ACEPT-AIR

LIFE+ 09 ENV/GR/000289

Action 7

Deliverable D20.

TITLE: Proposed measures for the attainment of required PM concentration reductions

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Coordinated by:

EXECUTIVE SUMMARY

The main objective of LIFE09 ENV/GR/000289 project "Development of A Cost Efficient Policy Tool for reduction of Particulate Matter in AIR (ACEPT-AIR)" is to provide the National, Regional and Local Authorities in Greece with the means to reduce Particulate Matter (PM) concentration levels and achieve attainment of EU air quality standards. Focus has been given to three urban centres with significant air pollution problems over the last decades: Athens Metropolitan Area (AMA), Thessaloniki Metropolitan Area (TMA) and Volos Greater Area (VGA).

Intensive measurement campaigns of PM_{10} and $PM_{2.5}$, the two size fractions included in EC legislation, were carried out in order to characterize in detail particulate air pollution in these three cities. In addition, emission source strengths have been estimated by the application of receptor models and the compilation of emission inventories for natural and anthropogenic sources. All the concentration and emission strength data collected have been incorporated into ACEPT-AIR Policy Tool. The Policy Tool has been applied for testing the quantitative forecast of PM_{10} and $PM_{2.5}$ concentrations based on emission reductions applied on prominent sources.

Based on the comprehensive characterization of particulate air pollution in the three cities and the application of ACEPT-AIR Policy Tool, a set of measures has been proposed for effective air quality management. These measures form the core of the guidelines for Action Plan formulation, to be provided to key stakeholders of the project.

The major stakeholder at the ACEPT-AIR project, the Ministry of Energy, Environment and Climate Change, has the competence and responsibility of air quality management and monitoring. The historical data of exceedances of PM_{10} (and NO_2) limit values during the last decade shows in general a downward trend and is directly or indirectly linked to the development of measures targeting mainly the reduction of traffic emissions, reduction in fossil fuel use due to energy efficiency improvements or interventions in favour of alternative fuels and renewable energy sources in the urban areas. According to ACEPT-AIR outcome, new measures for $PM_{2.5}/PM_{10}$ should be especially focused on the traffic and biomass combustion sectors because they represent major emission sources in the central areas.

The present report provides a summary of mitigation measures targeted to each major emission source based on the general outcome and experience gained by ACEPT-AIR project.

ΠΕΡΙΛΗΨΗ

Βασικός στόχος του έργου LIFE09 ENV/GR/000289 "Ανάπτυξη ενός Εργαλείου άσκησης αποτελεσματικών πολιτικών για τη μείωση των αιωρούμενων σωματιδίων στον αέρα (ACEPT-AIR)" είναι να παρέχει στις Εθνικές, Περιφερειακές και Τοπικές Αρχές τα μέσα για την μείωση των συγκεντρώσεων αιωρούμενων σωματιδίων (PM) και την επίτευξη των Ευρωπαϊκών προτύπων ποιότητας της ατμόσφαιρας. Τρία αστικά κέντρα στην Ελλάδα επιλέχθηκαν για μελέτη: η Αθήνα, η Θεσσαλονίκη και ο Βόλος.

Στα πλαίσια του έργου πραγματοποιήθηκαν εντατικές μετρήσεις των PM_{10} και $PM_{2.5}$, των δύο σωματιδιακών κλασμάτων που περιλαμβάνονται στην Ευρωπαϊκή νομοθεσία, με στόχο τον λεπτομερή χαρακτηρισμό της ρύπανσης από αιωρούμενα σωματίδια στις τρεις πόλεις. Επιπλέον, η συνεισφορά των διαφόρων πηγών εκπομπής υπολογίστηκε με εφαρμογή μοντέλων αποδέκτη και με ανάπτυξη μητρώων εκπομπών για τις φυσικές και ανθρωπογενείς πηγές. Το σύνολο των δεδομένων συγκέντρωσης και εκπομπών που συλλέχθηκαν ενσωματώθηκαν στο Εργαλείο Άσκησης Περιβαλλοντικής Πολιτικής ACEPT-AIR. Πραγματοποιήθηκε επίσης και εφαρμογή του Εργαλείου ACEPT-AIR για τον έλεγχο της δυνατότητας ποσοτικοποίησης των συγκεντρώσεων των PM_{10} και $PM_{2.5}$ βάσει σεναρίων μείωσης των εκπομπών βασικών πηγών σωματιδίων.

Ο ολοκληρωμένος χαρακτηρισμός της ρύπανσης από αιωρούμενα σωματίδια στις τρεις πόλεις και η εφαρμογή του Εργαλείου Άσκησης Περιβαλλοντικής Πολιτικής οδήγησαν στην ανάπτυξη μιας ομάδας μέτρων ελέγχου για αποτελεσματική διαχείριση της ποιότητας της ατμόσφαιρας. Τα μέτρα αυτά αποτελούν τον πυρήνα των οδηγιών για την ανάπτυξη Σχεδίου Δράσης από τις σχετικές Αρχές της χώρας.

Ο κύριος φορέας χρήστης των αποτελεσμάτων του έργου, το Υπουργείο Περιβάλλοντος, Ενέργειας και Κλιματικής Αλλαγής, έχει την αρμοδιότητα της παρακολούθησης και διαχείρισης της ποιότητας του αέρα. Ιστορικά δεδομένα σχετικά με τις υπερβάσεις των οριακών τιμών για τις συγκεντρώσεις των PM_{10} (και του διοξειδίου του αζώτου) καταδεικνύουν μια πτωτική τάση την τελευταία δεκαετία, άμεσα ή έμμεσα συνδεδεμένη με την εφαρμογή στοχευμένων μέτρων, κυρίως για την μείωση των εκπομπών της κυκλοφορίας και τη μείωση της χρήσης ορυκτών καυσίμων. Τα αποτελέσματα του ACEPT-AIR υποδεικνύουν ότι τα νέα μέτρα ελέγχου θα πρέπει να στοχεύσουν στην κυκλοφορία αλλά και την καύση βιομάζας, δύο πηγές που αποτελούν μεγάλο ποσοστό των συνολικών εκπομπών σε κεντρικές αστικές περιοχές.

Η παρούσα μελέτη περιλαμβάνει μια περίληψη των μέτρων ελέγχου που προτείνονται για κάθε σημαντική πηγή εκπομπής, καθώς και τα γενικά συμπεράσματα που προέκυψαν από την εφαρμογή του έργου ACEPT-AIR.

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1. INTRODUCTION

The main objective of ACEPT-AIR project is to provide the National, Regional and Local Authorities in Greece with the means to reduce Particulate Matter (PM) concentration levels and achieve attainment of EU air quality standards. Focus has been given to three urban centers with significant air pollution problems over the last decades: Athens Metropolitan Area (AMA), Thessaloniki Metropolitan Area (TMA) and Volos Greater Area (VGA).

The accumulation of population and commercial activities in Athens and Thessaloniki, the two largest urban centers in Greece, has resulted in intense traffic and urbanization conditions with considerable burden to local and regional air quality. Volos is a medium-sized city but presents several diverse pollution sources, such as a number of industries in and around the city and a busy harbor used both for commercial activities and tourism. In addition, its topography, with the foothills of Mount Pelion to the northeast and other hills to the northeast surrounding the city, restricts the transport and dispersion of pollutants and contributes to severe air pollution events.

In line with EU legislation, the Greek Ministry for the Environment, Energy and Climate Change has been monitoring the concentration levels of PM_{10} and $PM_{2.5}$, through the National air pollution monitoring network, which operates several fixed PM monitoring stations. A number of control measures have been also applied and their effect is evident by the decreasing trend in PM concentrations over the last decade. Nevertheless the annual limit values for PM_{10} set by EU is still not attained in urban areas impacted by traffic and industrial activities, while exceedances of the respective daily limit value are observed even in urban background sites.

The data collected during the project and the implementation of ACEPT-AIR Policy Tool has led to the development of a set of mitigation measures for the reduction of PM concentrations in the air. The present report summarizes these proposed control measures.

2. METHODOLOGY

Intensive measurement campaigns of PM_{10} and $PM_{2.5}$, the two size fractions included in EC legislation, were carried out in order to characterize in detail particulate air pollution in these three cities. PM chemical components, such as major elements, metals and ionic species, as well as their carbon content, were quantified and related to specific sources. The obtained PM_{10} and $PM_{2.5}$ databases were further utilized for the quantification of the relative contribution of each source to PM concentration levels, through receptor modeling. In addition, emission inventories for natural and anthropogenic sources have been compiled. All the concentration and emission

strength data collected have been incorporated into ACEPT-AIR Policy Tool. The Tool's calculation algorithm developed in the framework of the project allows for the estimation on PM concentration changes due to increases or decreases in specific emission source strengths. The Policy Tool has been applied for testing the quantitative forecast of PM_{10} and $PM_{2.5}$ concentrations based on emission reductions applied on prominent sources.

Based on the comprehensive characterization of particulate air pollution in the three cities and the application of ACEPT-AIR Policy Tool, a set of measures has been proposed for effective air quality management. These measures form the core of the guidelines for Action Plan formulation, to be provided to key stakeholders of the project.

3. DEVELOPMENT OF CONTROL MEASURES

Long-term analysis of PM concentrations at the three studied areas has shown a decreasing trend. The threshold limits of both $PM_{2.5}$ and PM_{10} are currently not exceeded in the suburban areas but this is not a result that should lead to complacency towards effective mitigation measures for the reduction of air pollution in large urban centres. The concentrations are much higher in traffic impacted central areas with fewer but yet emerging exceedances.

The need for mitigation measures becomes evident if one considers that due to the economic crisis affecting Greece, gaseous precursors such as NOx and primary PM_{10} emissions have been reduced by more than 50%, while for others like SO_2 the reduction is more than 90%. Although the latter appears to be a technology and regulation based reduction and may be permanent this is not the case for other pollutants. Their concentrations may rise again when the economy recovers.

The application of source apportionment techniques has allowed also for the identification of the main factors contributing to increased PM levels. One interesting observation lies with the secondary aerosol component representing sulphate, nitrate and secondary organic species, which appears to constitute a major component of the PM mass not directly linked to a primary emission source but is the result of atmospheric chemistry by conversion of gaseous components to particulate matter at variable timescales and dependent on atmospheric conditions.

More specifically the sulphate component, which is rather stable once formed as ammonium sulphate and has a large life time in the atmosphere, is observed at considerably higher concentrations in the Eastern Mediterranean area than existing measurements in Western and South Western Europe. Despite the reductions in emissions and some peaks in Volos and Thessaloniki possibly attributed to local sources, a background level for this component appears unaffected on an annual basis by local urban sources and can be attributed to long range transport. Mitigation

measures at a Regional and International level is therefore suggested for this component.

The major stakeholder at the ACEPT-AIR project, the Ministry of Energy, Environment and Climate Change, has the competence and responsibility of air quality management and monitoring. The historical data of exceedances of PM_{10} (and NO_2) limit values during the last decade shows in general a downward trend and is directly or indirectly linked to the development of measures targeting mainly the reduction of traffic emissions, reduction in fossil fuel use due to energy efficiency improvements or interventions in favour of alternative fuels and renewable energy sources in urban areas. According to ACEPT-AIR outcome, new measures for $PM_{2.5}/PM_{10}$ should be especially focused on the traffic and biomass combustion sectors because they represent major emission sources in the central areas.

Traffic emissions from vehicle exhaust and non-exhaust origins remain a constant source of PM_{10} and $PM_{2.5}$ with equal share in the coarse and fine fraction at a level of 5-18% at Urban Background sites to 44% at the Thessaloniki traffic site. Especially the non-exhaust component mixed with mineral dust may represent a major fraction of the PM_{10}. Measures of traffic management and emission reductions from vehicles are already in place but must be intensified. These already included an age limit of 23 years, which has been implemented for all urban, semi-urban and long distance buses. Also the limit of 11 years was set as the higher permissible age for buses in public transport. Under the provisions of the same law, economic incentives were given in the owners for the replacement of vehicles with new or used vehicles of small age. Of the 5000 semi-urban and long distance buses licensed in Greece, 1846 buses have been replaced since 2004, of which 1746 with new and 100 with used of age lower than 5 years. Further reductions may provide small amount of PM concentration reductions but significant to attain compliance with limit values.

On the other hand given the fact that traffic emissions do not change significantly during the year with the exception of the August holiday period, it is interesting to observe that more than half of the exceedances at central and traffic stations (after removing the African dust influence) occurred during the cold days of the winter period when intensive wood burning had (after 2010) become a major practice for residential heating in large areas of Greek cities due to the economic crisis. Based on ACEPT-AIR results, during 2011-2012 the annual average relative contribution of wood burning for residential heating is between 17 to 35 % of PM_{10} and 20 to 32% of $PM_{2.5}$ at the different urban areas considerably increased with respect to contribution during 2002 (7% in PM_{10} and 11% in $PM_{2.5}$).

Significant role also play distant or surrounding industrial emissions for energy or materials (cement, petrochemicals) production in terms of secondary organic, nitrate and sulphate aerosol leading to an average of 30 % of the PM_{10} mass concentration. Heavy oil combustion is another source of minor contribution averaged over the whole of the year (generally below 10% for $PM_{2.5}$).

A summary of mitigation measures targeted to each major emission source and the respective current source contributions as quantified through the project are presented in Table 1 below:

Table 1 Summary of control measures targeting at specific emission sources.

Source	Measure	Level of influence	Description
Road traffic 5 - 44% of PM_{10}: Exhaust 5 - 29% Non-exhaust 10 - 15% 4 - 38% of $PM_{2.5}$: Exhaust 5 - 34% Non-exhaust 2 - 5%	Low emission zones (LEZ)	National and local	Expand and prioritize the recently (2012) implemented unlimited access for electric and hybrid low emission cars in the so called "green ring", where regular vehicles are entering depending on odd/even days with respect to their number plate last digit.
	Parking	Local	Creation of large parking lots at main transport interfaces (train and metro stations) at the outskirts of the city (park and ride system) with incentives (low fares) in order to promote the combined use of car and public transport.
	Street cleaning	Local	Tandem use of sweeping and, more importantly, water washing, especially during dry periods of the year. It is evident that non exhaust traffic emissions lead to a major part of the coarse fraction of road dust that can be removed by street cleaning
	Promoting low-carbon and low-NO_x vehicles and new technology vehicles	National and local	Implement further Reductions in Road Tax and Import Tax for low emission vehicles (for NO_2 and PM). Incentives to withdraw aged private vehicles and replacement with modern (E5/E6) vehicles. Installation of particle filters in heavy duty commercial vehicles.
	Expand public transport Network	Local	Continuous expansion of Metro lines in Athens (currently only 3) and completion of the Metro in Thessaloniki. Improvement of Public Bus Network for an efficient, ecologic and faster public transportation (metro, train, and tram)

Road traffic 5 - 44% of PM_{10}: Exhaust 5 - 29% Non-exhaust 10 - 15% 4 - 38% of $PM_{2.5}$: Exhaust 5 - 34% Non-exhaust 2 - 5%	Reducing road transportation for goods	National and local	Creating a terminal outside the Athens Metropolitan Area serviced by rail line to the Piraeus harbour while currently trucks travel for 50 km within the central axis of the Athens Metropolitan Area.
	Renewal of car/taxi/motorcycle fleet.	National	Subsidies for increasing the share of hybrid, natural gas and Liquefied Petroleum Gas (LPG) taxis. Promoting the replacement of 2-strokes motorcycles by 4 –strokes.
	National and local	Reduced fares of public transport	Reduced fares for public transport during intensive Sahara dust intrusions or forecasted intense pollution episodes
	Improving public fleet	Local	Increase the share of natural gas buses (currently at 35%). Enforce the measure of withdrawal of old technology urban and regional buses
	Vehicle and road maintenance	National and local	Increase the frequency of inspection programmes to public vehicles to ensure that in-use engines continue to have functional controls and proper maintenance. Maintaining roads in good repair to reduce the contribution of PM from road surface wear
Heavy oil combustion / Shipping <1 - 12% of PM_{10} <1 - 33% of $PM_{2.5}$	Combat the illegal trade of adulterated fuel	National and local	Incidents of adulterated fuel circulation and use are still common in Greece. Continuous controls are needed to eliminate this phenomenon
	Stricter legislation for industrial heavy fuel oil users	Local	Monitor with inspection checks the fuel efficiency of burners, boilers and power generators of small and medium scale industries operating machinery using heavy fuel oil
	Industrial facilities	Local	Impose high standards for fuels and increase inspections to facilities

Precursors of secondary particles 13 - 49% of PM_{10} 21 - 53% of $PM_{2.5}$	Stricter legislation for harbour	National and local	Docking at the large commercial harbours is only permitted to vessel with engines operating with low sulphur content. These rules need to be enforced and monitored
	Large Industry using fossil fuel for power generation or other industries	Local	The introduction of natural gas in the national energy system is one of the largest investments ever carried out in Greece and it constitutes a major priority of the national energy policy. An important part of the infrastructure, mainly the high pressure transmission system and the medium pressure network, which is necessary for the transport of natural gas to the main regions of consumption, has been completed. Expansion projects of Greek natural gas system are under way in order to link more cities and industries to the system (e.g. Aliveri, Megalopolis, etc). Moreover, in the areas connected to the natural gas network, natural gas stations for feeding CNG (Compressed Natural Gas) vehicles have been created. The high levels observed across Athens and in the whole of the country may be partly due to long range transport of secondary pollutants or gaseous precursors from outside Greece. This is an area where policy makers must intensify efforts for resolving problems of trans boundary pollution in Europe.

Biomass burning 17 - 35% of PM_{10} 22 - 36% of $PM_{2.5}$	Reduction of low efficiency wood burning for residential heating	Local	High price of diesel for residential heating during the economic crisis resulted in the use of wood in a large scale in the densely populated areas of Greek urban centres, leading to high pollution episodes during stagnation periods in winter. Information material and training to discourage citizens from this inefficient form of energy are needed. Introduction of natural gas and Renewable energy Sources Improvement of the thermal behaviour of residential buildings and promotion of energy efficiency appliances and heating equipment. News bulletins advising for reduction in wood burning during forecasted atmospheric stagnation periods.
Environmental education and awareness raising	Local		Communication campaigns through the media and dissemination of "best practices" should be favoured in order to sensitize population on the opportunity of the previous measures.