



Fuel Economy and CO₂ Emissions of Light-Duty Vehicles in Morocco

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Prepared by

Amr El-Abyad

Contributors

Hossam Allam

Matthias Gasnier

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1 INTRODUCTION

The transport sector is responsible for about a quarter of the world energy consumption and a similar attribution to global CO₂ emissions. A growing international concern over climate change induced by the burning of fossil fuels has been accelerating. Also the security and sustainability of oil supplies are subjects of growing global concerns. In response to those challenges many countries all over the world are working on curbing oil consumption and finding alternative resources. That's why many countries worldwide have introduced fuel consumption/ economy or CO₂ emissions standards towards the end of improving vehicles energy efficiency. A number of initiatives around the world have been introduced to help countries with regard to fuel economy standards. The Global Fuel Economy Initiative (GFEI) comes as an effort of five organizations¹ to promote improvements in vehicle fuel economy. This initiative aims to achieve 50 % improvements by 2050 in all vehicles globally compared to that in the year 2005. The initiative's main activities include: data development and analysis, policy support, and raising awareness (GFEI, 2013).

1.1 OBJECTIVES

In line with the United Nations Environmental Program (UNEP) work on promoting sustainability and the GFEI's efforts in prompting the introduction of more energy efficient vehicles, this report comes as part of sequel aiming to analyze the status and trends of fuel economy standards in at least four Arab countries as the region still lacks fuel economy standards. This report presents an analysis of the Moroccan case study and eventually comes out with a discussion on how to improve the fuel economy performance of the Moroccan LDVs fleet with the associated recommendations.

¹FIA Foundation, International Energy Agency (IEA), International Transport Forum (ITF), United Nations Environment Programme (UNEP), and the International Council on Clean Transportation (ICCT).

2 METHODOLOGY

The report is about the trend patterns in fuel economy and CO₂ emissions. It views the status of emissions and fuel consumption through the lens of changing weighted averages for new Light Duty Vehicles (LDVs) for the years 2009, 2012 and 2013. Thus the report provides a sense of changing state of emissions and Fuel consumption in Morocco.

Accordingly, figures for sales of new Light Duty vehicles have been obtained along with the official figures for CO₂ emissions and fuel consumption for almost all the models. Figures for total LDVs on the road for the study years have also been obtained to put the trends in perspective and to feed into the report's discussion on improving fuel economy and the associated recommendations.

Figures for new LDVs sales in 2009, 2012 and 2013 have been obtained from manufacturers and were collected by an automotive markets consultant, Matthias Gasnier. For reliability, the figures were cross-checked with sample figures for new LDVS sales from IHS consulting as well as total figures of different model sales in Tunisia obtained from the International Organization of Motor Vehicle Manufacturers (OICA). Data are classified by Vehicle's make; model; fuel type and engine size.

Manufacturers' specifications manual and compilations of the French Environment and Energy Management Agency (ADEME) have been used to arrive at the manufacturers' labeled figures for fuel economy and CO₂ emissions. Then GFEI methodology (GFEI, 2014) has been used in calculating the weighted average annual fuel economy, and the weighted average annual CO₂ emissions:

The definition of the GFEI for LDVs has been used in deciding on the vehicles to be included in the report study (GFEI, 2014). The definition is as provided in Table-1.

2.1 ASSUMPTIONS

Morocco has no local driving cycle. Since the Moroccan market is predominantly European, the study team obtained data for fuel economy/consumption based on the New European Driving Cycle (NEDC) in units of Liter/100 km.

Because for some models the emissions figures were not available, the report eliminated those models from its analysis. Those models have made up a maximum of 0.6 % of all models throughout the study years. Another assumption is that new LDVs sold through unauthorized dealers and parallel markets are a minor portion of new vehicles and could not be covered in the present study due to lack of data. Therefore the studied new LDVS in the report comprise

90% of total new LDVS in Tunisia for the study years, at worst.

The Moroccan LDVs sale figures are perceived to have very sensitive commercial value and hence the process obtaining the LDVs sales figures were met with significant obstacles. The study team instead managed to obtain the sales figures for the years 2009, 2012 and 2013.

Table 1: The GFEI definition of LDVs

Vehicle Segment	Examples
A: Mini / Micro / Small town car <i>Smallest cars, with a length between 2.50m to 3.60m.</i>	Citroën C1 Fiat Panda Smart Fortwo
B: Small compact <i>Slightly more powerful than the Minis; still primarily for urban use; length between 3.60m and 4.05m</i>	Mitsubishi Colt Opel Corsa Suzuki Swift
C: Compact <i>Length between 4.05m – 4.50m</i>	Mazda 3 Subaru Impreza Volvo S40
D: Family cars <i>Designed for longer distance; fits 5- 6 people; length is 4.50m to 4.80m</i>	BMW 3 series Chrysler Sebring Lexus IS
Light vans <i>Size is similar to D, but interior volume is maximized to accommodate larger families</i>	Chevrolet Uplander Ford Galaxy Volkswagen Sharan
Big / Full size cars <i>Have generous leg room; can comfortably transport 5 - 6 people; generally have V8 engines and are 5m or longer in length</i>	Cadillac DTS Jaguar XJ Mercedes-Benz E Class
SUV / All terrain <i>The original cars were utility cross-country vehicles with integral transmissions like the Jeep</i>	Dodge Durango Jeep Grand Cherokee Nissan Patrol Toyota Land Cruiser

2.2 DRIVING CYCLES

Implementation of fuel economy standards requires the enforcing agency to test the fuel economy or consumption figures presented model manufacturers. The applicable driving cycle should mimic typical driving patterns, behavior stops, accelerations, speed ranges with duration for each of urban and highway driving. For comparison across vehicles, a combined or overall fuel consumption or economy cycle is used, combining urban and highway cycles with different weightage according to the cycle's location origin. In the United States the used driving cycle is called Corporate Average Fuel Economy (CAFE). In Europe, the used driving cycle is the New European Driving Cycle (NEDC), used as the basis of the present study.

3 BACKGROUND

Morocco is a North African and Arab country with a population of 7 million. It is classified as a *low-middle-income* economy according to the World Bank classifications based on GNI per capita (WB, 2014). Morocco had an average GDP growth rate of 4% over the past three years, 2011-2013 (World databank, 2014). In Morocco, the cities of Casablanca, Rabat, Fes, Meknes and Agadir are specifically highly urbanized and characterized with high travel demand.

Morocco has a thriving industrial sector. Among the preferred sectors for foreign direct investment (FDI) are automotive, aeronautic, electronic, food processing, offshore activities and marine products, which together contribute an average 30% to GDP (Ernst & Young, 2011). The automotive industry provides for both the local market and for export.

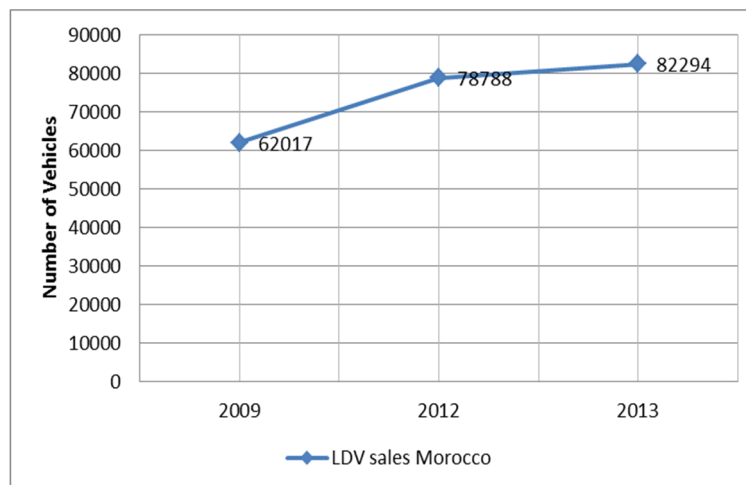


Figure 1: Sales of new LDVs in Morocco

The steady GDP growth and the low population growth rates compared to Arab countries are accompanied by a steady increase of total vehicle stock, from 2.36 million to 2.72 million vehicles on the road between 2009 and 2012 (OICA, 2012). Likewise, sales of Light Duty Vehicles (LDVs) have shown steady increase in the past years as illustrated in Figure 1 above.

Growth in vehicle sales is expected by some market researchers to be 8.3% in 2015 as compared to 2014, a significant rise, with passenger cars specifically growing faster than other vehicle categories (Business Monitor International, 2014).

A significant portion of new LDVs in Morocco is Diesel fueled, often more than three quarters of the sales, while the rest is gasoline-fueled.

Out of all LDV sales in Morocco in 2013 consisting of 59 brands, the top 10 brands alone represented 58% of the sales as enlisted in below. They were all diesel vehicles, and the most common engine size is the moderate 1500cc.

Table 2: Top 10 LDV models in 2013 in Morocco

Make	Model	Engine Size (cc)	Fuel Type	Sales
DACIA	Logan	1500	diesel	10170
DACIA	Dokker	1500	diesel	6855
DACIA	Sandero	1500	diesel	5717
DACIA	Duster	1500	diesel	5187
RENAULT	Clio	1500	diesel	4500
FORD	Fiesta	1500	diesel	3933
FIAT	Doblo	1300	diesel	3764
HYUNDAI	i10	1100	Petrol	2595
FORD	Focus	1600	diesel	2578
PEUGEOT	301	1600	diesel	2376

Medium to small sized LDVs is the common choice among consumers in Morocco possibly attributed to the modest income levels per capita and the high gasoline and diesel prices among other factors explained in the following sections.

4 REGULATIONS AND POLICY ENVIRONMENT

Since 1999 Morocco has been embarked on an accelerated path towards trade liberalization and a market oriented economy. Now prices are determined according to market forces without substantial government interference. All goods and services may be imported. This comes in line with a Moroccan policy of developing local industries, especially in technology-intensive industries where automotive industry upholds a key position in government strategy.

Free trade agreements signed with USA, Turkey, Arab Countries and the European Union (EU) facilitate Morocco's access to diverse markets. Meanwhile, that orientation serves Moroccan aspirations of turning into a regional hub for automotive industries. Government policies are put in place to capitalize on Morocco's trade relations; industrial free zones are dedicated to automotive manufacturers, training programs are set up to prepare specialized labor, that is, in addition to tax breaks and assistance with capital.

4.1 CUSTOMS AND TAXATION

Value Added Tax (VAT) is levied on both local made cars and imported ones in two different schemes. For imported ones it includes the due domestic consumption tax, import duties, if any, and the customs value. The VAT rate varies between 7% and 20% (PKF, 2012), taking into account trade agreements and investment relations with producer. In 2012 custom duties on cars imported from EU were eliminated. Asian cars are subject to 17.5% import duties, while Free Trade Agreement with the USA had led to lowered import tariffs on American cars. Reduced tariffs facilitate growth in ownership rates.

The EU also happens to be the biggest market of Moroccan made cars. For the Moroccan consumer, a diversified market exists with free competition between authorized dealers of various brands, where European producers who also happen to be the major investors in Moroccan domestic LDVs production take up a large share. Second and third tier automotive industries exist as well in Morocco with a considerable role for Asian companies which have set up their production lines in Morocco.

Fuels for LDVs in Morocco are subsidized, though the subsidy system is much less intense than other Arab countries. With rising international oil prices, Morocco has been subsidizing retail fuel since 2000 while they had been indexed to international prices before that year. Starting from 2012/2013 fuel subsidies have been capped and linked to oil prices fluctuations.

Furthermore, reduction of tariffs on European vehicles was followed by an increase in annual taxes proportional to the vehicle's horsepower. Apart from initial registration fees of 50 dirhams (approx. 4.6 Euros) for each horsepower unit, annual taxes on vehicles were increased on a horsepower sliding scale for different horsepower ranges of 8 or less, 11-14 and 15 or

more. Luxury vehicles, defined as having a market cost of 400,000 dirham (approx. 36,000 Euros) are subject to a three-fold duty, including a rate that is function of the cost in addition to the standard initial registration fees and horsepower taxes.

4.2 FUEL PRICES

Fuel prices have been in steady increase in Morocco and are presently non-subsidized and subject to taxation unlike to many other countries in Africa that remain highly subsidized.

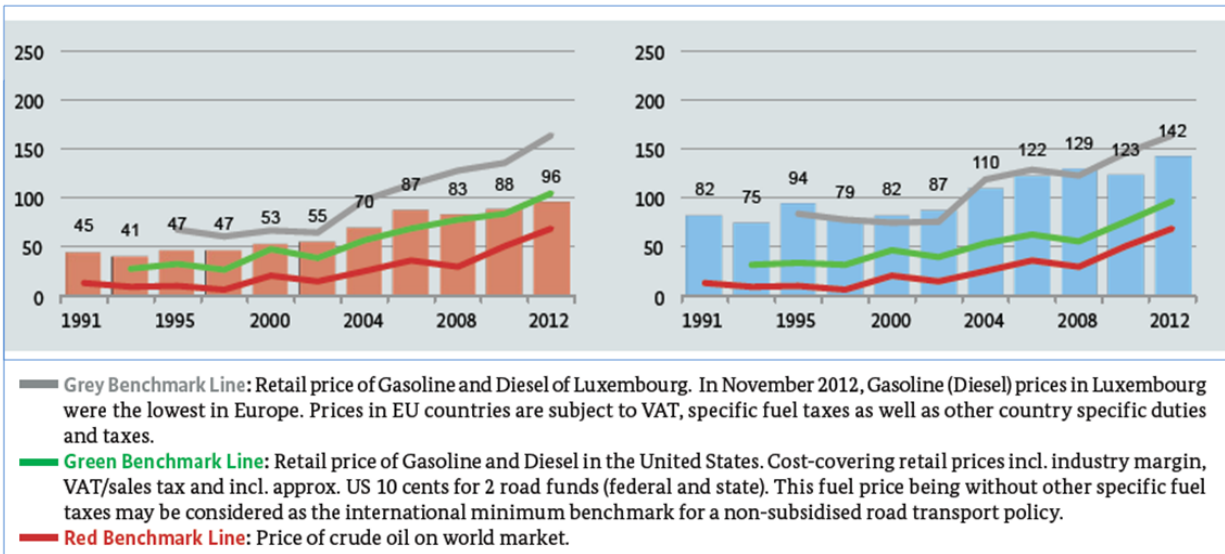


Figure 2: Trends of transportation fuel prices in Morocco in US-cents/liter for diesel and super gasoline respectively (GIZ, 2014)

Figure 2 above shows the gradual increase in fuel prices in Morocco, showing diesel (on the left) and super gasoline (on the right), showing high prices comparable to the US retail price in the case of diesel and comparable to the high EU prices in the case of gasoline.

5 RESULTS

Figure 3 shows fuel economy (l/100km) trends for new LDVs in Morocco for the years 2009, 2012, and 2013. The trends charted include the trend of gasoline vehicles, diesel vehicles, and the combined weighted average of both, i.e. all new LDVs. Since the majority of new LDVs have always been diesel vehicles, the weighted average FE is closer to the average FE of Diesel fueled LDVs.

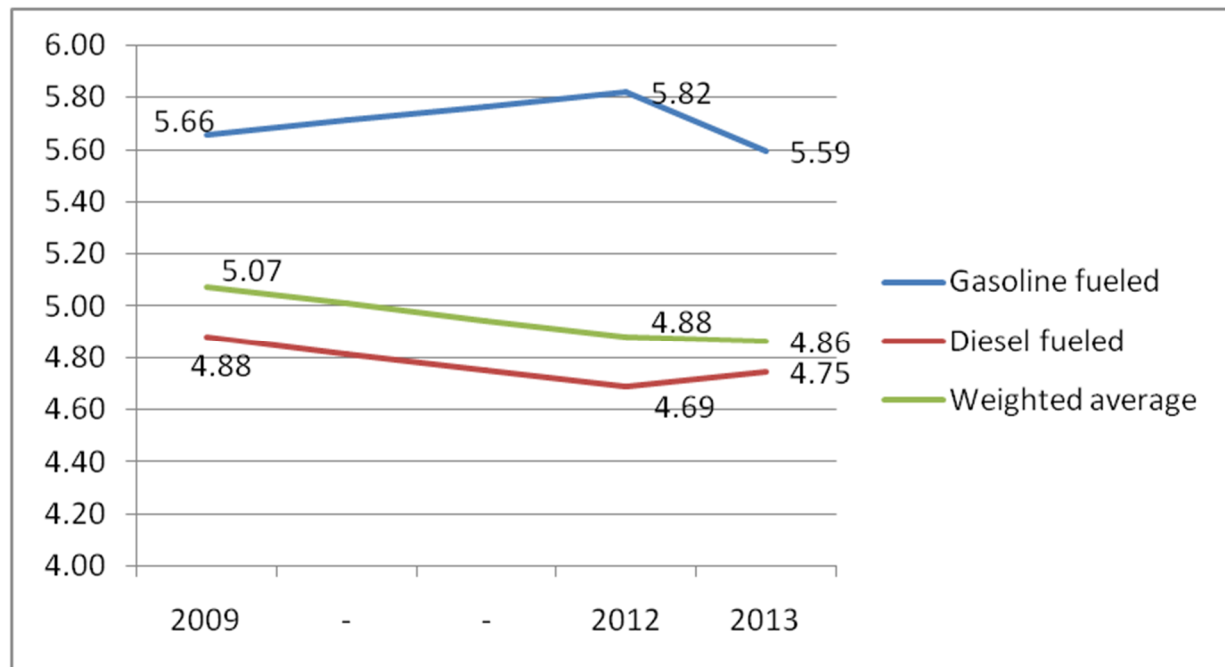


Figure 3: Average Fuel Economy of new LDVs (l/100km) in Morocco in recent years

The weighted averages of fuel consumption for new gasoline LDVs were close for the years 2009 and 2012 at 5.66 liter/100km, 5.82 liter/100 km and 5.59, respectively. Figure 7 shows the aforementioned trend for diesel vehicles.

In a similar pattern,

Assumptions

Morocco has no local driving cycle. Since the Moroccan market is predominantly European, the study team obtained data for fuel economy/consumption based on the New European Driving Cycle (NEDC) in units of Liter/100 km.

Because for some models the emissions figures were not available, the report eliminated those models from its analysis. Those models have made up a maximum of 0.6 % of all models

throughout the study years. Another assumption is that new LDVs sold through unauthorized dealers and parallel markets are a minor portion of new vehicles and could not be covered in the present study due to lack of data. Therefore the studied new LDVS in the report comprise 90% of total new LDVS in Tunisia for the study years, at worst.

The Moroccan LDVs sale figures are perceived to have very sensitive commercial value and hence the process obtaining the LDVs sales figures were met with significant obstacles. The study team instead managed to obtain the sales figures for the years 2009, 2012 and 2013.

Table 1 shows the trend of CO₂ emissions of new LDVs in Morocco for the years 2009, 2012 and 2013 calculated according to the GFEI methodology.

Table 3: Average CO₂ emission rate (gCO₂/km) of new LDVs in Morocco

Year	2009	2012	2013
Gasoline LDVs	134.3	134.3	130.3
Diesel LDVs	133.6	125.0	125.2
Weighted average	135.4	126.6	125.9

It is also notable that only a small portion of LDVs sold are of larger engine sizes of 1.6 liters or more. In 2013, the portion was only 11%, where as the vast majority, 89%, were 1.6 liters or less.

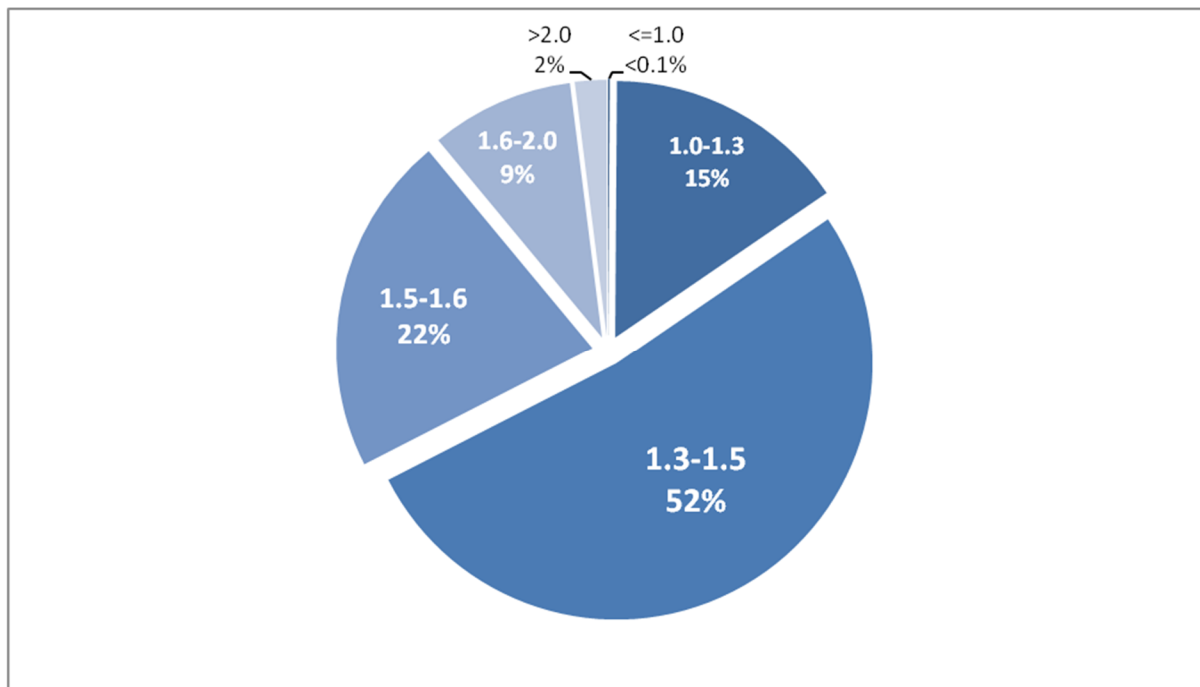


Figure 4: Distribution of engine sizes (liters) of new LDVs in Morocco in 2013

Furthermore, if observing gasoline-fuelled LDVs separately, none of them exceed 1.6 liters in capacity (100% equal or less than 1.6 liters). This shows the inclination of the market in general toward LDVs of smaller engine sizes.

6 DISCUSSION OF DATA

Non-OECD fuel economy averages for LDVs in L/100km for 2005, 2008 and 2011 were 7.5, 7.6, 7.5, while OECD averages were 8.1, 7.6 and 7 (Fuel Economy State of the World, 2014), which positions Morocco at a favorable state in comparison, being below 5 l/100km in 2012 already.

These sustainable levels for fuel economy may be partially attributed to the high fuel prices relative to the per capita income in Morocco, being classified by the World Bank as a lower-middle income country, and demand for relatively low engine sizes in vehicles is apparent.

The above is applicable to diesel LDVs CO₂ emissions rates as well. In 2009, the CO₂ weighted average emissions for diesel LDVs were significantly higher than those in 2012 and 2013. This may be due to considerable sales in 2009 of certain models that were not sold in 2012 and 2013. Those were: Toyota Prado, Toyota Corolla, Volkswagen Passat, Kia Sportage and Kia Carens. Those models have high levels of CO₂ emissions that affected the average emission rates.

Fuel economy of diesel-fueled LDVs had been lower than gasoline despite the use of larger diesel LDVs with larger engine sizes. Generally, diesel engines show better fuel consumption than gasoline ones unless vehicle features such as a much larger engine size or body weight offset the characteristic.

Year 2009

For gasoline LDVs, Hyundai I10, Kia Picanto, Dacia Logan, Dacia Sandero, Fiat Punto, Fiat Albea and Suzuki Alto made up about 85% of total Gasoline LDV sales.

For diesel LDVs, Dacia Logan, Fiat Doblo, Peugeot Partner, Citroen Berlingo, Dacia Sandero, Ford Fiesta, Toyota Corolla, Renault Megane, Peugeot 206, Renault Symbol, Peugeot 308, Peugeot 207, Volkswagen Passat, Hyundai Accent, Hyundai Santa-Fe, Volkswagen Touareg, Volkswagen Polo, Toyota Prado, Renault Clio and Kia Carens made up 87% of diesel LDVs sales.

The fuel economy of the best-selling 85% gasoline LDVs had a higher incidence of vehicles with a fuel economy exceeding 5 Liters/100 km.

Year 2012

Hyundai I10, Fiat Punto, Ford Focus, Dacia Logan, Dacia Sandero, Renault Clio, Peugeot 206, Ford Fiesta, Volkswagen Polo, Dacia Duster, Peugeot 208 and Renault Megane made up 91% of the sales of new gasoline LDVs. Fuel economy levels remained almost the same, with a slight rise from 5.66 liter/100km to 5.82 liter/100 km. The increase is attributed to a larger variety of models and variants though the total sales of new LDVs decreased.

Dacia Logan, Dacia Sandero, Dacia duster, Ford Fiesta, Fiat Doblo, Peugeot 206, Citroen Berlingo, Peugeot Partner, Renault Clio, Nissan Qashqai, Volkswagen Polo, Renault Megane, Dacia Dokker, Hyundai ix35, Peugeot 308, Ford Kuga, Peugeot Biper, Citroen C4, Hyundai Accent, Citroen C3, Opel Astra and Hyundai i30 made up 87% of new diesel LDVs sales. It is that most of them had fuel economy/consumption levels in the order of 3 and 4 liter/100km which explains the better fuel economy/consumption average of diesel LDVs than gasoline ones. The fuel economy levels for new diesel LDVs witnessed a small improvement from 4.88 to 4.69 due to the improvements in fuel economy of diesel models sold in 2012 despite the much larger sales volumes in 2012.

Year 2013

Hyundai I10, Fiat Punto, Dacia Sandero, Renault Clio, Peugeot 208, Ford Focus, Dacia Logan, Ford Fiesta, Dacia Duster, Peugeot 301, and Volkswagen Polo made up 89% of new gasoline LDVs sales for 2009. The improvement is attributed to the fact despite the models and variants sold in 2013 were much similar to those of 2012, the less efficient Dacia models, Renault Megane, Ford Focus and Peugeot 206 sold less in 2013.

Dacia Logan, Dacia Duster, Dacia Dokker, Dacia Sandero, Ford Fiesta, Fiat Doblo, Renault Clio, Ford Focus, Peugeot 301, Citroen Berlingo, Nissan Qashqai, Hyundai ix35, Peugeot Partner, Volkswagen Polo, Peugeot 206, Peugeot Biper, Hyundai i30, Ford Kuga, Renault Megane, Opel Astra, Hyundai Accent, Citroen C-Elysee, Hyundai Santa-Fe, Citroen C4 and Ford Transit were up to 91% of new diesel LDVs sales for 2013. Fuel consumption/efficiency average figure increased by 0.06 liter/100 km because there had been no sizeable improvement in fuel efficiency of models sold in Morocco from 2012 to 2013, while the sales volumes of new diesel LDVs increased by more than a couple of thousand vehicles with a bit more marketed models and variants.

7 CONCLUSIONS

Morocco managed to maintain outstanding fuel economy compared to global averages. The averages of diesel LDVs, which comprise the bulk of the market sales, were considerably lower than both OECD and non-OECD averages and even performing better than the Tunisian case. Gasoline LDVs also showed a similar trend though they were close to Tunisian averages.

Both European and domestic production of European brands dominate the Moroccan market by far. Thus, the European increasingly stringent fuel efficiency standards have impacted Morocco as well. That a large share of Moroccan domestic production is exported to Europe drives the Moroccan made cars to keep up with European ones in terms of fuel economy. Furthermore, the lower GDP per capita in Morocco compared to the manufacturing origin of the brand coupled with relatively high fuel prices, though still lower than international prices, pushes the Moroccan market towards the lower end of the engine-size spectrum. Also, the variants sold in Morocco are usually of smaller horsepower. Together, these factors are a viable explanation of the exemplary fuel economy performance of the Moroccan market.

Furthermore, LDVs sold in Morocco boast more technological sophistication than Tunisian ones with the market showing preferences for lower engine sizes. Although the LDVs market in Morocco is free to a large extent, with a regulatory slant favoring European producers, the government set the playing field for the introduction of modern energy efficient diesel LDVs by the enforcement of fuel quality standards of Euro 4/5 diesel rendering the marketing of modern technology diesel vehicles possible. The privatized refining industry responded positively to government regulation. Meanwhile, the pump price of diesel in Morocco is cheaper than gasoline pushing for an increased demand for the fuel-efficient diesel LDVs in the efficiency sensitive Moroccan market.

Despite the current favorable status of the fuel economy in Morocco, it is difficult to showcase its good position due to limited data and assessments of the automotive industry. It is therefore recommended to conduct annual reviews of the status of fuel economy in Morocco such as the present study and to also cover the rest of vehicle categories. Such annual assessment will ensure monitoring the status of fuel economy and maintaining its progress and maintaining the present policy and regulatory environment as well as offering a good example and guidance for other countries of similar conditions.

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Annex-1: Sample LDV data

Make	Model	Engine Size (cubic centimeters)	Fuel Type	Sales	Fuel Economy (Liter/ 100 km)	CO2 emissions
CITROEN	Berlingo	1600	diesel	2282	5.3	139
CITROEN	Nemo	1400	diesel	443	4.5	119
CITROEN	C-Elysee	1600	diesel	929	4.3	112
CITROEN	C3	1600	diesel	534	4.2	109
CITROEN	C4	1600	diesel	857	4.2	110
CITROEN	DS4	1600	diesel	26	4.4	115
DACIA	Dokker	1500	diesel	6855	5.2	139
DACIA	Duster	1500	diesel	5187	5	139
DACIA	Logan	1500	diesel	10170	3.8	119
DACIA	Sandero	1500	diesel	5717	4.5	120
FIAT	Doblo	1300	diesel	3764	7.4	137
FORD	Transit	1800	diesel	830	6.6	172
FORD	Fiesta	1500	diesel	3933	3.7	98
CITROEN	C-Elysee	1200	Gasoline	105	5.3	115
CITROEN	C1	1000	Gasoline	88	4.6	108
CITROEN	C3	1200	Gasoline	60	3.5	99
Dacia	Duster	1600	Gasoline	274	8	185
DACIA	Logan	1400	Gasoline	536	7.8	165
DACIA	Sandero	1400	Gasoline	1010	7	165
FIAT	Punto	1200	Gasoline	1714	5.2	126
FORD	Fiesta	1250	Gasoline	437	5.6	129
FORD	Focus	1600	Gasoline	860	6	139
HYUNDAI	i10	1100	Gasoline	2595	4.7	108
HYUNDAI	i30	1400	Gasoline	59	6.1	142