DEFINING THE POLICY FOR REDUCTION OF CO_2 EMISSIONS FROM THE ROAD TRANSPORT SECTOR IN REPUBLIC OF MACEDONIA

Dr. Nikola Krstanoski
Professor of Transport Engineering
University "St. Kliment Ohridski"
Faculty for Technical Sciences - BITOLA
Department for Traffic and Transport Engineering
7000 Bitola
Republic of Macedonia
nikola.krstanoski@uklo.edu.mk
tel. ++389/47 207 747
fax. ++389/47 203 370
Dr. Beti Krstanoska
Public Health Care Center
Bitola

Abstract

Acknowledging the significance of the climate change problem and the necessity to take effective actions for its mitigation, Republic of Macedonia ratified the UN Framework Convention on Climate Change in 1997, and became a party to the Convention on April 28, 1998. In line with the efforts to define a sound CO_2 emission reduction policy, in this paper, the authors define a model for estimation of CO_2 emissions from the road transport sector over the next 25 years. Then, they identify the possible measures for reduction of the CO_2 emissions and test those measures against the model. The implemented model is a macroscale model, based on variables such as: the number and type of vehicles, average annual traveled distance per type of vehicle, average fuel consumption, etc. This model has been used to estimate the total annual fuel consumption from the road transport sector. Then, the Intergovernmental Panel of Climate Change (IPCC) – Tier 1 methodology has been applied to estimate the CO_2 emissions. The problem of uncertainty related to the length of the forecasting period, as well as to the future economic development of the country, has been facilitated by defining two scenarios: "Do nothing" and "Implement mitigation measures".

Keywords: CO_2 emissions from road transport, CO_2 emission prediction, CO_2 emissions in Macedonia

JEL Code: Q51, Q54

Introduction

Acknowledging the significance of the climate change problem and the necessity to take effective actions for its mitigation, Republic of Macedonia ratified the UN Framework Convention on Climate Change in 1997, and became a party to the Convention on April 28, 1998. As a party to the Convention, the country has committed to define and implement a long-term policy for reduction of its greenhouse gases (GHG) emissions. Immediately after the ratification, under the Ministry of environment and physical planning, the first efforts were made to develop a National Action Plan for reduction of GHG emissions and the first inventory of CO_2 emissions by sectors was done.

The inventory report [1] has shown that the transport sector is to be blamed for about 8% of the total emissions of CO_2 in Macedonia (Figure 1). The road transport is the source of about 96% of the total CO_2 emissions from the transport sector in Macedonia [1].

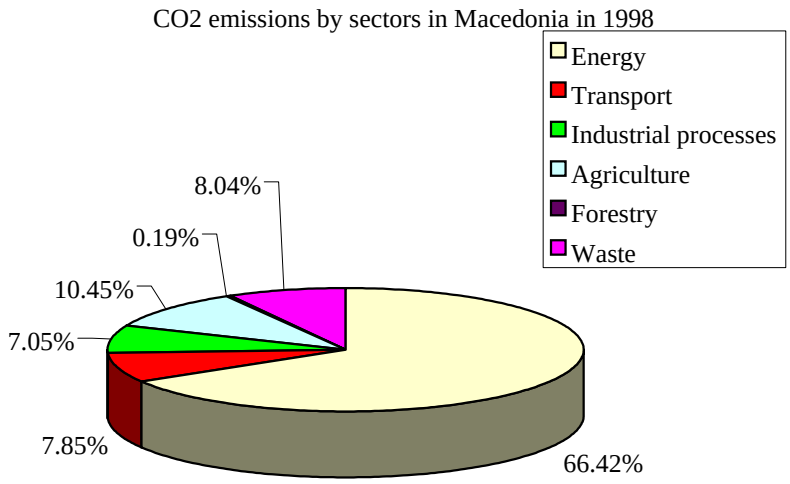

Figure 1. CO2 – equivalent emissions by sectors in Macedonia in 1998
Source: [1]

Compared with other countries, the contribution of CO_2 emissions from the road transport sector is relatively low. This is partly because of the specific situation in which Republic of Macedonia found

itself during the 1990's. It was a period of political and economic transition after gaining independence in 1991, a period when the country's economy experienced rapid decline.

Today, in line with the expected economic recovery, the growth of the transport sector is likely to happen over the next decades. This growth will also lead to increased CO_2 emissions, and a well-defined national policy for its reduction is very much needed.

Recognizing the need for a sound policy, in this paper, the authors define a model for estimation of CO_2 emissions from the road transport sector over the next 25 years. Then, they identify the possible measures for reduction of the CO_2 emissions and test those measures against the model.

The objective of the paper

The main objective of this paper is to present the model for estimation of CO_2 emissions from the road transport sector in Macedonia over the next 25 years. This model should help the identification of possible mitigation measures, as well as of the expected effects of their implementation.

Definition of the model

The selection of the model to be implemented in Macedonia, has been greatly determined by the very limited availability of data about both: environmental and transportation indicators.

Therefore, the only viable solution seemed to be an implementation of a macroscale model, based on variables such as: the number and type of vehicles registered in Macedonia, average annual traveled distance per type of vehicle, average fuel consumption per type of vehicle, etc. This model has been used to estimate the total annual fuel consumption from the road transport sector. Then, the Intergovernmental Panel of Climate Change (IPCC) – Tier 1 methodology has been applied to predict the CO_2 emissions [2]. The problem of uncertainty related to the length of the forecasting period, as well as to the future economic development of the country, has been facilitated by defining two scenarios: "Do nothing" and "Implement mitigation measures".

The model for estimation of the total annual fuel consumption by the transport sector has been defined as follows:

$$F_j = \sum_{i=1}^{n} V_{i,j} \cdot K_{i,j} \cdot a_{i,j} \qquad (1)$$

where:

F_j – total annual fuel consumption of fuel type "j" (gasoline or Diesel)

$V_{i,j}$ – number of vehicles of type "i" (passenger cars, buses, commercial vehicles, tractors and motorbikes), consuming fuel of type "j"

$K_{i,j}$ – average annual number of kilometers traveled by vehicle of type "i", consuming fuel of type "j"

$a_{i,j}$ – average fuel consumption (l/100 km) by vehicle of type "i", consuming fuel of type "j"

n – number of types of vehicles

Given the relation (1), it is of crucial importance to forecast the model variables.

Forecast of the road transport variables

The number and the structure of macedonian vehicle fleet have been forecasted over the next 25 years by means of the rate of vehicle ownership and the percentages of share for each type of vehicle.

It is well-known that the change of rate of vehicle ownership over a longer period follows an S – shaped curve. This is because the number of vehicles increases slowly during the period of initial motorization, then it is beginning to increase rapidly, and finally it reaches the period of saturation. If the rate of vehicle ownership is expressed as number of vehicles per 1000 inhabitants, then its saturation rate takes values between 450 and 700 depending on the specific factors for each country. Republic of Macedonia should reach a saturation value at approximately 450 vehicles per 1000 inhabitants.

In order to analyze the trend of the rate of the vehicle ownership in Macedonia, its values have been collected for the period between 1950 and 2005 (Figure 2).

As can be seen from the Figure 2, several disturbances of the original trend can be recorded. The first disturbance has been noticed in 1985 and 1986, when the trend curve has been moved (delayed) for about 5 years. The second disturbance can be seen in the years after 1993. This disturbance has been prolonged until today.

Here, an assumption has been made that Macedonia will return to its economic development with a rate of growth of 4% per year [3] which will cause a return of the trend of the rate of vehicle ownership to its initial curve, in 2007 (optimistic scenario) or in 2012 (pessimistic scenario) – Figure 2.

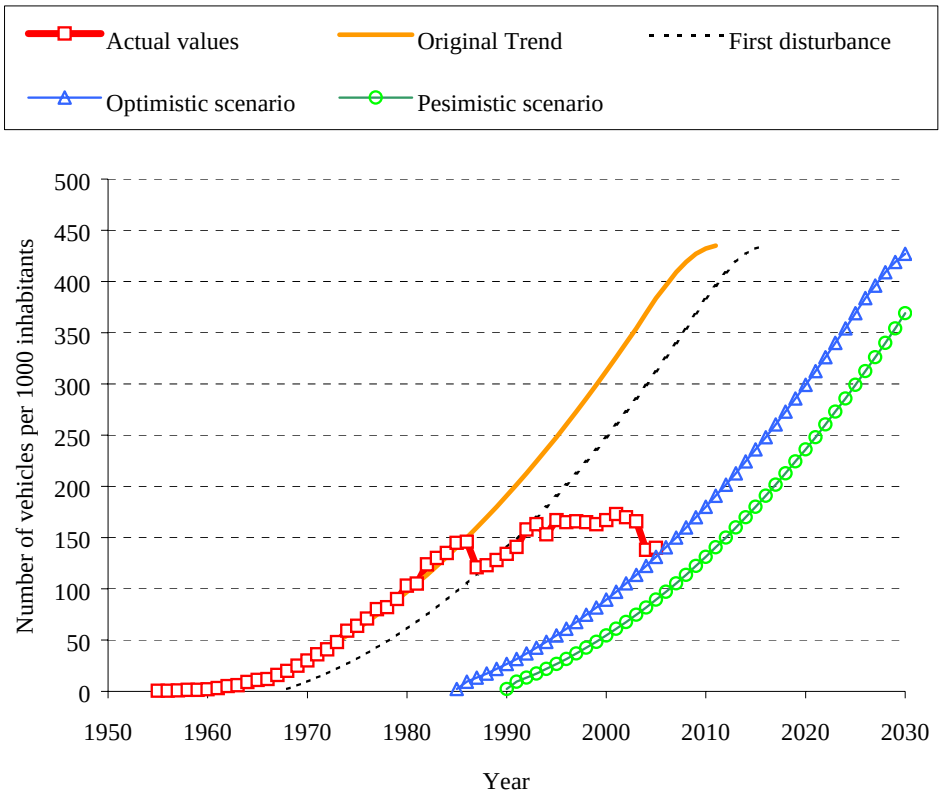

Figure 2. Rate of vehicle ownership – actual values and forecast

This approach results in a rate of ownership of about 427 vehicles/1000 inhabitants in 2030 for the optimistic scenario, and 369 vehicles/1000 inhabitants for the pessimistic scenario.

The values of the rate of vehicle ownership combined with the projected population, has been used to predict the total number of vehicles. The population projection has been taken over from the Demographic Institute of Macedonia [4].

The predicted total number of vehicles in Macedonia for both scenarios is shown in Figure 3.

The structure of the vehicle fleet in Macedonia for the period from 1992 to 1998 is given in Table 1. The values from the table show relative stability over the period from 1992 to 1998. Therefore, it is

assumed that the percent of vehicles by type will stay approximately same over the period of forecasting. An exception of this is being made with regard to the portion of commercial vehicles, where a decrease of 0,7% per year is assumed, and an equivalent increase is given to the number of cars.

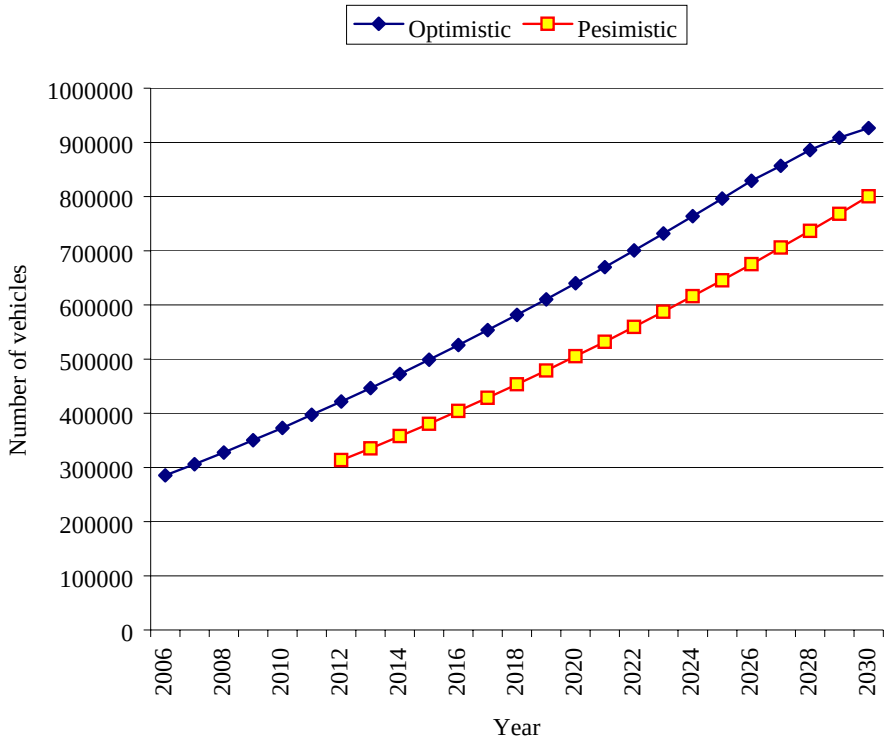

Figure 3. Prediction of the total number of road vehicles for the both scenarios of development

Table 1. Structure of vehicles by type

	1992	1993	1994	1995	1996	1997	1998	Assumed % for the forecasting period
Motorcycles	0.85	0.89	0.49	0.71	0.83	1.04	1.08	1
Cars	86.37	86.09	88.04	87.63	87.39	87.43	87.44	88 (increasing 0,7 % per year)
Buses	0.87	0.87	0.82	0.78	0.75	0.73	0.75	0.8
Commercial vehicles	5.95	5.97	5.83	5.68	5.96	5.99	6.08	5.8 (decreasing 0,7 % per year)
Special vehicles	1.85	1.95	2.01	2.18	2.21	2.21	2.24	1.8
Tractors and sp. Vehicles	1.96	1.97	0.94	1.00	0.86	0.73	0.66	0.8
Trailers	2.15	2.26	1.88	2.03	1.99	1.86	1.75	1.8
Total	100	100	100	100	100	100	100	100

Source: [5].

The forecast of the structure of vehicles in Macedonia over the next 30 years, based on the above assumptions, is given in Table 2.

Table 2. Forecast of the structure of the road vehicle fleet in Macedonia for the period 2006 - 2030

Year	Passenger cars		Buses		Commercial vehicles		Motorbikes		Spec. and tractors		**Total without trailers**	
	Optimistic scenario	Pessimistic scenario	Optimistic scenario	Pessimistic scenario	Optimistic scenario	Pessimistic scenario	Optimistic scenario	Pessimistic scenario	Optimistic Scenario	Pessimistic scenario	**Optimistic scenario**	**Pessimistic scenario**
2006	250937	249973	2281	2272	15113	15055	2852	2841	7414	7386	**278597**	**277527**
2007	269220	251205	2447	2284	15908	14844	3059	2855	7954	7422	**298589**	**278609**
2008	288315	252560	2621	2296	16709	14637	3276	2870	8518	7462	**319440**	**279825**
2009	308108	253915	2801	2308	17506	14427	3501	2885	9103	7502	**341019**	**281038**
2010	328447	255147	2986	2320	18289	14207	3732	2899	9704	7538	**363158**	**282112**
2011	349481	257368	3177	2340	19063	14038	3971	2925	10326	7604	**386018**	**284275**
2012	371040	275954	3373	2509	19817	14738	4216	3136	10963	8153	**409409**	**304490**
2013	393101	295066	3574	2682	20548	15424	4467	3353	11614	8718	**433305**	**325243**
2014	415839	314835	3780	2862	21264	16100	4725	3578	12286	9302	**457895**	**346676**
2015	439051	335108	3991	3046	21953	16755	4989	3808	12972	9901	**482956**	**368619**
2016	462930	356031	4208	3237	22620	17397	5261	4046	13677	10519	**508697**	**391230**
2017	487023	377254	4427	3430	23244	18005	5534	4287	14389	11146	**534618**	**414122**
2018	511989	399285	4654	3630	23854	18603	5818	4537	15127	11797	**561442**	**437852**
2019	537111	421565	4883	3832	24414	19162	6104	4791	15869	12455	**588381**	**461805**
2020	563114	444661	5119	4042	24956	19707	6399	5053	16637	13138	**616226**	**486601**
2021	589487	468171	5359	4256	25455	20216	6699	5320	17417	13832	**644416**	**511796**
2022	616483	492294	5604	4475	25920	20699	7005	5594	18214	14545	**673227**	**537608**
2023	644106	517034	5856	4700	26350	21151	7319	5875	19030	15276	**702661**	**564037**
2024	672046	542143	6110	4929	26729	21562	7637	6161	19856	16018	**732378**	**590812**
2025	700594	567851	6369	5162	27068	21940	7961	6453	20699	16777	**762692**	**618183**
2026	729751	594161	6634	5401	28195	22956	8293	6752	21561	17555	**794433**	**646825**
2027	754111	621075	6856	5646	29136	23996	8569	7058	22281	18350	**820952**	**676125**
2028	779587	648296	7087	5894	30120	25048	8859	7367	23033	19154	**848686**	**705759**
2029	799385	676100	7267	6146	30885	26122	9084	7683	23618	19976	**870240**	**736027**
2030	815399	704490	7413	6404	31504	27219	9266	8006	24091	20814	**887673**	**766933**

Other model variables are: the average annual distance traveled and the average specific consumption of fuel for each type of vehicle. The statistical data for 2004 are given in Table 3:

Table 3. Average annual traveled distance and average fuel consumption in Macedonia in 2004

Type of vehicle	Average annual traveled distance (km/year)	Average fuel consumption (l/100 km)
Passenger car	10 000	8
Buses	62 000	38
Com. vehicles	45 000	32
Motorbikes	3 000	3
Spec. veh and tractors	1000	80

Baseline CO_2 emissions from road transport – "Do nothing scenario"

The scenario “Do nothing” is an attempt to forecast the CO_2 emissions from the road transport sector in Macedonia, if no policy and specific mitigation measures are to be taken over the forecasting period.

This scenario includes the following assumptions:

- Macedonian economy will reach full recovery and this will result in a steady growth in the transport sector beginning from 2007 according to the optimistic scenario, or in 2012 according to the pessimistic scenario. Accordingly, the vehicle fleet will increase as given in Table 2.
- The economic growth and the improved standard of the population will lead to increasing of the annual distance traveled by the passenger cars. It is assumed that the average annual distance traveled by a car will increase by 2,5% per year, thus reaching the value from 10000 km/year/vehicle in 2006 to about 18000 km/year/vehicle in 2030. Also, it is assumed that the 30% /70% ratio of Diesel /gasoline cars will remain in the future.
- The average traveled distance by the other categories of vehicles is assumed not to change significantly.
- Today, the average vehicle in Macedonia is about 14 years old. Therefore, even in case of achieving the wanted economic growth, it will take some time to accomplish a significant renewal of the vehicle fleet. This is very important, since the new generations of vehicles have much better fuel economy characteristics. Since by this scenario, no specific governmental measures to help faster renewal of the vehicles are being expected, only a “natural”, slow, renewal is assumed. In accordance with this, an annual 1% reduction of the average fuel consumptions is being assumed.

Given the above assumptions, and by the application of the equation (2), it is possible to estimate the annual fuel consumption by the road transport sector in Macedonia. These estimates are shown in Figure 4.

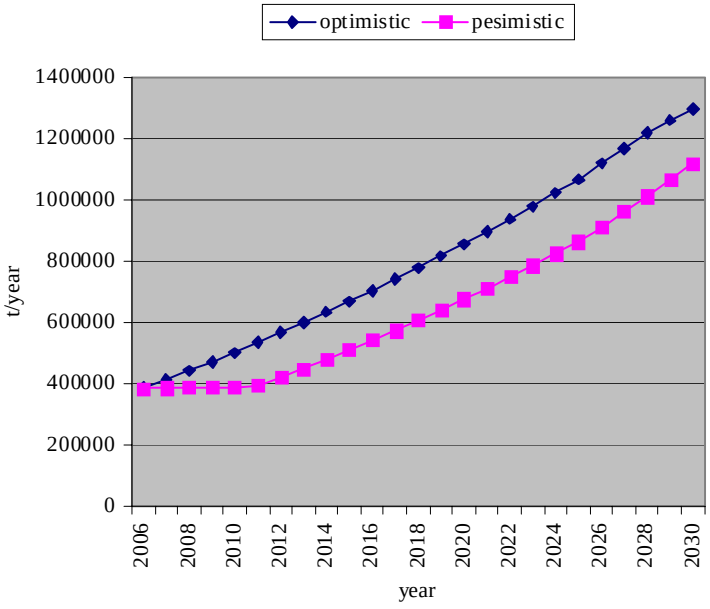

Figure 4. Predicted annual consumption of fuel by the road transport sector in Macedonia over the period 2006 – 2030 ("Do nothing" scenario)

Given the annual fuel consumption, based on the Tier 1 methodology recommended by IPCC [2], the CO_2 emissions from the road transport sector in Macedonia are computed. The resulted estimates are given in Figure 5.

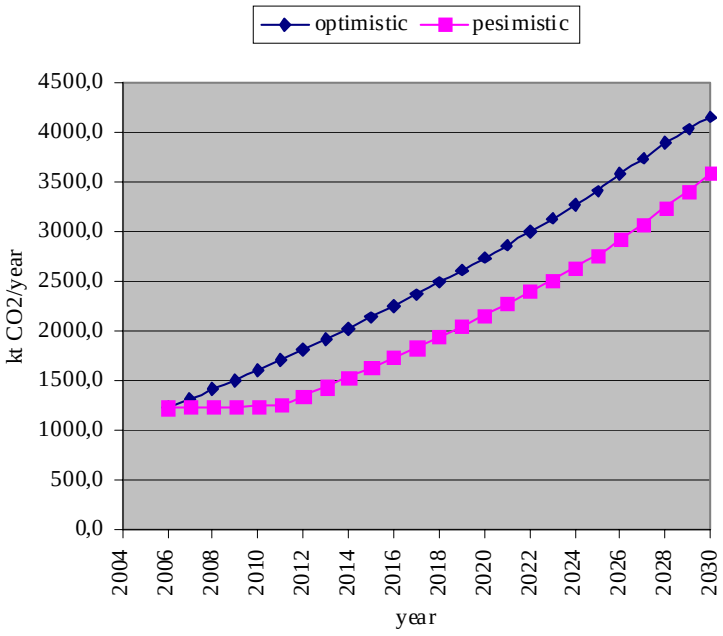

Figure 5. . Predicted annual emissions of CO_2 from the road transport sector in Macedonia over the period 2006 – 2030 ("Do nothing" scenario)

Mitigation measures for reduction of CO_2 emissions from transport sector

In order to meet the GHG emission reduction targets agreed at Kyoto, European Union has taken many steps to develop a robust, credible and cost-effective strategy to reduce CO_2 emissions. In 1998 the Commission of the European Communities has issued a Communication on transport and CO_2 [6] that contained policy approaches which were expected to contribute curbing the growth in CO_2 emissions from transport. In addition, the emission reduction potential of certain number of promising measures was assessed.

Regardless of the scenario of the development of the transport sector in Macedonia, eventually, it is to be expected growth in both: the number of vehicles and the usage of the vehicles. This will result in greater consumption of fuel, which in turn will greatly increase the emissions of CO_2. In order to alleviate this unfavorable situation, many complex measures organized in a well-defined national strategy for transport and environment must be taken. Still the experience from the developed countries has shown that it is very difficult to make even small progress in this direction.

Basically there are three ways to reduce CO_2 emissions from the transport sector:

1. **Reduction of vehicle-kilometers**. Some of the possible measures to achieve this are: a) to practice integrated land-use and transportation planning; b) to achieve greater use of transport modes with higher capacities – public transport; c) to achieve greater shift to modes that use electric power and other energy sources d) to develop integrated multimodal transport system; e) to improve traffic management and control; f) to develop and implement city logistics systems; etc.
2. **Energy – efficiency improvements of the vehicles.** These measures are mostly related to the manufactures of vehicles and the regulatory policies of the countries that produce vehicles. The aim is to reduce the specific energy consumption for the same performance of the vehicles;
3. **Vehicles that use alternative energy** sources**.** Some of examples of alternative fuels are: natural gas, electric power, alcohol, fuel cells and so on.

The measures listed within the first group are the most difficult to implement, since they require a system approach to the problem. There have been no studies in Macedonia that will relate the implementation of such measures to the decrease of the pollution. One study in Netherlands [7] suggests that measures like promotion of public transport and bicycling, introduction of tolls, increased fuel taxes, all combined together, can lead to a reduction of about 15% of the existing vehicle-kilometers.

Mitigation measures from the second group are easier to implement, since the vehicle industry itself is making efforts to increase the efficiency and to reduce the pollution from vehicles. In this case, the country should find a way to support replacement of old vehicles by new ones. Within this project, an assumption will be made that the existing old vehicles will be gradually replaced by new ones that consume less and pollute less. In addition, it is assumed that while the efficiency of the vehicles will increase, the average annual distance per vehicle will increase too.

The measures from the third group will be neglected here since the portion of vehicles that use alternative fuel is not expected to be significant by the horizon year.

Therefore, the scenario “Implement mitigation measures” includes the following assumptions:

- Energy-efficiency improvement of vehicles
    a) The policy measures will be taken in order to speed the renewal of the vehicles in Macedonia. This is important since the new vehicles consume less and pollute less compared with the old vehicles. These policy measures in general will include measures like tax and custom discounts for new vehicles, tax and custom incentives for commercial vehicles and buses etc.
    b) The European standards of the quality of fuels will be applied.
- Reduction of the level of increase of vehicle-kilometers
    c) Practice of integrated land-use and transport planning.
    d) Support and development of urban public transport that would attract more car users to public transport – planning and investing in improvement of public transport, combined with measures of support such as priority treatment and parking policy.

e) Planning and development of integrated multimodal transport system. Investing in transport terminal centers with transfers between air, railway, road, developing of container system, etc.

f) Support of electric modes of transport. Electrifying of the railway, and greater use of railway. Introducing tramway in Skopje.

g) Improvement of traffic management and control system. Improvement of traffic flows.

h) Development of City logistics systems that have great potential to reduce the movement of supply commercial vehicles in cities.

By application of measures (a) and (b) it is expected that the average fuel consumption pre vehicle will decrease by following percents:

- 1,8% per year for passenger cars
- 2.0% per year for buses
- 1,5% per year for commercial vehicles
- 0,5% per year for motorcycles
- 2,0% per year for special vehicles and tractors

Thus, for example, if in 2000 the average fuel consumption for a passenger car is 8 l/100 km, then under this assumption, its average consumption will decrease to 5 l/100 km in 2030. This is in compliance with the industry expectances regarding the development of the vehicle technology.

By application of all measures from (c) to (h), and based on experiences of other countries, it is assumed that the annual distance traveled by a passenger car will not increase to 18000 km/year per vehicle what would happen if nothing is done, but will increase to 15000 km/year (17% smaller increase).

The average distance traveled by buses and commercial vehicles is not expected to change significantly. However, there will be an increase of the traveled vehicle-kilometers that would come from the increase of the vehicle fleet.

Once input data are defined as above, the model (2) allows computation of the total annual consumption of fuel from the road transport sector in Macedonia. The result of the computation is shown in Figure 6.

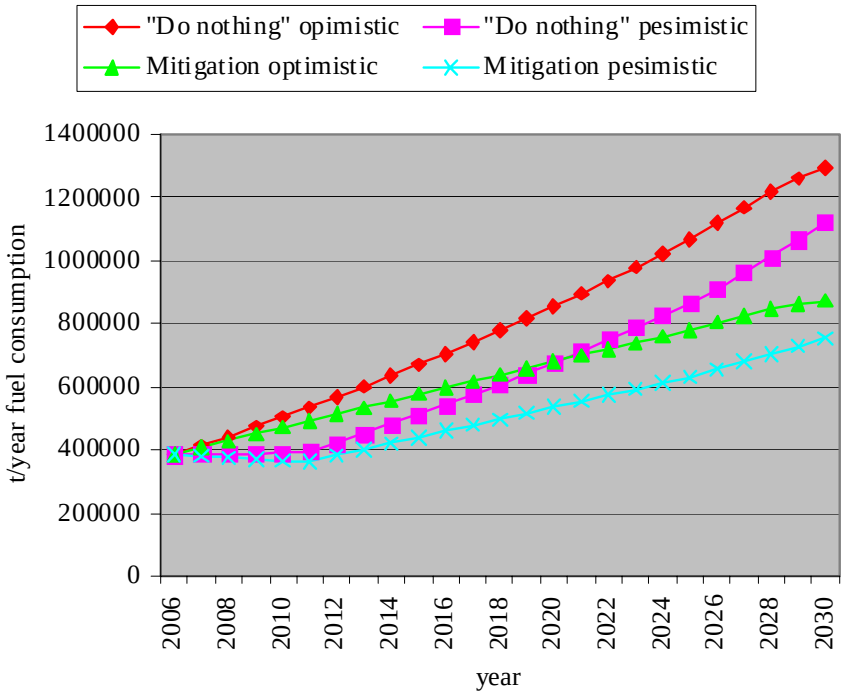

Figure 6. Estimation of the total annual fuel consumption in Macedonia for both: “Do nothing” and the “Implement mitigation” scenarios

Given the annual fuel consumption, the implementation of the Tier 1 IPCC Methodology allows an estimation of the CO_2 emissions from the road transport sector under the scenario “Implement mitigation measures”. These estimates are shown in Figure 7.

Conclusion

The problem of climate change as a result of the GHG emissions is widely recognized throughout the world, nowadays. Though, Republic of Macedonia is relatively insignificant source of CO_2 emissions, it must join the efforts of the international community to reduce its emissions in the future.

In this article, a model for estimation of the CO_2 emissions from the road sector in Macedonia is presented and two scenarios have been analyzed: what is likely to happen if no policy actions are to be taken and if such mitigation measures are to be implemented over the next 25 years.

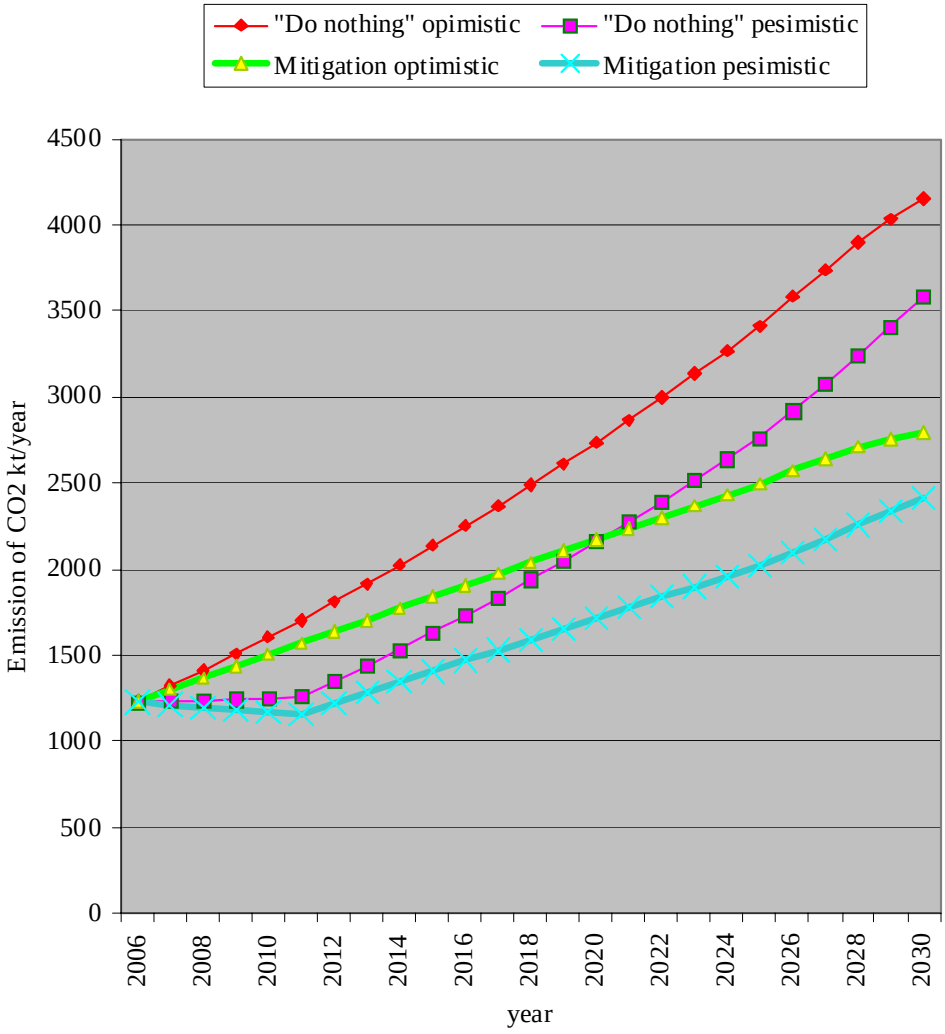

Figure 7 Estimated CO_2 emissions from road transport according to the "Do nothing" and "Mitigation" scenarios

The problem of the great uncertainty related to the length of the prediction as well as to the uncertain economic development of the country, has been facilitated by assuming certain scenarios of both: the economic trends in Macedonia and the application of CO_2 reduction policy measures.

The results of the analysis show that with the application of the suggested policy measures, a reduction of about 32% of CO_2 emissions are to be expected in 2030, compared with the case when no mitigation actions are to be taken.

Finally, it should be emphasized that the primary objective in this article, has not been to focus on precise estimation of the CO_2 emissions, but rather on the rising of the awareness of the macedonian public and the macedonian authorities about the need of active and sound policy for reduction of CO_2 emissions from the road transport sector.

The presented model represents good framework for the policy makers by providing them with a tool to analyze "if-then" scenarios. This will hopefully lead to a policy that can be implemented and can have real life effects.

References

[1] MACEDONIA's FIRST NATIONAL COMMUNICATION under the UNFCCC, Ministry of Environment and Physical Planning, Republic of Macedonia, Skopje 2003.

[2] REVISED 1996 IPCC GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES, Intergovernmental Panel on Climate Change, 1996.

[3] Dimitar Hadzimishev, "Possibilities for development of the energy sector in Republic of Macedonia over the period of 1996 – 2020", ZEMAK.

[4] Spatial Plan of Republic of Macedonia, Ministry for Urbanism, Construction and Environment, 1998.

[5] Statistical review 339, Transport and telecommunication in Macedonia, Statistical Office of Republic of Macedonia.

[6] Communication (COM(1998) 204 final) on transport and CO_2, Commission of the European Union, 1998.

[7] Transport structure plan project team, Second transport structure plan: Part D, Joint policy statement of the Ministers, Netherlands, 1990