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FACING THE AIR POLLUTION PROBLEM IN MACEDONIA: REDUCTION AND MITIGATION MEASURES

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***Abstract**: In recent years, air pollution in Macedonia is very acute problem. Apart of industry and energy production, significant contribution to the increase of the concentration of pollutants with harmful effect on the health, ecosystems and materials has intensiveness of oil production and its use in the road transport (MOEPP, 2015). Concentrations of main air pollutants – suspended particles and nitrogen dioxide are continuously exceeding the limit values in all monitoring stations for the whole analyzed period (2005-2015). The national annual reports, elaborating the air pollution problem and its consequences, don't comprise a comprehensive and categorized list of measures with a potential to reduce or mitigate the contribution of different air pollution sources, between them road transport. Hence, the core of this paper is through analysis of air pollution from road transport, to present and categorize a wide range of short-to-long term measures aimed to improve air quality by reducing and mitigating the impact from road transport.*

***Key words:** road transport, measures, categorization, suspended particles, nitrogen dioxide*

1. INTRODUCTION

Urban air pollution from mobile sources is a by-product of the production of urban transport services. Although those services are essential for the economic health of a city and for the welfare of all its inhabitants (Gwilliam et al., 2004) at the same time they contribute for harmful environmental impacts.

Air pollution is a cause for serious concerns in urban areas in Macedonia. Limit values for air quality, especially those for suspended particles, defined in order to protect health, are significantly exceeded. The situation is most serious in the biggest urban centers in Macedonia, like Skopje, Tetovo, Bitola (MOEPP, 2017). Several sources and reasons for these problems with air quality have been identified, but they may differ not only in one urban area, but also between several urban areas. Generally, it may be pointed out that apart of the industry, energy production and households heating with wood during the winters, road transport is also a significant source of air pollution in urban areas. The contribution of road transport to air pollution comes from the high traffic intensity and also from older vehicle fleet and inappropriate maintenance of the vehicles (MOEPP, 2017).

In this paper, a review and categorization of measures proposed for protection of urban air quality is presented. Before defining these reduction and mitigation measures, categorized from short-to-long term, an analysis was needed to be done to stress out the extent of air pollution problem in urban areas and factors that contribute road transport to be one of the main pollution sources. For that reason, the trends of pollutant concentrations for the period 2005-2015 were analyzed, considering only the concentrations of particles and nitrogen oxides, as main pollutants in the air.

2. ROAD TRANSPORT AND AIR POLLUTION IN MACEDONIA

2.1. Vehicle fleet condition

In the transport sector the biggest impact on air pollution have emissions from road transport (MOEPP, 2017). Road transport emissions are highest in urban areas, where dense road network and high vehicle frequency is typical. Road transport contributes for the emissions of nitrogen oxides, suspended particles, carbon monoxide, benzene, heavy metals and other pollutants.

One of the key reasons for road transport air pollution, which is common for most of the urban areas in Macedonia, is old and inappropriately maintained vehicle fleet. At national level, approximately half of the passenger cars and buses are old and belong in the category of high polluting vehicles (MOEPP, 2017). Traffic jams and poorly developed public transport or complete absence of public transport additionally worsens the situation.

Based on the data from the vehicle register (MOEPP, 2017), in 2015 the total number of registered motor vehicles in Macedonia was 436.502 (fig. 1). Passenger vehicles are dominating with 88%, followed by light duty vehicles (8%).

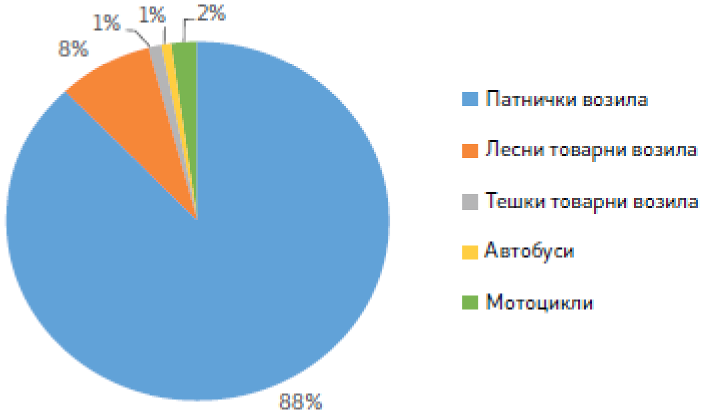

Fig. 1: Participation of different vehicle types in national fleet in 2015

Categorized by age (fig. 2), approximately 60% of the passenger vehicles and half of the buses are still in the classes with high emissions (Euro 0 - Euro 2), while this part at light and heavy duty vehicles is smaller (40% and 20%, respectively) (MOEPP, 2017).

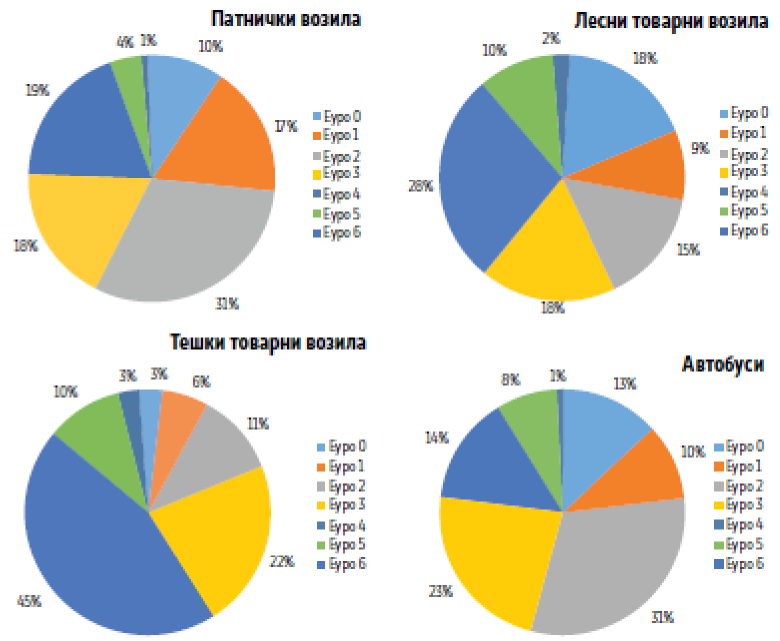

Fig. 2: Participation of registered passenger vehicles, heavy duty vehicles, light duty vehicles and buses, divided according to Euro emission classes, 2015

According to the data from the vehicle registry (MOEPP, 2017), the part of the passenger cars, light duty vehicles and busses belonging to the oldest vehicle category (Euro 0) is still relatively high (10-18%). Belonging to Euro 0, means that these vehicles don't have built-in system for exhaust emission treatment, which makes them a high polluting vehicles.

2.2. Trend of the concentrations of suspended particles (PM_{10} and $PM_{2.5}$) for the period 2005-2015

Pollution caused by suspended particles is at high level and is spread all over the urban areas in the country. The average annual values of PM_{10} exceed the annual limit value (40 μg/m^3) in all monitoring stations placed in urban areas (except for the monitoring station located in the village Lazaropole), in every year since 2005 (fig. 3).

The highest annual average values of PM_{10} exceeding 120 μg/m^3 are measured in Tetovo and Skopje (Lisice). It is not possible to make a statistical analysis of the trend because of the data shortage. Still, an assessment could be made that the level of concentrations stays stable in the whole period between 2005 and 2015. It is estimated that the average value of PM_{10} at urban locations is approximately 80 μg/m^3 (MOEPP, 2017).

Participation of road transport in the total emissions of PM_{10} was around 2% in 2014. In 2014 the main sources for suspended particles (PM_{10}) were heating in the households, industrial processes and energy production, which participated with 36%, 33% and 20% in the primary emissions. The yearly trends of national emission of $PM_{2.5}$ and PM_{10} are similar, because emission sources are mainly the same. The total emissions of PM_{10} in 2014 were 33.000 tones, and total emissions of $PM_{2.5}$ were 22.000 tones (MOEPP, 2017).

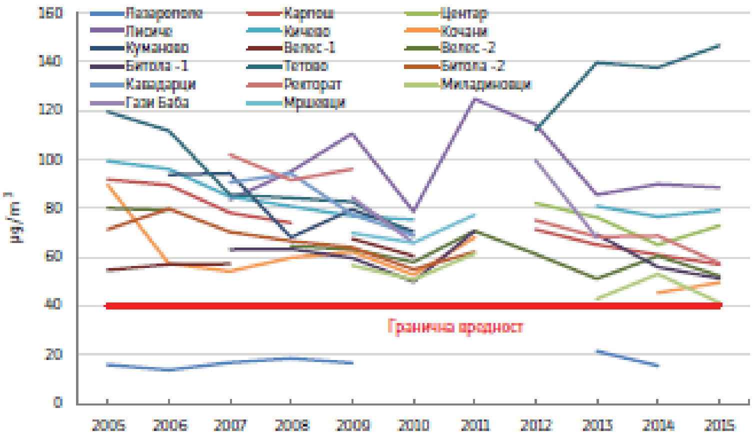

Fig. 3: Average annual values of PM_{10} for the period 2005-2015

The variations of the yearly emissions are mainly caused by the oscillations in industrial production or mild winters, when the need for households heating was decreased (MOEPP, 2017).

Concentrations of PM_{10} in urban areas have shown equal seasonal variations (MOEPP, 2017); concentrations are higher in the period December-January (fig. 4).

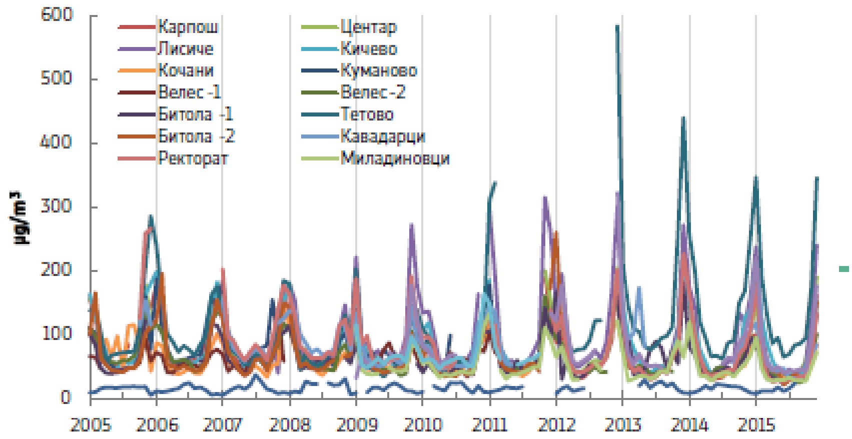

Fig. 4: Average monthly values of PM_{10} for the period 2005-2015

High PM_{10} concentrations during the winter are connected with the higher direct emission (households heating, especially usage of wood), but also with the meteorological conditions which limit dispersion of the emission and alleviate the chemical reactions, creating secondary particle, for example, from the vehicle exhaust emissions (MOEPP, 2017). During the winter months, smog appearance is typical in the towns settled in the valleys.

To summarize: the concentrations of suspended particles are on the high level during the whole analyzed period without significant trend of decrease.

2.3. Trend of the concentrations of nitrogen dioxide (NO_2) for the period 2005-2015

The main sources of NO_2 emission are the high temperature heating processes (heating, energy production and fuel combustion in vehicle engines). The emissions are mainly in the form of NO, which is quickly transformed to NO_2 in the atmosphere.

The main part of the national NO_2 emissions comes from the energy sector (41% in 2014) and road transport (40% in 2014). The total amount of nitrogen oxides emissions in 2014 was around 32.000 tones (MOEPP, 2017).

According to the data from the national emission inventory, nitrogen oxides emissions originating from transport in the past years have stayed at the same level. However, the appraisal of the trends of NO_2 concentrations is a challenge, because of the significant degree of insecurity and small coverage with monitoring data (MOEPP, 2017).

Monitoring of NO_2 concentrations is under serious impact of non regular maintenance and aging of the instruments; as a result, the time series are often without the continuity. In the first several years the yearly limit values of NO_2 were exceeded at all monitoring stations in Skopje and at the monitoring station in Kicevo (fig. 5). The highest concentrations of NO_2 are measured in the center of Skopje, near the frequent roads (MOEPP, 2017).

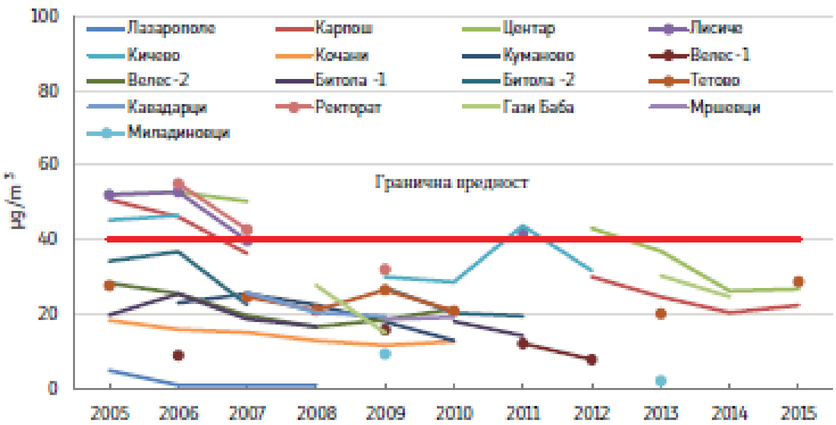

Fig. 5: Average annual values of NO_2 concentrations

In the last years, the limit value is not exceeded. Having in mind that monitoring results for NO_2 concentrations contain significant insecurity, it cannot be confirmed weather the limit values of NO_2 won't be exceeded in the future (MOEPP, 2017). Hence, the instruments for NO_2 measurements should be regularly maintained in order to obtain credible data referring the concentration level.

According to the measurements of air quality, there is a clear and equal seasonal variation of NO_2 concentrations, which may be linked with the meteorological conditions, i.e., unfavorable conditions for air mixing in winter time (MOEPP, 2017).

To summarize: yearly limit value of NO_2 is exceeded at the stations which follow traffic pollution; still, there is a future possibility for exceeding the NO_2 limit values. Road transport has the biggest influence on NO_2 concentrations, especially in the urban areas and near the frequent roads and crossroads.

3. UNDERTAKEN AND PLANNED MEASURES FOR EMISSION REDUCTION

According to the national legislation, measures for air quality improvement should be conducted when the pollutants' concentration limit values for health protection are exceeded (MOEPP, 2017). As a reminder of the previous analysis, limit values for suspended particles are exceeded at the territory of the whole country.

In order the measures defined in the National plan for ambient air protection (brought in 2012) to be more effectively implemented, during 2013-2014 several measures in energy sector, transport and production processes as key sectors for the total air pollution were conducted. At the same time, activities have been started for conducting the short-term and long-term measures, listed in this plan (MOEPP, 2014). However, the list of the measures in this plan defined for road transport isn't complete, meaning that the attention has been placed only at the legislation frame for supporting alternative fuels and other emission control technologies, emission inventorying and providing support for the public transport, without considering other sustainable modes. For an in-depth analysis of the road transport impact on air pollution and definition of the measures, it is necessary that measures for traffic control, inspection/maintenance programs, demand management and development of transport policies should be also included.

In other national reports, such as Annual report for the quality in the environment for 2014, referring the road transport, measures that are listed for a decrease of pollutants include renewal of the national vehicle fleet, usage of clean fuels with low sulfur content (in accordance to the demands listed in the Book of rules for clean fuels quality), promotion of alternative transport, speed limitation (in order to decrease fuel consumption) and introduction of low emission zones. As a support for these measures, in 2014 the import of used vehicles under Euro 1 and Euro 2 had been stopped, i.e., since January 1, 2015, the import of vehicles at least above Euro 3 has been permitted (MOEPP, 2015).

At the same time, the majority of these measures are conducted only in the capital city because of the highest traffic (and population) intensity (MOEPP, 2015). For example: during the winter period a special traffic regime for high duty vehicles is introduced, using the ring-road and avoiding the entrance in the city; for decreasing the road transport PM_{10} emissions, calcium magnesium acetate was provided, in order to reduce the dust concentrations from the road re-suspension; in 2013 the city of Skopje undertook promotional campaigns and subsidies for improvement of the cycling, public transport and introduction of electric vehicles.

However, the current renewal of national vehicle fleet and orientation to the low emission vehicles is still not visible in the national emission assessment (MOEPP, 2017). There are many factors which influence the renewal rate, such as economic situation in the country, legislation and regulations, transportation subsidies, taxation of the new vehicles/different types of vehicles. Based on all this, the consumers decide when and what type of car to buy.

Similar, in other national annual reports, measures are listed without going into detailed analysis or categorization. For example, the following measures as effective measures for air pollution control in urban areas are just mentioned: public transport improvement in bigger areas, promotion of the usage of low emission vehicles and cycling, creation of the pedestrian zones and low emission zones, decreasing the impact of the road dust by improving the streets cleanness, especially in the dry periods. Further on, it is mentioned that a national regulation for emission control is needed, introducing the measures for vehicle fleet renewal and fuel quality control (MOEPP, 2017).

Hence, this approach of definition and elaboration of measures in annual reports was an impulsion for creating a categorized scheme of short-to-long time measures in road transport, containing several sub-categories, all aimed at reducing and mitigating the air pollution contribution from this source.

4. PROPOSAL AND CATEGORIZATION OF MEASURES IN ROAD TRANSPORT

In order to provide an acceptable transport system, reduction and mitigation measures must be developed and implemented to prevent deterioration of the air quality (http://www.epd.gov.hk/epd/english/environmentinhk/eia_planning/sea/files/99_chap-8.pdf; 26.08.2017). It must be clear that measures in road transport should not be solely undertaken; it should be continuously worked at measures appropriate for other sources of pollution. Hence, overall environmental policy decisions cannot be separated from transport sector policy decisions (Gwilliam et al., 2004).

Categorization of the reduction and mitigation measures in road transport is presented at fig.6. The measures are categorized in two main groups: short- and medium- term measures and long-term measures; then a sub-categorization in five groups was performed:

- traffic control measures
- inspection/maintenance program
- transport policies
- emission control technologies
- demand management.

In order to decrease air emissions, during the development and implementation of these measures, a common effort is needed from the central and local governments, business sector, non-governmental organizations, but also from the citizens as well.

Most measures on their own may only generate a small reduction in road vehicle emissions. Hence, these proposed measures are not mutually exclusive: studies show that transport interventions are often combined in the aim of achieving a greater impact (Conlan et al., 2016). For example, a program aimed at encouraging drivers to reconsider their journeys and choice of vehicles can also be used to promote low emission vehicles; a bus quality partnership may generate improvements in overall bus services, assisting shift to an alternative mode of travel, as well potentially improving the emission standards of the buses.

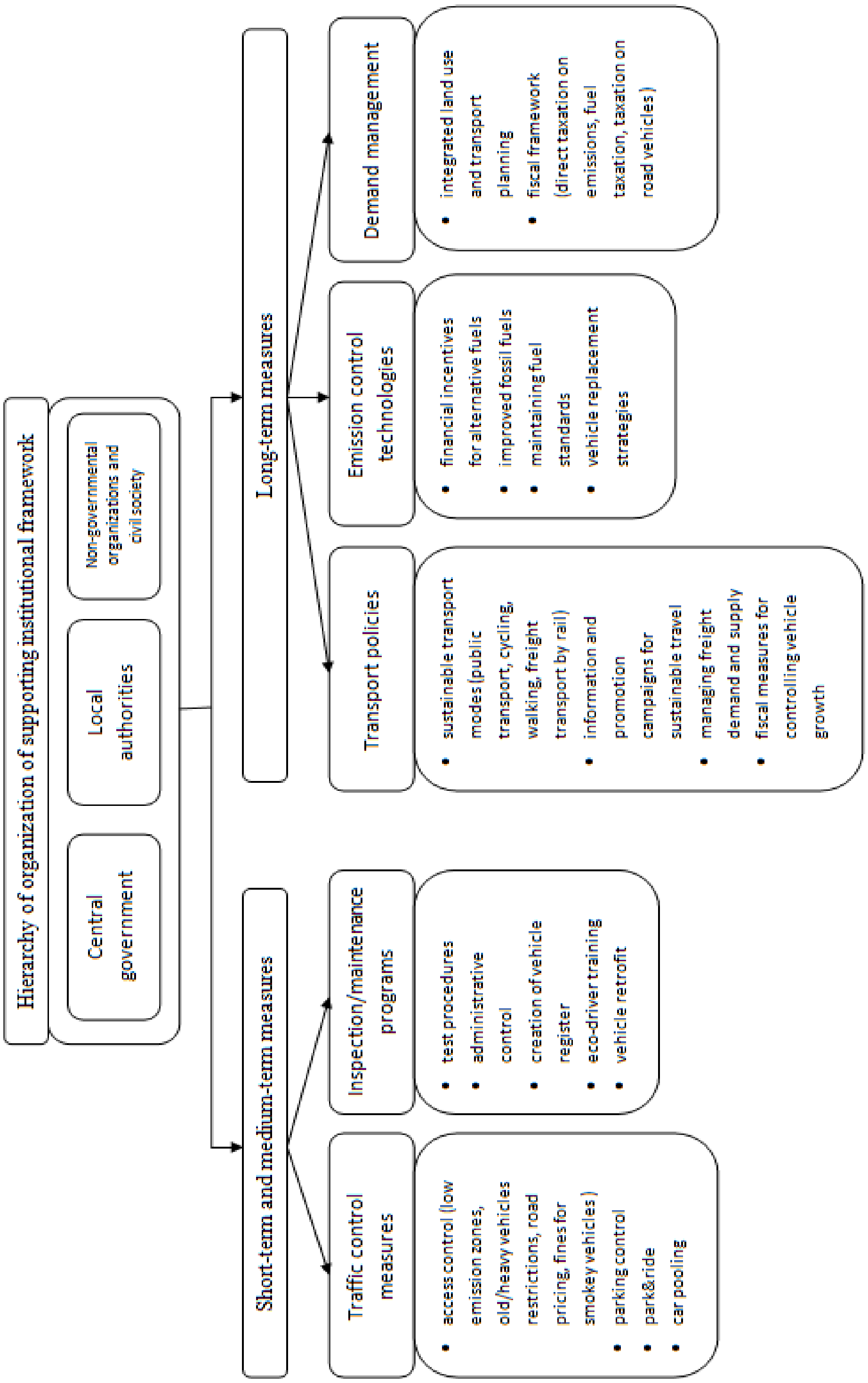

Fig. 6: Scheme of the categorized measures in road transport for air pollution reduction and mitigation

The evidence suggests that greater reductions of pollutants and improvements in air quality may occur when a number of measures are integrated and packaged together (Conlan et al., 2016). For example, a low emission zone designed to target the higher polluting vehicles can be supported by a package of complementary measures. Such complementary measures can include: improvements in walking, cycling, bus facilities; traffic management and pricing mechanisms (to discourage, for example, zone peripheral parking); and incentives to encourage uptake to meet vehicle emission compliance such as retrofit schemes.

There are many different opportunities for traffic emission reduction, but for many of them, especially for the long-term measures, large investments for improvement of the traffic network and infrastructure at local level would be needed (MOEPP, 2017). The "most aggressive and bold" measures to control transport related emissions should be undertaken in those urban areas with the most serious air quality problems and where the transport sector is a major contributor (Gwilliam et al., 2004).

5. CONCLUSION

Apart of the industry, energy production and households heating, another important sector of air pollution in urban areas in Macedonia is road transport. Analyzing the pollution trends from road transport, is could be confirmed that this sector has significant contribution, especially in nitrogen dioxides emission (MOEPP, 2017). For PM_{10} and $PM_{2.5}$ the contribution from road transport is not very high, but considering other sources, pollution with particulates is a very serious problem for the whole country.

In Macedonia, air quality is followed through monitoring of air pollutants concentrations, which gives precise information for the range of the problem. Hence, available monitoring data provide the creation of the pollutants trends in ambient air, as well as identification of the contribution of every pollution source (MOEPP, 2017). This is useful for deciding which measures for air pollution reduction are most needed in which sector and where they would have the biggest effect.

Considering the contribution from road transport emissions, condition of the vehicle fleet and current pollution trends, the future activities for air quality improvement should be directed towards air pollution reduction from road transport.

Therefore, the purpose of this paper is to assist national and local government policymakers to identify the roles that the road transport play in urban air quality pollution. More importantly, the intention is to give support by proposing a categorized scheme of measures to reduce and mitigate the impact from road transport emissions. Presented scheme of short-to-long term measures is detailed and comprises five groups of measures, including traffic control, inspection/maintenance program, transport policies, emission control technologies and demand management, which weren't taken into account in national yearly reports. Supported by the authorities and citizens, designed and implemented appropriately, such measures would have a potential not only to reduce air pollutant emissions but also would provide wider environmental benefits, such as climate change mitigation, noise reduction, congestion alleviation and economic development of the society (Conlan et.al., 2016).

6. REFERENCES

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