

Analysis of New Passenger Cars Market of UK and of Their CO₂ Emissions

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ABSTRACT

This work analyses the new passenger cars' market of Great Britain during last years. The sales of new passenger cars and a number of parameters, such as kind of fuel, vehicle weight, engine displacement, engine maximum and specific power, vehicle segment and exhaust CO₂ emissions on the New European Driving Cycle, are analyzed and discussed. This analysis is performed in the case of the entire British market and also for every segment and firm presented in this country. The contribution of each engine and vehicle parameter, vehicle segment and firms on exhaust CO₂ emissions are presented and discussed.

INTRODUCTION

In recent years, global warming and the gases that provoke it are under great discussion. Carbon dioxide is by far the most significant pollutant, among the rest anthropogenic Green House Effect Gases (GHG) emissions, having a share of about 82% on global total effect [1]. The main sources of anthropogenic CO₂ emissions are energy production by 39%, transport by 26%, households (heating) by 19% and industry by 16% [1]. On global scale, 5 units of that 26% of transport emitted CO₂ are emitted from passenger cars [1]. More specifically, the share of European passenger cars' (PC) is 12% of the total anthropogenic CO₂ of EU [1].

According to the Official European Statistical Organisation, Eurostat, United Kingdom (UK) CO₂ emissions correspond to 13% of European total CO₂ emitted [1], since UK is one of the most economically developed countries of European Union (EU). That brings UK among the greater European CO₂ emitters. From 1985 to 2003, transport sector in UK accounted for about one fourth of total CO₂ emissions [1, 2]. Transport sector CO₂ emissions show an increase of 27% [2] between 1985 and 1995 and 8% from 1995 to 2003 [1], most of which comes from road transport [2]. Road transport dominates in transportation emitted CO₂, as the automobile share rises from 91% to 93.4% within 1973 to 1990 [3] and continues to increase during 1990

to 2003 to reach 94% [1]. The greatest contribution of all means of road transport is made by passenger cars.

Exhaust CO₂ emissions depend on several parameters, such as, fuel used, vehicle weight [4, 5], engine displacement, engine max. and specific power, vehicle segment and driving cycle [6]. The use of Diesel instead of gasoline can reduce CO₂ emissions through the greater energy content that Diesel appears to have [7]. Further CO₂ reduction can also be accomplished through the reduction of vehicles weight [5] and/or by optimizing combustion efficiency.

This paper performs an analysis of UK new passenger cars market and of their CO₂ emissions. The most significant engine and vehicle parameters influencing CO₂ emissions are analyzed. The greater emitting segments and firms are also shown and discussed. The evolution of CO₂ emissions in UK by new passenger cars is also presented and discussed. The conclusions give a detailed picture of new passenger cars registered during last years in UK and their contribution to CO₂ emission.

METHODOLOGY USED

The statistical data used here is a compilation of data presented in the internet sites of Eurostat [1], World Resources Institute [8], International Road Federation [9], Association of European Automobile Manufacturers (ACEA) [10], Society of Motor Manufacturers and Traders Limited [11] and Car Fuel Data [12]. The German Federal Motoring Authority [13] publishes the vehicle weight and CO₂ emissions of the passenger cars certified in Germany. The CO₂ emissions are obtained according to the official European certification procedure on the New European Driving Cycle (NEDC) [14]. The average values have been calculated on the basis of sales of all models. The data from 1995 until 2003 are used and analyzed in this work.

RESULTS AND DISCUSSION

1. TOTAL REGISTRATIONS

From year 1995 to 2003 there is an increase of 24.2% in total passenger car registrations in UK reaching the value of 2,397,409 units in 2003 (figure 1). The greatest amount of those cars consists of gasoline cars, with a decreasing tendency after 1999 where the maximum percentage of 86% is reached. Until 1999 the share of gasoline PCs shows an increase of about 6% while Diesels' one decreases by the same percentage. After 1999, following the general trends of the other EU countries [7], Diesel percentage increases to reach 26.7% in 2003 (figure 1).

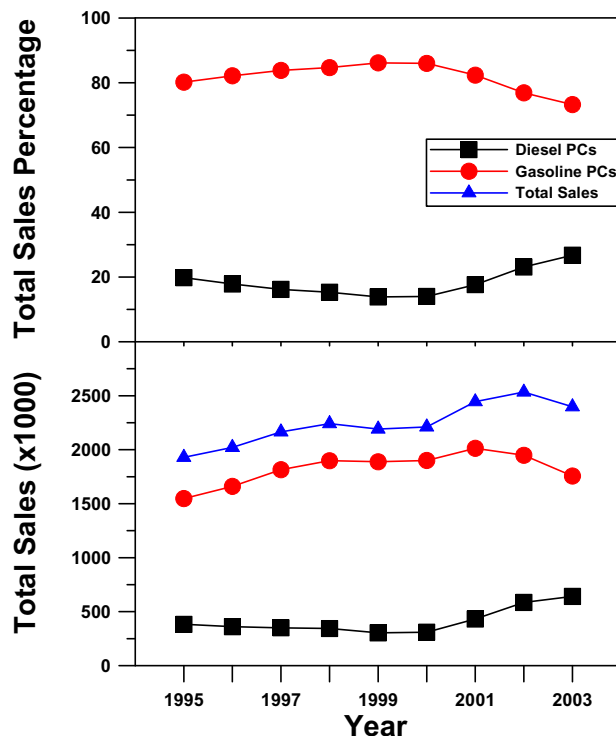


Figure 1. Total sales (x1000) and percentage of Diesel and gasoline new passenger cars in UK from 1995 to 2003.

2. EVOLUTION OF AVERAGE VALUES

Figure 2 shows the average values of vehicle weight, engine displacement, max. and max. specific power for all Diesel and gasoline new passenger cars registered in UK from 1995 to 2003.

Average engine displacement of Diesel new PC increases of about 5% during 1995-2003, while that of the gasoline ones appears to be relatively constant. Sorrell [15] reports that the increase of Diesel PC displacement was 1.98% and that of gasoline ones was 10.57% from 1983 to 1990. The average vehicle weight

of both Diesel and gasoline new PC shows an increase during these years, of 15% for Diesel and 5% for gasoline PC. It is obvious that safety, emission control and luxury equipment lead to heavier and heavier cars. The average values of max. power and max. specific power show a remarkable increase of 41% and 13% for Diesel and gasoline new PC respectively, while the corresponding values of max. specific power are 34% and 14%. It is obvious that engines become more and more efficient through those years as the most reliable tool to judge this efficiency is max. specific power.

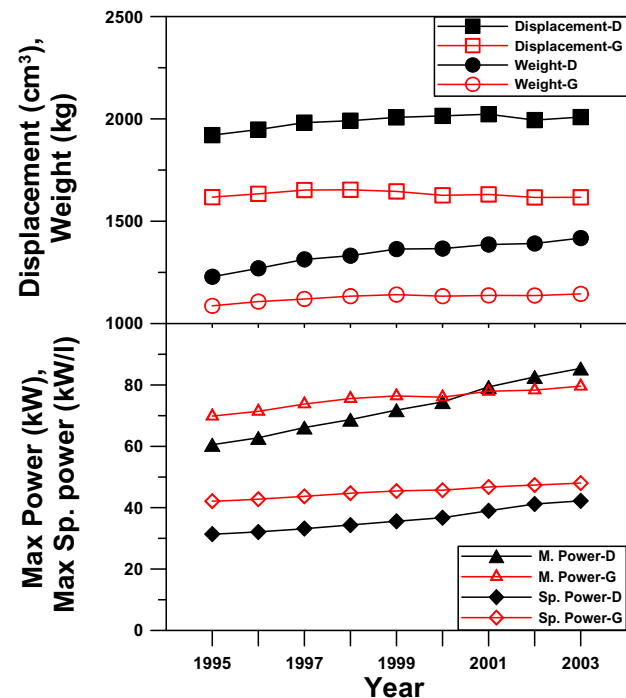


Figure 2. Average values of displacement, weight, max. power and max. specific power of Diesel and gasoline new passenger cars from 1995-2003.

Figure 3 shows the average values of CO₂ emissions of both Diesel and gasoline new PC on urban (ECE), extra urban (EUDC) and entire New European Driving Cycle (NEDC), for all cars registered in UK from 1995 to 2003.

Although, weight and displacement generally increase during these years (figure 2), CO₂ emissions continuously decrease on the NEDC, due to the increased combustion efficiency, leading to lower fuel consumption and thus to lower CO₂ emissions. This decrease is 16% and 20% for Diesel and gasoline cars respectively.

On EUDC, both types of cars show almost the same emissions from 1995 to 1997. That happens because (as it is further analyzed in this article) a relatively high percentage of Diesel cars (10%) belongs to high emitters category (200 g/km and higher) while that does not happen to gasoline ones (only 2% emits over 200

g/km). From 1997 and on, both Diesel and gasoline curves have a decreasing drift until they almost intersect in 2003.

However, both Diesel and gasoline new PC have a significant increase of CO₂ emissions on ECE during the years examined. Emissions of Diesel new PC increase by 43% from 1995 to 1998, while a slight decrease is observed after that year. Similarly, emissions of gasoline new PC increase by 51% during the same years and then remain practically constant. This indicates that, even CO₂ emissions on the NEDC decrease, there is no guarantee that real world CO₂ will also decrease, as the relative parts of real urban and extra-urban mileage of each vehicle must be taken into consideration.

A change on the CO₂ emissions curves of figure 3 is observed after 1997-1998. This is due to the preparation of Euro3 emissions limits (introduction of Diesel oxidation catalyst, higher volume of Three Way Catalysts (TWC) in the case of case of gasoline passenger cars,...).

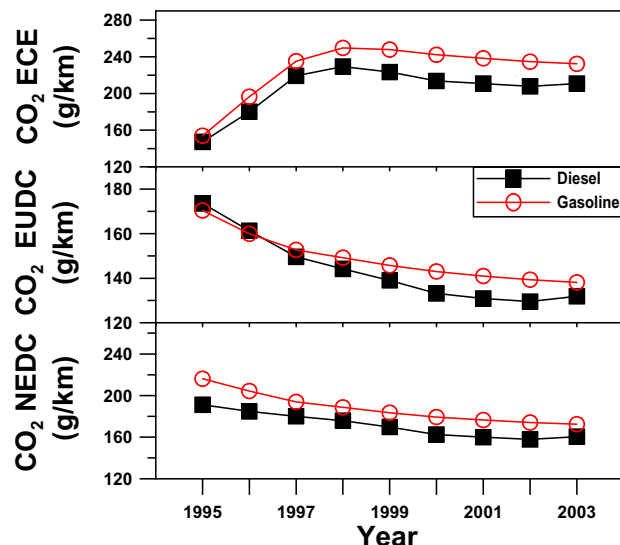


Figure 3. Average CO₂ emissions of Diesel and gasoline new PC on ECE, EUDC and NEDC during 1995-2003.

3. ANALYSIS OF PC MARKET CHARACTERISTICS

3.1. Vehicle weight

Diesel and gasoline new PCs are divided respectively into 6 and 7 weight categories. Figure 4 shows the sales and the sales' percentages of each weight category of Diesel cars. Until 1998, the first range in terms of sales and percentage is that of the 1000-1200; however, the 1200-1400 becomes predominant after this year and the 1400-1600 will be predominant in the near future.

Category of 1000-1200 kg was the best seller in year 1995 accounting more than 160,000 sales.

Nevertheless, in 2003 reached less than 80,000 sales having a reduction of 52%. The same happened to the class 0-1000 kg appearing a great reduction from approximately 74,000 to 25,000 sales. The share of the two mentioned categories was transposed to the classes 1200-1400 kg and to 1400-1800 kg. The class 1200-1400 kg was the second best seller (87,000 sales) in 1995 with great distance from the first one. In 2005 that category dominates the market having sales of about 230,000. The second most dominant category is that of 1400-1600 kg. Initially it was negligible (17,000 sales in 2005) but in 2003 became the second best seller with more than 200,000 sales. The range 1600-2000 kg substantially increased its sales by 3.5 times. Finally, class 2000-3500 kg has no significant increase (8,000 cars more from 1995 to 2003).

The corresponding percentages of each category make clear the reduction of light vehicles. Ranges of 0-1000 kg and 1000-1200 kg decrease continuously. The first one passed from almost 20% in 1995 to only 4% in 2003. If this tendency continues in the future years, then this category will almost disappear. The same behavior is also held by the category 1000-1200 which lost 30 percentage units of its market share (from 42% to only 12%). On the contrary, the categories 1200-1400 kg, 1400-1600 kg and 1600-2000 kg show a significant increase (13, 27 and 7 percentage units respectively (from 22% to 35%, from 4% to 31% and from 4% to 11%). More specific, the percentage of the class 1400-1600 kg increased 7.5 times and the one of 1600-2000 kg increased 3 times. Range 2000 kg to 3500 kg remains practically constant.

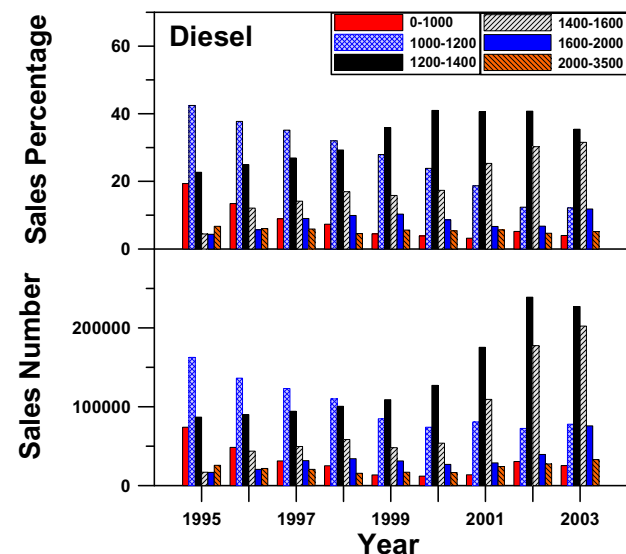


Figure 4. New passenger car sales and their percentage per weight in kg. Diesel vehicles from 1995-2003.

These results show that there is a general transposition of the market to heavier cars. This is in part due to the production of safer, more luxurious and more environmental friendly cars, something that makes them

to be equipped with extra or heavier devices. It must be noted that CO₂ emissions increase with vehicle weight, as more fuel must be consumed to move the extra weight [4, 5]. Consequently, the weight increase observed here is not benefit to CO₂ emissions. The encouraged point is that the sales of the very heavy PC (more than 2000 kg) do not increase.

In terms of sales and percentage, the range 1000-1200 kg is the predominant one in the case of gasoline passenger cars during the years studied. Like Diesel vehicles, gasoline ones show a decrease at their lighter categories (figure 5). Sales of classes 0-800 kg and 800-900 kg clearly decrease. The first class, whose sales were already low: 102,000 in 1995, dropped to 26,000 in 2003, which means four times less during these years. Obviously, if that trend continuous, that category will be disappeared from the market. Next category (800-900 kg), even though it was the second best seller in 1995 with 305,000 sales, in 2003 drops to less than half. The share of the two previous ranges is generally transposed to 900-1000 kg and 1000-1200 kg ones. The category 900-1000 kg shows an increase of 83% in its sales and becomes the second best seller in 2003 with 377,000 cars (from 206,000 in 1995). The category 1000-1200 kg was the best seller in 1995 with about 500,000 units and keeps being after a 30% increase till 2003 to reach 640,000 units. Class 1200-1300 kg is the only one that fluctuates. Initially increases from 225,000 sales in 1995 to 364,000 in 2000 and then declines to 190,000 in 2003. The two last categories 1300-1500 kg and 1500-3000 kg have a clear increase. The class 1300-1500 kg, which was one of the least sellers in 1995 with 145,000 units, is the third best seller in 2003 (305,000 units) after an increase of 110%. Finally, range 1500-3000 kg, even though is a minor range, shows an increase of 52%, from 68,000 to 103,000 sales.

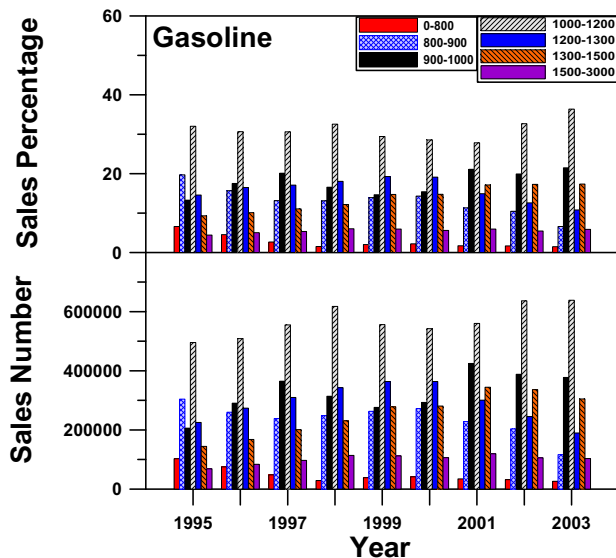


Figure 5. New passenger car sales and their percentage per weight in kg. Gasoline vehicles from 1995-2003.

Some interesting conclusions can be obtained through the corresponding percentage of each range. A general decrease of light vehicles and an increase of heavier ones occur during these years (figure 5). More specifically, ranges 0-800 kg and 800-900 kg show a remarkable decrease: from 6.5% to 1.5% and from 19% to 6.5% respectively. If this decrease continues, these categories will almost disappear in the future. The percentages of the remaining categories have an upward trend. The range 900-1000 kg, 1000-1200 kg, 1300-1500 kg and 1500-3000 kg increase by 8, 4, 8 and 1.5 percentage units respectively (from 13%, 32%, 9%, 4% respectively in 1995). The category 1000-1200 kg is the dominant one during all years (32% in 1995 and 36% in 2003). The only exception to that general trend of the "heavy" vehicles is category 1200-1300 kg which reduces its market share from 14.6% to 10.8%.

3.2. Engine Displacement

Displacement categories of Diesel cars are shown in figure 6. The main range is the 1900-2000 cm³ one, followed closely by the 1800-1900 cm³. Sales of the 0-1400 cm³ category have a very sharp increase from the ultimate zero to 29,000 in 2002 and to 44,000 in 2003. That increase partially happened because of the transposition of sales from the very next category (1400-1600 cm³) which shows a decrease of 17,000 units during these years (from 40,000 units in 1995 to 23,000 in 2003). The most dominant category of all in 1995 was that of 1600-1800 cm³ (125,000 sales), but showing a significant decrease to be one of the minor ranges (52,000 sales in 2003). The 1800-1900 cm³ category, taking advantage of the 1600-1800 cm³ reduction, increases very sharply: from 38,000 units in 1995 to 165,000 units in 2003 (increase of 337%). Range 1900-2000 cm³ was the second best seller in 1995 (110,000 units); however, after a great increase, it became the first seller in 2003 (210,000 units). Increased sales are held by range 2000-2500 cm³ which almost duplicates them from 49,000 to 87,500. The same tendency is occurred by the class 2500-3000 cm³ which has a significant increase of 192%. Even though the category >3000 cm³ does not represent many cars (3,500 in 1995 and 11,600 in 2003), it shows a very significant increase of 230%.

The corresponding percentages of the previous ranges shows that PC having displacement less than 1400 cm³ have a clear increase from almost zero to 6.5%. Categories 1400-1600 cm³ and 1600-1800 cm³ significantly decrease from 10.5% to 3.5% and from 33% to 8% respectively. That is due to market's shift to lower (0-1400 cm³) or upper (1900-10000 cm³) ranges. The class 1800-1900 cm³ increases from 25% to 10% and the class 1900-2000 cm³ from 28.5% to 33.1%. The rest categories do not have a significant change.

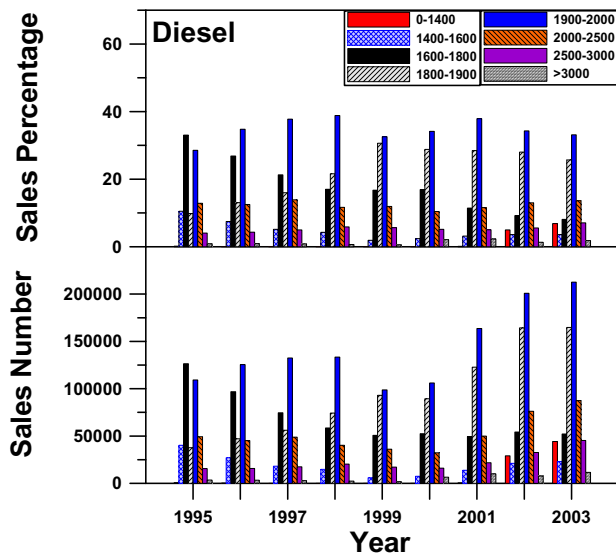


Figure 6. New passenger car sales and their percentage per displacement in cm^3 . Diesel vehicles from 1995-2003.

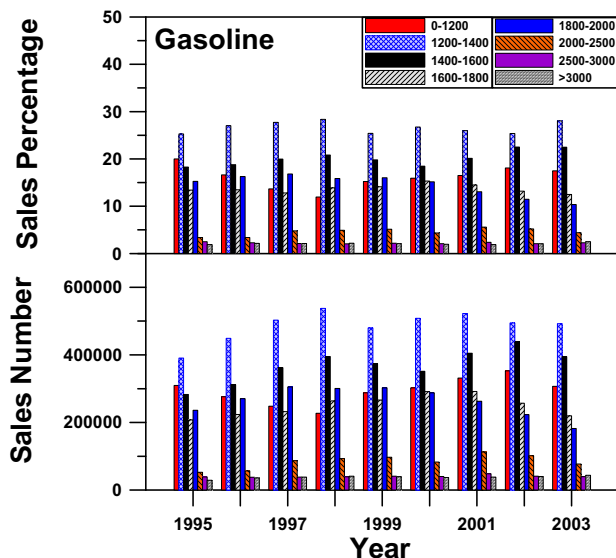


Figure 7. New passenger car sales and their percentage per displacement in cm^3 . Gasoline vehicles from 1995-2003.

The dominant category in gasoline cars' displacement classification is, for all years, the class 1200-1400 cm^3 . In 1995 accounted 391,000 units while in 2003 accounted 492,000 units (26% increase). The second best seller in 2003 is the class 1400-1600 cm^3 which illustrates a significant increase from 283,000 to 394,000 units (39%). Increase is also shown at the categories 2000-2500 cm^3 (46%, from 52,000 to 77,000) and >3000 cm^3 (49%, from 29,000 to 43,000). These increases at the above classes are attributed to the decreases of 0-1200 cm^3 and 1800-2000 cm^3 and to the stability of the rest ranges.

Almost every displacement range appears to have relatively constant percentage of sales during these years (figure 7). The corresponding changes are less than 3.5 percentage units. The only exception is the category 1800-2000 cm^3 which has a decrease from 15% to 10%.

3.3. Max. Power and Max. Specific power

Figure 8 shows that there is a general transposition of the sales to higher categories of max. power. The main range in terms of sales and percentage was 60-70 kW until 2000, when the range 80-100 kW become predominant. Ranges less than 70 kW have a notable decreased tendency. The first one reduces from 114,000 to 50,000 sales, the second from 77,000 to 45,000 sales and the third from 132,000 to 69,000 sales. The share of the above classes is gathered to the rest ones which all show a significant increase. The category with the greatest increase is that of 80-100 kW (438%) which accounts 44,000 sales in 1995 and 237,000 in 2003.

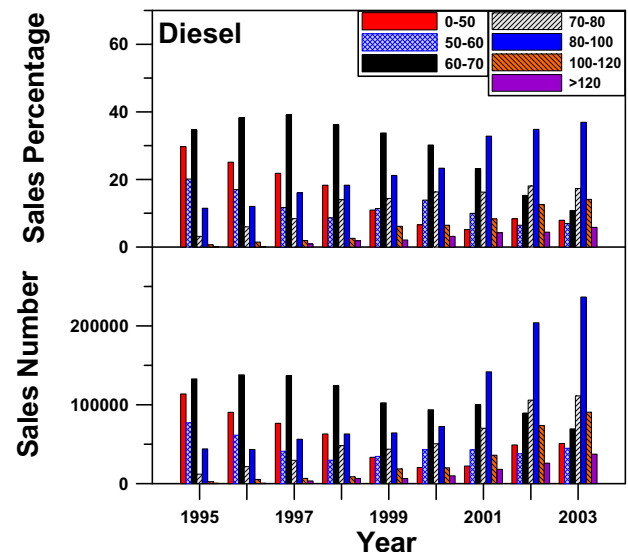


Figure 8. New passenger car sales and their percentage per max. power in kW. Diesel vehicles from 1995-2003.

The same conclusions are also clearly illustrated in sales' percentages approach. Ranges of lower max. power, less than 70kW show a clear decrease (from 30% to 8%, from 20% to 7% and from 35% to 11% for the ranges 0-50 kW, 50-60 kW and 60-70 kW relatively). It must be noted that those three ranges were the dominant ones in 1995, but they will be almost disappear in the future. On the contrary, the rest ranges show an increase: 14 percentage units (from 3% to 17%) in the case of 70-80 kW, 24 percentage units (from 11% to 37%) for the 80-100 kW, 14 percentage units (0.5% to 14%) for the 100-120 kW and 6 percentage units (0.1% to 6%) for >120 kW. That general transposition of the market to higher max. power categories can be correlated with the increase of

average displacement of Diesel cars (figure 2) or by the combustion improved efficiency.

Unlike Diesel cars, gasoline cars' max. power classification show some different specific tendencies (figure 9). The ranges 40-60 kW, 70-80 and >100-120 increases, while the ranges 0-40 kW, 60-70 kW and 80-100 kW decreases. This statement shows that the sales of gasoline engines are more concentrated to the increased ranges. The range 40-60 kW, which is the dominant one in 1995, increases by 56%, from 412,000 to 642,000 units, and remains by far the best seller category in 2003 as well. The category 70-80 kW is almost duplicated from 154,000 to 301,000, the 100-120 kW one increases from 60,000 to 180,000 (3 times more) and the last >120 kW range increases from 90,000 to 175,000 sales (almost doubled). The three ranges that decrease are the 60-70 kW, which decreases from 231,000 to 134,000 units, the 0-40 kW one from 240,000 to 38,000 units (almost disappear) and the 80-100 kW from 360,000 to 283,000 units.

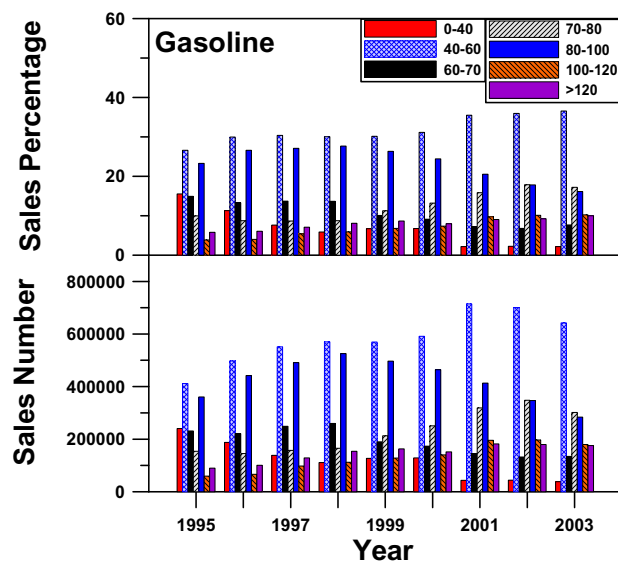


Figure 9. New passenger car sales and their percentage per max. power in kW. Gasoline vehicles from 1995-2003.

According to sales' percentages, category 0-40 kW shows a remarkable decrease from 15.5% to 2%, while the very next category, 40-60 kW, appears to have an increase from 26% to 36%. Ranges 60-70 kW and 80-100 kW show a decrease (8 and 7 percentage units respectively, from 15 % and 23% respectively in 1995), while the rest show an increase (4 to 7 percentage units). These increases and decreases can be explained through car manufactures offer and consumers' habit, which are directly correlated. Consumers ask for more powerful engines and car manufactures are more concentrated to certain categories. That transposition to higher max. power categories indicates better combustion efficiency of the gasoline engines through the years. Displacement is not a factor in this case

since, according to figure 2, its average value remains relatively stable in the case of gasoline vehicles.

Figure 10 shows Diesel cars' max. specific power classification. The general view of that figure is that there is transposition of sales from low max. specific power categories to higher ones.

The two first categories (20-25 kW/l and 25-30 kW/l) have such decreases during these years (90% and 94% respectively) that they almost disappear. The sales of all higher categories show significant increases. The range 30-35 kW/l increases by 56% (from 57,000 to 90,000 units), this of 35-40 kW/l is the only that remains practically unchanged (from 140,000 to 143,000 units, or an increase of only 2%), while the last three categories (40-45 kW/l, 45-50 kW/l and >50 kW/l) increase from almost ultimate zero in 1995 to 165,000, 128,000 and 102,000 units in 2003.

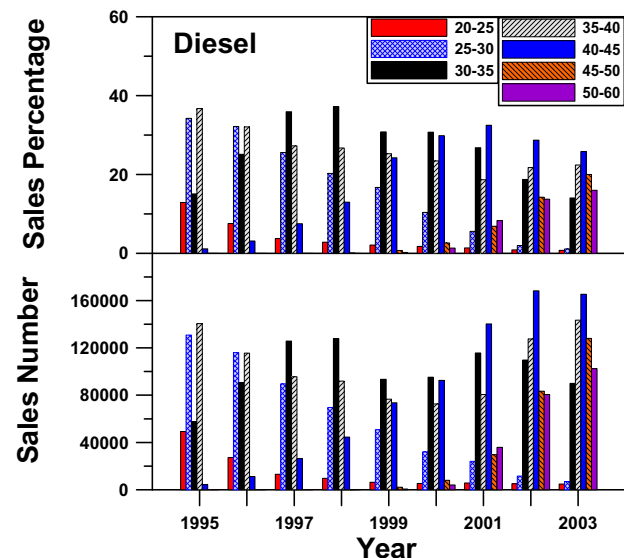


Figure 10. New passenger car sales and their percentage per max. specific power in kW/l. Diesel vehicles from 1995-2003.

According to sales' percentages, lower ranges <30 kW/l, have a significant decreased tendency. The first mentioned class passes from 12% to 1% and the second one from 34% to 1%. The 30-35 kW/l medium category percentage remains practically constant (from 15% to 14%) while the 35-40 kW/l one passes from 36% to 22%. Higher categories (40-60 kW/l) show a remarkable increase as they pass from approximately zero in 1995 to 25% (40-45 kW/l), 20% (45-50 kW/l) and 16% (>50 kW/l) in 2003. These results show that during these years combustion efficiency of Diesel engines increases and the high max. specific power engines are sold more than the lower ones.

The same general tendency is also illustrated in the case of gasoline PC (figure 11). Ranges 20-35 kW/l and 35-45 kW/l are the only which decrease. The first one