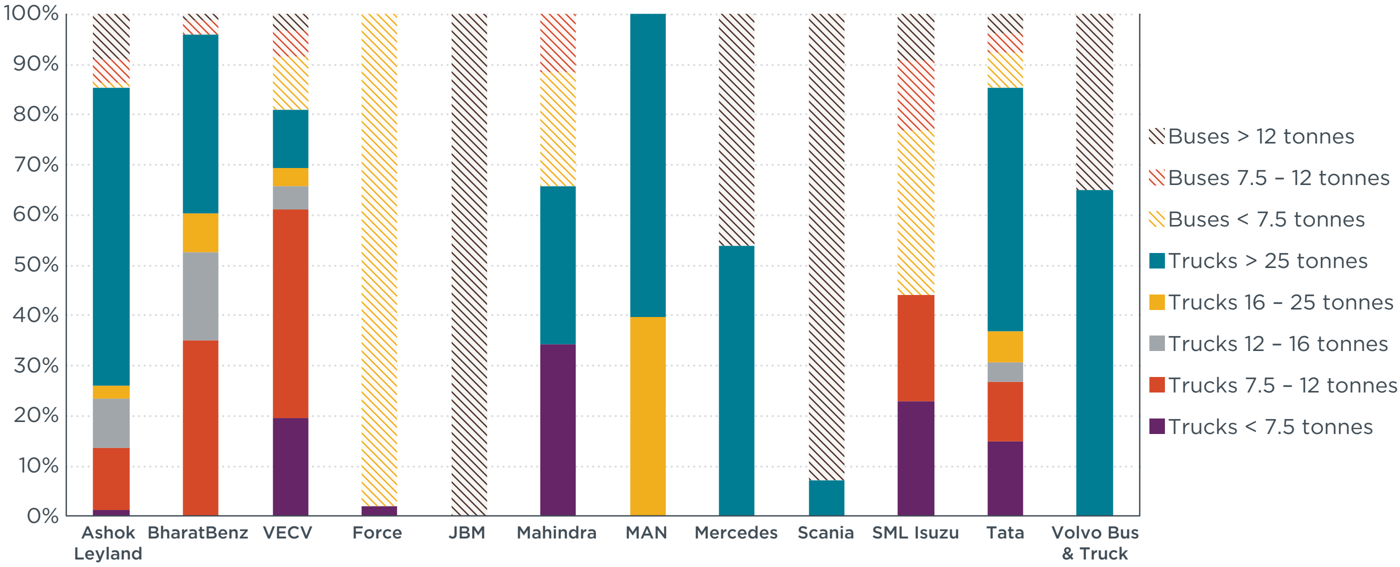

Figure 4. Manufacturer breakdown of sales by segment and gross vehicle weight

Leyland gained 10% market share in the truck segment and lost 2% in the bus segment. Force motors, which only manufactures buses, doubled its market share since 2013–14 and became the second highest in bus sales in 2017–18, after Tata. While Tata only had a 25% increase in the volume of units sold in 2017–2018 compared to 2013–2014, Ashok Leyland's volumes doubled in the same period.

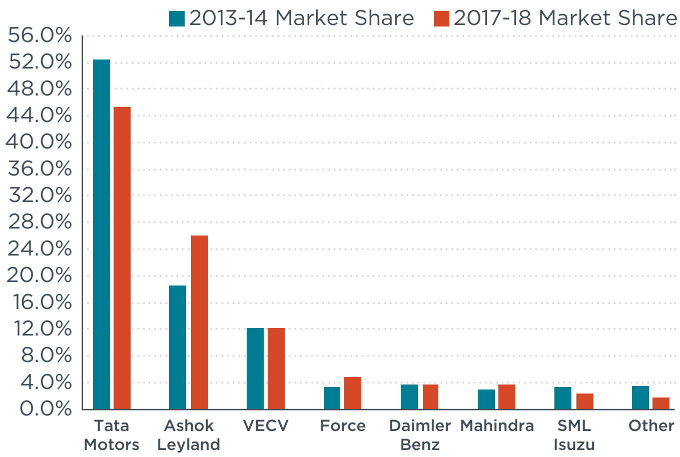

Figure 5. Manufacturer market shares 2013–14 versus 2017–18

TOP VEHICLE MODELS BY SEGMENT

Table 1 presents information about the top-selling truck and bus models for various GVWR segments. As further evidence of its dominance in sales, Tata has the best-selling model for all truck and tractor truck categories except in one segment, where it was displaced by Ashok Leyland. In the bus category, Force entered the market and gained a significant market share in the lighter end of the spectrum. For the larger buses, Ashok Leyland's models are the most popular.

The top seller has a greater than one-third share of total sales in only one truck category, and in the remaining five categories, the top model makes up only between 12% and 24% of the segment's total sales. Meanwhile, in one of the bus segments, the top model was nearly half of total sales, and in the remaining two segments, the top models represented between 14% and 27% of sales. This is a reversal when compared to the 2013–14 sales, when more consolidation was seen in trucks than in buses.

The right-side columns of Table 1 detail the percentage of sales represented by the five and 10 best-selling models in each segment. Using this metric, we can ascertain the level of heterogeneity in these segments. The top five sellers constitute more than half of segment sales in only three truck categories in 2017–18, whereas in 2013–14, this was true for five truck categories; this indicates more diversification of models and a possible shift in market capture. However, in the bus category, the top five sellers constitute more than half of segment sales in two of the three categories. The heaviest bus category has the most model diversity.

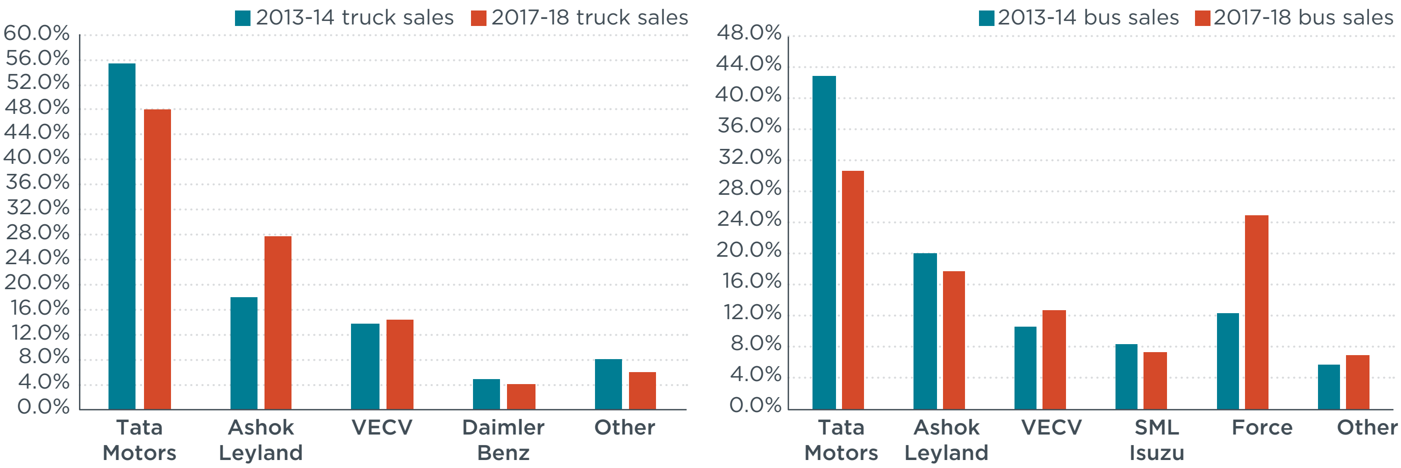

Figure 6. Market share truck and bus breakdown 2013–14 vs 2017–18

Table 1. Top-selling vehicle models by gross vehicle weight segment

Segment	Rank/Model	FY 2017–18 sales	Top model %: of segment sales	Top 5 models: % of sales	Top 10 models: % of sales
Trucks < 7.5 tonnes	1/Tata SFC 407 2/Tata SFC 410 3/Eicher Pro 10.59 4/ Mahindra LK Zoom 5/ Eicher 10.5	17,356	39%	64%	81%
Trucks 7.5–12 tonnes	1/Tata LPT 1109 2/Ashok Leyland Boss 1113 3/Eicher 11.10 4/Ashok Leyland eComet 1012 5/Tata Ultra 1012	8,636	14%	45%	66%
Trucks 12–16 tonnes	1/Tata LPT 1109 2/Ashok Leyland Boss 1213 3/Ashok Leyland Guru 4/Tata Ultra 1518 5/BharatBenz 1217	4,051	19%	73%	100%
Trucks 16–25 tonnes	1/Tata LPT 1613 2/Ashok Leyland 1618 3/MAN CLA 4/Eicher Terra 16 5/BharatBenz 1617R	4,316	24%	84%	100%
Trucks > 25 tonnes	1/Ashok Leyland 3718 2/Tata Prima 3138.K 3/Tata LPT 3118 4/Tata Signa 3118 T 5/Tata LPT 2518	18,944	12%	41%	61%
Tractor trucks > 25 tonnes	1/Tata Prima LX 4028S 2/Tata Prima LX 4928S 3/Ashok Leyland 4923 4/Ashok Leyland 3518 5/Tata LPS 3518	9,314	15%	46%	65%
Buses < 7.5 tonnes	1/Force Traveller 2/Tata Starbus 3/Tata LP 410 4/Eicher Pro 10.75 5/Tata LP 712	19,960	44%	72%	86%
Buses 7.5–12 tonnes	1/Ashok Leyland Lynx 2/Tata LP 912 3/Tata LP 1112 4/Tata LP 909 5/Tata Starbus	4,665	27%	55%	78%
Buses > 12 tonnes	1/Ashok Leyland Viking 2/Tata LPO 1512 3/Tata LPO 1613 4/Ashok Leyland Cheetah 5/Ashok Leyland 12 M	2,829	14%	46%	72%

HDV engine characteristics

Engine-specific research on market conditions, test procedures and duty cycles, technology potential, and economic impacts is also critical to developing robust, engine-based regulation. Sharpe (2015) explored the engine characteristics of HDVs in India to suggest a possible classification scheme that could be used in an engine-based efficiency regulation. This section compares how the market has changed since 2013–14 with respect to engine size and power classifications.

Figure 7 displays the volume of units sold for each unique size and power combination for HDV engines, and the size of the bubble corresponds to the volume of units sold.

There was a slight shift in sales between engine sizes 2.5 and 4 liters, and 4.5 and 8 liters, wherein sales of the smaller engines decreased slightly while sales increased in the larger size category. Sales of engines between 8 and 9.5 liters increased substantially from 2013–14. Indeed, a large portion of the increase in overall sales in 2017–18 was engines between 8 and 9.5 liters.

Figures 8 and 9 show the engine size distributions for each of the GVWR bins for trucks and buses as a comparison between 2013–14 and 2017–18. From Figure 8, it is evident that the engine sizes are most tightly grouped for trucks less than 12 tonnes, with the large majority of engines between 3 and 4 liters; grouping in this range has not changed since 2013–14. Trucks between 12 and 25 tonnes primarily have engines that range from 3 to 6 liters, and some newer engines smaller than 3 liters have been introduced since 2013–14 and contribute to about 10% of sales in this grouping in 2017–18. The heaviest truck engines are predominately between 5 and 7 liters and there is no noticeable change in this category for 2017–18. Figure 9 shows that engines are generally fall between 2 and 4 liters for buses less than 12 tonnes, with manufacturers in 2017–18 completely moving away from engines smaller than 2 liters and shifting to engines between 2 and 4 liters. However, the engine size distribution for the heaviest class of buses covers a relatively large range, from 5 up to 13 liters. Buses greater than 16 tonnes make up only a miniscule portion of the bus market, 0.7%, and if we exclude these, the engine size distribution is tightly concentrated between 5 and 6 liters; no significant changes in engine size for buses were observed between 2013–14 and 2017–18.

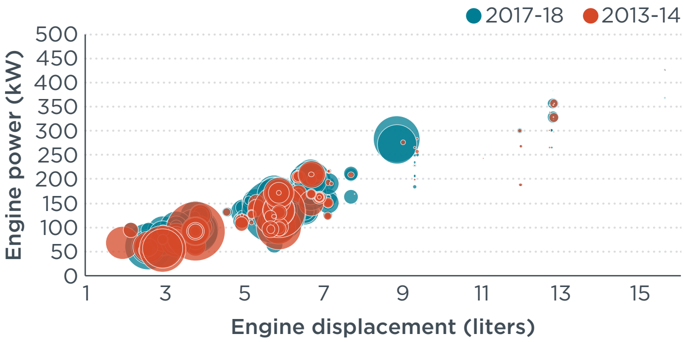

Figure 7. Sales-weight plot of engine size and power points

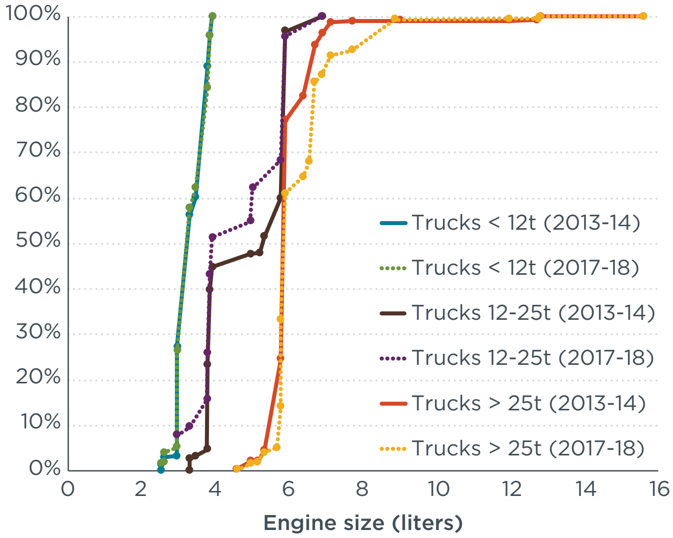

Figure 8. Engine size distributions for trucks in the three example vehicle weight categories

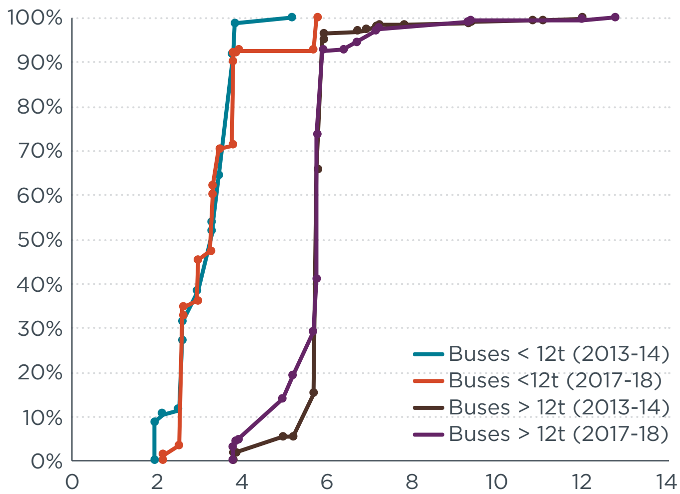

Figure 9. Engine size distributions for buses in the two example vehicle weight categories

Vehicle categorization in the context of fuel consumption standards

This section provides a brief overview of the fuel consumption regulation that India has implemented thus far for commercial trucks and buses. We discuss both the vehicle-categorization approach that has been employed with the initial set of HDV standards and considerations as India moves forward with the next round of standards, which are expected to be centered around simulation modeling.

VEHICLE CLASSIFICATION IN THE EXISTING FUEL CONSUMPTION STANDARDS

As referenced above, in August 2017, the Government of India published final fuel consumption standards for commercial HDVs. The vehicle classes affected by this rule are:

- Motor vehicles for the carriage of passengers with nine or more seats in addition to the driver's seat and a GVW exceeding 12 tonnes
- Motor vehicles for the carriage of goods with a GVW exceeding 12 tonnes

The standards are an equation based on GVW and axle configuration. The equation provides normalized values of fuel consumption in liters per hundred kilometers (l/100 km). The regulations set minimum performance requirements, similar to the existing Bharat Stage emissions standards. To demonstrate compliance, each vehicle model and configuration is required to meet threshold fuel consumption levels that are determined by evaluating each model over a CSFC test at 40 kilometers per hour (kph) and 60 kph. More information about the various elements of the fuel efficiency regulation for HDVs can be found in the ICCT's policy update (Garg & Sharpe, 2017).

In addition to the fuel efficiency standards for new HDVs greater than 12 tonnes, the Government of India finalized efficiency requirements for commercial vehicles between 3.5 and 12 tonnes in July 2019 (Ministry of Power, 2019). This regulation is also based on CSFC testing.

India's fuel consumption standards for HDVs greater than 12 tonnes contain nine subcategories under the N3 category—six for rigid trucks and three for tractor-trailers. Grouping is based on GVW, and both the rigid trucks and tractor-trailers are also segmented according to their axle configuration. These are labeled N3-1 through N3-9 in Figure 10. Note that the labeling for each segment (e.g., N2-1, N2-2, etc.) in the figure was developed in order to facilitate discussion in this paper, and this is not a naming convention used by the Government of India. In the standards for light- and medium-duty commercial vehicles from 3.5 to 12 tonnes, there are two regulatory subcategories: 3.5 to 7.5 tonnes and 7.5 to 12 tonnes. Both of these are 4x2, which is the only axle configuration sold in the less-than-12-tonne segment.

For buses, there is one category for vehicles greater than 12 tonnes (M3-1) and two categories for buses less than 12 tonnes: 3.5 to 7.5 tonnes (M2-1) and 7.5 to 12 tonnes (M2-2). In the figure, each of the boxes represents a unique regulatory subcategory with its own equation that determines the maximum allowed fuel consumption level for vehicles in that subcategory. The y-axis is vehicle GVW, and the bottom and top of each box represents the lowest and highest GVW values, respectively, that are included in that subcategory. For example, in the N3-1 category, the compliance equation for the 40 kph compliance test is:

$$Y = 0.362X + 10.327$$

where
X = gross vehicle weight of the vehicle in tonnes; and
Y = maximum fuel consumption value (l/100km).

To extend the example, if we take a 4x2 rigid truck with a 13-tonne GVW, this means a 15.03 l/100 km fuel consumption limit over the 40 kph CSFC test.

Figure 11 shows new commercial vehicle sales in fiscal year 2017–18 broken into the 14 regulatory segments from Figure 10. The sales in each category range from roughly 10,000 to more than 60,000. Sales were largest for the 4x2 7.5 to 12-tonne rigid trucks (approximately 62,500 units), followed by 3.5 to 7.5-tonne buses (approximately 46,300 units), and then 4x2 3.5 to 7.5-tonne rigid trucks (approximately 44,900 units). Sales in the next six categories range from about 32,000 to 39,000 units, and sales in the five smallest groups range from roughly 11,000 to 22,000 units.

In addition to vehicle sales, Figure 11 also displays estimated fuel consumption for the HDVs sold in FY 2017–18 by regulatory subcategory. These are the checkered columns, and the values correspond to the righthand y-axis. These values are derived by multiplying estimated annual kilometers from previous studies (Karali, Gopal,

Figure 10. Categorization scheme in India's fuel efficiency regulations for commercial vehicles

Sharpe, Delgado, Bandivadekar, & Garg, 2017 and Karali, Abhyankar, Sharpe, & Bandivadekar, 2019) by fuel use rates, which are themselves calculated using the equations that set the maximum fuel consumption levels for each regulatory subcategory.[2] For each regulatory subcategory, we took the midpoint GVW value and used the equation for the 60 kph CSFC tests; the only exception was vehicles 3.5 to 7.5 tonnes, for which we used the equation for the 50 kph tests.

Using these estimates for annual kilometers traveled and fuel use in liters per 100 km, the breakdown of fleet-level fuel consumption for vehicles sold in FY 2017–18 differs from the distribution in sales. Each of the three tractor-trailer categories consume a disproportionately large amount of fuel, and this is due to their higher fuel consumption rates and because they travel more annual kilometers than the rigid trucks. Tractor-trailers in the 4x2 35 to 40-tonne group are the biggest fuel consumers by a fairly large margin, with roughly 1.4 billion liters of fuel used in FY 2017–18; this represents about 20% of total truck fuel use and 17% of HDV fuel use overall. After these tractor-trailers are eight categories of vehicles that consume between about 500 and 800 million liters annually (6%–10% of total HDV fuel use each) and the remaining five groups range from roughly 150 million to 400 million liters (2%–5% of total HDV fuel use each).

Engine size and power is closely correlated with overall vehicle fuel consumption. Figure 12 summarizes engine power minimum (identified by the circles), maximum (triangles), and sales-weighted average (stars) for each of the 14 regulated vehicle groups. The distribution of engine power ratings is an important consideration in a regulatory context, as all of the vehicles in each segment must be below a certain fuel consumption level in order

2 Estimated annual kilometers: rigid trucks 3.5 to 7.5 tonnes: 35,000 km; rigid trucks 7.5 to 37 tonnes: 69,000 km; rigid trucks and tractor-trailers 40 tonnes or greater: 89,500 km; all buses: 110,000 km.

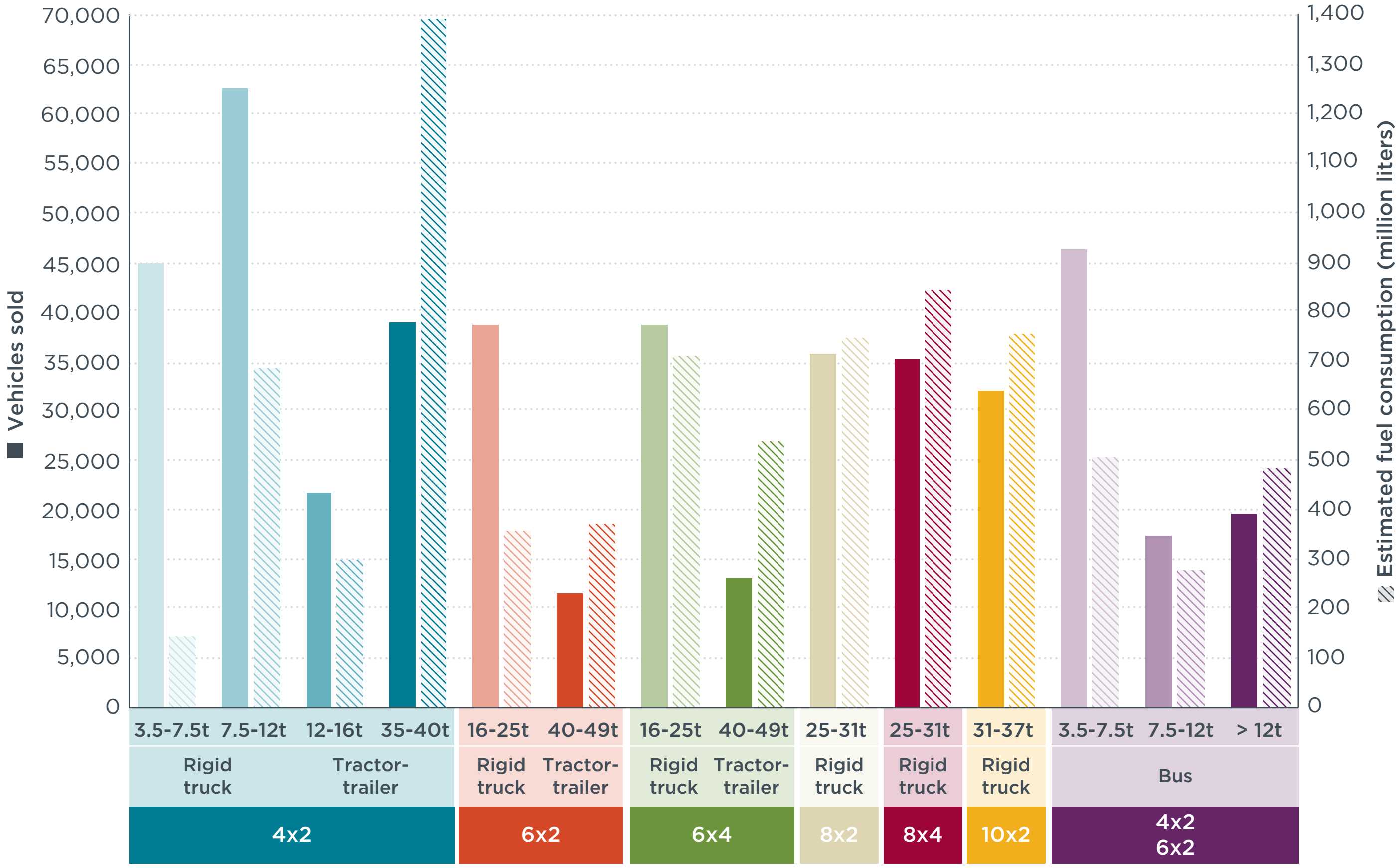

Figure 11. Commercial vehicle sales and estimated fuel consumption by regulatory subcategory for commercial vehicles sold in FY 2017–18

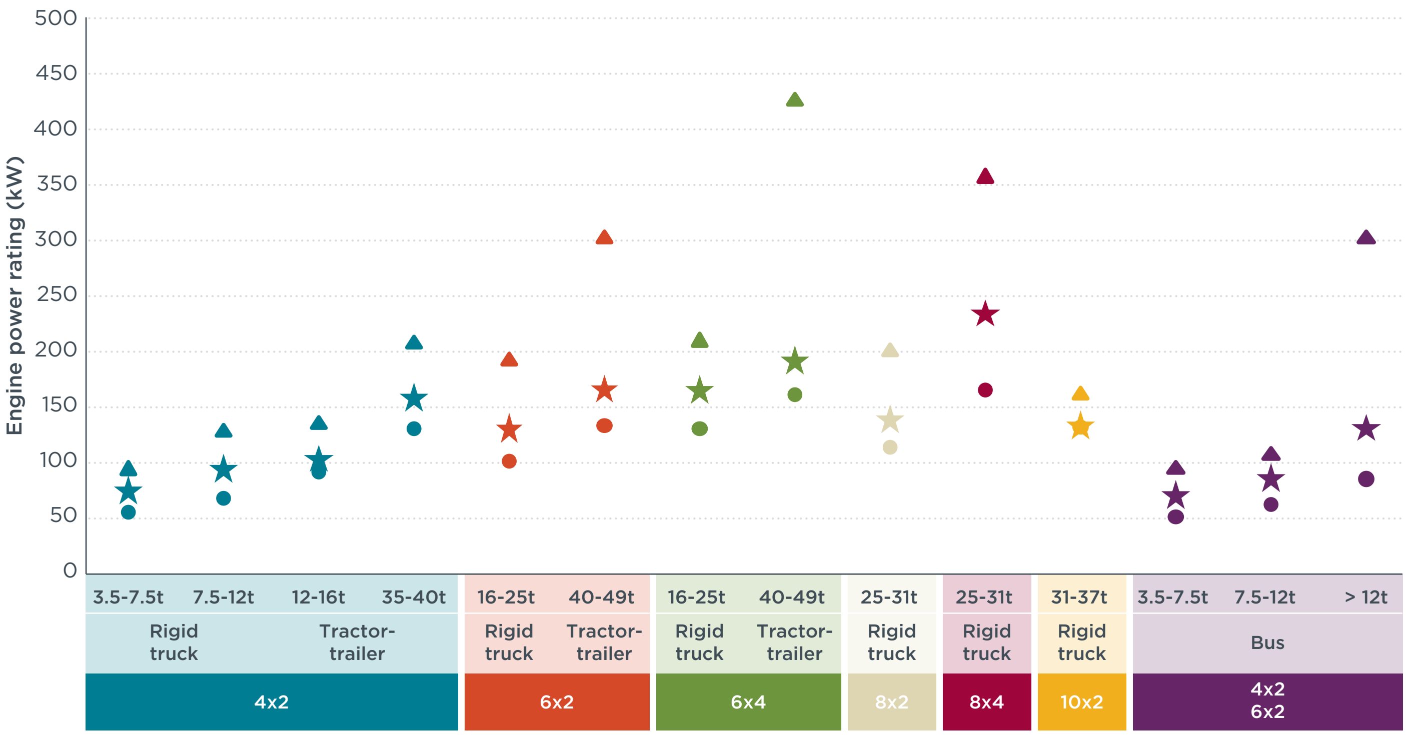

Figure 12. Minimum, maximum, and sales-weighted average engine power ratings in each regulatory subcategory

to achieve compliance in India's existing fuel economy standards.[3] In Figure 12, there are four instances in which the maximum engine power rating is more than 50% larger than the sales-weighted average power: 6x2 40–49 tonne tractor trucks, 6x4 40–49 tonne tractor trucks, 8x4 25–31 tonne rigid trucks, and buses greater than 12 tonnes. In each of those four categories, the maximum engine power rating ranges from roughly two to three times as large as the minimum power rating. A relatively wide range of engine power like this makes it more difficult to create a single compliance equation to equitably evaluate all vehicles in the segment.

Figure 13 is a plot of all of the unique gross vehicle weight and engine power combinations that are present in India's new HDV sales market. The data points are color-coded by regulatory subcategory in the same way as in Figures 10 and 11. In general, engine power increases as vehicles increase in size, particularly for GVW values below around 15 tonnes. However, at certain GVW values—e.g., at roughly 16,000, 19,000, 25,000, 31,000, 35,000, 37,000, 40,000, and 49,000 kg—there are a range of engine power ratings, which form vertical lines. At several of these GVW points, there is a large discrepancy between the smallest and largest engine power values; this is also shown in Figure 12.

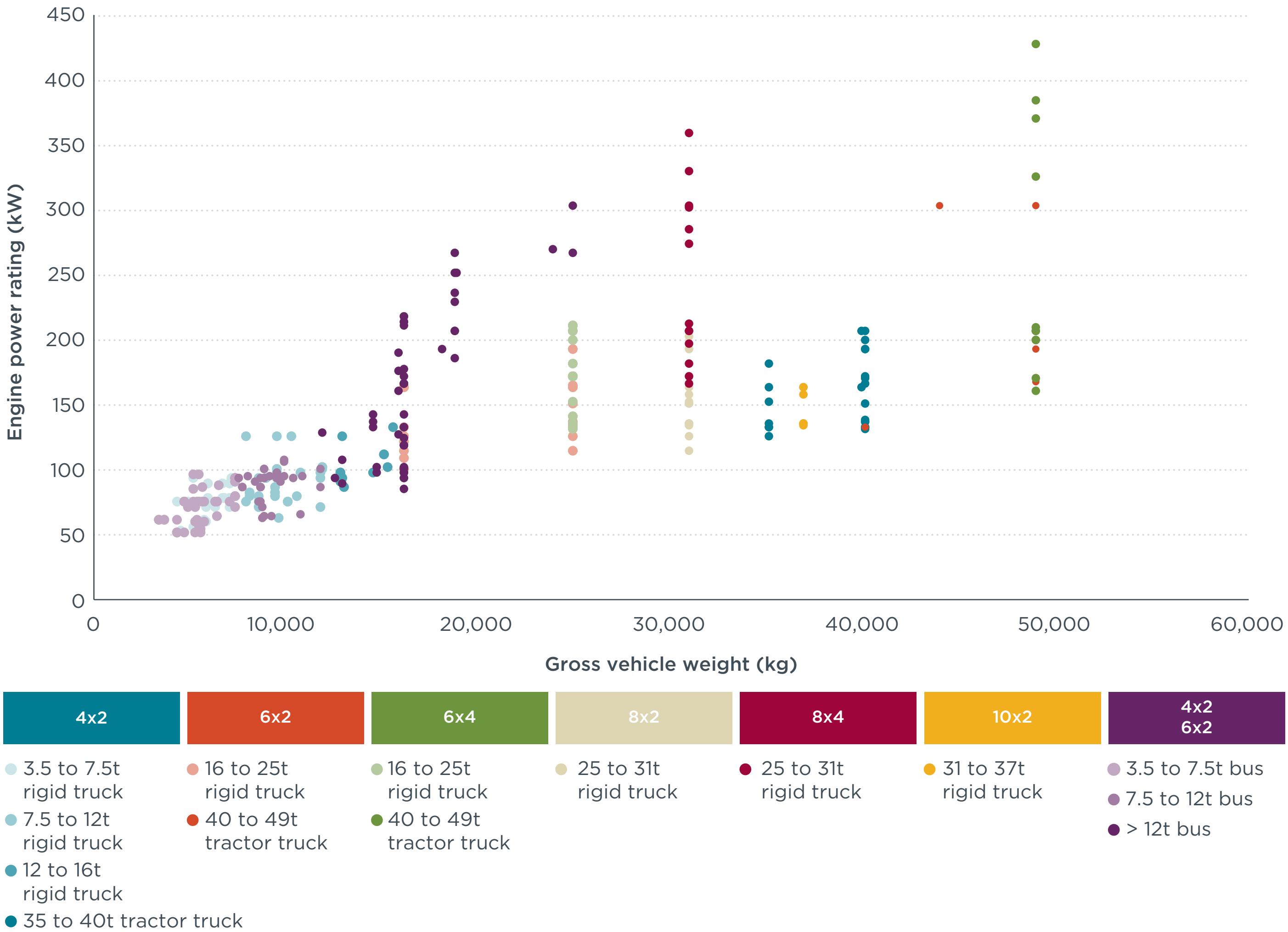

Figure 13. Combinations of gross vehicle weight and engine power ratings by regulatory subcategory

3 The fuel efficiency standards for HDVs greater than 12 tonnes are based on 'pass/fail' performance thresholds rather than corporate averaging, as is the case with fuel efficiency regulations in the United States, Canada, and the European Union. The efficiency standards for 3.5 to 12-tonne HDVs also require all vehicles to be under maximum fuel consumption values.

Considerations for the vehicle-categorization approach in an India-specific version of VECTO

In May 2017, the European Union adopted a certification procedure for the CO_2 emissions and fuel consumption of HDVs. Because of the diversity of configurations in the heavy-duty sector and the associated testing challenges, carrying out the CO_2 certification in the same fashion as for passenger and light commercial vehicles is not viable. Therefore, a component testing and vehicle simulation approach was selected to determine the CO_2 emissions and fuel consumption of HDVs in the European Union. Internationally, this is not a new approach. The United States, Canada, China, and Japan also use vehicle simulation in some form for certification (Kodjak, Sharpe, & Delgado, 2015).

Many stakeholders in India—including policymakers, commercial vehicle manufacturers, and component suppliers—have recommended that India transition to a simulation-based regulatory approach to be more closely aligned with trends in other major markets. Rather than developing a completely new simulation model for evaluating fuel efficiency and CO_2 performance for HDVs in India, there is significant interest in modifying VECTO for the Indian context. As referenced above, the proposed name for India's adaptation of VECTO is the Bharat Energy Efficiency Tool (BEET; Petroleum Conservation and Research Association, 2019).

Adapting VECTO for use in India will involve several steps. These include developing a vehicle categorization framework and baseline vehicle characteristics for each regulatory segment, developing a set of India-specific duty cycles, developing a vehicle and component testing program to support the validation of the BEET model, and making the necessary revisions to the VECTO source code. We discuss the first point, developing a vehicle categorization scheme for the BEET model, in the next section. The remaining steps required for BEET development and validation are discussed in a companion study (Sharpe, Delgado, Rodriguez, & Miller, 2019).

CONSIDERATIONS FOR VEHICLE CATEGORIZATION IN THE BEET

The vehicle grouping scheme in the VECTO developed for the European Union is shown in Figure 14. There are 18 categories for trucks (groups zero through 17) and six categories for buses (B1 through B6). As with the categorization framework in the fuel efficiency standards in India, the VECTO segmentation is based on GVW, axle configuration, and the distinction between rigid trucks and tractor-trailers for certain axle configurations. In Figure 14, the solid-colored segments (groups 4, 5, 9, 10) are those categories in which newly produced vehicles in the European Union have been required to use VECTO for vehicle CO_2 certification since January 1, 2019. Since July 1, 2019, all vehicles—i.e., not just vehicle models receiving type approval for the first time—in these four groups have been required to undertake the VECTO certification process. All new vehicle registrations in groups 1, 2, and 3 will be required to use VECTO starting January 1, 2020. For groups 11, 12, and 16, the VECTO requirement begins on July 1, 2020. The remaining gray-colored segments (including the six bus categories) are not required to certify using VECTO, but

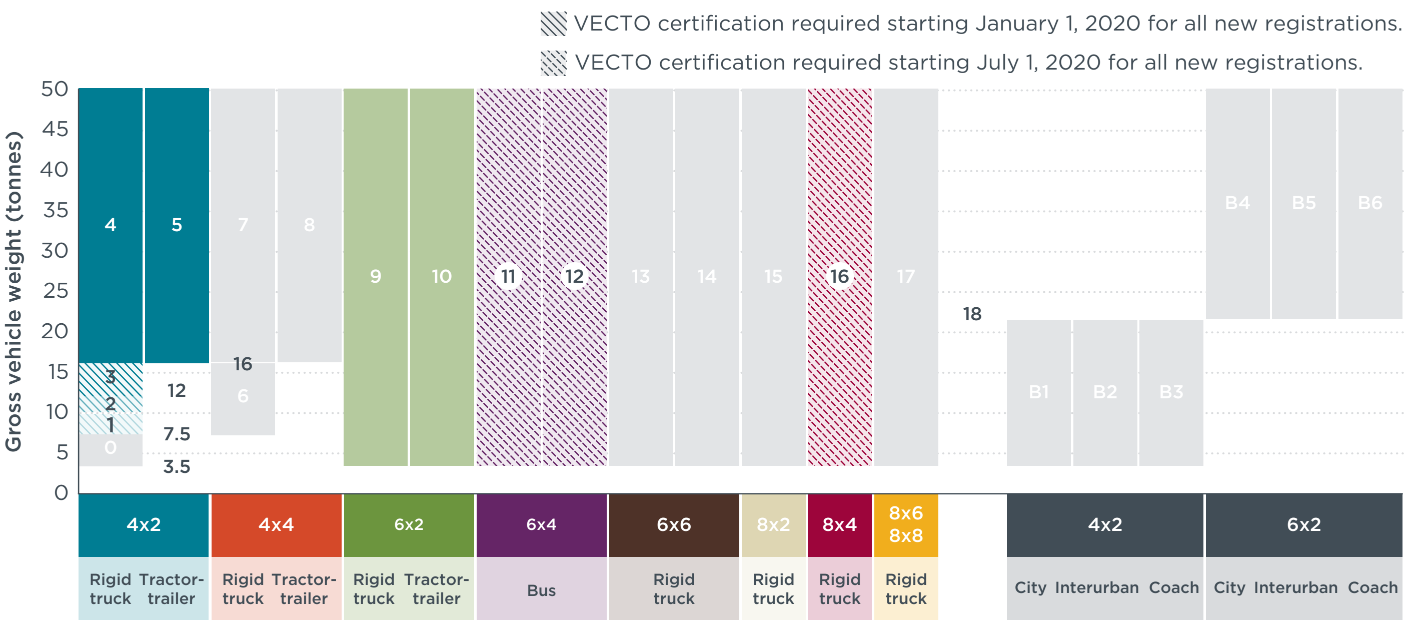

Figure 14. Categorization scheme in VECTO

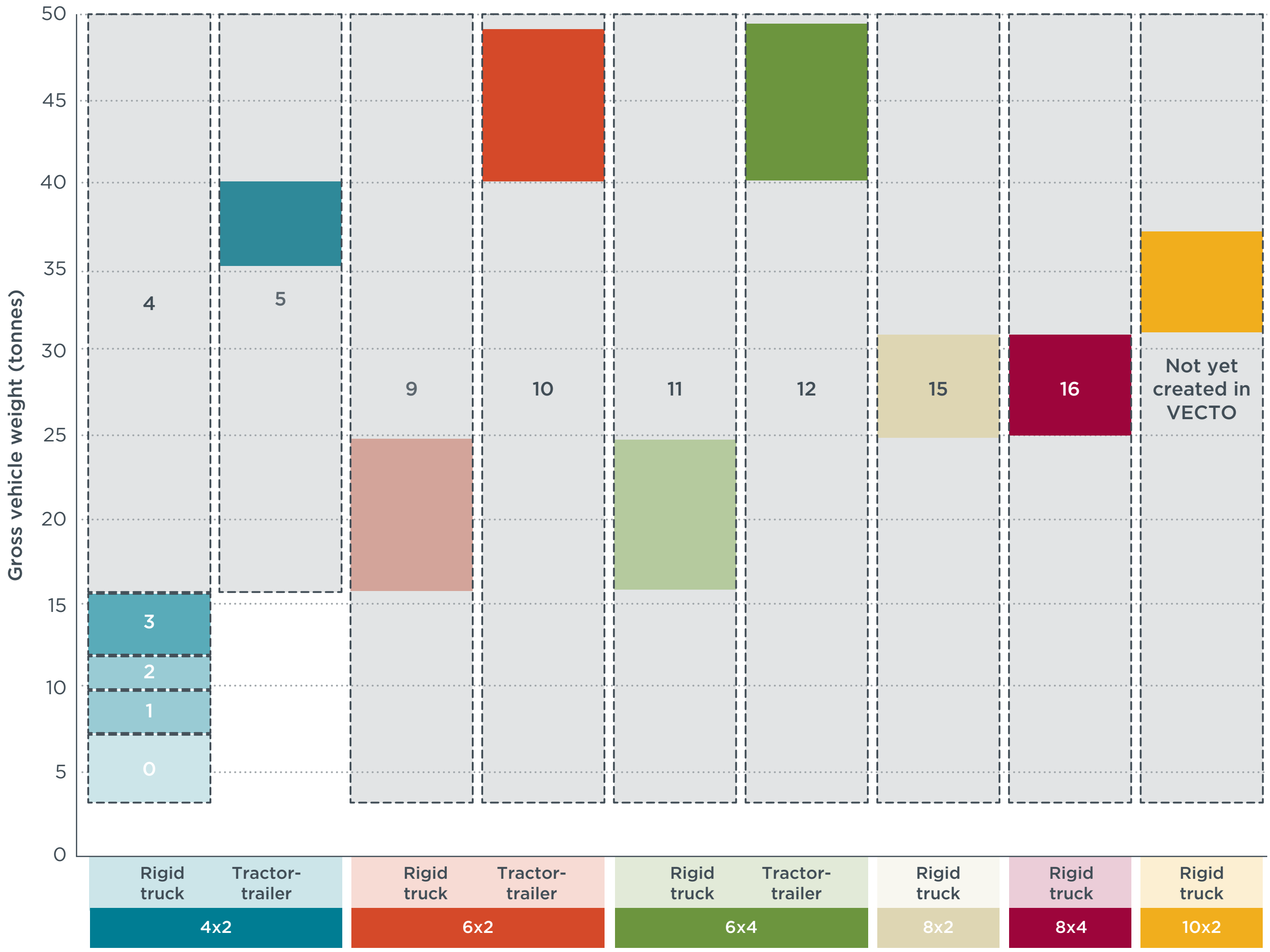

Figure 15. Comparison of the categorization schemes for trucks in VECTO and the current HDV fuel efficiency regulations in India

the European Commission will consider VECTO certification requirements and mandatory CO_2 limits for these vehicle groups in the coming years.[4]

The VECTO vehicle grouping for trucks is also very similar to the classification system in India's fuel efficiency regulation. Figure 15 shows the VECTO vehicle groups overlaid on top of India's categories, and nearly all of the boxes in color are contained within a VECTO vehicle group. The exception is the 7.5 to 12-tonne segment for rigid trucks, which is one category in India's fuel efficiency regulation but maps to two categories in VECTO (i.e., 7.5 to 10 tonnes and 10 to 12 tonnes). Moreover, while there is a distinct segment for 10x2 trucks in the Indian fuel consumption regulation, at present there is no such category in VECTO.

4 In the final CO_2 regulation for HDVs in the European Union, the European Commission established that by the end of 2022, it will formally consider VECTO certification and CO_2 standards for the remaining vehicle categories, including trailers.

With respect to bus classification, VECTO differentiates between 4x2 and 6x2 buses. The three 4x2 bus types are 18 tonnes or less, and the three 6x2 bus types are greater than 18 tonnes. This is different from the approach in India, where both the 4x2 and 6x2 axle configurations are grouped together, and the three GVW ranges are 3.5 to 7.5 tonnes, 7.5 to 12 tonnes, and greater than 12 tonnes.

As policymakers consider adapting VECTO to evaluate vehicle performance for India's own fuel efficiency regulation, they can either maintain their current vehicle-categorization approach or adopt a modified version of the framework used in the existing version of VECTO. However, given the close similarities in the segmentation schemes used by the European Union and India—particularly for trucks—we recommend that India modify the vehicle grouping system in VECTO. India already has a fuel efficiency regulation for HDVs greater than 12 tonnes and will be collecting fuel consumption data for these vehicles over constant speed test cycles. This real-world testing data can be used in the validation effort for the BEET model. Additionally, the resources required to revise the categorization framework in VECTO are relatively minor. Another advantage of India maintaining its current vehicle segments is that doing so will provide some degree of continuity in the transition from CSFC-based testing to certification that is centered around VECTO.

Conclusions and future work

This paper updated ICCT's commercial vehicle market analysis from FY 2013–14 with more recent data from FY 2017–18. It also discussed the issue of vehicle categorization as India develops its next round of fuel efficiency standards, which are expected to be based on simulation modeling. Results show the Indian HDV market remains fairly concentrated, as the top three manufacturers account for roughly 85% of sales. By itself, Tata Motors accounts for 45% of the overall commercial HDV market, with 48% of truck sales and 31% of bus sales. While Tata's market share is still nearly double that of its next largest competitor, Ashok Leyland, Tata's share has dropped 8% since FY 2013–14. The majority of Tata's decrease in sales has been in the bus segment, as it surrendered roughly 20% of the market, with much of those sales captured by Force Motors.

One of the defining characteristics of Indian trucks and buses is that they have much smaller engines than the trucks and buses in other major markets such as the United States, Europe, and China. The distribution of engine size and power combinations found in the HDV market in India has stayed relatively constant since 2013–14, with the only substantive change being that more engines between 8 and 10 liters were sold in 2017–18.

As regulators in India embark on creating an India-specific version of VECTO for use in subsequent fuel efficiency regulations, we recommend modifying the vehicle grouping system in VECTO to reflect India's categorization scheme in its existing efficiency standards. By maintaining the same vehicle groups as in the CSFC-based standards, policymakers, industry, and other relevant stakeholders can more easily use real-world CSFC testing data to validate the BEET model.

Future ICCT research will continue to support the development and validation of BEET, as well as the broader efforts to design and implement policies to improve the fuel efficiency of commercial trucks and buses in India. This includes the development of a set of India-specific duty cycles, a comprehensive vehicle and component testing campaign, and the requisite modifications to the VECTO source code.

References

Garg, M. & Sharpe, B. (2017). *Fuel consumption standards for heavy-duty vehicles in India*. Retrieved from the International Council on Clean Transportation, https://theicct.org/publications/fuel-consumption-stds-hdvs-india-update-201712

Karali, N., Gopal, A., Sharpe, B., Delgado, O., Bandivadekar, A., & Garg, M. (2017). *Improved heavy-duty vehicle fuel efficiency in India: Benefits costs, and environmental impacts*. Retrieved from Lawrence Berkeley National Laboratory, https://ies.lbl.gov/publications/improved-heavy-duty-vehicle-fuel

Karali, N., Abhyankar, N., Sharpe, B., & Bandivadekar, A. (2019). Im*proving fuel efficiency for heavy-duty vehicles 3.5–12 tonnes in India: Benefits, costs, and environmental impacts*. Retrieved from Lawrence Berkeley National Laboratory, https://vehicle-grid.lbl.gov/publications/improving-fuel-efficiency-heavy-duty

Kodjak, D., Sharpe, B., & Delgado, O. (2015). Evolution of heavy-duty vehicle fuel efficiency policies in major markets. M*itigation and Adaptation Strategies for Global Change, 20*(5), 755–775. doi: 10.1007/s11027-015-9632-5

Ministry of Power (2019). The Gazette of India 2311/2019, ii.3.ii (E). https://www.greengazette.in/documents/government-gazette-2311-2019-ii3ii-e_20190716-232-02311.pdf

Sharpe, B. (2015). *Market analysis of heavy-duty vehicles in India*. Retrieved from the International Council on Clean Transportation, https://theicct.org/publications/market-analysis-heavy-duty-vehicles-india

Sharpe, B., Delgado, O., Rodriguez, F., & Miller, J. (2019). *Adapting the Vehicle Energy Consumption Calculation Tool (VECTO) for use in India and other countries*. Retrieved from the International Council on Clean Transportation, https://theicct.org/publications/adapting-vecto-india-20190926

U.S. Environmental Protection Agency Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles (2011). Federal Register, Vol. 76, Number 179. https://www.federalregister.gov/documents/2011/09/15/2011-20740/greenhouse-gas-emissions-standards-and-fuel-efficiency-standards-for-medium--and-heavy-duty-engines