2011

Permitted Road Transport Specific Emissions of CO2 in Palestine

By: Ali Shaath and Naser Abu Sharbak

Ministry of Transport, Palestine

1/7/2011

Abstract

This paper has been prepared to present standards, measurements and projections of the mean CO2 emissions of potential passenger cars stock on actual road conditions to 2015 and 2020. To this aim, on road sampling exercise was conducted and four emissions were measured using the exhaust gas analyzer KM9106. CO_2 emission was approaching its maximum value of about 15% of the total value of the measured vehicle emissions. This is due to improvements in engine manufacturing and using Catalytic Converters. However, most cars in Palestine are still older ones not using Catalytic Converters; hence its value is high. CO2 emissions of new passenger cars registered in Palestine are monitored in order to meet the objectives of Regulation EC 443/2009. This calls for an average CO2 emission of 130 g/km for new passenger cars registered in Palestine to be met by vehicle measures in 2015. This decreases to 95 g/km in 2020. The Palestinian National Authority, in support of enforcing this regulation, has produced a set of actions, including, Customs and Taxes fundamental reductions for new passenger cars meet the regulations (Euro 5 and above). This reduction is from 75% to 50% for petrol cars, 30% for hybrid cars, and only 10% for electric cars, which is considered the lowest in the region. This design was made to reduce the prices of new passenger cars in order encourage people to replace their old cars with newer ones and therefore reduce on-road emissions.

Similar regulations are gradually being developed for other vehicle categories as well, more prominently for light commercial vehicles and buses.

Keywords
CO_2 emissions, passenger cars, Palestine

Introduction:

The Palestinian National Authority (PNA) is adopting the European Union regulations for all aspects of vehicles when entering the PNA territories. Therefore, the PNA is affected by the the European Parliament and the Council Regulation No. 443/2009 containing mandatory CO2 emissions limits for new passenger cars. This regulation implies that each vehicle allowed in the PNA areas must achieve a fleet-average CO2 emission target of 130 g/km by 2015 for all new cars registered in the PNA. A legislative proposal for a draft regulation to reduce CO2 emissions from light commercial vehicles has been adopted by the European Commission in October 2009, setting a maximum value of 175 g/km for 2016 and a long-term target of 135 g/km for 2020. These regulatory tools are expected to have a significant impact on the emissions of CO2 by passenger cars and light commercial vehicles in the years to come.

According to this regulation, a so-called limit value curve sets specific emissions targets for each manufacturer based on the average vehicle mass sold by the particular manufacturer. The formula to calculate the limit value curve is:

$$\textbf{\textit{Permitted specific emissions of CO2}} = 130 + a \times (M - M0)$$

Where M is the reference vehicle mass (in kg), $M0$ = 1289 kg is a mass constant and a = 0.0457.

This is an empirical formula takes into account the different market segments of various vehicle manufacturers. This formula is set in such a way that heavier cars will have to improve more than lighter cars compared to today, but that manufacturers will still be able to make cars with emissions above the limit value provided these are balanced by cars which are below the formula values.

The regulation also defines a long-term target of 95 g/km to be reached by 2020. From 2016 onwards, the value of $M0$ will be annually adjusted to reflect the average mass of passenger cars in the previous three calendar years.

Manufacturers' progress will be monitored each year by the Member States on the basis of new car registration data. To this aim, it is important that the manufacturer is clearly identified and distinguished from the make. Table 1 below shows the actual position of the most prominent car manufacturers in terms of the average CO2 emissions of the new cars they manufactured in 2006. These are based on detailed statistics included in the CO2 monitoring database (European Commission, 2010). The database, which was established with Decision 1753/2000/EC of the European Parliament and of the Council, includes detailed volumes of vehicle models registered in each of the EU27 member states, providing information on the weight, power, capacity, fuel and type approval CO2 emissions of each car.

Table 1: *Average mass and CO2 emissions of new cars per manufacturer*

Manufacturer	**mass (kg)**	**CO2 (g/km)**
BMW	1453	182
DaimlerChrysler	1472	184
Fiat	1112	144
Ford	1319	162
GM	1257	157
Porsche	1596	282
PSA	1201	142
Renault	1234	147
Volkswagen	1366	165
Toyota	1214	152
Nissan	1202	164
Mitsubishi	1245	169
Honda	1261	153
Mazda	1296	173
Suzuki	1152	164
Subaru	1384	216
Hyundai	1349	165
Total*	**1288.8**	**159.2**

* Mass and CO2 are sales weighted

Table 2 shows the additional progress that the manufacturers will have to make in order to achieve their targets by 2015 under the above mentioned legislation, taking the limit formula into account and assuming the same average weight as in 2006, given in table 1. It is not possible to estimate the corresponding emission reductions required for 2020, as the $M0$ of the limit curve has not been determined yet (it will be calculated on the basis of the average mass of passenger cars in the previous three calendar years, i.e. 2017-2019). Assuming the same limit formula and average mass, the reductions required to achieve the 2020 target can then be calculated and are shown in table 2. If the average mass of the vehicle increases (as it historically does) the necessary reductions should be even larger than those shown in Table 2. The table shows that some manufacturers are close to their average target while others are way beyond. Of course, it should be recognised that manufacturers have the right to pool at will and to be monitored as one entity for the purpose of meeting their targets. In forming a pool, manufacturers must respect the rules of competition law and the information that they exchange should be limited to average specific emissions of CO2, their specific emissions targets, and their total number of vehicles registered.

Table 2: *CO2 reductions required to meet 2015 and 2020 targets by manufacturer*

Manufacturer	**CO2 reduction (g/km) in 2015**	**CO2 reduction (g/km) in 2020**
PSA Peugeot-Citroen	16	51
Renault	20	55
Fiat	22	57
Honda	25	59
Toyota	25	60
GM	28	63
Ford	30	66
Volkswagen	31	66
Hyundai	32	67
Nissan	38	73
Suzuki	41	75
Mitsubishi	41	76
Mazda	43	78
BMW	45	80
DaimlerChrysler	46	81
Subaru	81	117
Porsche	138	173

The discussed regulation does not specify the technology by which the CO2-average level should be reached (technology-neutral approach) by manufacturer, i.e. whether small, gasoline, diesel, hybrid, plug-in hybrids, electric or alternative fuel vehicles will be introduced, as long as the average CO2 emission level is reached. It should also be made clear that the mean CO2 levels refer to the certification test procedure. However, the CO2 emission rate for each technology to be introduced will depend on the actual driving pattern on roads. It has to be expected that different vehicle technologies will perform differently over real-world operation, despite meeting the target of 95 g/km over the certification test procedure. For example, a hybrid gasoline vehicle is a very good performer (low CO2) in urban driving through the frequent involvement of the electric motor and the regeneration of braking energy back to the batteries. However, in highway driving where the electric motor has only a secondary role to play and braking is infrequent, a small diesel vehicle may actually be a better performer due to the higher efficiency of the diesel engine over the gasoline engine in the hybrid vehicle. Therefore, the certification test procedure value alone is not necessarily the only determinant of CO2 emissions of each technology in real-world driving. As a result, the mean CO2 emission of the stock in real-world conditions will depend on the penetration rates of different new technologies, and the difference in CO2 emissions of each technology between real-world and type-approval driving conditions.

On-road CO2 Emission Assessment:

Air pollution is considered as the most environmental problem, and one of the most important elements of this problem is the pollution from automobile engines. Many pollutants from fossil fuels burnt in the engine are produced and make tremendous harm to mankind and other parts of environment.

The whole world is responsible for this problem, so every country in the world must take actions to control emitting these pollutants and also decrease them. In Palestine (and as a result of the difficult political situation and the absence of specialized institutes) there is a lack of information about the size of this problem in Palestine, and the Palestinian automobile certifications are based on the European Union regulations.

In the year of 2008 there was an on road evaluation of the air pollution from gasoline engines in the West Bank, Palestine, was conducted by Birzeit University. The study clarified that the high percentage of old cars among the registered cars (about 50%) is the main problem. Old cars produce very large amounts of carbon monoxide CO due to the absence of the catalytic converter used in the newer cars, and this converter converts most of CO to CO2.

The study was concerned with the main pollutants emitted from petrol engines which are considered the main source of Carbon Monoxide (CO) production on earth, CO is a product of incomplete combustion of hydrocarbon-based fuels, and it enters the bloodstream through the lungs and forms carboxyhemoglobin which affects healthy and ill people. CO is most likely to occur at low air-to-fuel ratios in the engine. These conditions are common during vehicle starting when air supply is restricted, when cars are not tuned properly, and at altitudes, where "thin" air effectively reduces the amount of oxygen available for combustion(except in cars that are designed or adjusted to compensate for altitude). In urban areas, the motor vehicle contribution to carbon monoxide pollution can exceed 90 percent. [EPA, 1993].

Hydrocarbons (C_XH_Y) are emitted mainly from gasoline engines, hydrocarbon pollution results when unburned or partially burned fuel is emitted from the engine as exhaust, and also when fuel evaporates directly into the atmosphere. C_XH_Y include many toxic compounds that cause cancer and other adverse health effects. C_XH_Y also react with Nitrogen Oxides (NO_X) in the presence of sunlight to form Ozone. A very significant fraction comes from cars in urban areas. The NO_X are highly reactive gases, they are colorless and odorless, they can often be seen combined with particles in the air as a reddish-brown layer over many urban areas, and the formation of NO_X is favored by high temperatures and excess oxygen. Motor vehicles are the primary source of NO_X.

Carbon Dioxide (CO_2) is a product of perfect combustion, as a pollution concern, it doesn't directly impair human health, but it is a "greenhouse gas" that traps the earth's heat and contributes to the potential for global warming.

In this paper the above four emissions are measured using the exhaust gas analyzer KM9106 which is available at Birzeit University laboratories.

Table 3: Groups of car numbers, percentages, with the average amounts of emissions from each group for one car.

Group (year)	CO (mg/m^3)	C_XH_Y (mg/m3)	NO_X (mg/m3)	CO_2 (%)
80-83	20272	3030	567	12.9
84-87	20630	2880	627	12.3
88-91	16788	3720	502	14.1
92-95	4082	490	739	13.8
96-99	2467	4070	430	14.3
2000-2003	472	2620	422	14.6
Total (Average)	18253	3180	575	13.7

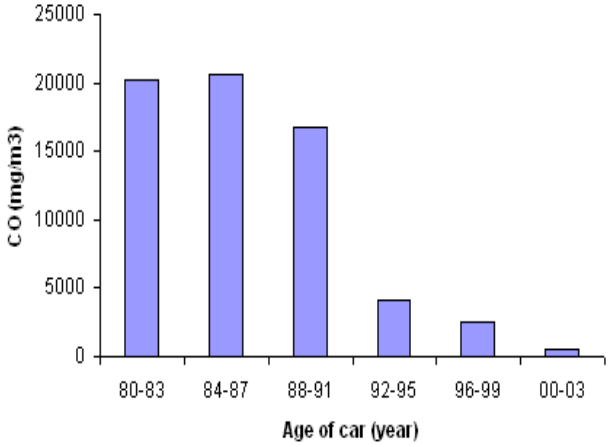


Figure 1: CO emitted from all groups.

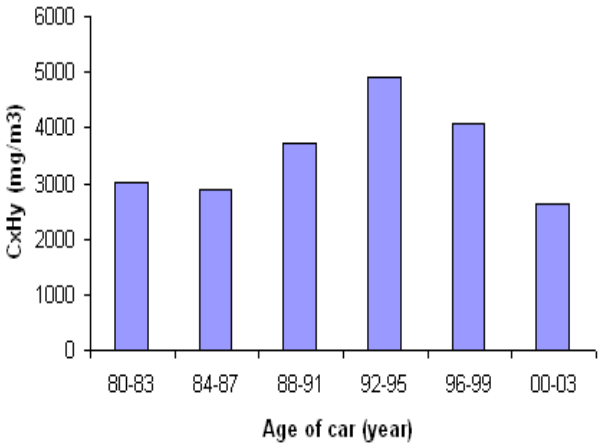


Figure 2: C_xH_y emitted from all groups.

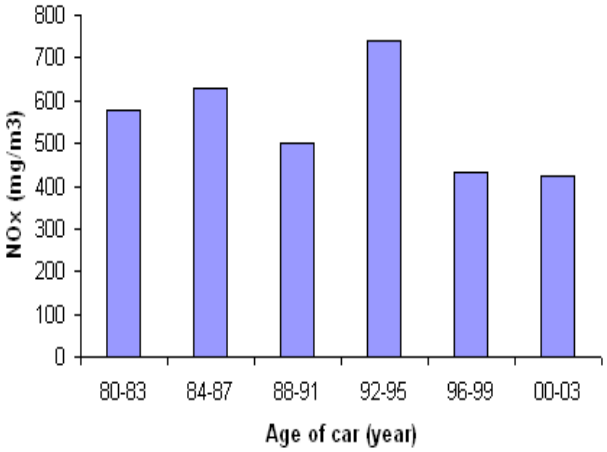


Figure 3: NO_x emitted from all groups.

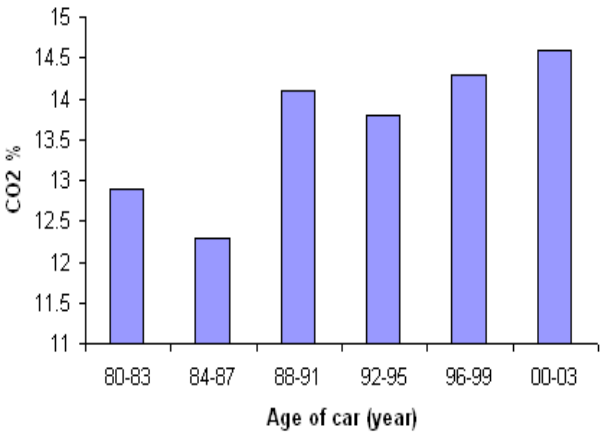


Figure 4: CO_2 emitted from all groups.

It is clear from Fig. 1 that old cars emit very large amounts of CO due to the fact that CO increases with older engines, another important factor which decreases the amount of CO in newer cars is the Catalytic Converter which converts most CO to CO_2

C_XH_Y in Fig. 2 increase until 1995. With the development of fuel injection systems and Catalytic Converter applications, C_XH_Y become lower.

Fig. 3 shows the effect of car age on NO_X which also started decreasing after 1996 due to the use of exhaust gas recirculation (EGR) in modern engine technology.

CO_2 in Fig. 4 is approaching its maximum value (about 15%); this is due to improvements in engine manufacturing and using Catalytic Converters, however most cars in West Bank are not using Catalytic Converters hence its value is high.

The study also contains a comparison of petrol engine emissions among several references from other countries, the NO_X situation in Palestine is not very serious and the CO_2 production is nearly the same as in neighboring Israel.

Table 2: Comparison of petrol-engine emissions among several references of countries.

Emission(g/km)	West Bank (WB)	Israeli Occupation (IL-O)	USA	Denmark (without catalyst) (DN-WC)	Denmark (with catalyst) (DN-C)
CO	15.2	13.5	13	15.4	2.22
C_XH_Y	2.7	2.2	1.75	1.26	19.
NO_X	0.6	1.2	0.87	1.07	0.2
CO_2	242	290	260	148	179

Table 2 and Figures 5 to 8 show the results of amounts of pollutants in g/km compared with several references, (Israel, USA, and Denmark). The first comparison is with the Israel which has direct influence on and control over the Occupied West Bank which suffers from land expansion; roads are restricted, narrow, rough, and limited. Therefore, it is clear that amounts of on-road pollutants in West Bank may exceed the values of other countries for these reasons.

CO emission in Palestine therefore exceeds that in Israel by 13% ; while it exceeds Denmark by 585%. In C_XH_Y case its amount exceeds Israel by 23%, while exceeds that in Denmark by 1320%. It should be noted that the NO_X situation is not very serious because engines in West Bank are older than in Israel with lower compression ratios, this will prevent NO_X from forming in larger amounts. CO_2 production is nearly the same as in Israel, since it is limited by the amounts of carbon constituent in fuels.

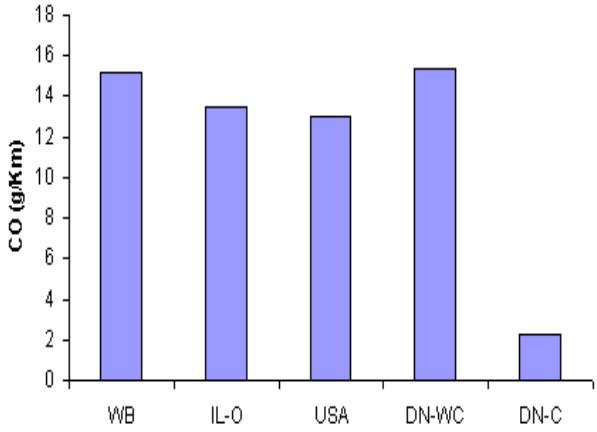


Figure 5: Average CO emission per car.

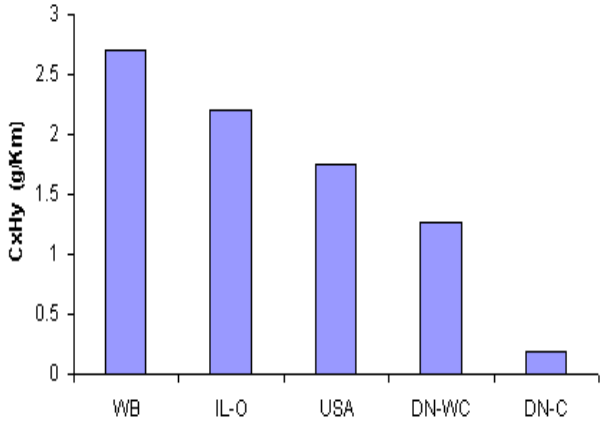


Figure 6: Average C_xH_y emission per car.

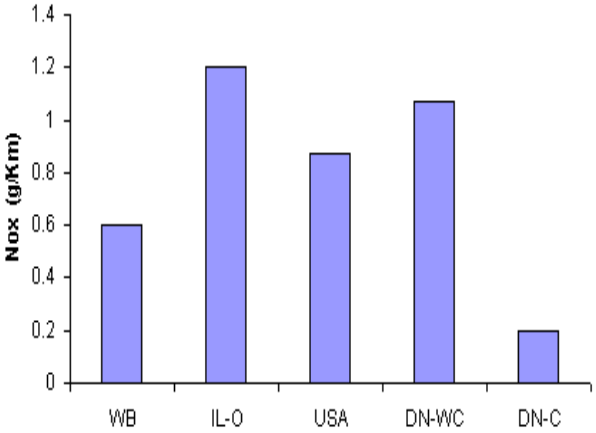


Figure 7: Average NOx emission per car.

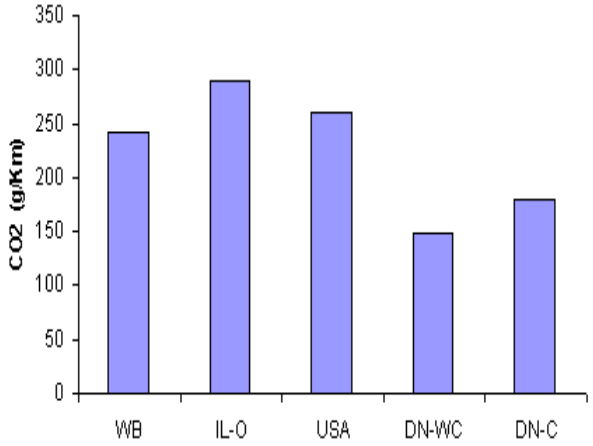


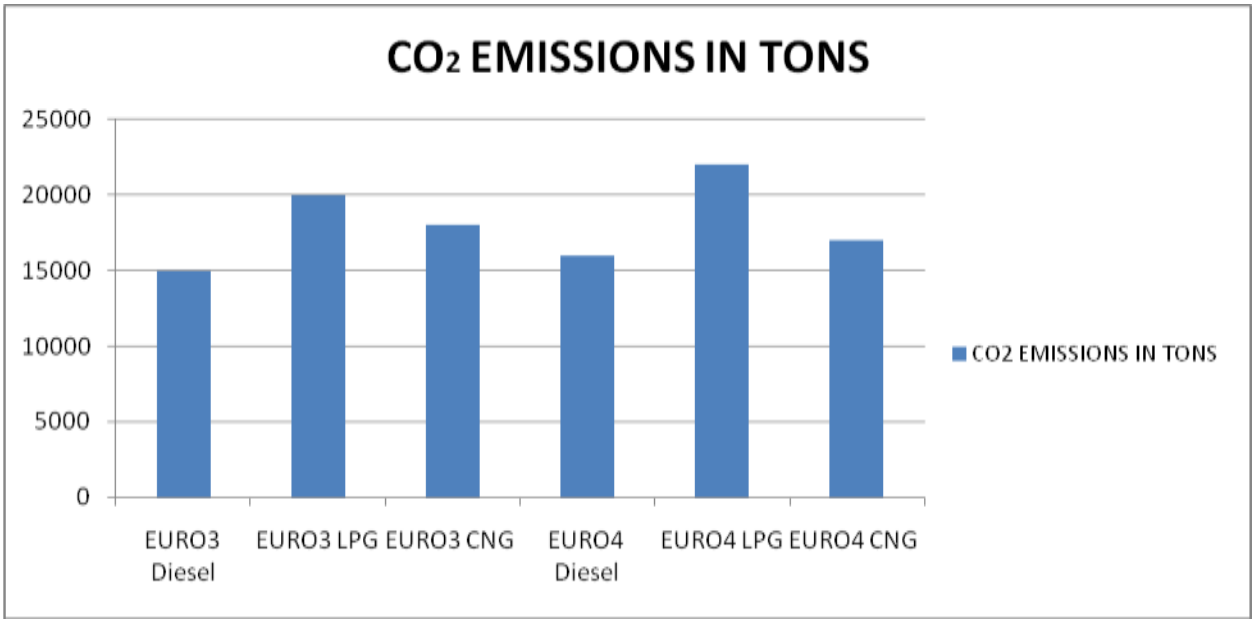
Figure 8: Average CO2 produced per car.

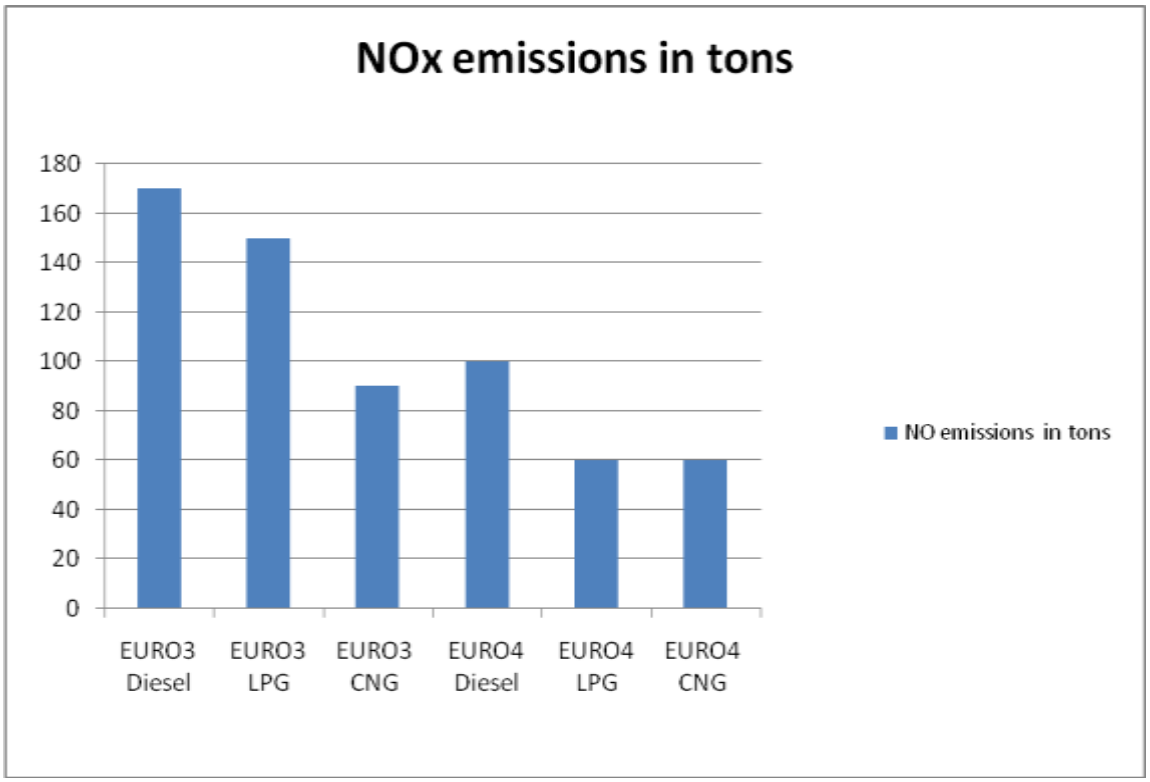
The Palestinian National Authority has made a strategic action plan to reduce the pollution of vehicles exhaust gases, and in order to achieve this target, there are three main actions are dealt with:

1. the percentage of the old cars working in the streets must be reduced.
2. the use of public transportation must be increased.
3. Clean kinds of fuel must be used.

An integral part of this action plan, in march 2009 the Customs and Taxes for new cars were reduced from 75% to be 50% for petrol cars, 30% for hyprid cars, and only 10% for electric cars, which is considered the lowest in the region. This design was made to reduce the prices of new cars in order encourage people to replace their old cars with new ones and therefore reduce on-road emissions.

The Palestinian Ministry of Transport through a technical assistance from the World Bank is currently assisting the bus operators sector to implement a long-term strategy for strengthening the public transport sub-sector. In the West Bank there are about 85 bus companies using about 850 buses and covering about 80% of the West Bank. More than 50% of these buses models are below the year 2000, and most of them were bought as used vehicles, which means old buses old emission certifications.





Analysis and Forward Planning:

Since fuel combustion is the largest polluting item in Palestine, public transportation vehicles need special attention. One area of potentially radical change is to examine whether changes in fuel types would provide significant benefit. The options to meet the future target of 95 g/km (tailpipe only) include shift of new vehicles to smaller cars and penetration of hybrid and electric vehicles. Full electric vehicles may be introduced but it is still considered that their numbers will be relatively small to have a substantial impact on mean CO2 emissions. Plug-in hybrids are the other option for an advanced technology. However, it is considered that their performance is similar to the electric with a range extender. Between the four available technologies, downsized gasoline, downsized diesel, hybrid and electric with range extender, any mix is considered possible as long as the average CO2 target of the new registrations is met.

In order to demonstrate the real-world effect on CO2 emissions of the various parameters and scenarios in Palestine, a rather comprehensive on-road evaluation program must be soon conducted. To this aim, in field measurements and projections must be used as the base-case for setting or verifying future emission values. In Palestine its planned, as it is a country with a fast fleet replacement, to start with applying that EU formula targets for new registration vehicles in order to immediately reflect on the total fleet as well. It should be noted that 35%of the total registered fleet of vehicles has been replaced with much newer model year of registration. This was conducted withen the last three years, ie an average of 12% of the total fleet is being replaced in annual bases. It should be emphasized that such replacement is in full compliance with the EU regulations

Discussion and Conclusions

Generally, the overall emissions from passenger cars in Palestine, as a result of applying the European Union “EURO” Standards and Regulations, are gradually decreasing in an effort to reduce the impact of road transport on greenhouse gas emissions and climate changes. The main tool that has been introduced to improve levels of CO2 emissions from passenger cars is the use of the European Union Regulation 443/2009 in Palestine (EURO V) that stipulates that passenger cars to be first time registered in 2015 need to emit 130 g/km CO2 at an average over the certification tests. The regulation does not infer into the technologies that need to be introduced to achieve this neither it addresses the impact that on-road vehicle operation may have on actual CO2 emissions, compared to the certification tests. Therefore, how actual CO2 emissions will evolve and how effective would be the use of this Regulation will be in controlling on-road CO2 emissions are important issues that will have to be revealed into the future. In order to provide some preliminary response to such a question, the Ministry of Transport in collaboration with the Vehicles Technical Testing centers is planning to perform an extensive on road study in order to project CO2 emissions of passenger cars into the future levels implicated by the proposed formula.

it is highly recommended that the effect of different vehicle operation conditions according to their technology on total CO2 emissions is investigated under local Palestinian conditions. Therefore, methodology, tools, and parameterisation of fuel consumption and CO2 emissions for passenger cars and light commercial vehicles must be developed.

Overall, this exercise appears useful to and may be used to better understand vehicle fleet activity and emissions data and thus to be able to improve environmental protection measures in Palestine.

References

[1] UN-ECE, 2005. Regulation No. 101 - Rev.2 -Emissions of carbon dioxide and fuel consumption. http://www.unece.org/trans/main/wp29/wp29regs101-120.html

[2] European Commission, 2010. Measures for monitoring the average specific emissions of carbon dioxide from new passenger cars. CO2 monitoring database http://ec.europa.eu/environment/air/transport/co2/co2_monitoring.htm

[3] Israeli Central Bureau of Statistics, Emission of Air Pollutants from Fuel Composition, by type of consumer, 2002.

[4] Palestinian Central Bureau of Statistics, Licensed Road Vehicles in Remaining West Bank by Government and Type of Vehicle, 2002.

[5] Birzeit University, Air Pollution from Gasoline Engines in the West Bank of Palestine, Mohammad Karaen, 2008.

[6] The Ministry of Transport & World Bank, Strategic Assessment on Energy Efficiency and Security for Public Transport in the West Bank, Ramallah, May 2009.

[7] The Ministry of Transport & World Bank, Technical Assistance in the Passenger Transport Sector Development, Ramallah, April 2009.

[8] The United Nations Office for the Coordination of Humanitarian Affairs, West Bank Movement and Access, Palestine, June 2010.