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Comparisons of Vehicle Technology and Fuel Efficiency: Across 10 countries (2010 update)

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FIA Foundation for the Automobile and Society
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icct THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION
ITS UCDAVIS INSTITUTE OF TRANSPORTATION STUDIES

COMPARISONS OF VEHICLE TECHNOLOGY AND FUEL EFFICIENCY ACROSS 10 COUNTRIES – 2010 UPDATE

Final Report

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EXECUTIVE SUMMARY

ANALYSIS OVERVIEW

This report examines the new vehicle fleets for model year 2010 in six emerging market, non-OECD countries relative to the new vehicle fleets in USA, Australia, Germany and France, as four example OECD countries. The non-OECD countries include the BRIC nations (Brazil, Russia, India and China) as well as Malaysia and South Africa. This analysis updates an earlier analysis performed for the IEA using 2008 data to also include 2010 data, which allows for some examination of time trends.

While the OECD countries typically report the average fuel economy of new vehicles in each year, such information is generally not available publicly for most developing countries. In general, developing country fleets have large percentages of small cars that has led many to conclude that the fleets are fuel efficient. Through a detailed analysis of data, not only can the average fuel economy of new cars be measured with better accuracy, but other statistics of interest can also be assessed, such as fuel economy across market/size class and the presence of various technologies on vehicles (and the fuel economy effects of these technologies).

A key question that the analysis seeks to answer is the extent of the gap in fuel economy between developing and OECD countries that is associated with the employment of more fuel efficient technology in the latter countries. A large fuel economy gap between OECD and developing country vehicles of the same size and performance indicates a significant technology gap that could be addressed with policy measures promoted by the FIA Foundation.

METHODOLOGY

The comparison of vehicle and fuel economy differences and an analysis of the cause of the differences require an understanding of the major reasons for the differences in fuel economy. The vehicles sold in the 10 countries include some common models as identified by nameplate but also include many models that are unique to specific countries. Moreover, the most obvious and visible difference is the size mix of vehicles sold; the sample includes the US with the largest size mix in the world to India, which has the smallest size mix among major countries. The vehicle technology mix differs but outside of diesel engine penetration, this is certainly less obvious. Diesel engine penetration does vary widely, with France having one of the highest levels of diesel penetration in the world at about 75% of all new vehicles, while diesel penetration in the US and China is less than 1% of the new vehicle fleet in 2008. Hence, we have used a methodology to assess the fleet both from a "top down" viewpoint of aggregate data analysis and a bottom-up viewpoint of examining individual high sales volume models in each country. Table E-1 summarizes some of the major features of each market in 2010.

		SALES (millions)	FC L/100KM	DIESEL MKT. SHARE	LTTRUCK MKT. SHARE	HIGH SALES CLASSES
USA		10.51	9.31	0.6%	44.6%	C, D, M-TRK
GERMANY		2.80	6.44	44.4%	25.4%	B, C, D
FRANCE		2.35	5.57	74.7%	28.0%	B, C, C-TRK
AUSTRALIA		0.87	8.74	24.1%	39.1%	B, C, M-TRK
CHINA		11.40	7.69	1.3%	31.9%	B, C, C-TRK
INDIA		2.42	6.07	35.8%	28.1%	A,B, S-TRK
RUSSIA		1.51	8.02	5.5%	29.0	B, C, C-TRK
MALAYSIA		0.50	7.09	7.7%	15.5%	B, C, D
SOUTH AFRICA		0.55	7.69	19.3%	39.5%	B, C, M-TRK

Table E-1: Selected Characteristics of the 2010 Light Duty Fleet
(M-TRK, C-TRK and S-TRK refer to medium size, compact and mini-trucks which include SUV, van and pickup truck models)

Due to issues with the 2010 fuel economy data for Brazil, we could not include this country in the 2010 update, but the data analysis for all other countries follow a uniform procedure. The first step was a detailed qualitative assessment of the fleet of new cars in terms of manufacturers, vehicle sizes, model availability, and vehicle pricing. Second, a quantitative analysis of the differences in the fleet in terms of mix by size class, weight engine size, power and fuel economy was developed. The quantitative analysis relies on a mathematical decomposition of the differences to several selected variables such as performance, diesel penetration, automatic transmission penetration and weight differences within class. Third, a detailed difference analysis is documented, with the results illustrating the actual causes of differences in fuel economy between countries, especially to examine if there are substantial technology differences contributing to fuel economy. Finally, a "bottom-up" analysis of individual models is used to examine the results of the difference analysis and lend substance to the arguments.

FINDINGS – OECD COUNTRIES

The analysis of vehicle specification and fuel economy data from the new light vehicle fleets of 9 countries shows the considerable diversity of local forces affecting the characteristics of the fleet. The most obvious lesson from the data is that policies aimed at improving fuel economy have to be tailored to the forces in each country and a single policy such as fuel economy standards cannot be uniformly effective across all nations.

The comparison across four OECD countries provides the following lessons

- First, vehicle fuel efficiency technology is very similar across all developed countries in spite of significant differences in fuel prices and incomes, showing that fuel economy regulations rather than economic forces control manufacturer technology introduction plans. (see Figure E-1 below)
- Second, economic instruments such as fees and rebates ("feebates') based on vehicle fuel efficiency can have significant market effects by drawing consumers to the most efficient vehicles, even when there are stringent fuel economy standards. There is also some evidence that manufacturers subject to fee-bates may "pull ahead" technology introduction to take advantage of the

market response, based on France’s experience with the fee and rebate system called Bonus Malus.

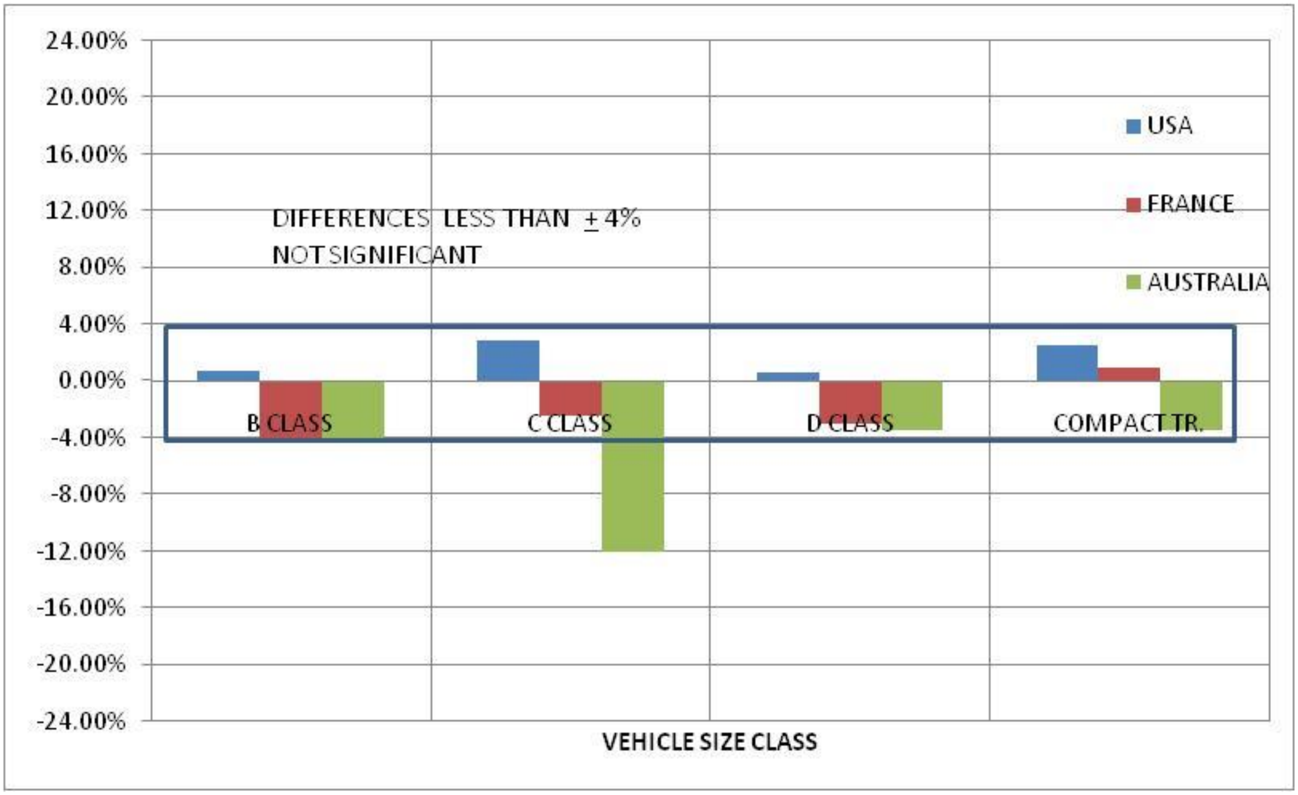

Figure E-1: Size class specific fuel consumption differences relative to Germany (adjusted for diesel penetration, weight and performance; negative percentages indicate worse FC)

- Third, developed nations that rely on imported vehicles for most or all of their vehicle fleet enjoy a free rider effect of having the latest fuel economy technology since most vehicles are imported from the EU, Japan and Korea. Nations that do not have a domestic car industry typically do not have enough sales and economies of scale, especially at the individual vehicle make/model level, to justify a unique design for that country. The Australian situation shows that improvements in its light vehicle fleet have kept pace with the EU and US fleets even though there are no fuel economy standards. 85% of the Australian fleet is imported and its domestic manufacturers do not see any future for Australia specific designs. Fuel economy technology may lag the level in the EU or Japan by a modest one to two years due to the lag in the timing of new model introduction.

The "macro" data of fleet average fuel economy or CO2 emissions published by the regulatory agencies also confirms that fuel consumption reduction in the OECD countries appears to be remarkable consistent in terms of percent reductions over time, although there are small year-to-year variations. Figure E-2 shows the rate of decline in the four countries examined in this report using the official statistics on fuel consumption or CO2, normalized to the 2002 value at 100%.

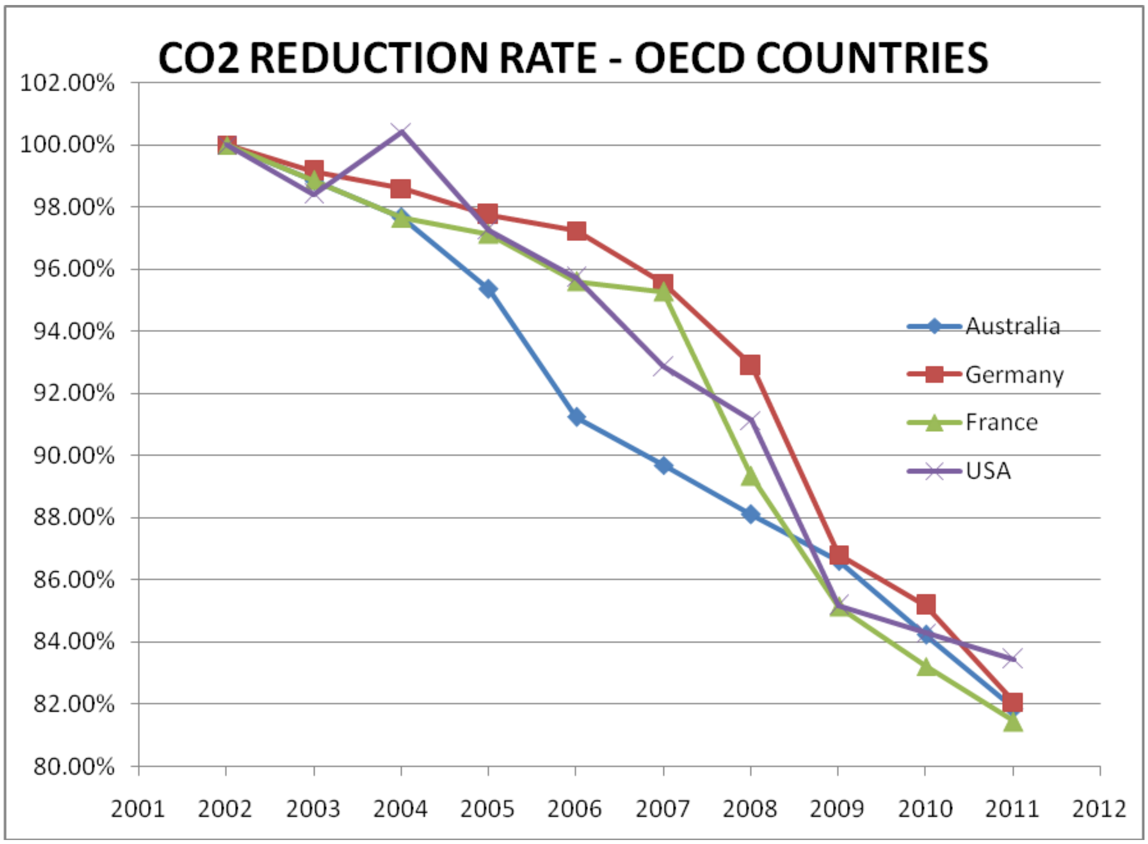

Figure E-2: New Vehicle Fleet CO_2 Emissions Decline Relative to 2002

By 2011, all four countries showed a 17 ± 0.7% reduction relative to 2002, which is remarkably similar given the differences in local fuel prices, vehicle taxes, fleet composition and the vehicles covered by regulation. One explanation is that the developed country markets are being supplied by the same set of major global auto-manufacturers, who are responding to regulatory pressure by adopting similar technology for all developed country markets (and, as shown in the next section, for many developing country markets).

The figure also shows that Australian fuel consumption decline occurred earlier than in the other OECD countries with a steep decline in the 2003 to 2006 period when other OECD countries were showing modest or no declines. Our analysis showed that in this period, the Australian consumers abandoned the large car and large SUV models manufactured domestically and moved to smaller international models as the tariff barriers against imports was lowered over the period. Similarly, the steep reduction in French fleet fuel consumption between 2007 and 2009 is evident and this corresponds to the introduction of the fee and rebate regime. Hence, both local factors and international technology adoption trends explain the short term trends in fuel consumption and the relative differences between countries.

FINDINGS - DEVELOPING COUNTRIES

In the context of developing countries, there are additional specific findings

- In countries where most of the vehicles are imported or simply assembled from knock-down kits, the same free rider effect of obtaining the latest fuel efficiency technology from the EU and Japan is observed, as in South Africa. Here again, there is a modest time lag in technology introduction.
- The situation in countries with significant domestic production and/or restriction of imports, the situation is more complex. Products manufactured locally by global auto-manufacturers generally employ new technology but with a somewhat larger time lag of 4 to 5 years relative to OECD countries in many cases, but not always, depending on the local market's competitiveness. Products manufactured by purely domestic manufacturers, such as Tata in India, Lada in Russia, or Wuling in China typically feature older technology and are 15 to 25 percent less fuel efficient **relative** to their OECD counterparts of equal size and performance as indicated in Figure E-3 below. However, these products are usually smaller, low performance vehicles and their fuel economy may be good on an absolute scale.

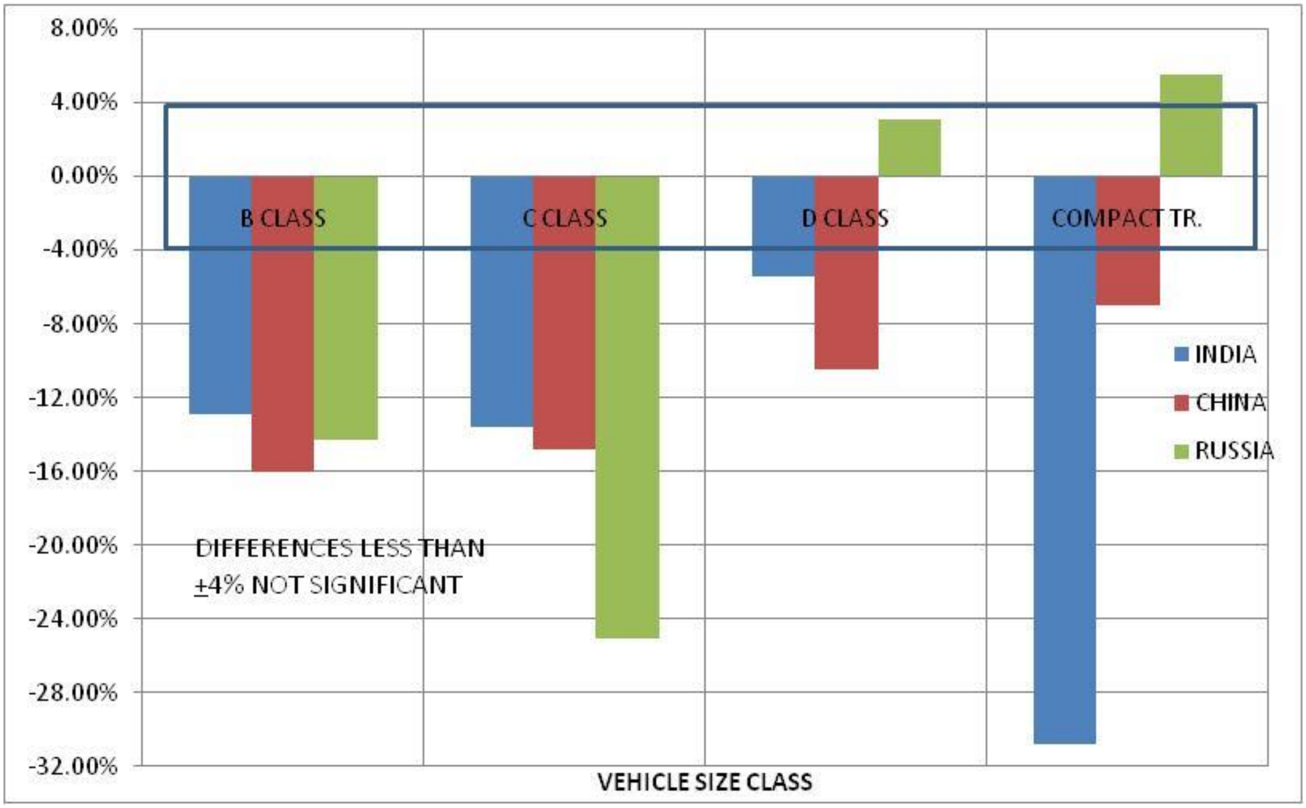

Figure E-1: Size class specific fuel consumption differences relative to Germany (adjusted for diesel penetration, weight and performance; negative percentages indicate worse FC)

- A major factor that may inhibiting the adoption of new technology in the older design vehicles manufactured domestically is that these products are usually very low price models sold to the most cost sensitive buyers, at prices that are less than half the price of similar size vehicles sold in the OECD. The old technology models may also be perceived as easier to maintain and repair in a developing country environment.

The above findings are based on the 2008 and 2010 data, but the steep increases in global fuel price since 2009 is changing the picture. Sales of these older design models appear to be fading and it is possible that technology in developing countries will converge to the technology used in the OECD in the future with a modest time lag as consumer demand for more efficient products grows in developing countries.

A separate issue (not based on any of the data in this report) is the applicability of new technology being introduced in OECD countries to the developing country environment. The EU manufacturers have, in particular, adopted the technology of using downsized direct injection turbocharged gasoline engines as a primary method of meeting future fuel consumption or CO_2 standards, but the technology is better suited to high speed driving rather than low speed driving conditions prevalent in much of the developing world. Other technology solutions such as high compression ratio engines may be better suited to these conditions, and it is possible that the technologies may diverge significantly between the EU and the developing world in the future.

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1. INTRODUCTION

The rapidly growing car fleets in the so-called BRIC countries (Brazil, Russia, India and China) has led to concern that greenhouse gases from passenger transportation will increase significantly unless the vehicles sold in these countries are made very fuel efficient. There has been little analysis or data available on the technology and fuel economy of the vehicles sold in developing countries relative to those sold in the OECD member countries. The data situation is improving since China has introduced fuel economy standards and both India and China have an official test procedure to rate vehicle fuel economy. Other countries also are beginning to report out summaries of registration data and making this data available.

This report examines the new vehicle fleets for model year 2010 in six emerging market, non-OECD countries relative to the new vehicle fleets in USA, Australia, Germany and France, as four example OECD countries. The non-OECD countries include the BRIC nations (Brazil, Russia, India and China) as well as Malaysia and South Africa. This analysis updates an earlier analysis performed for the IEA using 2008 data to also include 2010 data, which allows for some examination of time trends.

While the OECD countries typically report the average fuel economy of new vehicles in each year, such information is generally not available publicly for most developing countries. In general, developing country fleets have large percentages of small cars that has led many to conclude that the fleets are fuel efficient. Through a detailed analysis of data, not only can the average fuel economy of new cars be measured with better accuracy, but other statistics of interest can also be assessed, such as fuel economy across market/size class and the presence of various technologies on vehicles (and the fuel economy effects of these technologies). A key question that the analysis seeks to answer is the extent of the gap in fuel economy between developing and OECD countries that is associated with the employment of more fuel efficient technology in the latter countries. A large fuel economy gap between vehicles of the same size and performance indicates the technology gap that could be addressed with policy measures promoted by the FIA Foundation.

Outside of the US and the EU, the data issues are still somewhat problematic as there is no official data set that has detailed vehicle sales data by vehicle nameplate, engine and transmission along with data on the official fuel economy test value. The US has this data in the form of the US Corporate Average Fuel Economy (CAFE) compliance reporting data set and the EU has similar data for compliance with CO_2 regulations, but such data has to be assembled for other countries. In all countries, this data has to be externally supplemented with data on technological characteristics of vehicles that affect fuel economy.

The IEA has purchased registration data from a commercial supplier and has augmented this data with data on vehicle characteristics (weight) as well as test fuel economy. Section 2 of this report documents the data bases developed along with the data sources, and also the models selected for more detailed analysis

The comparisons of the new vehicle fleets in each country are conducted at two different levels. One is at the fleet-wide level, where sales data by vehicle nameplate is available but not the detailed technology and fuel economy data. The second is on the subset of the high sales volume models where we collected very detailed data to permit analyses of technology differences. The analysis provides a detailed representation of the new vehicle fleet fuel economy in each country and the reasons for the differences in fuel economy including vehicle size, weight, horsepower, and use of efficiency technology.

The comparison across OECD countries is described in detail in section 3 of this report. It should be noted that the EU had not covered “commercial” light vehicles under its fuel economy regulation to 2010 while the US and Australia include all vehicles up to 4 tons gross vehicle weight. The analysis here presents results with and without light commercial vehicles to make comparisons equitable across all countries.

Section 4 provides similar comparisons of the developing nations using Germany as a benchmark, partly because the German fleet has mix of vehicles that represents virtually all classes sold in the world and a near equal split of petrol and diesel vehicles, and partly because German vehicles have the reputation for being advanced in terms if the employment of fuel efficient technology. The principal focus of this analysis is to answer the question: Are vehicles sold in developing countries as efficient as those sold in OECD countries, particularly those sold in Germany? If not, what is the potential to improve efficiency by adopting technology employed in the OECD?

Conclusions regarding the policy implications of these findings are provided in Section 5.

2. DOCUMENTATION OF DATA USED IN THE ANALYSIS

2.1 VEHICLE CLASSIFICATION

In order to provide statistics on a comparable basis across countries, light duty vehicles were classified into size or market classes using the European notation system that is approximately consistent with the US system for larger vehicles. In this system, cars are classified into five classes, as follows:

- **A class** which are 'entry' level very small cars with engines of 1 litre or smaller displacement. These cars have been introduced in the US only since 2007, but auto-manufacturers are planning several new models for introduction in the US by 2011/12. The Fiat 500, Smart car and the Suzuki Alto are typical models

- **B class** cars which are classified as sub-compacts in the US. This size of vehicle is very popular in Southern Europe and India, and in much of the developing world. The VW Polo, Peugeot 206 and Toyota Yaris are typical models and engine displacement is usually in the 1.1 to 1.6 liter range.

- **C class** cars classified as compacts in the US and are the most popular size in Northern Europe, Japan and China. Typical models include the VW Jetta, Toyota Corolla, Ford Focus and Honda Civic, with engine sizes typically in the 1.5 to 2.2 L range.

- **D class** cars are classified as midsize in the US and are the largest part of the market there, but are generally regarded as large cars in the rest of the world. The Honda Accord, Ford Fusion and Toyota Camry are typical models and engine sizes range from 2.2L to 3.5 L in the US, and 2L to 2.5L in the rest of the world.

- **E class** cars are restricted to luxury vehicles in most of the world except North America, and usually include only the large Mercedes, BMW and Jaguar sedans. In the US, Ford, GM, Chrysler and Toyota offer large non-luxury vehicles, but the market share of these vehicles has been declining for the last 20 years and now accounts for less than 5% of the US light vehicle market.

- F class cars are “sports” cars, and this is not a size based class but one based on market intent. However, most cars in this class have interior sizes comparable to B and C class cars or are 2-seaters, and have only 2 doors. Cars in this class have a very wide range of engine sizes and prices, but have near zero market share in most developing countries, and relatively modest share (<5%) in developed countries. The non-homogeneity of cars in this class make international comparisons across countries difficult and unreliable.

Light duty trucks have always been a major part of the North American market and have only recently increased in popularity in other parts of the world. They include pick-up truck, van and sports utility body styles and we have classified them in four size classes:

- **Micro vans** which are van body derivatives of A class or B class car platforms are used extensively in China and Southern Europe but are not sold in North America or Australia. Typical models include the Wuling utility van (similar to the Suzuki micro-van) and the Renault Kangoo, and engine displacement is similar to that for B-class cars.

- **Compact pickup trucks, vans and SUVs** are popular around the world and typical models include the Honda CR-V, Fiat Ducato and Ulysse, and the Renault Espace and Express. In general, the vehicles are powered by engines in the 2 $\pm$ 0.5 L displacement range with the upper end of the range more popular in North America.

- **Midsize pickup trucks, vans and SUVs** are largely a North American and Australian phenomenon although some models like the Mercedes M class SUV, the Chrysler van, the Honda Odyssey van and the Jeep Grand Cherokee SUV have modest sales in Europe. Engine sizes are in the typically in the 3 to 4L range and have six cylinders, although some European versions offer four cylinder engines in the 2.5L displacement range.

- **Large pickup trucks, vans and SUVs** are sold primarily in North America in any volume and are manufactured only in the US. The market share for these vehicles peaked in 2006, but even in 2010 they had over 10 percent of the North American market. Typical engines are eight cylinder units with 4+ L displacement.

In addition, sales were also allocated to engine type. The vast majority of sales are gasoline or diesel powered and the data indicated that less than 0.5% of new vehicles in any of the countries except India and Australia (where they are in the 1 to 3% range) were powered by CNG or LPG. Fleet penetration of CNG and LPG is actually higher than indicated by new vehicle data, but these include aftermarket conversions for which we had no data.

Hybrid vehicles are not yet sold in India but have very low sales in Europe and China (a few thousand or less than 0.1% of sales). Hybrid vehicles are rapidly increasing in popularity in the US and sales were nearly at 300,000 units in 2008, or at 2.5% of the fleet, and 3.5% in 2010, which is still relatively small. On the other hand, diesels are well represented in France, where fleet penetration stood at about 80% in 2008 and 2010, and in India where penetration is at 31.5%. Diesels are less than 1% of sales in China and the US. In the instances where engine types account for less than 1 % of the fleet, we have not analyzed any of their specific efficiency characteristics.

Commercial vehicles are defined in the EU as those vehicles primarily intended for cargo transport. In Europe as well as most of the other countries examined in this study, the van body vehicle is the most dominant light commercial vehicle type, while in the US and Australia, the pick-up truck is the largest seller. Many light cargo vehicles share their body and drive-train with a passenger vehicle (often with the same name) and we have also classified commercial vehicles into the same four classes as passenger trucks. In this case, many European large vans are included in the same size as the large pickups common in the US. Since the US does not have a separate “commercial” category, we created one for this analysis by reclassifying all pickup trucks and cargo vans as commercial for the US.

2.2 DATA SETS ANALYZED

Development of the data set to permit detailed comparisons of fuel economy was a major part of the effort, largely undertaken in-house by the IEA. However, it should be noted that vehicle models in the EU and China (defined as a unique combination of nameplate, engine size, power and transmission type) encompass many hundreds of different types and it was not possible to develop data on so many models. Rather, the IEA selected the highest sales volume models in most countries to provide the comparisons required. This subset of 25 to 50 models usually accounts for 70 to 80 percent of all sales in each country.

The IEA data set was not used for analysis of US fuel economy. As noted, data on US light vehicles is very comprehensive as the Department of Transportation provides a nameplate/ engine/ transmission specific listing of sales and fuel economy. In addition, detailed vehicle specifications are published in *Automotive News* and *Ward's* and we have appended the specifications to the DOT database. This allows very comprehensive analysis of all of the data instead of using a sub-sample as was required in other countries. Fuel economy data is based on the combined city and highway fuel economy with a 55/45 weighting, but we have used the actual test fuel economy, not the adjusted fuel economy to reflect on-road conditions.

Engine technology data available include engine size, layout (OHV/OHC), number of cylinders, compression ratio, aspiration, valve lift and timing control (presence/absence) and fuel injection type (port/direct). Data on transmission type and number of gears, drive type (2wd/4wd) and vehicle curb weight are also available. No data on aerodynamic drag or rolling resistance is available but we do have data on the use of fuel efficient electric power steering. This data was used a reference set to be obtained for select high sales volume vehicles in other countries.

The total data set reflected light vehicle sales of 13.393 million 10.513 million in model years 2008 and 2010 respectively, which was down significantly from the more typical

16 million sales. It should also be noted that 2008 was a year of record fuel prices in the US and the sales and fuel economy may be somewhat unusual compare to earlier years,

2.3 DATA FOR ALL OTHER COUNTRIES

Detailed sales data at the nameplate/ engine/ transmission level was not publicly available and we used the registration data for calendar year 2008 and 2010 obtained form R. L. Polk by IEA. The data is coded in an unusual format that identifies a “model year” that may be the year of first introduction for the nameplate, but there is some uncertainty in the exact vehicle model year. The data is provided at not only the nameplate/ engine/ transmission level but also includes body style and trim option variations, requiring aggregation to the required level.

Data on vehicle fuel economy and on vehicle technical specifications were not included in the Polk database, and because of the relatively complex layout of the database, it was not easy to match the registration data to any database containing vehicle technical specifications. The total number of models across the 10 countries was over a thousand, thus making a complete dataset manually a daunting task. Instead, IEA obtained data on vehicle weight, HP and fuel economy for models that constitute approximately 80% to 85% of sales in each country, or for about half the models in the database. In addition, some effort was made to obtain representation of vehicles in all classes, including the low sales volume classes. This method results in the fleet-wide averages being not affected significantly; for example, the computed CO_2 emissions for the French fleet was 138 g/km while the official figure was 140 g/km. The small under-estimate is due partially to the fact that many high fuel consumption cars are sold at low volumes and are, hence, not included in the data.

Fuel economy data was obtained from the vehicle certification data which reports the EU official data from the NEDC test. The IEA data did not have vehicle specification data for commercial European vehicles and many models did not have fuel economy information. This data was added by HDS. Missing fuel consumption data was added using manufacturer websites, the UK Department of Transportation van data available at http://vanfueldata.dft.gov.uk/, and “Auto Motor und Sport Auto Katalog” published by Motor Presse Stuttgart GmbH & Co. In addition, ICF added vehicle size class data for all commercial vehicles. Luxury cars were also re-classified to be more consistent in price and performance with other non-luxury vehicles in the same class. As a rule, all luxury cars were identified by brand name (e.g., Audi, BMW, Lexus) and the cars were moved up one size class relative to their actual size. Hence, the BMW Mini was classified as a subcompact and the BMW 3 series car as a “midsize” car. This resulted in all midsize and large luxury cars being classified in E class.

2.4 MISSING DATA

As noted, the data on fuel economy and vehicle specifications were available for only 70 to 80 percent of all vehicles depending on country. However, there were also other important fields in the Polk data set that were incomplete. The fuel type field was blank in about 6% of records for India and 2.4% for Brazil, but was missing in 15.5% of records in both China and Russia, and the latter two figures were considered unacceptably large. In Brazil, Russia and China, diesel sales in light vehicles are very small (~ 0.5 to 1% of all sales) and hence, we reclassified all vehicles with fuel type unspecified in these three countries to gasoline (or flex-fuel for Brazil). In India, diesel penetration in the light vehicle market is about 35% of sales so that a uniform shift was not possible; a model by model analysis was used but this resulted in most unclassified models being moved to gasoline. The US sample is complete at 100% since we are using the official CAFE dataset.

Other fields used in the analysis where many records were incomplete were horsepower (HP) and transmission type. HDS was able to track down the HP ratings for most vehicles from the manufacturer websites or from Wikipedia articles for discontinued models as of 2011. Data on transmission type was also incomplete for India and no data was available for Russia, Brazil and South Africa. For India, the data was incomplete for a few high volume models and we assumed that automatic transmission penetration was similar to other models in the same vehicle class. In Russia, Brazil and South Africa, w assumed that the automatic transmission penetration at the class level was equal to that of Germany simply because we used Germany as the reference case for comparison.

2.5 ALTERNATIVE FUEL VEHICLES

As discussed in section 2.2, alternative fuel vehicles are not a large fraction of the fleet in any of the countries examined. The sole exception is in Brazil, where the vast majority of vehicles sold are flex fuel ethanol gasoline vehicles. For these vehicles, we obtained the gasoline (petrol) specific fuel economy for comparison, although the fuel economy on ethanol and gasoline-ethanol blends are nearly identical to that on gasoline if compared on an energy input basis (ethanol has 67% of the energy of petrol per unit volume). India has 3.5% of its vehicle sales that are fueled by CNG in 2010, largely concentrated in 2 models used in taxi fleets. Australia has 1.4% of its new car fleet fueled by LPG although we understand this figure reflects new car sales – another 6 to 7% are converted to LPG in the aftermarket, and these are not accounted for in this analysis. We have used fuel economy on a gasoline equivalent basis for AFVs in India and Australia.

Hybrid gasoline –electric cars are not alternative fuel vehicles but it is interesting to note that their penetration varies substantially. They are a factor only in developed countries, and sales in the US in absolute terms are relatively high but still are only 3.65% of new vehicle sales. In Germany and France, hybrid sales are less than 0.5% of total sales, but because French new car sales are over 80% diesel, hybrid sales are 2.5% of <u>gasoline vehicle</u> sales. Hybrid penetration in Australia is only somewhat higher than in Europe but less than 1%, and sales in other countries are less than 0.1% of new car sales. It should be noted that global sales of hybrids are dominated by two models, the Toyota Prius and Honda Civic, both of which are C class cars.

2.6 FUEL ECONOMY COMPARISON FACTORS

The official fuel economy test from which the fuel economy numbers are derived varies across the four countries. The US utilizes the Federal Test Procedure which has city cycle with an average speed of 31.5 km/h and a highway cycle with a an average speed of

77.6 km/h. Europe, Australia and China used the “New European Driving Cycle” or NEDC which is a stylized cycle consisting of 4 repeats of a city cycle with an average speed of 18.7 km/h and a highway cycle of with an average speed of 62.6 km/h and a maximum speed of 120 km/h. Because the US city cycle and the highway cycle are at higher average speeds, vehicles tend to operate more efficiently and the fuel consumption of the same vehicle will generally be lower on the US test than on the European test. The difference depends on the power to weight ratio of the vehicle but for an average car, studies (e.g., ICCT, 2007) have determined that the US fuel consumption multiplied by 1.13 equals the fuel consumption as measured on the EC test. We have used this correction factor to adjust the US fleet fuel consumption value to NEDC values.

India also uses the NEDC but modifies it for Indian conditions by limiting the maximum cycle speed to 90km/h. There are also some other procedural changes to the test protocol that make the Indian test somewhat different. No specific study is available to estimate the effect of the Indian procedure relative to the NEDC procedure. As a result, we compared the reported fuel economy of ‘identical’ vehicles for Europe and India. The vehicles are identical in terms of published specifications but there may engine calibration differences and tire differences that could affect fuel economy but are unknown. The comparison yielded a figure that suggested that fuel consumption measured in India is 2.75% higher than the NEDC, which is a reasonable difference, given that the changes to the drive cycle are relatively modest. We have used this value to adjust Indian fuel consumption to NEDC values, recognizing the potential for some error.

3. ANALYSIS OF OECD COUNTRY FLEETS AND FUEL CONSUMPTION

3.1 METHODOLOGY

The comparison of vehicle and fuel economy differences and an analysis of the cause of the differences require an understanding of the major reasons for the differences in fuel economy. The vehicles sold in the 10 countries include some common models as identified by nameplate but also include many models that are unique to specific countries. Moreover, the most obvious and visible difference is the size mix of vehicles sold; the sample includes the US with the largest size mix in the world to India, which has the smallest size mix among major countries. The vehicle technology mix differs but outside of diesel engine penetration, this is certainly less obvious. Diesel engine penetration does vary widely, with France having one of the highest levels of diesel penetration in the world at about 80% of all new vehicles in 2008 declining to 74% in 2010, while diesel penetration in the US and China is less than 1.5% of the new vehicle fleet in 2008 and 2010. Hence, we have used a methodology to assess the fleet both from a “top down” viewpoint of aggregate data analysis and a bottom-up viewpoint of examining individual high sales volume models in each country.

The first step was a detailed qualitative assessment of the fleet of new cars in terms of manufacturers, vehicle sizes, model availability, and vehicle pricing. Second, a quantitative analysis of the differences in the fleet in terms of mix by size class, weight engine size, power and fuel economy is provided in charts. Third, a detailed difference analysis is documented, with the results illustrating the actual causes of differences in fuel economy between countries, especially to examine if there are substantial technology differences contributing to fuel economy. Finally, the bottom-up analysis is used to examine the results of the difference analysis and lend substance to the arguments.

3.2 QUALITATIVE ASSESSMENT OF THE FLEET

The countries examined in this analysis span the range of size and diesel penetration mix observed in the world, but overall sales volumes and sales growth also differ enormously. The discussion below provides a qualitative assessment of the differences between the fleets of developed (OECD) countries, and contrasts the fleets of the BRIC countries and Malaysia/ South Africa to those of the OECD countries in the next section. The discussion below includes the sales of light commercial vehicles (which are not included in the fuel economy and GHG regulations in the EU). We have used the 2010 German fleet as the reference fleet since it has roughly equal mix of gasoline and diesel vehicles, and has a good distribution of sales in virtually all classes so that class specific comparisons of both diesel and gasoline vehicles can be made with all countries in the sample.

3.2.1 OECD Countries

German Fleet

The German sales mix is almost evenly spread between the B, C and D classes of cars with each of these sizes accounting for 21 to 23% of the fleet, while large/luxury cars account for 7% of sales. The remaining car size classes – A and F - have much more limited penetration at 1 to 3%. Light trucks account for 25.8% of the fleet with most of the trucks in the compact class which alone accounts for 16% of total sales.. Typically most of the commercial (cargo) light trucks are vans in Europe, and pickup trucks are rarely used. Fleet average diesel penetration for the German sample was 44.4% in 2010, down from 47.3% in 2008, but the diesel penetration by class is very skewed to the larger vehicle classes. Diesel penetration in the A and B class vehicles is less than 15%, but reaches 65% in the luxury E class. The larger light truck classes are also over 90% diesel. The German market also has a high degree of competition and although the VW group is dominant, six other manufacturers have market shares in the 10% range.

German fleet fuel efficiency is close to the European average for non-commercial vehicles and was estimated at 151.1 and 164.8 g/km CO_2 in 2010 and 2008 by the EU. Our sample including commercial vehicles is at 168.5 g/km or 6.75 L/100km in 2008, while the passenger vehicle fleet was at 164 g/km or 6.64 L/100km. In 2010, our estimate for the total fleet is 157 g/km The EU commercial vehicle average has been estimated at about 180 g/km, so that the sample result appears quite defensible and accurate. It should be noted that over the 2008-2010 period, German manufacturers and especially the German luxury car manufacturers rapidly ramped up fuel economy technology introduction to improve efficiency – in fact, the reduction in passenger vehicle CO2 emissions between 2008 and 2010 was identical to the reduction achieved between 2001 and 2008!

US Fleet

The US market is unique in having a market share for light trucks of about 45% in 2010, down slightly from 50% in 2007. The three domestic manufacturers accounted for about half the market and specialize in larger vehicles. The three Japanese manufacturers (Toyota, Nissan and Honda) and the Korean manufacturer Hyundai together account for over 40% of the market and are strong in smaller vehicles and compact trucks, while the European manufacturers specialize mostly in luxury and performance vehicles. The US has the largest average vehicle size among the 10 country sample. The D-class car is considered a "mid-size" car in the US and is the middle class family vehicle with the largest share of the market at over 22%, as is the compact van and midsize SUV. Luxury cars and large trucks each account for almost 10% of the market. Corporate Average Fuel Economy regulations mandate a fuel economy of at least 27.5 mpg for cars and 22.5 mpg for trucks in 2008, and actual levels are at 31.5 mpg and 23.6 mpg respectively for actual CAFÉ. These numbers include some credits for manufacture of ethanol flex-fuel vehicles and for test procedure changes, and the actual test fuel economy levels are shown in the table below

	2008	2010
Official CAFE, mpg	27.1	29.3
CAFE Adjusted for credits, mpg	26.7	28.85
CO_2 g/km US Test	206.8	191.4
CO_2 g/km NEDC equivalent	233.6	216.3

Diesel penetration was very small since VW (the only major seller of light duty diesels) had temporarily suspended diesel sales in the US 2008 and about 14,000 diesels were sold mostly by Mercedes. VW re-entered the market in 2010 with diesel sales rising to 62,200 units. No other alternative fuel vehicles were sold at market penetration approaching even 0.1%. Hybrids, though popular, had a relatively limited market of 356,000 vehicles in 2010 with about two-thirds sold in the C segment. Virtually all cars and light trucks have automatic transmission with manual transmission share of the fleet at 6%, mostly in small cars.

French Fleet

The French fleet is among the most fuel efficient in Europe, and France was the only major country in Europe to attain the 140 g/km carbon dioxide standard in 2008. CO2 emissions further declined to 130.5 in 2010 according to the EU. Fleet wide diesel penetration was slightly over 82% in 2008 but declined to 75% in 2010. Gasoline vehicles were sold primarily in the smallest vehicles and sports cars, with diesel penetration in cars larger than B class at over 85%. Vehicle size mix in 2008 was also weighted heavily towards the B-segment, which is the typical family car in France, and this segment alone accounted for about 40% of light vehicle sales. Compact and medium trucks have approximately a 20% combined market share, and micro trucks like the Renault Kangoo have about a 5% market share. The local French manufacturers, Peugeot-Citroen and Renault have the largest market shares, followed by Fiat, VW and Ford. The market for vehicles of class D and E size is quite small at about 10% of the market and luxury car sales are also quite small relative to the US or Germany. Inclusion of light commercial vehicles raises the total to 5.60 L/100km in 2008, but the net decline to 2010 is small as the 2010 total fleet efficiency is calculated at 5.55 L/100km This is because commercial vehicles gained some market share with the total truck share increasing from 27.9% to 29.2% over the 2008-10 period. France also has a relatively low automatic transmission penetration rate of 7.6 percent.

Australian Fleet

The Australian market has historically resembled the US market but over the 2000- 2008 period, the sales of larger vehicles declined and the market for smaller vehicles has increased, especially for the compact and midsize SUV classes, since 2006. Light truck share in 2008 was 35% which was second only to the US market. While the large E class of cars still commands 17% of passenger vehicle sales (largely due to the locally manufactured vehicles being in this class), the C class is the most popular with over 31% of sales, while compact SUV sales account for a little over 10%. In addition, diesel penetration has climbed for very low levels to about 20% of the new vehicle fleet in 2008, increasing further to 25% in 2010. About 50% of the medium and large truck market (commercial vehicles) is diesel, but diesel penetration is in the 10 to 15 percent range in the C and D class car segments, which have high sales volumes.

The fleet fuel consumption values are estimated to be only slightly lower than those of the US, at 9.29 L/100km for 2008, or about 217 g/km CO2 for the vehicle analysis sample which is slightly lower than the official value of 222 g/km, largely due to incomplete records on some commercial vehicle models. For 2010, our estimate for fleet fuel consumption is 8.74 L/100km or 210.2 g/km CO2, which is close to but slightly lower than the official figure of 212.6 g/km. The net differences in both years are quite small and associated with small differences in sales figures and CO2 values at the model level. Although Australia uses the NEDC test and has aligned its regulations with those in the EU, we found an odd anomaly in the Australian CO2 numbers at the model specific level, which in many cases differed from the EU level for identical vehicles by 3% to 5%, but were also identical in some cases.

3.3 ANALYSIS AND RESULTS

The data for 2008 and 2010 were utilized for a detailed decomposition analysis described in the earlier report to the IEA. The decomposition analysis allocates the differences in fuel consumption of the fleet between two countries to

- Differences in the mix of size classes sold
- Diesel penetration differences
- Differences in consumer preference for options and performance (engine size)
- Differences in the preference for automatic transmissions
- Differences in Fuel Efficiency technology adoption

The effect of each of these factors is examined holding all other factors constant, so that the partial effect is measured accurately and the sum of all of the above effects explains the entire difference in fuel consumption. The formulae used to allocate the differences to each factors is provide in Appendix A.

Tables 3-1 and 3-2 show the analysis of differences for 2008 and 2010 respectively, between the other OECD countries and Germany, which is used as the reference benchmark. The results for each country are discussed below.

2008		Size Mix	Diesel	Performance and Trim	Transmission	Technology	Total
USA	DELTA FC	-1.266	-1.109	-0.658	-0.304	0.258	-3.080
	% FC	-18.76%	-16.43%	-9.75%	-4.51%	3.82%	-45.63%
AUSTRALIA	DELTA FC	-0.696	-0.780	-0.330	-0.186	-0.390	-2.382
	% FC	-10.31%	-11.56%	-4.88%	-2.75%	-5.78%	-35.28%
FRANCE	DELTA FC	0.134	0.494	0.109	0.023	0.319	1.079
	% FC	1.99%	7.31%	1.61%	0.34%	4.73%	15.98%

Table 3-1: Allocation of Fuel Consumption Differences Relative to Germany for 2008 (Negative numbers are fuel consumption increases from German consumption values)

2010		Size Mix	Diesel	Performance and Trim	Transmission	Technology	Total
USA	DELTA FC	-1.208	-0.985	-0.548	-0.282	0.153	-2.870
	% FC	-18.76%	-15.30%	-8.51%	-4.38%	2.38%	-44.56%
AUSTRALIA	DELTA FC	-0.665	-0.676	-0.240	-0.115	-0.560	-2.256
	% FC	-10.33%	-10.50%	-3.72%	-1.78%	-8.69%	-35.02%
FRANCE	DELTA FC	0.208	0.515	0.230	0.027	-0.150	0.830
	% FC	3.23%	8.00%	3.56%	0.43%	-2.33%	12.88%

Table 3-2: Allocation of Fuel Consumption Differences Relative to Germany for 2010 (Negative numbers are fuel consumption increases from German consumption values)

USA

The differences between the US and Germany remained relatively consistent between 2008 and 2010 with US consumption about 45% higher than the German new fleet fuel consumption. The size mix differences accounted for almost 19% of the 45%, diesel for about 16%, higher option content and larger engines for about 9% and the use of automatic transmissions for about 4.5%. The remaining difference is only in the range of 2% to 4% that is associated with fuel economy technology, showing that there is hardly any difference in the technology content between the two countries (the small <u>positive</u> difference for the US is partly due to higher hybrid vehicle sales in the US). This is a surprising finding since fuel prices are much higher Germany than in the US, suggesting that regulatory drivers rather than fuel prices are constraining technology requirements in both countries.

France

While new fleet fuel consumption was lower in France than in Germany by 16% in 2008 and 13% in 2010, most of the differences can be explained by the smaller size mix in France (2% to 3%), higher diesel penetration (7% to 8%) and the lower option content and performance of French cars (1.5% to 3.5%). However, it is notable that the technology effect went from about +5% in 2008 to -2% in 2010 relative to Germany. A more detailed analysis at the size class level showed that many French models from Peugeot, Citroen and Renault in the A, B and C class made special efforts to have very low CO2 emissions in 2008 due to the introduction of the “Bonus Malus” fee and rebate program in France that was effective in promoting low fuel consumption cars. By 2010, the German manufacturers had essentially caught up and even surpassed the French manufacturers due to strong pressure from the EU on complying with the light vehicle CO2 standards. A similar effect is seen in Australia. It is noteworthy that the economic fee and rebate program was successful not only in motivating customers to move to smaller vehicles, but also affecting technology supply by motivating manufacturers to “pull ahead” technology introduction.

Australia

As noted, Australia lies between the US and Germany in many of its light vehicle fleet characteristics, but Australia imports most of its cars from Japan and the EU. Sales of domestic vehicles (that are uniquely Australian models) had declined to less than 20% of the fleet by 2008 and to about 15% of the fleet in 2010. While the Australian fleet had 35% higher FC than Germany in both 2008 and 2010, the difference could be attributed to size mix (10.3% in both years), diesel penetration (10.5% and 11.5%), higher option content and engine size (4% to 5%), and higher automatic transmission penetration (2% to 3%) which still left a technology difference that accounted for about 6% difference in 2008 and widened to 9% in 2010. A detailed analysis of differences showed that about 3% is attributable to the different certification levels between the EU and Australia on average for ostensibly identical vehicles, which the auto-industry suggests is due to tyre and trim differences (although we are not able to confirm this).

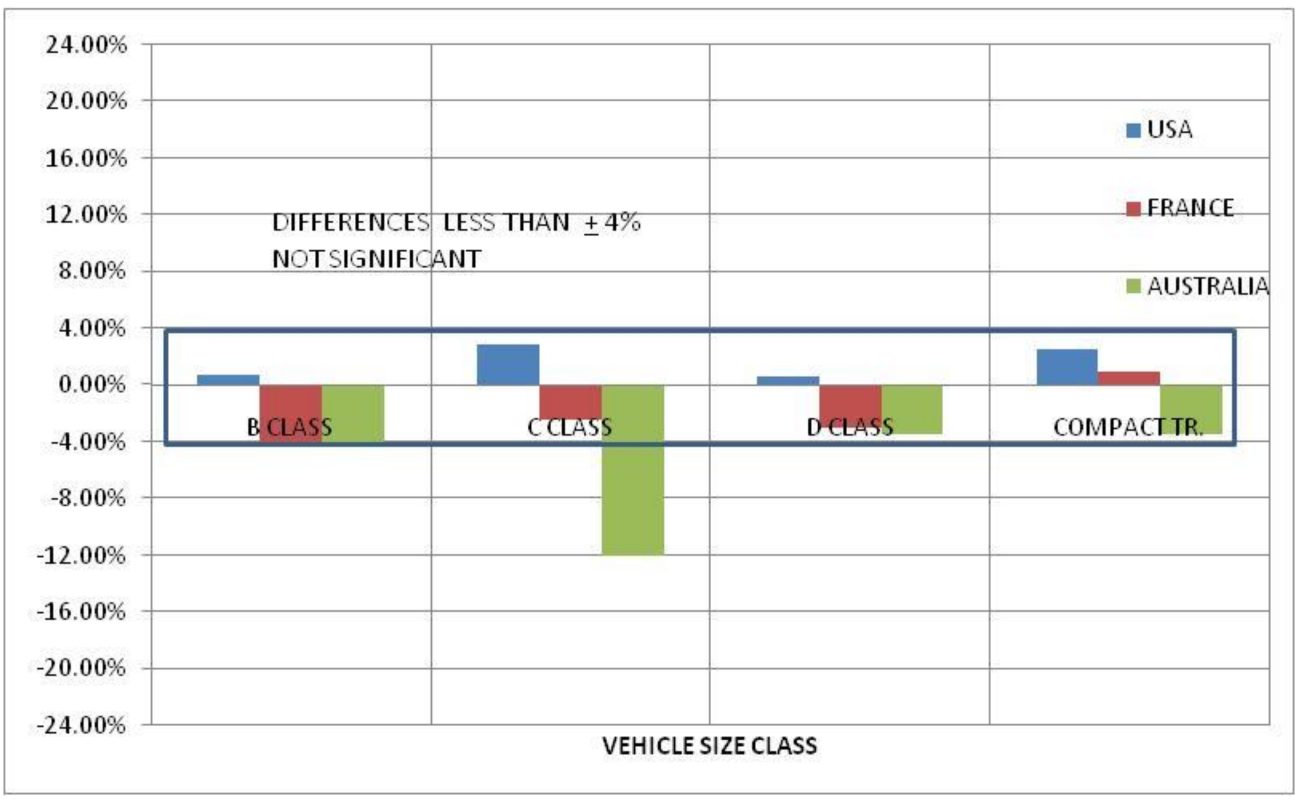

Figure 3-1: Size class specific fuel consumption differences relative to Germany
(adjusted for diesel penetration, weight and performance; negative percentages indicate worse FC)

The similarity of fuel consumption at the size class level (after adjustment for diesel penetration and performance differences) is shown in Figure 3-1. The significant difference in Australian C class vehicle fuel economy was found to be due to the high fuel consumption of 2 popular models in Australia that were replaced with more fuel efficient models in 2011/12.

The widening gap between Australia and Germany from 2008 to 2010 appears to be a temporary effect since new technology introduction appears to lag by a year or two between the EU and Australia possibly due to the timing of model introductions. Australian data for 2011 and 2012 confirmed additional significant reductions (especially in the C class) in fuel consumption with some reduction of the technology gap between Germany and Australia.

3.4 COMPARISON TO OFFICIAL ESTIMATES

The "macro" data of fleet average fuel economy or CO2 emissions published by the regulatory agencies also confirms that fuel consumption reduction in the OECD countries appears to be remarkable consistent in percent reductions over time, although there are small year-to-year movements. Figure 3-2 shows the rate of decline in the four countries examined in this report using the official statistics on fuel consumption or CO2, normalized to the 2002 value at 100%.

By 2011, all four countries showed a 17 $\pm$ 0.7% reduction relative to 2002, which is remarkably similar given the differences in local fuel prices, vehicle taxes, fleet composition and the vehicles covered by regulation. One explanation is that the developed country markets are being supplied by the same set of major global auto-manufacturers, who are responding to regulatory pressure by adopting similar technology for all developed country markets (and, as shown in the next section, for many developing country markets).

The figure also shows that Australian fuel consumption decline occurred earlier than in the other OECD countries with a steep decline in the 2003 to 2006 period when other OECD countries were showing modest or no declines. Our analysis showed that in this period, the Australian consumers abandoned the large car and large SUV models manufactured domestically and moved to smaller international models as the tariff barriers against imports was lowered over the period. Similarly, the steep reduction in French fleet fuel consumption between 2007 and 2009 is evident and this corresponds to the introduction of the fee and rebate regime. Hence, both local factors and international technology adoption trends explain the short term trends in fuel consumption and the relative differences between countries.

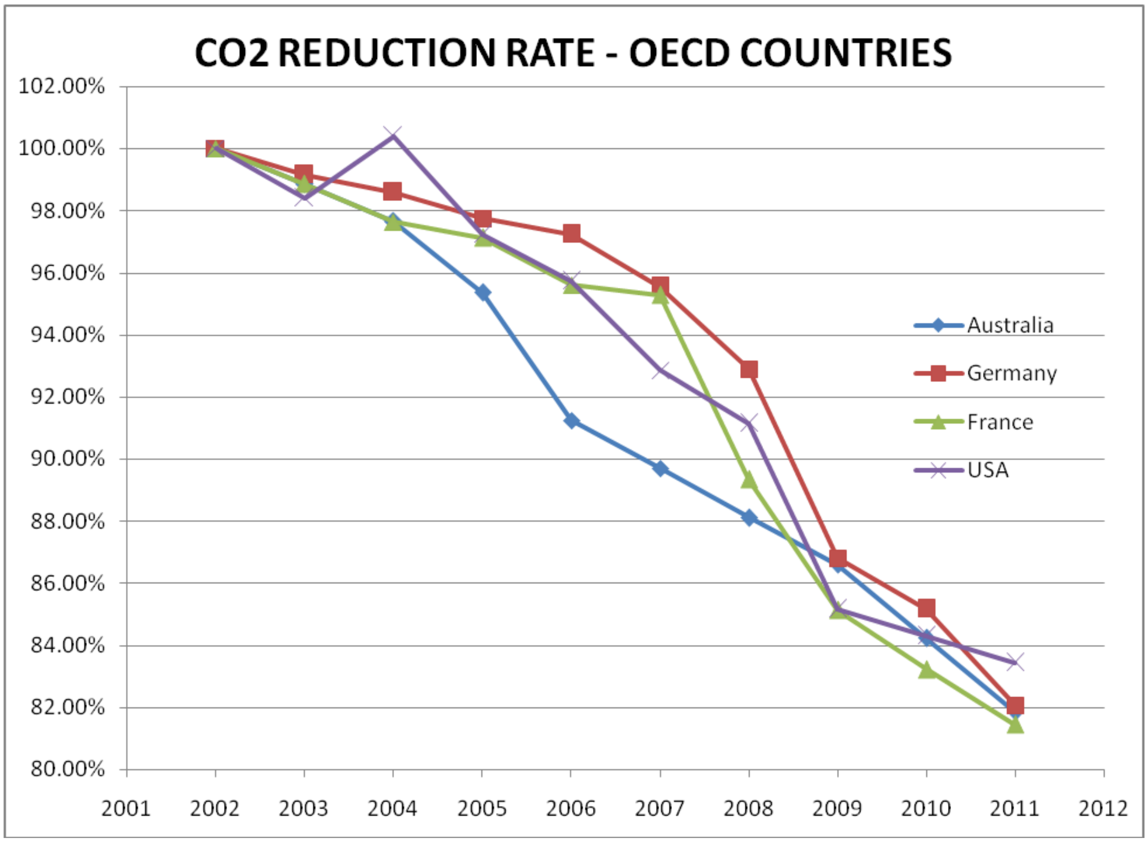

Figure 3-2: New Vehicle Fleet CO_2 Emissions Decline Relative to 2002

4. ANALYSIS OF DEVELOPING COUNTRY FLEETS AND FUEL CONSUMPTION

4.1 QUALITATIVE ASSESSMENT OF THE FLEET

Six additional country fuel economy data were analyzed as part of this effort, and they are India, China, Russia, Brazil, South Africa and Malaysia. They were selected based both on data availability as well as size of the automotive fleet among developing nations. In addition, all six manufacture vehicles domestically and the vehicles in three countries include domestic designs, while the other three manufacture global products designed in OECD countries. A review of the light vehicle fleets in each country is given below.

Indian fleet

Unlike many other markets, sales in the Indian market are concentrated in a few vehicle models. In fact, just two models (the Suzuki/Maruti Swift and Alto) account for almost one third of total sales and 16 vehicle models account for over 80% of sales. The Indian market is primarily concentrated in the very small classes of cars with small engines. As shown in Figure 4-1, over 30% of most 16 most popular vehicles are powered by engines with less than 1 litre displacement (a size not sold in North America) and 90% of these vehicles are powered by engines under 1.5 L displacement. The very small engine size is also indicative of the relatively low performance of the fleet which enhances fuel economy.

Fuel economy and sales data for India are not easily available and there is no official fleet fuel consumption estimate to provide guidance on the accuracy of our estimates. Nevertheless, anecdotal information from the ARAI (Automotive Research Association of India) is that 2006 new vehicle fleet average fuel economy on the official Indian test was about 6.3L/100km. Our fuel consumption estimate from the sample for 2008 is 5.75 L/100km, but this may be due to sample bias of selecting the most popular vehicles, and the actual estimate for 2008 may be about 5% higher. However, on the NEDS cycle, the sample base fuel consumption is 2.75% lower due to the test procedure correction factor, at 5.6 L/100km. In 2010, fuel consumption **increased to 6.09 L/100km** largely due to a significant increase in SUV sales whose market share jumped by 5 percent, offsetting a 5% decline in the share of the smallest cars (Class A and

B). Diesel market share in 2008 was about 20% in cars but nearly 100% in light trucks, and the Polk data provides a combined estimate of 34.4% diesel penetration, with about 1.5% of vehicles using CNG (this does not include aftermarket conversions). Diesel market share increased slightly in 2010 to 37%, and CNG vehicle market share increased to 3.5%. In addition, manual transmissions are dominant although the use of automatic transmissions is increasing in larger vehicles; the smallest vehicles do not offer an automatic option.

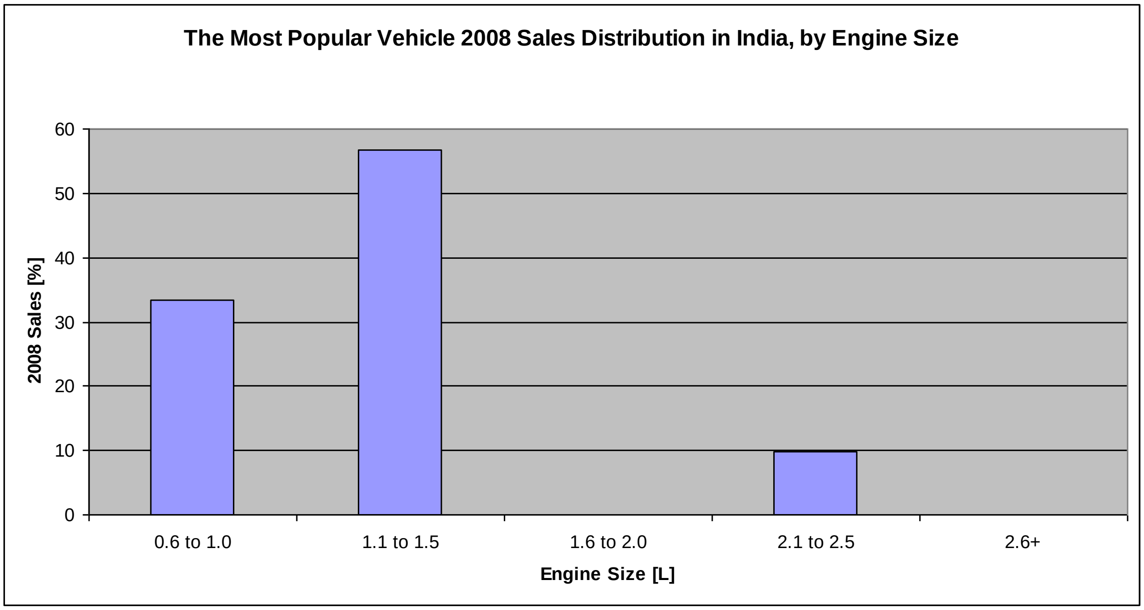

Figure 4-1: Engine Size Mix of the Analysis Sample

Technologically, the fleet can be divided into three vehicle types

- modern vehicles of European or Japanese design manufactured locally
- older models of European or Japanese design still sold in India but phased out in the EC
- models of Indian design

New cars of European or Japanese design appear to have virtually the same technology as that offered worldwide and these models including the Suzuki Alto and Swift, the Hyundai i10 and Santro, and the Chevy Spark, account for almost 60% of the market. Many models offer advanced electric power steering, and almost all models in this category offer fuel injection. Older models of foreign origin are sold as price leaders, but their sales are declining rapidly and they represented no more than 10% of the market even in 2008, and only about 5% in 2010.

These models like the Maruti 800 and Omni use old design 2-valve engines, but are being phased out with increasingly stringent emission standards.

The third segment includes all models manufactured by Tata Motors and Mahindra who jointly account for about 30% of the market. Mahindra markets small SUVs exclusively and they are mostly diesel powered. The Tata Motors engines are not up to the latest international levels in design with 2valves/ cylinder and relatively low specific output. Tata also manufactures a unique micro-truck (the Ace) with a small 2 cylinder engine rated at 16HP that is efficient in absolute terms but very inefficient for having such a low power engine. Many of Mahindra's SUVs use a naturally aspirated diesel engine although a modern turbocharged common rail diesel has been introduced in their new Scorpio model. This segment may fall between the first two segments in technological sophistication. The increased popularity of SUVs has resulted in Mahindra selling more than Tata in the 2012-2013 time frame.

Chinese Fleet

Unlike the Indian market, the Chinese market does not have sales concentrated in a few models. Instead, there are a very large number of makes and models available with many makes and models unique to the Chinese market. Even though China total light vehicle sales in 2010 were over four times Indian sales at 11.38 million compared to 2.42 million in India, sales of the top selling car models are approximately similar to sales of India's top selling models at about 200,000 per year. Only the GM- Wuling utility vehicle sold in cargo and passenger versions has very high sales of over 500,000 per year. As a result, the combined sales of the top 38 models account for only about 55% of total sales. Many models sell in the range of 20,000 to 40,000 units per year making detailed analysis more difficult.

The Chinese market's distribution of engine sizes is significantly different from the distribution in India. About half the vehicles have engines between 1.1 and 1.6L displacement, but 40% have engines over 1.6L displacement. Even the small but significant sales fraction of vehicles with engines under 1.1L is largely due to the GM- Wuling mini-utility van that had no counterpart in most of the world. Figure 4- 2 shows the distribution of vehicles by engine size for CY 2008 in China.

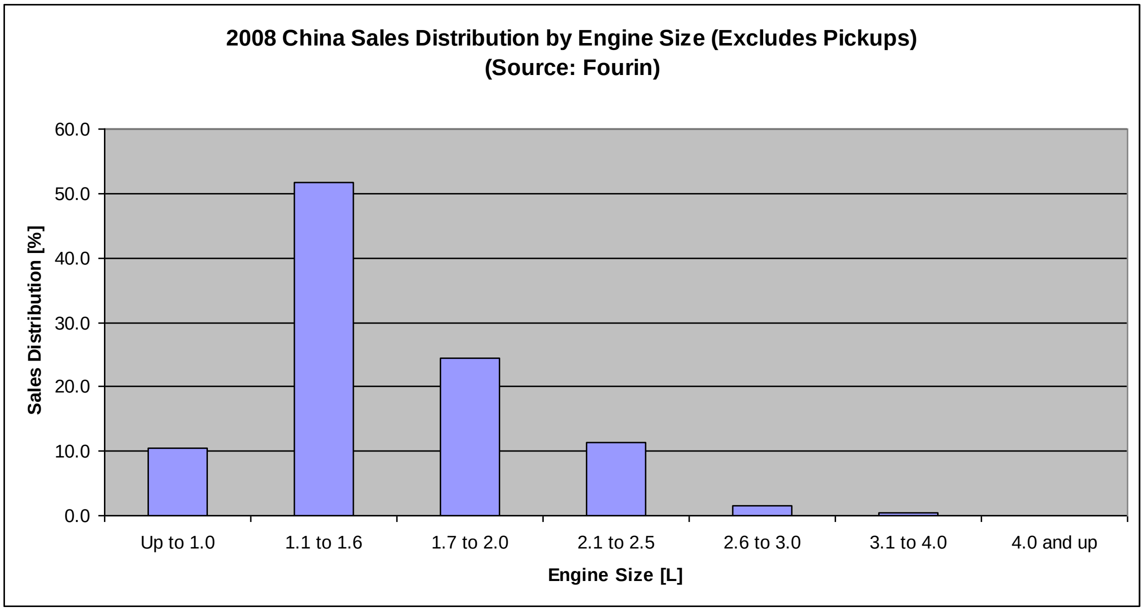

Figure 4-2: Engine size distribution for the Chinese fleet

Vehicles in the Chinese market can also be grouped into the same three vehicle types as in India, but unlike India, China has a relatively large fraction of imported vehicles which are mostly luxury vehicles or midsize SUV models. Almost all the world's major manufacturers have joint ventures in China offering virtually the same products as those sold in OECD countries, although the smaller engine size options appear to have the dominant market share in these vehicles in China. In addition, several older designs, notably the VW Santana and the Suzuki micro-van dating from the 1980s, are still produced in quantity and serve as price leaders in their class. As in India, the market share for the older designs is declining rapidly. Chinese manufacturers with their own indigenous designs have proliferated in the last decade with about 20 manufacturers making from 10 to 500 thousand vehicles per year. Many joint venture partners are also developing their own indigenous designs that are planned for the export market.

As noted, most joint venture vehicles are technologically equivalent to OECD models, and many indigenous models have engine technology that is essentially on par with engines sold in the OECD with 4-valves/ cylinder, variable valve timing and port fuel injection. Direct injection (gasoline) technology has not yet been adopted in locally produced cars, and diesel passenger cars have a near zero market share through 2010. Diesels are not used even in the utility and SUV models. Transmission technology in many indigenous models appears to be behind OECD levels and 4-speed automatic transmissions were still the most common transmission for indigenous design cars, while 5 and 6 speed transmissions are more common in Europe and North America. However, there are reports that transmission technology will soon be significantly upgraded with a number of world class transmission suppliers like ZF and Aisin setting up joint ventures in China.

Russian Fleet

Russian light vehicle sales collapsed in 2009 much like the rest of Western Europe, but have since rebounded smartly and are expected to set a new record on 2.8+ million units in 2013. The Russian fleet is currently dominated by sales of Western European brands and to a lesser extent, Japanese and Korean brands. Many of the global auto-manufacturers have local production facilities that produce the latest or the previous generation model of vehicles sold in their home markets, while Lada is the only large scale domestic producer that had a significant market share. The Lada models had ancient technology (dating from the 1970 Fiat models) but were known to be heavy and rugged as well as easy to repair. Sales in Russia continue to be good, with Lada being the most popular C class model. Lada signed an agreement with Renault and will likely launch a more modern set of products in the 2013-2016 time frame.

The Russian light vehicle market is dominated by the C class and B class cars, but sales of SUVs and luxury cars are growing rapidly. Russia has emerged as one of the few markets for large US style SUV models, and although sales are not very large in absolute terms, the sales volume for such SUVs is twice as large as the sales volume in the German market. In addition, sales of high end and luxury cars have been growing faster than the market as a whole recently, and experts claim that Russia is one of the most profitable car markets in the world for the German luxury car manufacturers.

Brazilian Fleet

The Brazilian market has seen healthy growth over the last decade as the economy grew rapidly. The Brazilian vehicle market is dominated by Fiat, VW and GM and the models sold in Brazil appear to lag their OECD counterparts technologically by only by a few years. The Brazilian market is heavily concentrated in the B and C class, but between 2008 and 2010, the small SUV market showed surprising growth, practically doubling market share from about 10% to 20%.

Brazil is also unique in having widespread ethanol fuel availability and the sales of ethanol vehicles and flex-fuel vehicles have changed over time with rapid changes to the relative prices of ethanol and gasoline. Starting from near zero in 2002, flex-fuel vehicles had a 75% market share in 2008 and 77% share in 2010. Diesel engines are used only in some light commercial vehicles so most of the fleet (>90%) is gasoline/ ethanol engine powered. However, consumers switch from petrol to ethanol depending on relative pricing, and in the 2009 to 2011 time frame, ethanol prices exploded leading most owners to switch back to petrol

The fuel economy on ethanol blends like E85 is significantly lower on a volumetric basis due to the fact that ethanol has only 60% of the energy content of petrol. Hence fuel consumption values on E85 are typically 25 to 30 percent higher than on petrol. Unfortunately, the IEA database for 2010 may not fully account for the difference between fuel consumption on E85 and petrol and the net numbers suggest unreasonably high fuel consumption for petrol. The 2008 data was uniformly for petrol, and the data analysis showed that Brazilian cars had near equivalent fleet fuel economy to that of Germany. After accounting for size mix differences and diesel penetration differences, the technology lag relative to Germany in 2008 was very small. In the important B and C classes, the technology lag resulted in a 5% fuel consumption difference relative to Germany, and the fact that new OECD models are introduced with a 2 to 3 year delay in Brazil seems to account fully for the difference. No detailed data analysis for Brazil was completed for this report due to the 2010 data quality issues which could not be resolved within the time constraints of this project.

Malaysian Fleet

Although Malaysia is a relatively small country, it is unique for its size in having a domestic auto industry that accounts for over 75% of total Malaysian sales over the 2002 to 2010 time frame. Malaysia started vehicle production in the 1980s with a collaboration between Proton (the domestic company) and Mitsubishi. The company started production of rebadged Mitsubishi Lancer in 1985, and it was restyled in 1992 using the old platform. It subsequently launched other cars based on the 1991 Mitsubishi Lancer platform. In 2000, Proton launched a domestically designed series of vehicles but because of poor quality, it failed in the market leaving the door open for a second Malaysian company, Perodua to enter the market. Perodua produced B and C segment cars in collaboration with Toyota and its sales overtook Proton sales in Malaysia in the late 2000 time frame. Proton improved its products and resumed collaboration with Mitsubishi in 2009, and its sales have since revived. Hence, the local market was dominated by sales of older design Japanese vehicles over the 1990 to 2009 period.

The Malaysian light vehicle market is dominated by sales in the B, C and D segments of cars which account for about 70% of sales. Like the North Asian countries, there are no diesel models except in the medium and large light truck segments, and diesel penetration was only 6% in 2008 and 8% in 2010. As a result of the relatively large average vehicle size and lack of dieselization, average FC for the fleet was 7.55 L/100 km in 2008 and declined to 7.1 L/100km with the introduction of more modern Japanese design models in 2010.

South African Fleet

South Africa is unique in the African continent in that it has a domestic automotive industry, which currently “produces” over 500,000 cars annually, with about 30% of production exported. Sales in South Africa are typically in the 600,000 to 700,000 range so that domestic producers have about a 60% market share. Although there are tariff barriers to importing fully built vehicles, the cost of production in South Africa is high and had been estimated to be about 20 to 25% higher than in the EU. This is because the domestic industry is more an assembly operation than a true production operation in the sense that a large fraction of the components are imported, and the actual domestic content of vehicles assembled in South Africa is only in the 35% range. In addition, sales volumes per model are quite low, with even the best-selling vehicle having annual sales of less than 50,000 units per year. Import duties on fully built vehicles have been decreased steadily since 1996 and were at about 40% in 2008-2010 and have since been reduced to 25%. Imported vehicle prices are now much closer to those produced domestically and domestic vehicle market share is falling as a result.

The market is quite fragmented with seven domestic vehicle “producers”, and virtually all of the world’s large manufacturers have sales outlets in South Africa. The market leaders are VW and Toyota, with market shares of about 20% each followed by GM and Ford with about 10% market share. Surprisingly, the German luxury auto-manufacturers are well represented with a 10 to 12% market share and Mercedes and BMW having local production facilities. The silver lining of having low sales per model and only assembly operations is that all no South Africa specific designs are economical, and assembly of vehicles are necessarily of international designs that incorporate modern fuel efficiency technology.

The car market is primarily in the B and C segments which accounted for almost 44% of light vehicle sales, but the D segment which includes the German luxury cars had a 12% share. The market for mid-sized pickup trucks is also quite large and commercial vehicles make up over 25% of the light vehicle market. Diesel market share in 2010 was close to 20%, but most diesels are concentrated in the truck classes and in the luxury car classes, which are dominated by German makes (Mercedes, BMW, Audi). The large vehicle size and strong pickup market result in relatively high fuel consumption of 7.7 L/100km in 2010.

4.2 DECOMPOSITION ANALYSIS RESULTS

The analysis uses the same methodology as the decomposition analysis for the OECD countries, with Germany as the reference country for benchmarking. Tables 4-1 and 4-2 show the details of the decomposition analysis for 2008 and 2010 respectively.

2008		Mix	Diesel	Performance/ Trim	Transmission	Technology	Total
CHINA	DELTA FC	0.348	-0.954	0.226	-0.105	-0.723	-1.208
	% FC	5.16%	-14.14%	3.35%	-1.56%	-10.70%	-17.90%
INDIA	DELTA FC	0.804	0.117	0.609	-0.007	-0.313	1.210
	% FC	11.91%	1.73%	9.02%	-0.10%	-4.64%	17.92%
RUSSIA	DELTA FC	-0.053	-0.856	0.057	0.000	-0.453	-1.305
	% FC	-0.79%	-12.68%	0.85%	0.00%	-6.71%	-19.33%
SOUTH AFRICA	DELTA FC	0.014	-0.749	-0.054	0.000	-0.186	-0.975
	% FC	0.21%	-11.10%	-0.80%	0.00%	-2.76%	-14.45%
MALAYSIA	DELTA FC	0.163	-0.713	0.659	-0.168	-0.739	-0.797
	% FC	2.41%	-10.56%	9.76%	-2.48%	-10.94%	-11.81%

Table 4-1: Decomposition Analysis of the 2008 Fleet Relative to the German Fleet

2010		Mix	Diesel	erformance/Tri	Transmission	Technology	Total
CHINA	DELTA FC	0.174	-0.912	0.420	-0.082	-0.846	-1.246
	% FC	2.70%	-14.16%	6.52%	-1.28%	-13.13%	-19.34%
INDIA	DELTA FC	0.480	0.161	0.525	0.020	-0.838	0.348
	% FC	7.45%	2.49%	8.16%	0.31%	-13.01%	5.41%
RUSSIA	DELTA FC	-0.290	-0.822	0.311	-0.070	-0.712	-1.582
	% FC	-4.50%	-12.76%	4.83%	-1.09%	-11.06%	-24.58%
SOUTH AFRICA	DELTA FC	-0.481	-0.587	0.083	-0.199	-0.068	-1.253
	% FC	-7.47%	-9.12%	1.28%	-3.09%	-1.06%	-19.46%
MALAYSIA	DELTA FC	0.198	-0.697	0.608	-0.210	-0.535	-0.636
	% FC	3.07%	-10.83%	9.45%	-3.26%	-8.31%	-9.87%

Table 4-2: Decomposition Analysis of the 2010 Fleet Relative to the German Fleet

China

In 2008, the Chinese fleet fuel consumption was about 18% higher than German FC, in spite of the smaller average vehicle size that should have provided a 5% benefit. The net -23% size adjusted (i.e., 18 + 5) differential can be explained by lower diesel penetration which accounted for 14.1%, higher use of automatics (about 1.5%) and lower vehicle technology which accounted for a 10.7% differential, offset somewhat by lower vehicle weights and performance levels which accounted for a positive 3.35%. The 2010 data was quite similar but the vehicle technology differential increased to 13.1% from 10.7%, indicating that German vehicle fuel efficiency technology adoption was occurring at a faster rate than in China.

A detailed decomposition by size class showed that the A, B and C classes as well as the Wuling micro-van have significantly higher fuel consumption than German models of equal size and performance, and the differentials are in the 13 to 16% range for the cars and 24% for the micro-van in 2010. Larger car classes have a lower technology based differential of 8 to 10%. In addition, the technology differentials in all classes have increased from 2008 to 2010, suggesting that German models in all classes have adopted more technology in the 2 years (the increase in differences between 2008 and 2010 are on the order of 3 to 4% but are present in all classes).

In 2008,we noted that the differentials in the smaller car classes was due to the existence of many local manufacturer’s models in these classes and these models often employ older lower cost designs to enable a cheap product. As an example, the Wuling micro-van is based on a Mitsubishi van design from the late 1970s although the power-train was modernized in the 1990s using Suzuki engines. Even so, the technology employed is at least 15 years old, but the price of the van is under $6000, which is less than half the price of a similar size vehicle in Germany. These low cost vehicles are still popular and explain much of the differential in technology for smaller vehicles.

China also has a very large number of joint venture manufacturers that manufacture modern international designs of vehicles in China. Our analysis suggests that these vehicles are technologically identical to OECD models but the latest technology historically moved to China with a modest time lag of 2 to 3 years. This could explain the increased technology differential in 2010, due to the rapid change in German technology in the 2008-2010 period. However, it is not completely clear if the latest EU technology of using downsized, turbo-charged engines is well suited to low speed Chinese driving conditions, and the official test result based fuel economy may not see the decline in technology differentials if the EU technology proves less transferable to developing countries.

India

The Indian fleet had 5.4% lower fuel consumption than the German fleet, in contrast to the fleet fuel consumption in China which was 19% higher. The fleet average size mix was also smaller than the German mix which should alone have provided a 7.5% advantage in fuel consumption if Indian vehicle technology was on par with Germany. Higher diesel penetration in the smaller size classes, and significantly lower vehicle performance levels along with the mix should have resulted in the Indian fleet being 18.4% more efficient rather than only the 5.4% in actuality, and the 13% differential is due to the lower technology of the Indian fleet. It is remarkable that the technology differential in 2010 between the Indian and German fleets is virtually identical to the technology differential between the Chinese and German fleets.

However, many of the same underlying forces are responsible for the technology differential. India does not have any “domestic” vehicle designs except one model in production but there are several popular low cost models that are older designs, notably the Maruti 800, Hindustan Ambassador and Fiat. (these models have become less popular in the post-2010 time frame). The one domestic design is the Tata Nano, which is an ultra-low cost model with relatively basic technology. These vehicles sell for less than $5000 but given their size and performance, the fuel consumption is about 13% higher than German models in the B and C classes and 26% in the A class (where the Nano and Maruti 800 are popular models). The micro truck class has a similar 27% technology differential due to the unique characteristics of the Tata Ace with a 16 HP engine that has no real equivalent in the EU market.

In the D and E classes, all of the cars are imported, and again, the decomposition analysis shows that in these classes, the technology difference is in the 0 to 5% range, with any difference associated only with the time lag between model introduction in the EU and India.

Much like Chinese vehicles, the technological gap between Indian and German vehicles for fuel economy increased between 2008 and 2010,but rose more sharply because some vehicles like the Nano were introduced in 2010. The common findings between India and China are encouraging in that low cost vehicle technology is similar globally and is approximately at the 1990-2000 level of OECD technology. As in China, it is not clear if the EU technology of direct injection, downsized, turbocharged engines will be suitable for Indian conditions and the technology gap may grow as a result, in the near term.

Russia

The Russian fleet had 24.6% higher fuel consumption than the German fleet in 2010, and is the only one among "developing" countries to have a larger average size of vehicle. Of course, Russia embodies a mix of developing country and developed country characteristics. The size adjusted differential in fuel consumption is 20.1% and as can be seen from table 4-2, the technology specific difference between Russian and German vehicles is 11%, which is comparable to but slightly smaller than the 13% differential in China and India.

Russia has one major "domestic" car manufacturer, Lada, which produces several versions of an old design Fiat model that dates from the 1970s. The Lada cars are technologically backward, but have the virtues of ruggedness and ease of repair, as well as relatively low cost. Most models continued to use old design 2 valve petrol engines to 2010, and are in the B and C classes. Lada accounts for about half of all cars produced in Russia, while the other 50% are local assembly of major OECD manufacturer's models. The detailed class specific analysis shows the influence of the Lada cars as the B and C class vehicles have a technology gap of 14% and 25% respectively while the technological gap in the other classes in on the order of 0 to 6%.

Hence, Russia shares some of the same factors that explain the technological gap in India and China, in having a significant percentage of its fleet comprised of low technology content, older design, inexpensive vehicles. Lada has signed a major agreement with Renault-Nissan as of 2008 and is expected to largely replace the old Lada models with modern designs sourced from its new partners. In addition, Russian driving conditions and population density are more akin to those in Western Europe, and we anticipate that the Russian market will gradually evolve to being technologically much closer to the EU market, with a technological lag associated only with new model migration time lags. In this sense, the Russian new vehicle fleet will be similar to the one in Australia where larger and more rugged vehicles have a higher sales mix than in the EU, but technological differences will be limited. The similarity of effects in China, India and Russia is illustrated in Figure 4-1.

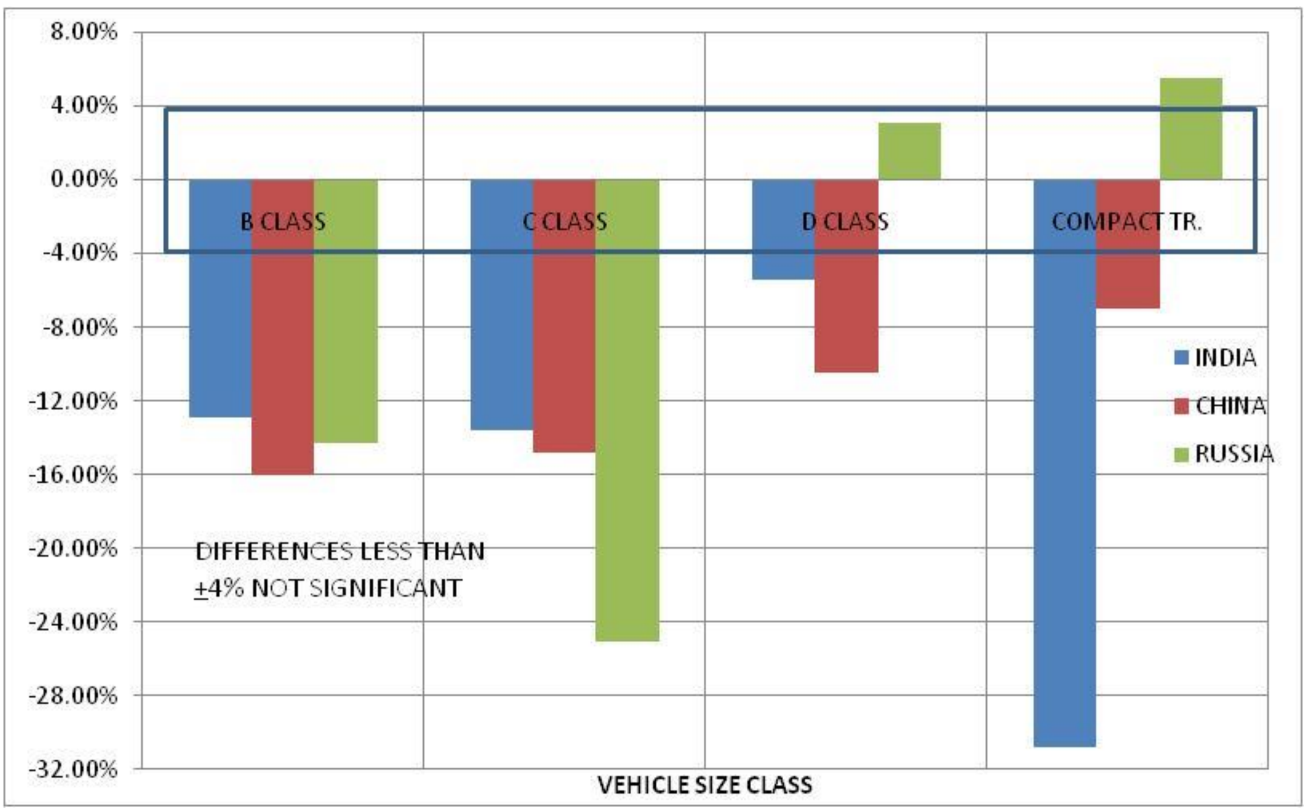

Figure 4-1: Size class specific fuel consumption differences relative to Germany
(adjusted for diesel penetration, weight and performance; negative percentages indicate worse FC)

South Africa

The South African fleet had 19.5% higher fuel consumption than the German fleet in 2010. Interestingly, the average vehicle size in South Africa is larger then the average German vehicle, and this accounts for 7.5% of the 19.5% difference. Low diesel penetration and the higher trim/option content of cars in South Africa account for 9% and 3% of the fuel consumption difference respectively and together, the three factors explain the difference completely. Hence, **there are virtually no technological differences** between the South African and German fleet. A very similar result was obtained from the 2008 decomposition analysis and the details are in Table 4-1.

Of course, the result is has to be expected given that the South African industry only assembles vehicles exported from the EU and Japan, and the models assembled in South Africa are not specially designed for the region. The larger vehicle size and option content is due to the unusual mix in South Africa, where the class with the highest sales is the midsize truck class that includes pickup and SUV models and accounts for over 25% of total sales. This class is also relatively highly dieselized (over 50% diesel). It should be noted that the reference German midsize truck class is principally composed of diesel cargo vans so that fuel economy comparisons are not between like models in this class.

In spite of these differences, it is clear that one advantage of importing or simply assembling OECD vehicle models is access to the latest technology and hence, highest fuel efficiency vehicles.

Malaysia

The Malaysian fleet was almost 10% less fuel efficient than the German fleet in 2010, in spite of a smaller mix of vehicles, with lower average performance and weight in each class than the German fleet. The mix and weight adjusted differential of 21.1% is explained by the lower diesel penetration which accounts for 10.8% of the 21.1% difference, the high automatic transmission penetration which accounts for 3.3% and a net technology differential of 7%. The 2008 data, which would not include some model updated by the two major domestic manufacturers (Proton and Perodua) indicated a technology differential of close to 10%.

The data at the size class level shows that the technology differential is largely in the A and B class vehicles as well in the medium truck class, all of which are dominated by the older design domestic models that are 15 to 20 percent less fuel efficient than a European model of the same size and performance level. In other classes where imports are dominant, there appears to be little or no technology differential. Hence, the Malaysian fleet has similar characteristics to the Indian, Chinese and Russian fleets where domestic producers have continued production of old vehicle designs, and sell these vehicles as entry level low priced vehicles in their (sometimes protected) home market.

As in the other countries, these older designs appear to be fading from the market, perhaps in response to the sharp increase in world oil price since 2008. As noted, both Proton and Perodua are rapidly updating their products and we expect that by 2015, the technology gap will be narrowed considerably. The only issue is the suitability of the EU technology path to local driving conditions, but this may be less of an issue in Malaysia with its moderate population density and relatively high income level.

5. SUMMARY OF FINDINGS AND RECCOMENDATIONS

The analysis of vehicle specification and fuel economy data from the new light vehicle fleets of 10 countries shows the considerable diversity of local forces affecting the characteristics of the fleet. The most obvious lesson from the data is that policies aimed at improving fuel economy have to be tailored to the forces in each country and a single policy such as fuel economy standards cannot be uniformly effective across all nations.

The comparison across four OECD countries provides the following lessons

- First, vehicle fuel efficiency technology is very similar across all developed countries in spite of significant differences in fuel prices and incomes, showing that fuel economy regulations rather than economic forces control manufacturer technology introduction plans.
- Second, economic instruments such as fees and rebates ("feebates') based on vehicle fuel efficiency can have significant market effects by drawing consumers to the most efficient vehicles, even when there are stringent fuel economy standards. There is also some evidence that manufacturers subject to fee-bates may "pull ahead" technology introduction to take advantage of the market response, based on France's experience with the fee and rebate system called Bonus Malus.
- Third, developed nations that rely on imported vehicles for most or all of their vehicle fleet enjoy a free rider effect of having the latest fuel economy technology since most vehicles are imported from the EU, Japan and Korea. Nations that do not have a domestic car industry typically do not have enough sales and economies of scale, especially at the individual vehicle make/model level, to justify a unique design for that country. The Australian situation shows that improvements in its light vehicle fleet have kept pace with the EU and US fleets even though there are no fuel economy standards. 85% of the Australian fleet is imported and its domestic manufacturers do not see any future for Australia specific designs. Fuel economy technology may lag the level in the EU or Japan by a modest one to two years due to the lag in the timing of new model introduction.

In the context of developing countries, there are additional specific findings

- In countries where most of the vehicles are imported or simply assembled from knock-down kits, the same free rider effect of obtaining the latest fuel efficiency technology from the EU and Japan is observed, as in South Africa. Here again, there is a modest time lag in technology introduction.
- The situation in countries with significant domestic production and/or restriction of imports, the situation is more complex. Products manufactured locally by global auto-manufacturers generally employ new technology but with a somewhat larger time lag of 4 to 5 years relative to OECD countries in many cases, but not always, depending on the local market's competitiveness. Products manufactured by purely domestic manufacturers, such as Tata in India, Lada in Russia, or Wuling in China typically feature older technology and are 15 to 25 percent less fuel efficient **relative** to their OECD counterparts of equal size and performance. However, these products are usually smaller, low performance vehicles and their fuel economy may be good on an absolute scale.
- A major factor inhibiting the adoption of new technology in the older design vehicles manufactured domestically is that these products are usually very low price models sold to the most cost sensitive buyers, at prices that are less than half the price of similar size vehicles sold in the OECD. The old technology models may also be perceived as easier to maintain and repair in a developing country environment.

The above findings are based on the 2008 and 2010 data, but the steep increases in global fuel price since 2009 is changing the picture. Sales of these older design models appear to be fading and it is possible that technology in developing countries will converge to the technology used in the OECD in the future with a modest time lag as consumer demand for more efficient products grows in developing countries.

A separate issue (not based on any of the data in this report) is the applicability of new technology being introduced in OECD countries to the developing country environment. The EU manufacturers have, in particular, adopted the technology of using downsized direct injection turbocharged gasoline engines as a primary method of meeting future fuel consumption or CO2 standards, but the technology is better suited to high speed driving rather than low speed driving conditions prevalent in much of the developing world. Other technology solutions such as high compression ratio engines may be better suited to these conditions, and it is possible that the technologies may diverge significantly between the EU and the developing world in the future.

APPENDIX A

DECOMPOSITION ANALYSIS METHODOLOGY

The decomposition analysis explains the difference in the new vehicle fleet fuel consumption ratings of two different country fleets in terms of the contributions of different factors affecting fuel consumption. The size mix differences between two fleets is the most obvious but the analysis goes beyond the mix difference to also allocate the difference to the difference in diesel penetration in each country, the difference in the average performance level and option content of each size class, the penetration of automatic transmissions, and differences in fuel economy technology penetration.

The average fuel consumption of the fleet is the market share weighted fuel consumption by market class. When comparing the average consumption difference between two country (A and B, respectively) fleets, we can write the difference as follows

$$
\begin{aligned}
FC_A - FC_B &= \Sigma\ (FC_{Ai} * m_{Ai} - FC_{Bi} * m_{Bi}) \\
&= \Sigma\ (FC_{Ai} - FC_{Bi})* m_{Ai} + FC_{Bi} * (m_{Ai} - m_{Bi})
\end{aligned}
$$

Where m is the market share and subscript A and B refer to the country and subscript 'i' to the market class. The first term in the equation above is the difference in fuel consumption at the class level for each country where the products are comparable in terms of consumer attributes, and the difference can be attributed to technology differences. The second term is the contribution of mix of sizes sold to the overall difference. Since the sample for Germany is being used as the reference, we have used the fuel consumption at the size class level as the comparative gauge, and is country 'A' in all the following comparisons.

The fuel consumption difference at the size class level can be further decomposed into the observable differences plus other differences attributable to technology differences that require detailed knowledge of individual vehicle technology characteristics. The major observable differences include

- diesel penetration
- differences in weight

- differences in performance (HP/WT)
- difference in automatic transmission penetration.

The penetration differences and differences in weight and performance were quantified in Section 3.3. The relationship to fuel consumption is also well known: diesel engines provide a 25 $\pm$ 2 percent reduction in fuel consumption, a 10 percent reduction in weight at constant performance provides a 6 $\pm$ 0.3 percent increase in fuel consumption, a 10 percent increase in (HP/WT) ratio results in a 2 $\pm$ 0.2 percent increase in fuel consumption while an automatic transmission imposes a fuel consumption penalty of 5 $\pm$ 1 percent relative to a manual transmission with the same number of gears. Any remaining difference can be attributed to fuel efficiency technologies used in one country but not the other. Of course, the small uncertainty band around each observable technology implies that small residuals on the order of 5% or less imply little or no difference in other technology between countries. In essence, the analysis breaks down the fuel consumption at the size class level as follows

$$
\begin{aligned}
(FC_{Ai} - FC_{Bi}) / FC_{Bi} = \quad & T_d*(m_{Aid} - m_{Bid}) && \text{(diesel)} \\
& + T_t*(m_{Ait} - m_{Bit}) + \ldots && \text{(auto. Transmission)} \\
& + T_p*((HP/WT)_{Ai} - (HP/WT)_{Bi})/(HP/WT)_{Bi} && \text{(performance)} \\
& + T_w*(WT_{Ai} - WT_{Bi})/WT_{Bi} && \text{(weight difference)} \\
& + \text{Other technology effects (\%)}
\end{aligned}
$$

Where the left hand side is the percent difference in fuel consumption at the size class level, i, between country A and country B and T_d is the technology benefit (25%) of dieselization in percent times the difference in market share in diesels ($m_{aid} - m_{bid}$) for class i, between country A and B and so on.

The country specific data provides the values of ($m_{Aid} - m_{Bid}$) and ($m_{Ait} - m_{Bit}$), while vehicle specification data provides the horsepower and weight values. This allows each term to be evaluated and the decomposition analysis completed.

APPENDIX B:

DETAILED RESULTS OF DECOMPOSITION ANALYSIS FOR 2010

							FC(l/100km)	
US	Diesel	Weight	HP/Curbwt	Trans	Other Tech	**FCger-Fcus**	**USA**	**Germany**
A	-1.23%	6.64%	-1.53%	-4.02%	-9.19%	-0.501	5.37	4.87
B	-2.80%	-5.77%	-5.40%	-3.71%	0.72%	-1.173	6.92	5.74
C	-8.10%	1.29%	-3.25%	-3.86%	2.84%	-0.756	6.82	6.07
D	-15.55%	-2.06%	-5.40%	-3.61%	0.60%	-2.217	8.52	6.30
E	-19.19%	1.24%	-4.79%	-2.02%	-3.88%	-2.875	10.04	7.16
F	-1.45%	-5.31%	-1.70%	-1.92%	-3.53%	-1.439	10.35	8.91
MICRO TRUCK	-12.36%	2.05%	-5.17%	-3.73%	5.85%	-1.034	7.73	6.70
COMPACT TRUCK	-15.38%	-2.50%	-5.22%	-3.75%	2.53%	-2.265	9.31	7.05
MEDIUM TRUCK	-23.51%	2.45%	-7.43%	-2.46%	8.41%	-2.443	10.84	8.39
LARGE TRUCK	-24.85%	-11.37%	-9.79%	-4.01%	17.28%	-4.191	12.80	8.61
Fleet Average	-10.94%	-10.19%	-5.72%	-3.65%	-0.32%	-2.869	9.31	6.44

France							**FC(l/100km)**	
Class	Diesel	Weight	HP/Curbwt	Trans	Other Tech	**FCger-FCfr**	**France**	**Germany**
A	2.32%	1.82%	-1.75%	0.65%	-1.54%	0.073	4.80	4.87
B	12.33%	1.72%	1.31%	0.51%	-4.31%	0.595	5.15	5.74
C	13.52%	1.85%	1.15%	0.34%	-2.45%	0.764	5.30	6.07
D	8.54%	1.21%	1.30%	0.24%	-3.14%	0.475	5.82	6.30
E	4.56%	2.80%	0.33%	-0.27%	-2.44%	0.340	6.82	7.16
F	9.36%	2.01%	5.28%	0.18%	6.03%	1.657	7.25	8.91
MICRO TRUCK	9.51%	2.69%	4.75%	0.49%	0.61%	1.024	5.67	6.70
COMPACT TRUCK	8.79%	5.79%	3.46%	0.59%	0.89%	1.151	5.90	7.05
MEDIUM TRUCK	0.89%	2.56%	3.22%	1.46%	-7.63%	0.042	8.35	8.39
LARGE TRUCK	0.14%	-6.72%	3.34%	0.88%	-1.57%	-0.352	8.96	8.61
Fleet Average	7.57%	7.82%	2.78%	0.74%	-3.33%	0.869	5.57	6.44

Australia							FC(l/100km)	
Class	Diesel	Weight	HP/Curbwt	Trans	Other Tech	**FCger-FCaus**	**Australia**	**Germany**
A	-1.20%	8.86%	-2.72%	-4.02%	-4.01%	-0.155	5.02	4.87
B	-2.36%	3.75%	-4.25%	-2.71%	-3.97%	-0.606	6.35	5.74
C	-6.13%	2.11%	-4.36%	-0.64%	-12.02%	-1.618	7.69	6.07
D	-13.44%	-2.39%	-3.06%	-3.64%	-3.46%	-2.212	8.51	6.30
E	-18.94%	1.40%	-5.58%	-2.10%	-3.77%	-2.924	10.09	7.16
F	-1.28%	1.64%	-4.47%	-3.34%	1.32%	-0.583	9.49	8.91
MICRO TRUCK	-11.68%	2.95%	-3.53%	0.43%	-14.68%	-2.414	9.11	6.70
COMPACT TRUCK	-8.68%	-2.57%	-3.25%	0.61%	-7.49%	-1.916	8.96	7.05
MEDIUM TRUCK	-7.77%	2.45%	-4.36%	1.93%	-11.30%	-1.975	10.37	8.39
LARGE TRUCK	-9.73%	-3.04%	0.71%	-1.52%	-9.72%	-2.616	11.22	8.61
Fleet Average	-5.07%	-4.76%	-4.07%	0.23%	-12.66%	-2.303	8.74	6.44

India							FC(l/100km)	
Class	Diesel	Weight	HP/Curbwt	Trans	Other Tech	**FCger-FCin**	**India**	**Germany**
A	-1.23%	12.07%	0.28%	0.61%	-25.94%	-0.807	5.67	4.87
B	6.90%	6.86%	0.25%	0.59%	-12.86%	0.098	5.64	5.74
C	5.79%	13.93%	0.06%	0.10%	-13.56%	0.361	5.71	6.07
D	-2.77%	0.12%	3.12%	-0.22%	-5.43%	-0.345	6.64	6.30
E	-5.61%	-1.67%	0.42%	-1.71%	1.10%	-0.579	7.74	7.16
F	2.02%	8.67%	-5.48%	-1.75%	-16.45%	-1.330	10.24	8.91
MICRO TRUCK	1.44%	17.94%	14.55%	0.66%	-27.79%	0.426	6.27	6.70
COMPACT TRUCK	9.54%	5.90%	7.22%	0.89%	-31.83%	-0.636	7.68	7.05
MEDIUM TRUCK	-9.45%			2.21%	12.91%	0.451	7.94	8.39
LARGE TRUCK	0.15%			0.99%	-3.35%	-0.195	8.80	8.61
Fleet Average	-2.13%	31.57%	2.66%	0.87%	-26.80%	0.375	6.07	6.44

China							FC(l/100km)	
Class	Diesel	Weight	HP/Curbwt	Trans	Other Tech	**FCger-FCch**	**China**	**Germany**
A	-1.23%	0.71%	1.05%	0.51%	-13.06%	-0.665	5.53	4.87
B	-2.80%	6.72%	-3.53%	-0.26%	-16.61%	-1.134	6.88	5.74
C	-8.58%	8.18%	-1.66%	-0.99%	-14.82%	-1.320	7.39	6.07
D	-15.57%	4.99%	-0.70%	-2.35%	-10.48%	-2.001	8.30	6.30
E	-19.19%	8.83%	-0.39%	-1.54%	-8.21%	-1.848	9.01	7.16
F	-1.45%	11.10%	5.18%	-2.58%	-13.88%	-0.148	9.06	8.91
MICRO TRUCK	-11.67%	18.04%	7.82%	0.59%	-24.22%	-0.698	7.39	6.70
COMPACT TRUCK	-14.63%	5.90%	2.38%	-1.16%	-6.96%	-1.193	8.24	7.05
MEDIUM TRUCK	-21.67%	-0.96%	1.72%	-0.49%	6.20%	-1.504	9.90	8.39
LARGE TRUCK	-21.77%	-3.04%	-1.54%	-0.45%	-3.96%	-3.825	12.43	8.61
Fleet Average	-10.76%	13.43%	-1.59%	-0.78%	-16.51%	-1.246	7.69	6.44

Russia							FC(l/100km)	
Class	Diesel	Weight	HP/Curbwt	Trans	Other Tech	**FCger-FCrus**	**Russia**	**Germany**
A	-1.23%	5.07%	-2.49%	-0.83%	-6.10%	-0.287	5.16	4.87
B	-2.80%	9.42%	-2.65%	-0.37%	-14.33%	-0.690	6.43	5.74
C	-8.60%	13.27%	-0.08%	-0.07%	-25.09%	-1.571	7.64	6.07
D	-15.25%	-2.01%	0.68%	-2.18%	3.11%	-1.169	7.47	6.30
E	-17.37%	4.67%	-2.62%	-1.58%	-4.98%	-2.008	9.17	7.16
F	-1.45%	7.29%	-5.00%	-2.87%	-9.12%	-1.118	10.03	8.91
MICRO TRUCK	-10.43%	3.66%	-2.14%	-1.58%	-3.04%	-1.048	7.74	6.70
COMPACT TRUCK	-14.06%	-2.13%	2.20%	-1.06%	-4.97%	-1.766	8.81	7.05
MEDIUM TRUCK	-13.31%	1.88%	-4.54%	-1.03%	5.50%	-1.091	9.48	8.39
LARGE TRUCK	-18.93%			0.75%	-8.36%	-3.110	11.72	8.61
Fleet Average	-9.71%	8.65%	-0.46%	-0.32%	-17.87%	-1.582	8.02	6.44

Malaysia							FC(l/100km)	
Class	Diesel	Weight	HP/Curbwt	Trans	Other Tech	**FCger-FCmal**	**Malaysia**	**Germany**
A	-1.23%			-3.90%	-12.43%	-1.038	5.91	4.87
B	-2.80%	14.76%	-5.27%	-3.12%	-20.58%	-1.177	6.92	5.74
C	-8.70%	2.54%	-1.31%	-3.85%	3.05%	-0.547	6.62	6.07
D	-15.57%	2.57%	5.67%	-1.91%	-1.97%	-0.795	7.09	6.30
E	-19.04%	6.20%	-2.80%	-2.10%	2.21%	-1.316	8.48	7.16
F	-1.45%	5.39%	5.39%	-3.18%	-8.37%	-0.201	9.11	8.91
MICRO TRUCK	-10.27%	9.20%	-1.10%	-3.90%	-5.05%	-0.836	7.53	6.70
COMPACT TRUCK	-15.46%	16.95%	-2.09%	-2.69%	-1.20%	-0.331	7.38	7.05
MEDIUM TRUCK	-2.40%	4.63%	3.26%	-1.72%	-16.93%	-1.272	9.67	8.39
LARGE TRUCK	-8.89%	-3.04%	0.52%	-4.01%	3.99%	-1.111	9.72	8.61
Fleet Average	-9.16%	17.04%	-1.10%	-2.64%	-13.12%	-0.636	7.08	6.44

South Africa							FC(l/100km)	
Class	Diesel	Weight	HP/Curbwt	Trans	Other Tech	**FCger-FCsa**	**South Africa**	**Germany**
A	-1.23%	6.56%	-2.53%	-1.72%	-6.98%	-0.305	5.17	4.87
B	-1.83%	3.17%	-2.43%	-3.74%	0.57%	-0.255	6.00	5.74
C	-7.63%	4.38%	-2.00%	-2.94%	-3.33%	-0.790	6.86	6.07
D	-12.66%	3.05%	-3.52%	-3.65%	5.15%	-0.829	7.13	6.30
E	-11.87%	2.24%	-4.07%	-2.10%	0.14%	-1.330	8.49	7.16
F	-1.25%	4.05%	-4.70%	-2.75%	-5.45%	-1.001	9.91	8.91
MICRO TRUCK	-12.36%	9.72%	-2.32%	0.63%	-4.80%	-0.673	7.37	6.70
COMPACT TRUCK	-10.51%	2.26%	-0.21%	-3.69%	1.42%	-0.848	7.90	7.05
MEDIUM TRUCK	-13.12%	-3.21%	4.99%	1.56%	-6.66%	-1.651	10.05	8.39
LARGE TRUCK	-1.70%			-1.36%	-15.43%	-1.953	10.56	8.61
Fleet Average	-6.25%	5.09%	-1.70%	-1.28%		-0.318	7.69	6.44

GFEI
GLOBAL FUEL ECONOMY INITIATIVE
www.globalfueleconomy.org

50BY50
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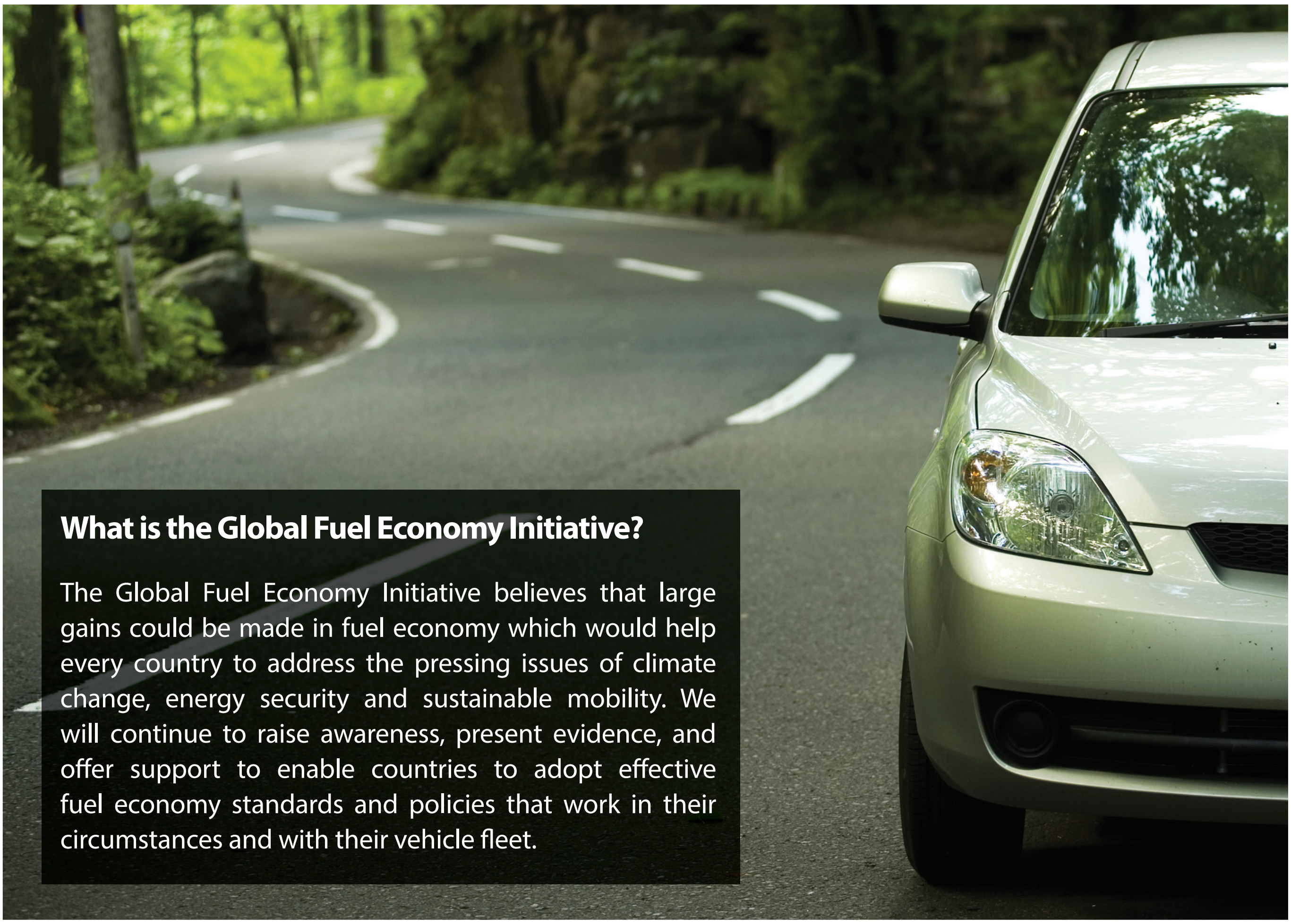

What is the Global Fuel Economy Initiative?

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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