GLOBAL FUEL ECONOMY INITIATIVE

International Energy Agency

INTERNATIONAL COMPARISON OF LIGHT-DUTY VEHICLE FUEL ECONOMY 2005-2015

Ten years of fuel economy benchmarking

Working Paper 15

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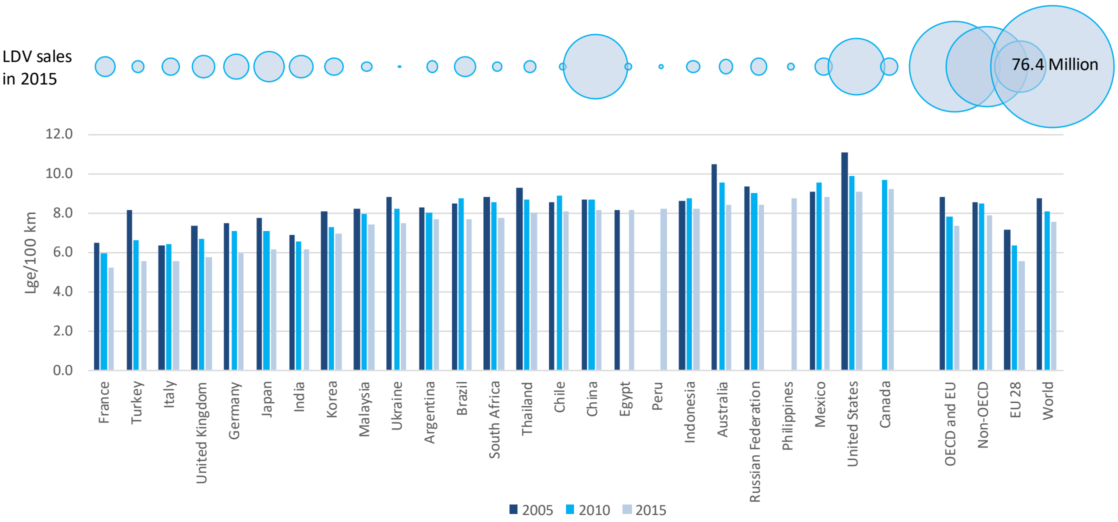
Executive summary

Fuel economy development over the past decade

Without exception, all countries monitored in this report showed an improvement in the average fuel economy of the light-duty vehicles (LDVs) entering the national fleet in the period between 2005 and 2015. The country that made the greatest progress (measured as percentage improvement over 2005 values) was Turkey, followed by the United Kingdom and Japan (Figure 1).

Figure 1 • Average new LDV fuel economy by country, normalised to the WLTC, 2005-15



Notes: Lge/100 km = litres of gasoline equivalent per 100 kilometres; OECD and EU = member states of the European Union and specified member countries of the Organisation for Economic Co-operation and Development (Australia, Canada, Chile, Japan, Korea, Mexico, Turkey and United States); Non-OECD = specified non-OECD countries (Argentina, Brazil, China, Egypt, India, Indonesia, Malaysia, Peru, Philippines, Russian Federation, South Africa, Thailand and Ukraine); **WLTC** = Worldwide harmonised Light Vehicle Test Cycle.

Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Average LDV fuel economy improved in all regions between 2005 and 2015, but clear differences exist between countries and regions.

The annual improvement in average fuel economy at the global level slowed during the course of the past decade, from 1.8% in 2005-08 to 1.2% in 2012-15 and 1.1% in 2014-15 (Table 1). Two main counteracting trends are apparent:

- OECD countries saw their annual improvement rate drop to only 1.0% between 2012 and 2015. Annual rates of improvement have particularly declined in the past few years (0.8% between 2013 and 2014, and 0.5% between 2014 and 2015).
- The rate improvement in fuel economy accelerated in non-OECD countries over the same period, reaching 1.4% per year, on average, between 2012 and 2015.

This has resulted in a major change in comparison with the first half of the last decade: since 2014, non-OECD countries have achieved faster fuel economy improvements than OECD economies.

The slowdown in improvement of average fuel economy in OECD economies is primarily attributable to a trend reversal (away from fuel economy improvements) that occurred in Japan between 2014 and 2015, as well as a gradual increase in the overall share of sales in OECD economies that have higher fuel consumption averages compared with the regional average. This trend is well illustrated by the growth in LDV registrations that took place in the United States (the

OECD economy with one of the highest fuel consumption per km) between 2010 and 2015. These effects were partly mitigated by continued fuel economy improvements in Europe.

The acceleration of improvement observed in non-OECD countries is consistent with the growing importance of markets (such as China and Brazil) that have enacted or tightened fuel economy policies over the past few years, and with China's increasing share of the non-OECD LDV market. These factors outweighed the stagnation of average fuel economy in other major non-OECD markets, such as the Russian Federation and India.

Overall, fuel economy improvement rates were significantly lower, both in OECD and non-OECD countries, than those required to meet the 2030 Global Fuel Economy Initiative (GFEI) target of halving fuel consumption to 4.4 Lge/100 km from 8.8 Lge/100 km in 2005 (Table 1).

Table 1 • Global fuel economy developments, 2005-15

<table>
<tr><th colspan="3"></th><th colspan="2">2005</th><th colspan="2">2008</th><th colspan="2">2010</th><th colspan="2">2012</th><th colspan="2">2014</th><th colspan="2">2015</th><th colspan="2">2030</th></tr>
<tr><td rowspan="3">OECD and EU average</td><td colspan="2">average fuel economy (Lge/100 km)</td><td colspan="2">8.8</td><td colspan="2">8.2</td><td colspan="2">7.8</td><td colspan="2">7.6</td><td colspan="2">7.4</td><td colspan="2">7.3</td><td rowspan="6" colspan="2"></td></tr>
<tr><td colspan="2" rowspan="2">annual improvement rate (% per year)</td><td colspan="3">-2.3%</td><td colspan="2">-2.8%</td><td colspan="2">-1.6%</td><td colspan="2">-1.3%</td><td colspan="3">-0.5%</td></tr>
<tr><td colspan="12">-1.8%</td></tr>
<tr><td rowspan="3">Non-OECD average</td><td colspan="2">average fuel economy (Lge/100 km)</td><td colspan="2">8.5</td><td colspan="2">8.5</td><td colspan="2">8.4</td><td colspan="2">8.2</td><td colspan="2">8.0</td><td colspan="2">7.9</td></tr>
<tr><td colspan="2" rowspan="2">annual improvement rate (% per year)</td><td colspan="3">-0.1%</td><td colspan="2">-0.3%</td><td colspan="2">-1.4%</td><td colspan="2">-1.2%</td><td colspan="3">-1.6%</td></tr>
<tr><td colspan="12">-0.8%</td></tr>
<tr><td rowspan="3">Global average</td><td colspan="2">average fuel economy (Lge/100 km)</td><td colspan="2">8.8</td><td colspan="2">8.3</td><td colspan="2">8.1</td><td colspan="2">7.8</td><td colspan="2">7.6</td><td colspan="2">7.6</td><td colspan="2">4.4</td></tr>
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<tr><td colspan="12">-1.5%</td></tr>
<tr><td rowspan="2">GFEI target</td><td rowspan="2">required annual improvement rate (% per year)</td><td>2005 base year</td><td colspan="14">-2.8%</td></tr>
<tr><td>2015 base year</td><td colspan="10"></td><td colspan="4">-3.7%</td></tr>
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Notes: OECD and EU = member states of the European Union and specified member countries of the Organisation for Economic Co-operation and Development (Australia, Canada, Chile, Japan, Korea, Mexico, Turkey and United States); Non-OECD = specified non-OECD countries (Argentina, Brazil, China, Egypt, India, Indonesia, Malaysia, Peru, Philippines, Russian Federation, South Africa, Thailand and Ukraine).

Key point • Annual improvement rates are slowing in OECD countries and accelerating in non-OECD countries. Both rates are below those needed to achieve the 2030 GFEI target.

Fuel economy drivers

The polarisation of average fuel economy rates between different OECD countries, already observed in earlier assessments, is also evident in 2015 sales. LDVs sold in North America and Australia continued to use more fuel per km than those sold in any other OECD economy. This is chiefly attributable to the larger sales-weighted average weight, footprint[1], power rating and engine displacement of LDVs sold in North America than those sold in any other country. In the case of Mexico, high average fuel consumption is the combined effect of these vehicle attributes and lags in the deployment of fuel-saving technologies. Compared with 2013, the gap has closed between the average fuel economy of new LDVs sold in the United States and those sold in Canada, Mexico and Australia, as a result of US LDVs seeing the greatest fuel economy improvements. At the other extreme, France has overtaken Japan as the country with the best average fuel economy. The average fuel economy of LDVs sold in non-OECD countries tends to be clustered around the average value for China, which is the non-OECD market with by far the most LDV sales. India is the

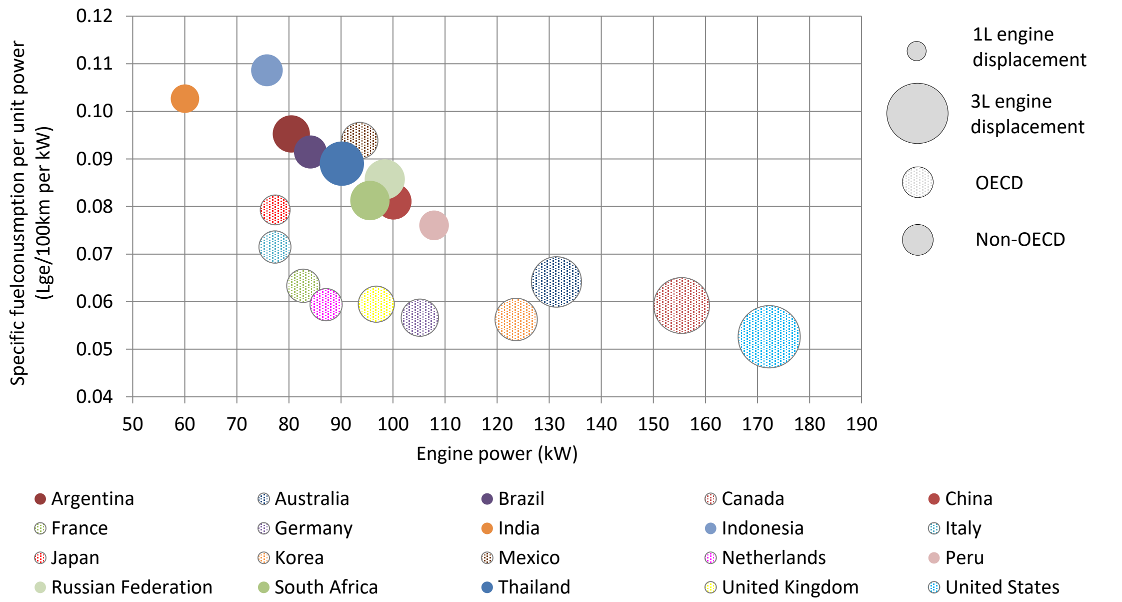
[1] Vehicle footprint denotes the area formed by wheelbase and axle width and is generally used as a proxy for vehicle size.

main non-OECD country out of this cluster, the market with the lowest power, weight, engine displacement and vehicle footprint.

The evolution of vehicle segments suggests that sales of crossovers (medium-sized sport utility vehicles [SUVs] and pick-up trucks) have experienced significant growth across all countries: their market share has tripled over the past decade. Crossovers are but one example of a global evolution towards larger vehicles that has occurred over the past decade, and has intensified since 2010.

Countries with the best average fuel economy tend to have a higher proportion of LDV sales with lower power and displacement engines, lower weight and a smaller footprint. In OECD countries belonging to the cluster with higher average fuel consumption per km (North America, Australia and, to a lesser extent, Korea), these parameters contrast starkly with those observed in other regions. However, the degree of deviation from average values is not uniform across all countries: the variability between the market with the highest and lowest average national values in 2015 was three times as large for power than for footprint, 2.4 times larger for engine displacement and 1.7 times larger for weight. The evolution of engine power, displacement, weight and footprint over time shows growing shares of vehicle sales in the upper-middle half of the ranges and tracks fairly closely the development of market segmentation, despite the fact that global average weight and footprint did not change significantly between 2005 and 2015.

Figure 2 • Specific fuel consumption per unit of engine power plotted against engine power ratings for selected OECD and non-OECD countries, 2015



Note: L = litre; OECD = Australia, Canada, France, Germany, Italy, Japan, Korea, the Netherlands, United Kingdom, United States; Non-OECD = Argentina, Brazil, China, India, Indonesia, Peru, Russian Federation, South Africa, Thailand.

Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • When comparing vehicles with similar power ratings, LDVs sold in OECD countries use less fuel compared with those marketed in non-OECD countries. This indicates a significant technological gap in engine technology deployment between OECD and non-OECD countries.

LDV powertrain technologies are a strong determinant of average fuel economy. Six out of seven markets with the highest fuel consumption per km had diesel and hybrid shares below 5%. Following small increases between 2005 and 2012 in European markets, diesel's share has stabilised globally to 15%, reflecting the growth of gasoline-intensive markets such as China and the United States. Japan was the only country where hybrid LDV's had a market share exceeding 10% in 2015.

Technological differences across countries are not limited to powertrain choices; on average, new LDVs in non-OECD countries have significantly higher specific fuel consumption per kilowatt (kW) compared with OECD countries (Figure 2). This confirms the existence of a significant technological gap or time lag in engine technology deployment between OECD and non-OECD countries.

Fuel economy and vehicle prices

Average new LDV prices vary widely between countries. In 2015, the gap between the highest and lowest average vehicle price in the countries monitored here was twice as large as the LDV price in the cheapest market. Comparison between average prices in OECD and non-OECD countries for 2015 reveals that new LDVs sold in the former are on average one-third more expensive, 65% more powerful, 38% heavier and have a 22% larger footprint than those sold in the latter. However, vehicles sold in OECD countries consume about 7% less fuel per 100 km than those sold in non-OECD countries. These statistics suggest that average vehicle prices are not strongly driven by fuel economy parameters, but rather by other attributes. The main determinants of average national vehicle price include vehicle segmentation, engine power and the market share of premium brands.

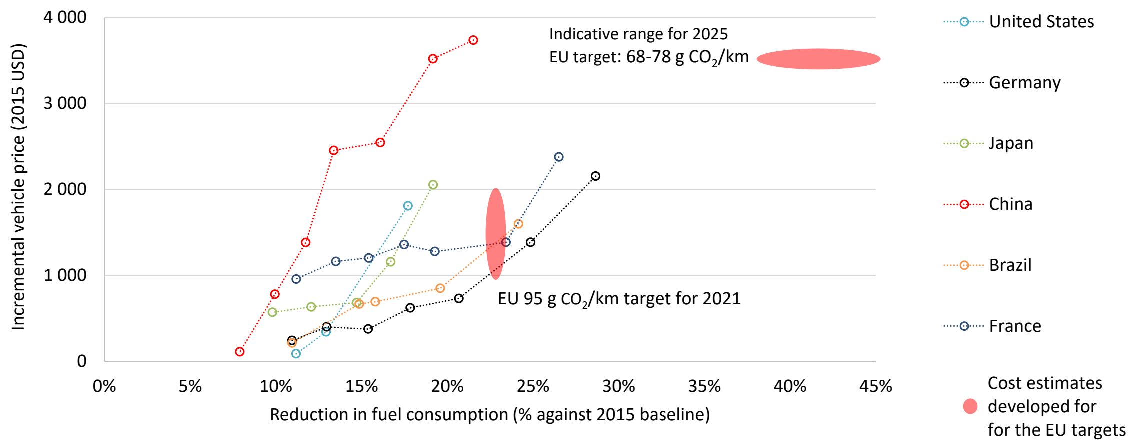
The impact of fuel economy on vehicle prices is difficult to isolate but becomes more discernible when LDVs are compared across narrow segments and power ratings. Price dynamics within each segment and power class depend on market structure,[2] differences in vehicle attributes other than fuel economy (above all, engine power), and the use of efficient and more costly technologies.

The comparison of global average prices for the 25% most fuel-efficient vehicles (defined as the subset of the top 25% of all vehicles when models are ranked by fuel efficiency) with the average of each segment and power class suggests that fuel economy improvements tend to be frequently coupled with positive price increments for vehicles marketed at low prices. Price increments are much less frequent in large-vehicle segments. This is due to a greater relevance, in the determination of prices for large vehicles, of drivers like brand and engine power with respect to technological cost.

Overall, the analysis of price increments and fuel economy improvements across all segments and all countries indicates that consumers across the world pay a price premium for a 15% fuel economy improvement ranging between USD 500 and 2 500, with a global average value in the order of USD 100 per percentage point reduction in fuel use per km. These ranges grow to USD 800-4 000 for a 20% improvement. Price increments tend to be lower in national markets with a high share of diesels (EU member states) and higher in markets where the most popular vehicles are priced well below more efficient models (China). In the case of Europe, price premiums are in the same range of costs as those estimated for the deployment of technologies allowing EU regulatory targets for passenger cars to be met.

[2] Price differences of vehicles in a segment and power class when ranked by fuel economy are not only dependent on the deployment of efficient vehicle technologies but also on other attributes like brand, vehicle equipment and differences in size.

Figure 3 • Price increments per percentage point fuel economy improvement[3] in selected markets, 2015



Note: g CO_2/km = gram of carbon dioxide per kilometre.

Sources: the price assessment is from IEA elaboration and enhancement for broader coverage of IHS Markit database; the technology cost estimates for the EU targets are based on the range given by ICCT (2015a) for passenger cars; the indicative target range for 2025 is that indicated by the European Parliament in 2015 (EP, 2015).

Key point • The price premium for a 15% fuel economy improvement ranges between USD 500 and USD 2 500 and has a global average of USD 1 500. Price premiums are not uniform across major markets.

Insights from the country reports

The analysis of individual markets broadly confirms key findings that emerged in the latest assessment of technology and policy drivers of fuel economy in new LDVs:

- The combined adoption of regulatory instruments, such as fuel economy standards, and fiscal incentives, such as vehicle taxes differentiated on the basis of the emissions of carbon dioxide (CO_2) per km, have led to the highest energy savings from LDVs.
- Fuel economy standards have provided effective improvements in fuel economy, except in cases where standards were met well in advance of the target date. The case of Japan is illustrative in this respect: fuel economy stopped improving after the target was met.
- The presence of fuel economy targets has led to the prioritisation of fuel economy improvements over other vehicle characteristics (such as weight and size) by original equipment manufacturers (OEMs) and consumers.
- Differentiated vehicle taxation has been effective at improving fuel economy, even when it was not coupled with fuel economy standards, especially in markets with lower purchasing power due to low average income levels.

[3] Each point represents a subset of the total sales constituted by a portion of the most fuel efficient vehicles within each "category", i.e. each segment and power class. The subsets of the most fuel efficient vehicles in each of category are combined using a sales-weighted average to calculate their reduction in fuel use per km and price increment compared to the sales-weighted average of all vehicles sold, all categories combined. For one specific country, the top dot would represent the combination of, for example, the 5% most efficient models within each category sold in that country, the second top dot the 10% most efficient models within each category, the third top dot the 15% most efficient models within each category, etc.

Recommendations

Fuel economy improvement rates over the past decade have been significantly lower, both in OECD and non-OECD countries, than the rate of improvement required to meet the 2030 GFEI target. This calls for more effective action for the future.

Country-level results, and in particular the large improvements in LDV fuel economy being achieved in the European Union and China, show that stronger action on the combined adoption of fuel economy policies (including regulatory instruments such as fuel economy standards) and fiscal incentives (such as vehicle taxes differentiated on the basis of emissions of CO_2 per km) can deliver effective fuel economy improvements. This is especially important in a period characterised by a slowdown in fuel economy improvements in OECD countries.

Price analysis suggests that achieving fuel economy improvements may come at a lower cost for consumers if efforts are focused on larger vehicle segments and power classes, even after accounting for the upward impact of fuel-saving technologies on vehicle prices. Policies should therefore include provisions requiring greater relative fuel economy improvements in these classes, especially in the non-OECD: this would generate opportunities to deploy fuel saving technologies in the most energy intensive portion of the vehicle market (larger segments tend to have engines with high power and displacement, and are, by definition, vehicles with greater weights and larger footprints, and therefore higher fuel use per km) and would also have positive consequences on the limitation of market shifts towards larger vehicles.

It is essential to continue monitoring the evolution of international fuel economy to allow the assessment of the effectiveness of actions aimed at improving fuel economy, as implemented by individual countries, and the impacts these actions collectively have on global fuel consumption.

Policy actions that are measurable solely against test results will not close the gap in fuel economy between test and real-world driving conditions. Achieving greater accuracy and representativeness of tested fuel economy as against real-world consumption will require the use of on-road tests, similar to the real driving emissions (RDE) test procedure for air pollutants, and the introduction of in-use conformity tests of randomly selected production vehicles.

Introduction

This report follows a series of GFEI working papers investigating the fuel economy of newly registered LDVs across the world over time and is the first assessment of global LDV fuel economy spanning over ten years of registrations.

It builds on methodological improvements introduced in the latest report (IEA, 2016a) and maintains the broad country coverage that has always characterised these analyses. The report updates information published in GFEI Working Papers 11 and 12 (IEA, 2014 and 2016a) and includes insights on the interactions between fuel economy and vehicle price, with estimations of the price that consumers are currently willing to pay for more efficient vehicles in a selection of major global markets.

Three new countries are also added to the series of country reports first developed in 2016: Australia, Italy and the United Kingdom.

The report is structured in two main parts. The first part comprises:

- An assessment of LDV fuel economy progress up to 2015, describing the main indicators in 2015, progress compared with the previous year (2014) and the ten-year trend.
- Analysis of key developments for a selection of major fuel economy drivers, outlining the status per country in 2015 and the ten-year evolution of these variables for key regional clusters – Europe, Chile, Japan and Korea on the one hand, North American OECD economies (Canada, Mexico and the United-States) and Australia on the other hand, completed by non-OECD countries – and for the world.
- A section focusing on LDV prices, aiming to find greater insight into the costs of energy efficiency in the LDV market.

The second part comprises a set of 17 country reports containing information on key socio-economic indicators, brief outlines of the policy framework influencing vehicle fuel economy, and several graphs outlining key vehicle characteristics over time.

Two annexes provide detail on the methodology adopted to develop the IEA-GFEI database underpinning all the analysis and include statistical tables with information on vehicle registrations, average CO_2 emissions per km (in g CO_2/km), fuel consumption, power, displacement, weight, footprint and price.

Status of LDV fuel economy

Status in 2015

The global LDV[4] stock exceeded 1.1 billion vehicles in 2015, up from 0.95 billion in 2010 and 0.82 billion in 2005 (IEA, 2016b). Nearly four in ten LDVs are now in circulation in non-OECD countries, up from 25% in 2005 and 33% in 2010. This indicates that market growth was stronger in non-OECD countries, where ownership rates are far below the saturation point attained in most of the OECD economies.

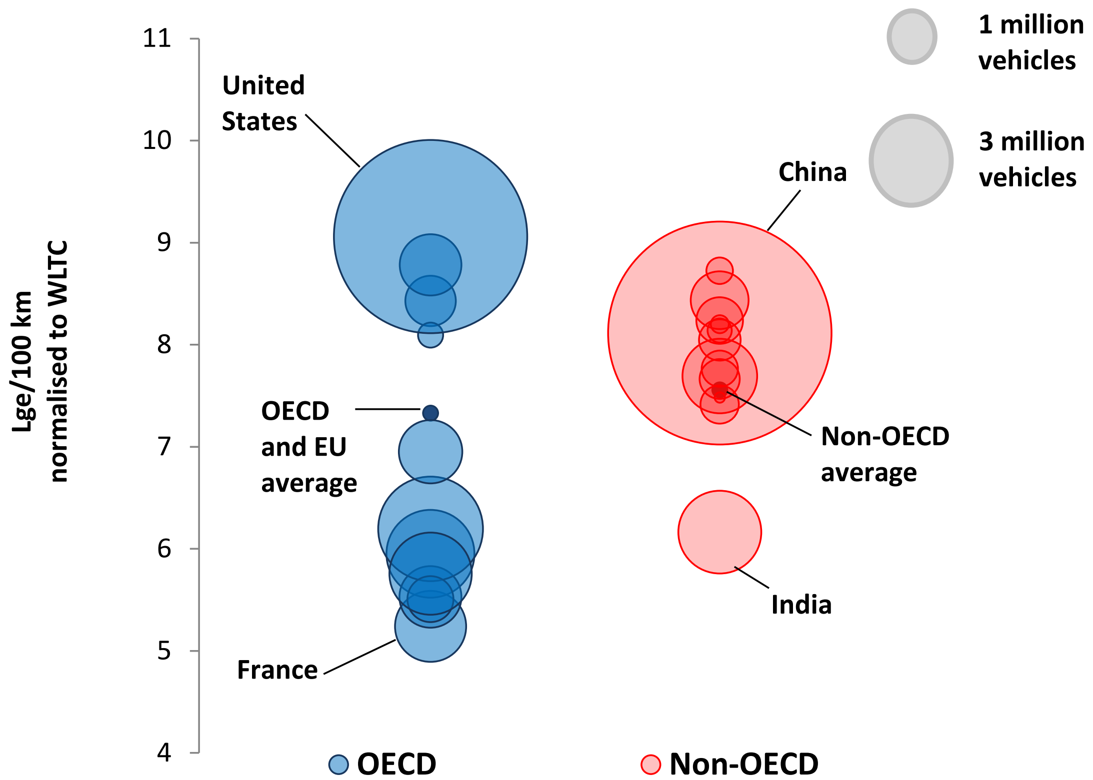
In 2015 LDV sales amounted to 88.5 million vehicles, a quarter more than in 2010 and a third more than in 2005 (IEA, 2016b). New LDV registrations were evenly split between OECD countries (51%) and non-OECD countries (49%) in 2015. The OECD sale shares declined from 54% in 2010 and 69% of 2005. The 2010-15 decline in OECD market share has taken place during a period of strong

[4] LDVs comprise passenger cars of all market segments and light commercial vehicles (LCVs).

market growth in the United States, where sales grew from 10 million to more than 15 million LDVs, confirming the very strong dynamics of the non-OECD LDV markets (especially China).

Figure 4 confirms the polarisation of average fuel economy in different OECD countries already observed in earlier years (IEA, 2014 and 2016a). The higher fuel consumption per km in North American countries and Australia is largely attributable to greater weight, footprint and power rating compared with European countries and Chile, Japan and Korea. In the case of Mexico, analysis shows that it has experienced the combined effect of these vehicle attributes and lags in the deployment of fuel-saving technologies. Compared with 2013, Canada, Mexico and Australia moved closer towards the United States, while France has overtaken Japan as the country with the best-performing average fuel economy. Figure 4 also confirms the tendency for non-OECD countries, except for India, to cluster around a similar fuel economy average, close to 8.0 Lge/100 km.

Figure 4 • Fuel economy distribution across new LDV sales in selected OECD and non-OECD countries, 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Fuel consumption in OECD countries ranges between 5.2 Lge/100 km and 9.2 Lge/100 km. OECD countries include the highest and lowest national average, while average fuel economy in non-OECD countries (except for India) tends to be clustered close to 8.0 Lge/100 km.

Table 2 provides a summary of a range of the most representative indicators characterising global LDV registrations in 2015. It shows that India and the United States (together with Australia and Canada) are at the two extremes of the ranges for all indicators, and confirms that significant heterogeneity exists among OECD countries (broadly reflecting the groupings in Figure 4), with Europe and Japan at the opposite end to Australia, Canada and the United States. Values in Table 2 also confirm the clustering observed in Figure 2 for non-OECD countries, even if there are important outliers (weight and engine displacement are at the top end of the range in Thailand, for instance, due to the popularity of pick-up trucks).

Table 2 • Summary of country-specific LDV market characteristics and fuel economy, 2015

Year: 2015	Fuel economy (Lge/100 km, NEDC)	Fuel economy (Lge/100 km, WLTC)	Power (kW)	Displacement (cm^3)	Empty weight (kg)	Footprint (m^2)
Argentina	7.0	7.7		1 738	1 417	4.0
Australia	7.7	8.4	131	2 340	1 602	4.3
Brazil	6.8	7.7	84	1 534	1 163	3.8
Canada	8.2	9.2			1 667	4.4
Chile	7.4	8.1	97	1 880	1 427	4.1
China	7.2	8.1	100	1 689	1 384	4.1
Egypt	7.3	8.1			1 340	4.0
France	4.9	5.2	83	1 544	1 353	4.1
Germany	5.5	6.0	105	1 741	1 467	4.2
India	5.7	6.2	60	1 333	1 085	3.5
Indonesia	7.3	8.2			1 151	3.6
Italy	5.1	5.5	77	1 496	1 293	3.9
Japan	5.5	6.2	77	1 394	1 208	3.6
Korea	6.4	7.0		1 975	1 573	4.1
Malaysia	6.6	7.4			1 218	3.8
Mexico	7.8	8.8			1 427	4.1
Peru	7.3	8.2			1 348	4.0
Philippines	7.7	8.7			1 481	4.0
Russian Federation	7.5	8.4	98	1 871	1 389	4.0
South Africa	7.1	7.8	96	1 838	1 482	4.1
Thailand	7.5	8.0		2 062	1 607	4.2
Turkey	5.2	5.5	82	1 539	1 356	4.2
Ukraine	6.9	7.5			1 475	4.1
United Kingdom	5.4	5.8	97	1 682	1 427	4.1
United States	8.0	9.1	172	2 901	1 742	4.5
OECD countries	**6.8**	**7.6**	**126**	**2 181**	**1 534**	**4.2**
Non-OECD countries	**7.0**	**7.9**	**94**	**1 662**	**1 339**	**4.0**
All countries above	**6.9**	**7.7**	**112**	**1 956**	**1 452**	**4.1**

Notes: cm^3 = cubic centimetres; kg = kilogram; m^2 = square metre; the OECD, non-OECD and all-country aggregates shown above only refer to the selection of countries monitored here and listed in the table; fuel economy values shown here differ from other summary results discussed in this analysis because they do not account for all EU member states.

Key point • India and the United States (together with Australia and Canada) are at the two extremes of the ranges for all indicators, and significant heterogeneity exists between OECD countries, with Europe and Japan also at the opposite end to Australia, Canada and the United States. Non-OECD countries, other than India, tend to be more closely clustered around non-OECD average values.

The worldwide average engine power of newly registered LDVs was 112 kW in 2015. The gap in average power among countries was very large (60-172 kW) and very similar to 2013, when it ranged between 57 kW and 173 kW (IEA, 2016a), and the gap has generally been increasing during the past decade.

The average global engine displacement was close to 2 000 cm^3 (commonly expressed in litres [L]) in 2015 and has followed a downward trend over the past decade; this is consistent with growing penetration of engine technologies delivering greater power per unit volume (and therefore resulting in engine downsizing), as well as a shift towards markets with lower engine displacements (on average, LDV engines in OECD countries were more than 30% larger than those in non-OECD countries). The ratio between the highest average engine displacement (2.9 L in the United States) and the lowest (1.3 L in India) was slightly lower (2.2) than for the average power rating (2.9).

The average vehicle weight ranged between 1 085 kg in India and 1 742 kg in the United States, confirming less extreme differences between countries compared with power or displacement. This is also reflected in a narrower weight gap between averages in OECD and non-OECD countries (around 13%). Over time, LDVs have not been subject to major weight shifts since 2005; limited changes in OECD countries and a convergence of non-OECD countries towards the global average has led to a stable average global vehicle weight.

Footprint was the most homogeneous indicator across all markets: its average value across non-OECD economies was only 6% lower than the corresponding OECD figure. The largest footprint at the country level was 4.5 m^2 in the United States, whereas India had the smallest average footprint of 3.5 m^2. As in the case of weight, the global average footprint has remained almost the same since 2005.

Recent trends: 2014-15

Between 2014 and 2015, the global average fuel economy improved by 1.0% on a yearly basis, which is 0.5% less than the five-year (i.e. 2010-15) average improvement in fuel economy and around one-third of the speed of improvement required to meet the 2030 GFEI target.

Fuel economy improvements in non-OECD countries outpaced those in OECD countries (Table 3). This is a major change from the trends observed in previous assessments. There are two major reasons for this: trends occurring within specific markets, and effects attributable to market changes within OECD and non-OECD country groupings.

Between 2014 and 2015, OECD countries improved their average fuel economy by 0.5%, compared with 1.8% between 2012 and 2013. This resulted from the combination of a weakening improvement trend in North America, a trend reversal in Japan, continued improvements taking place in Europe, and market shares that have not experienced major changes in 2015.

- The United States achieved only a small 0.5% annual improvement in average fuel economy, marking a slowdown in improvement compared with the 2.3% average improvement over the 2012-13 time period. This reflects a tendency towards an increase in the average power of new vehicles and is consistent with the fall in oil and petroleum fuel prices.
- Japan, the second-largest LDV market among OECD countries, even saw its average fuel economy get worse by 4.5%. This is a complete trend reversal with respect to earlier years. It was coupled with a decline in hybrid sales, the stagnation of vehicle weight and footprint, and an increase in average power and engine displacement, which follows years of slight reductions. This reversal still allows Japan to meet its 2015 policy targets, thanks to a sizeable margin available between the 2015 policy target and the 2014 average fuel consumption per km, which was already well below the policy target.
- Most European OECD countries experienced average annual fuel economy improvements of 2% to 3%, which are much closer to the 3.6% improvement rate needed to meet the 2030 GFEI target, but still falling short of it. The continued improvement in fuel economy in Europe in 2015 is coherent with the weaker impact of changes in oil prices (due to the high fuel taxation regime applied in all European countries, changes in oil prices result in a lower percentage change in fuel prices).

Annual improvement in fuel economy in the selected major non-OECD countries monitored in this analysis increased from 0.3% between 2012 and 2013 to 1.6% between 2014 and 2015. This was driven by recent improvements taking place in large non-OECD markets, including Brazil, China and

Malaysia. In Brazil, the acceleration in fuel economy improvements is coherent with the deployment of fiscal incentives for vehicles with the best performance (TransportPolicy, 2016). In China, it is consistent with the tightening of the fuel economy standards and the full introduction of Corporate Average Fuel Economy (CAFE) targets that took place in 2015 (ICCT, 2014b).

Table 3 • Market evolution 2014-15, average fuel economy and market size

	Average fuel consumption (Lge/100 km)		Vehicle sales (thousands)		Change in average fuel consumption	Market growth
	2014	2015	2014	2015	2014-2015	2014-2015
France	5.4	5.2	2 126	2 254	-3.3%	6.0%
Turkey	5.6	5.5	746	938	-2.1%	25.8%
Italy	5.7	5.5	1 471	1 700	-3.3%	15.6%
United Kingdom	5.9	5.8	2 798	3 005	-2.1%	7.4%
Germany	6.1	6.0	3 257	3 435	-3.2%	5.4%
Japan	5.9	6.2	5 374	4 860	4.9%	-9.6%
Korea	7.0	7.0	1 612	1 779	-1.1%	10.4%
Chile	8.1	8.1	327	282	0.3%	-13.7%
Australia	8.5	8.4	1 081	1 123	-1.1%	3.8%
Mexico	8.8	8.8	1 427	1 681	-0.3%	17.8%
United States	9.1	9.1	15 710	16 576	-0.5%	5.5%
Canada	9.2	9.2	1 767	1 833	0.3%	3.7%
EU28	5.7	5.6	14 006	15 204	-2.1%	8.6%
OECD & EU average	**7.4**	**7.3**	**42 395**	**44 665**	**-0.5%**	**5.4%**
India	6.2	6.2	2 889	3 048	0.2%	5.5%
Malaysia	7.8	7.4	621	650	-4.6%	4.7%
Ukraine	7.6	7.5	97	47	-2.0%	-52.3%
Argentina	7.4	7.7	645	712	3.8%	10.3%
Brazil	7.9	7.7	3 318	2 469	-2.6%	-25.6%
South Africa	7.8	7.8	613	587	-1.0%	-4.2%
Thailand	8.1	8.0	877	763	-0.6%	-13.0%
China	8.3	8.1	20 561	22 145	-2.1%	7.7%
Egypt	8.0	8.1	270	259	2.1%	-3.9%
Peru	8.1	8.2	162	144	1.4%	-11.4%
Indonesia	8.0	8.2	1 192	959	3.3%	-19.6%
Russian Federation	8.5	8.4	2 319	1 484	-0.8%	-36.0%
Philippines	8.8	8.7	246	314	-0.3%	27.4%
Non-OECD Average	**8.0**	**7.9**	**33 811**	**33 580**	**-1.6%**	**-0.7%**
World	**7.6**	**7.6**	**76 206**	**78 245**	**-1.1%**	**2.7%**

Key point • Improvement in fuel economy in OECD countries is slowing with a growing market, while non-OECD countries experience acceleration of fuel economy advancement in a shrinking market.

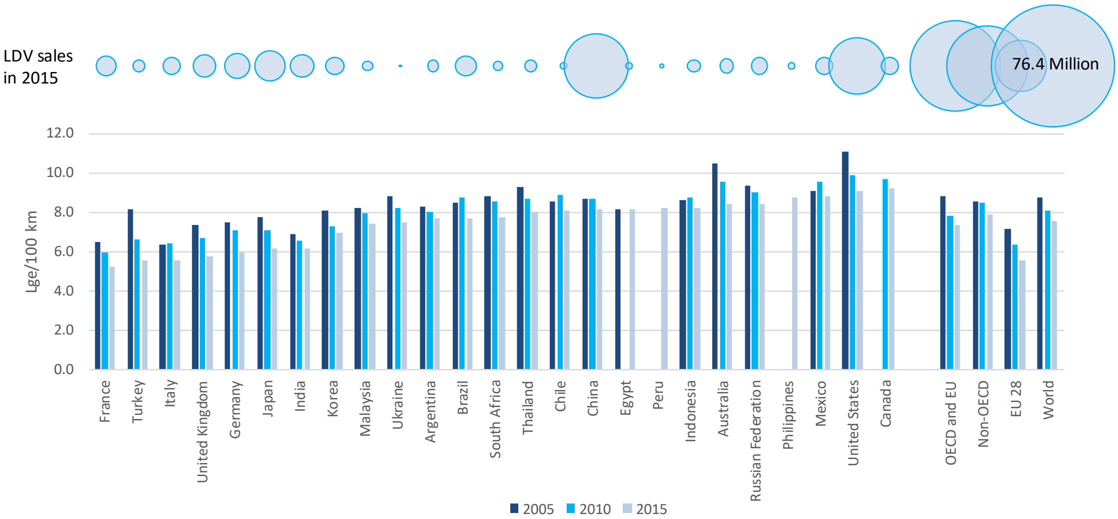
The growing relevance of the Chinese market, with higher than average fuel consumption per km than the non-OECD average, modest improvement rates in Russia, stagnating values in India and net increases in fuel use per km in Argentina and Indonesia, led to improvement rates in non-OECD countries that fell below the progress observed in the most virtuous markets (the EU countries).

Ten years of fuel economy development: 2005-15

The data update for this year's report has enabled analysis of the five-year period 2010-15, in addition to the period 2005-10. Figure 5 and Table 4 display the trends in global average fuel economy in the countries monitored here, including details for 2005, 2010 and 2015.

Without exception, all countries showed an improvement in average fuel economy in 2015 compared with 2005. When looking at the change over the past decade, the greatest progress (measured in terms of percentage improvement over 2005 values) occurred in Turkey, followed by the United Kingdom and Japan.

Figure 5 • Average new LDV fuel economy by country, normalised to the WLTC, 2005-15



Notes: OECD and EU = the 28 EU member countries and Australia, Canada, Chile, Japan, Korea, Mexico, Turkey and United States; Non-OECD = Argentina, Brazil, China, Egypt, India, Indonesia, Malaysia, Peru, Philippines, Russian Federation, South Africa, Thailand and Ukraine.

Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Average fuel economy has improved in all regions between 2005 and 2015, but clear differences are evident among countries and regions.

Between 2010 and 2015, the improvement in average fuel economy at the global level slowed in comparison with the period between 2005 and 2010.

- OECD countries saw their annual improvement rate drop to only 1.0% between 2012 and 2015. Annual improvement rates have particularly been declining in the past few years (0.8% between 2013 and 2014, and 0.5% between 2014 and 2015).
- Improvements in fuel economy accelerated in non-OECD countries over the same period, reaching 1.4% per year, on average, between 2012 and 2015.

The reduction in fuel use per km was significantly lower, both in OECD and non-OECD countries, than the rate of improvement required to meet the 2030 GFEI targets.

Table 4 • Global fuel economy developments, 2005-15

			2005	2008	2010	2012	2014	2015	2030
OECD and EU average	average fuel economy (Lge/100 km)		8.8	8.2	7.8	7.6	7.4	7.3	
	annual improvement rate (% per year)			-2.3%	-2.8%	-1.6%	-1.3%	-0.5%	
			-1.8%						
Non-OECD average	average fuel economy (Lge/100 km)		8.5	8.5	8.4	8.2	8.0	7.9	
	annual improvement rate (% per year)			-0.1%	-0.3%	-1.4%	-1.2%	-1.6%	
			-0.8%						
Global average	average fuel economy (Lge/100 km)		8.8	8.3	8.1	7.8	7.6	7.6	4.4
	annual improvement rate (% per year)			-1.8%	-1.6%	-1.3%	-1.3%	-1.1%	
			-1.5%						
GFEI target	required annual improvement rate (% per year)	2005 base year	**-2.8%**						
		2015 base year							**-3.7%**

Notes: OECD and EU = member states of the European Union and specified member countries of the Organisation for Economic Co-operation and Development (Australia, Canada, Chile, Japan, Korea, Mexico, Turkey and United States); Non-OECD = specified non-OECD countries (Argentina, Brazil, China, Egypt, India, Indonesia, Malaysia, Peru, Philippines, Russian Federation, South Africa, Thailand and Ukraine).

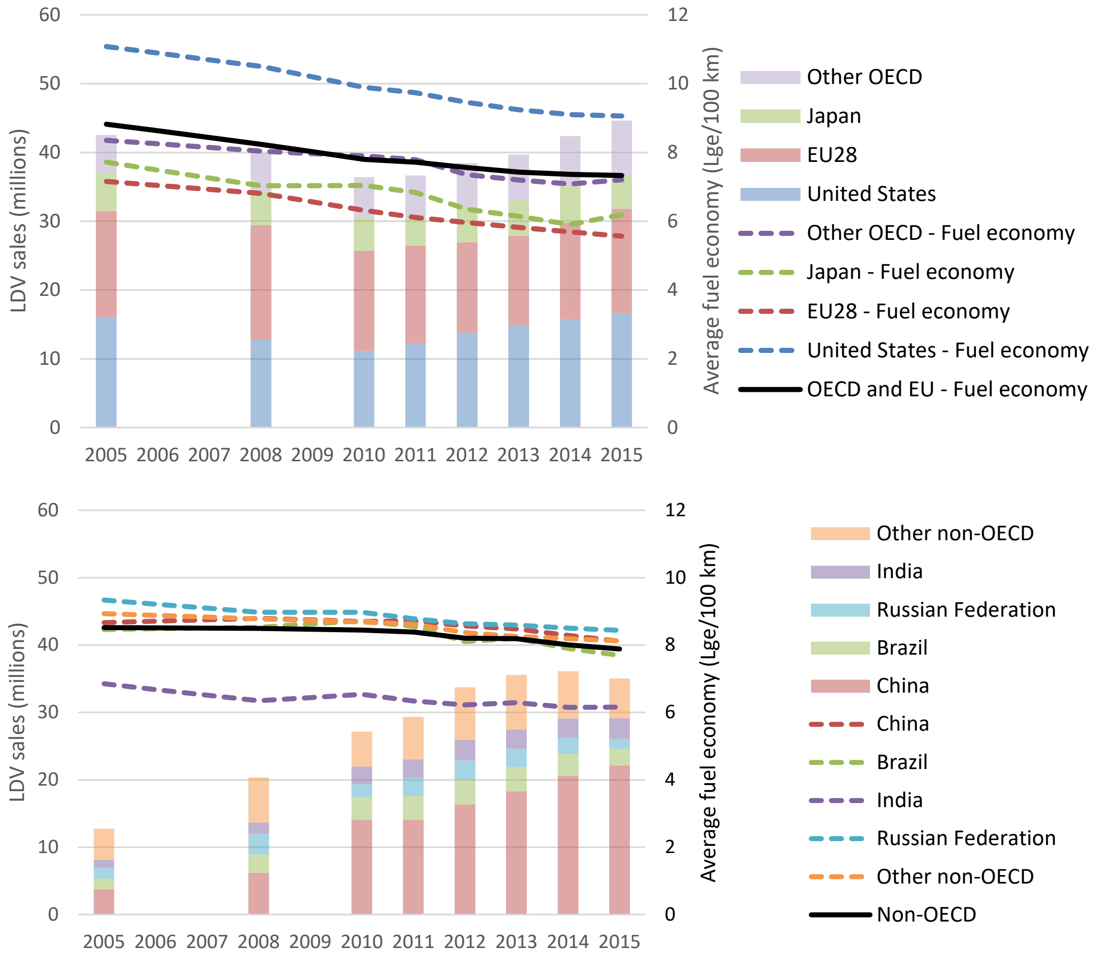
Key point • Annual improvement is slowing in OECD countries and accelerating in non-OECD countries. Both rates are below those needed to achieve the GFEI target.

Figure 6 provide further insight into the trends in fuel economy improvement in OECD and non-OECD countries.

- The slowdown in average fuel economy improvement in OECD countries is primarily attributable to a trend reversal in Japan between 2014 and 2015, and the strength of the vehicle market in OECD countries in the upper cluster of Figure 4, well-illustrated by the growth of LDV registrations in the United States between 2010 and 2015. These effects were partly mitigated by continued fuel economy improvement in Europe.
- The acceleration in improvement observed in non-OECD countries is consistent with the major growth in market size of the non-OECD, the growing importance of markets (such as China and Brazil) that began to enact or tighten fuel economy policies over recent years, and the increasing relevance of China as a market.[5] These factors outweighed the flattening average fuel economy in other major non-OECD countries, such as the Russian Federation and India.

[5] In 2015, China accounted for half of all non-OECD LDV registrations (IEA, 2016b) and about thirds of the total in the non-OECD countries monitored here. These shares in 2005 were 20% and 33%, respectively.

Figure 6 • LDV sales by market between 2005 and 2015 (bars) combined with average new LDV fuel economy (lines), 2005-15



Notes: Other OECD = Australia, Canada, Chile, Korea, Mexico and Turkey; Other non-OECD = Argentina, Egypt, India, Indonesia, Malaysia, Peru, South Africa, Thailand and Ukraine.

Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • OECD countries saw their annual improvement rate drop by more than 60%, to only 1.3%, between 2010 and 2015. Fuel economy improvement accelerated in non-OECD countries over the same period, reaching 1.4%. This represents a major change compared with the evolution observed in the first part of the last decade.

Box 1 ● Real-world versus tested fuel economy

Test standards have been a major topic for discussion in recent years. As in the case of earlier assessments (e.g. IEA, 2016a), this report is based on fuel economy values that are obtained from official tests. However, increasing evidence (as highlighted in ICCT, 2015b) demonstrated that test procedures have not been accurately reflecting fuel consumption in real-world driving conditions. The gap between reported CO_2 emissions from lab tests and road results has been estimated to reach as much as 50%, especially in Europe.

Key reasons for this widening gap are flexibility in the type approval procedure (allowing for unrealistically low driving resistances and unrepresentative conditions during laboratory testing), excessive weight given to stationary conditions in the test cycle (leading to the over-representation of the fuel savings offered by technologies such as stop-start systems and hybrid powertrains with respect to real-world driving) and the exclusion of auxiliary devices such as air conditioning and entertainment systems in the testing phase (ICCT, 2015b).

The new test procedure (Worldwide harmonised Light Vehicle Test Procedures [WLTP]), recently endorsed by the World Forum for the Harmonisation of Vehicle Regulations (WP.29) of the United Nations (UNECE, 2014), comprises a newly developed test cycle (Worldwide Harmonised Light Vehicle Test Cycle [WLTC]), which better reflects real-world vehicle operation. Its adoption will help reducing the gap between tested and real-world on-road fuel economy and will help provide more accurate and representative information to consumers, enabling better estimates on expected CO_2 emission reductions from road transport.

While this is a development in the right direction, it will not close the gap between tests and real-driving conditions. Achieving increased accuracy will require the use of on-road tests, similar to the RDE test procedure for air pollutants, while in-use conformity tests of randomly selected production vehicles should also be introduced (ICCT, 2015b).

Fuel economy drivers

This section follows the lines set by the latest edition of the GFEI benchmarking analysis (IEA, 2016a) and provides additional insight into the evolution of the main drivers of vehicle fuel economy, with further detail behind the major indicators introduced in Table 2 above. This section looks at the characteristics of the main global vehicle markets with respect to segmentation, powertrain technology, engine size, engine power, vehicle weight and footprint. Each subsection starts with an overview of the situation across countries in 2015 and is followed by a brief analysis of the evolution of key parameters over time, focusing on the main clusters of countries identified in Figure 4.

Segmentation

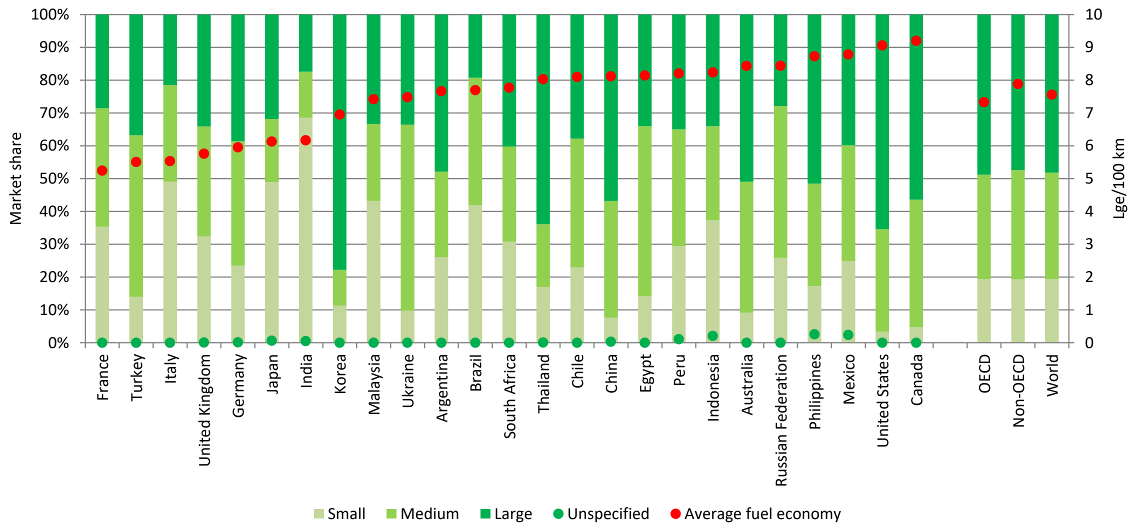
The allocation of models to different market segments (listed in Figure 8) is primarily centred on the classification suggested by IHS Markit data until 2013.[6] This comprises mini cars (A), small cars (B) and small vans/pick-ups (grouped in a broader segment including all "small" vehicles), medium cars (C) and crossovers, i.e. medium sized vans and SUV/pick-ups (grouped in a "medium" vehicle segment), large cars (D), very large cars (E), luxury cars (F) and large SUV/pick-ups (grouped under a broader "large" vehicle segment).

The allocation of models to each segment is not based on numerical indicators and is, to some extent, based on subjective interpretations. In order to mitigate this subjective aspect and simplify

[6] The IHS Markit classification changed for the 2014 and 2015 data, but the IEA-GFEI database was reworked to maintain, to the largest possible extent, the same criteria used in earlier releases of IHS Markit data.

the analysis, this subsection refers to three main vehicle segments: small, medium and large. New registrations belonging to these segments result from the aggregation of detailed classes, as indicated in the legend of Figure 8.

Figure 7 • New LDV market by vehicle segment by country, 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Markets with a high share of large vehicles tend to be characterised by higher average fuel consumption per km as compared to markets where registration of small vehicles predominates.

Figure 7 shows large differences in the market share of the three vehicle segments between countries. In 2015, almost 70% of LDV sales in the United States belonged to the large segment. Australia, Canada, China, Korea, the Philippines and Thailand also have more than half of their new registrations in this segment. At the opposite end, India's market shows the highest percentage for small vehicles. Other markets having more than half of newly registered cars in the small segment include Brazil, Italy, Japan and Malaysia.

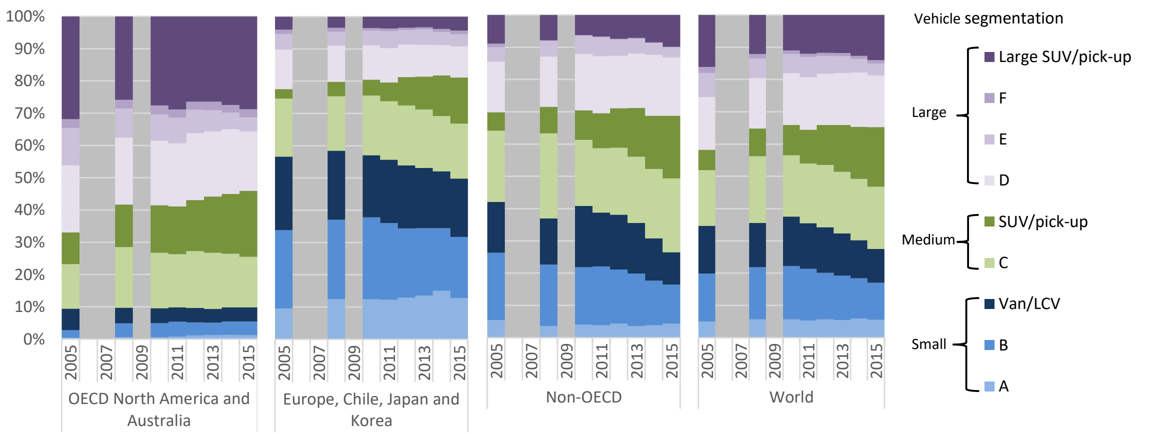
Comparing vehicle segmentation (Figure 7) with average fuel economy (Figure 6) shows that markets with a high share of large vehicles tend to be characterised by higher fuel consumption per km than to markets where small vehicle registrations predominate. For example, the United States and Canada had the highest share of large LDVs and an average fuel consumption of 9.1 Lge/100 km, the highest all countries studied in this analysis.

Figure 7 also shows that the vehicle segmentation is not sufficient to explain variations in average LDV fuel economy values. China, Korea and Thailand have market structures where large SUVs or pick-up trucks command a major share, but also have average levels of fuel economy that were more than 15-30% more energy efficient than those in Canada or the United States. Argentina and Mexico also had a similar distribution of vehicle segments, but Argentina's average fuel economy was almost 15% better than Mexico's.

In 2015, OECD countries had very similar market segmentation to non-OECD countries. Compared with 2013, non-OECD countries experienced a 10% increase in large vehicle sales, while market segmentation in OECD countries remained relatively stable. The average fuel economy in OECD countries was almost 8% better than that in non-OECD markets: 7.3 Lge/100 km compared with 7.9 Lge/100 km, respectively. Even though non-OECD countries saw large vehicles gaining market share, the gap in average fuel economy between OECD and non-OECD countries shrank by 2%

between 2013 and 2015, suggesting that the deployment of fuel-saving technologies has been catching up.

Figure 8 • Vehicle size evolution, major regions, 2005-15

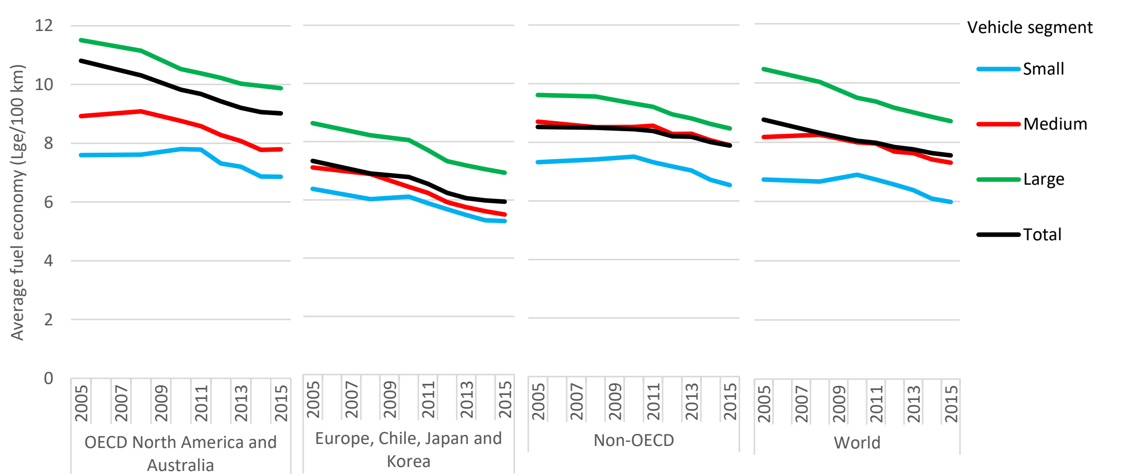


Notes: Non-OECD = Argentina, Brazil, China, Egypt, India, Indonesia, Malaysia, Peru, Philippines, Russian Federation, South Africa, Thailand and Ukraine; Europe = France, Italy, Germany, Turkey and the United Kingdom; OECD North America and Australia = Australia, Canada, Mexico, and United States.

Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Crossovers (medium SUVs and pick-ups) have experienced significant growth across all country clusters. Combining results for crossovers and large vehicles shows that the upper half of the range of vehicle segments has gained relevance in all countries, especially after 2010.

Figure 9 • Average fuel economy by segment, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Fuel consumption per km is lower in Europe, Chile, Japan and Korea than in all other clusters, even for similar market segments.

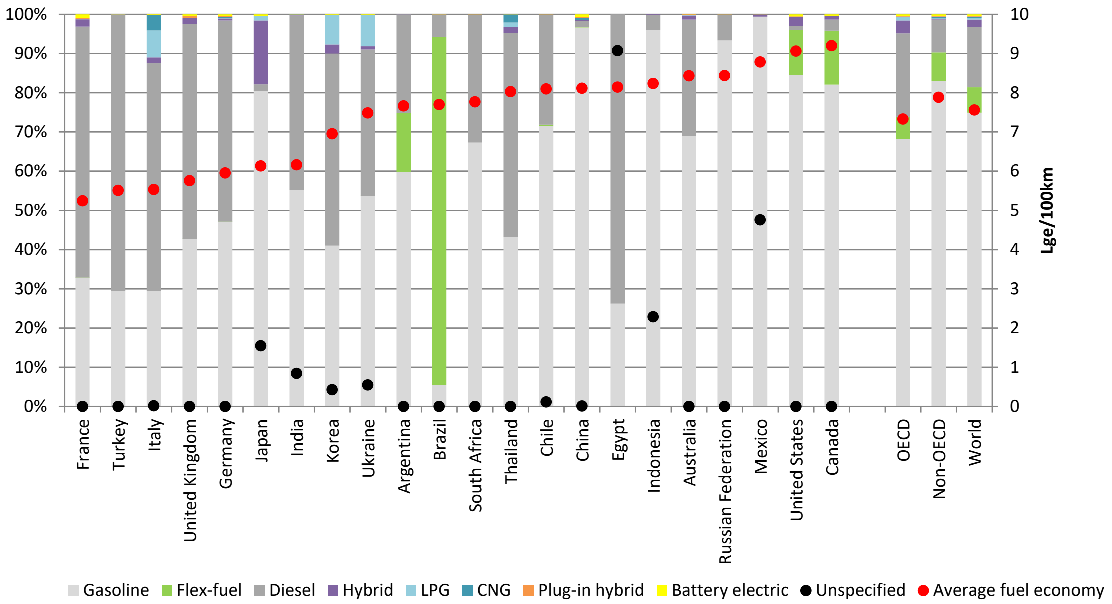
The evolution of vehicle segments by country cluster (Figure 8) suggests that crossovers (medium SUVs and pick-ups) have experienced significant growth across all country clusters: their market share has tripled in the past decade. Combining crossovers with large vehicles shows that the upper half of the range of vehicle segments has gained relevance in all countries, especially after 2010. Small LDVs gained market share or remained stable before 2010. Since then, they have lost relevance in all country clusters, except the OECD cluster of North America and Australia, where they already accounted for a small fraction of the total market. Globally, small vehicles still accounted for almost 30% of all LDV registrations in 2015.

Plotting fuel economy by market segment (Figure 9) shows significant differences across the country clusters identified in Figure 4:

- Fuel consumption per km is lower in Europe, Chile, Japan and Korea than in all other clusters, even for similar market segments. This is consistent with higher shares of diesel and hybrid powertrains in Europe, Chile, Japan and Korea than in other regions (Figure 11). This is also coupled with engine and vehicle attributes that are remarkably different when compared with OECD North America and Australia, and fairly similar to those of non-OECD countries.
- Weakening improvement in fuel economy in North America during 2014 and 2015 took place across all segments, but was not uniform. Given their higher market share, trends affecting medium and large vehicles had a stronger influence on the average fuel economy for all new registrations.
- Results for Europe, Chile, Japan and Korea showed a clear downward trend in fuel consumption per km until 2014, followed by a slowdown in improvement between 2014 and 2015 that reflects the rebound observed in Japan in 2015. In this case, regional averages are mostly influenced by trends occurring in the small and medium segments.
- The recent acceleration in fuel economy improvements in non-OECD countries has been driven by improvements taking place across all segments since 2013, a change in the trend for small and medium segments compared with earlier years. The same change in trend occurred in the large market segment from around 2008.

Powertrain technology

Figure 10 • New LDV market by vehicle powertrain by country, 2015



Notes: CNG = compressed natural gas; LPG = liquefied petroleum gas.

Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Countries with high diesel shares have often better average fuel economy than countries with low diesel shares.

LDV powertrain technologies have proven to be a strong determinant of average fuel economy in different countries. Countries with higher shares of diesel or hybrid powertrains have better average fuel economy compared with countries with a higher proportion of gasoline or flex-fuel cars (Figure 10). Six out of seven markets with the highest fuel consumption per km had diesel and hybrid powertrains commanding market shares below 5%. These results match the findings in IEA (2016b).

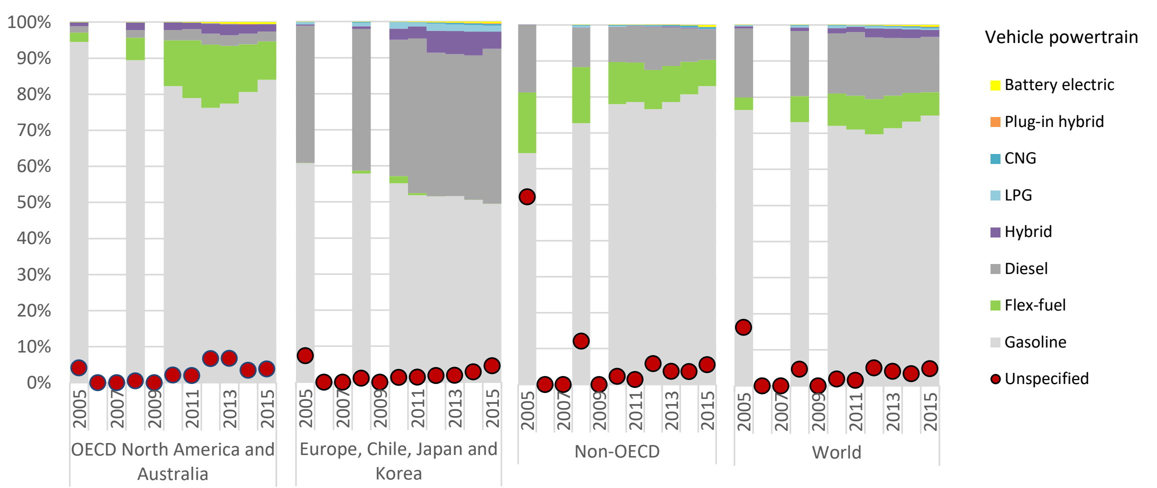
LDV markets in major European countries, as well as in Korea, India and Thailand, were dominated by diesel cars, with a share of over 40% in each respective market. Thailand's average fuel use per km was at the higher end of this group, at 8 Lge/100 km, followed by Korea at 7 Lge/100 km. This is consistent with high market share of large SUVs in Korea and pick-up trucks in Thailand. In the case of Thailand, this is also consistent with the lower penetration of other fuel-saving technologies in non-OECD markets.

Japan was the only country where hybrid powertrains commanded market share exceeding 10% in 2015.

Flex-fuel powertrains were most common in the Americas. In Brazil, flex-fuel vehicles represented nearly the only powertrain available across all new LDVs. In Argentina, Canada and the United States, flex-fuel powertrains had more than 10% market share. The high share of flex-fuel vehicles in Brazil is coherent with a longstanding history of ethanol use as transport fuel. In other countries, especially in Canada and the United States, the fairly high prevalence of flex-fuel is more likely due to favourable policy regimes, such as the presence of credits in fuel economy regulations (TransportPolicy, 2016).

In 2015, liquefied natural gas (LNG) and compressed natural gas (CNG) only attained a market share close to 10% in Ukraine, Italy and Korea. Similar to flex-fuel LDVs, these market shares were achieved in countries with policy regimes that incentivised their deployment (including favourable policies for infrastructure, vehicle purchase and fuel pricing).

Figure 11 • Vehicle powertrain evolution, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Gasoline LDVs regained market share between 2012 and 2015, gaining on diesels, flex-fuel and natural gas. Advanced powertrains finally start to show.

Overall, OECD countries had a more diversified market than non-OECD countries, although gasoline still represents almost 70% of registrations in the OECD countries. Diesel's market share in Europe has remained stable since 2011. This followed years of continued increases, dating back well before

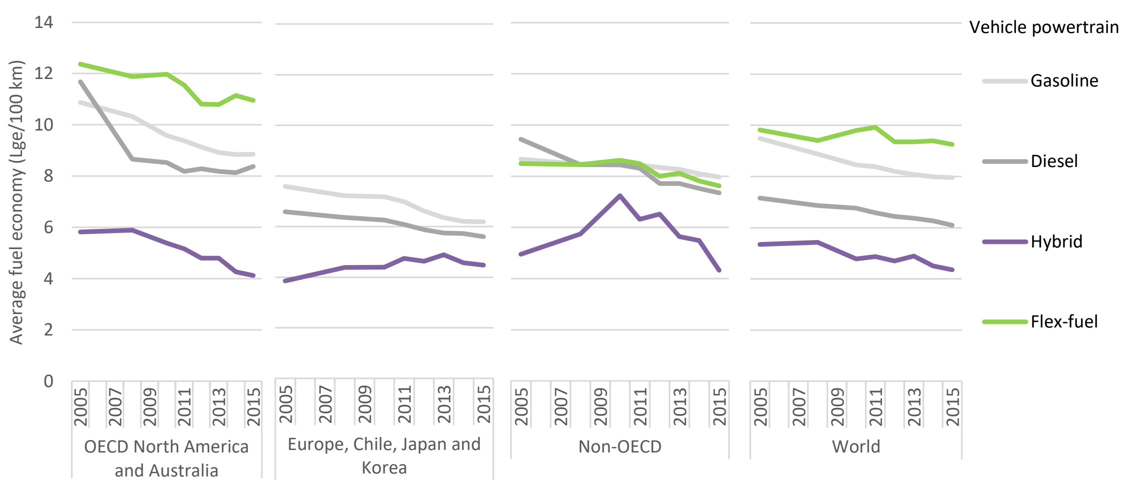
2005. At the OECD level, diesel powertrains declined slightly after 2011 because of the increased importance of North American sales, mainly consisting of gasoline-powered LDVs (Figure 11).

Non-OECD countries have experienced a substantial rise in gasoline-fuelled LDVs between 2008 and 2015. This is primarily due to the increasing relevance of a gasoline-intensive markets, such as China, in the non-OECD total. Similarly, the reduced share of flex-fuel vehicles was mainly caused by the decreased importance of Brazilian LDV sales within the non-OECD.

Overall, Figure 11 indicates that gasoline-fuelled vehicles represented almost three-quarters of the worldwide LDV market in 2015. After a slight decline between 2005 and 2012, primarily due to the growing market share of diesels in Europe and flex-fuel vehicles in North America, gasoline-powered LDVs started to regain ground, reflecting the growing relevance of gasoline-intensive markets such as China and the United States. The second most popular powertrain category was diesel, fluctuating around 15-20% between 2005 and 2015. Flex-fuel engines remained primarily confined to Brazil and, following a few years' increase in North America in the late 2000s, are now losing market share – since 2010, their global market share has fallen from 10% to 6%. Hybrids have primarily been deployed in Japan, where their market share stagnated in the three years following 2012. In 2015, hybrids had similar fuel economy levels across all regions (most likely because they were used in similar vehicle types, primarily mid-size sedans) (Figure 12). On average, they were almost twice as efficient as internal combustion engines (ICEs).

Plug-in and electric vehicles are growing rapidly in selected countries (see IEA [2016c] for further details), but their share remains at less than 0.5% on a global scale.

Figure 12 • Average fuel economy by fuel type, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • The average fuel economy of the powertrains used in the OECD region aggregating Europe, Chile, Japan and Korea is better as compared to other regions. In 2015, hybrids had similar fuel economy levels across all regions (most likely because they were used on similar vehicle types, primarily mid-size sedans). On average at the global level, in 2015 they were almost twice as efficient as ICEs.

The average fuel economy of the powertrains used in the OECD region aggregating Europe, Chile, Japan and Korea is better as compared to other regions. Diesels in Europe were 10% more efficient than gasoline vehicles in 2015, even if they were more frequently used in larger vehicles. Diesel powertrain performance continuously improved in Europe, Chile, Japan and Korea between 2005 and 2015, while improvement in the fuel economy of gasoline-powered vehicles stagnated between 2014 and 2015, reflecting the reversal of the fuel economy trend that occurred in Japan.

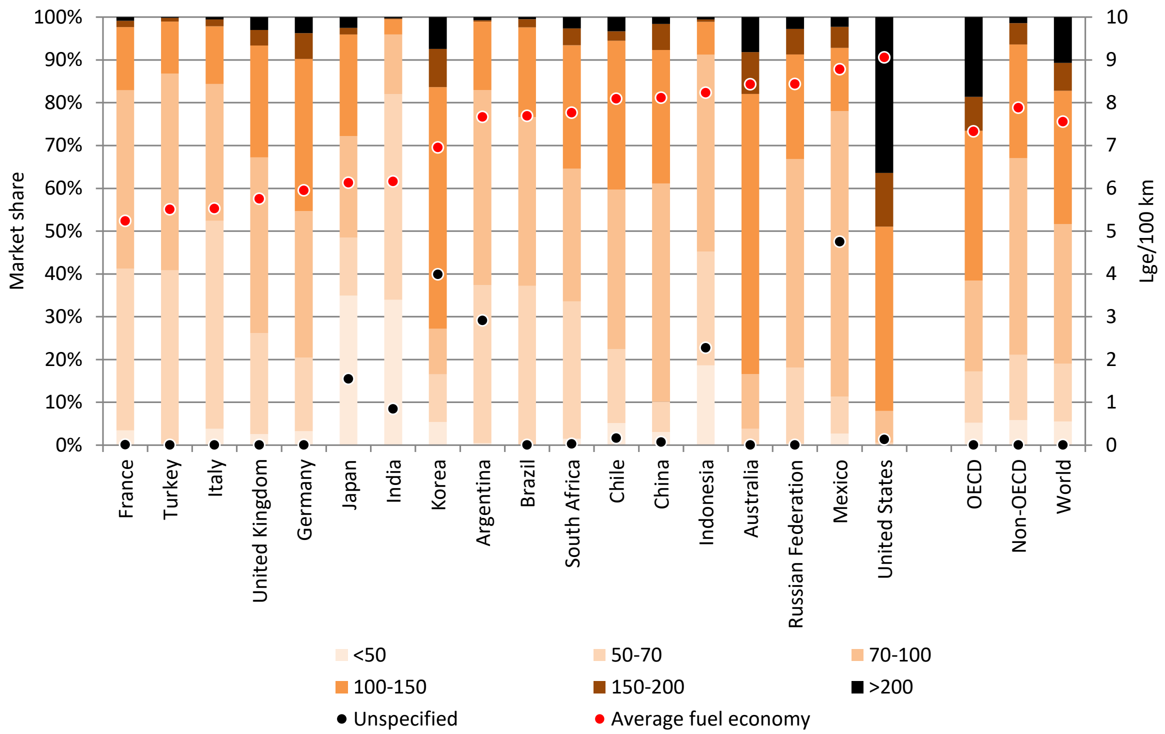
Average fuel economy by powertrain in OECD North America and Australia is spread out across a much wider range of values. In 2015, hybrids, the most efficient powertrain technology, often equipping mid-size sedans, consumed slightly more than 4 Lge/100 km. This is a value that is now fairly similar across all markets. At the opposite end of the range, the average consumption of flex-fuel LDVs (primarily used in large LDVs, because of credits allowed by the North American regulatory framework) exceeded 11 Lge/100 km. Notwithstanding these wide differences, the regional average fuel economy is very close to the results shown in Figure 12 for gasoline LDVs, reflecting their high market share in the OECD North America and Australia country cluster.

For non-OECD countries, the fuel economy of LDVs using gasoline, flex-fuel and diesel engines are very close to each other and, therefore, also similar to the regional average. All three powertrains experienced improvements between 2013 and 2015. In the case of diesel, the improvement trend has been maintained across the whole decade.

Power

Figure 13 shows that in the United States, about 50% of new LDVs had engines above 150 kW, significantly higher than the power rating observed in any other country where data are available. At the other end of the spectrum, France, Turkey and Italy had more than 80% of new LDV registrations with engines below 100 kW, being 30 percentage points above the world average share.

Figure 13 • New LDV market by engine power and country, 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • The distribution of power classes across vehicle markets suggests that more powerful vehicles tend to be coupled with larger fuel consumption per km, even if this effect can be partly offset by the adoption of better vehicle technology within power classes.

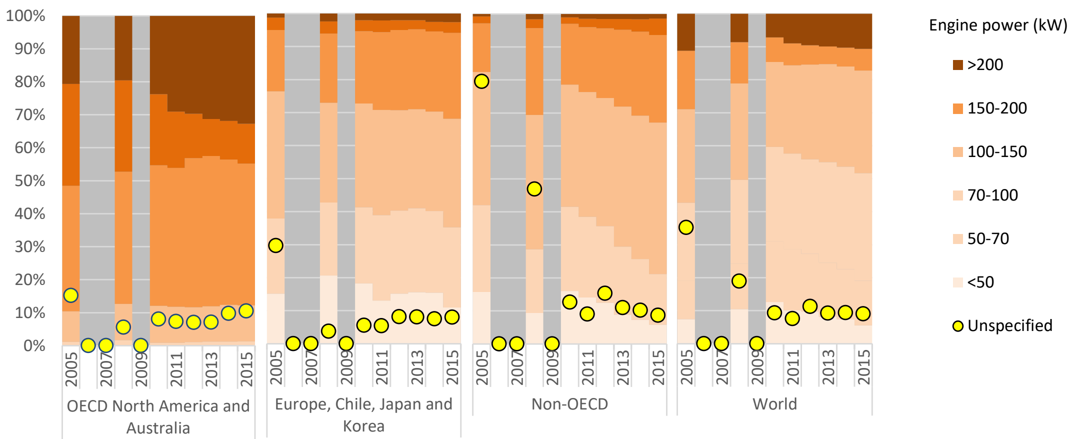
The distribution of power classes across vehicle markets shown in Figure 13 suggests that more powerful vehicles tend to be coupled with higher fuel consumption per km. This effect, however, can be partly offset by the adoption of better vehicle technology. The comparison of the distribution of power classes in countries with similar average fuel economy but with contrasting power ratings, such as Germany and India, or Australia and the Russian Federation, suggests that the deployment of fuel efficient technologies is not evenly spread within power classes across all countries.

Power ratings in OECD countries belonging to the high fuel economy cluster of Figure 4 were in stark contrast to the ranges observed in all other global regions across the whole time period 2005-15 (Figure 14). In the period 2008-15, the proportion of LDVs with a power rating exceeding 200 kW grew by 67% in OECD North America and Australia, mostly at the expense of vehicles in the 150-200 kW segment. In Europe, Chile, Japan and Korea, vehicles above 150 kW had minor market shares.

LDVs in non-OECD countries have power ranges that are comparable to those in the OECD cluster including Europe, Chile, Japan and Korea. In the non-OECD countries, LDVs with low power ratings have lost sizeable fractions of their market share in the past five years, finishing 2015 with an average power that exceeded the values of the main European markets and Chile, Japan and Korea (Table 2). In 2010, vehicles up to 70 kW represented 40% of the non-OECD LDV market. Their market share was only half that in 2015. Vehicles with engines over 150 kW have more than doubled their market share in the same period, but did not exceed 5%.

Globally, LDV engines above 150 kW had fairly small market shares, mainly due to the increasing importance of non-OECD markets in total new vehicle registrations. Nevertheless, the market share of LDVs with engines smaller than 50 kW halved in the five years up to 2015, mostly taken up by the vehicles whose power ranged between 70 kW and 150 kW.

Figure 14 • Engine power evolution for OECD and non-OECD, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Power ratings in OECD North America and Australia were in stark contrast to the ranges observed in all other global regions. In the non-OECD, LDVs with low power ratings lost a sizeable fraction of their market share in the past five years.

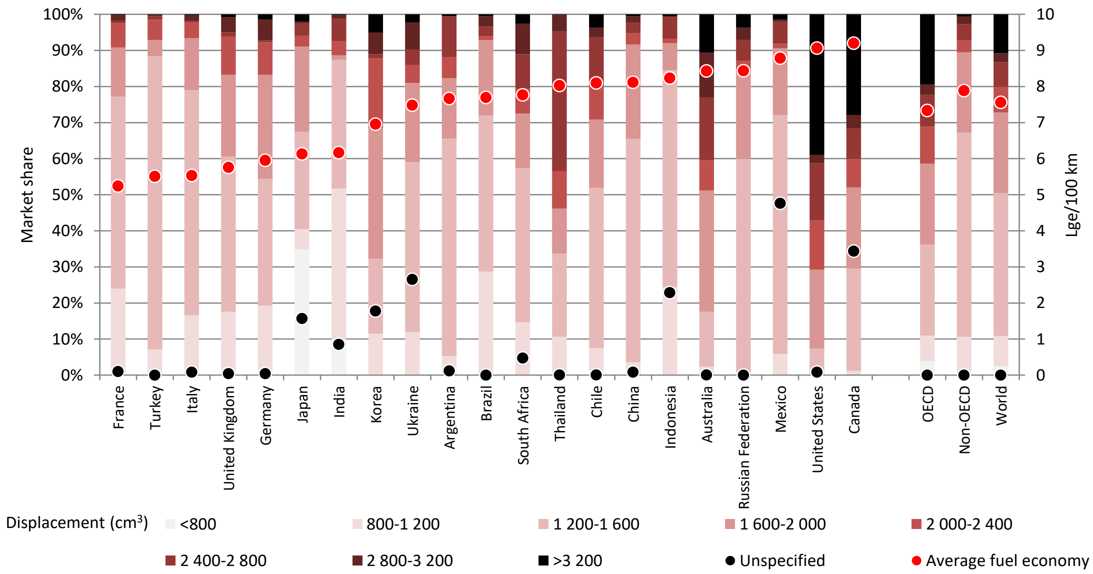
Displacement

Countries with the best average fuel economy tend to have an LDV market with a higher share of engines with low displacement (Figure 15). Exceptions are similar to those already identified for power, with an additional difference attributable to larger displacements in countries with a high share of diesel powertrains, even if the displacement gap with gasoline ICEs is narrowing over time.

Korea and Thailand (both characterised by a rather high diesel market share) have fairly large engine displacements as compared with countries with a similar fuel economy. Mexico and the Russian Federation have a fuel economy in the same range as Australia and the United States, but significantly smaller engine displacements. All these markets have a major focus on gasoline ICEs. India and Germany, both diesel-intensive countries, follow a similar pattern, with Germany having higher average engine displacement and yet lower average fuel economy. These differences confirm that greater deployment of fuel-saving technologies allows similar fuel economy targets to be met with engines that have larger engine volumes and greater power outputs.

The effect of diesel on displacement is visible when comparing technologically advanced countries such as Japan and the European markets of Italy and France, which have similar average fuel economy and power. In the (diesel-intensive) European countries, the average engine displacement is well above the Japanese average (Table 2).

Figure 15 • New LDV market by engine displacement and country, 2015

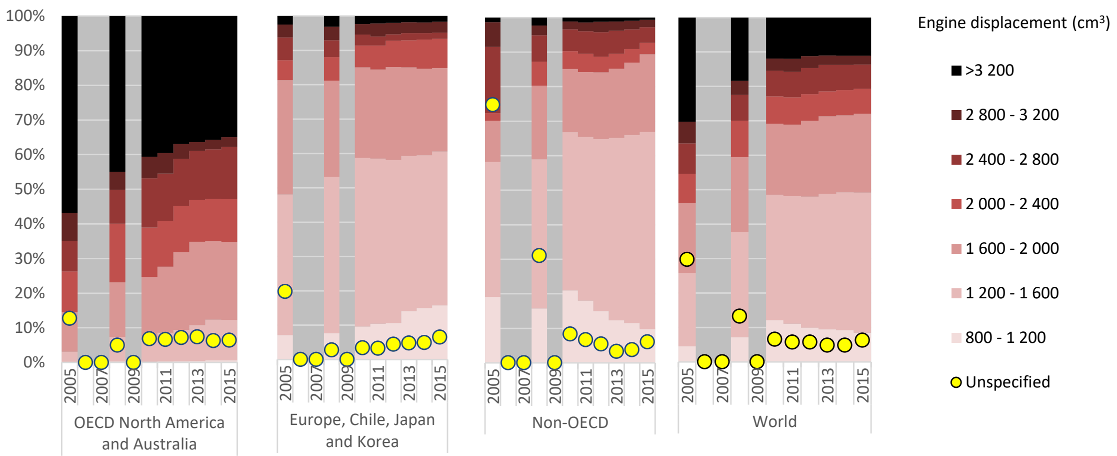


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • The distribution of engine displacement across vehicle markets indicates that large engines tend to be coupled with higher fuel consumption per km, even if this effect is partly mitigated by diesel's share of the market, as diesel engines tend to have larger displacement that gasoline-powered ICEs with similar fuel economy.

Contrary to power and market segments, engine displacement has tended to decline over the past decade, especially in Europe. This is largely attributable to increased power output per unit displacement achieved by all ICE, and in particular by diesel engines (**Error! Not a valid bookmark self-reference.**). As in the case of engine power, stark contrasts exist between North America and Australia and the rest of the world (notwithstanding the specific case of Thailand, see Figure 15).

Figure 16 • Engine displacement evolution for OECD and non-OECD, 2005-15

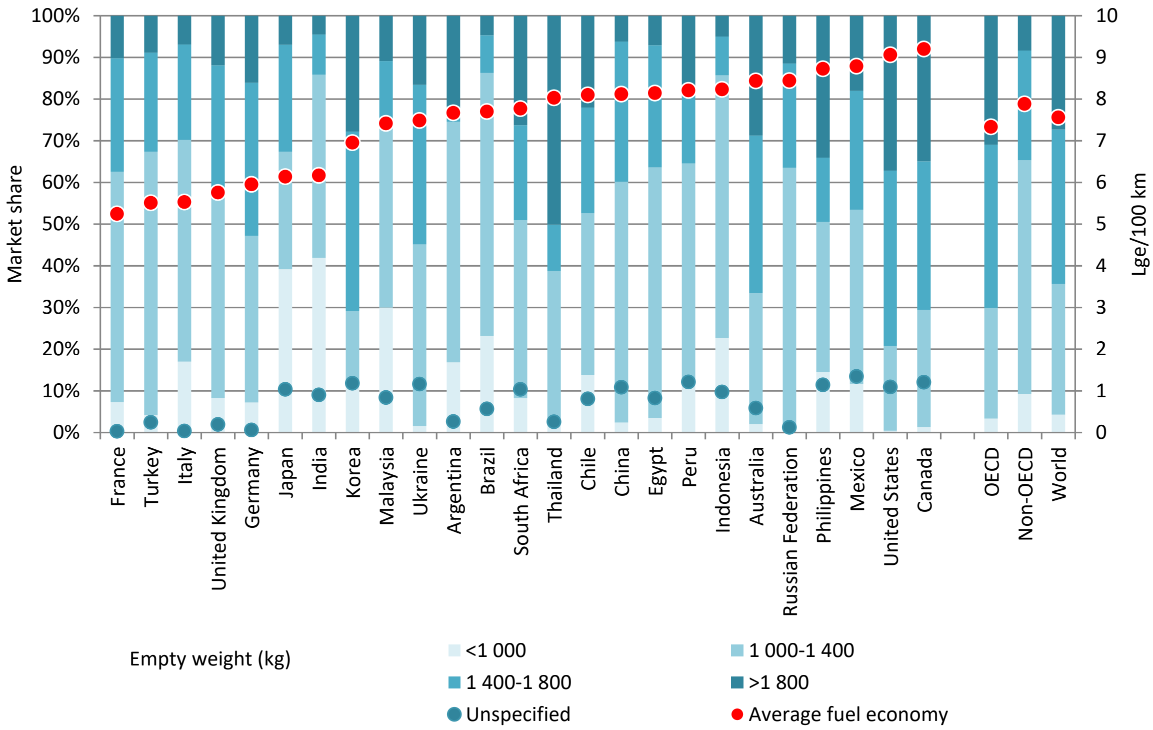


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Contrary to power and market segments, engine displacement has tended to decline over the past decade, especially in Europe. This is largely attributable to increased power output per unit displacement achieved by all ICEs, and in particular by diesel engines.

Weight

Figure 17 • New LDV market by vehicle empty weight by country, 2015

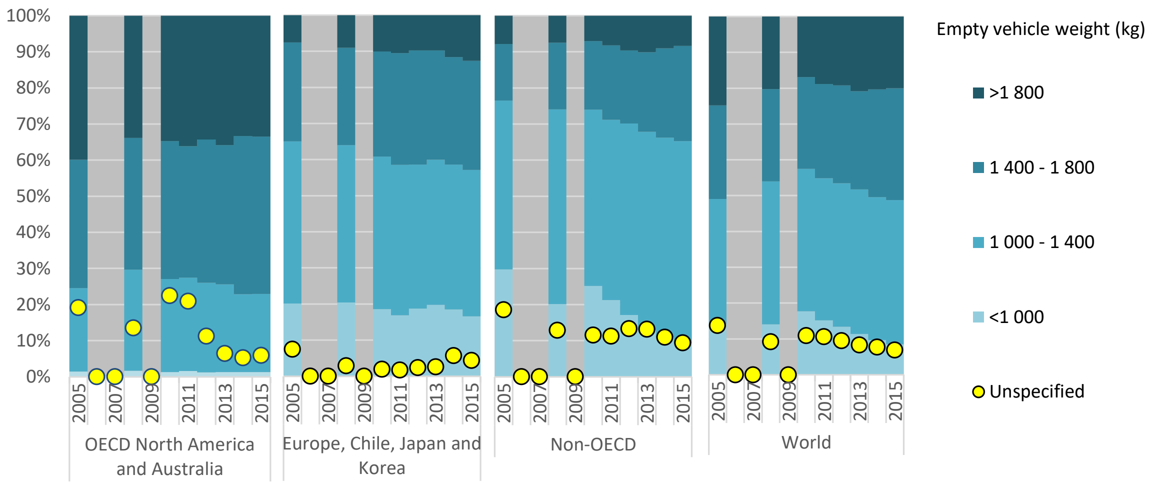


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Countries with lighter vehicles tend to have a better average fuel economy compared with countries with heavier vehicles. As in the case of engine displacement, this effect is less evident in countries with a high diesel market share.

Countries with a higher share of heavy vehicles tend to have comparatively poorer average fuel economy (Figure 17). Weight certainly has an impact on fuel economy: heavy vehicles tend to consume more fuel due to the need to overcome higher inertial forces. However, the lack of a clear trend in Figure 17 indicates that weight is not the only determinant of vehicle fuel economy. Korea and Thailand, for instance, had higher average vehicle weight compared with countries with similar fuel use per km. Both countries also had much higher diesel market share, suggesting that heavier diesels managed to have a similar average fuel economy as lighter gasoline vehicles. Similar considerations can be extended to the comparison of markets with comparable fuel economy – Japan as against European markets, such as Italy or France.

Figure 18 • Vehicle weight evolution for OECD and non-OECD, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • The weight of newly registered LDVs shifted towards the middle segment (1 000-1 800 kg) between 2005 and 2015, a development that mirrors that of engine power and market segmentation. OECD North America and Australia are, once more, in stark contrast with the rest of the global regions.

Between 2005 and 2015, the average weight of global LDVs remained stable, but this took place in a context that saw a growing share of newly registered LDVs shifting towards the middle segment (1 000-1 800 kg). The evolution of the share of LDVs weighting more than 1 400 kg mirrors fairly closely the developments in engine power (vehicles with more than 100 kW) and market segmentation (vehicles in the upper half of all market segments). The move towards the middle segment has mostly been driven by non-OECD countries, where over 80% of all new LDVs were between 1 400 and 1 800 kg in 2015, compared with 65% in 2005. Non-OECD countries also saw the market share of light-weight vehicles fall very significantly between 2005 and 2015, while vehicles of more than 1 800 kg kept a stable market share of 8-9% across the decade.

New vehicles in Europe, Chile, Japan and Korea were lighter on average than those in non-OECD countries in 2015, with vehicles weighing less than 1 000 kg commanding a share of sales that remained close to 20%. The stark contrast between OECD North America and Australia and the rest of the global regions, already observed for engine power and displacement, is confirmed here: in the past decade OECD North America and Australia, taken together, had almost no sales below 1 000 kg and 30% of new LDVs weighing more than 1 800 kg.

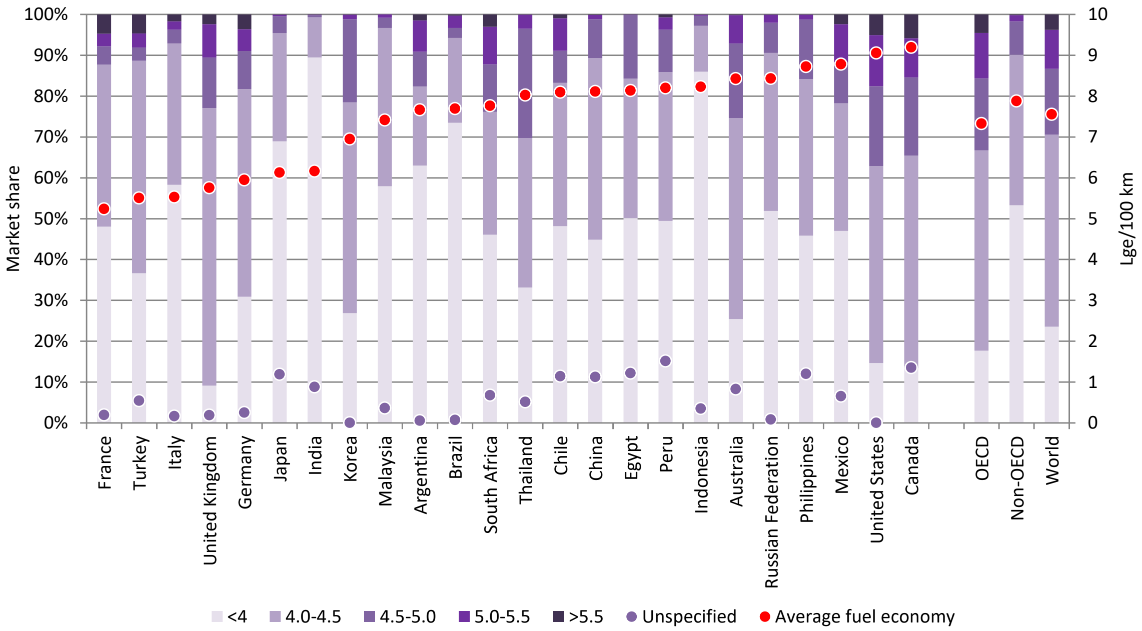
Worldwide, the evolution of empty vehicle weight between 2010 and 2015 showed a 50% decrease in the market share of LDVs weighing less than 1 000 kg and the stabilisation of the share of LDVs above 1 800 kg.

Footprint

Vehicle footprint denotes the area formed by wheelbase and axle width and is generally used as a proxy for vehicle size. A larger vehicle footprint often implies a larger frontal area, which in turn negatively affects fuel economy due to higher aerodynamic drag.

Of the main global LDV markets, Brazil, India, Indonesia and Japan were the countries with the largest share of vehicles with a footprint lower than 4 m^2 in 2015 (Figure 19). Several countries had market shares of vehicles with a footprint greater than 5 m^2 that exceeded 5%: Australia, Canada, France, Germany, Mexico, South Africa, Turkey, Ukraine, the United Kingdom and the United States.

Figure 19 • New LDV market by vehicle footprint by country, 2015



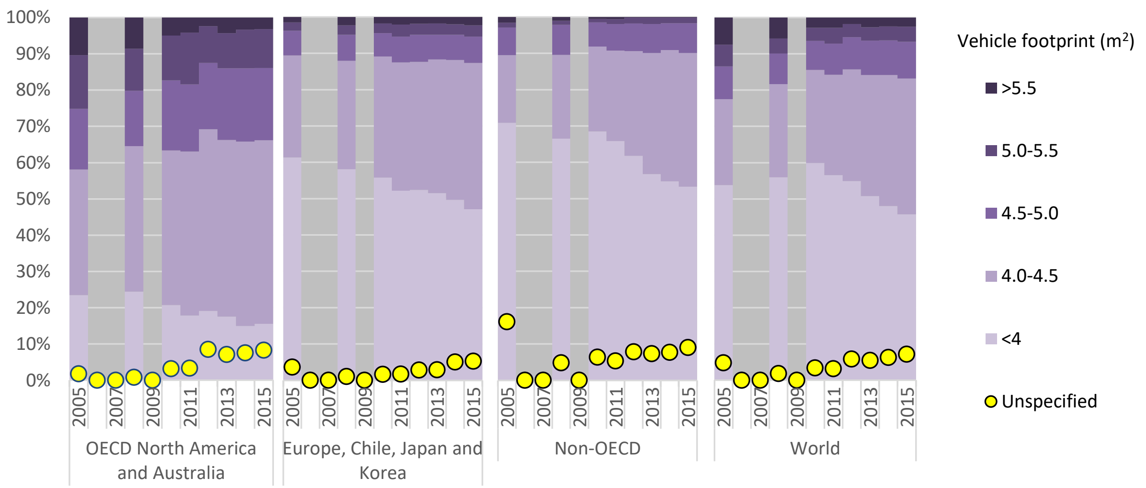
Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Even though there are a few notable exceptions (Brazil, India, Indonesia and Japan), footprint is the most homogeneous across all the fuel economy drivers considered in this analysis.

The evolution of vehicle footprint is very similar to that already discussed for weight (Figure 20). The global average has remained almost the same since 2005. Compared with OECD North America and Australia, non-OECD, Europe, Chile, Japan and Korea showed larger shifts – since 2010, new vehicles that were smaller than 4 m^2 lost a quarter of their market share in these regions. The loss was mainly taken up by migration towards the middle segment (4 to 4.5 m^2). Non-OECD, Europe, Chile, Japan and Korea have fewer vehicle registrations above 5.5 m^2, and vehicle footprints in OECD North America and Australia tend to be roughly 0.5 m^2 larger in comparison to the rest of the world.

Worldwide, the middle market segment between 3.5 and 4.5 m^2 grew by 15%, to nearly three-quarters of all LDV sales, between 2010 and 2015.

Figure 20 • Vehicle footprint evolution for OECD and non-OECD, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • LDV sales move towards the middle segments between 3.5 and 4.5 m² for both OECD- and non-OECD countries

Fuel-saving technology deployment

Figure 21 provides an update of the technology shares already monitored in earlier GFEI benchmarking assessments. It illustrates that OECD countries were ahead of non-OECD countries regarding most drivetrain technologies, both in 2005 and 2015. The market share of turbo charging has traditionally been high in Europe, as turbochargers are mostly applied to diesel ICEs. The proportion of vehicles with turbos has increased in the past decade to 2015 in all OECD countries scrutinised here, despite a stabilisation of diesel penetration, suggesting that other powertrains are increasingly equipped with this technology, allowing engine downsizing and thus higher energy efficiency (IEA, 2014). non-OECD countries with a higher market share of turbo charging, such as India and South Africa, also have a relatively higher market share of diesels.

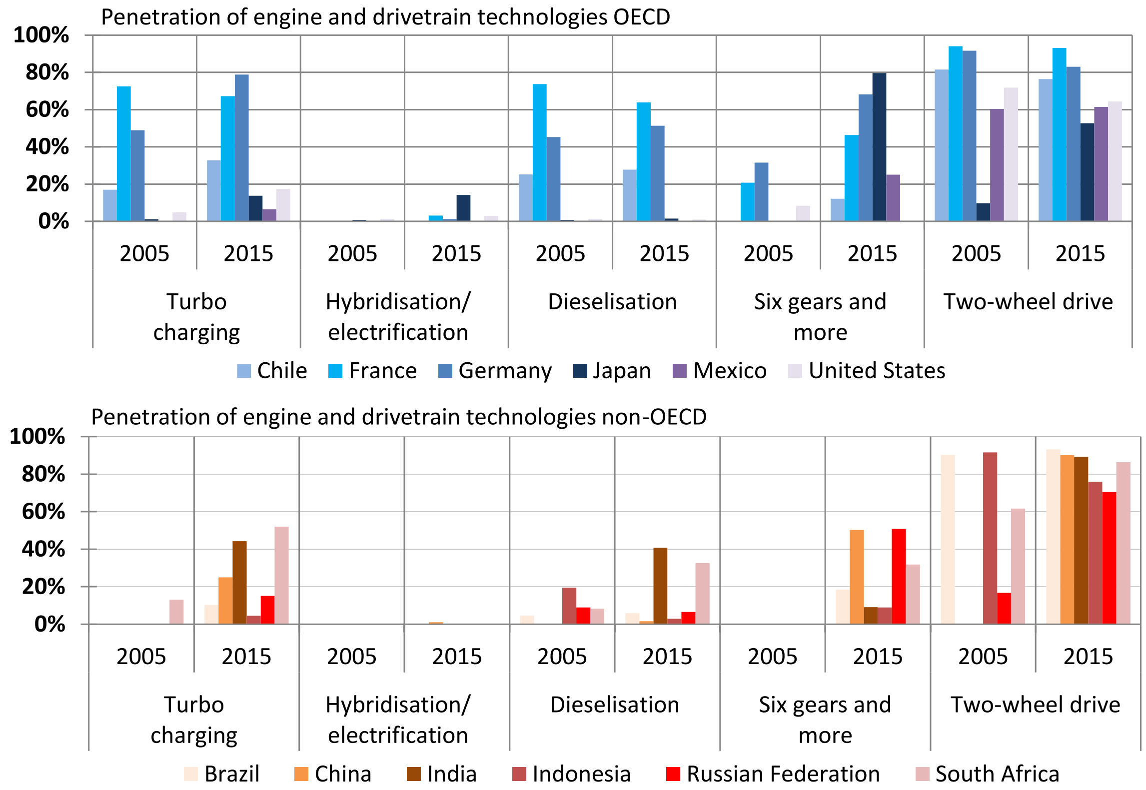
In most OECD countries, diesel market share slightly declined between 2005 and 2015. During the same period, non-OECD countries showed diesel growth in India and South Africa, while the Russian Federation and Indonesia saw a decline in diesels in their LDV market.

Hybridisation showed no visible market share in 2005 in the analysed countries. In 2015, France, Japan and the United States had the highest market share for hybrids. Few new hybrids entered the fleets of the non-OECD countries monitored here.

The market share of transmissions with more than six gears rose in both OECD- and non-OECD countries. In 2015, more than 80% of newly registered LDVs in Japan and the United States had six or more gears. In non-OECD countries, no country reached more than 50% market share with six or more gears, which shows a technological gap to be overcome.

Two-wheel drive is dominant in most OECD LDV markets. European countries are already at or above 80% market share, while the Americas are closer to 60% due to higher SUV sales. Non-OECD countries that showed significant shifts in the two-wheel drive market share are Russia and South Africa.

Figure 21 • Penetration of efficient engine and drivetrain technologies for selected OECD and non-OECD countries, 2005-15



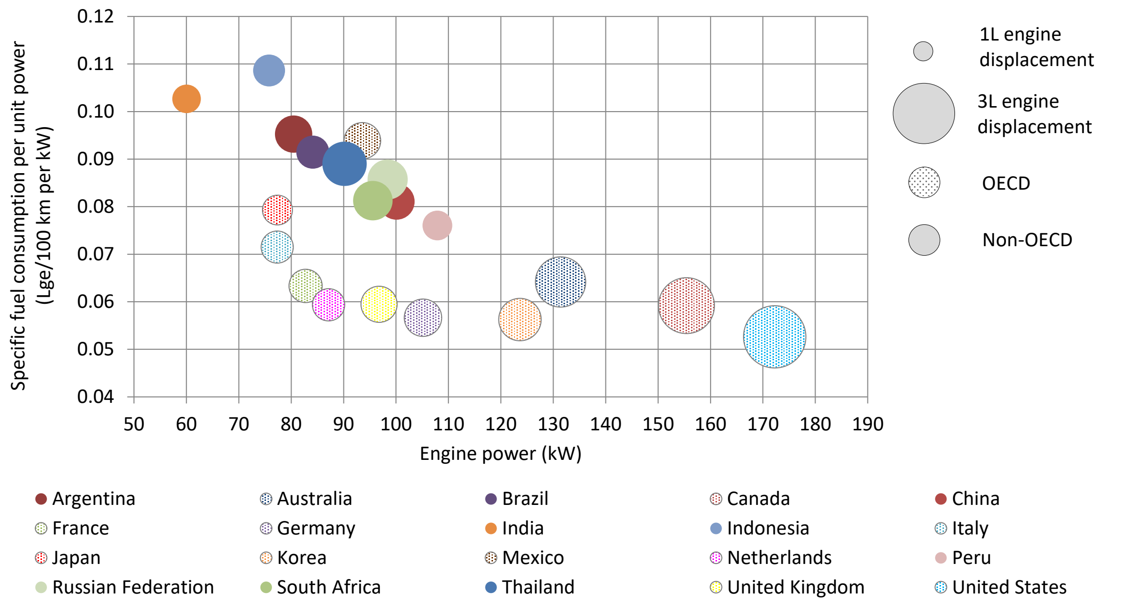
Note: No Chinese data available for 2005.
Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • OECD countries had more advanced technologies in their LDV markets compared with non-OECD countries, but major differences are also observed within both regions.

When comparing vehicles with similar power ratings, LDVs sold in OECD countries use less fuel than those marketed in non-OECD countries (Figure 22). This explains that, while the higher fuel use per km in certain OECD countries such as Australia, Canada, Korea and the United States is primarily due to vehicle attributes such as power, weight and footprint, the higher fuel consumption per km observed in Mexico, Philippines, the Russian Federation, Indonesia, Peru and China are also induced by a technological gap or time-lag in engine technology deployment. The high frequency of non-OECD economies in the top left of Figure 22, as well as the clustering of OECD countries in the lower part of the figure, is consistent with the characterisation of OECD countries as a premium vehicle market with respect to the rest of the world.

Compared with the assessment based on 2013 data (IEA, 2016a), Figure 22 shows a small improvement across most markets, but it does not suggest any generalised tendency for non-OECD economies to be catching up with OECD countries. Most OECD economies have specific fuel consumption per unit of power close to 0.06 Lge/100 km per kW. Korea, Germany and the United States achieve the lowest values. The trend reversal seen in Japanese average fuel economy that took place in 2015 came with a small improvement in specific fuel consumption per unit of power over 2014 and is therefore attributable primarily to a market shift towards larger vehicles. Among the non-OECD countries, India and Indonesia remain at the upper end of specific fuel consumption per unit of power. In Brazil, specific fuel consumption per unit of power moved closer to OECD economies compared with 2013, confirming the acceleration of fuel economy improvements that took place in 2014 and 2015.

Figure 22 • Specific fuel consumption per unit of engine power plotted against engine power ratings for selected OECD and non-OECD countries, 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • When comparing vehicles with similar power ratings, LDVs sold in OECD countries use less fuel than those marketed in non-OECD countries. This indicates a significant technological gap in engine technology deployment between OECD and non-OECD countries.

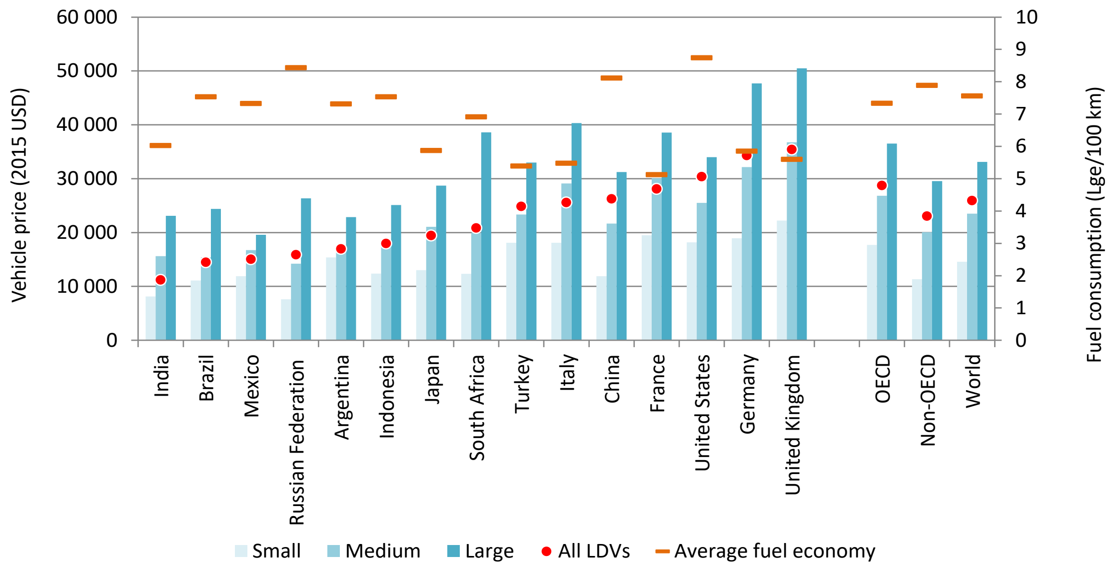
Fuel economy and vehicle prices

Status

Average new LDV prices vary widely between countries. Looking at the sample of countries monitored here (Figure 23), the range between highest and lowest average vehicle prices is twice as large as the LDV price in the cheapest market – while new LDVs cost only a little more than USD 11 000 (including taxes) in India, the average price of new LDVs is as high as USD 35 000 in the United Kingdom. This variability is also confirmed within market segments: small cars in the most expensive markets have costs of similar magnitudes to those applied to large cars in the least expensive markets.

The average fuel consumption of new LDVs is very similar in the least and the most expensive markets: 6.2 Lge/100 km in India, and 5.8 Lge/100 km in the United Kingdom. On the other hand, Indian cars are on average much smaller (3.5 m^2) and much less powerful (60 kW) compared with those sold in the United Kingdom (4.1 m^2 and 96 kW). Similar considerations could be extended to other markets: the comparison between the OECD and the non-OECD aggregates for 2015 reveals that new LDVs sold in OECD countries are on average a third more expensive, 65% more powerful, 38% heavier and 22% larger (i.e. with a greater footprint) than in non-OECD countries. However, they consume about 7% less fuel per 100 km than those sold in the non-OECD countries.

Figure 23 • New LDV prices by country, 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Average new LDV prices varied widely between countries.

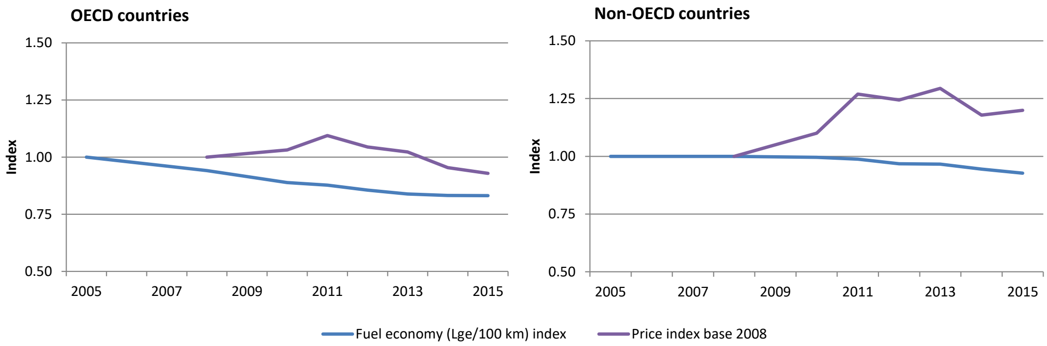
These data suggest that average vehicle price is not strongly driven by fuel economy parameters, but rather by other attributes. Taking a closer look at market segments in each of the markets listed in Figure 23 helps explain that the main factors with a strong influence on average vehicle price include vehicle segmentation (large-vehicle segments tend to be coupled with large weight, size and power ratings all together, and vice versa for small-vehicle segments) and the market share of premium brands. This can be expanded upon as follows:

- Vehicle markets with low average prices (India, Brazil, Mexico, Japan and South Africa) often have a high share of small cars and a strong presence of European and Japanese manufacturers, excluding premium brands.[7] Russia, with a significant portion of its new LDVs in the large market segment, is a notable exception. In Russia, low average car prices in the large segment are coupled with a significant presence of Korean manufacturers.
- Vehicle markets with the most expensive average car price had significant shares of their market taken by premium brands (the United Kingdom and Germany), or large proportions of new LDV registrations in the large vehicle segment (China and the United States).
- In the central cluster, France had a similar market distribution to Italy in respect to manufacturer categories, with fairly low shares of premium European brands, but larger shares of LDVs in the medium and large segments. In Turkey, the market structure was similar to Italy, but with a greater share of medium LDVs.

The limited relevance of fuel economy to the determination of vehicle price is also confirmed by the analysis of time series: between 2008 and 2015 the average price of new cars in the non-OECD countries increased significantly, while the fuel economy improvements accelerated only towards the end of the decade, when average prices actually declined. In the OECD countries, fluctuating vehicle prices across the decade 2005-15 were coupled with sizeable fuel economy improvements, especially prior to 2013 (Figure 24).

[7] For this exercise, European premium brands are assumed to comprise Audi, BMW, Jaguar, Mercedes and Mini. Japanese premium brands comprise Acura, Infiniti and Lexus.

Figure 24 • Indexes of LDV fuel economy and price, first available year to 2015.



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • No major correlation is suggested between fuel economy improvements and vehicle prices over time.

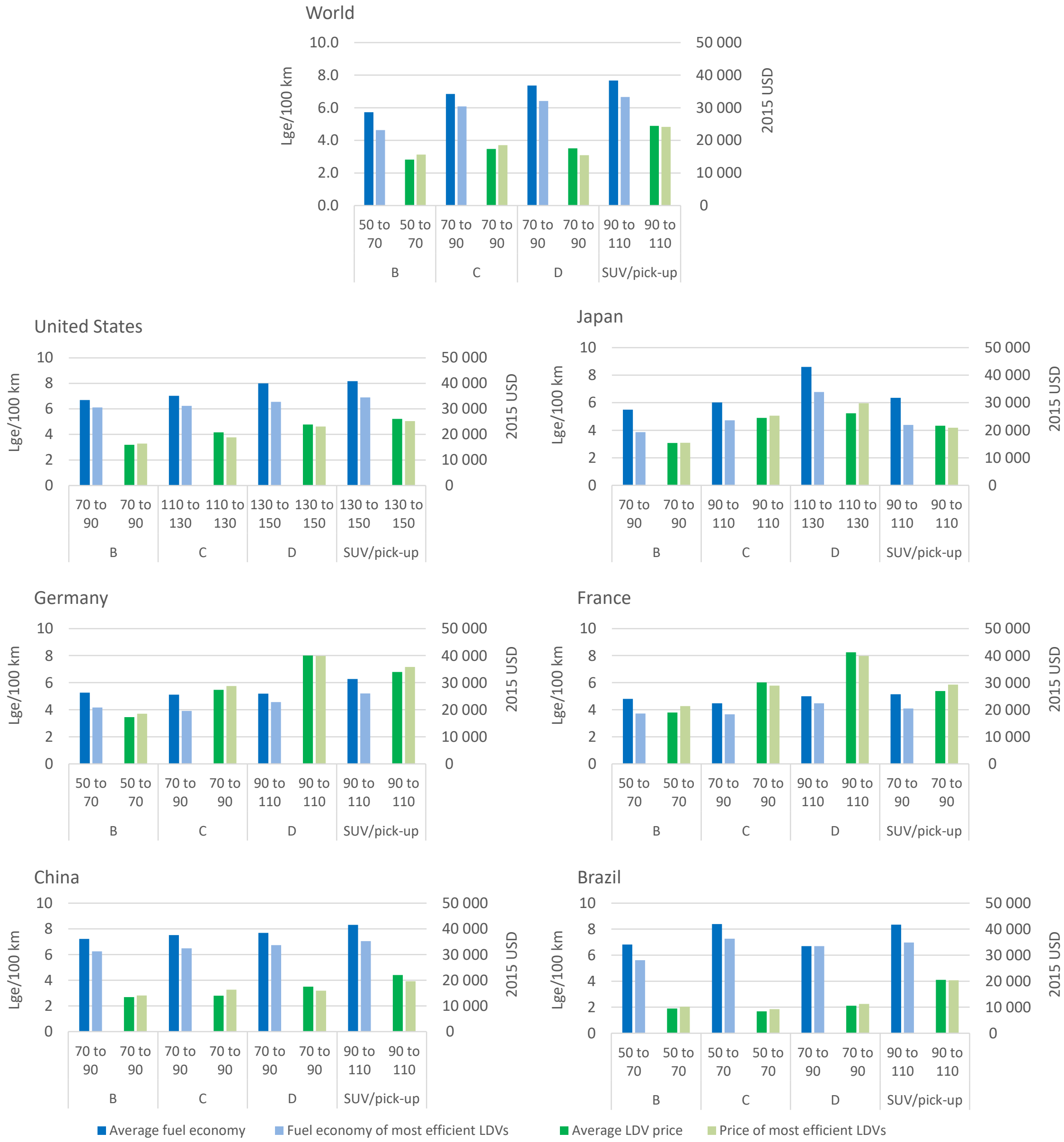
The impact of fuel economy on vehicle prices becomes more discernible when LDVs are compared across narrower ranges of segments and power ratings. Figure 25 provides a detailed overview of the average fuel consumption of LDVs belonging to some of the most representative segments and power ranges, as well as the average vehicle price of the top 25% of all LDV sales (ranked by fuel efficiency of each vehicle model and configuration). The information is presented for a selection of six representative OECD and non-OECD markets.

Differences in the incremental price of the 25% most efficient vehicles in the segment and power classes shown in Figure 25 are determined by reasons that could be grouped under three main categories:

- The price increment for the 25% most fuel-efficient vehicles in a given segment and power class depends on the market structure, i.e. the relative market share of vehicles priced above or below average because of attributes that are not directly related to fuel economy. This can have upward or downward impacts on price differences: efficient LDVs may be cheaper/more expensive than average simply because of lower/higher shares of premium brands in their pool, compared with the average of the same segment and power class.
- The price increment depends on residual differences in the vehicle attributes used to narrow down the analysis, e.g. lower power for the 25% most efficient vehicles than for the average of the market segment scrutinised. This effect, narrowed down by the choice made here to look at specific segments and power ranges, tends to have downward effects on the price differential
- The price difference is related to the use of efficient and more costly technologies (e.g. hybridised or plug-in vehicles) because technology clearly tends to have an upward influence on vehicle price (Figure 26).[8]

[8] In some cases (e.g. two-wheel drive vs. four-wheel drive versions of the same model), lower fuel use per km is actually also coupled with lower cost.

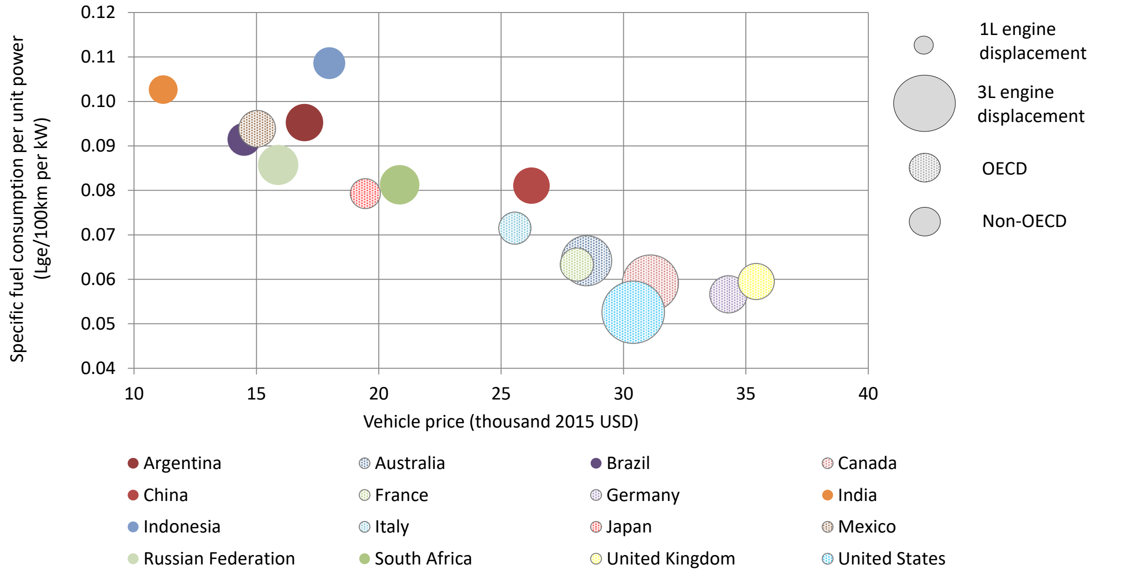
Figure 25 • Average fuel consumption of LDVs belonging to some of the most representative segments and power ranges in six representative OECD and non-OECD markets, 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point: The incremental price of the 25% most efficient vehicles in specific segments and power classes may be positive or negative. The global average suggests that positive increments tend to be more frequent for vehicles marketed at low prices, while negative increments are more frequent for large vehicle segments.

Figure 26 • Specific fuel consumption per unit of engine power and average engine displacement plotted against vehicle price for selected OECD and non-OECD countries, 2015



Key point • Lower consumption per km per unit power provides an indication of higher deployment of fuel saving technologies. Technology deployment tends to be greater for vehicles marketed at higher prices. Fuel saving technologies are also more intensively used in OECD countries.

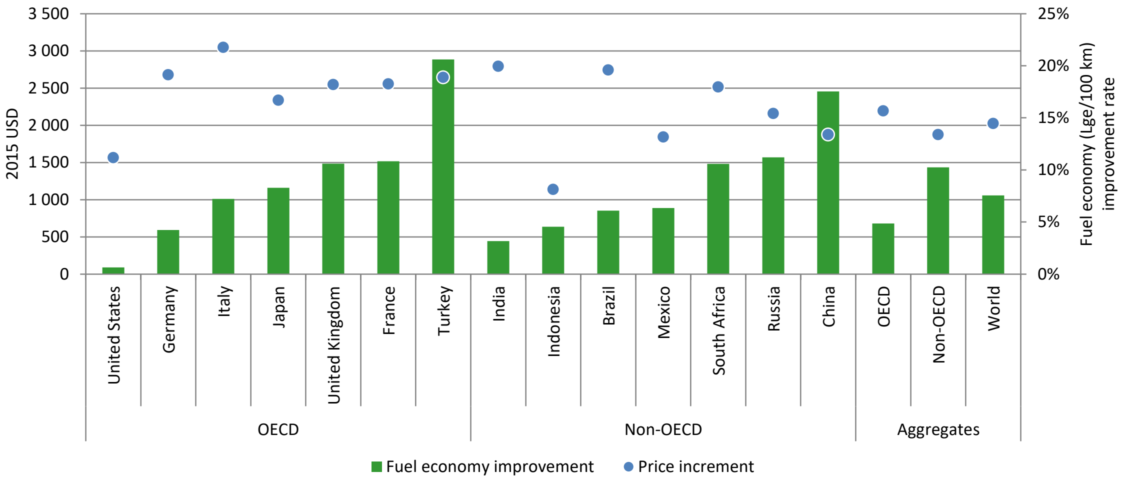
The comparison of global average prices for the 25% most fuel-efficient vehicles and the average of each segment and power class suggests that positive price increments for fuel efficiency tend to be more frequent for vehicles marketed at low prices, while negative differences (attributable to a stronger relevance of the brand and power effects over technological costs) are more frequent for large vehicle segments. The following are a selection of examples that help understand these dynamics:

- In the United States the price difference can be as low as USD -2 000 for vehicles in the C segment (medium cars) and a power rating ranging between 110 kW and 130 kW. The negative price differential between average LDVs and the 25% most efficient ones is due to the larger share, in the efficient vehicle cluster, of Japanese cars such as the Mazda 3, offering lower fuel consumption at a price that is below the average of this segment and power class. At the opposite end, LDVs in the B segment (small cars) and with a power rating of 70 kW to 90 kW are on average USD 500 more expensive than the average LDV in the same segment and power class. In this case, the price of the 25% most efficient cars is driven up by the Honda CR-Z hybrid, which costs about USD 4,500 more than the average.
- In Japan, the lowest price gap (actually negative) takes place for SUVs and pick-ups with an average power of 90 kW to 110 kW. In this case, the 25% most efficient vehicles are about USD 800 cheaper than average. This segment is dominated by the sales of one single model: the Honda Vezel, accounting for more than 40% of sales. The difference between the 25% most efficient vehicles and the average is then determined by the difference in fuel economy and price of the two-wheel drive and the four-wheel drive version of this small SUV. The highest price increment in Japan (USD 3 700) occurs for LDVs in the D segment (large cars, most frequently sedans) and an average power ranging between 110 kW to 130 kW. This can be explained by the significant market share (6%) of vehicles from premium brands (including the Mercedes Benz C180, which, on average, is about USD 15 000 more expensive than the typical car in this size and power class) amongst the 25% most efficient LDVs.

- In Germany, the price difference is very small (about USD -200) for LDVs in the D segment (large cars) with power ratings of 90 kW to 110 kW. This can be explained by the significant share of a high-volume model, the 2.0 litre diesel Volkswagen Passat (accounting for 10% of the total market in the class) priced below the average of this class, as well as a relevance of premium brands in the pool of 25% most efficient LDVs, lower than in the whole set of vehicles in the same segment and power class. In Germany, the highest price increment occurs for SUVs and pick-ups with a power rating of 90 kW to 110 kW. The 25% most efficient LDVs in this segment cost about USD 1 900 more than the average. This is caused primarily by the high share of LDVs from premium European manufacturers (e.g. the Audi Q3 and Q5, BMW X1 and X3, Range Rover Evoque) in the pool of most efficient LDVs.
- In France, high negative price differences occur in the C segment with average power of 70 kW to 90 kW (USD -1 200) because of a much lower market share of premium brands amongst the most efficient cars. The SUV/pick-up segment with 70 kW to 90 kW power range has the highest positive price increment in France. In this case, more than 4% of the 25% most efficient vehicles are Mitsubishi Outlanders, a plug-in hybrid costing almost USD 28 000 more than the average vehicle in the segment.[9] Other expensive models, including the BMW X1 and Renault Kadjar, are also in the 25% most efficient LDVs in France.
- In Brazil, price increments are negative (USD -200) for the 25% most efficient SUVs and pick-ups with an average power of 90 kW to 110 kW. In this segment, one of the cheapest models of this segment (the Ford Focus EcoSport) is also the second most efficient available on the market. The price increment is highest (USD 900) for cars in the C segment with an average power of 50 kW to 70 kW. This is heavily influenced by the relative price and fuel economy of different motorisations of the Fiat Palio, accounting for a major portion (52%) of the vehicles in this segment. The 1.4 L version, more efficient and costly when compared with the 1.0 L version, increases the cost of the top 25% most efficient vehicles in the segment compared with the average cost.
- In China, the price increment for the 25% most efficient vehicles is highest for cars in segment C with 70 kW to 90 kW of power. The majority (85%) of the efficient vehicles are models produced by joint ventures with European, Japanese, Korean or North American manufacturers. These vehicles only represent half (47%) of the total LDVs in the segment. Price incremenets are negative (USD -2 400) for SUVs and pick-ups with 90 kW to 110 kW power. This is consistent with lower average power (-4%) and weight (-8%) compared with the average car in the segment, as well as the absence of four-wheel drive versions among the 25% most efficient vehicles (as opposed to roughly 10% of all SUVs and pick-ups in this class).

[9] Under the French bonus-malus system (a feebate scheme allocating a one-off registration fee or rebate according to the vehicle-specific CO_2 emissions), the Mitsubishi Outlander was eligible for a EUR 3 300 rebate in 2014 and 2015.

Figure 27 • National average fuel economy improvements and price differences for the 25% most efficient LDVs from the average of main market segments and power classes



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • Fuel economy improvements and average price differences coupled with the 25% most efficient LDVs vary significantly across countries. The global average suggests that consumers are currently paying a price premium for fuel economy improvements in the order of USD 100 for each percentage point of fuel economy improvement.

Price differences between the 25% most efficient LDVs and the average of all LDVs, calculated at the national level, vary significantly across countries (Figure 27).[10]

- In the United States, the fuel economy improvement delivered by the 25% most efficient vehicles is close to 13% of the 2015 average fuel use per km. The average price increment coupled with this variation is as low as USD 90. The small improvement in the average fuel economy delivered by the 25% most efficient LDVs suggests that fuel economy tends to be rather homogeneous in the main market segments and power classes. This is consistent with a weak relevance of fuel economy in the determination of vehicle choices, something that is coherent with a small impact of fuel economy improvement on the average LDV price.
- In Europe, the 25% most efficient LDVs deliver an average fuel economy improvement ranging between 17% and 22%. The similar range of improvement delivered by the 25% most efficient models and configurations in all major EU markets analysed indicates that the fuel economy offered across LDVs sold in the European Union is similar. The price premiums associated with these improvements range between USD 1 000 and USD 1 500 in Italy, France and the United Kingdom. In Germany, the price premium is as low as USD 600. Price increments in France and Germany converge at higher rates of fuel economy improvement (see Figure 28). The low value seen in Germany is influenced by the dynamics of brand share. This is especially relevant for the D segment, where the relevance of premium brands is weaker in the 25% most efficient LDVs, as discussed earlier.
- Results for the major non-OECD markets with high shares of small vehicles and similar price profile by segment, such as Brazil and India, indicate that the most efficient 25% of vehicles are characterised by average fuel economy that is, on average, 20% better than those of the average LDVs. Improved fuel economy in India and Brazil is coupled with incremental prices

[10] This is the result of sales-weighted average fuel economy improvements and price increments characterising the main segment and power classes in each country. This assessment is carried out for market segments including mini cars (A), small cars (B), medium cars (C), large cars (D), vans and SUV/pick-ups. It excludes luxury cars, due to the very low relevance of fuel economy in influencing their price, even within specific power classes.

ranging between USD 450 and USD 850, respectively. This suggests that the market differentiation is similar to Europe. Comparatively higher prices of fuel-efficient LDVs in Brazil than in India are also consistent with the fairly low cost increments coupled with fuel savings due to diesel technologies, particularly significant in India (see also the comment to Figure 28, further below).

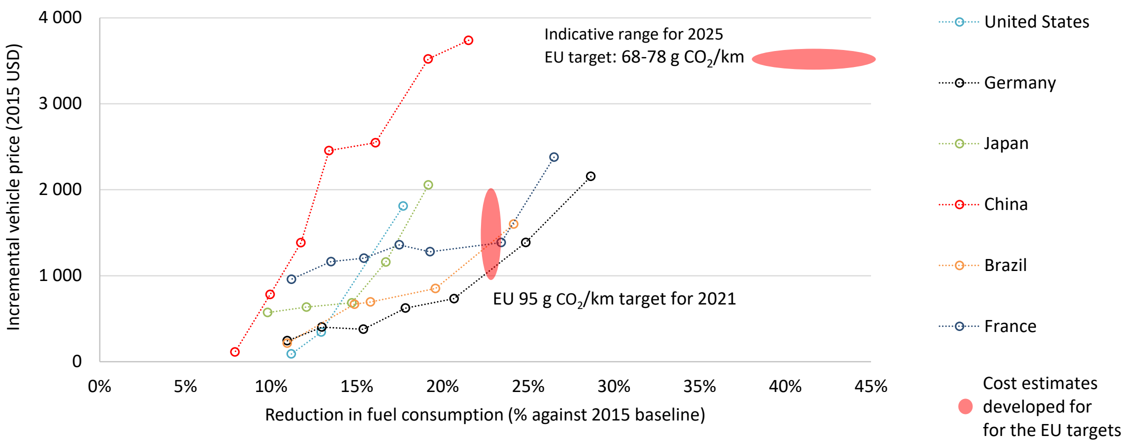
- In Indonesia, the fuel economy improvement associated with the 25% of LDVs with the lowest fuel economy in each segment and power class is less than 10% than the national average. This confirms that low fuel taxes limit the interest of OEMs in diversifying the choice of vehicles they offer, given the lower interest from consumers in fuel economy improvements. The limited price increment in Indonesia is consistent with a narrower differentiation of fuel-saving technologies in the 25% most efficient LDVs. Similar considerations could be extended to Mexico, where the price premium for a 13% fuel economy improvement also falls in the range USD 500 to 1 000.
- In Turkey and China, the 25% most efficient LDVs allow for a fuel economy improvement comparable or slightly lower than in Europe. The lower improvement found in China is consistent with the low penetration of diesels. The high price increment for efficient LDVs is consistent with high market share, in some of the main segments and power classes, of vehicles that are priced well below competing models. This high price increment is likely to reflect the contextual effect of market dynamics with upward observations (as in the case of Chinese vehicles from joint ventures with European, Japanese, Korean or North American manufacturers) on vehicle prices and incremental costs attributable to fuel-saving technologies.

The aggregation of these results at the global level indicates that, on average, consumers across the world are paying a price premium for fuel economy improvements in the order of USD 1 500 for a 15% fuel economy improvement (Figure 27), or USD 100 per each percentage point reduction in fuel use per km.

Figure 28 shows, for a selection of key global vehicle markets, the weighted average prices of vehicles having a fuel economy rating that is better than the average of the average vehicles on sale,[11] which suggests that the price premium for fuel economy improvements of 15% currently paid by consumers in most of the markets displayed in Figure 28 actually ranges between USD 500 and 2 500. These values grow to USD 800 and 4 000 for a 20% improvement. Price increments tend to be lower in markets with a high market share of diesels (EU member states) and higher in countries with large proportions of large vehicles (the United States) or in markets where the most popular vehicles are priced well below more efficient models (China). In the case of Europe, price premiums are in the same range of cost increments assessed by a range of studies analysing the investment in technology required to meet EU regulatory targets for passenger cars (ICCT, 2013; IKA, 2012; TNO et al., 2011).

[11] Each point represents a subset of the total sales constituted by a portion of the most fuel efficient vehicles within each "category", i.e. each segment and power class. The subsets of the most fuel efficient vehicles in each of category are combined using a sales-weighted average to calculate their reduction in fuel use per km and price increment compared to the sales-weighted average of all vehicles sold, all categories combined. For one specific country, the top dot would represent the combination of, for example, the 5% most efficient models within each category sold in that country, the second top dot the 10% most efficient models within each category, the third top dot the 15% most efficient models within each category, etc.

Figure 28 • Price increments per percentage point fuel economy improvement in selected markets, 2015



Note: the indicative target for 2025 is as indicated by the European Parliament in 2015 (EP, 2015). The technology cost estimates for the EU targets are based on the range given by ICCT (2015a) for passenger cars.

Source for the price assessment: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Key point • The price premium for a fuel economy improvement of 15% currently paid by consumers in most major car markets ranges between USD 500 and 2 500. Price premiums are not uniform across the main markets.

Conclusions and recommendations

Without exception, all countries monitored in this report showed an improvement in average fuel economy in 2015 compared with 2005. Nevertheless, the improvement at the global level slowed over the decade, from 1.8% in 2005-08 to 1.2% in 2012-15, and 1.1% in 2014-15. This is the result of two main counteracting effects:

- The OECD countries saw their annual improvement rate drop to only 1.0% between 2012 and 2015. Annual improvement rates were seen to decline especially in the past few years (0.8% between 2013 and 2014, and 0.5% between 2014 and 2015).
- Fuel economy improvement accelerated in the non-OECD countries over the same period, reaching 1.4% per year, on average, between 2012 and 2015.

This resulted in a major change in comparison with the first part of the last decade. Since 2014, the non-OECD countries have achieved faster fuel economy improvements than the OECD countries.

The reduction in fuel use per km taking place overall was significantly lower than the rate of improvement required to meet the 2030 GFEI target.

However, country-level results, and in particular the successes being achieved in the European Union and China, show that stronger action on the combined adoption of fuel economy policies (including regulatory instruments, such as fuel economy standards, and fiscal incentives, such as vehicle taxes differentiated on the basis of the emissions of CO_2 per km) can deliver effective fuel economy improvements. This is especially important in a time period characterised by a slowdown in fuel economy improvements in the OECD countries.

The price analysis suggests that achieving fuel economy improvements may come at a lower cost for consumers if efforts are focused on larger vehicle segments and power classes, even after accounting for the upward impact of fuel-saving technologies on vehicle prices. Policies should therefore include provisions requiring greater relative fuel economy improvements in these classes, especially in the non-OECD: this would generate opportunities to deploy fuel saving technologies in the most energy intensive portion of the vehicle market (larger segments tend to have engines with high power and displacement, and are, by definition, vehicles with greater weights and larger footprints, and therefore higher fuel use per km) and would also have positive consequences on the limitation of market shifts towards larger vehicles.

Continuing to monitor the evolution of international fuel economy is essential for assessing the effectiveness of actions aimed at improving fuel economy that are implemented by individual countries, and the impacts these actions have collectively on global fuel consumption.

Policy actions that are measured solely against test results will not close the gap between test and real-world driving results. Achieving greater accuracy and representativeness of fuel economy and real-world consumption will require the use of on-road tests, similar to the RDE test procedure for air pollutants, and the introduction of in-use conformity tests of randomly selected production vehicles.

Country reports

Australia

Country spotlight

Population (million) (World Bank, 2016a):	23.7
Urban population (% of total) (World Bank, 2016b):	89%
GDP per capita (2014 USD/year) (World Bank, 2016c):	56 300
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015):	123; 128

Fuel tax class (2014) (GIZ, 2015): taxed petroleum fuels

In 2015, about 1.1 million LDVs were sold in Australia (IHS Markit, 2016). The LDV stock totalled 16.3 million vehicles (IEA, 2016b). LDV ownership was close to 0.7 vehicles per capita, among the highest globally.

To date, Australia is one of the few OECD countries without mandatory fuel economy standards, although various voluntary standards have been in place since 1978 (UNEP, 2016). The latest voluntary standard dates from 2005, when the Federal Chamber of Automotive Industry set a target of approximately 222 g CO_2/km (New European Driving Cycle [NEDC]) for all light-vehicles below 3.5 tonnes sold from 2010. However, the government is currently working on developing a corporate-average CO_2-based standard for LDVs and a pollutants emission standard for HDVs (DIRD, 2016).

Australia does not have tax schemes favouring energy efficiency. It publishes a Green Vehicle Guide, rating LDVs for environmental performance and fuel consumption (GreenVehicleGuide, 2016).

Market profile and vehicle characteristics

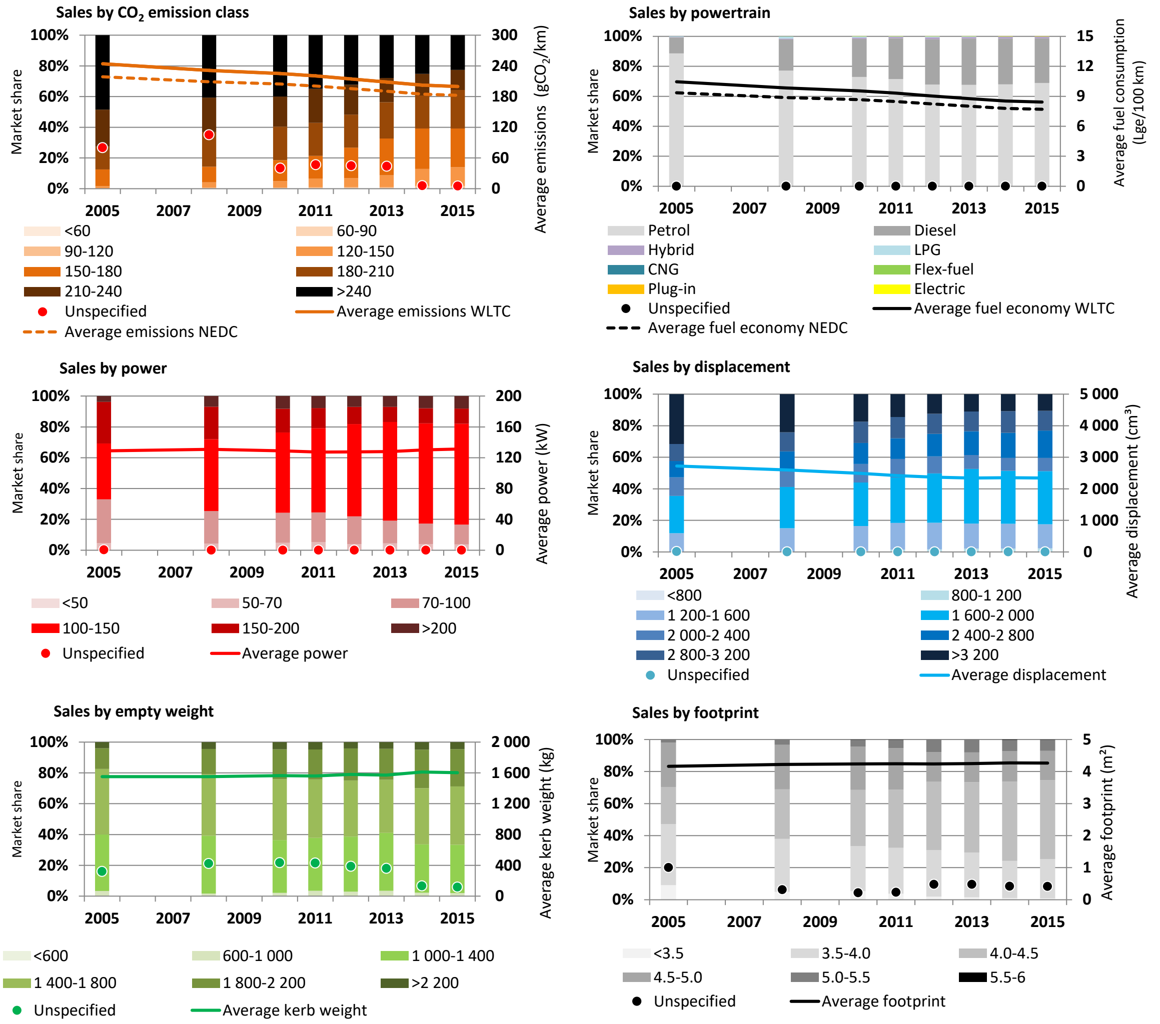
Australia has among the lowest population densities in the world, which is consistent with its high vehicle ownership of 0.7 vehicles per capita. The number of newly registered LDVs has been relatively stable since 2012. Australia has only a limited amount of vehicle production within its own borders: approximately 170 000 vehicles in 2015, covering around 15% of the Australian LDV market (OICA, 2016). The most popular brands are Toyota, Mazda and Holden, accounting for 40% of Australian LDV sales in 2015.

Australia's LDV market is dominated by large vehicles, similar to Canada and the United States. Unlike these countries, Australia has not yet implemented mandatory fuel economy standards. Nevertheless, Australia's average CO_2 emissions per km experienced a steady decline between 2005 and 2015. The market share of vehicles emitting more than 210 g CO_2/km approximately halved in the last ten years, while the market share of LDVs in the 120-150 g CO_2 per km category tripled in the same period. The average fuel economy improved, reaching 8.4 Lge/100 km in 2015, around 7% below the United States. Gasoline vehicles had a 60% market share. Diesels represent almost 30% of all LDV sales.

Average engine power did not change between 2010 and 2013, but increased from 128 kW to 131 kW between 2013 and 2015. Overall, LDVs with a power range between 100 kW and 150 kW gained market share against other power classes. Average displacement fell by almost 15% between 2005 and 2015, but hardly any change took place between 2013 and 2015.

The weight of new LDVs slowly increased between 2008 and 2014, followed by a small decrease back to 1 600 kg between 2014 and 2015. Also, the footprint rose between 2005 and 2015, with a slowdown between 2013 and 2015.

Figure 29 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, Australia, 2005-15

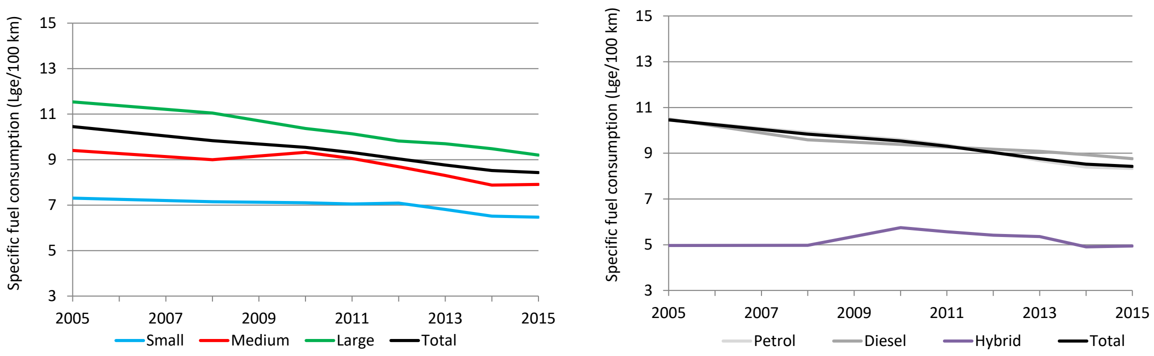


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Analysis of fuel economy trends

The left-hand side of Figure 30 shows different trends for the three size segments. Large vehicles experienced continuous improvements in fuel economy during the ten-year period between 2005 and 2015. Medium-sized vehicles saw their average fuel economy worsen between 2008 and 2010, improve again between 2010 and 2014 and stagnate between 2014 and 2015. The fuel economy of small vehicles improved only modestly until 2012 and in 2015.

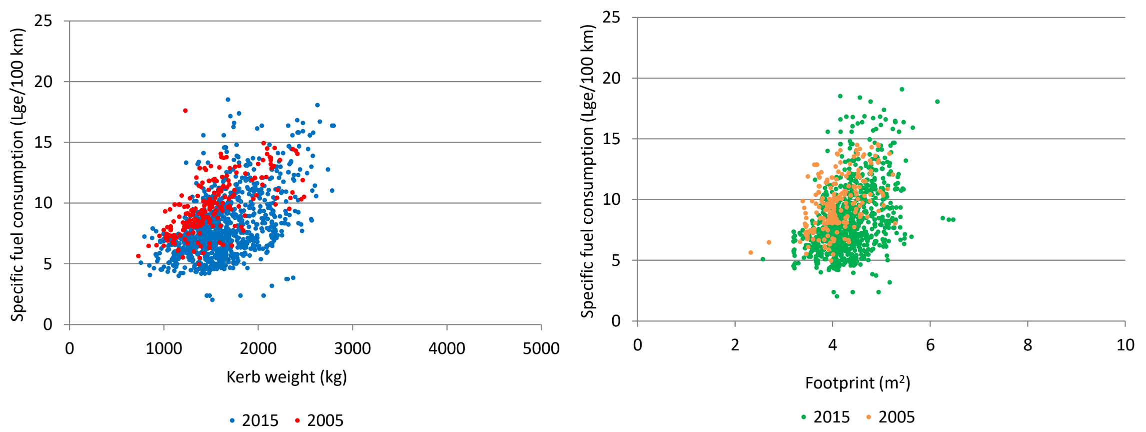
Figure 30 ● Average new LDV fuel consumption per km by vehicle segment and powertrain, Australia, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

The average fuel economy of diesels fluctuated around that of gasoline and exceeded the fuel consumption per km of gasoline vehicles after 2012. This consistent with the large share of diesels (80%) sold in the large vehicle segment. The small market size of hybrids largely explains their fluctuating fuel economy development.

Figure 31 ● Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, Australia, 2005 and 2015

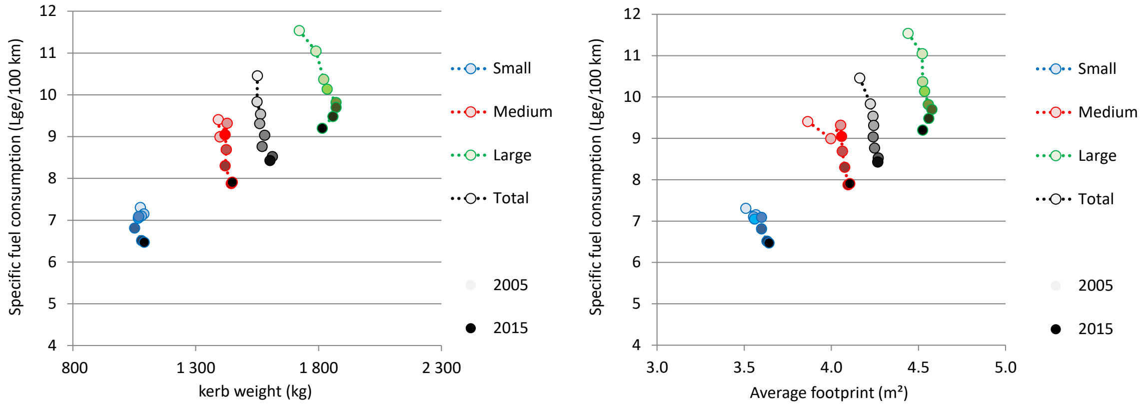


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

The plots comparing average fuel economy with weight and footprint (Figure 31) show movement towards improved fuel economy under similar weight and slightly increasing footprint between 2005 and 2015. Also, the number of unique models sold increased substantially, accompanied with a larger spread.

Fuel economy improvements that occurred between 2011 and 2015 were coupled with fairly constant average vehicle weight and footprint in almost all market classes (the sole exception being an increase in footprint for LDVs in the medium segment) (Figure 32). Fuel economy improvements were lowest for small vehicles and greatest for the vehicles in the high weight and large footprint segments. The development of average footprint shows that the average footprint of small vehicles grew, while that of large vehicles shrank between 2012 and 2015.

Figure 32 • Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, Australia, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Brazil

Country spotlight

Population (million) (World Bank, 2016a):	207.8
Urban population (% of total) (World Bank, 2016b):	86%
GDP per capita (2014 USD/year) (World Bank, 2016c):	8 500
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015):	127; 102

Fuel tax class (2014) (GIZ, 2015): taxed petroleum fuels

In 2015, approximately 2.5 million LDVs were sold in Brazil (IHS Markit, 2016). This represents a decline against the previous two years, but was sufficient to maintain Brazil as the largest market in South America. The LDV stock totalled 38.6 million registered vehicles (IEA, 2016b). LDV ownership was 0.18 vehicles per capita, similar to other countries in the region.

In 2012, the Brazilian government introduced the "Inovar-Auto" programme to foster the adoption of more efficient vehicles through fiscal incentives. Manufacturers and importers meeting a fuel economy target benefit from a tax reduction on industrial products of up to 30%. This effectively offsets the 30% tax rate that was established before the introduction of the fuel economy regulation (TransportPolicy, 2016).

A voluntary label informing consumers about the fuel economy performance of vehicle models was introduced in 2007 (ICCT, 2014c). The “Inova Energia” programme also provided grants and loans to stimulate innovation in energy efficiency, including in transport (IEA, 2016c).

Biofuels have been promoted by the Brazilian government since 1975. In 2014, biofuels accounted for 19% of total road transport fuel use in (IEA, 2016a).

Market profile and vehicle characteristics

In 2015, 2.5 million new vehicles were registered in Brazil, which was a drop of more than 25% compared with 2014 (IHS Markit, 2016). Nevertheless, Brazil is still the largest LDV market in Latin America and is the seventh largest LDV market worldwide. In the same year, Brazil produced more than 2.3 million LDVs, making it the world’s ninth-largest producer (OICA, 2016). Most vehicles sold are produced by foreign OEMs; Fiat, Chevrolet and Volkswagen represented almost 50% of the Brazilian LDV market in 2015.

Between 2014 and 2015, a steep decline was observed in CO_2 emissions per km, from around 190 g CO_2/km to 130 g CO_2/km, while CO_2 emissions were stable between 2005 and 2013. The downward trend is coherent with growth in the market share of vehicles having specific emissions of 120-150 g CO_2/km and a 75% decrease in the market share of vehicles with specific emissions of 210-240 g CO_2/km over the last five years.

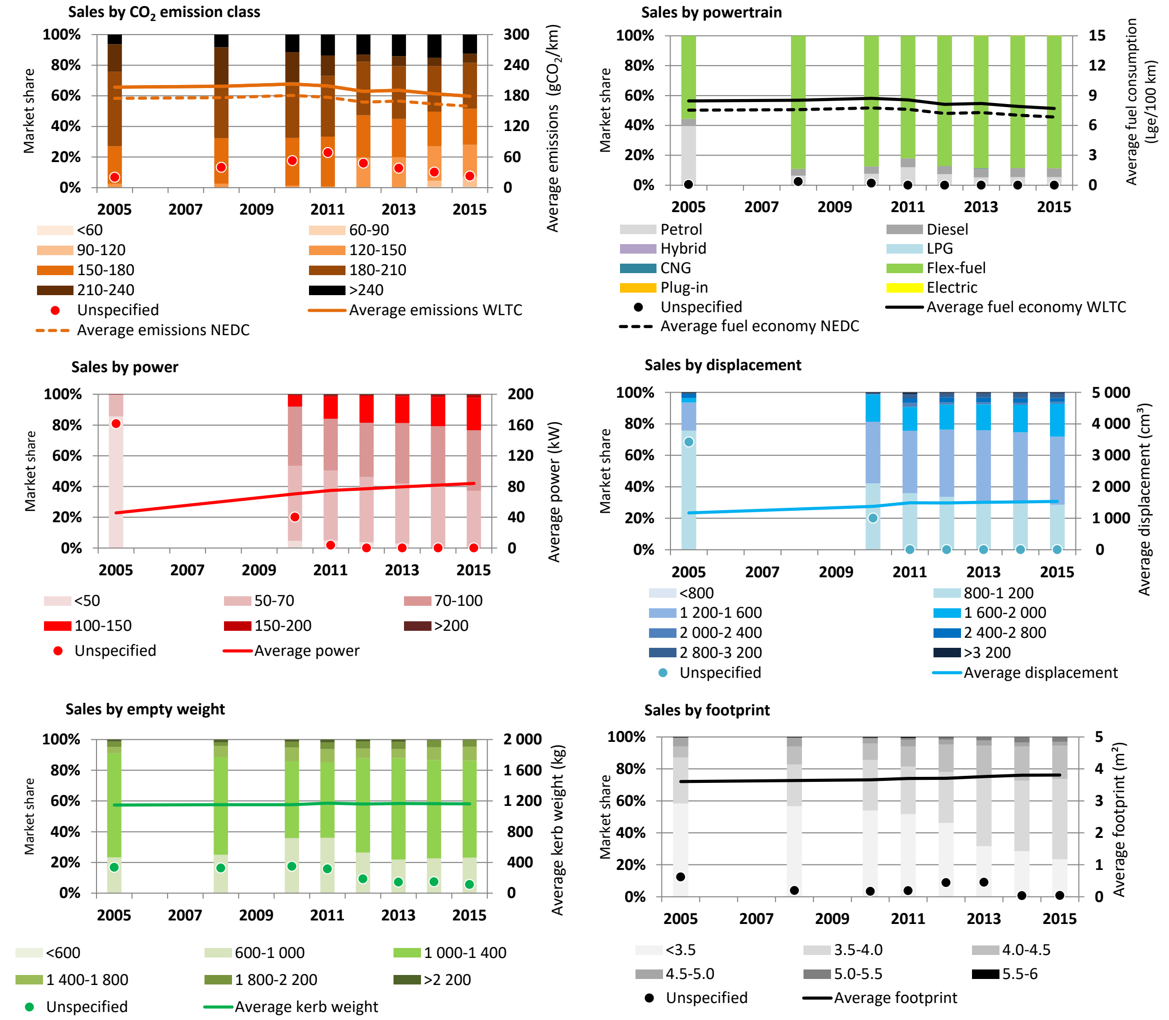
Average fuel economy improved to 7.7 Lge/100 km in 2015, down one percentage point from 2014. Brazil’s average fuel economy was still slightly higher than the global average fuel economy of 7.6 Lge/100 km.

Due to the National Alcohol Programme (Proàlcool, created in 1975 and enabling the production of ethanol for use as transport fuel from sugarcane), gasoline blended with anhydrous ethanol (with shares between 18% and 27%) is widely available in Brazil. Many vehicles have been produced to allow for blending of hydrous ethanol (also available as transport fuel) in any ratio. Flex-fuel vehicles (i.e. vehicles which are able to use variable shares of gasoline and ethanol) already reached a market share of more than 50% in 2005 (Figure 33, top right). By 2013, their share increased to almost 90%, thanks to almost universal availability across vehicle models. This share remained steady in the subsequent two years.

Between 2013 and 2015, average engine power steadily increased from 80 kW to 84 kW. This was mainly the result of increased sales in the 100-150 kW segment. Overall, the engine power of vehicles sold in Brazil was similar to that of Argentina, but more than 10% lower than for Chile and Mexico.

Engine displacement went down by 3% between 2013 and 2015. This indicates that more power is being generated per litre. The average weight of LDVs declined over these three years and the majority of LDVs weighed between 1 000 kg and 1 400 kg. The average footprint remained relatively unchanged, but between 2013 and 2015 the share of newly registered vehicles with a footprint of less than 3.5 m^2 fell, which led to a small increase towards 4 m^2.

Figure 33 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, Brazil, 2005-15

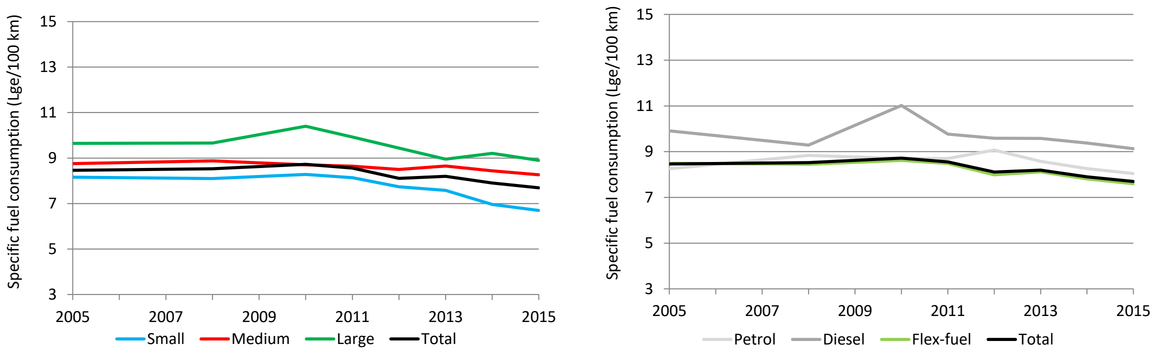


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Analysis of fuel economy trends

Between 2010 and 2015, Brazil's sales-weighted average fuel economy improved slightly, reaching 7.7 Lge/100 km in 2015 (Figure 34). The fuel economy trend within the large vehicle segment fluctuated significantly over the same period, while newly registered small LDVs experienced a stable decline in specific fuel consumption to less than 7.0 Lge/100 km. Diesel LDVs experienced a steep improvement in average fuel economy between 2012 and 2014, reaching similar fuel economy levels in 2015 as those observed in 2008. Diesel LDVs had higher specific fuel consumption compared with gasoline LDVs, due to the fact that diesels are almost exclusively sold in the large segment, a pattern also observed in other emerging economies.

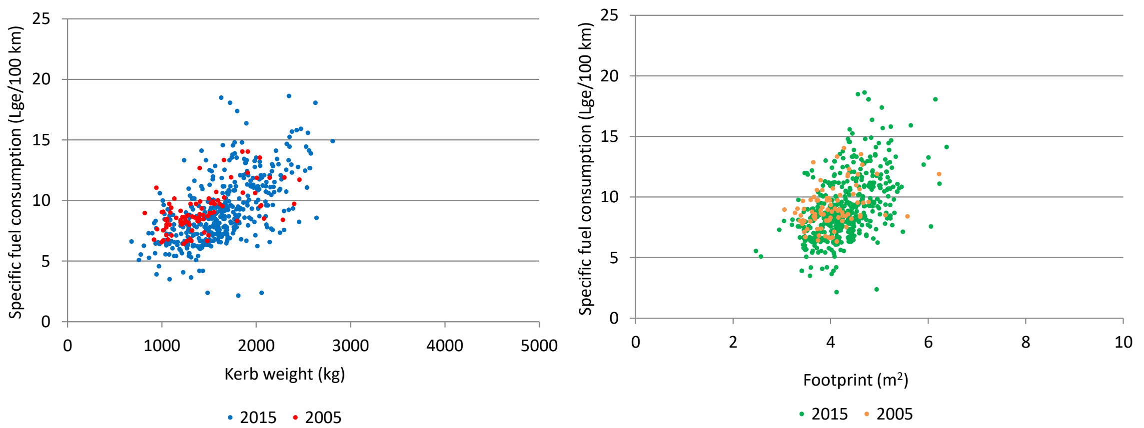
Figure 34 • Average new LDV fuel consumption per km by vehicle segment and powertrain, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

On the metrics of vehicle weight and average fuel economy, the range of variability in new models increased in 2015 as compared with 2005 (Figure 35, left). Overall, a small shift to the right implies that new LDVs increased in weight, but overall were slightly more fuel efficient. The right-hand side of Figure 35 similarly shows more variability in the footprint of models sold in 2015 compared with 2005; however, the average fuel economy remained relatively stable.

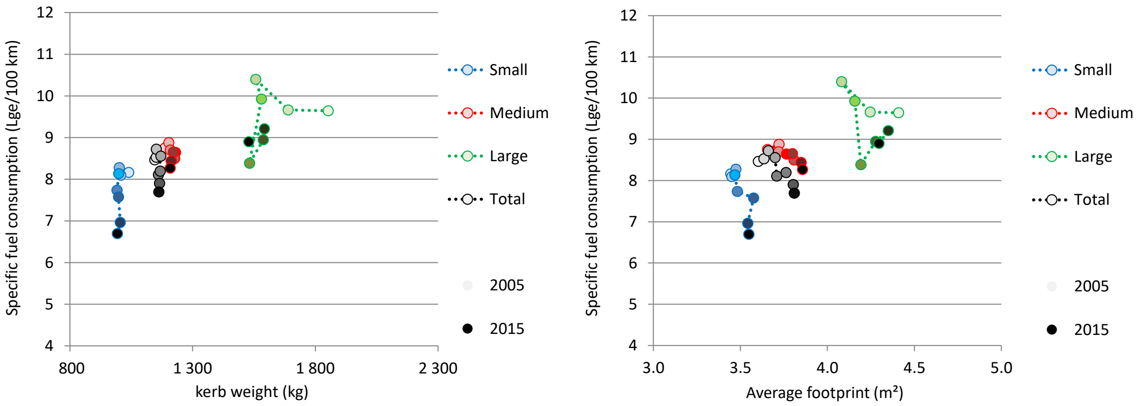
Figure 35 • Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, Brazil, 2005 and 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Large cars became lighter and more efficient between 2005 and 2012 (Figure 36), followed by fluctuations in fuel economy despite a steady average weight. Newly registered vehicles in other size classes had stable average weight and improving fuel economy in recent years. Total average fuel economy was mostly driven by trends in small and medium LDVs. A similar trend holds for vehicle footprints (Figure 36). The fuel economy improvement in the small and medium vehicle segment in the past few years suggests that the LDV regulations adopted in 2012 have primarily affected small and medium LDVs.

Figure 36 ● Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, Brazil, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Chile

Country spotlight

Population (million) (World Bank, 2016a): 17.9

Urban population (% of total) (World Bank, 2016b): 90%

GDP per capita (2014 USD/year) (World Bank, 2016c): 13 400

Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015): 152; 109

Fuel tax class (2014) (GIZ, 2015): highly taxed petroleum fuels (gasoline)

In 2015, around 280 000 LDVs were sold in Chile (IHS Markit, 2016). In the same year the LDV stock totalled about 2.9 million, with LDV ownership of 0.16 per capita (IEA, 2016a).

Since 2012, vehicle labels providing information to consumers on fuel economy and pollutant emissions became mandatory (Lopez, 2014). In 2014, the Chilean Congress also approved tax reform introducing progressive fees on vehicles for which specific fuel consumption and pollutant emissions surpass a certain threshold (GFEI, 2015; Lopez, 2014). As a result, diesel vehicles with high nitrogen oxide (NO_X) emissions are subject to higher tax. Furthermore, Chile has banned the import of used vehicles, preventing inefficient vehicles from entering the Chilean LDV market (UNEP, 2015).

Market profile and vehicle characteristics

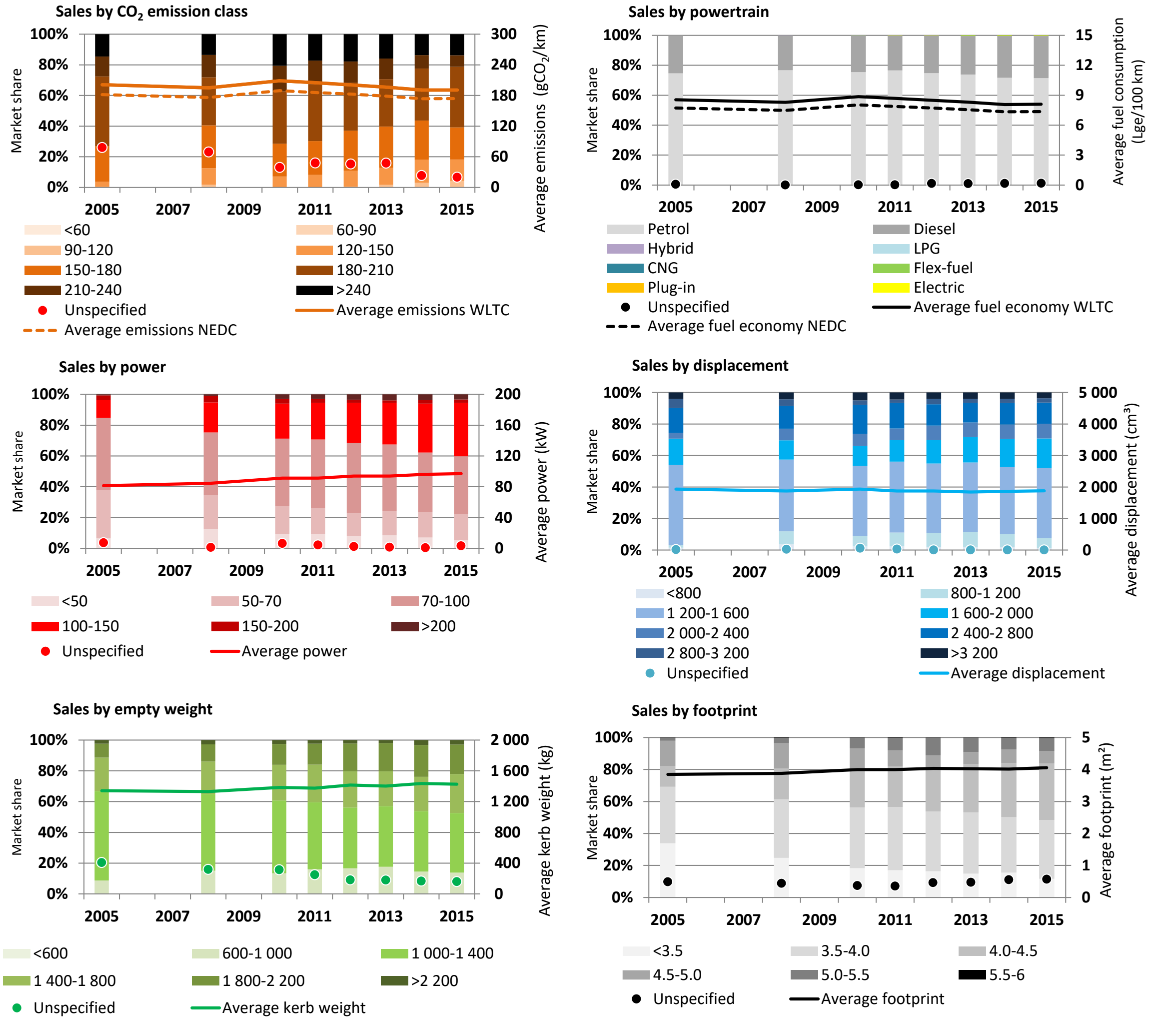
In 2015, just over 280 000 new LDVs were registered in Chile (IHS Markit, 2016). This represented a further fall in LDV sales since 2013, when sales totalled almost 380 000 LDVs. Chile has no domestic LDV production, but exports vehicle parts. The Chilean car market is dominated by Korean, Japanese and North American OEMs.

CO_2 emissions per kilometre decreased from 200 g CO_2/km to 190 g CO_2/km between 2013 and 2015. Sales of vehicles in the heaviest emission class (>240 g CO_2/km) declined significantly, while the market share of vehicles emitting 120-150 g CO_2/km increased in 2014. Between 2013 and 2015, the average fuel economy improved from 8.3 Lge/100 km to 8.1 Lge/100 km, 10% above the global average and 30% above the United Kingdom, the European country with average power, weight and footprint characteristics that are closest to Chile.

The market share of LDVs powered by diesel fuel grew from around 25% in 2013 to 30% in 2015 in Chile. This is consistent with the tax advantage given in 2015 to vehicles with a better fuel consumption/km (Lopez, 2014 and ICAP, 2016) and suggests that this outweighed the component of the same tax based on NO_x emissions/km.

The average power of new LDVs continues to increase and reached almost 100 kW in 2015. This is similar to power ratings in South Africa and the United Kingdom. Average engine displacement decreased until 2013, but rose again between 2013 and 2015 towards 1.9 L. Newly registered LDVs were around 2% heavier in 2015 compared with 2013, but had almost the same weight as in 2014. The average footprint of Chilean LDV registrations gradually increased from 3.8 m^2 in 2005 to 4.1 m^2 in 2015.

Figure 37 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, Chile, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

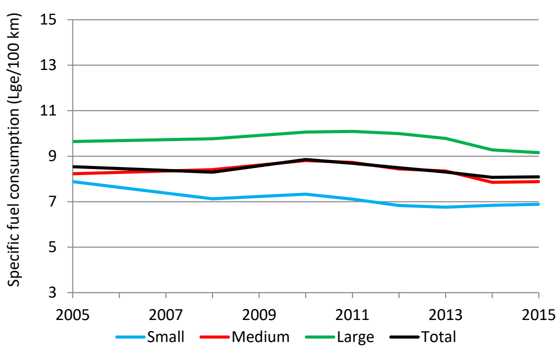
Analysis of fuel economy trends

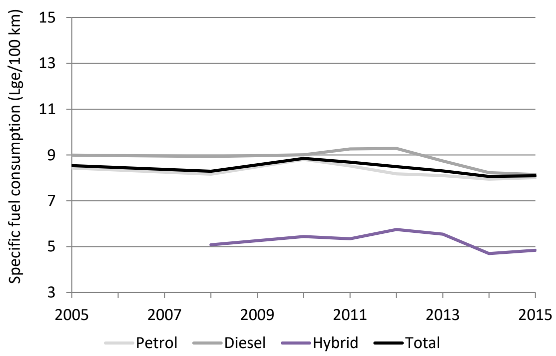
Improving average fuel economy began in 2010, but slowed in 2014 and levelled off in 2015 (Figure 38). In the small vehicle segment, specific fuel consumption has been rising since 2012. Moreover, the fuel economy of vehicles in the small and medium segments did not significantly improve between 2014 and 2015. On the other hand, the average fuel use per km of large vehicles declined between 2011 and 2015, slowing in the last year. Diesels had almost the same specific fuel consumption in 2015 as in 2013, as did gasoline powertrains. Hybrids remained about 35% more efficient than the average of all LDV sales.

The market saw a modest movement towards heavier, larger and more fuel-efficient vehicles between 2005 and 2015 (Figure 39). As in the case of Brazil, the wider vertical distribution of points on both plots shows that the distribution of both weight and footprint widened over the past decade.

Figure 40 suggests a clear tendency towards smaller and lighter vehicles in the small vehicle segment. Buyers of small vehicles may have paid more attention to the fuel economy label than those of medium-sized and large cars, possibly due to higher sensitivity to fuel costs (e.g. stricter budget constraints in the case of buyers of small cars). The fuel economy of medium vehicles improved, while the average weight of large LDVs increased in parallel of an increasing fuel use per km until 2013, thereafter experiencing a trend reversal in 2014 and 2015. Footprint evolved in a similar fashion to weight, except for small vehicles. This segment experienced only minor changes in footprint between 2010 and 2015.

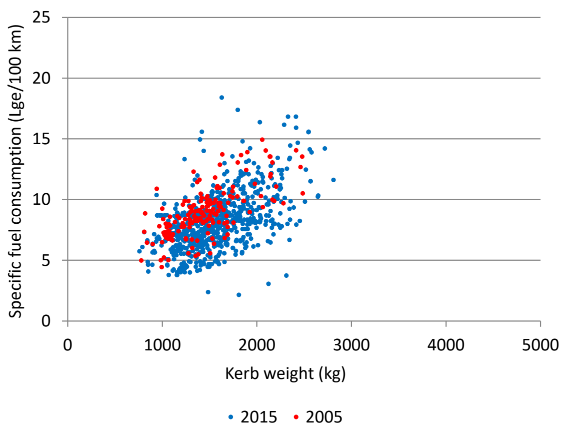
Figure 38 ● Average new LDV fuel consumption per km by vehicle segment and powertrain, Chile, 2005-15

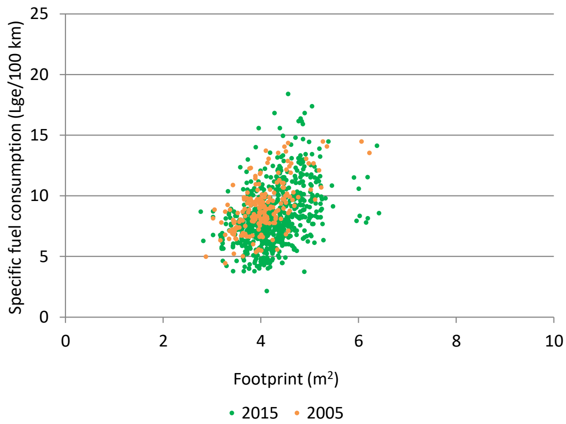




Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

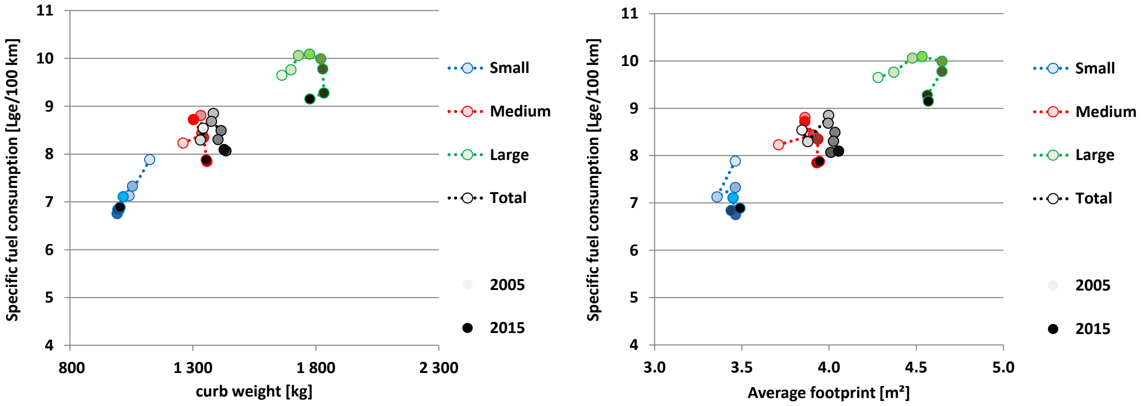
Figure 39 ● Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, Chile, 2005 and 2015





Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Figure 40 • Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, Chile, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

China

Country spotlight

Population (million) (World Bank, 2016a):	1 371
Urban population (% of total) (World Bank, 2016b):	56%
GDP per capita (2014 USD/year) (World Bank, 2016c):	8 000
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015):	117; 109

Fuel tax class (2014) (GIZ, 2015): taxed petroleum fuels

In 2015, more than 22 million LDVs were sold in China (IHS Markit, 2016), consolidating its status as the world's largest car market. China's on-road LDV stock reached about 142 million cars in the same year, and China's LDV ownership averaged 0.10 LDVs per capita (IEA, 2016a). Fuel economy regulations for passenger cars were first introduced in 2005. During Phases I and II individual models were required to meet specific thresholds, which were differentiated on the basis of vehicle weight. Corporate average fuel consumption (CAFC) targets were established with the introduction of Phase III (2012-15). Phase IV, which took effect on 1 January 2016, targets a new sales fleet average specific fuel consumption of 5 Lge/100 km (based on the NEDC; this would correspond to 5.6 Lge/100 km using the WLTC) by 2020 if all manufacturers are able to meet their specific CAFC targets (TransportPolicy, 2016). Flexibility schemes allow for highly efficient cars (battery electric vehicle [BEV]/plug-in hybrid electric vehicle [PHEV]) to be counted multiple times per vehicle when calculating the CAFC values. LCVs are subject to standards that differ both by target value and compliance structure; individual LCV models are still subject to fuel consumption targets (TransportPolicy, 2016). Labels showing fuel economy, fuel type, rated power and empty weight, among other information, were made mandatory for passenger cars in 2009 (ICCT, 2014c).

Market profile and vehicle characteristics

China is the largest LDV market in the world. In 2015, LDV sales grew by almost 8% on a yearly basis to 22 million vehicles. In the same year, China produced 22.9 million LDVs, which also makes it the world's largest LDV producer (OICA, 2016). More than half of the LDVs sold come from joint ventures with foreign car manufacturers, such as FAW-Volkswagen, Hyundai-Beijing, Shanghai-General Motors, etc.

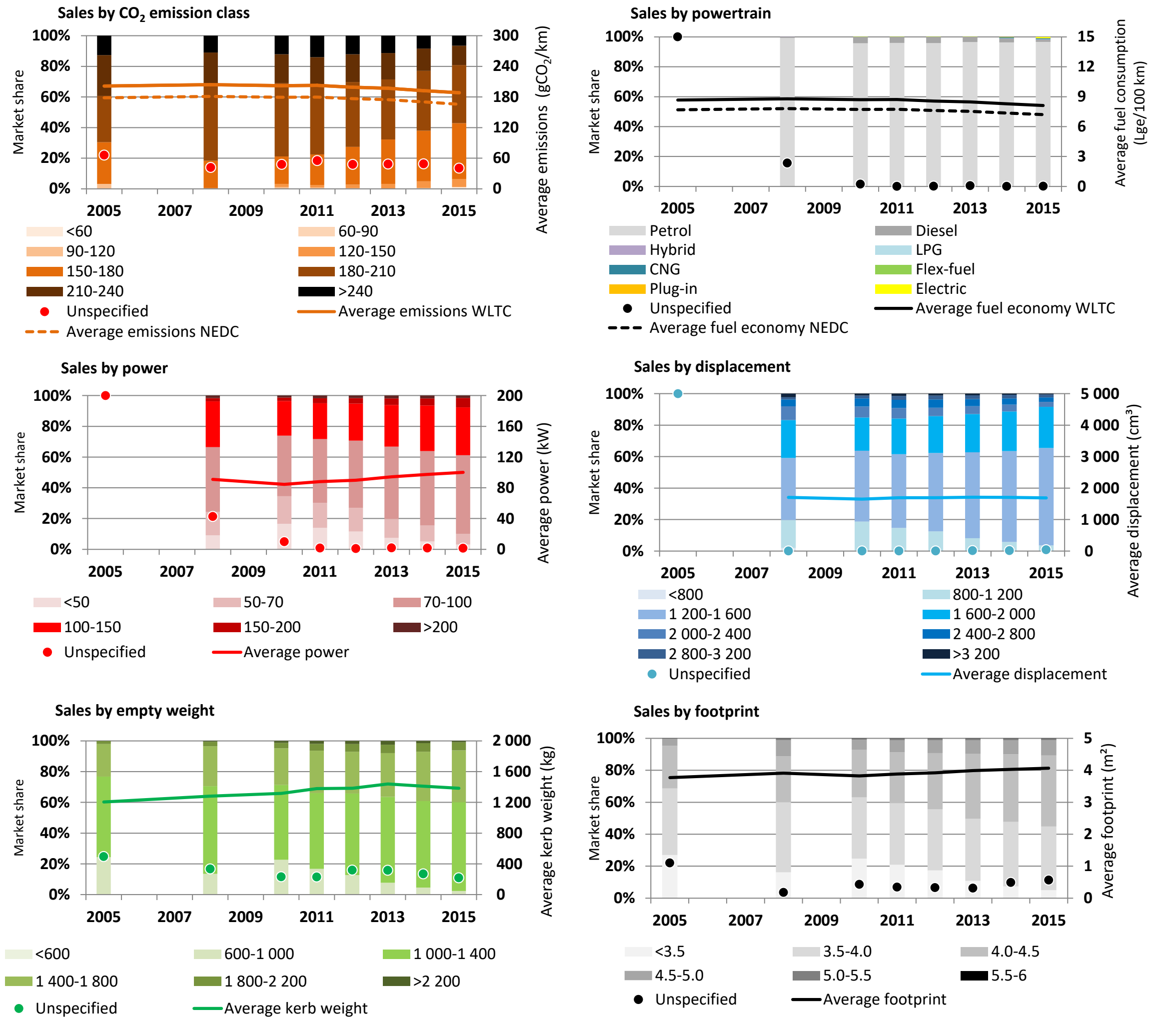
The average specific CO_2 emissions of Chinese new vehicle sales have been decreasing steadily since 2010. Between 2010 and 2015, sales shares of newly registered LDVs that emit more than 210 g CO_2/km shrank and vehicles with slightly better emissions per km, in the 150-180 g CO_2/km range, saw rapidly growing market shares. The average fuel economy of new Chinese LDVs gradually improved from 8.5 Lge/100 km in 2013 to 8.1 Lge/100 km in 2015, which is 10% higher than the worldwide average.

In 2015, gasoline engines dominated the Chinese market, representing almost 95% of new LDV registrations. Record sales of electric vehicles resulted in a 1% market share in 2015.

Engine power has grown steadily since 2010, but a slowdown was noticed between 2013 and 2015. Nevertheless, the average engine power of newly registered vehicles has surpassed 100 kW in 2015, similar to Germany. Vehicles with a power rating in the 100-150 kW range experienced the largest growth in market share. Between 2013 and 2015, engine displacement was almost static. The Chinese LDV market shares of vehicles with the smallest and largest engines have been decreasing until 2015, leading to reduced variability in engine size.

During the period 2013-15, the average weight of newly registered vehicles decreased by almost 4%. This trend is the reverse of that observed for 2005-13. The evolution of the average footprint of newly registered LDVs went in the opposite direction: it grew by 6% between 2010 and 2015. New registrations of LDVs of less than 3.5 m^2 dropped by 80%, showing clear signals that Chinese car buyers prefer larger vehicles as higher incomes allow.

Figure 41 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, China, 2005-15

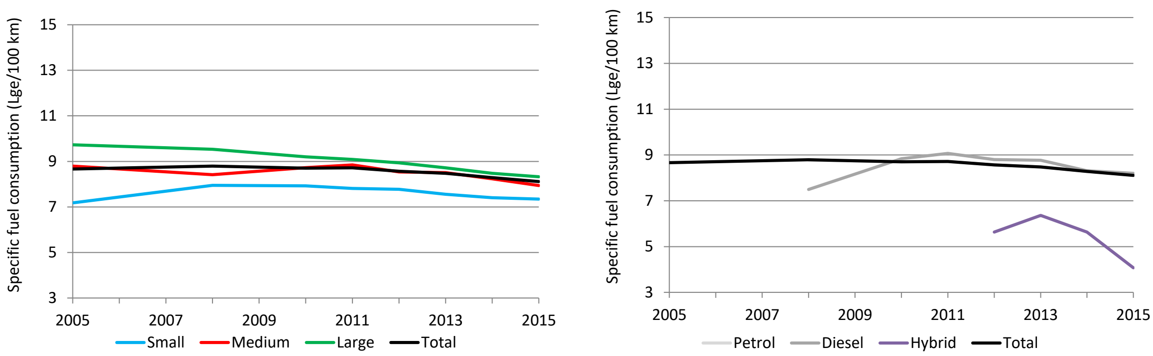


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Analysis of fuel economy trends

Specific fuel consumption first grew from 2005-2008, then declined thereafter to 2015 (Figure 42). The gap between the fuel economy of medium and large LDVs narrowed between 2010 and 2015 compared with earlier years. Between 2013 and 2015, the average fuel economy of small LDVs improved at a slower rate than in previous years. The average fuel economy of conventionally-powered LDVs was very similar across the different powertrains. The years after 2013 show a steep improving trend in hybrid fuel economy.

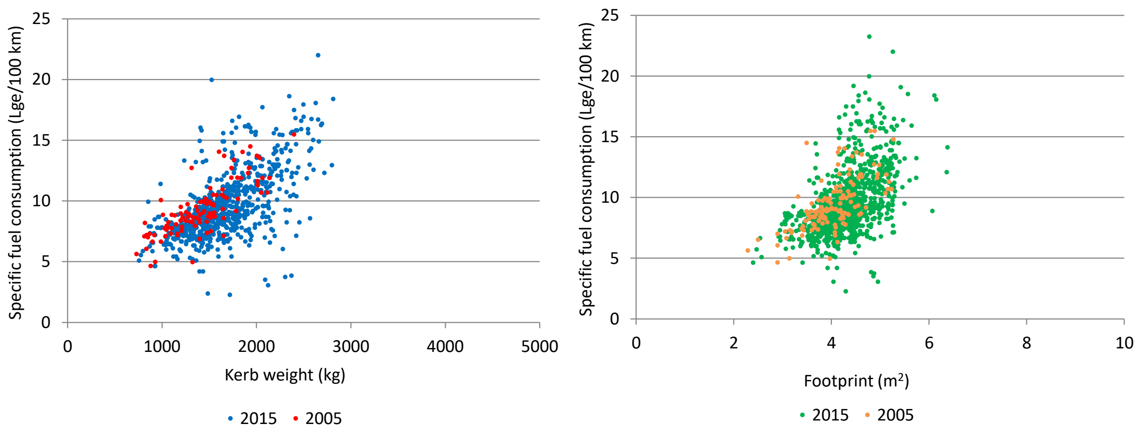
Figure 42 • Average new LDV fuel consumption per km by vehicle segment and powertrain, China, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

The availability of models increased in 2015 compared to 2005 and 2013 (IEA, 2016a), spreading out across the weight and footprint spectrum, with a much wider range of models offered in 2014 and 2015 having better fuel economy than in 2013.

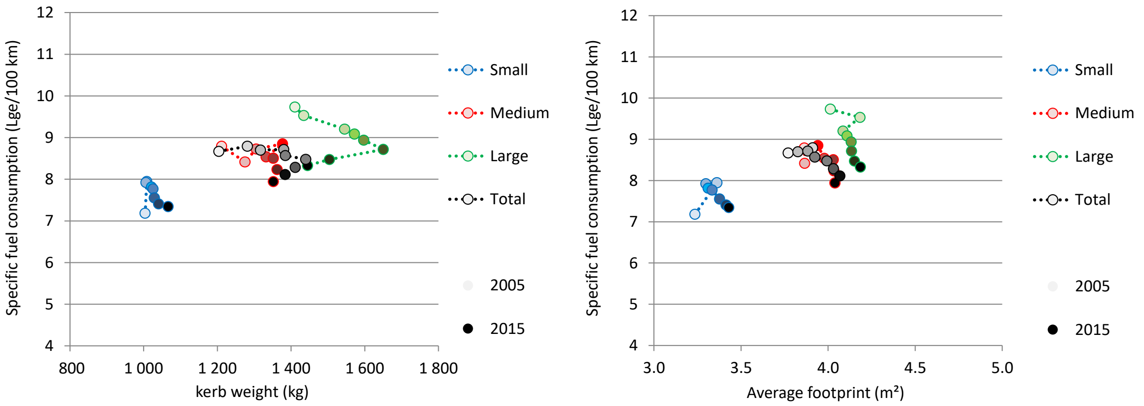
Figure 43 • Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, China, 2005 and 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Comparing average weight with average fuel economy, the large segment showed the most erratic trends from year to year (Figure 44). After steady weight growth between 2008 and 2012, the average weight of new large LDVs fell by almost 15% in just two years. This is consistent with the tightening of compliance of fuel economy standards that occurred in 2015. The average weight of small and medium LDVs has increased from 2005-2015, but the weight increase of medium vehicles stopped in the last years, and their fuel economy has begun to improve. Footprint showed similar developments to weight, but with less volatility.

Figure 44 • Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, China, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

France

Country spotlight

Population (million) (World Bank, 2016a):	66.8
Urban population (% of total) (World Bank, 2016b):	80%
GDP per capita (2014 USD/year) (World Bank, 2016c):	36 200
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015):	179; 163

Fuel tax class (2014) (GIZ, 2015): highly taxed petroleum fuels

In 2015, almost 2.3 million LDVs were sold in France (IHS Markit, 2016). The on-road vehicle stock amounted to about 30 million cars (IEA, 2016a), and LDV ownership averaged 0.45 LDVs per capita. Voluntary CO_2 emission standards were first introduced in the European Union in 1998, and they became mandatory in 2009. The 2015 target of 130 g CO_2/km for passenger cars was met ahead of schedule in the case of France (EEA, 2016). By 2021, average passenger car CO_2 emissions are required to reach 95 g CO_2/km (based on NEDC). LCVs are required to attain 147 g CO_2/km (based on NEDC) (TransportPolicy, 2016). In addition to the EU emission standards, France introduced a feebate scheme in 2008 (revised on a regular basis in the following years) that redistributes revenues from taxation on vehicles with high specific fuel consumption to vehicles with superior performance. In its latest update, fees can reach up to EUR 8 000, while rebates can be as high as EUR 6 000 per vehicle (MEEM, 2016). A label that displays specific fuel consumption, CO_2 emissions and efficiency class was made mandatory in France in 2006 (MEEM, 2012).

Market profile and vehicle characteristics

France produced almost 2 million cars in 2015, placing it as the third-largest LDV producer in the European Union since 2014. The production was dominated by French manufacturers PSA (Peugeot and Citroën) and Renault-Nissan (OICA, 2016).

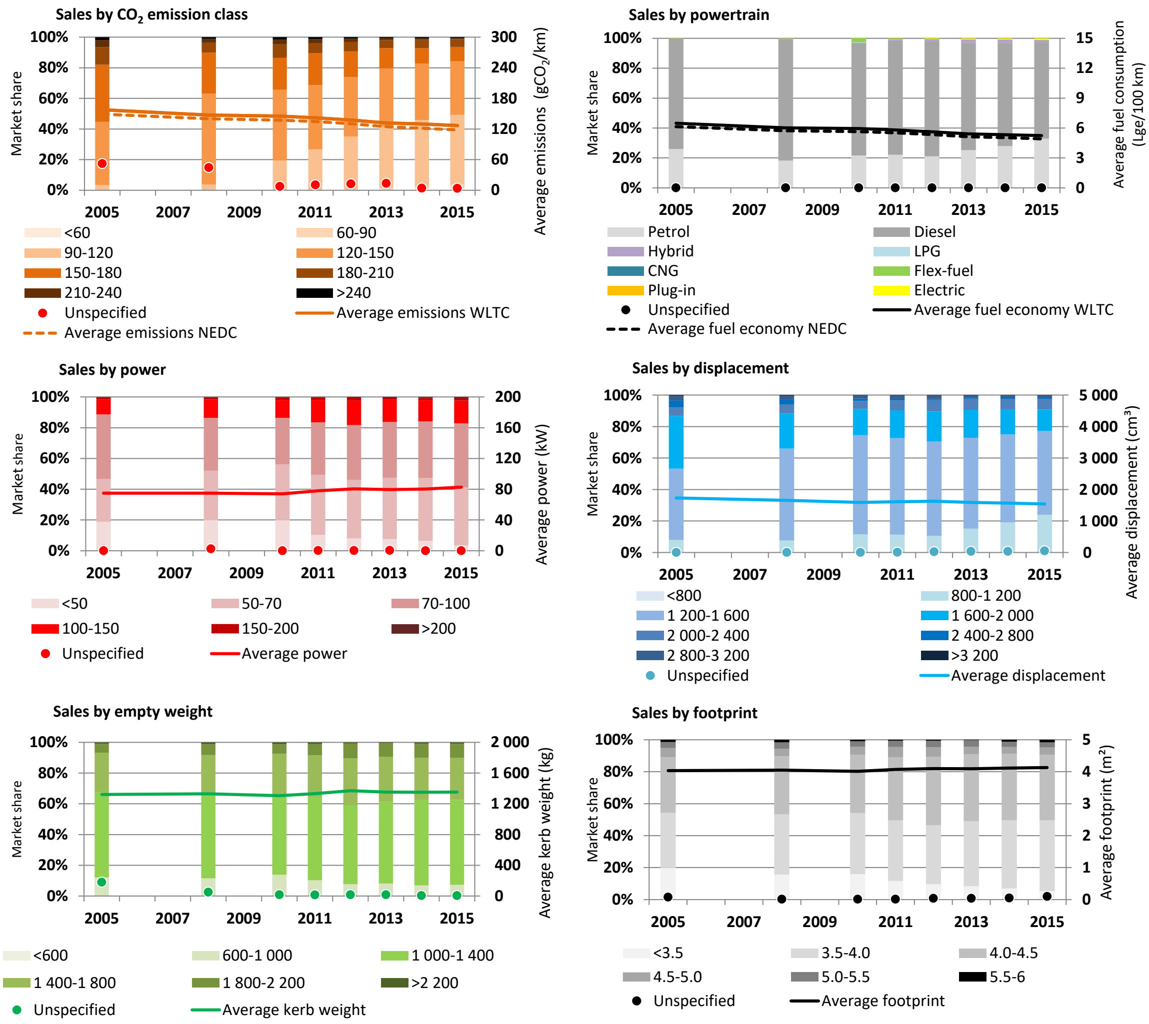
Average per kilometre CO_2 emissions have continuously declined in France since 2005. After an acceleration in improvement between 2010 and 2013, specific CO_2 emissions declined at a slower pace between 2013 and 2015. In 2015, average CO_2 emissions of newly registered LDVs were 120 g CO_2/km. The 90-120 g CO_2/km segment represented almost 50% of sales in 2015, while the market share of high-emission segments has shrunk. Average fuel economy of new LDVs steadily progressed, attaining 5.3 Lge/100 km in 2014 and 5.2 Lge/100 km in 2015.

Diesels have continued to lose market share from 2013, declining from 72%% to 65% market share in 2015, while gasoline LDVs represent 32% of the market. More advanced powertrains gained market shares too, although they did not exceed 3% of the LDV market in 2015. Electric vehicles reached a 1% market share in 2015.

Over the past three years, average power rose modestly from 80 kW in 2013 to 83 kW in 2015. Newly registered French LDVs were almost 20% less powerful than their German or British counterparts, yet similar to Italian ones. After a slight increase between 2010 and 2012, average engine displacement declined to 1.5 L in 2015. The market share of vehicles with 0.8-1.2 L engines saw the most growth, while the market share of vehicles with 1.6-2.0 L engines has declined.

Between 2013 and 2015, the average weight of new LDVs fluctuated around 1 350 kg with no clear change in the market share of weight classes. The average footprint of newly registered vehicles grew slightly from 2010 onward. In 2015, the average footprint in France was a little more than 4.1 m^2, equal to the global average. Vehicles with a footprint of less than 3.5 m^2 almost disappeared, conforming to a trend of diminishing sales of small vehicles across OECD countries, but the average footprint across the past decade remained nearly the same (Figure 48).

Figure 45 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, France, 2005-15

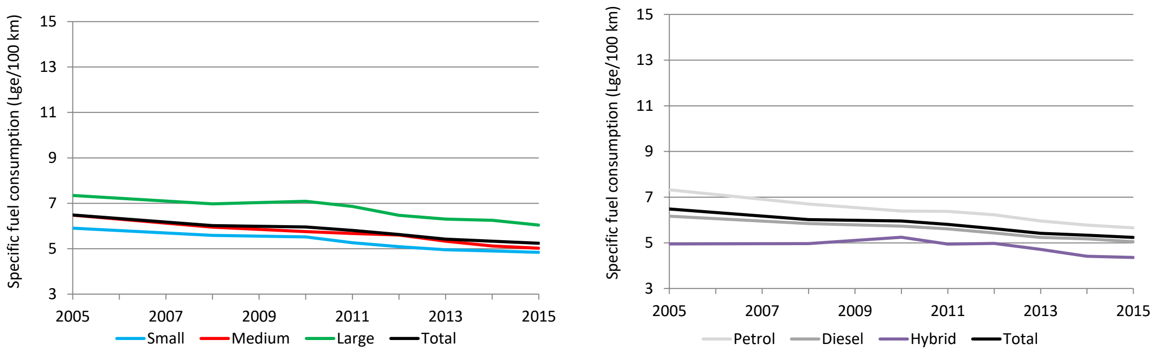


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Analysis of fuel economy trends

The average fuel economy of newly registered small and medium LDVs converged between 2012 and 2015 (Figure 46). The average specific fuel consumption of large vehicles improved after 2010, reaching 6 Lge/100 km in 2015. This efficiency level is equal to total average fuel economy in Japan or Germany, showing clear differences among advanced LDV markets. All powertrains are gaining efficiency, although new diesels are still 10% more efficient than new gasoline-powered LDVs of comparable size, weight, and performance. Diesels represent more than 50% of new registrations in all market segments, with an average fuel consumption for diesels of 5 Lge/100 km. In 2015, Hybrids drove down total sales-weighted specific fuel consumption with an average of 4.4 Lge/100 km, which was 15-25% ahead of conventional powertrains.

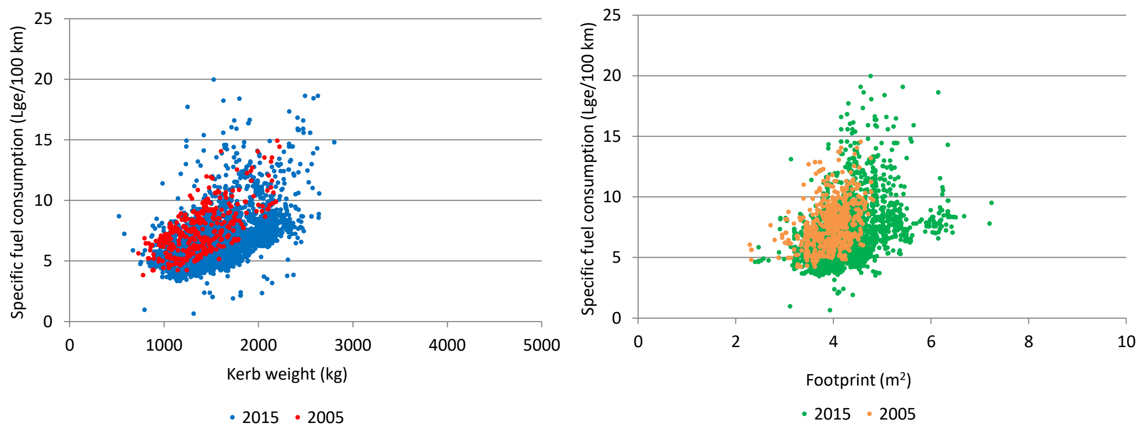
Figure 46 ● Average new LDV fuel consumption per km by vehicle segment and powertrain, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

The number of LDV models available increased substantially between 2005 and 2015, implying a diversifying market (Figure 47, left). The average weight and footprint of new LDVs sold in France was nearly constant between 2005 and 2015, and was accompanied with clear improvement in specific fuel consumption. Compared with the results of 2013 (IEA, 2016a), the 2015 vehicle models (blue and green dots in the figures below) have shifted further downwards, signifying continued improvements in average fuel economy (Figure 47).

Figure 47 ● Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, France, 2005 and 2015

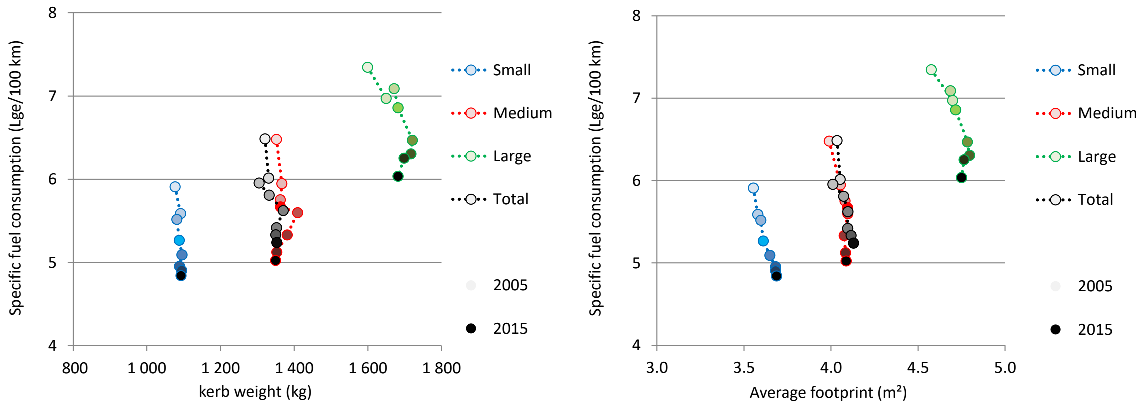


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Plotting average fuel economy against average weight shows a clear downward trend across all vehicle segments, even if the average weight of large LDVs increased until 2011, and then fell again between 2012 and 2015. These results highlight the impact of EU fuel economy standards coming into effect in 2009 and national fuel economy policies on vehicle taxes, favouring vehicles with lower fuel consumption per km. Nevertheless, average fuel economy improvement slowed in 2014 and 2015. This is consistent with the fact that France reached the European 2015 target on specific CO_2 emissions in advance, and so fuel economy standards are no longer a binding constraint on automakers.

The average footprint of all vehicle segments increased only marginally, while average fuel consumption improved (Figure 48, right).

Figure 48 • Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, France, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Germany

Country spotlight

Population (million) (World Bank, 2016a):	81.4
Urban population (% of total) (World Bank, 2016b):	75%
GDP per capita (2014 USD/year) (World Bank, 2016c):	41 200
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015):	180; 158

Fuel tax class (2014) (GIZ, 2015): highly taxed petroleum fuels

In 2015, about 3.4 million LDVs were sold in Germany (IHS Markit, 2016). The German LDV stock amounted to 42 million cars in the same year (IEA, 2016a), resulting in a LDV ownership of around 0.51 cars per capita. Voluntary CO_2 emission standards were first introduced in the European Union in 1998 and became mandatory in 2009. By 2021, passenger cars are required to attain CO_2 emissions of 95 g CO_2/km (based on NEDC), and LCVs must reach 147 g CO_2/km (based on NEDC, TransportPolicy, 2016). In Germany cars are subject to an annual vehicle circulation tax based on engine displacement, CO_2 emissions and pollutant emission class. Furthermore, gasoline and diesel fuels are taxed differently, with diesel being on average 12% cheaper per litre at the fuel pump. New vehicles have been required to have a label showing specific fuel consumption, CO_2 emissions and efficiency class since 2004 (Ricardo AEA, 2011). In May 2016, the German government also announced a policy package to support the deployment of PHEVs and BEVs (BMWi, 2016).

Market profile and vehicle characteristics

Germany is the fourth car manufacturer globally (after China, the United States and Japan) and the main one in Europe, producing over 6 million LDVs in 2015. Germany's domestic LDV market grew from 3.2 million LDVs sold in 2013 to 3.4 million in 2015. Volkswagen, Daimler and BMW, cover almost 50% of the German LDV market.

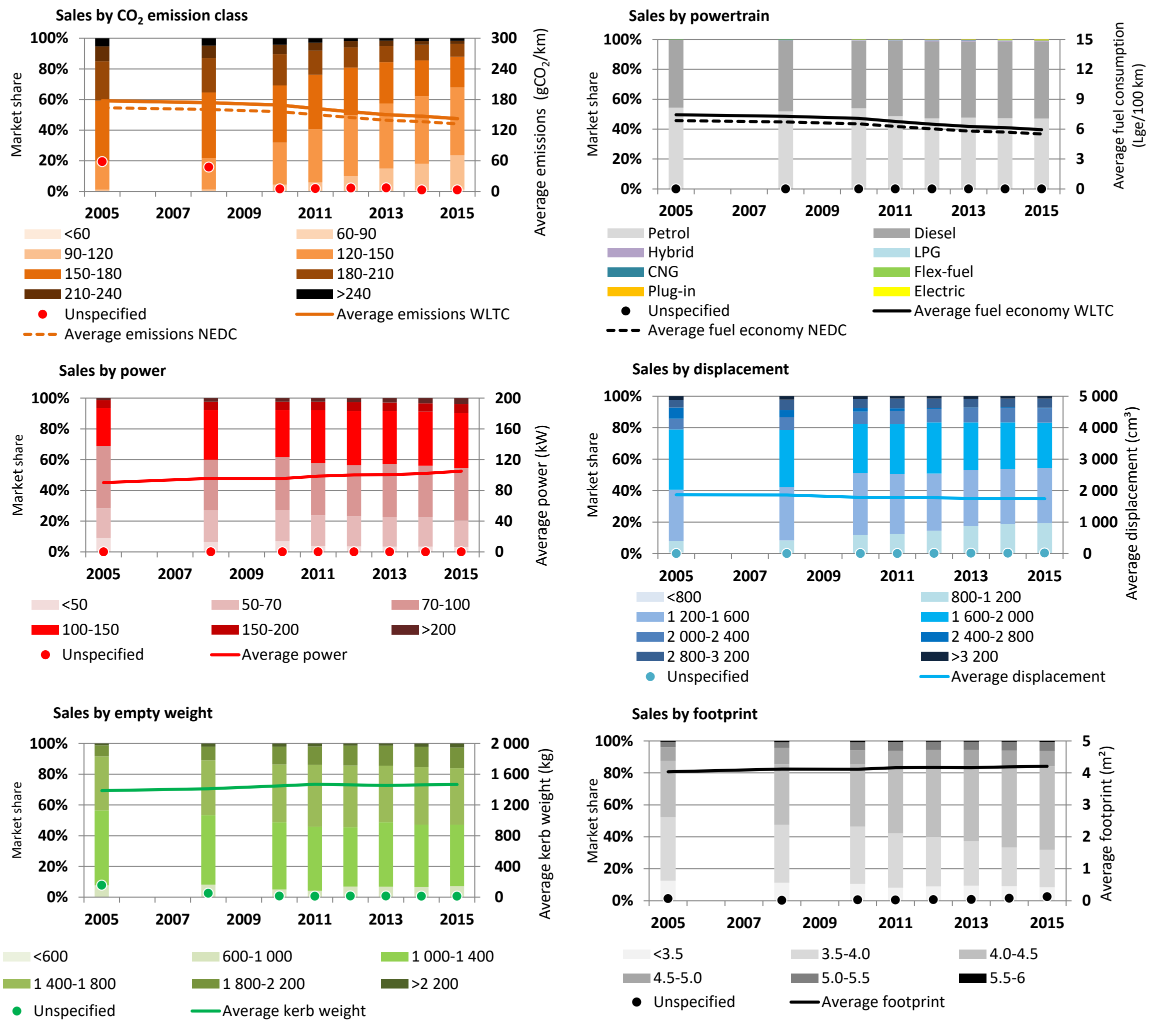
Since 2010, the average specific CO_2 emissions of newly registered German LDVs fell substantially. The progress achieved through 2013 (IEA, 2016b) continued in 2014 and 2015, consolidating improvements after the implementation of fuel economy standards in 2009. In 2015, average emissions of new car sales in Germany reached 140 g CO_2/km. As in other European countries, 2014 and 2015 were characterised by an increasing market share of vehicles with emissions ofv90-120 g CO_2/km and a falling market share of vehicles with emissions of more than 150 g CO_2/km. The average fuel economy of newly registered LDVs reached 6.0 Lge/100 km in 2015, which is ahead of the global average of 7.6 Lge/100 km. However, Germany's average fuel consumption per km in 2015 was 7% higher than the EU average (5.6 Lge/100 km).

The respective market share of different powertrains has remained relatively stable over the past five years. Advanced powertrains are still far from mature and large government incentive schemes were not announced until mid-2016, following a decline in hybrid LDV sales between 2013 and 2015. Increasing shares of PHEVs and BEVs shall be taking place in the coming years, following the recent introduction of policies supporting their market deployment (BMWi, 2016).

Average power increased between 2010 and 2015, reaching 105 kW in 2015. Moreover, the market share of 100-150 kW vehicles slowly rose at the expense of 50-70 kW vehicles. In 2015, average power was 17% higher than in 2005, growing another 5% compared with 2013. Average displacement modestly decreased from 2013 to 2015. In 2015, average displacement was 1.7 L, which was 13% larger compared with the average engine size of LDVs sold in France. However, technological advancements have allowed cars to have smaller engines with equal power, partially offsetting further fuel economy deterioration due to increases in engine power.

Since 2010, average LDV weight has fluctuated between 1 450 kg and 1 470 kg. The average footprint of newly registered LDVs slowly rose to 4.2 m[2] in 2015, surpassing the worldwide average.

Figure 49 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, Germany, 2005-15

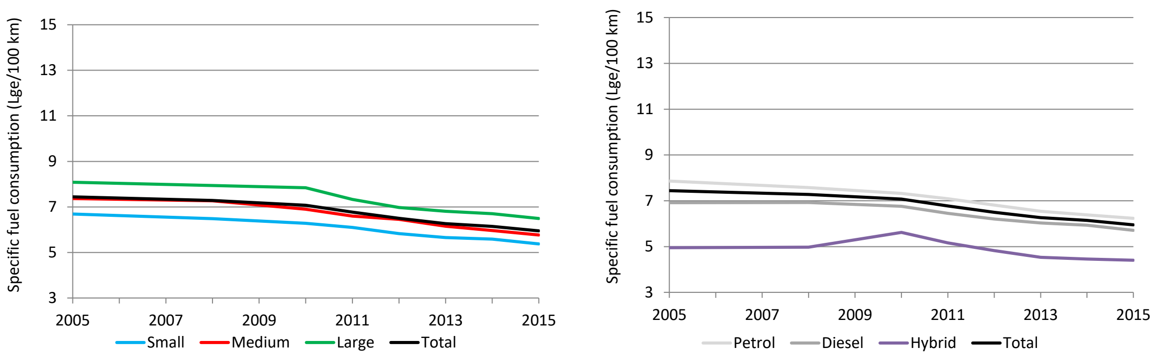


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Analysis of fuel economy trends

A trend of improving average fuel economy has been evident for all vehicle sizes, with a slight acceleration between 2014 and 2015 (Figure 50, left). As for other EU members, results confirm the continued effectiveness of European fuel economy standards enacted in 2009. Advancement in fuel economy by powertrain has seen parallel developments for gasoline and diesel LDVs, with a small advantage for diesel. However, the average fuel economies of diesel and gasoline are closer to each other than in France, which can be explained by the higher share of diesels in the large vehicle segment compared with the LDV market in France. Improvement in hybrid fuel economy slowed between 2013 and 2015, but was still far ahead of conventional powertrains.

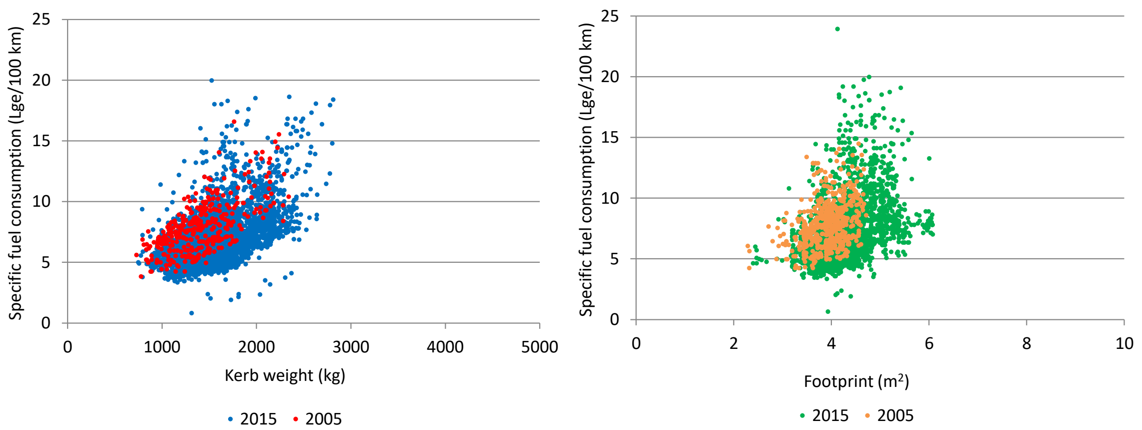
Figure 50 ● Average new LDV fuel consumption per km by vehicle segment and powertrain, Germany, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

A clear distinction between models sold in 2005 versus 2015 is evident when comparing weight with specific fuel consumption (Figure 51). The cloud of LDVs moved slightly to the right and substantially down, implying a shift to heavier but more efficient vehicles. Footprint plotted against specific fuel consumption shows even more horizontal movement, indicating larger LDV models being sold in 2015 compared with 2005.

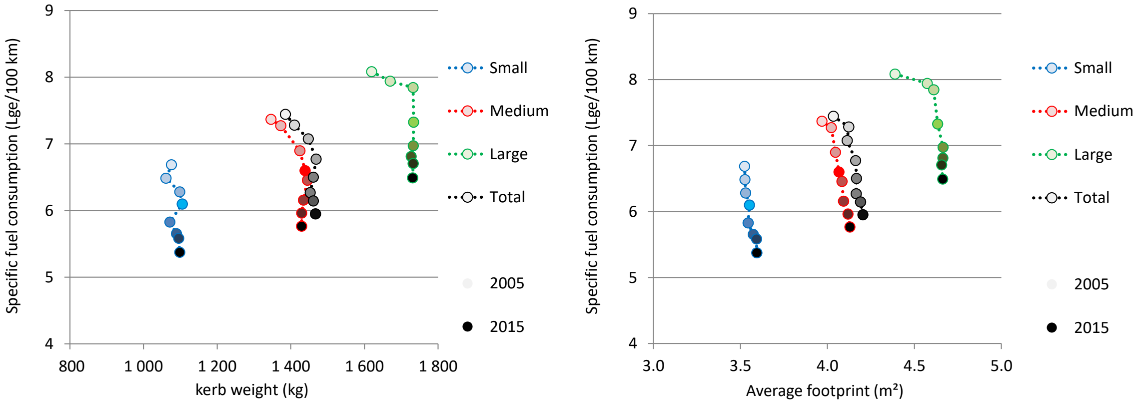
Figure 51 ● Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, Germany, 2005 and 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

From 2009 onwards small and medium vehicles gradually became heavier (Figure 52, left), but nonetheless clear fuel economy improvements were seen in all segments. Since 2013, the rate of specific fuel consumption improvement has been slowing down in all segments. The average footprint of small LDVs increased slightly, while the footprint of medium and large LDVs grew more substantially. The increase in the average footprint and weight of large vehicles taking place prior to 2010, and stopping after that, suggests that the introduction of mandatory fuel economy standards in the EU (which started in 2009) had a significant impact in the prioritization of design features of new vehicles in this class, leading to a greater relevance of fuel economy improvements over size and weight increases.

Figure 52 • Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, Germany, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

India

Country spotlight

Population (million) (World Bank, 2016a):	1 311
Urban population (% of total) (World Bank, 2016b):	33%
GDP per capita (2014 USD/year) (World Bank, 2016c):	1 600
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015):	110; 91

Fuel tax class (2014) (GIZ, 2015): taxed fuel price for gasoline, subsidised diesel

In 2015, about 3.1 million LDVs were sold in India (IHS Markit, 2016). The LDV stock totalled 30.1 million cars (IEA, 2016a), implying an ownership rate of only 0.023 LDVs per capita, which is the lowest among the group of countries discussed in this report. India has the strongest growth prospects for future LDV sales, however, and LDV ownership is likely to increase dramatically once personal income approaches and exceeds USD 5 000 per year. In January 2014, the Indian government adopted CO_2 emission regulations, which will take effect from April 2016 (TransportPolicy, 2016). The standard sets a fleet target of about 130 g CO_2/km for 2016, which will go down to 113 g CO_2/km in 2021 (based on NEDC) (TransportPolicy, 2016).

Market profile and vehicle characteristics

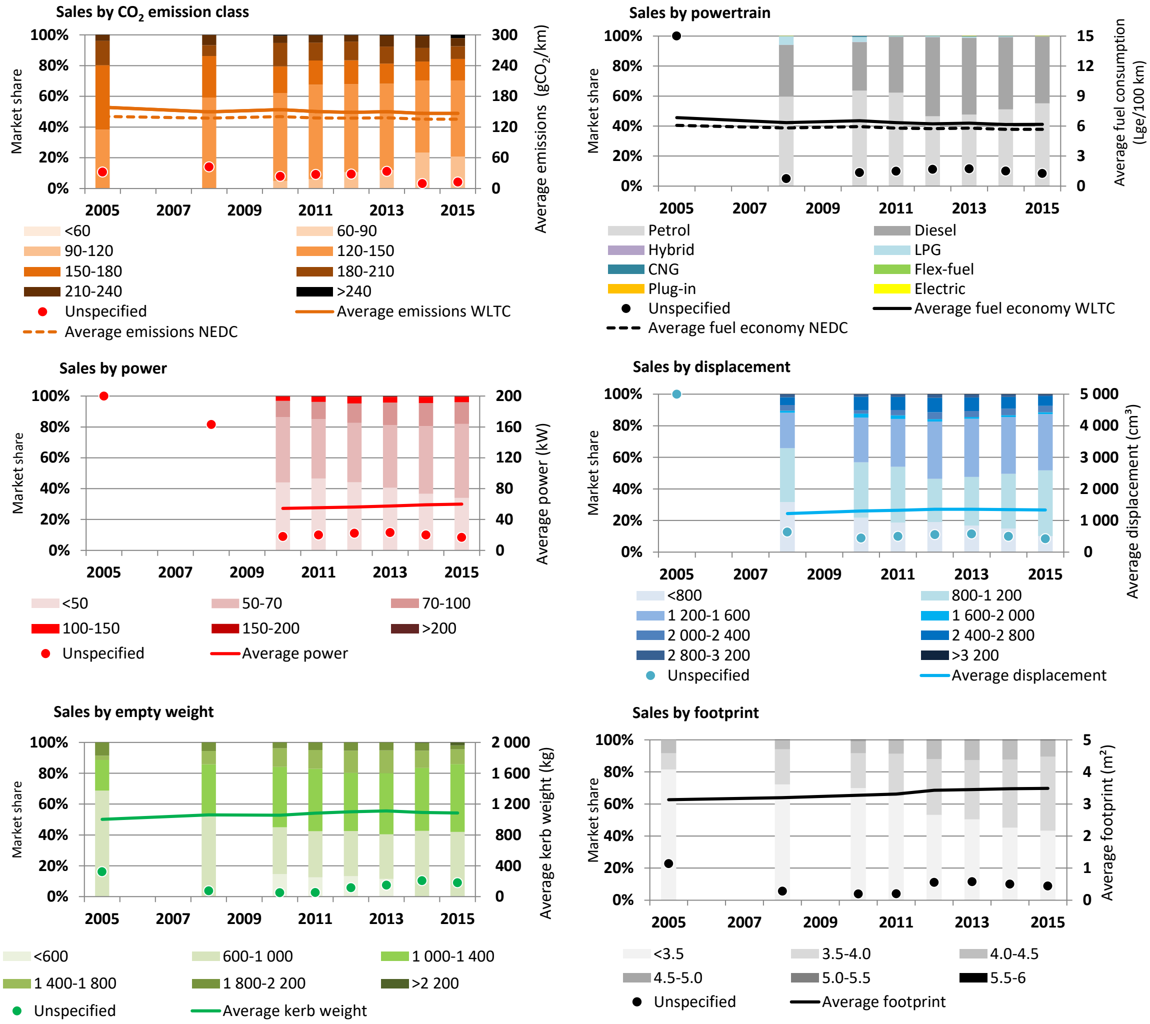
India's LDV market was the fifth-largest in the world in 2015, with just over 3 million cars sold, equal to the United Kingdom (IHS Markit, 2016). India is also positioning itself as a vehicle manufacturer, with 3.8 million vehicles produced in 2015, making India the sixth-largest producer worldwide (OICA, 2016). India has multiple domestic producers, including Maruti, Mahindra and Tata, whose market share fell between 2005 and 2015, but still represented around 65% of new sales.

Average CO_2 emissions of newly registered LDVs have hovered around 150 g CO_2/km across the past decade. Vehicles emitting 90-120 g CO_2/km have increased in market share to almost one-fifth in 2015. The average fuel consumption per km of new LDVs improved by a modest 2% from 2013 to 2015 to 6.2 Lge/100 km. India's average specific fuel consumption of new LDVs is 20% below the global average and around 25% lower than that of China and Indonesia. After four years of substantial growth between 2008 and 2012, diesel's market share fell, losing 16% of its market share to gasoline LDVs from 2012 to 2015. Diesel LDVs accounted for 45% of the market in 2015, and the remaining 55% of the market went to gasoline LDVs. Advanced powertrains had a negligible market share.

In 2015, new LDV engines had on average 10% more power than in 2010. The middle segment of 70-100 kW gained the most market share between 2013 and 2015, indicating that more customers bought slightly more powerful LDVs than in previous years. Nevertheless, vehicles in India are among the least powerful cars worldwide. For example, new LDVs in Germany are 75% more powerful and nevertheless have a slightly better average fuel economy. This comparison indicates that improved technologies could further advance India's average fuel economy. Average engine displacement declined by 2% from 2013 to 2015. India's LDV market moved towards the middle segments, with decreasing market shares of LDVs in low (<0.8 L) and high (more than 1.6 L) engine displacement segments.

Average weight increased between 2010 and 2013, but stabilized in 2014 and 2015, showing that the interest for relatively small vehicles remains strong in India. The average footprint of new LDVs is still growing, having reached 3.5 m^2 in 2015, while still remaining the smallest average footprint of all countries covered in this report. Only 10% of LDVs sold were larger than 4 m^2.

Figure 53 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, India, 2005-15

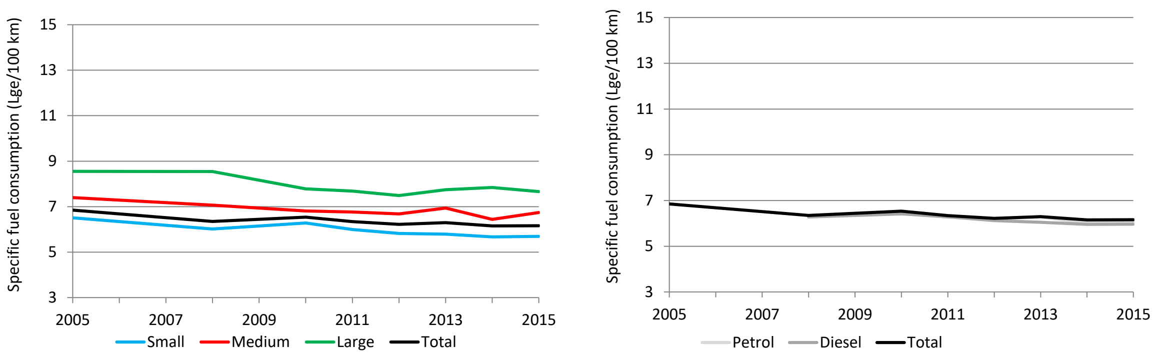


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Analysis of fuel economy trends

Average fuel economy by vehicle segment improved in the decade preceding 2015, despite some fluctations (Figure 54, left). The efficiency of diesel and gasoline LDVs is very similar, with a slight advantage for diesel LDVs (Figure 54, right). In contrast to most non-OECD countries, diesel powertrains are also widely available in the smaller segments in India.

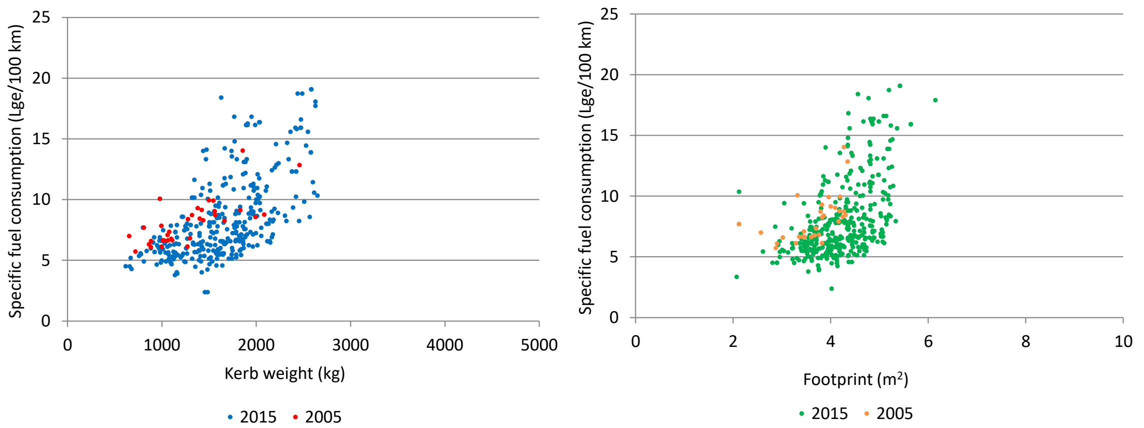
Figure 54 • Average new LDV fuel consumption per km by vehicle segment and powertrain, India, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

The graphs plotting fuel economy against LDV weight and footprint are much less populated in comparison with those for Europe, North America and China, indicating a lower variety of LDV models available to the market (Figure 55). Nevertheless, the number of models available increased substantially between 2005 and 2015. New LDVs clearly improved their specific fuel consumption despite increases in their weight and footprint between 2005 and 2015.

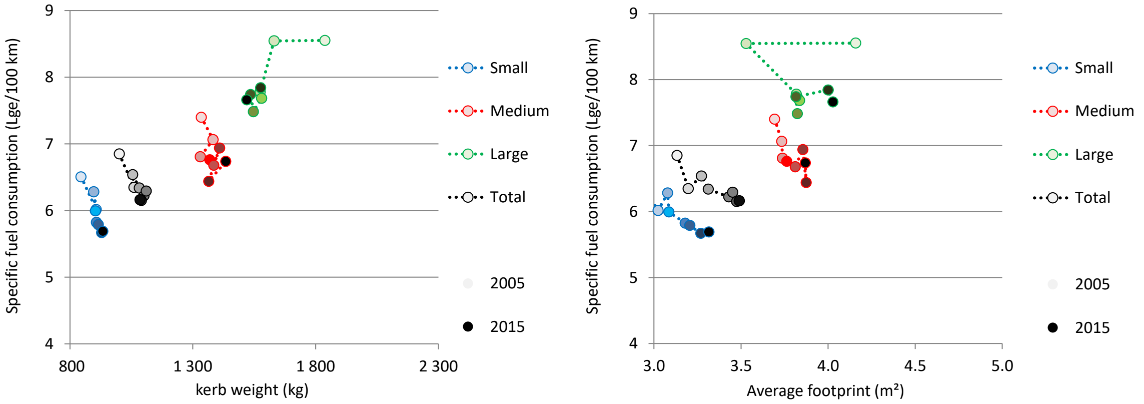
Figure 55 • Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, India, 2005 and 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

LDV weight has slightly increased for small vehicles, while the weight of medium and large LDVs hardly changed, nor have medium and large vehicles improved in terms of average specific fuel consumption between 2010 and 2015. The footprint indicator shows more extreme differences for all vehicle segments. The footprint of small vehicles grew significantly, while large LDVs moved back and forth in average size between 2010 and 2015. The overall increase of footprint across all sales has been driven primarily by small LDVs, the most relevant by market share in India.

Figure 56 • Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, India, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Indonesia

Country spotlight

Population (million) (World Bank, 2016a):	258
Urban population (% of total) (World Bank, 2016b):	54%
GDP per capita (2014 USD/year) (World Bank, 2016c):	3 300
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015):	93; 80

Fuel tax class (2014) (GIZ, 2015): taxed fuel price for petroleum fuels

In 2015, about 960 000 LDVs were sold in Indonesia (IHS Markit, 2016). The on-road LDV stock totalled more than 9 million vehicles (IEA, 2016a). LDV ownership was 0.034 per capita. This is higher than India's ownership level, but still more than ten times lower than the average European ownership level. In 2015, fuel price subsidies were abolished in Indonesia (The Economist, 2015). The low crude oil price masked the impact on fuel prices at the filling station. As a result, prices for diesel in 2015 were even lower than the year before, when diesel was still subsidised. Indonesia has no fuel economy regulations to date.

Market profile and vehicle characteristics

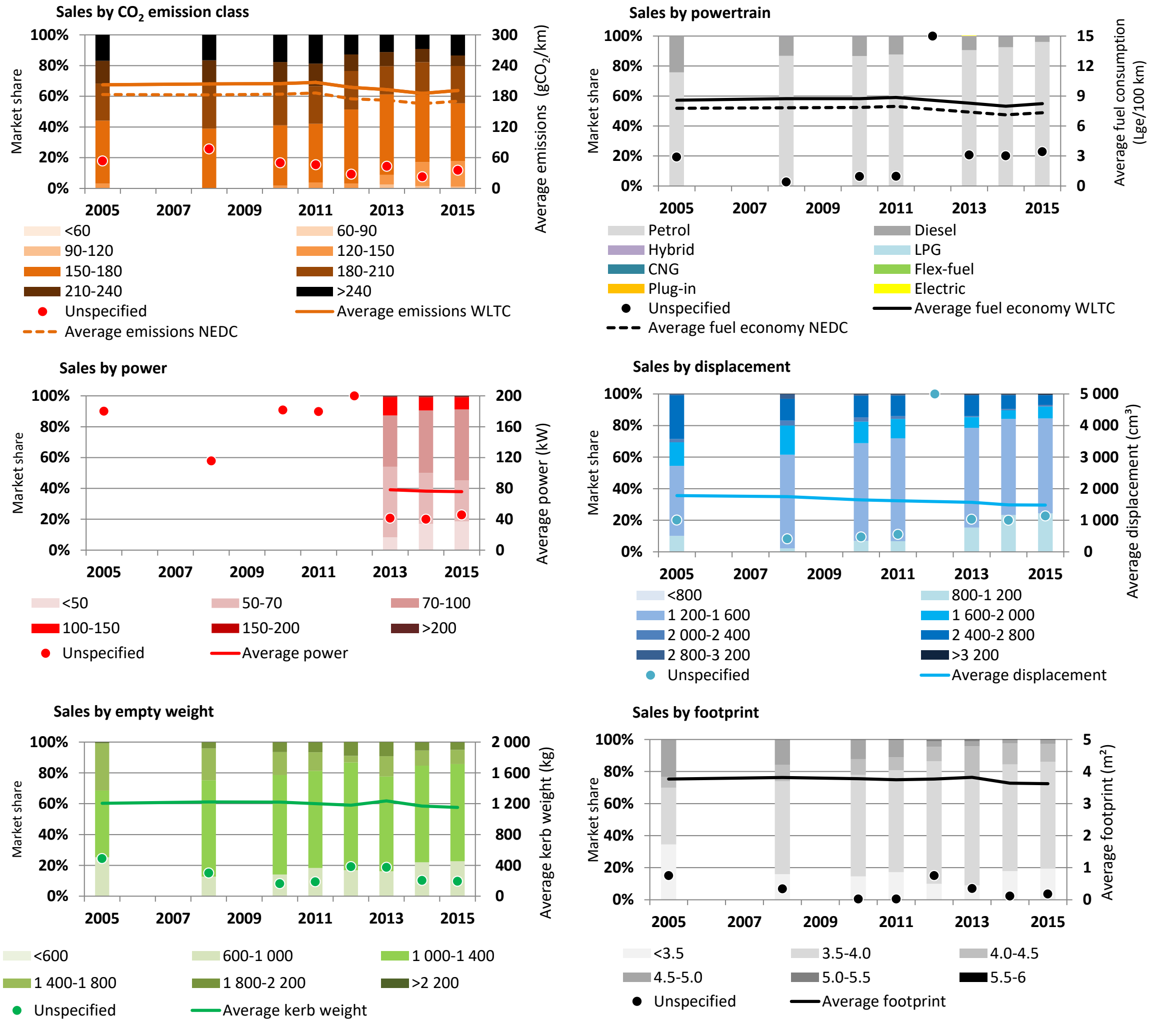
After significant growth in Indonesia's LDV market up to 2013, almost 20% fewer LDVs were registered in 2015 compared with 2013, amounting to 960 000 vehicles registered (IHS Markit, 2016). In the same year, Indonesia's LDV production fell by almost 15% to 1 million vehicles (OICA, 2016). Japanese OEMs, such as Toyota, Daihatsu and Honda, represented the major part of Indonesia-produced LDVs through 2015.

Average specific CO_2 emissions for new LDVs increased between 2014 and 2015 to 190 g CO_2/km, after a downward trend between 2011 and 2013. The market diverged, with higher market shares for vehicles emitting 120-150 g CO_2/km and heavy emitters (vehicles that emit more than 180 g CO_2/km). In 2015, average fuel economy experienced the same trend reversal as CO_2 emissions. The Indonesian LDV market has been dominated by gasoline-fuelled vehicles. After 2012, the market share of diesel gradually began to erode. The lack of policy action is consistent with little signs of a market growth for more advanced powertrains.

New data for the most recent years enable insights into the market share by average power and displacement in the Indonesian LDV market. As opposed to most other countries in this study, average power declined between 2013 and 2015, to 76 kW. Nonetheless, average power in Indonesia was still around 25% higher than the average of newly registered LDVs in India. The share of low-powered engines (less than 50 kW) rose, while engines with 100 kW are gaining market shares. Average displacement also declined, falling to 1.5 L in 2015. Furthermore, smaller engines (0.8-1.2 L) are on the rise, while engines of more than 1.6 L are losing market share. A reason for this shift could be the greater affordability of smaller vehicles for a larger group of people.

After a small peak in 2013, the average weight of newly registered Indonesian LDVs dropped to below 1 200 kg per vehicle. Heavy LDVs lost market share, while medium weight (1 000-1 400 kg) LDVs became gained market share. The average footprint also fell after 2013 to 3.6 m^2 in 2015.

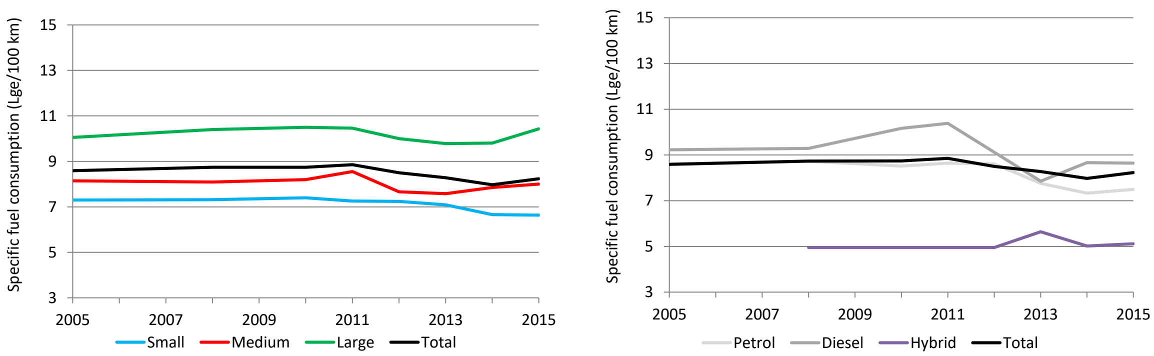
Figure 57 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, Indonesia, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Analysis of fuel economy trends

Figure 58 • Average new LDV fuel consumption per km by vehicle segment and powertrain, Indonesia, 2005-15

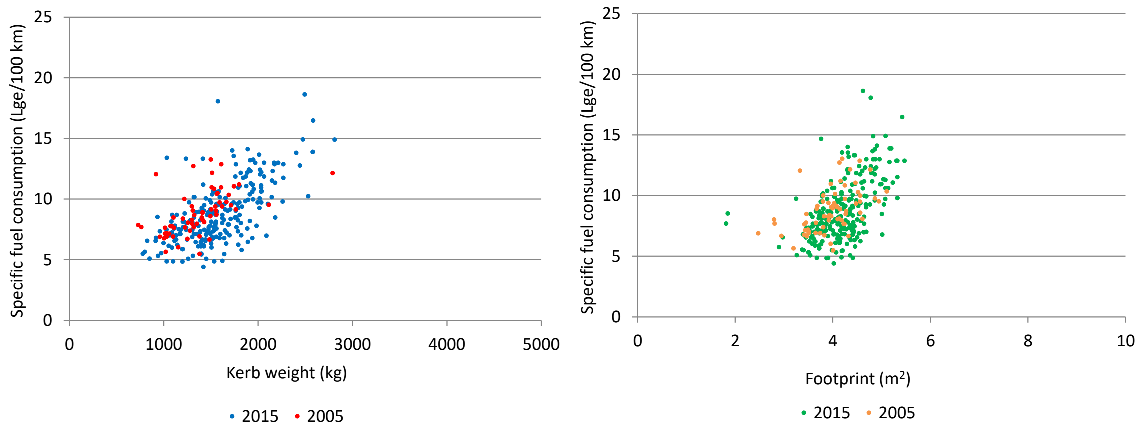


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

The worsening of average fuel economy in 2015 can be attributed to developments in the medium and large vehicle segments (Figure 58, left). Small LDVs saw an improving average fuel economy after 2010, although the improvement rate was modest between 2014 and 2015. The fuel economy of hybrids was far ahead of that of the conventional fuel types (Figure 58, right), and the volatility of average fuel economy in diesels was a result of very low market shares in all years.

As in India, the number of LDV models shown in the graphs of specific fuel consumption as a function of weight or footprint (Figure 59) was much lower for Indonesia than for OECD countries or China. Indonesia showed a slight vertical movement, corresponding to improvements in fuel economy, between 2005 and 2015, but this trend is less clear than for India. No clear trend is observed on the right-hand side of Figure 59, implying limited uptake of efficient technology over time.

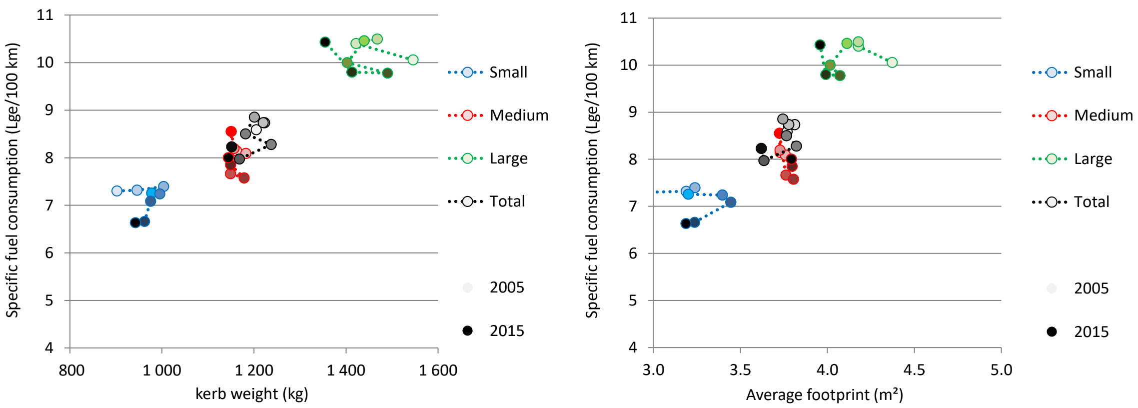
Figure 59 ● Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, Indonesia, 2005 and 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

The absence of a fuel economy standard generates stagnating or erratic trends of vehicle fuel economy developments against weight and footprint (Figure 60).

Figure 60 ● Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, Indonesia, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Italy

Country spotlight

Population (million) (World Bank, 2016a):	60.8
Urban population (% of total) (World Bank, 2016b):	69%
GDP per capita (2014 USD/year) (World Bank, 2016c):	29 800
Average price gasoline (USD cent per L, 2014) (GIZ, 2015):	214; 201

Fuel tax class (2014) (GIZ, 2015): taxed petroleum fuels

In 2015, about 1.7 million LDVs were sold in Italy (IHS Markit, 2016). The LDV stock totalled 26 million (IEA, 2016a). LDV ownership amounted to 0.43 LDVs per capita. Voluntary CO_2 emission standards were introduced in the European Union in 1998, and became mandatory in 2009. By 2021, CO_2 emissions of passenger LDVs must fall to 95 g CO_2/km. The EU target for LCV in the same year is 147 g CO_2/km (TransportPolicy, 2016).

In 2003, Italy introduced a project to promote CNG and LPG within the transport sector, which led to deployment of methane infrastructure (ODYSSEE-MURE, 2011). Favourable fuel taxes and scrapping incentives were introduced to boost natural gas vehicles (NGV System Italia, 2010). Furthermore, Italian BEVs are exempt from ownership tax for the first five years of their registration, followed by a tax that is 25% of conventionally powered vehicles (ACEA, 2016).

Market profile and vehicle characteristics

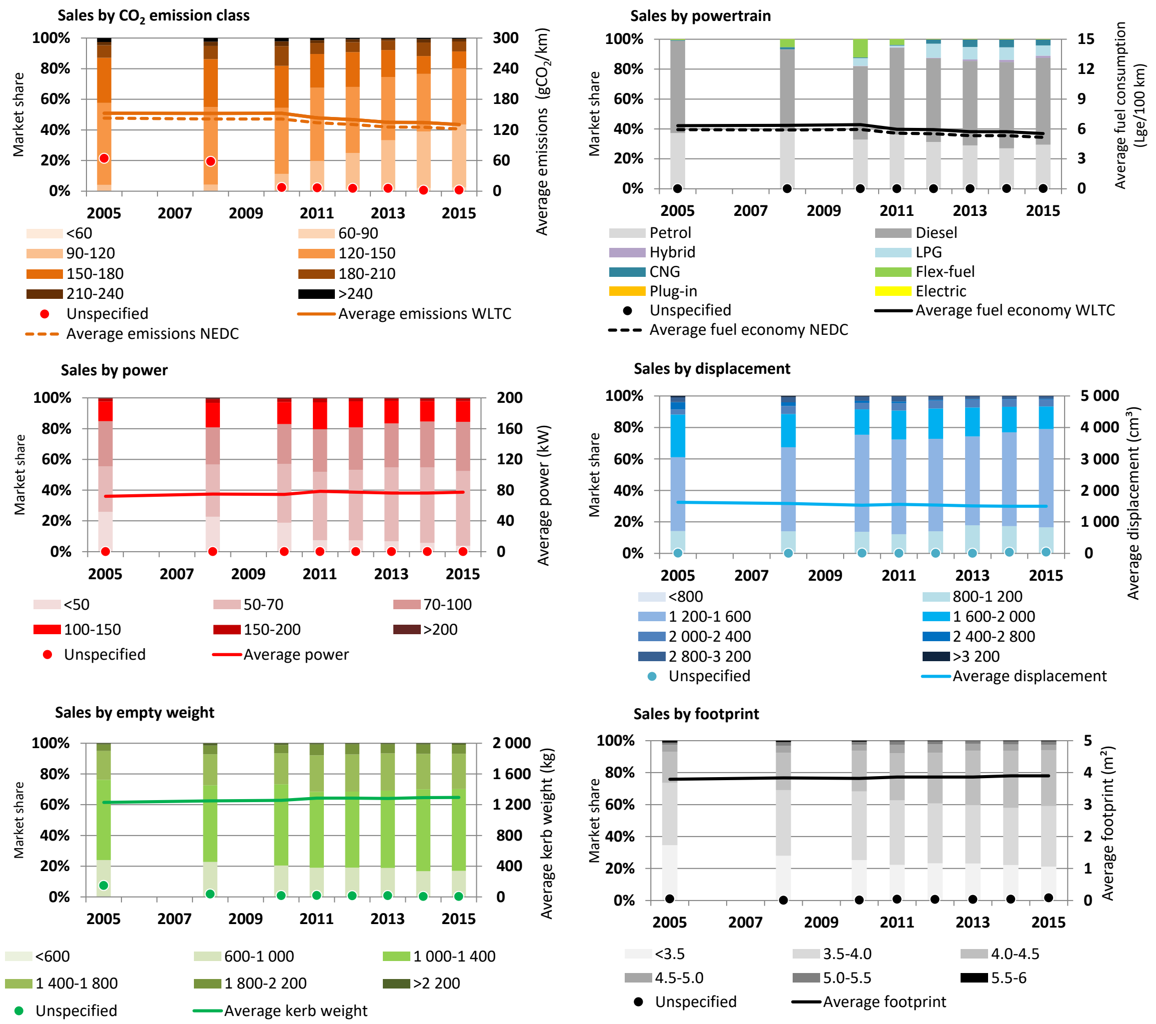
Italy is the fourth-largest economy in the European Union, and LDV registrations are slowly recovering from the economic challenges faced there between 2010 and 2013, with new registrations totalling 1.7 million in 2015 (IHS Markit, 2016). LDV production in Italy experienced a 45% increase between 2014 and 2015, reaching almost 1 million vehicles (OICA, 2016). As a result, Italy is the nineteenth largest vehicle producer worldwide, with approximately half the production volume of France. Fiat, which merged with Chrysler in 2014 in the FCA group, is the main Italian OEM. The FCA group owns several Italian brands, such as Alfa Romeo and Maserati.

Italian specific average CO_2 emissions started to decline after 2010, falling by 15% in five years. These improvement rates are similar to Germany's following the European-wide implementation of fuel economy standards. The market share of vehicles emitting 90-120 g CO_2/km grew fourfold to 40% between 2010 and 2015. The greatest losses in market share occurred in the upper-middle segment (150-210 g CO_2/km), which halved between 2010 and 2015. Diesels lost popularity between 2005 and 2010, but regained market share in the years leading up to 2015, when they accounted for almost 60% of the LDVs sold in the Italian market. In the most recent years, a growing presence of CNG and LNG vehicles has followed the introduction of favourable policies for natural gas vehicles in 2010. This development resulted in the market share for natural gas vehicles growing to around 10%.

The average power of new LDVs increased by 7% since 2005, reaching 78 kW in 2015. Average power of new cars sold in Italy grew the slowest and maintained the lowest absolute value across major European countries. Registrations of vehicles with engines below 50 kW decreased by 75% between 2010 and 2015. Most of the lost market share went to the segment one power class up (50-70 kW). Average displacement of new LDVs fell by almost 10% in ten years, to 1.5 L in 2015. LDVs with engines between 1.2 L and 1.6 L represented more than 60% of the Italian LDV market in 2015. Hence smaller engines provided the same amount of engine power over time.

Newly registered LDVs became 5% heavier between 2005 and 2015. Three-quarters of all vehicles sold after 2010 had a kerb weight between 1 000 kg and 1 800 kg. During the same period, the average footprint grew by 3% to 3.9 m^2 in 2015.

Figure 61 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, Italy, 2005-15



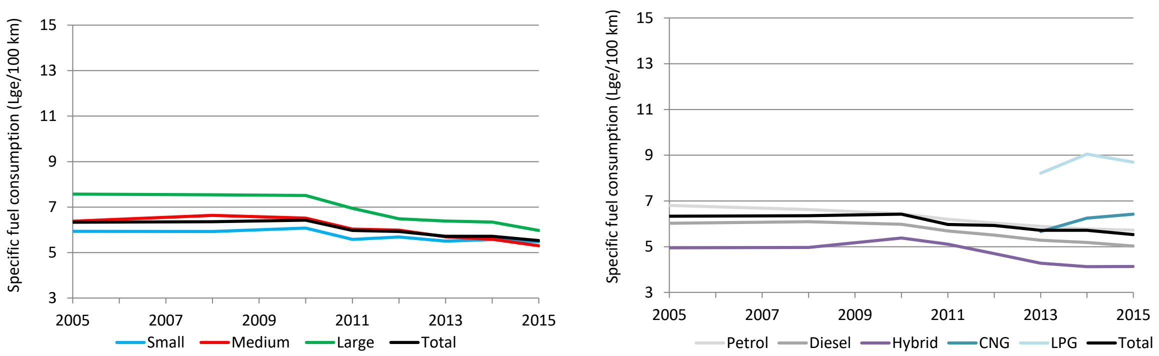
Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Analysis of fuel economy trends

Fuel economy trends in Italy show similar patterns to the other European countries covered in this report, where all segments experienced similar improvements (Figure 62, left). The fuel economy gap between small and medium LDVs narrowed, differing by less than 3% in 2015, as in the case of the United Kingdom. Large vehicles used on average 6 Lge/100 km in 2015, a value more than 10% lower than the average for small vehicles in the United States. Total average fuel economy is close to that of the small and medium segments, which constitute the majority of sales.

Regarding powertrains, diesels were more efficient than gasoline vehicles (Figure 62, right). CNG had a fuel consumption profile slightly higher than conventional powertrains in 2015. LPG vehicles used twice the amount of fuel per km on average compared with new diesel LDVs.

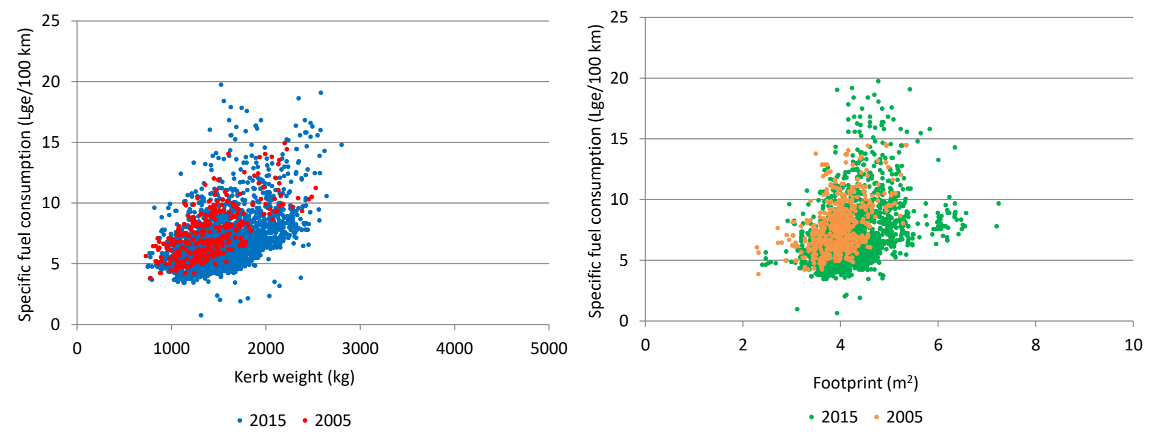
Figure 62 ● Average new LDV fuel consumption per km by vehicle segment and powertrain, Italy, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

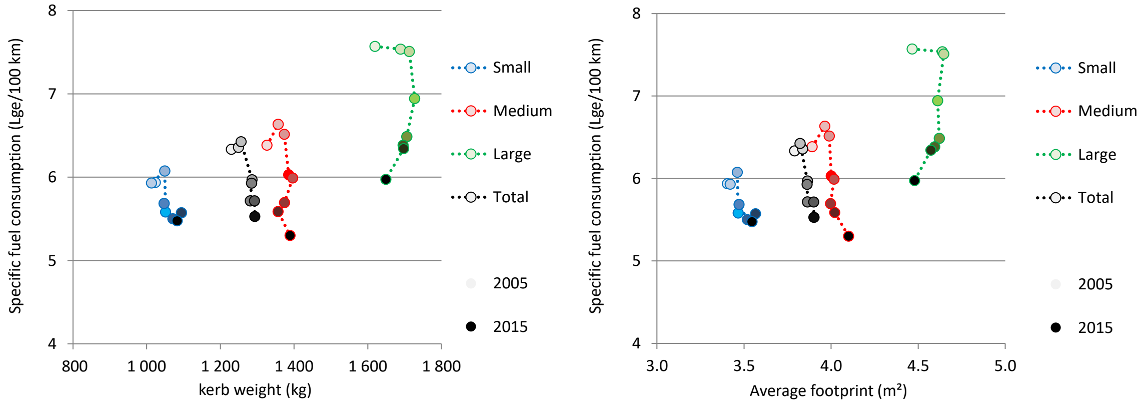
The graphs comparing weight and footprint to specific fuel consumption exemplify the relatively homogeneous trends within the European Union (Figure 63). New vehicles became heavier and larger, but also underwent significant improvements in specific fuel consumption. Even though Italy's LDV market was already well-established in 2005, the market continued to diversify up to 2015, a trend that is also observed for other European countries in this report.

Figure 63 ● Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, Italy, 2005 and 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Figure 64 ● Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, Italy, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

The average fuel economy improved across all segments to 2015 (Figure 64), although small vehicles improved much less than medium and large vehicles. Similar patterns are visible for average footprint (Figure 64, right). Overall, weight and footprint increased, due to the larger shares of small and medium LDVs.

Japan

Country spotlight

Population (million) (World Bank, 2016a):	127
Urban population (% of total) (World Bank, 2016b):	94%
GDP per capita (2014 USD/year) (World Bank, 2016c):	32 500
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015):	138; 110
Fuel tax class (2014) (GIZ, 2015): taxed fuel price for petroleum fuels	

In 2015, 4.8 million LDVs entered the Japanese vehicle fleet (IHS Markit, 2016), bringing its on-road LDV stock to 62 million vehicles (IEA, 2016a). LDV ownership was slightly below 0.49 LDVs per capita. Fuel economy standards have a long history in Japan. The first regulation was put in place in 1979, and applied first to 1985 vehicles. The Top Runner Program, introduced in 1999, required all vehicles in a given weight class to exceed the fuel economy of the best-performing model within three to ten years (TransportPolicy, 2016). Fuel economy labelling has also been mandatory since the year 2000 (ICCT, 2014c). Japanese fuel economy standards have resulted in ambitious improvement targets in the past. Recent regulatory targets (for 2020) are less aggressive than in Europe, despite the fact that average national new sales fuel economy in Europe and Japan in 2013 were similar in magnitude. In addition to fuel economy standards, tax incentives encourage consumers to buy lighter vehicles. Vehicles that perform significantly better than the target values are also eligible for tax reductions (TransportPolicy, 2016). This helps explain why Japanese vehicles met fuel consumption targets ahead of time.

Market profile and vehicle characteristics

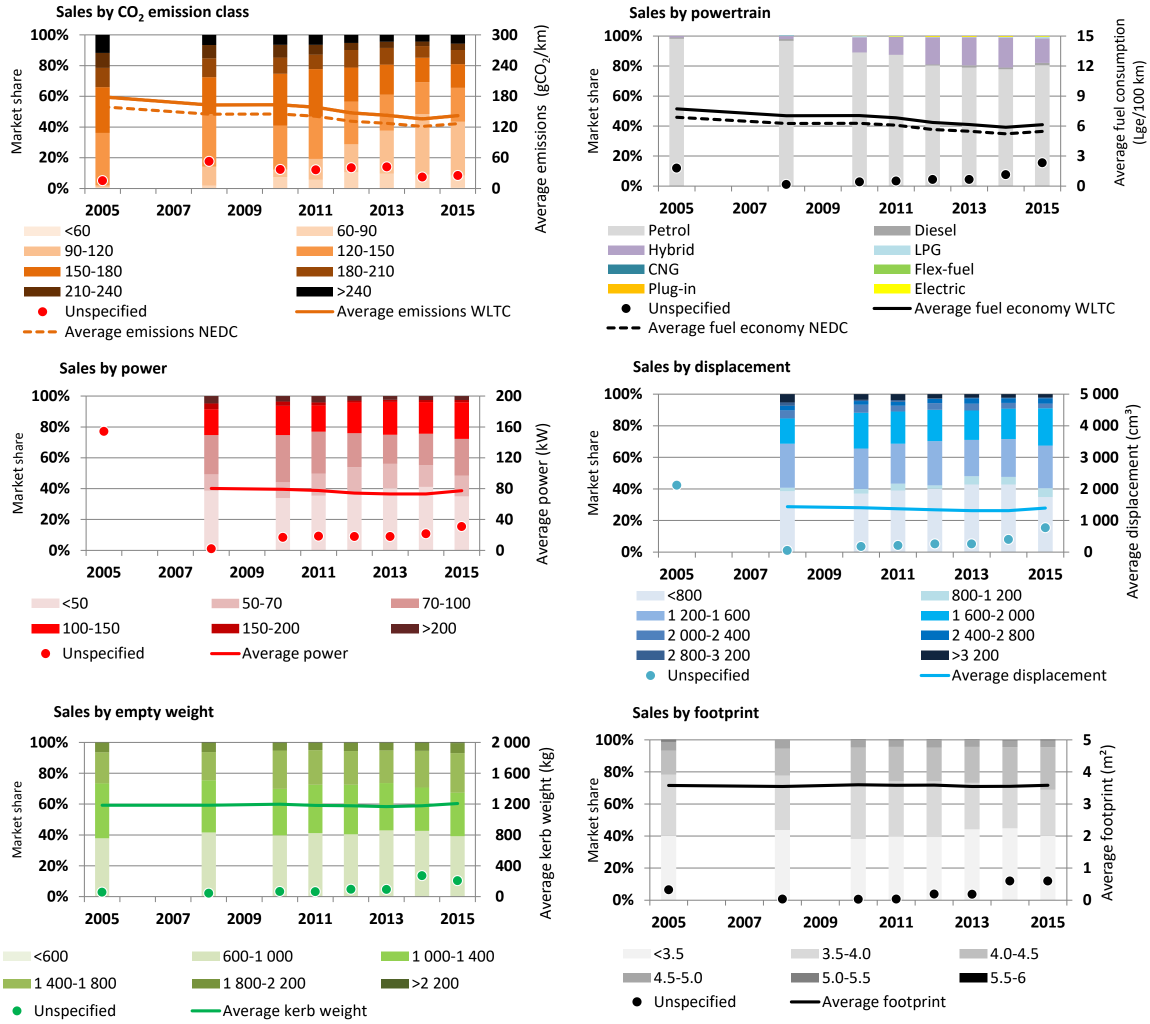
Producing approximately 8.7 million LDVs in 2015, down 10% from 2013, Japan ranks as the third-largest LDV manufacturer globally after China and the United States (OICA, 2016). Japan produced many more vehicles than its domestic sales of 4.9 million LDVs in 2015, maintaining its position as premier global exporter (IHS Markit, 2016). Japanese cars remain popular around the world, with brands such as Toyota, Honda and Suzuki. Foreign OEMs struggle to gain market share in the Japanese market – Japanese OEMs account for more than 90% of domestic LDV sales.

After nine consecutive years of decreasing CO_2 emissions per vehicle-kilometre, Japan's new LDVs emitted almost 5% more CO_2 per kilometre in 2015 compared with the previous year. In 2015, the most outstanding change was a surge in high-emission LDVs (more than 180 g CO_2/km), while lower emission LDVs (60-120 g CO_2/km) lost market share. Japan is still the only market with a double-digit market share of hybrid vehicles, although this dropped below 15% in 2015. Japan had almost no diesel registrations, leading to an average fuel consumption of 6.1 Lge/100 km.

Average power per new LDV went up by 6% to reach almost 80 kW between 2013 and 2015, after eight years of decreasing. Vehicles below 50 kW lost 5% market share between 2014 and 2015, indicating a trend reversal. Nevertheless, Japanese LDVs had a 20% lower average power than German LDVs while having the same average fuel economy, emphasising technological differences. Average displacement of newly registered LDVs also went up to 1.4 L between 2013 and 2015, being at least 7% smaller than the nearest OECD country. Most market growth has been observed in the 1.6-2.0 L segment. The demand for smaller engines of less than 0.8 L is decreasing.

The average weight of newly registered LDVs has hardly grown since 2005, with a small upward trend between 2013 and 2015. The second-largest segment of 1 800-2 200 kg has gained the most market share, while light vehicles of 600-1 000 kg became less popular. Average footprint also experienced almost no change over the years 2005-15, albeit rising a little in the latest two years.

Figure 65 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, Japan, 2005-15

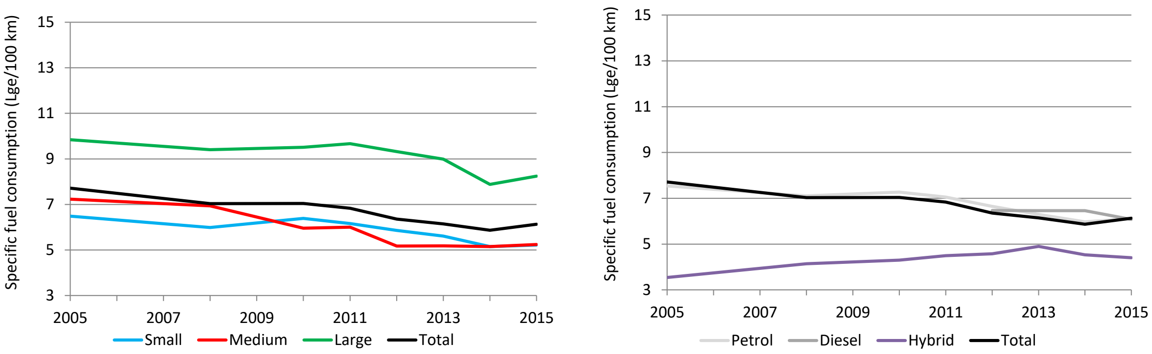


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Analysis of fuel economy trends

In Japan, a significant gap exists between large vehicles and the other segments (Figure 66, left), and is larger than in European OECD countries. After a rapidly falling fuel consumption per km for large LDVs from 2011 to 2014, a trend reversal occurred in 2015. Due to high market share of hybrids, new medium LDVs were more fuel efficient than small vehicles between 2010 and 2014, converging after 2012. Segmentation by powertrain shows that gasoline-powered vehicles dictated Japan's total average fuel economy (Figure 66, right). Hybrids experienced a worsening specific fuel consumption between 2005 and 2013, which was reversed in the two years after. However, this was not enough to prevent total average fuel consumption from rising.

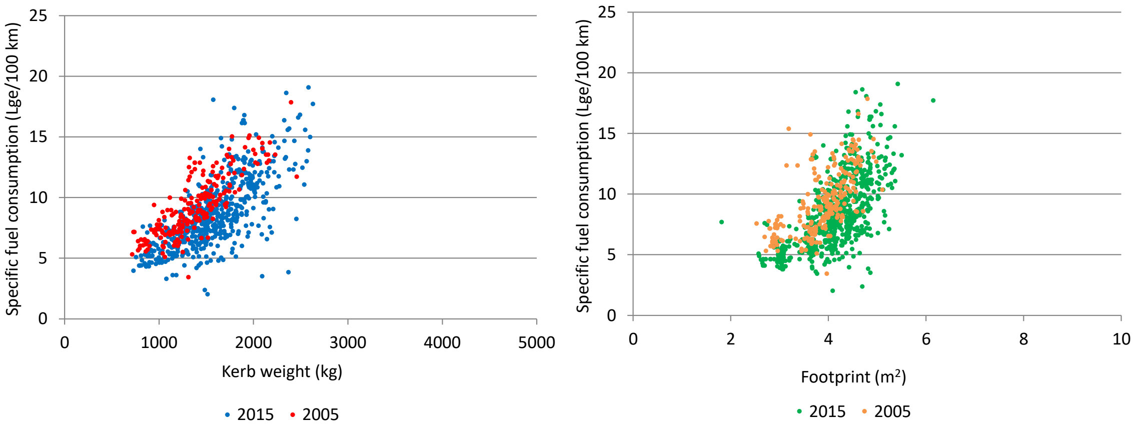
Figure 66 ● Average new LDV fuel consumption per km by vehicle segment and powertrain, Japan, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

A neat reduction in specific fuel consumption was observed for most weight classes between 2005 and 2015 (Figure 67, left). The same trend was observed with regard to footprint (Figure 67, right). Like most markets in this study, more LDV models were available in 2015 compared with 2005, leading to a more diversified market.

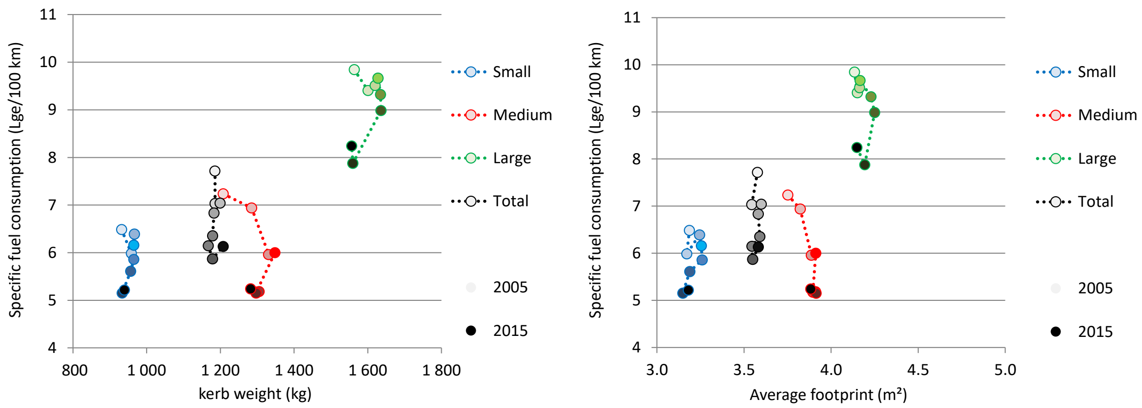
Figure 67 ● Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, Japan, 2005 and 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

An overall downward trend in specific fuel consumption was seen for all vehicle segments (Figure 68), similar to other countries with extensive fuel economy policy regimes. Newly registered small LDVs became somewhat lighter over time, alongside positive progress in specific fuel economy. Medium-sized LDVs experienced several trends, first becoming heavier, then losing weight, accompanied by stagnating specific fuel consumption. Large vehicles lost weight as well, while becoming 10% more fuel efficient in between 2011 and 2015. Changes in footprint were much less pronounced than in the case of weight, for all segments (Figure 68, right).

Figure 68 • Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, Japan, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Mexico

Country spotlight

Population (million) (World Bank, 2016a): 127

Urban population (% of total) (World Bank, 2016b): 79%

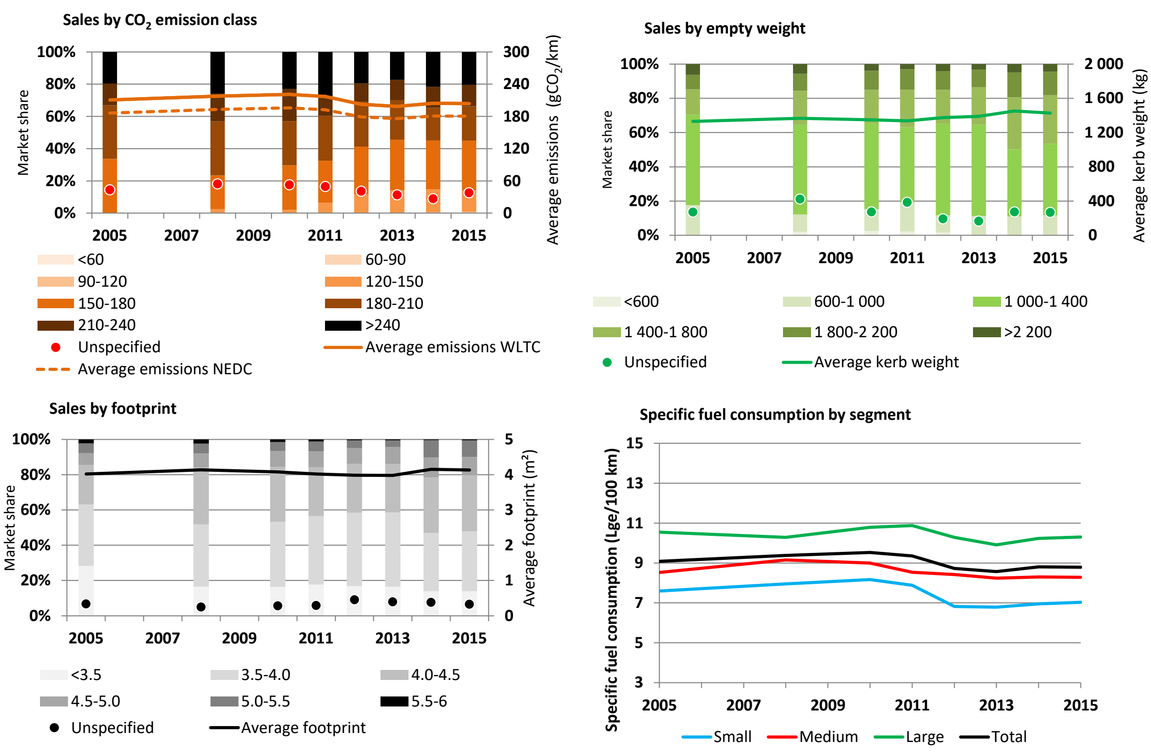
GDP per capita (2014 USD/year) (World Bank, 2016c): 9 000

Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015): 103; 102

Fuel tax class (2014) (GIZ, 2015): taxed fuel price for petroleum fuels

In 2015, about 1.4 million LDVs were sold in Mexico (IHS Markit, 2016), while Mexico's LDV fleet reached 24 million (IEA, 2016a). The LDV ownership rate was 0.20 LDVs per capita, slightly higher than other Latin American countries with comparable per-capita income. In 2013, the Mexican government adopted fuel economy regulations similar to the US CAFE standards, although with less ambitious targets and more flexibility for car manufacturers and importers (SEGOB, 2013). Similar to the United States and Canada, Mexican fuel economy targets are footprint based. In contrast to these countries, Mexican manufacturers are permitted to pool their performance for the purposes of compliance (TransportPolicy, 2016).

Figure 69 • LDV market by g CO_2/km, weight and footprint, 2005-15 and time series of specific fuel consumption by segment, Mexico



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Market profile and vehicle characteristics

Mexico's LDV market grew rapidly until 2015, following a contraction between 2008 and 2010. In 2015, more than 1.6 million LDVs were sold, an increase of 18% year-on-year (IHS Markit, 2016). Mexico produces many more vehicles than it registers domestically and took seventh place globally, with almost 3.4 million units produced (OICA, 2016). All vehicles originate from foreign OEMs, topped by Nissan, Chevrolet and Volkswagen.

Average CO_2 emissions of newly registered LDVs fell between 2010 and 2013 in Mexico, but increased again a little between 2013 and 2015, finishing at slightly more than 200 g CO_2/km. More specifically, the market share of high-emission vehicles (>240 g CO_2/km) grew by 20% between 2013 and 2015, while the medium segment (150-180 g CO_2/km) became less popular. The average fuel economy of new LDVs reversed course after 2013, rising to 8.8 Lge/100 km. Nearly all LDVs sold were gasoline powered.

Average engine power remained relatively stable at around 94 kW between 2010 and 2015. Approximately two-thirds of new Mexican LDVs were between 70 kW and 100 kW, although data quality is somewhat limited. Up to 2014, the middle segment of 1 000-1 800 kg lost market share to more extreme weight classes at both ends of the spectrum, favouring very heavy vehicles (> 2 200 kg). Average displacement continuously fell from 2008, to 1.7 L in 2015, a value between the engine displacement of Chile and Brazil.

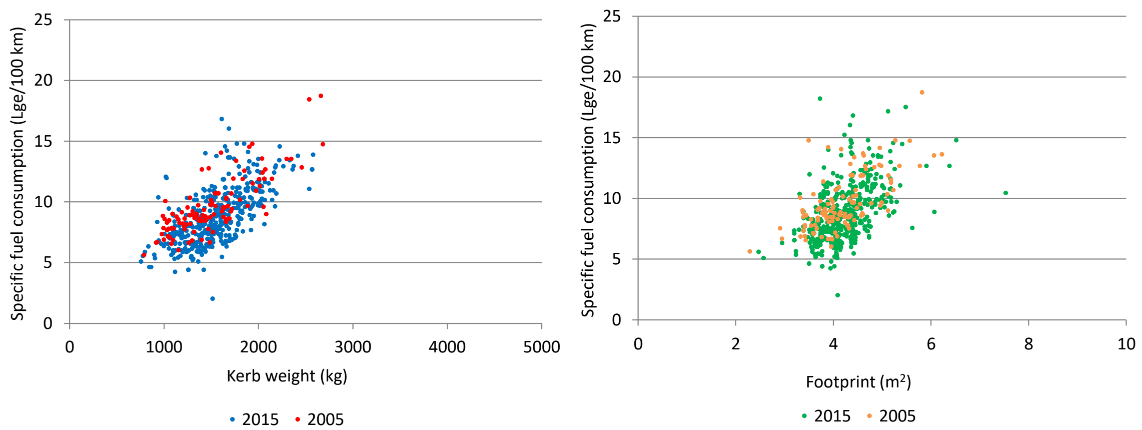
Newly registered Mexican LDVs grew in weight between 2010 and 2014. However, in 2015 this trend was reversed. Mexican vehicles had the same average weight as the United Kingdom. Average footprint has been relatively stable around 4 m^2, slightly below the global average.

Analysis of fuel economy trends

Mexican LDV sales lean towards the large segment. Small and large LDVs experienced increasing specific fuel consumption between 2013 and 2014, while medium LDVs remained stable (Figure 69).

Data show no clear development in weight or footprint compared with specific fuel consumption between 2005 and 2015 (Figure 70), although the number of LDV models available increased significantly. New LDVs also became heavier over time.

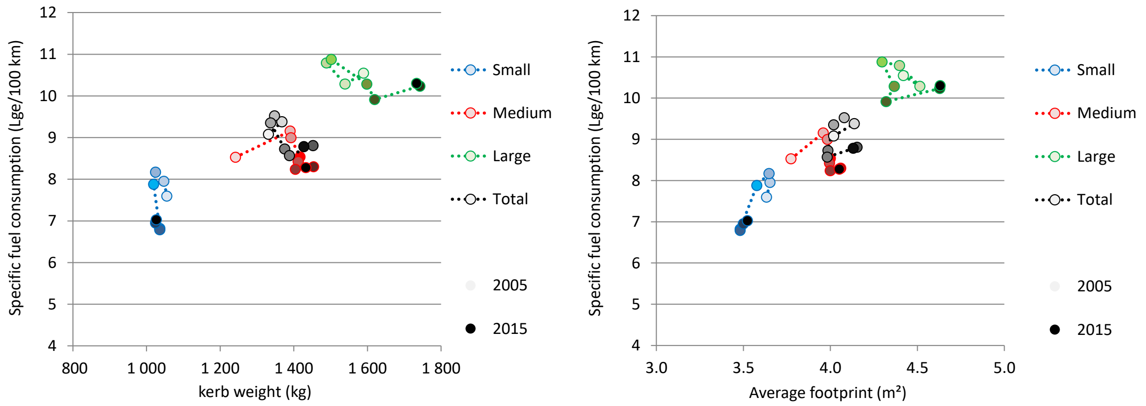
Figure 70 ● Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, Mexico, 2005 and 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

The weight of small and medium LDVs remained stable over time (Figure 71), while average footprint declined. Large LDVs became heavier in the second half of the past decade. The footprints of medium and large LDVs did not follow any clear trend across the period 2005-15.

Figure 71 ● Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

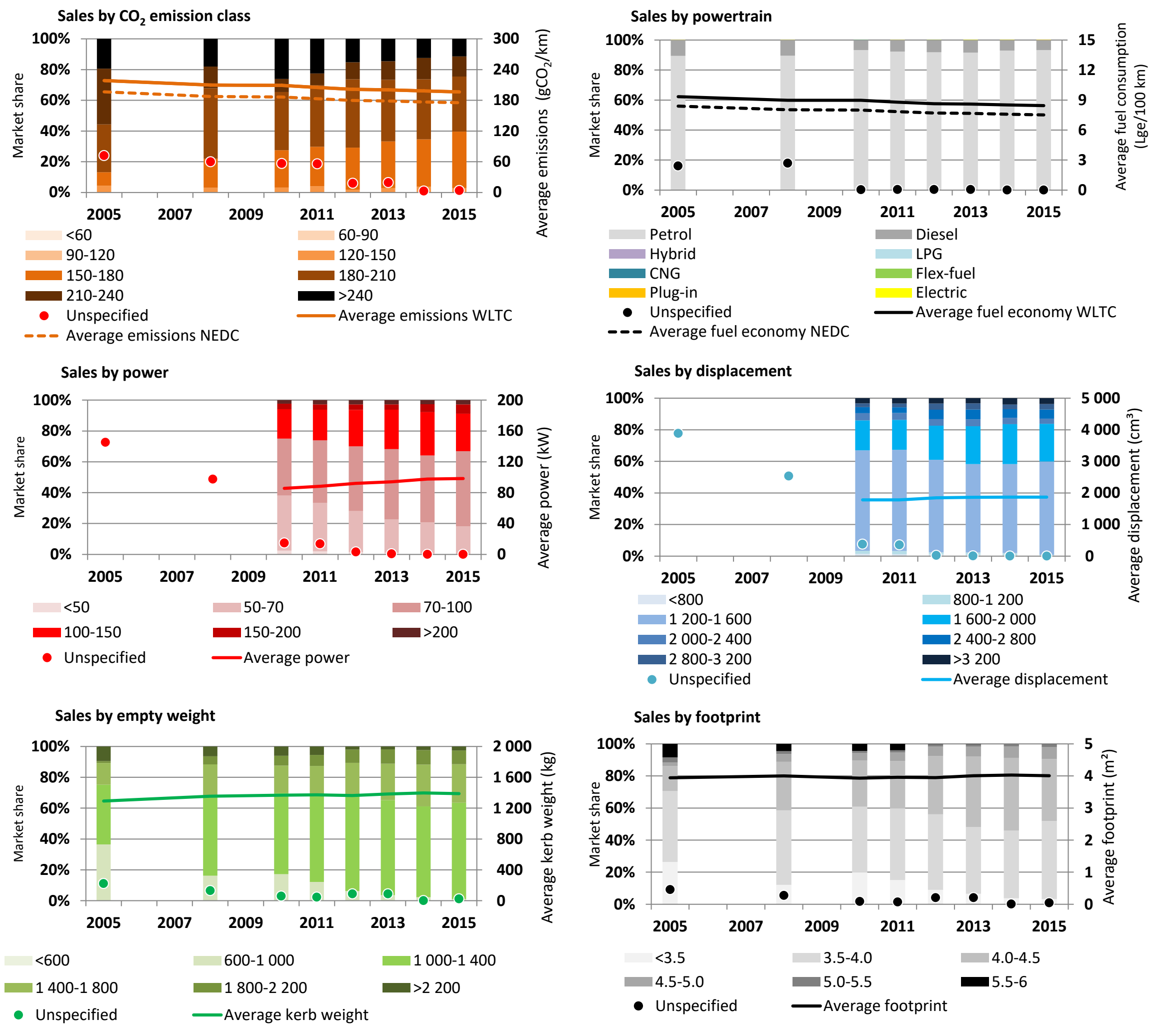
Russian Federation

Country spotlight

Population (million) (World Bank, 2016a): 144
Urban population (% of total) (World Bank, 2016b): 74%
GDP per capita (2014 USD/year) (World Bank, 2016c): 9 100
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015): 75; 81
Fuel tax class (2014) (GIZ, 2015): subsidised fuel price for petroleum fuels

In 2015, new LDV registrations in the Russian Federation totalled about 3 million (IHS Markit, 2016). The on-road stock of LDVs is estimated at 34 million in the same year (IEA, 2016). LDV ownership attained nearly 0.24 LDVs per capita, which is much higher than the average for other countries with comparable levels of personal income. Fuel economy is not regulated in the Russian Federation. However, the Russian Federation levies an annual circulation tax on vehicle owners, which increases progressively with vehicle power (Ernst & Young, 2010).

Figure 72 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, Russian Federation, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Market profile and vehicle characteristics

The Russian Federation faced economic difficulties after 2012, which were also reflected in the LDV market. In 2013, more than 2.7 million new vehicles were registered, close to the 2008 record of 3 million vehicles (IHS Markit, 2016). In 2015, registrations dropped to fewer than 1.5 million, which represented a contraction of more than 40% in just two years. LDV production also fell by 27% to 1.3 million vehicles between 2014 and 2015 (OICA, 2016). For the first time, Lada did not have the largest market share, which was taken over by Hyundai Kia.

Average CO_2 emissions of newly registered LDVs have slowly decreased, falling to 175 g CO_2/km in 2015. The market share of the 150-180 g CO_2/km segment increased by 50% in five years, while that of high-emission vehicles (>240 g CO_2 per vehicle) halved during the same period. Gasoline engines have been the main powertrain in the Russian LDV market. In 2015, 93% of new LDV registrations were powered by a gasoline-fuelled engine.

Between 2010 and 2015, new LDV engines became 15% more powerful, a trend that decelerated in the last year. High-power engines (more than 150 kW) increased their market share at the expense of smaller 50-70 kW engines. During the same period, average engine displacement grew by 5%. By contrast, European Union countries saw growing engine power at the same time as downsizing engine displacement.

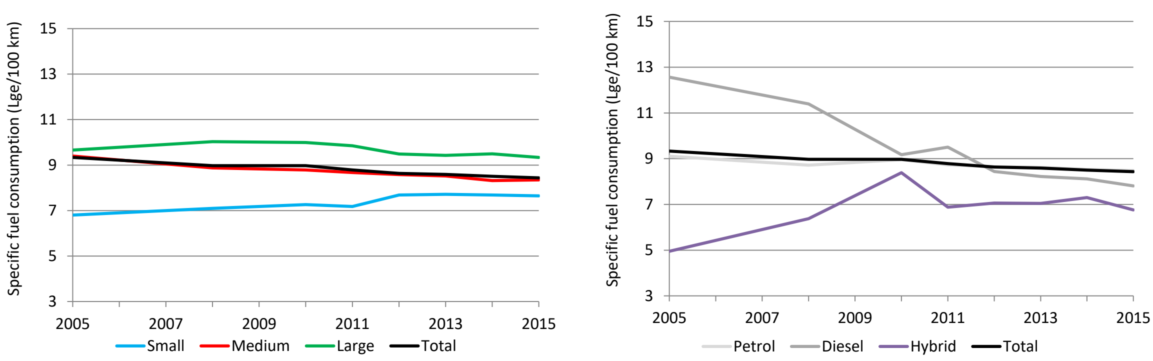
Average vehicle weight in the Russian LDV market fluctuated between 1 350 kg and 1 400 kg, which was higher than most non-OECD countries. The average LDV footprint hovered at around 4 m^2. Market share data indicate a movement towards the middle segment, with less than 10% outside 3.5-4.5 m^2.

Analysis of fuel economy trends

From 2010, large vehicles experienced improving specific fuel consumption, with stagnation between 2012 and 2015 (Figure 73, left). Medium-sized LDVs have seen a continuous decrease in specific fuel consumption since 2005, in line with the total average fuel economy. Newly registered small LDVs saw a deteriorating average fuel economy for most of the years since 2005. However, from 2012 onward this trend reversed, with a minor move towards improvement.

Specific fuel consumption by powertrain also demonstrated contradicting trends (Figure 73, right). While diesels saw improving fuel economy, hybrid vehicles worsened. The trend seen in gasoline LDVs was reflected in total specific fuel consumption due to their high market share.

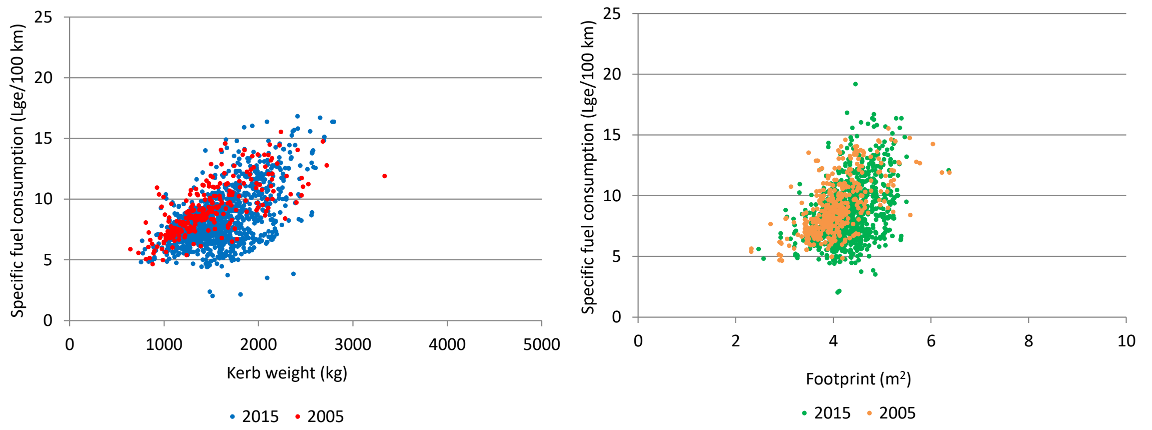
Figure 73 • Average new LDV fuel consumption per km by vehicle segment and powertrain, Russian Federation, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Despite a slowdown in the improvement of average fuel consumption, clear improvement is evident in specific fuel consumption of vehicle models with the same weight between 2005 and 2015. The graph comparing LDV footprint with specific fuel consumption shows LDV models with a larger footprint experiencing limited specific fuel consumption improvement in 2015 compared with 2005.

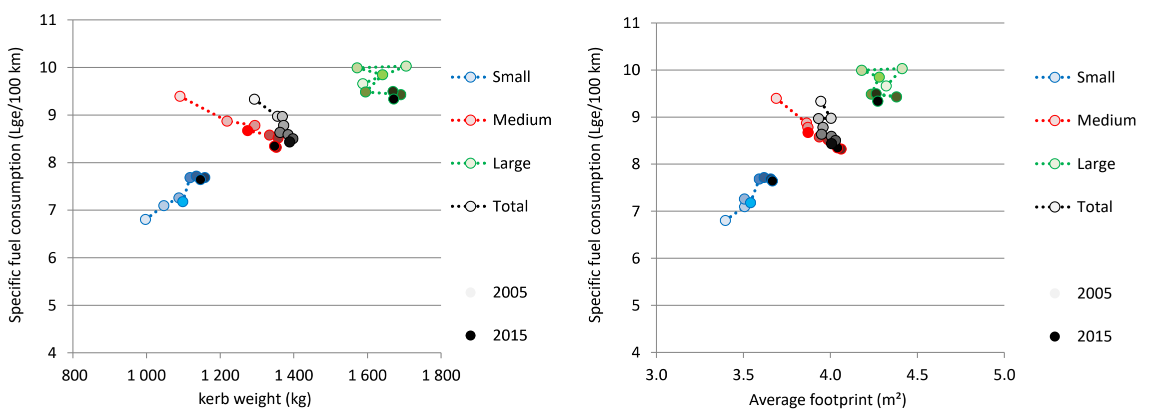
Figure 74 ● Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, Russian Federation, 2005 and 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

The contradicting trends described above are evident in different vehicle segments (Figure 75, left). Since 2010, all vehicle types gained weight, and small LDVs experienced deteriorating specific fuel consumption, while medium LDVs saw improving average fuel economy. Newly registered large LDVs gained some weight between 2010 and 2015, but average fuel economy did not change. The absence of fuel economy regulations is consistent with contradicting trends in the Russian LDV market.

Figure 75 ● Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, Russian Federation, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

South Africa

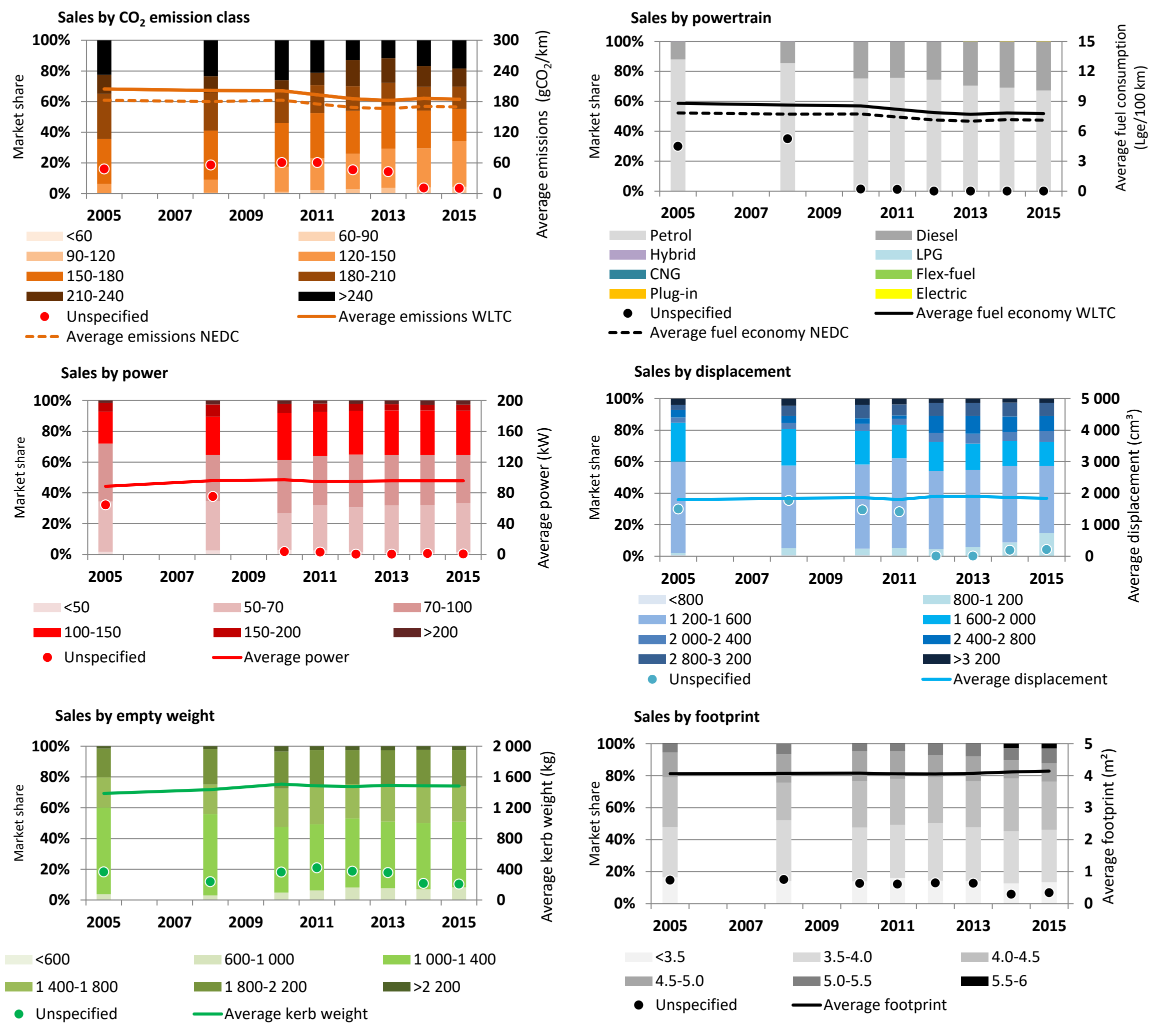
Country spotlight

Population (million) (World Bank, 2016a):	55
Urban population (% of total) (World Bank, 2016b):	65%
GDP per capita (2014 USD/year) (World Bank, 2016c):	5 700
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015):	119; 117

Fuel tax class (2014) (GIZ, 2015): taxed fuel price for petroleum fuels

In 2015, about 590 000 LDVs were sold in South Africa (IHS Markit, 2016). The LDV stock reached 6.6 million vehicles (IEA, 2016a). The LDV ownership rate was 0.12 cars per capita. South Africa has no fuel economy regulations. Since 2008, car dealerships have been obliged to inform clients about the specific fuel consumption of the car through a labelling scheme (UNEP, 2012). Differentiated vehicle registration taxes, including a component that varies according to the CO_2 emissions per km of the vehicle, were introduced in 2010 (OECD, 2013).

Figure 76 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, South Africa, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Market profile and vehicle characteristics

South Africa is one of the leading economies in Africa, which is also reflected in its LDV market, the largest in the continent, even if the number of newly registered LDVs plateaued between 2012 and 2015. In 2015, LDV registrations went down by 4% compared with 2014, to 590 000 vehicles (IHS Markit, 2016). By contrast, South Africa's LDV production grew by 10% year-on-year to 580,000 vehicles in 2015, making it the 23rd largest producer in the world (OICA, 2016). Toyota, Volkswagen and Ford represented almost 50% of new LDV registrations in 2015.

South Africa experienced a downward shift in specific CO_2 emissions between 2010 and 2012, pushed by an updated taxation system. However, progress did not continue, depicted by a flat trend between 2013 and 2015. During the period 2010-15, the market share of diesel LDVs grew from one-quarter to one-third of new LDV registrations. For major EU countries, higher diesel market share comes with lower average CO_2 emissions, but in South Africa this trend was less obvious, mostly caused by more than 80% of diesels being sold in the large car segment. Advanced powertrain technologies are almost non-existent, except for a small amount of electric vehicles.

Average engine power remained relatively stable between 2012 and 2015, at around 96 kW, with almost no change in relative market share. Displacement decreased to 1.8 L between 2013 and 2015, which was similar to the Russian Federation and Chile. Half of all new engines were less than 1.6 L.

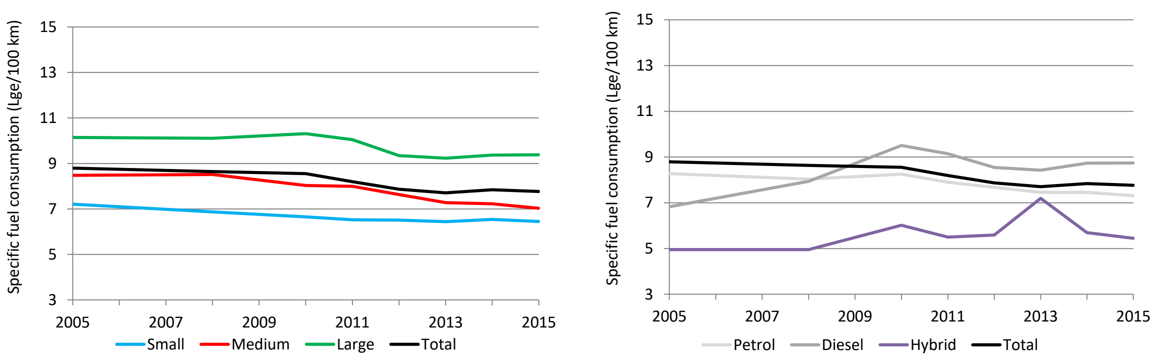
Average weight of newly registered LDVs remained relatively stable in the five most recent years. The average footprint of new LDVs mostly hovered around 4.0 m^2 and rose between 2013 and 2015 towards the worldwide average of 4.1 m^2.

Analysis of fuel economy trends

Medium and large vehicles were primarily responsible for the 2010-12 improvement in specific fuel consumption, as well as for the slowdown towards 2015 (Figure 77, left). The total average fuel economy trend suggests that large vehicles dominated the South African LDV market. Newly registered small LDVs modestly improved their average fuel economy from 2005 to 2013, after which it worsened a little.

Diesel-fuelled vehicles experienced an improvement in specific fuel consumption between 2010 and 2012, while they lost half of this improvement in the period 2013-15. The large gap in specific fuel consumption between diesel- and gasoline-driven LDVs (8.7 Lge/100 km vs 7.3 Lge/100 km) confirms the worsening fuel economy as being caused by more diesel registrations.

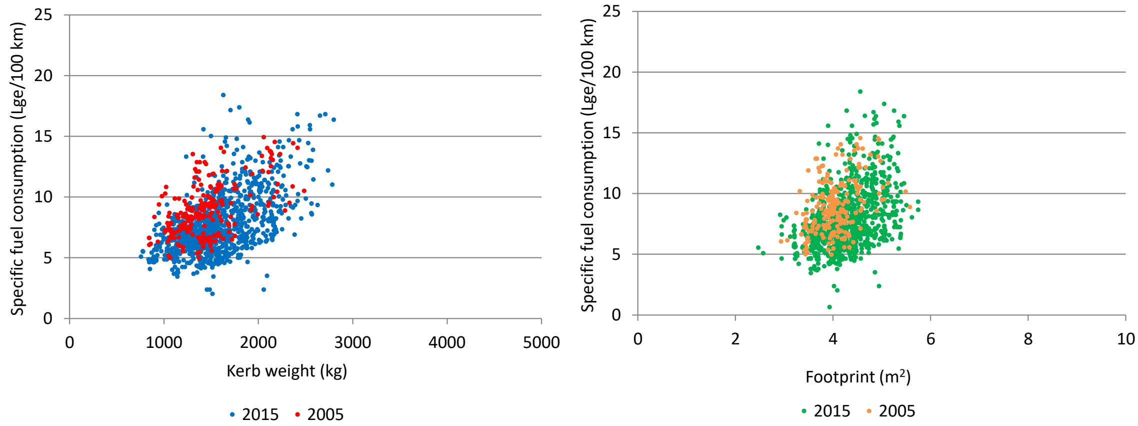
Figure 77 • Average new LDV fuel consumption per km by vehicle segment and powertrain, South Africa, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

South Africa's LDV market diversified in the direction of heavier and larger vehicles from 2005 to 2015 (Figure 78). Furthermore, LDVs of equal weight improved specific fuel consumption from 2005 to 2015 vehicle models.

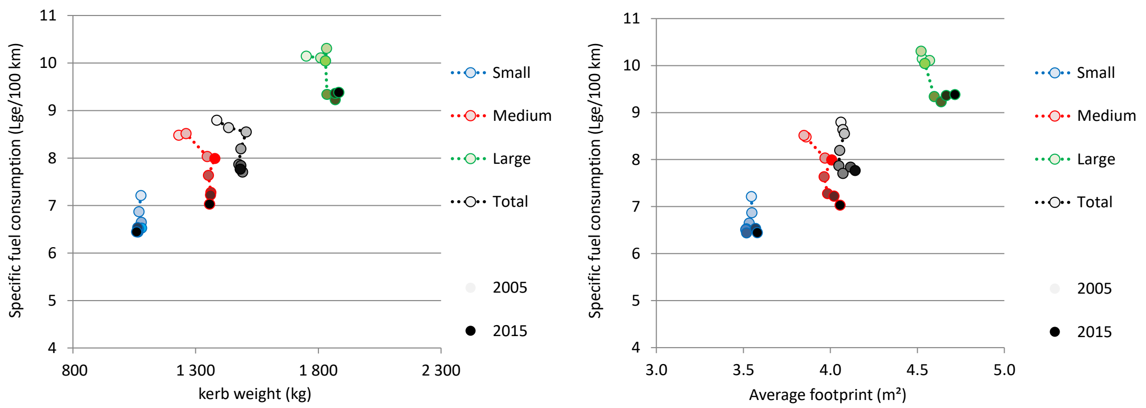
Figure 78 • Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, South Africa, 2005 and 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Plots of fuel consumption by vehicle segment as a function of empty weight and footprint (Figure 79) show that the introduction of the differentiated taxation of newly registered vehicles in 2010 had a visible impact on the way vehicles were marketed in South Africa. Prior to 2010, South Africa followed a pattern characteristic of unregulated and developing car markets: vehicle weight and footprint increased, while fuel economy improvement was of secondary importance for most consumers. After 2010 and until 2013, the line graphs are almost vertical, suggesting that fuel economy became a reference parameter for vehicle sales, limiting or cancelling the earlier shift towards heavier and larger cars in all segments. Despite the good developments in 2010 to 2013, fuel economy improvements stagnated in 2014 and 2015, when footprints increased slightly across all segments.

Figure 79 • Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, South Africa, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Thailand

Country spotlight

Population (million) (World Bank, 2016a):	68
Urban population (% of total) (World Bank, 2016b):	50%
GDP per capita (2014 USD/year) (World Bank, 2016c):	5 800
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015):	150; 100

Fuel tax class (2014) (GIZ, 2015): no entry

In 2015, the Thai market for new LDVs totalled nearly 760 000 vehicles (IHS Markit, 2016). The LDV stock reached almost 12 million in the same year (IEA, 2016a). LDV ownership was 0.175 LDVs per capita, which is high compared with other countries with similar average income: Thailand has almost double the ownership rate of China, despite the fact that Chinese per capita income is about USD 2 200 higher. LDV ownership in Thailand is also higher than in Brazil or Chile, while per-capita income is 50-100% higher in these countries. More than 50% of newly registered LDVs in Thailand are pick-up trucks. This is largely a result of tax breaks for these vehicles. Thailand has no fuel economy standards in place, but is currently developing them. Since October 2015, car dealerships have been obliged to inform clients about the specific fuel consumption of vehicles for sale (in addition to information such as the pollutant emission class of the vehicle) through a labelling scheme based on CO_2 ratings. The scheme has been used as the basis for the new excise tax rates from 1 January 2016 (FIA Foundation, 2016). A tax incentive for the production of “eco-vehicles” was established in 2009, offering reduced excise taxes (17% instead of 30%) for cars complying with specific requirements (UNESCAP, 2011).

Market profile and vehicle characteristics

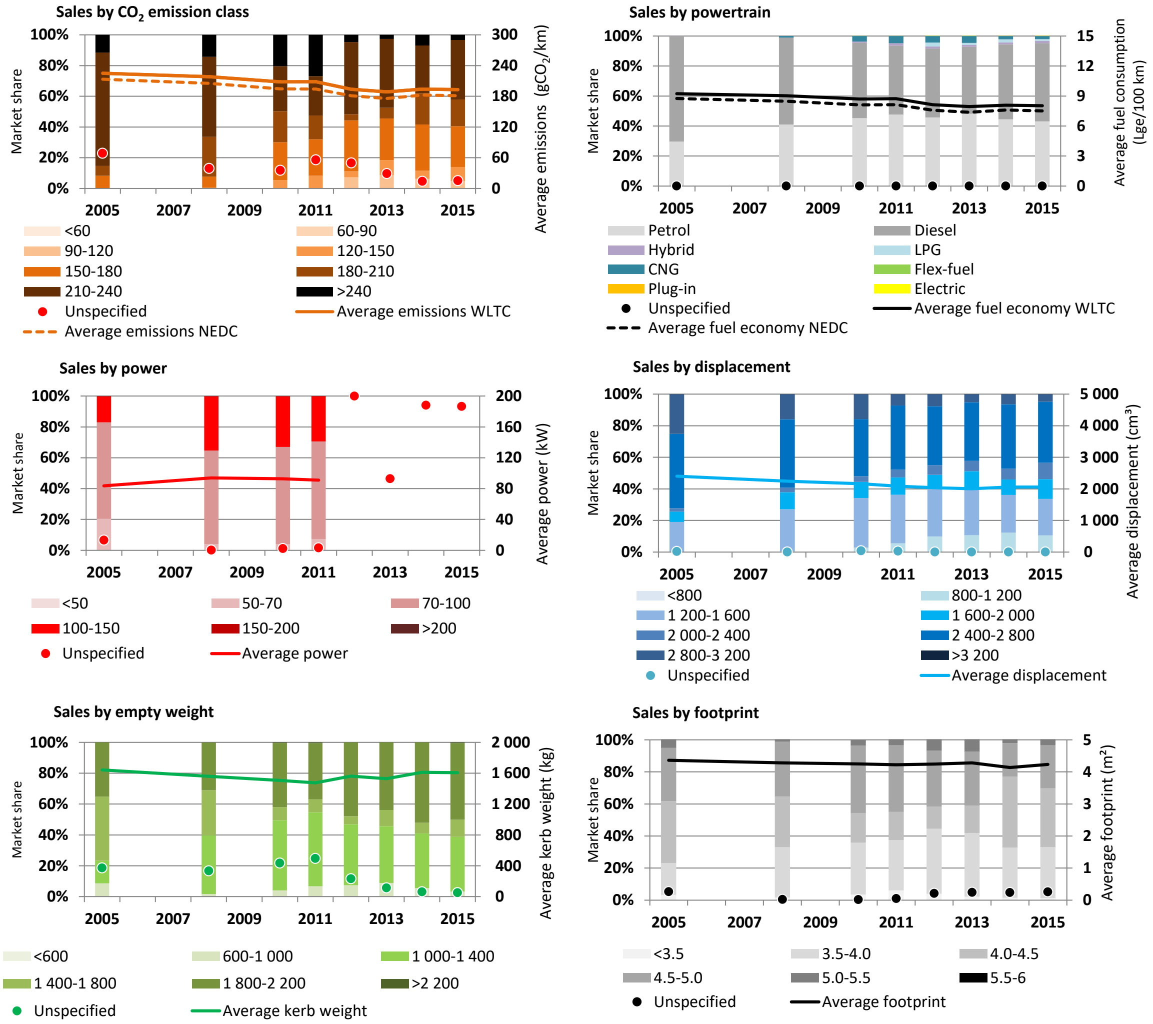
After a rapid expansion of LDV registrations between 2011 and 2013 as a result of the First Car policy – a tax refund scheme to foster domestic car production after the 2011 flood, Thailand’s LDV market shrunk by more than 40% between 2013 and 2015, falling to 760 000 registrations in the latest year (IHS Markit, 2016). Japanese OEMs remain as popular as in 2013, leading the market with approximately 90% of LDV sales. As in many emerging economies, growth slowed down in the years up to 2015. At the same time, domestic production of LDVs was stable between 2014 and 2015, maintaining its twelfth place worldwide by producing almost 1.9 million vehicles.

In 2015, newly registered LDVs emitted on average 193 g CO_2/km, the third year without noticeable improvement. High-emission vehicles (210-240 g CO_2/km) lost 20% of their market share between 2012 and 2015, while low-emission vehicles (90-120 g CO_2/km) halved their share in the same period, leading to stagnating progress. Diesel and gasoline engines had equal market share in 2012, after which diesels gained in popularity, growing by 15% between 2012 and 2015, while gasoline vehicles lost 5%. CNG and LPG cars did not sustain their popularity, going from 6% market share in 2013 to 3% in 2015.

Data regarding the average power of newly registered LDVs was insufficient for clear outcomes. After a steep decline in average displacement up until 2013, a reverse trend was seen up to 2015, approaching 2.1 L in 2015. Average displacement in Thailand was more than 40% higher compared with other Southeast Asian countries, such as Indonesia, primarily because of the high sales share of pick-up trucks.

After a small reduction in average weight between 2012 and 2013, new LDVs in 2014 and 2015 weighed around 1600 kg, which was roughly 5% more than 2013. Few vehicles were sold in the two lowest weight categories, while the high segment (1 800-2 200 kg) encompasses more than 50% of the market. The average footprint of newly registered LDVs shrank between 2013 and 2014 due to the First Car policy which targeted consumers buying their first new car ever – mostly small or lower medium class cars, but increased between 2014 and 2015, when the scheme ended. The rise in weight and footprint could be one of the main causes of stagnating improvement in fuel economy.

Figure 80 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, Thailand, 2005-15

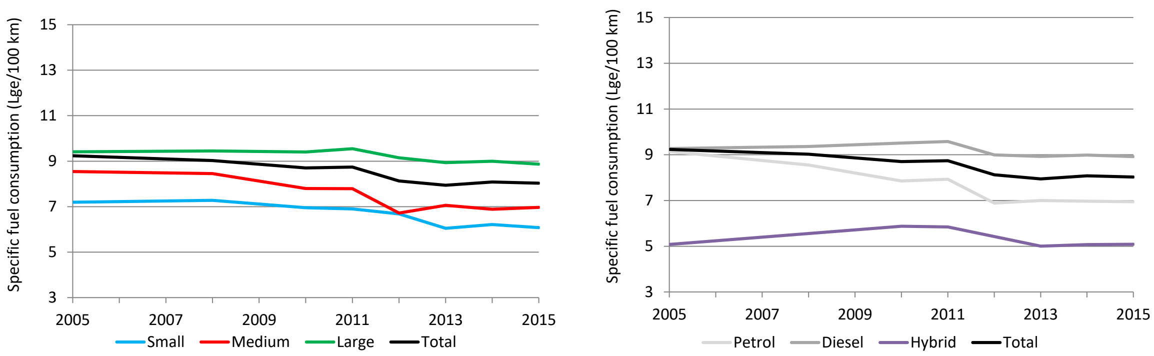


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Analysis of fuel economy trends

All vehicle segments saw nearly flat average fuel economy between 2013 and 2015 (Figure 81). The total average fuel consumption of 8.0 Lge/100 km was just above the non-OECD average of 7.9 Lge/100 km. Diesel and gasoline powertrains had a similar trend in average fuel economy (Figure 81, right). However, since diesels were mostly sold in pick-up trucks, they had an average fuel economy that was approximately 30% worse than gasoline-fuelled vehicles, providing further insight into the reasons for stagnating fuel economy, alongside the increased popularity of diesels. The gap between diesels and gasoline powertrains was also observed in other emerging economies due to the bias of diesels for larger vehicles and SUVs.

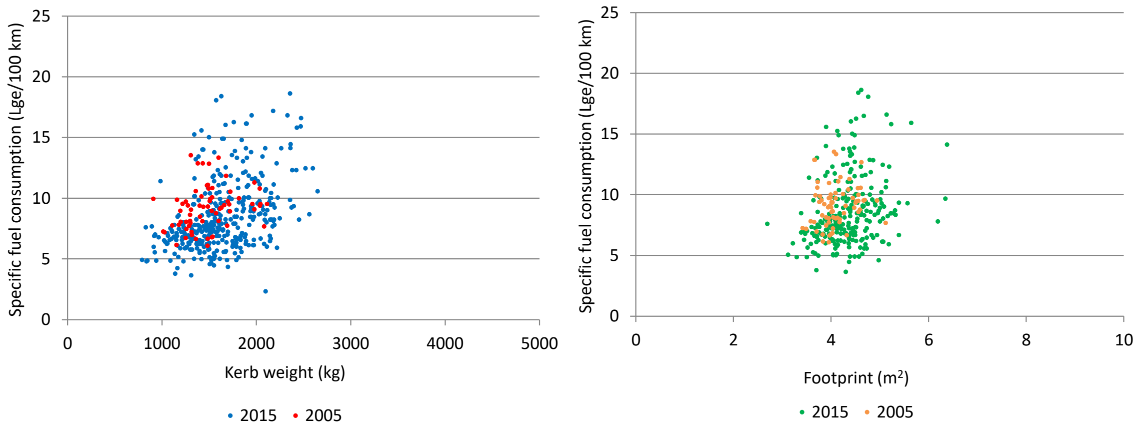
Figure 81 • Average new LDV fuel consumption per km by vehicle segment and powertrain, Thailand, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Thailand's LDV market was limited in a similar way to India and Indonesia regarding available model types, confirming a trend within the South/Southeast Asia regions. The 2015 data points are more spread out in comparison to the clouds in 2005, indicating a more diversified market (Figure 82). LDVs of equal weight became somewhat more efficient up to 2015, with no clear trend for footprint compared with specific fuel consumption. The results for 2013 (IEA, 2016a) showed a much clearer specific fuel consumption improvement with similar weight over time, confirming the recent stagnation in average fuel economy in Figure 81.

Figure 82 • Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, Thailand, 2005 and 2015

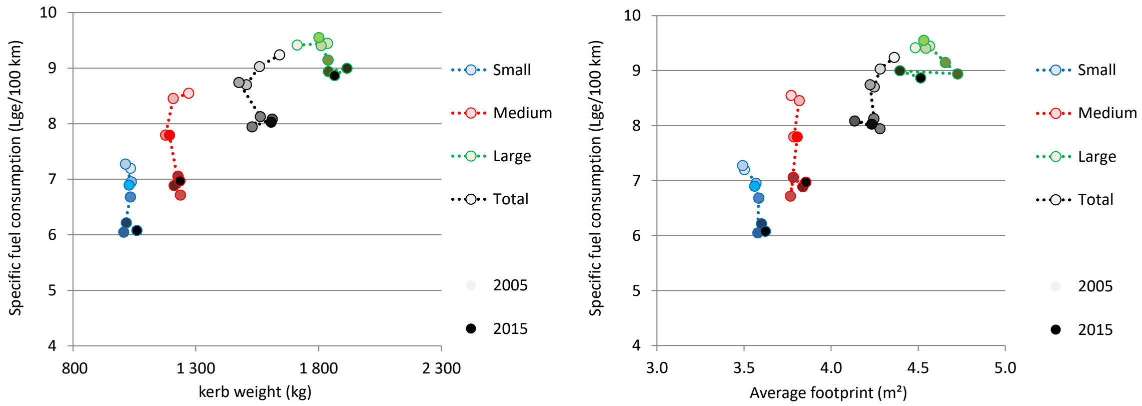


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Both small and medium LDVs experienced decreasing average weight with stalling improvement in fuel economy (Figure 83, left). Over the ten years 2005-15, large LDVs grew heavier and average fuel economy development also stagnated.

Footprint data show similar signs of stagnation (Figure 83, right). Small vehicles saw their specific fuel consumption improve, while their footprint grew somewhat larger, though stagnating between 2012 and 2015. Medium vehicles reduced in size under strong specific fuel consumption advancement. Large vehicles showed unclear developments, strongly influencing total specific fuel consumption progress.

Figure 83 • Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, Thailand, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Turkey

Country spotlight

Population (million) (World Bank, 2016a):	78.6
Urban population (% of total) (World Bank, 2016b):	73%
GDP per capita (2014 USD/year) (World Bank, 2016c):	9 000
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015):	206; 190

Fuel tax class (2014) (GIZ, 2015): highly taxed petroleum fuels

In 2015, about 940 000 LDVs were sold in Turkey (IHS Markit, 2016). The LDV stock reached 7.5 million in the same year (IEA, 2016a), and LDV ownership attained 0.095 cars per capita, lower than in countries with a comparable income level (e.g. Brazil). Turkey does not have dedicated fuel economy policies in place, but it imposes gasoline and diesel taxes that are among the world's highest (GIZ, 2015). Turkey also imposes an annual vehicle circulation tax that is a function of engine size (with progressive increases above 1.6 L) and vehicle age (the circulation tax decreases with vehicle age) (IA-HEV, 2016).

Market profile and vehicle characteristics

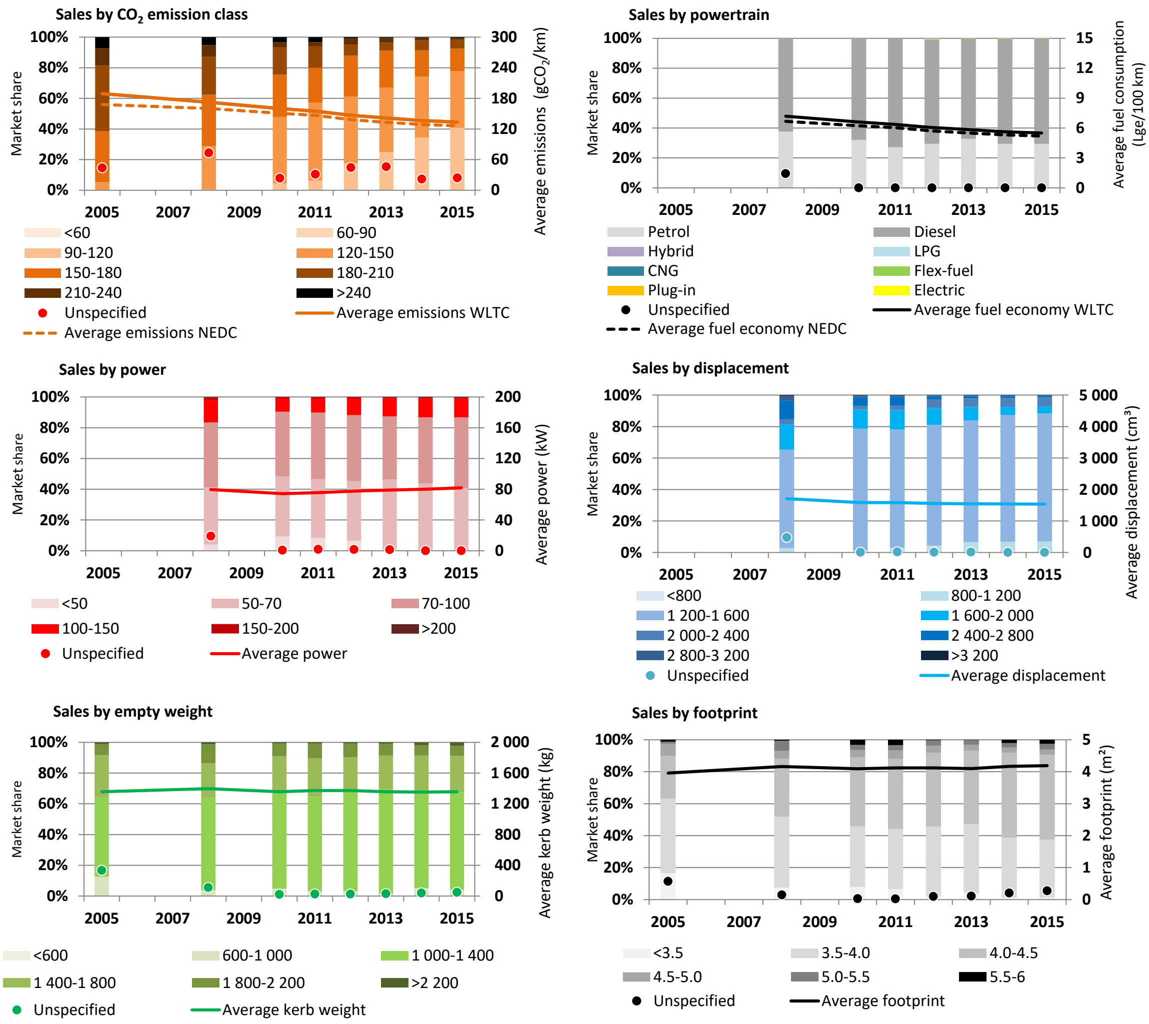
Turkey's LDV market size fluctuated between 750 000 and 850 000 vehicles in the period 2010-14. However, the LDV market suddenly grew by 25% to 940 000 vehicles in 2015 (IHS Markit, 2016). Turkey produces more LDVs than it registers; in 2015, the country produced 1.3 million vehicles, which is 16% more than the year before (OICA, 2016).

Turkey's average CO_2 emissions per km continuously fell between 2005 and 2015. In 2015, CO_2 emissions were approximately 135 g CO_2/km. High-emission vehicles (more than 180 g CO_2/km) quickly lost market share to low-emission vehicles (60-90 g CO_2/km). Average fuel economy improved by more than 30% in the same period. Turkey's average fuel economy was the second-best in the world, improving another 2.5% to 5.5 Lge/100 km in 2015. Between 2010 and 2015, almost 70% of LDV registrations were diesel powered, topping France as the country with the highest share of diesel sales. Sales of alternative powertrains remained very marginal.

Between 2010 and 2015, the average engine power of new LDVs rose by 10%, reaching 82 kW in 2015, similar to that in France. During the same five-year period, average displacement decreased to close to 1.5 L, down 4% from 2010. Increasing power while decreasing displacement indicates that Turkey's LDV market experienced similar technological improvements to EU countries.

The average weight of Turkish vehicles underwent little change, with a small drop from 1 375 kg to 1350 kg between 2011 and 2015. Almost 70% of the new LDVs weighed 1 000-1 400 kg. Surprisingly, vehicles above 2 200 kg more than doubled their market share between 2013 and 2015. Analysis of average footprint shows that Turkey's footprint floated between 4.1 m^2 and 4.2 m^2, increasing a little due to the increased popularity of SUVs in all segments.

Figure 84 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, Turkey, 2005-15

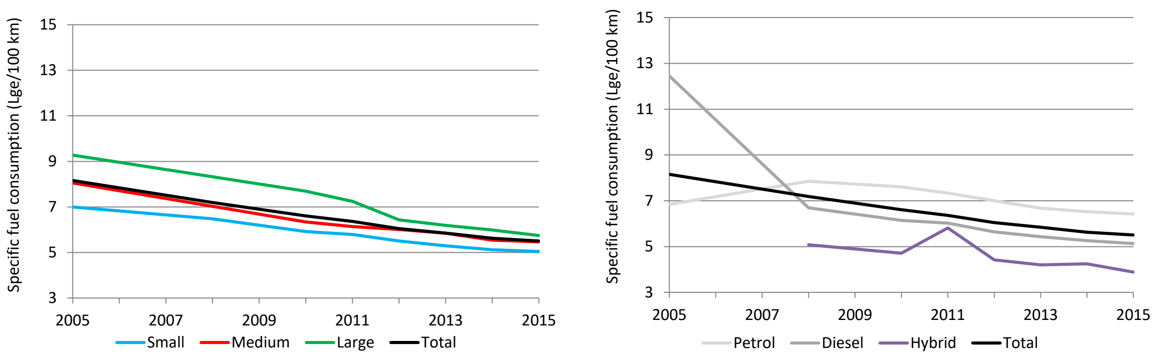


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Analysis of fuel economy trends

All segments saw a continuous downward trend for the period 2005-15 (Figure 85, left). The period 2011-15 was characterised by converging specific fuel consumption, particularly with respect to large vehicles. In the absence of fuel economy standards, this is evidence that wider vehicle efficiency and fuel policies also have the potential for substantial impacts on LDV fleet efficiency, partially driven by the popularity of regulated European OEM models in the Turkish market (IEA, 2016a). Also, both diesel- and gasoline-driven vehicles saw constant improvement from 2008 until 2015. In 2015, new diesel LDVs had an average fuel economy that was 25% better than their gasoline counterparts. Hybrid vehicles had the best fuel economy rating across all powertrains, exceeding diesels by 30% in 2015.

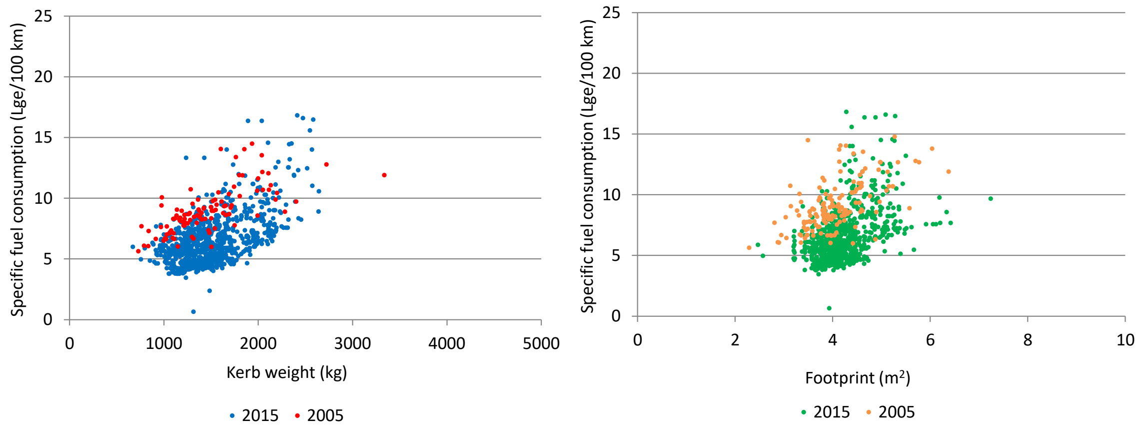
Figure 85 ● Average new LDV fuel consumption per km by vehicle segment and powertrain, Turkey, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Plotting vehicle model specific fuel consumption against weight and footprint (Figure 86) demonstrates progress similar to major European countries, such as France and Germany. LDVs with the same weight clearly had a better specific fuel consumption in 2015 compared with 2005. The same improvement is seen for LDV footprint. Between 2005 and 2015, Turkey's LDV market experienced an more extreme diversification of models compared with European economies (as demonstrated by the much greater 2015 clouds in Figure 86), even if newly registered LDV models hardly changed weight or size during the ten years up to 2015.

Figure 86 ● Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, Turkey, 2005 and 2015

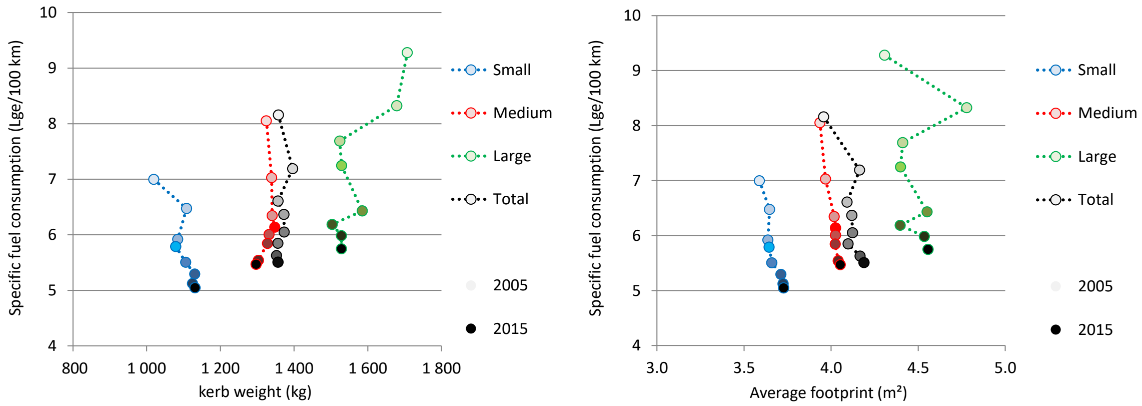


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

New small LDVs gained weight, while improving their specific fuel consumption (Figure 87, left). Medium and large LDVs lost weight while rapidly advancing in fuel efficiency. Large vehicles experienced the greatest improvement in specific fuel consumption. All three segments showed signs of stagnating average fuel economy improvement in the last three years up to 2015.

When comparing average fuel economy to footprint (Figure 87, right), newly registered small and medium LDVs experienced a small increase in footprint, while improving their average fuel efficiency. Large vehicles had fluctuating footprints, while average fuel economy improved at a faster pace than the other size segments.

Figure 87 • Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, Turkey, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

United Kingdom

Country spotlight

Population (million) (World Bank, 2016a):	65.1
Urban population (% of total) (World Bank, 2016b):	83%
GDP per capita (2014 USD/year) (World Bank, 2016c):	43 700
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015):	192; 199

Fuel tax class (2014) (GIZ, 2015): taxed petroleum fuels

In 2015, about 3 million LDVs were sold in the United Kingdom (IHS Markit, 2016). The LDV stock totalled nearly 30 million cars (IEA, 2016a). LDV ownership amounted to 0.521 LDVs per capita. Voluntary CO_2 emission standards were first introduced in the European Union in 1998, and they became mandatory in 2009. The 2015 target of 130 g CO_2/km for passenger cars was met in advance (EEA, 2016). By 2021, CO_2 emissions of passenger cars are required to meet 95 g CO_2/km (based on NEDC). LCVs are required to attain 147 g CO_2 /km (based on NEDC) (TransportPolicy, 2016).

Passenger vehicles that emit less than 100 g CO_2/km are not subject to annual circulation tax. Other advanced powertrains are subject to reduced tax rates (ACEA, 2016). Business BEVs are not eligible to pay company vehicle tax for vehicles registered after 2010. All vehicles below 50 g CO_2/km only have to pay 5% company tax, starting from 2015. Furthermore, the United Kingdom initiated a plug-in car grant in 2011, providing a 25% grant (up to GBP 5 000 or USD 6 150) for vehicles emitting less than 75 g CO_2/km (UK Government, 2016).

Market profile and vehicle characteristics

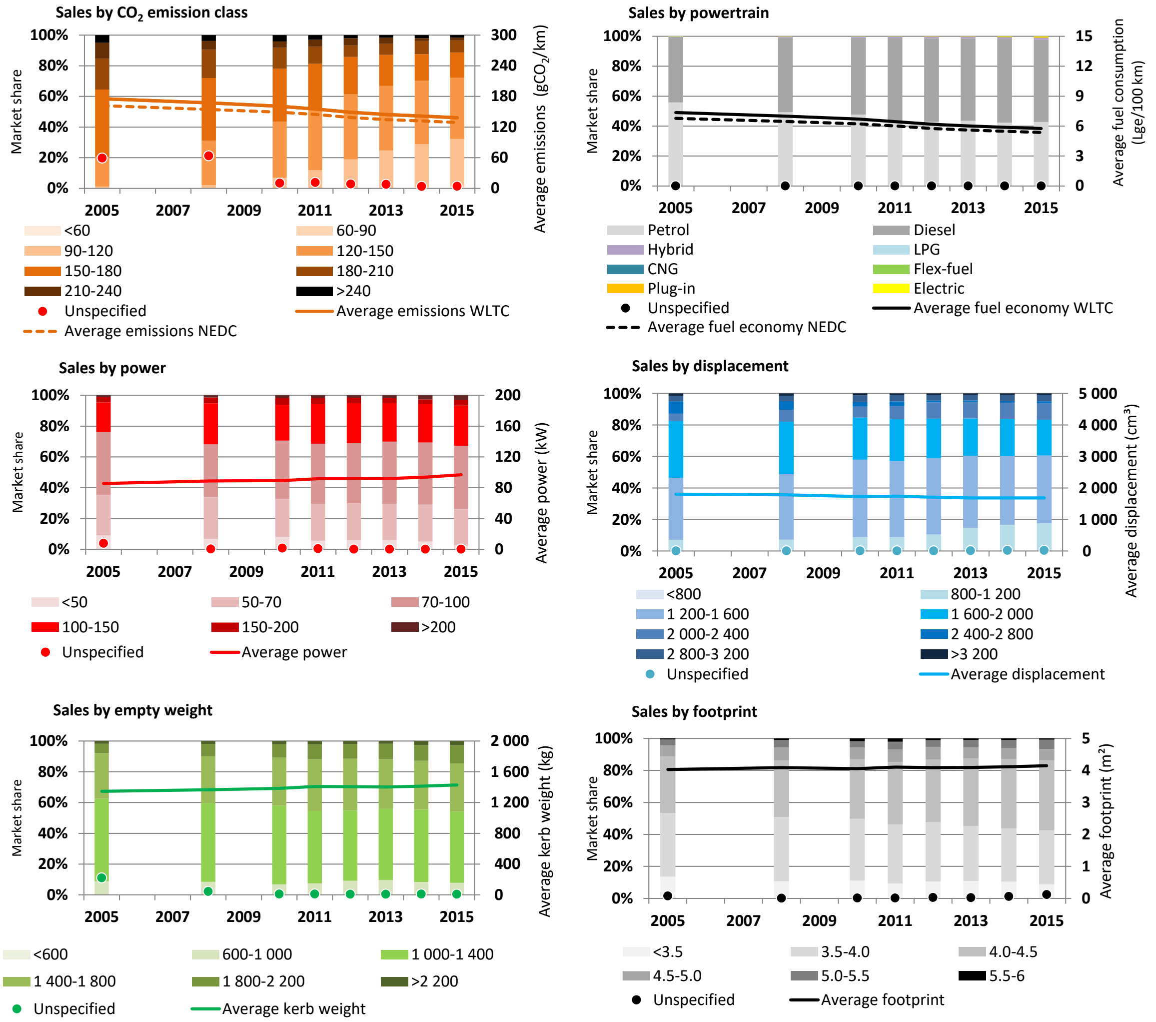
The UK LDV market grew by almost 50% in five years to more than 3 million newly registered LDVs between 2010 and 2015 (IHS Markit, 2016). Growth in domestic production was more modest, totalling 1.7 million vehicles in 2015, making it the thirteenth largest LDV producer in the world (OICA, 2016). European and US OEMs were most popular, holding more than 60% of the market share.

The United Kingdom experienced a clear downward trend in average LDV CO_2 emissions between 2005 and 2015 (Figure 88). After 2010, the market share of LDVs that emit 90-120 g CO_2/km grew almost fivefold, while that of vehicles emitting more than 150 g CO_2/km halved during the same period. Similar to many European countries, diesels became the dominant powertrain in the late 2000s. After 2011, around 55% of new vehicles sold were diesels, compared with 45% for gasoline-fuelled LDVs. More advanced powertrains represented less than 5% of the UK LDV market in 2015, although plug-in LDVs tripled their share in the three latest years. Improvement in average fuel economy slowed between 2013 and 2015 compared with the three previous years.

During the period between 2005 and 2015, average power of new LDVs rose by almost 15% to 97 kW in 2015. At the same time, average displacement continued to fall between 2008 and 2015. Engines with a displacement between 1.2 and 2.0 L lost market share, while smaller and larger engines both became more popular. LDVs with engines between 0.8 L and 1.2 L doubled in market share.

After a dip in average weight between 2011 and 2013, British LDVs became slightly heavier in 2014 and 2015. New LDVs in the UK are 6% heavier than new French LDVs, but 3% lighter than German ones. The average footprint of newly registered LDVs experienced a similar trend, growing slowly between 2013 and 2015. This is most likely caused by increased popularity of small and medium SUVs.

Figure 88 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, United Kingdom, 2005-15



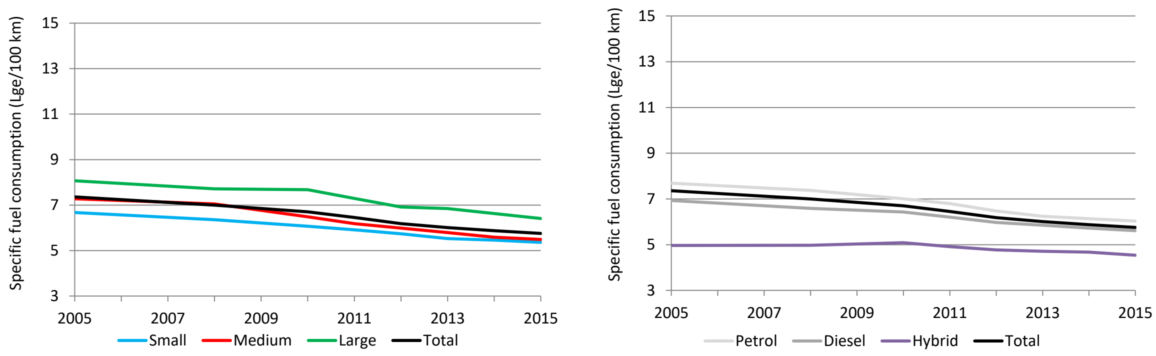
Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Analysis of fuel economy trends

All segments experienced continuous average fuel economy improvement, with an uneven pattern in the large segment (Figure 89, left). Small and medium vehicles converged to less than 2% difference in 2015.

As in other European countries, diesels were a little more efficient than gasoline LDVs. In 2015, the gap between both powertrains' specific fuel consumption was around 8%. Hybrids experienced a clear improvement between 2010 and 2015, being around 20% more fuel efficient than diesels. However, hybrids' low market share hardly affected the progress of total average fuel economy.

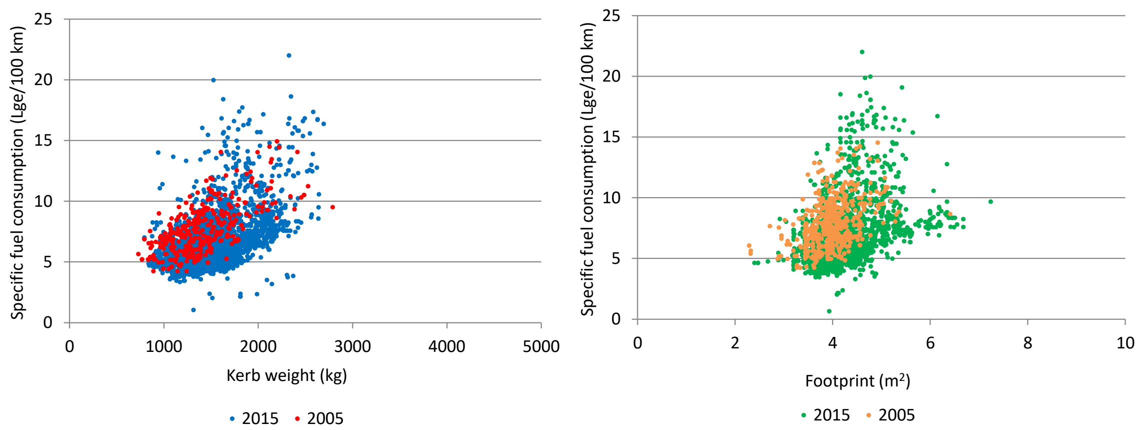
Figure 89 ● Average new LDV fuel consumption per km by vehicle segment and powertrain, United Kingdom, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

The UK followed EU trends when plotting weight and footprint against specific fuel consumption (Figure 90). New LDVs became more fuel efficient when comparing models of similar weight and footprint in 2015, as compared with models in 2005. Greater variability was also observed, as in other LDV markets.

Figure 90 ● Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, United Kingdom, 2005 and 2015

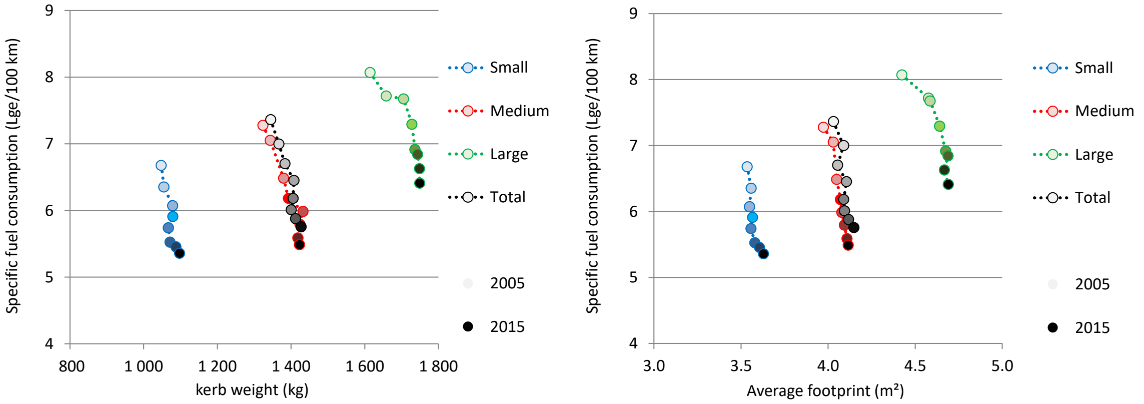


Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Very clear improvement in fuel economy was evident for all vehicle segments (Figure 91, left). These steady rates of improvement confirm that fuel economy regulations are delivering results comparable to other European countries. Total specific fuel consumption closely followed that of the medium segment. For all three segments, weight has been on the rise, somewhat inhibiting fuel economy improvements.

Comparing specific fuel consumption with average footprint shows that total average footprint closely followed the medium segment. All vehicle segments increased their footprint between 2005 and 2015, particularly small vehicles between 2012 and 2015. This increase ran during the same years as weight increased for small LDVs.

Figure 91 • Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, United Kingdom, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

United States

Country spotlight

Population (million) (World Bank, 2016a):	321
Urban population (% of total) (World Bank, 2016b):	82%
GDP per capita (2014 USD/year) (World Bank, 2016c):	55 800
Average price gasoline and diesel (USD cent per L, 2014) (GIZ, 2015):	86; 97

Fuel tax class (2014) (GIZ, 2015): taxed petroleum fuels

In 2015, about 16.6 million LDVs were sold in the United States (IHS Markit, 2016). The LDV stock totalled 204 million (IEA, 2016a). LDV ownership was slightly below 0.7 LDVs per capita. Each household in the United States owned on average 1.9 cars (US Census, 2016). Fuel economy regulations were first established in the 1970s. The CAFE standards were introduced in 1975. Fuel economy labelling of new cars was introduced as early as 1978 (ICCT, 2014c). Even if the United States pioneered their introduction, the historical evolution of regulatory limits underwent distinct phases, including decades (late 1980s, 1990s and early 2000s) of stagnation. This resulted in deteriorating fuel economy due to a market shift towards larger vehicles. In 2009, the stringency of fuel economy improvements for models entering the market between 2012 and 2016 was strengthened considerably. Compared with 2009, by 2016 average CO_2 emissions per km must be reduced by 26% (of about 4.2% per year). Targets were extended to 2025 and will require a 35% reduction in average fuel use per km from 2016 (TransportPolicy, 2016).

Market profile and vehicle characteristics

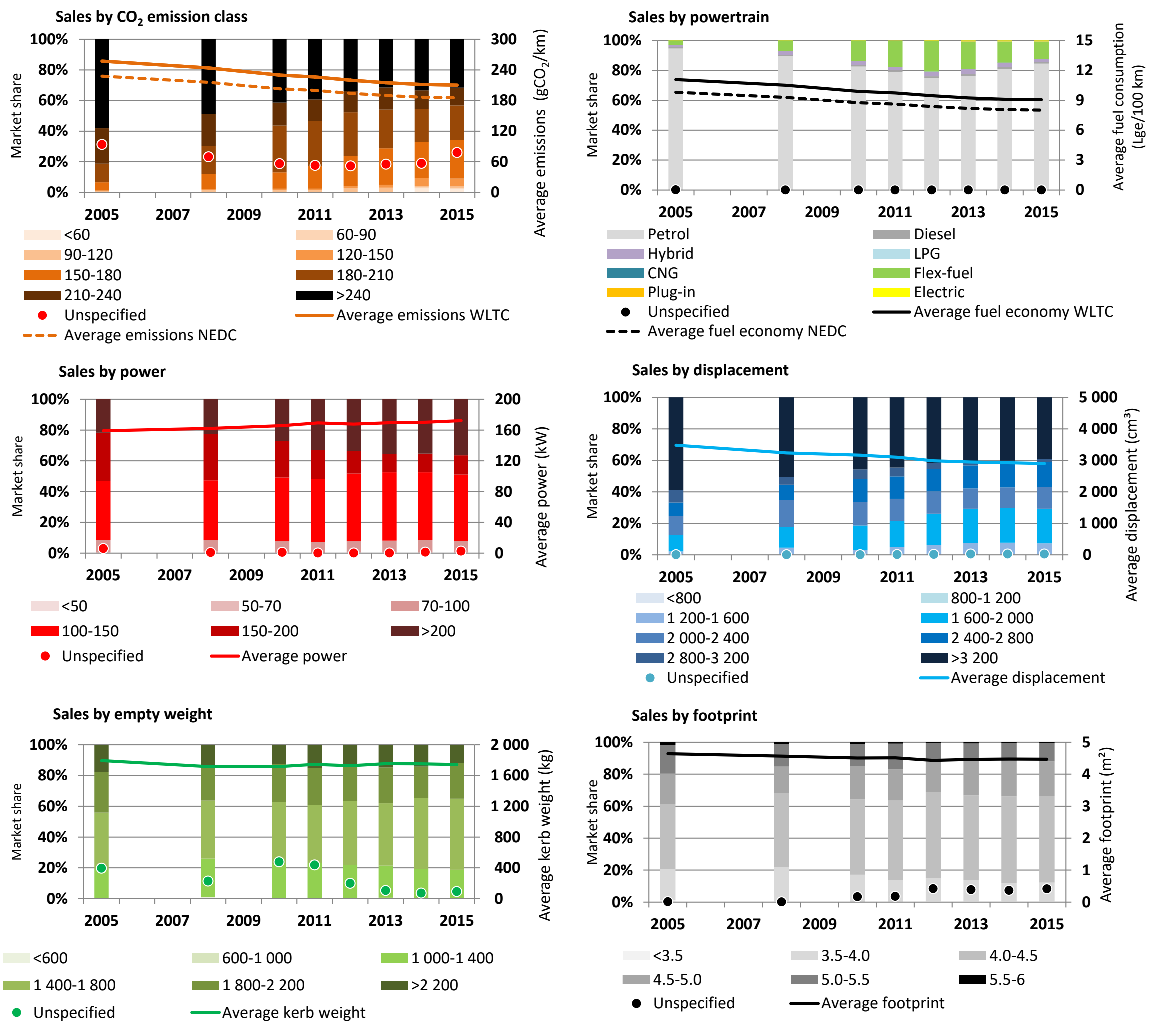
The United States is well known for its extensive vehicle stock and the high share of SUVs and pick-up trucks, accounting for almost 60% of all new LDVs. In 2015, LDV sales reached a new all-time high, with over 16.6 million new vehicle registrations (IHS Markit, 2016). Nevertheless, the US LDV market has been surpassed by China since 2010. As with registrations, domestic LDV production surged. In 2015, the United States overtook Japan as the second-largest global LDV producer. The number of vehicles produced surpassed 11.8 million in 2015, approximately half of China's production (OICA, 2016).

Newly registered LDVs had CO_2 emissions per km exceeding those of most other countries, reaching 210 g CO_2/km in 2015. However, serious improvements were observed, highlighted by the 19% difference in average fuel economy between 2005 and 2015. From 2010, vehicles in the segments under 180 g CO_2/km gained market share and even the market share of low-emission vehicles (less than 60 g CO_2/km) reached 2-3% after 2013, although the results are uncertain due to a relatively high number of unspecified vehicles. Regarding powertrains, flex-fuel lost its popularity after 2012 and hybrids' market share also diminished. In 2015, gasoline engines represented over 85% of total registrations, while diesels did not exceed 1%. Overall, between 2010 and 2015, average fuel economy of newly registered LDVs improved by almost 10% to 9.1 Lge/100 km.

Newly registered LDVs in the United States had significantly more power than in most OECD economies. Between 2005 and 2015, average power increased even further, from 160 kW to 170 kW, which was more than 60% higher than new LDVs in Germany. Vehicles in the highest power class (>200 kW) gained most market share, fuelled by a growing popularity of medium and large SUVs. A clear downward trend was noticed in engine displacement, implying engine technology advancement in the United States. Nevertheless, US LDV engines were among the largest in the world, reaching 2.9 L on average in 2015. The largest engine size category (>3.2 L) lost market share to smaller engines (1.6-2.0 L).

As in many other OECD countries, weight has been a relatively stable factor, fluctuating between 1 750 kg and 1 800 kg in the period between 2010 and 2015. In the last three years, heavy vehicles (>2 200 kg) and light vehicles of 1 000-1 400 kg lost market share to the middle segment. With an average footprint of over 4.5 m^2 in 2015, newly registered US LDVs were more than 10% larger than in other OECD countries. Between 2010 and 2015, almost no change in footprint was observed.

Figure 92 • LDV market by g CO_2/km, powertrain, power, displacement, weight and footprint, United States, 2005-15



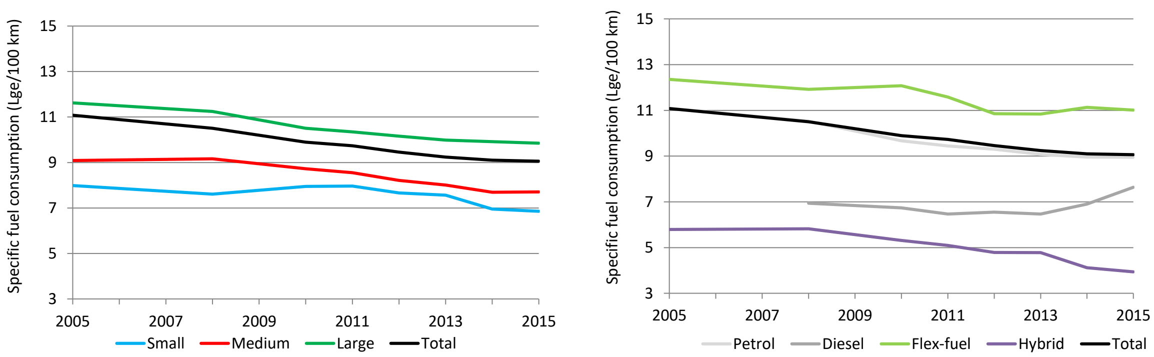
Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Analysis of fuel economy trends

The total fuel economy trend (Figure 93) shows that large vehicles dominate the US LDV market. Large and medium-sized vehicles saw a steady improvement in average fuel economy from 2005 to 2014, experiencing a flattening line between 2014 and 2015. Small LDVs saw am improvement in their average fuel economy between 2008 and 2011 and improved until 2015, although the average fuel consumption is two-thirds higher than the EU average and closer to countries such as Brazil.

The data confirm the dominance of gasoline LDVs and show large gaps between the efficiency of gasoline, diesel and hybrid vehicles (Figure 93, right). Newly registered hybrids had an average fuel economy that was almost 65% better than gasoline-driven vehicles. From 2013 to 2015, diesels saw a worsening in their average fuel economy, indicating that diesels were increasingly sold in the larger size segments. Flex-fuel LDVs showed the worst performance of any powertrain, finishing more than 20% above the total average fuel economy in 2015.

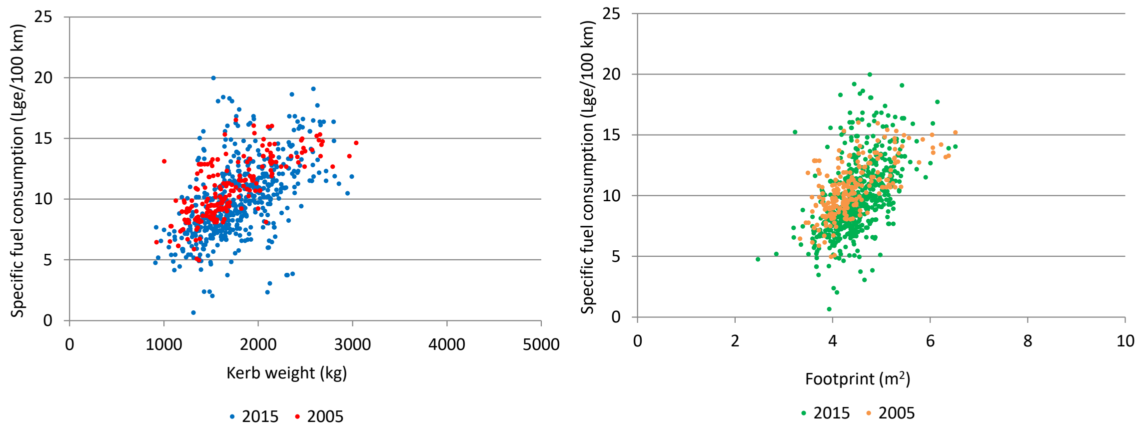
Figure 93 • Average new LDV fuel consumption per km by vehicle segment and powertrain, United States, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Weight and specific fuel consumption of new LDVs were more dispersed in 2015 than they were for new models in 2005 (Figure 94). An improving specific fuel consumption is apparent when weight or footprint is kept stable (both have changed little since 2013), given the higher frequency of 2015 records at the bottom of each plot in Figure 94.

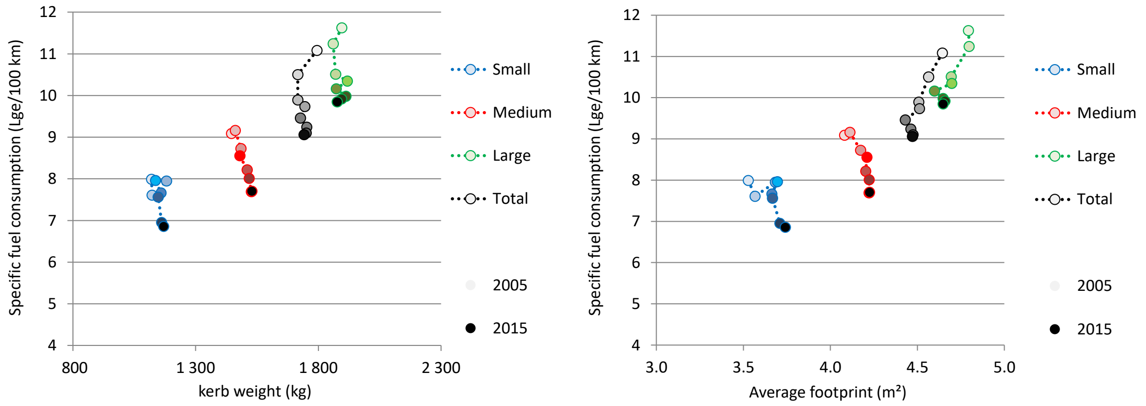
Figure 94 • Fuel consumption per km of new LDVs plotted against vehicle weight and footprint, United States, 2005 and 2015



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

All vehicle segments experienced fuel economy improvements with limited increase in weight (Figure 95). The large vehicle segment has been the most important in determining total average fuel economy. The CAFE standards are set in a way that assigns different targets to vehicles of different sizes, except for vehicles exceeding a maximum and minimum threshold. These vehicles are subject to an upper and lower limit that, in a given year, is independent on their size. This makes it more difficult to meet the target values for very large vehicles, and makes compliance easier for smaller ones. As already pointed out in IEA (2016a), Figure 95 suggests that this resulted in a tendency to reduce the average vehicle footprint in the large market segment, and in an increase in the small segment. Changes in the average size were not accompanied by major variations of vehicle weight in any of the market segments.

Figure 95 • Average new LDV fuel consumption per km by segment plotted against vehicle weight and footprint, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Methodological annex

The IEA-GFEI database

This report builds on information obtained from Polk and IHS Markit databases, purchased and collected in different years (2005, 2008 and, since 2010, in batches of two years), combined and crossed with additional information extracted from technical sources, to generate a single multi-year dataset, the IEA-GFEI database. This is the source of most of the results shown in this report.

The Polk and IHS Markit databases contain information on the number of vehicles registered at the model level, as well as a number of complementary characteristics (e.g. driven wheels, engine volume, engine power, valves per cylinder, fuel type, transmission type, turbo, empty weight, fuel economy, CO_2 emissions per km).

The data included in the IEA-GFEI database build on this information, crossing and complementing it with several additional inputs, entered at the model level or at lower disaggregation levels, starting from the models with the widest market coverage and aiming to achieve at least a 80% coverage for all markets and all parameters discussed in this report. The technical sources listed in Table 5 are used to source additional information on vehicle characteristics for the IEA-GFEI database.

Table 5 • Fuel efficiency and CO_2 emission data sources

Country	Data source
Australia	http://www.greenvehicleguide.gov.au/
Austria	http://www.autoverbrauch.at/ireds-133453.html
Brazil	http://pbeveicular.petrobras.com.br/TabelaConsumo.aspx
Canada	http://oee.nrcan.gc.ca/fcr-rcf/public/index-e.cfm
Chile	http://www.consumovehicular.cl/
China	http://chinaafc.miit.gov.cn/n2257/n2280/index.html
European Union	http://www.eea.europa.eu/data-and-maps/data/co2-cars-emission-10
France	http://www.ademe.fr/consommations-carburant-emissions-co2-vehicules-particuliers-neufs-vendus-france
Germany	http://www.pkw-label.de/autokauf/tool-neufahrzeuge-finden.html#/suche
India	http://www.siamindia.com/uploads/filemanager/256th-4W-FE-Data-Declaration.pdf
Japan	http://www.mlit.go.jp/jidosha/jidosha_fr10_000019.html
Korea	http://bpms.kemco.or.kr/transport_2012/main/main.aspx
Mexico	http://www.ecovehiculos.gob.mx/
New Zealand	https://www.energywise.govt.nz/tools/fuel-economy/
Saudi-Arabia	http://www.sls.gov.sa/Pages/ar/Consumer/FEManufacturers.aspx
Singapore	https://vrl.lta.gov.sg/lta/vrl/action/pubfunc?ID=FuelCostCalculator
South Africa	http://www.naamsa.co.za/ecelabels
Switzerland	http://katalog.automobilrevue.ch/
United Kingdom	http://carfueldata.direct.gov.uk/
United States	http://www.fueleconomy.gov/feg/download.shtml

Sources: IEA, 2014 and ICCT, 2016.

The markets included in this analysis represent more than 80% of worldwide LDV sales in 2015, and close to 90% when all monitored EU countries are included. With the multiplication of models available in developing markets, the database developed by the IEA based on the Polk data now holds more than 900 000 records.

Scope and key metrics

This report continues to incorporate the methodological changes introduced in the latest update published before this work (IEA, 2016a):

- The inclusion of LDVs, such as passenger cars, passenger light trucks (comprising SUVs, pick-ups and other large cars), as well as LCVs.
- The normalisation of all fuel economy estimates to the WLTC.[12]

[12] Three different test cycles are applied worldwide to measure specific fuel consumption (Lge/100 km) or fuel economy (MPG or km/Lge): the European NEDC, the US Corporate Average Fuel Economy (CAFE) and the Japanese JC08. The WLTP and its related test cycle (WLTC) have been developed (and are being refined) to replace region-specific approaches with a harmonised testing scheme (UNECE, 2014). The conversion of the results (published according to region-specific test results) was performed using conversion equations recently developed by the ICCT (2014a).

Statistical annex

This statistical annex presents statistics on some of the key indicators that are used for the analysis of this report. Data for all average parameters are only shown here when information is available for at least 50% of the total registrations. In most cases, the coverage exceeds 80% of the total.

Vehicle registrations (thousands)

	2005	2008	2010	2011	2012	2013	2014	2015
Argentina	354	568	627	766	768	864	645	711
Australia	951	975	986	943	1 058	1 074	1 081	1 123
Austria							335	342
Belgium							537	563
Brazil	1 617	2 706	3 308	3 351	3 568	3 528	3 318	2 469
Canada	1 491	1 639	1 505	1 500	1 588	1 664	1 767	1 833
Chile	183	231	281	321	322	350	327	282
China	3 685	6 206	12 850	12 562	13 716	14 948	20 465	22 073
Denmark							217	239
Egypt	112	232			175	171	270	259
Finland							117	120
France	2 485	2 507	2 296	2 112	2 006	1 931	2 125	2 254
Germany	3 515	3 311	2 911	3 063	3 120	2 992	3 252	3 430
Greece							76	81
India	1 076	1 655	2 592	2 683	2 907	2 676	2 888	3 032
Indonesia	468	519	646	752	884	1 152	1 171	939
Ireland							112	148
Italy	2 452	2 388	2 006	1 662	1 371	1 266	1 471	1 700
Japan	5 601	4 890	4 695	3 932	4 708	4 551	5 330	4 829
Korea	1 084	1 121	1 460	1 451	1 428	1 434	1 612	1 779
Luxembourg							53	50
Macedonia					5	4		
Malaysia	533	529	550	535	606	624	621	650
Mexico	1 056	947	760	826	924	1 001	1 393	1 641
Netherlands							438	508
Norway							174	184
Peru					166	165	161	142
Philippines					162	192	244	305
Portugal							168	208
Russian Federation	1 622	3 072	1 817	2 479	2 723	2 500	2 319	1 484
South Africa	538	454	435	493	585	596	613	587
Spain							966	1 184
Sweden							345	389
Switzerland							332	357
Thailand	677	597	766	748	1 216	1 246	877	763
Turkey	622	552	681	747	735	809	746	938
Ukraine	292	660	173	223	226	209	97	47
United Kingdom	2 760	2 419	2 146	1 997	2 112	2 348	2 796	3 003
United States	15 987	12 834	11 050	11 976	13 457	14 397	15 710	16 576

Average CO_2 emissions/km (in g CO_2/km)

	2005	2008	2010	2011	2012	2013	2014	2015
Argentina	196	195	188	189	185	186	173	181
Australia	244		225	220	214	208	202	200
Austria							143	138
Belgium							137	134
Brazil	197	198	203		189	191	184	179
Canada	219	224	225	224	229	224	213	213
Chile			209	205	201	196	191	191
China	201	204	202	202	199	197	192	187
Denmark							128	124
Egypt	191	191			193	194	186	190
Finland							145	141
France	158	147	145	142	137	132	129	126
Germany	178	174	169	162	156	150	147	142
Greece							122	119
India	159	150	154	150	149	150	147	147
Indonesia	202		205	207	197	193	186	192
Ireland							133	131
Italy		152	153	143	140	135	134	130
Japan	179	163	163	159	148	143	137	143
Korea	190	181	169	168	148	148	166	165
Luxembourg							143	141
Macedonia					155	151		
Malaysia	190	195	185	186	182	181	182	172
Mexico	211	218	221	217	203	199	204	204
Netherlands							128	122
Norway							129	121
Peru					192	191	188	190
Philippines					210	211	203	202
Portugal							122	119
Russian Federation		210	209	205	201	200	198	197
South Africa	205	202	202	193	186	182	186	185
Spain							133	129
Sweden							148	143
Switzerland							159	152
Thailand		218	208	208	194	189	194	193
Turkey	189		160	155	147	142	137	134
Ukraine			191		185	184	180	177
United Kingdom	176		161	155	149	145	141	138
United States	257	244	230	226	219	214	211	210

Average fuel consumption (in Lge/100 km)

	2005	2008	2010	2011	2012	2013	2014	2015
Argentina	8.3	8.3	8.0	8.0	7.9	7.9	7.4	7.7
Australia	10.5		9.5	9.3	9.0	8.8	8.5	8.4
Austria							6.0	5.7
Belgium							5.7	5.6
Brazil	8.5	8.5	8.7		8.1	8.2	7.9	7.7
Canada	9.4	9.6	9.7	9.7	9.9	9.6	9.2	9.2
Chile			8.9	8.7	8.5	8.3	8.1	8.1
China	8.7	8.8	8.7	8.7	8.6	8.5	8.3	8.1
Denmark							5.4	5.3
Egypt	8.1	8.1			8.2	8.2	8.0	8.1
Finland							6.1	5.9
France	6.5	6.0	6.0	5.8	5.6	5.4	5.3	5.2
Germany	7.4	7.3	7.1	6.8	6.5	6.3	6.1	6.0
Greece							5.1	4.9
India	6.8	6.3	6.5	6.3	6.2	6.3	6.2	6.2
Indonesia	8.6		8.7	8.9	8.5	8.3	8.0	8.2
Ireland							5.4	5.4
Italy		6.4	6.4	6.0	5.9	5.7	5.7	5.5
Japan	7.7	7.0	7.0	6.8	6.4	6.1	5.9	6.2
Korea	8.1	7.8	7.3	7.2	6.3	6.3	7.0	7.0
Luxembourg							5.9	5.8
Macedonia					6.4	6.2		
Malaysia	8.2	8.3	7.9	8.0	7.8	7.7	7.8	7.4
Mexico	9.1	9.4	9.5	9.4	8.7	8.6	8.8	8.8
Netherlands							5.4	5.2
Norway							5.9	5.8
Peru					8.3	8.2	8.1	8.2
Philippines					9.1	9.1	8.8	8.7
Portugal							5.0	4.9
Russian Federation		9.0	9.0	8.8	8.6	8.6	8.5	8.4
South Africa	8.8	8.6	8.6	8.2	7.9	7.7	7.8	7.8
Spain							5.5	5.3
Sweden							6.2	6.0
Switzerland							6.7	6.4
Thailand		9.0	8.7	8.7	8.1	7.9	8.1	8.0
Turkey	8.2		6.6	6.4	6.1	5.8	5.6	5.5
Ukraine			8.2		7.9	7.8	7.6	7.5
United Kingdom	7.4		6.7	6.5	6.2	6.0	5.9	5.8
United States	11.1	10.5	9.9	9.7	9.4	9.2	9.1	9.1

Average power (in kW)

	2005	2008	2010	2011	2012	2013	2014	2015
Argentina		76						
Australia	129	131	129	127	128	128	130	131
Austria							89	91
Belgium							85	88
Brazil				75	77	80	82	84
Canada								
Chile	81	85	91	91	94	94	96	97
China			84	88	90	94	97	100
Denmark							77	82
Egypt								
Finland							97	
France	75	75	74	78	80	80	80	83
Germany	90	96	95	99	100	100	102	105
Greece							73	
India			54	55	56	57	59	60
Indonesia							76	
Ireland							80	81
Italy	72	75	74	78	77	76	76	77
Japan		80	79	78	74	73	73	77
Korea								
Luxembourg							110	114
Macedonia					79	79		
Malaysia	72	74	78	80				
Mexico		116						
Netherlands							84	87
Norway							98	102
Peru								
Philippines								
Portugal							80	80
Russian Federation			86	88	92	94	98	98
South Africa			97	95	95	96	96	96
Spain							83	84
Sweden							104	108
Switzerland							115	118
Thailand	84	94	93	91				
Turkey		80	74	76	78	79	80	82
Ukraine								
United Kingdom	85	89	89	92	92	92	94	97
United States	159	162	166	169	167	169	170	172

Average displacement (in cm^3)

	2005	2008	2010	2011	2012	2013	2014	2015
Argentina		1 779			1 682	1 689	1 538	1 738
Australia	2 725	2 600	2 490	2 417	2 370	2 342	2 352	2 340
Austria							1 673	1 661
Belgium							1 624	1 618
Brazil				1 493	1 490	1 508	1 521	1 534
Canada								
Chile	1 933	1 876	1 935	1 873	1 873	1 843	1 865	1 880
China		1 703	1 651	1 696	1 694	1 709	1 705	1 689
Denmark							1 440	1 445
Egypt								
Finland							1 666	1 631
France	1 731	1 657	1 592	1 613	1 631	1 592	1 567	1 544
Germany	1 868	1 863	1 785	1 789	1 776	1 754	1 746	1 741
Greece							1 413	1 418
India		1 221	1 301	1 324	1 358	1 354	1 344	1 333
Indonesia		1 748	1 644	1 619			1 490	
Ireland							1 636	1 633
Italy	1 623	1 584	1 530	1 558	1 536	1 507	1 498	1 496
Japan		1 439	1 404	1 375	1 342	1 311	1 310	1 394
Korea							1 969	1 975
Luxembourg							1 869	1 873
Macedonia					1 621	1 606		
Malaysia	1 475	1 504	1 568	1 593	1 624	1 606	1 603	
Mexico		2 407						
Netherlands							1 491	1 502
Norway							1 786	1 796
Peru								
Philippines								
Portugal							1 544	1 519
Russian Federation			1 782	1 784	1 849	1 865	1 866	1 871
South Africa					1 902	1 899	1 865	1 838
Spain							1 596	1 582
Sweden							1 798	1 816
Switzerland							1 844	1 824
Thailand	2 404	2 243	2 165	2 089	2 040	2 004	2 058	2 062
Turkey		1 710	1 588	1 584	1 560	1 546	1 542	1 539
Ukraine					1 800	1 796		
United Kingdom	1 804	1 782	1 726	1 735	1 706	1 683	1 681	1 682
United States	3 483	3 235	3 167	3 096	2 979	2 943	2 925	2 901

Average kerb weight (in kg)

	2005	2008	2010	2011	2012	2013	2014	2015
Argentina	1 211	1 222					1 231	1 330
Australia	1 551				1 580	1 570	1 612	1 602
Austria							1 448	1 455
Belgium							1 404	1 409
Brazil	1 146	1 151	1 152	1 171	1 161	1 168	1 165	1 162
Canada	1 780		1 680	1 669	1 684	1 715	1 658	1 667
Chile		1 330	1 383	1 375	1 415	1 402	1 434	1 427
China		1 281	1 317	1 380	1 384	1 440	1 411	1 384
Denmark							1 273	1 294
Egypt	1 306	1 297			1 318	1 337	1 326	1 340
Finland							1 465	1 453
France	1 321	1 331	1 305	1 332	1 370	1 352	1 350	1 353
Germany	1 386	1 410	1 448	1 469	1 461	1 453	1 461	1 467
Greece							1 232	1 230
India	1 001	1 061	1 055	1 082	1 101	1 110	1 091	1 085
Indonesia		1 223	1 220	1 201	1 182	1 237	1 168	1 151
Ireland							1 422	1 427
Italy	1 230	1 249	1 256	1 286	1 285	1 281	1 293	1 293
Japan	1 185	1 186	1 199	1 183	1 179	1 167	1 179	1 208
Korea	1 595	1 530	1 533	1 517	1 492	1 517	1 539	1 573
Luxembourg							1 493	1 504
Macedonia					1 372	1 340		
Malaysia	1 099	1 123	1 159	1 177	1 205	1 228	1 220	1 218
Mexico	1 331		1 348	1 337	1 375	1 388	1 452	1 427
Netherlands							1 327	1 357
Norway							1 532	1 561
Peru					1 423	1 417	1 342	1 348
Philippines					1 505	1 527	1 483	1 481
Portugal							1 327	1 330
Russian Federation	1 293	1 356	1 369	1 372	1 362	1 384	1 398	1 389
South Africa	1 386	1 434	1 506		1 476	1 491	1 484	1 482
Spain							1 371	1 371
Sweden							1 551	1 566
Switzerland							1 506	1 514
Thailand	1 642	1 559			1 563	1 529	1 611	1 607
Turkey	1 358	1 396	1 356	1 372	1 373	1 356	1 352	1 356
Ukraine	1 173	1 290	1 354	1 349	1 412	1 411	1 451	1 475
United Kingdom	1 345	1 367	1 384	1 408	1 406	1 401	1 412	1 427
United States	1 795	1 716			1 725	1 751	1 751	1 742

Average footprint (in m²)

	2005	2008	2010	2011	2012	2013	2014	2015
Argentina	3.8	3.8	3.8	3.8	3.8	3.9	4.0	4.0
Australia		4.2	4.2	4.2	4.2	4.2	4.3	4.3
Austria							4.2	4.2
Belgium							4.2	4.2
Brazil	3.6	3.6	3.7	3.7	3.7	3.8	3.8	3.8
Canada	4.4	4.4	4.5	4.5	4.6	4.8	4.4	4.4
Chile	3.8	3.9	4.0	4.0	4.0	4.0	4.0	4.1
China		3.9	3.8	3.9	3.9	4.0	4.0	4.1
Denmark							4.0	4.0
Egypt	3.9	3.9			4.0	4.1	4.0	4.0
Finland							4.2	4.2
France	4.0	4.1	4.0	4.1	4.1	4.1	4.1	4.1
Germany	4.0	4.1	4.1	4.2	4.2	4.2	4.2	4.2
Greece							3.9	3.9
India		3.2	3.3	3.3	3.4	3.5	3.5	3.5
Indonesia	3.8	3.8	3.8	3.7	3.8	3.8	3.6	3.6
Ireland							4.2	4.2
Italy	3.8	3.8	3.8	3.9	3.9	3.9	3.9	3.9
Japan	3.6	3.5	3.6	3.6	3.6	3.5	3.5	3.6
Korea	4.2	4.2	4.1	4.2	4.2	4.2	4.1	4.1
Luxembourg							4.2	4.3
Macedonia					4.0	4.0		
Malaysia		3.7	3.8	3.8	4.0	3.9	3.9	3.8
Mexico	4.0	4.1	4.1	4.0	4.0	4.0	4.2	4.1
Netherlands							4.0	4.1
Norway							4.2	4.3
Peru					4.0	4.0	4.0	4.0
Philippines					4.1	4.1	4.0	4.0
Portugal							4.0	4.0
Russian Federation	3.9	4.0	3.9	4.0	3.9	4.0	4.0	4.0
South Africa	4.1	4.1	4.1	4.1	4.0	4.1	4.1	4.1
Spain							4.1	4.1
Sweden							4.3	4.3
Switzerland							4.2	4.2
Thailand	4.4	4.3	4.2	4.2	4.2	4.3	4.1	4.2
Turkey	4.0	4.2	4.1	4.1	4.1	4.1	4.2	4.2
Ukraine	3.9	3.9	4.0	4.0	4.0	4.0	4.1	4.1
United Kingdom	4.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1
United States	4.6	4.6	4.5	4.5	4.4	4.5	4.5	4.5

Average vehicle price (in 2015 USD)

	2005	2008	2010	2011	2012	2013	2014	2015
Argentina		20 591						
Australia		23 771						28 485
Austria							31 471	32 134
Belgium							28 936	29 642
Brazil					23 323	22 353		
Canada								
Chile								
China		19 413	21 430	25 693	26 489	27 624	26 826	26 239
Denmark							42 938	37 921
Egypt								
Finland							36 428	35 919
France	30 853	34 014	30 316	33 472	32 357	32 386	27 167	28 092
Germany	32 836	43 250	38 249	40 868	37 937	39 039	33 298	34 291
Greece							23 584	24 053
India			12 406	13 239	12 703	11 888	10 984	11 192
Indonesia								
Ireland								
Italy	28 004	32 975	29 154	31 335	28 800	29 546	25 024	25 559
Japan		20 696	25 538	28 584	27 112	22 097	18 529	19 453
Korea								
Luxembourg							35 579	37 060
Macedonia								
Malaysia		22 451						
Mexico		20 520						
Netherlands							28 951	31 439
Norway							55 543	45 012
Peru								
Philippines								
Portugal							30 361	30 220
Russian Federation			23 605	26 541	21 916	23 796	14 835	15 890
South Africa								
Spain							26 895	27 340
Sweden							41 053	34 964
Switzerland							45 315	43 143
Thailand		18 328						
Turkey		33 637						
Ukraine								
United Kingdom	34 937	35 757	32 385	35 644	34 723	35 887	36 909	35 424
United States	30 338	27 707	30 573	30 831	30 247	30 296	29 934	30 396

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Acronyms, abbreviations and units of measure

Acronyms and abbreviations

BEV	battery electric vehicle
CAFC	corporate average fuel consumption
CAFE	corporate average fuel economy
CNG	compressed natural gas
CO_2	carbon dioxide
EU	European Union
GFEI	Global Fuel Economy Initiative
ICE	internal combustion engine
IEA	International Energy Agency
LCV	light commercial vehicle
LDV	light-duty vehicle
LNG	liquefied natural gas
LPG	liquefied petroleum gas
NEDC	New European Driving Cycle
NO_x	nitrogen oxides
OECD	Organisation for Economic Co-operation and Development
OEM	original equipment manufacturer
PHEV	plug-in hybrid electric vehicle
R&D	research and development
RDE	real driving emissions
SUV	sport utility vehicle
WLTC	Worldwide harmonised Light vehicle Test Cycle
WLTP	Worldwide harmonised Light vehicle Test Procedures

Units of measure

cm^3	cubic metre
g CO_2/km	grams of carbon dioxide per kilometre
kg	kilogram
km	kilometre
km/Lge	kilometres per litre of gasoline-equivalent
kW	kilowatt
L	litre
Lge/100 km	litres of gasoline-equivalent per 100 kilometres
m^2	square metre
MPG	miles per gallon

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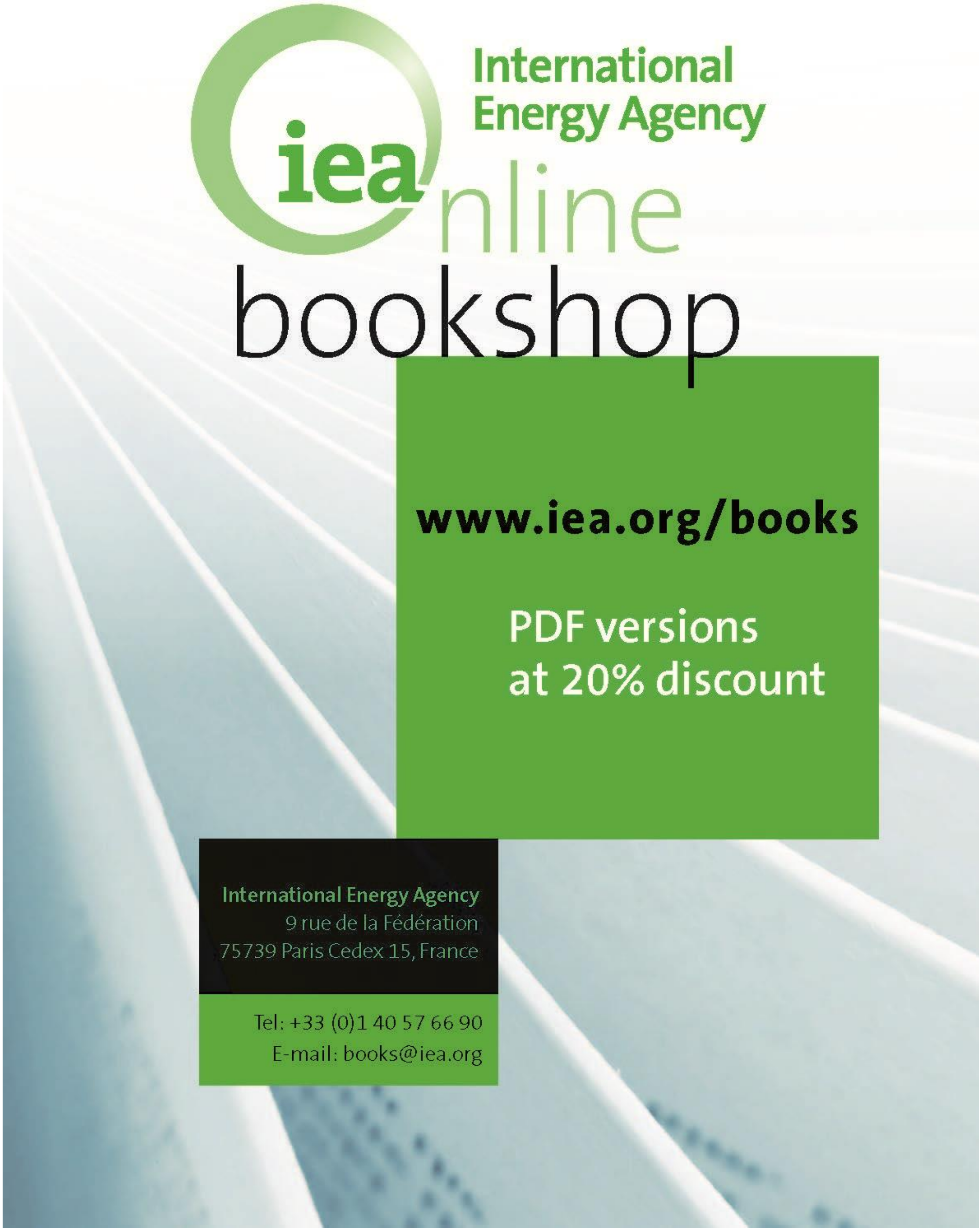
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What is the Global Fuel Economy Initiative?

The Global Fuel Economy Initiative believes that large gains could be made in fuel economy which would help every country to address the pressing issues of climate change, energy security and sustainable mobility. We will continue to raise awareness, present evidence, and offer support to enable countries to adopt effective fuel economy standards and policies that work in their circumstances and with their vehicle fleet.

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