LIFE Project Number

LIFE09 ENV/GR/00289

FINAL Report
Covering the project activities from 01/09/2010 to 31/08/2014

Reporting Date
12/05/2015

LIFE+ PROJECT NAME or Acronym

ACEPT-AIR

Project Data

Project location	Athens, Thessaloniki, Volos (Greece)
Project start date:	01/09/2010
Project end date:	31/08/2014 **Extension date:**
Total Project duration (in months)	48 months (including **Extension of** 0 **months**)
Total budget	€ 1,750,040
Total eligible budget	€ 836,449
EU contribution:	€ 836,449
(%) of total costs	47.8 %
(%) of eligible costs	49 %

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2. Executive Summary

ACEPT-AIR project **aims** to provide the National Authorities at Central, Regional and Local level with the means to **control $PM_{2.5}$ and PM_{10} concentrations** in the ambient atmosphere. Airborne Particulate Matter (PM) is a complex mixture of microscopic particles derived from both anthropogenic and natural sources. During the last decades toxicological and epidemiological data have provided evidence on the significant detrimental effects of PM on human health. Despite EU mitigation policies and air quality legislation setting limit values for exposure to PM, pollution from particulate matter remains a major environmental problem in several countries in the EU. Greece in particular is one of the EU countries where a great deal of improvement with respect to emission control strategies can be made. The **main objectives of ACEPT-AIR project** are (i) to unravel the relative contribution of the multiple anthropogenic and natural sources to the observed PM air concentrations, (ii) to document the relative contribution of secondary aerosol particles in relation to those from primary emissions and (iii) to combine all available data on a versatile Environment Policy Tool that may assist relevant authorities to develop cost-effective mitigation strategies for the control of particulate pollution in Greece.

The project has been implemented in **three urban areas** in Greece: **Athens**, the capital of Greece, **Thessaloniki**, the second larger city in the country and **Volos**, a medium sized city characterized by intense anthropogenic activities (such as a harbour for commercial and passenger vessels and industrial units in close vicinity to the city) and a topography that inhibits dilution and diffusion or air pollutants. The **key deliverables and output** of ACEPT-AIR project are:

- A database of PM_{10} and $PM_{2.5}$ concentrations and detailed chemical characterization for three urban areas in Greece (Athens, Thessaloniki and Volos);
- Identification of major PM emission sources and quantification of their contribution to ambient concentrations of PM_{10} and $PM_{2.5}$ at the three cities by receptor modelling;
- Emission inventories for anthropogenic and natural sources for the years 2000-2013 at the three cities and future projections;
- ACEPT-AIR Policy Tool, a public software that relates source contribution (from receptor modelling and emission inventories) with ambient PM concentrations and estimates changes in PM levels due to increases or decreases in the emissions of specific sources;
- Characterization of current situation of ambient air quality in the three areas and assessment of possible decreases in PM levels based on specific emission control scenarios;
- A set of guidelines for effective formulation of Action Plans for the three studied areas, based on the data collected and the application of ACEPT-AIR Policy Tool;
- Transfer of experience gained to national, regional and local authorities and training on the use of ACEPT-AIR Policy Tool;
- Organization of 1 International Conference and 1 Open Forum dedicated to policy makers, NGOs and stakeholders from the public and private sector;
- The ACEPT-AIR website, containing details on project objectives, actions and key results and outcome;

- Training of 110 secondary education teachers through the organization of seminars on air pollution at the three cities;
- 1 Layman's report on actions, tools, effects and long term benefits from the project;
- Production of information material for the general public: Notice boards at the three studied areas, 3 leaflets, 1 brochure and 1 DVD publicizing the project objectives and results;
- 12 press releases and 14 articles in the national and local press
- 5 publications in international scientific journals and 19 presentations in national on international conferences;
- 5 reports to the E.C., including Inception, Progress, Midterm and Final Reports.

The current report provides a **summary of the work** performed in the framework of the project, including key outcome. The **detailed results** are provided in the **Deliverables** of each Action, submitted together with this report (Deliverables D6-D32).

Chapter 3 provides an **introduction** on the environmental problem targeted, the project major objectives, methods and approaches employed for achieving these objectives, as well as the key results obtained. In addition, the environment benefits of the project outcome are discussed in terms of tools and data provided to policy makers and relevant authorities, as well as the implementation of EU regulation and future EU and global applicability of the developed software.

Chapter 4 provides a description of the **Project Management** system, including: a presentation of the coordinating and associated beneficiaries, a description of the management committees and their responsibilities, the working methods employed, an organigramme of ACEPT-AIR management team, a list of project implementation phases and planning / executing of relevant tasks and a timetable of Actions indicating foreseen and actual times. In addition, an evaluation of the management system is provided based on the management processes implemented, collaboration between partners and effective communication with the EC and Monitoring team.

Chapter 5 includes a description of the work performed in the framework of each project Action. The beneficiaries involved, methods employed and obtained results are mentioned for each Action. A list of Deliverables and Milestones are also provided and the foreseen and actual dates of completion are indicated. Any major problems encountered during the implementation of the Action are described. In addition, the perspectives of continuing the work done in each Action after the end of project are analyzed. Any complementary activities performed in the framework of each Action but outside the objectives and funding of LIFE+ are also mentioned. Section 5.1 includes the Actions related to the technical part of the project (Actions 2-7 and 10-12) and Section 5.2 includes the Actions related to dissemination activities (Actions 8 and 9).

Section 5.1.1 presents the work performed in the framework of **Action 2** "**Construction of PM concentration databases".** The measurement campaigns conducted in Athens, Thessaloniki and Volos are described, including instrumentation and analytical methods employed. A short description of ACEPT-AIR Database is provided. Summary results are presented on PM_{10} and $PM_{2.5}$ levels at the three studied cities and concentrations of major components: organic and elemental carbon, ions and major and trace elements.

Section 5.1.2 presents the work performed in the framework of **Action 3 "Application of state of the art source apportionment techniques based on the developed databases and receptor modelling".** The two receptor models used (Positive Matrix Factorization, PMF and Chemical Mass Balance, CMB) are described, as well as the input databases for each model. Results on the major sources and their contributions to PM concentration levels are provided for each city, including a comparison of the output of PMF and CMB models. Temporal variation in source chemical composition and strength is also discussed, in terms of seasonal variability as well as long-term variability in the course of the last decade.

Section 5.1.3 presents the work performed in the framework of **Action 4 "Construction of emission inventories"**. The anthropogenic and natural sources considered are described. Emission strengths for the three cities during the years 2000-2013 are presented, relevant long-term trends in emissions are discussed and future projections are performed.

Section 5.1.4 presents the work performed in the framework of **Action 5 "An operational platform for the Control PM concentrations Policy Tool"**. The design of the different modules of the Operational Platform (OP) of the Policy Tool is discussed, based on the project objectives and the feedback obtained by stakeholders. A description is provided on the development of the distinct OP modules: (i) Input databases,; (ii) Calculation code, (iii) Presentation interface, their testing through historical data and their final integration into the ACEPT-AIR Policy Tool. The content of the Application guide and manual for the ACEPT-AIR Policy Tool, compiled for the Tool's end users, are also provided.

Section 5.1.5 presents the work performed in the framework of **Action 6 "Development and application of a two-way direct interaction process with stakeholders"**. The key project stakeholders are presented, as well as other interested parties involved during the project implementation. Summary descriptions of the three Informative Events organized for stakeholders are provided. In addition, aspects of active participation of stakeholders in the project implementation are also presented.

Section 5.1.6 presents the work performed in the framework of **Action 7 "Active application of the developed policy tool"**. Summary results from the initial application of the ACEPT-AIR Policy Tool are presented. In particular, PM reductions in relation to the implementation of specific emission control scenarios are provided. Based on these results, a set of mitigation measures is proposed in order to decrease ambient PM concentrations and achieve attainment of EU air quality standards.

Section 5.1.7 presents the work performed in the framework of **Action 10 "Monitoring of Project progress"**. The amendment of the content of this Action, submitted with the inception report, is discussed. The external evaluators' committee who is responsible for the monitoring of the project progress is presented. The interaction of external evaluators with ACEPT-AIR project beneficiaries and the major feedback obtained are also presented.

Section 5.1.8 presents the work performed in the framework of **Action 11 "Action plan formulation for PM reduction"**. A summary of the air quality assessment at the three studied areas, with respect to PM levels and emission trends of natural and anthropogenic sources, is provided. In addition, the major points included in the Guidelines for effective Action Plan formulation for the three urban areas are presented. These Guidelines are based on the trend analysis of PM levels and emissions, as well as the results on PM concentration reductions obtained through the application of ACEPT-AIR Policy Tool.

Section 5.2.1 discusses the objectives of the **dissemination plan** developed in the framework of ACEPT-AIR project, with respect to both stakeholders and the general public. Section 5.2.2 presents a summary description of the **Open Forum and International Conference**

organized in the framework of the project. Section 5.2.3 describes the **dissemination activities** intended for the general public, such as the project website, erection of notice boards, production of dissemination material and a Layman's report, seminars for school teachers and press articles. Section 5.2.3 presents the work performed in the framework of **Action 12 "After-life communication & continuation plan"**. The main aspects of the After-Life communication & continuation plan which aspires to ensure the sustainability of the project outcome and further promote its objectives are discussed.

Section 5.3 presents an **evaluation of the project implementation**, in terms of success of the applied methodologies and achievement of the specific objectives set for each Action.

Section 5.4 presents an analysis of the **long-term benefits** of the project. Among the issues discussed are environmental benefits, long term sustainability of the developed technology, visibility for the environmental problem targeted, economic and social benefits, continuation of project actions and collaborations, replicability and demonstration of project outcome and best practices used. The innovation and demonstration value of the project outcome is described. In addition, long term indicators for a future assessment of the project success are provided.

Chapter 6 presents a summary description of the **financial report**, including: summary of costs incurred, details on the accounting system, partnership arrangements regarding financial transactions and reporting and name and address of the external auditor.

Chapter 7 provides a list of all Annexes submitted together with the Final Report.

3. Introduction

Air pollution is a major environmental problem across the European Union (EU). Despite the improvements in air quality with respect to certain pollutants, concentration levels of **airborne particulate matter (PM)** are still presenting exceedences of the relevant air quality limit values. At the same time toxicological and epidemiological evidence on the significant detrimental effects of PM_{10} and $PM_{2.5}$ (particles with aerodynamic diameters below 10 and 2.5 μm respectively) highlight the need for **new efforts towards reducing ambient PM** concentration levels in order to protect both public health and the environment.

Urban areas and some industrial regions in Greece are among those in the EU with a high number of limit values exceedances in PM_{10} ambient concentrations. ACEPT-AIR project aims to provide the **National Authorities** at Central, Regional and Local level with the means to **control $PM_{2.5}$ and PM_{10} concentrations** in the ambient atmosphere. In particular, the **project main objectives** are to unravel the relative contribution of the multiple anthropogenic and natural sources to the observed PM air concentrations, including secondary aerosol formation and to combine all available data on a versatile Environment Policy Tool that may assist relevant authorities to develop cost-effective mitigation strategies for the control of particulate pollution in Greece.

The project objectives have been achieved through a number of actions involving: (i) the implementation of **PM measurement campaigns** at three urban areas in Greece (Athens, Thessaloniki and Volos) for the assessment of PM_{10} and $PM_{2.5}$ concentration levels and detailed chemical characterization, (ii) the application of **receptor models** for the identification of major PM sources and the quantification of their contribution to PM concentrations, (iii) the compilation of **emission inventories** for natural and anthropogenic sources and (iv) the development of a **software** which combines the above concentration and emission data and provides estimates of PM concentration levels with respect to changes in emissions of specific PM sources.

ACEPT-AIR project has provided **detailed characterization of the air quality** in three major urban areas in Greece with respect to particulate matter **concentration levels** and main **emission sources**. All the data collected have been incorporated into a versatile **Policy Tool** that may assist relevant authorities to develop **cost-effective mitigation strategies.** In addition, the **experience** gained through the project implementation has been **transferred to policy makers and stakeholders** in the public and private sectors through a well designed interaction process including both information activities as well as opportunities for dialogue and feedback on stakeholders' views and needs. A wide range of activities for the mobilization of the local societies have been also implemented with the aim to **increase public awareness** on air pollution and on detrimental to the environment practices and lifestyle choices (such as the use of fireplaces for residential heating).

In the long-term, ACEPT-AIR project may **improve the effectiveness of National, Regional and Local policies** regarding ambient air quality, in accordance with the requirements of Directive 2008/50/EC for air quality plans formulation and reductions of ambient PM concentrations, as well as WHO Guidelines for the protection of human health. ACEPT-AIR Policy Tool provides the means to policy makers and relevant authorities to take informed decisions on the implementation of specific emission control measures. The Tool design allows for an easy update of its input databases. It may be therefore **applied for other regions** as well, where there are available reliable emission strengths data.

4. Administrative part - Action 1: Project management

4.1 Description of the management system

ACEPT-AIR project was realized through the collaboration of N.C.S.R. "Demokritos" (NCSR "D"), acting as the coordinating beneficiary, Univeristy of Thessaly (UTH), Aristotle University of Thessaloniki (AUTH), AXON Envirogroup Ltd. (AXON) and Technical University of Crete (TUC). The **Partnership Agreement** was signed on 02/02/2011 and was submitted with the Inception report (Annex IV). All Actions, except Action 10 "Monitoring of project progress", were implemented according to the description provided in the Grant Agreement. An **amended** description of Action 10 was submitted with Inception Report (Annex X) and was accepted by the EC.

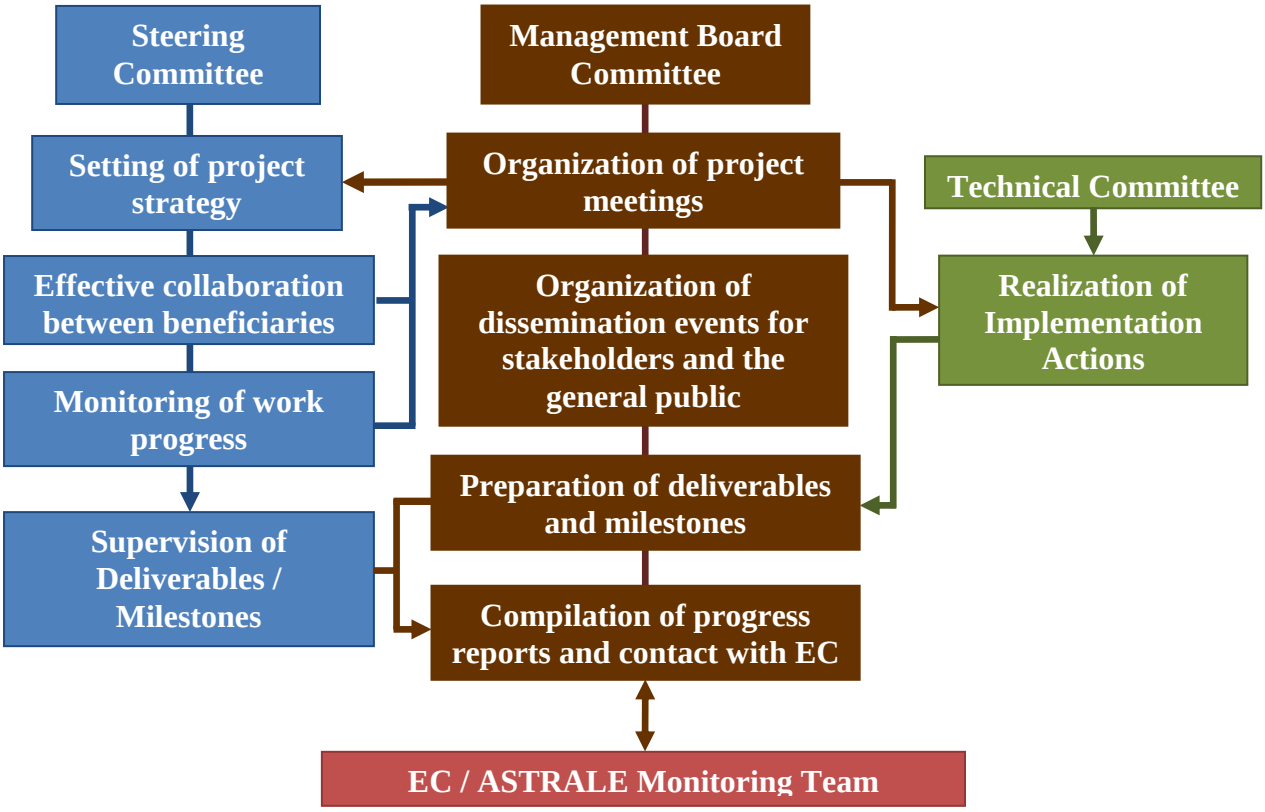
The **working method** was developed during the Plenary Meetings throughout the course of the project implementation. Each beneficiary was appointed as Action leader in one or more Actions. The implementation of the working scheme was further supported by three decision making bodies: the Management Board Committee (MB), the Steering Committee (SC) and the Technical Committee (TC). A schematic presentation of the Management System, including the responsibilities of each Committee, and the management team **organigramme** are provided in Figure 1. The working method followed during the different project phases (planning and execution of activities and tasks in each phase) is shown in Table 1.

The **Project Manager**, in collaboration with the **Scientific Secretary** and the **Financial Manager**, had the overall responsibility of the project management: Organize seven plenary meetings throughout the course of the project; Coordinate the implementation of project Actions in collaboration with the respective Action leader beneficiaries; Organize meetings with stakeholders; Identify potential problems and critical decisions to be dealt in MB and SC meetings; Monitor the progress of deliverables and milestones; Communicate with ASTRALE Monitoring Team and the European Commission; Manage ACEPT-AIR cost centre; Overall management of contractual, legal, financial and administrative issues.

4.2 Evaluation of the management system

The **project management process** was successfully implemented owing to the excellent collaboration between ACEPT-AIR beneficiaries. Some **problems** of administrative nature were encountered during the launch of the project, mostly due to the fact that the Finance Department of NCSR "D" had no earlier experience with LIFE projects. These problems caused small delays in the signing of the partnership agreement and the consequent transfer of the first instalment to the associated beneficiaries but they were successfully overcome early in the project implementation. The partnership agreement described the management rules and the responsibilities of each beneficiary in a clear and consistent way, enabling the smooth execution of the project. In addition, the frequent plenary meetings assisted towards the identification and solution of problems The well defined distribution of tasks between partners, set and supported by the Action Leaders, ensured the completion of all Actions, as shown in Table 2. Some delays due to the heavy load of measurements and analysis did not affect the overall successful implementation of the project.

All **communication** with the **EC and ASTRALE Monitoring team** was conducted by the project manager, K. Eleftheriadis. In general this communication scheme was effective. There was a crucial financial issue regarding the personnel cost reported by AUTH during the Midterm Report. In that case AUTH Finance Department requested and was granted permission to communicate directly with the EC LIFE unit in order to clarify the issue and obtain approval for these costs.



Project Manager: K. Eleftheriadis (NCSR "D")

Representatives of each beneficiary: A. Kungolos (UTH); C. Samara (AUTH); A. Progiou (AXON); M. Lazaridis (TUC)

Scientific Secretary: E. Diapouli

Financial Manager: K. Daniil / S. Dalaina / V. Galifianakis

External evaluators:

A. Chaloulakou (NTUA)

X. Querol (CSIC)

R. Harrison (University of Birmingham)

Representatives of stakeholders:

N. Manalis (Ministry of Environment, Energy & Climate Change)
G. Kourasis (Municipalities of Athens Metropolitan area)
D. Alexopoulos (Region of Thessaly)
K. Zervas (Municipality of Thessaloniki)
D. Patsios (Association of Motor Vehicle Importers)

Field experts:

V. Alexandropoulou
Th. Grigoratos
A. Argyropoulos
Th. Glytsos
K. Kavadias
S. Kipouros
A. Kouras
Th. Maggos
E. Manoli
D. Voutsa
S. Vratolis

Administrative staff:

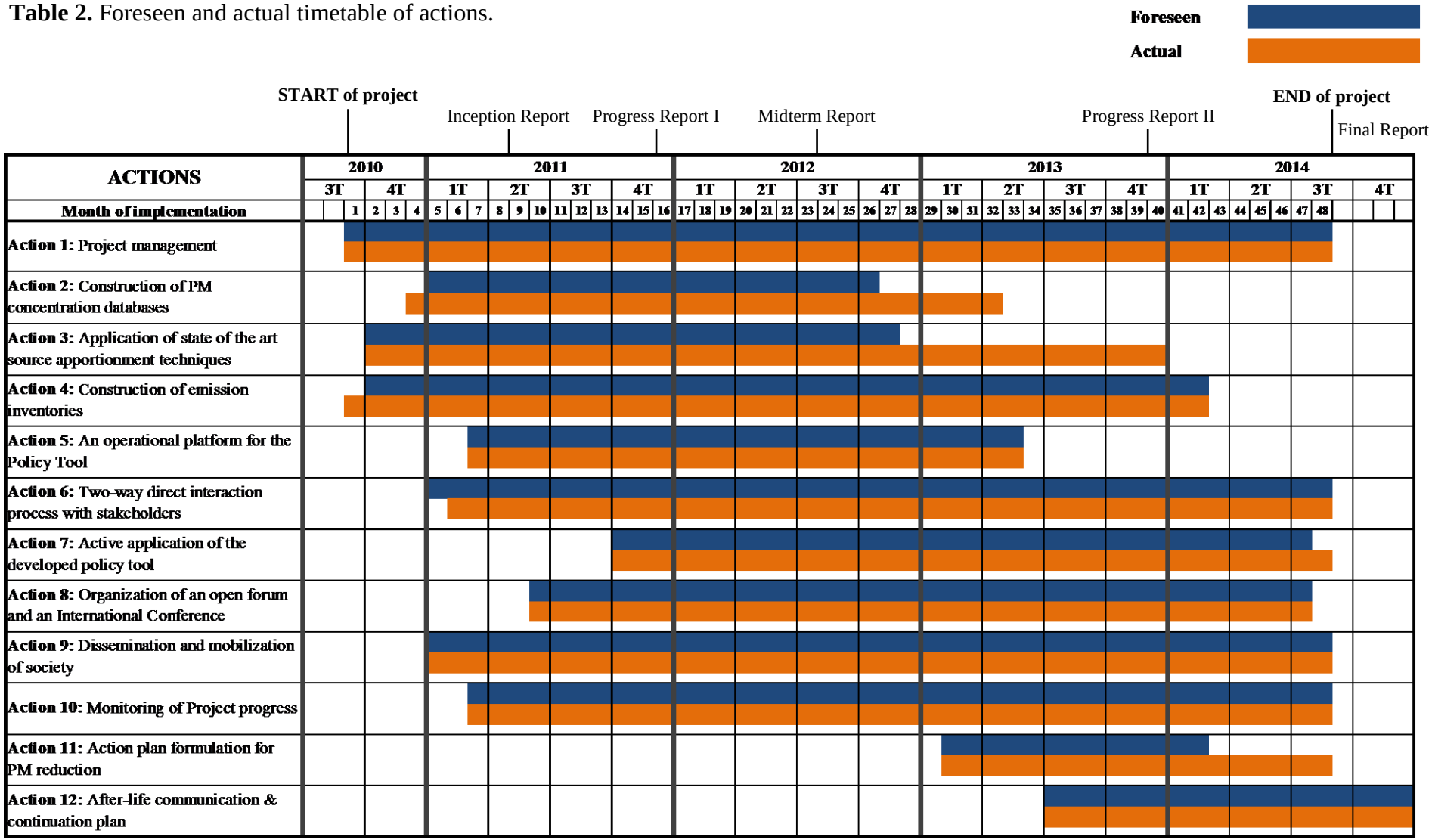
Ch. Papatheodorou
A. Papaoikonomou

Figure 1. Schematic presentation of the management system and organigramme of ACEPT-AIR management team.

Table 1. Project implementation phases and planning / execution of relevant tasks and activities (The Action leader is shown in italics).

Action	Tasks and activities				
ACTION 1 *NCSR "D"*	**Initiation of project** (09/2010) **Kick-off meeting** (10/2010)	**2nd Plenary Meeting** (03/2011) **3rd Plenary Meeting** (11/2011)	**4th Plenary Meeting** (03/2012) **5th Plenary Meeting** (02/2013)	**6th Plenary Meeting** (06/2013)	**7th Plenary Meeting** (03/2014)
ACTION 2 *AUTH*	Organization of field campaigns; Collection of historical data	Measurement campaigns in the three studied cities	Chemical analysis of collected samples		
ACTION 3 *NCSR "D"*	Historical source profiles and source contributions	Review of previous source apportionment results	Comparative application of Receptor modelling techniques	Source apportionment for ACEPT-AIR data	
ACTION 4 *TUC*	Collection of input data for emission inventories	Methodologies for emission spatial / temporal disaggregation	Completion of emission inventories (2000 – 2010)	Emission inventories (2010 – 2013)	
ACTION 5 *AXON*		Development of OP modules	Completion of the OP development and testing	Compilation of the application guide and manual for the OP	
ACTION 6 *AUTH*	Initial contact with key stakeholders	1st Meeting for stakeholders (12/2011, Athens)	2nd Meeting for stakeholders (04/2013, Thessaloniki)		3rd Meeting for stakeholders (04/2014, Volos)
ACTION 7 *AXON*			Identification of stakeholders' needs	Demonstration of ACEPT-AIR tool	Application of ACEPT-AIR Policy tool
ACTION 8 *UTH*		Time schedule for the Open Forum and Conference		Preparatory work for the two events	Open Forum (04/2014, Volos) International Conference (07/2014, Skiathos island)
ACTION 9 *UTH*	Website; Notice boards; Networking	Press releases; Presentations in conferences;	Production of leaflets	Seminars for secondary education teachers	Production of informative / dissemination material
ACTION 10 *NCSR "D"*	Submission of an amended description for Action 10	Visits by external evaluators	1st Evaluation Report		Visit by external evaluators; 2nd Evaluation Report
ACTION 11 *NCSR "D"*				Air quality in the three studied areas	Development of mitigation measures and policies
ACTION 12 *UTH*					Compilation of After-Life Communication plan
Monitoring	ASTRALE visit (03/2011)	ASTRALE visit (03/2012)	ASTRALE visits (06/2013)		EC & ASTRALE visits (05/2014)
Reports	Inception Report (04/2011)	Progress Report I (11/2011)	Midterm Report (07/2012)	Progress Report II (11/2013)	Final Report (01/2015)

Table 2. Foreseen and actual timetable of actions.



5. Technical part

5.1. Technical progress, per task

5.1.1. Action 2. Construction of PM concentration databases

Action 2 started on December 2010, one month earlier than foreseen in the initial planning and was completed with a delay of six months, on April 2013 (Table 2). In the framework of this Action a detailed database on **PM_{10} and $PM_{2.5}$ mass concentration and chemical composition** was constructed for the three studied areas: Athens Metropolitan Area (AMA), Thessaloniki Metropolitan Area (TMA) and Volos Greater Area (VGA). The database included historical data as well as data collected during ACEPT-AIR project. Action 2 was performed by **AUTH** (Action leader), **NCSR "D"** and **UTH**.

Measurement campaigns in AMA, TMA and VGA

ACEPT-AIR measurement campaigns were carried out during warm season of 2011 (June – September) and cold season of 2012 (January – April) at two sites in the **Athens Metropolitan Area**, two sites in **Thessaloniki Metropolitan Area** and one site in **Volos Greater Area**. Athens and Thessaloniki are the two largest cities in Greece, while Volos has the third largest of Greece's major commercial ports as well as a number of industrial facilities in the vicinity of the city. The monitoring sites were selected after consultation with the project stakeholders (the Ministry for the Environment, Energy & Climate Change, the Municipality of Thessaloniki and the Regional Union of Magnesia and N. Sporades) and three of the sites were hosted in stakeholders' stations. Specifically, the two sampling sites in AMA were located: (i) at Agia Paraskevi (AP), at the urban background station GAW-DEM[1] of the National Centre for Scientific Research "Demokritos" and (ii) at Nea Smyrni (NS), at the urban background station of the National Monitoring Network. The two sampling sites in TMA were located: (i) at an urban traffic station (UT) in the commercial city centre (Ionos Dragoumi) and (ii) at an urban background station (UB) in the upper part of the city (Eptapyrgio), both stations belonging to the Municipality of Thessaloniki. The sampling site in VGA was located on the roof of the University of Thessaly (UTH). The sampling sites in AMA/TMA and in VGA are shown in Figures 2 and 3, respectively.

The sampling campaigns were implemented by NCSR "D" and AUTH in Athens and Thessaloniki, respectively. In Volos, measurements were conducted by UTH in collaboration with NCSR "D". At all sites, **PM_{10} and $PM_{2.5}$ sampling** was carried out concurrently, on a 24-hr basis, according to the reference methods ISO/IEC EN-12341 and ISO/IEC EN-14907, by reference low volume samplers. Two typed of filters (Teflon and Quartz fiber) were simultaneously collected in order to allow for a number of different analyses for chemical speciation. The total number of valid samples collected at each site during warm and cold season is shown in Table 3. A minimum of 30 samples per site was aimed at, in order to allow for the subsequent application of source apportionment modeling in Action 3.

Due to the large size of AMA and TMA, the spatial distribution of PM concentrations was further examined by the use of the **mobile measurement platform** (Mobilab) of the APTL, CERTH which was subcontractor to the project. In both cities, Mobilab was employed for two 10-days periods, during warm and cold season field campaigns respectively. During the day the vehicle was moving in preselected routes, while a GPS was continuously recording its

[1] http://gaw.empa.ch/gawsis/reports.asp

position. Measurements were continued during night time, with the vehicle parked in areas of interest. The areas and routes monitored in the two cities are depicted in Figure 2. Mobilab measurements indicated a large spatial variability of PM mass concentrations across the two cities (Figure 4). PM number concentrations, which are mainly associated with particles of diameters smaller than 1 μm, presented a lower spatial variability (Figure 5). The measurements were also used in order to assess the selected sites for ACEPT-AIR field campaigns with respect to the PM levels in these two large urban agglomerations. The results supported the characterization of AP and NS as urban background stations, since these two areas presented the lowest concentrations across AMA. Similarly, UT and UB stations in TMA were found to be characteristic of traffic and urban background areas of the city as well.

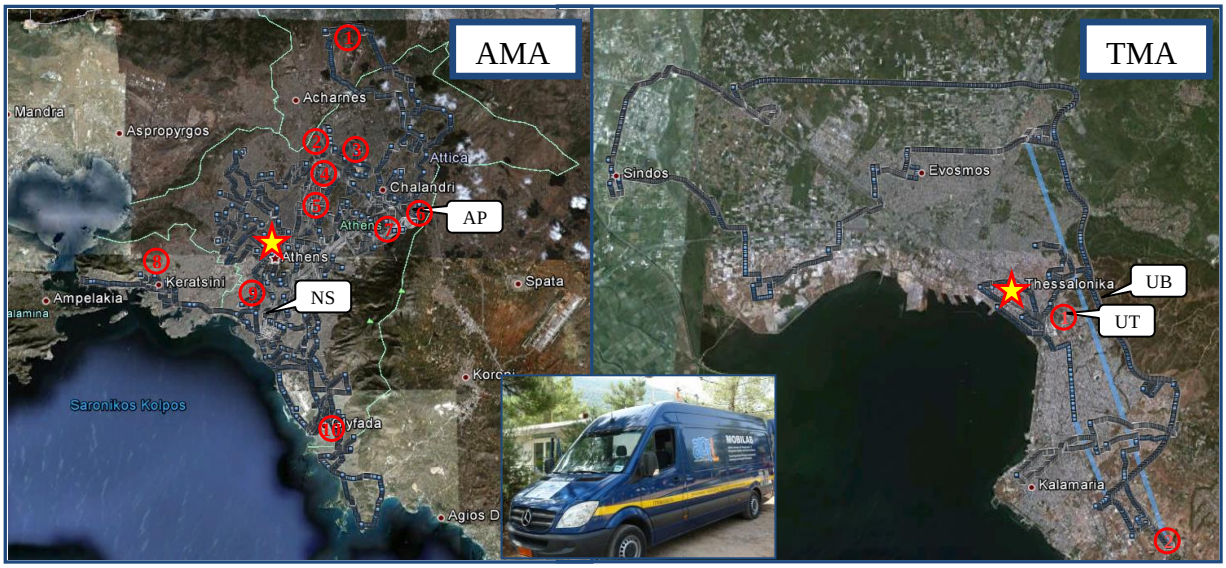


Figure 2. Maps of AMA and TMA depicting the city centres (by yellow stars), the sampling sites (AP and NS in AMA and UB and UT in TMA), the routes covered by Mobilab (shown in blue) and areas (numbered in red circles) where Mobilab night time measurements took place. A photo of Mobilab vehicle is also shown.

Figure 3. Map of VGA depicting the city centre (by yellow star) and the sampling site (UTH) (on the left); Photo of PM samplers measuring at UTH (on the right).

Table 3. Number of valid samples collected at each site (warm / cold season).

	AMA		TMA		GVA
	AP	**NS**	**UT**	**UB**	**UTH**
PM_{10}	48 / 47	40 / 41	28 / 26	26 / 24	9 / 23
$PM_{2.5}$	49 / 48	42 / 39	28 / 26	25 / 24	32 / 24

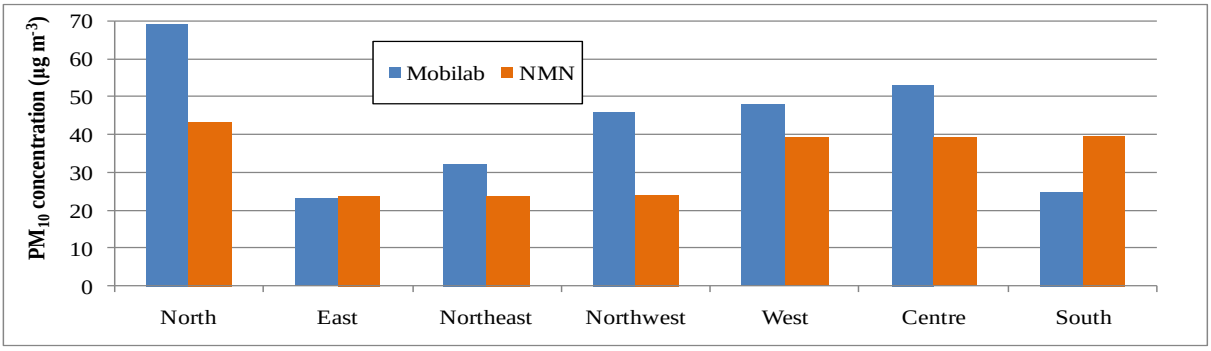


Figure 4. Mean Mobilab concentrations during day time measurements in different areas of AMA and the respective 24-hr concentrations measured at the closest station of the National Monitoring network (NMN).

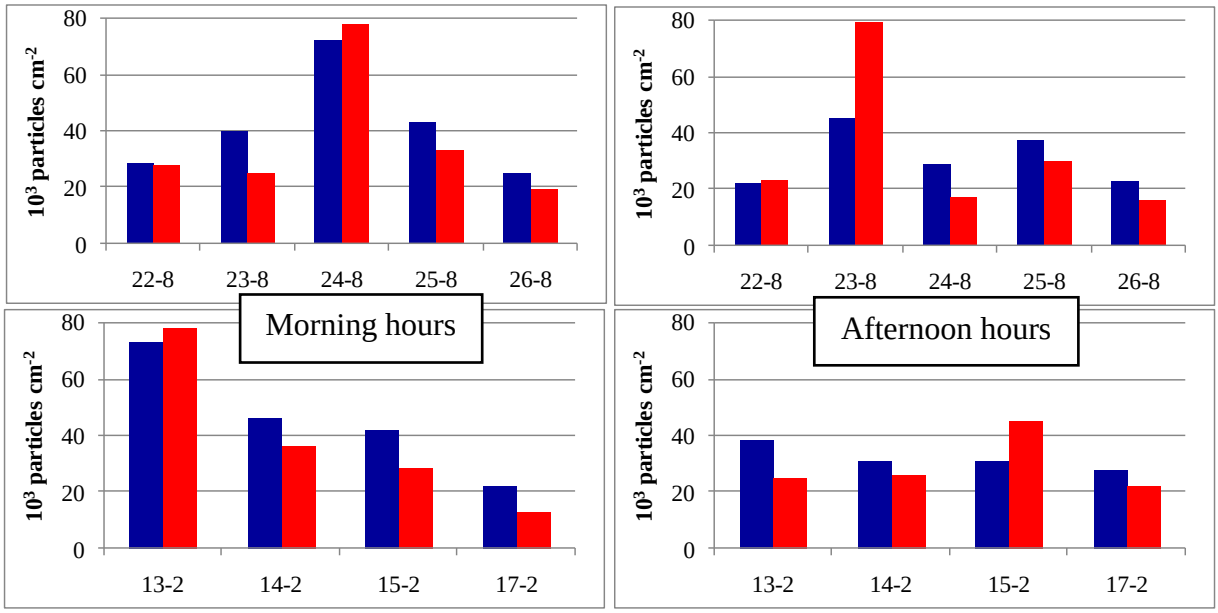


Figure 5. Mean number concentrations of ultrafine particles (diameters in the range 9-372nm) measured by Mobilab in TMA during the warm (upper graphs – August 2011) and the cold period (lower graphs - February 2012). Graphs on the left correspond to morning hours and graphs on the right to afternoon hours (■ city centre area ■ urban background area).

Chemical analysis of PM_{10} and $PM_{2.5}$ samples

The PM_{10} and $PM_{2.5}$ samples collected at each site were analyzed in order to obtain detailed **chemical characterization** of atmospheric particles. Specifically, ionic species and major and trace elements were quantified on Teflon filters, while elemental (EC) and organic (OC) carbon were quantified on Quartz fiber filters. The analytical methodologies applied are provided in Table 4.

Table 4. Description of the methods used for chemical speciation of PM_{10} and $PM_{2.5}$ samples.

Chemical class	Chemical components	Sample preparation	Analytical method
Carbonaceous species	OC, EC	-	TOT
Ionic species	SO_4^{2-}, NO_3^-, NH_4^+ Na^+, K^+, Cl^-, Ca^{2+}, Mg^{2+}	Aqueous extraction	IC
Major and trace elements	Mg, Al, Si, S, Cl, K, Ca, Ti, V, Mn, Fe, Ni, Cu, Zn, As, Br, Sr, Ba, Pb	-	ED-XRF
Trace elements	V, As, Sb, Co, Cr, Cd	Digestion with HNO_3^- / HCl mixture	GF-AAS

TOT: Thermal Optical Transmission Analysis; IC: Ion Chromatography; ED-XRF: Energy Dispersive X-Ray Fluorescence; GF-AAS: Graphite Furnace Atomic Absorption Spectroscopy

Construction of ACEPT-AIR PM Database

The **ACEPT-AIR Database** provides information for PM_{10} and $PM_{2.5}$ and corresponding chemical components' mass concentration levels for the three studied areas (AMA, TMA and VGA). The Database was constructed in Access 2010 (Microsoft Office, Windows) and has two platforms:

- The Historical Data platform, that includes concentrations for PM mass and chemical constituents measured at various sites within the studied areas during the period 2000-2010. Sources of these data were previous measurements of the project team, the records of the air pollution Monitoring Stations operated by national and local authorities (Greek Ministry of Environment, Municipality of Thessaloniki, etc), as well as published research works. The historical data were collected in the framework of the project and were examined with respect to sampling protocols, sampling and analytical methods and data analysis. Following strict quality control procedures, the collected data have been introduced in the historical database.
- The LIFE Data platform, that includes concentrations of PM_{10} and $PM_{2.5}$ and associated chemical components measured during 2011-2012 in the framework of the ACEPT-AIR project.

ACEPT-AIR Database is submitted along with Deliverables D6 "PM_{10} and $PM_{2.5}$ concentration databases for the three urban areas (AMA, TMA and VGA)" and D7 "PM_{10} and $PM_{2.5}$ chemical composition databases for the three urban areas (AMA, TMA and VGA)".

ACEPT-AIR campaigns: PM concentration and chemical composition in the three areas

Mean **PM concentration** levels measured during warm and cold season ACEPT-AIR campaigns are presented in Figure 6. During warm season, PM_{10} concentrations at the two background sites in Athens, the urban background site in Thessaloniki and in Volos were always below the 24-hr limit value of 50 μg m^{-3} set by Directive 2008/50/EC (with the exception of one day in AP where PM_{10} concentration barely exceeded 50 μg m^{-3}). As

expected, the respective levels at the traffic site in Thessaloniki were higher, with 13 out of 28 days exceeding the 24-hr limit value. Similarly, $PM_{2.5}$ levels during warm season were above the yearly target value set by EU (25 μg m^{-3}) only in TMA/UT. The situation was much different during cold season, when there was a significant increase in PM levels. The lowest concentration levels were again measured at the background sites; nonetheless both AP and UB background sites in Athens and Thessaloniki respectively presented exceedances of the EU 24-hr limit value for PM_{10} (2 out of 47 days in AP and 7out of 24 days in UB). At the more densely populated site of NS in Athens, and in Volos, PM_{10} concentrations were above the 50 μg m^{-3} limit value for 40% and 70% of the measurement days respectively, while mean cold season concentration in Volos was much higher than the annual limit value (74 μg m^{-3}). $PM_{2.5}$ levels were significant as well, with mean cold season values close or higher than the annual target value of 25 μg m^{-3}. It is known that the meteorological conditions during cold period generally favour the build-up of air pollution, mostly by temperature inversions that trap the cold air close to the ground and cause lower dispersion of pollutants. Nevertheless the dramatic increase of PM levels that we observed suggests as well a strong PM source during cold season, present also in background residential sites, such as residential heating.

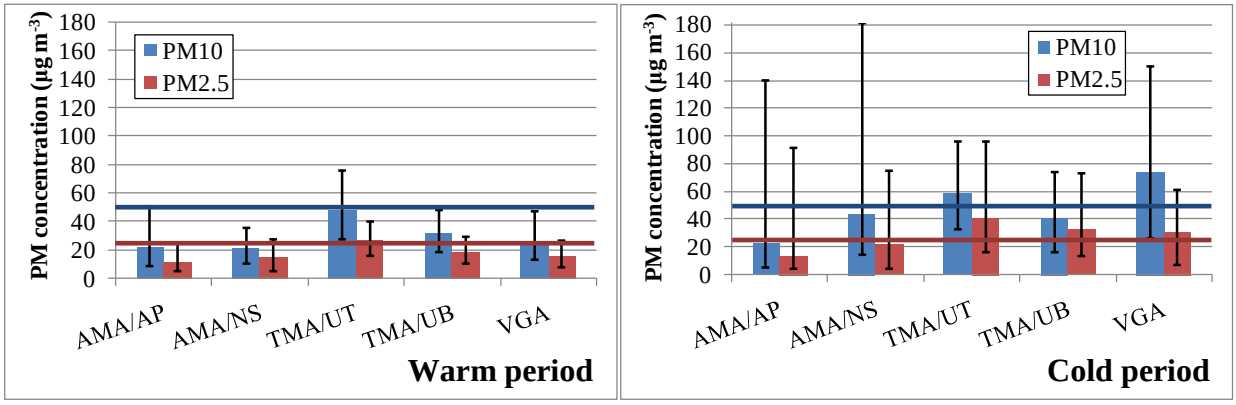


Figure 6. PM_{10} and $PM_{2.5}$ concentrations during warm (left) and cold (right) season at the three studied cities. Columns correspond to mean values and error bars denote range of 24-hr values. Blue and red lines depict the 24-hr EU limit value for PM_{10} and the yearly EU target value for $PM_{2.5}$, respectively.

PM chemical composition provides further insight into the origins of the problem. A major fraction of PM mass constitutes of carbonaceous particles which are associated with combustion sources. Elemental carbon in particular is often used as tracer for traffic emissions. The **OC and EC concentrations** measured at ACEPT-AIR sites during warm season were in agreement with the character of each site (Table 5). Relatively low levels were observed in AP, NS, UB and VGA (with the lowest values corresponding to AP site inside NCSR "D" campus). The background character of the stations was further demonstrated by OC/EC ratios much higher than 1.0, indicating relatively low contribution from traffic emissions, coupled with secondary organic formation which enhances OC levels (Figure 7). The highest OC/EC ratios were recorded in AP and in the PM_{10} fraction, and may be also related to primary biogenic organic carbon produced by the vegetation in NCSR "D" campus and in the nearby Hymettus Mountain. At the traffic site in Thessaloniki (UT), concentrations were significantly higher, among the highest values reported for other urban sites in European cities (Samara et al., 2014). The corresponding OC/EC ratios were around 1.0, similar to those found at kerbside sites and close to the ratio values reported for vehicular emissions.

During cold season, concentrations of both carbonaceous species were much higher at all sites, possibly due to the additional source of residential heating during this period. The

highest concentration were observed in the densely populated area of NS (24-hr concentration reaching up to 45 μg m^{-3} for OC and 6 μg m^{-3} for EC) and the UT site in Thessaloniki (maximum OC and EC concentration equal to 23 μg m^{-3} for OC and 11 μg m^{-3} for EC). OC concentrations contributed the most to total carbon at all sites during this season. Even the traffic site in Thessaloniki presented OC/EC ratios higher than 1.0 (around 3.0). The increase in OC/EC values during cold season may be attributed to biomass burning -which produces large amounts of organic carbon- and suggests intense use of fireplaces for residential heating.

Table 5. Basic statistics for organic (OC) and elemental (EC) carbon concentrations during warm and cold season [μg m^{-3}].

	OC - Warm		OC -Cold		EC - Warm		EC- Cold	
Site	**PM_{10}**	**$PM_{2.5}$**	**PM_{10}**	**$PM_{2.5}$**	**PM_{10}**	**$PM_{2.5}$**	**PM_{10}**	**$PM_{2.5}$**
AMA/AP	2.7±1.0	2.7±1.0	4.1±1.5	4.0±1.5	0.3±0.2	0.3±0.2	0.5±0.2	0.4±0.2
AMA/NS	4.4±1.5	3.2±1.0	9.3±7.9	8.9±7.6	0.8±0.4	0.6±0.3	1.4±1.0	1.2±0.9
TMA/UT	8.6±2.7	6.0±2.3	14.2±5.3	11.1±4.0	7.8±1.4	5.9±1.3	5.5±2.3	4.5±1.4
TMA/UB	4.1±1.7	3.3±1.3	8.7±5.0	8.7±5.0	0.7±0.3	0.5±0.2	1.2±0.8	0.9±0.4
VGA	4.6±1.1	3.7±1.0	10.8±4.5	10.0±4.0	0.8±0.4	0.6±0.2	1.5 ± 1.0	1.2±0.7

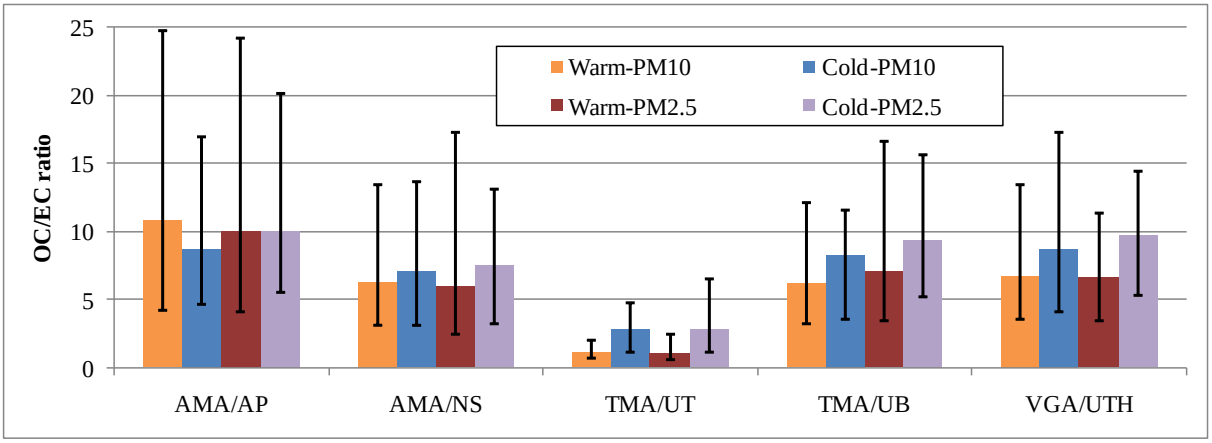


Figure 7. Organic-to-elemental concentrations ratio (OC/EC) calculated for PM_{10} and $PM_{2.5}$ during warm and cold season at the three studied cities. Columns correspond to mean values and error bars denote range of 24-hr values.

Among **ion species**, NH_4^+, SO_4^{2-} and NO_3^- presented the highest concentrations at both size fractions and all sites. In the coarse mode, Ca^{2+} contribution was also significant. Na^+, Mg^{2+} and Ca^{2+} were mostly found in the coarse mode, while K^+ and SO_4^{2-} in the fine mode. Cl^- and NO_3^- were more abundant in $PM_{2.5}$ in UT and UTH, while they were associated with larger particles in the two AMA sites and in the UB site in Thessaloniki (Figure 8). NH_4^+ presented higher values in $PM_{2.5}$ in relation to PM_{10}. This effect has been noted by other researchers as well and may be due to the formation of NH_4Cl (through reaction of NH_4NO_3 with NaCl from sea salt) and its subsequent volatilisation from the filter samples (Theodosi et al., 2011). Sea salt particles are found in the coarse mode thus affecting mainly PM_{10} and not fine particles.

Elemental analysis indicated that crustal elements (such as Mg, Al, Si, K, Ca and Fe) were the most abundant components, along with S, Zn and Br (mostly in $PM_{2.5}$) which are associated with anthropogenic activities and Cl (mostly in coarse particles) which corresponds to sea aerosol (Figure 9).

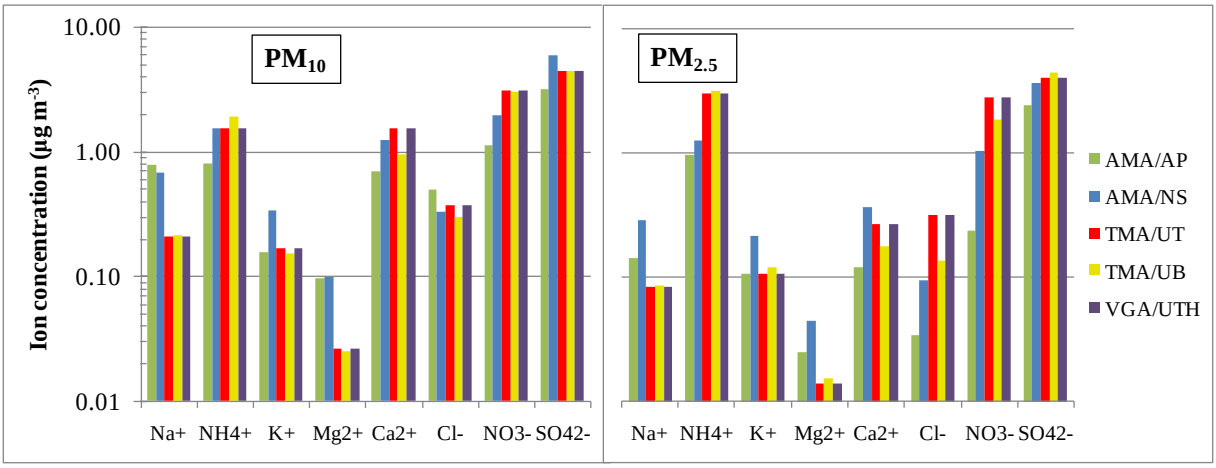


Figure 8. Mean concentration of major ionic components in PM_{10} (left) and $PM_{2.5}$ (right) at the studied areas.

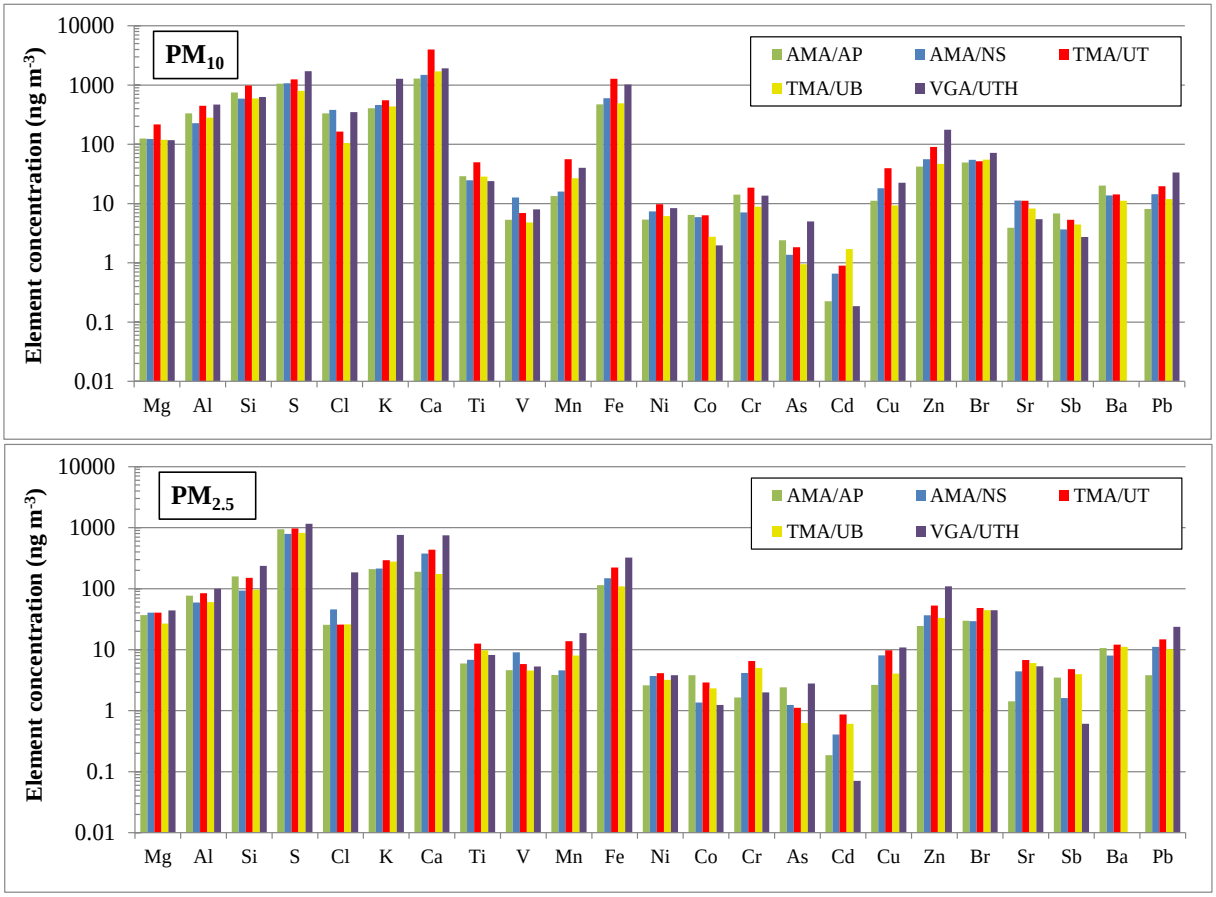


Figure 9. Mean concentration of major and trace elements in PM_{10} (upper) and $PM_{2.5}$ (lower) at the studied areas.

Mass closure of PM_{10} and $PM_{2.5}$ was conducted in order to obtain a comprehensive picture of the chemical components/source categories that influence the measured PM concentration levels. For this purpose, the chemical components were divided into six classes as follows: Minerals, Trace elements, Organic matter (OM), Elemental carbon (EC), Sea salt and Secondary inorganic aerosol (SECONDARY). Details on the formulas used in the calculation of mass in each category are given in Deliverable D7 "PM_{10} and $PM_{2.5}$ chemical composition databases for the three urban areas (AMA, TMA and VGA)". Secondary inorganic aerosol and Organic mass constituted large fractions of total PM mass (Secondary ranging from 15 –

32% in PM_{10} and 25 – 43 % in $PM_{2.5}$; Organic mass ranging from 21 – 42% in PM_{10} and 23 – 54 % in $PM_{2.5}$). Organic mass contribution was more pronounced during cold season pointing towards biomass burning for residential heating. Elemental carbon (EC), which is a marker for vehicular traffic emissions, presented low contribution (around 2 – 4%), except for the UT site in TMA where it accounted for 14% and 18% of PM_{10} and $PM_{2.5}$, respectively. Minerals were another major contributor to PM_{10} (15 – 33% at the different sites and seasons) with larger concentrations during warm season when the dry meteorological conditions favoured soil dust resuspension.

References

EU, 2008/50/EC - Directive of the European Parliament and of the Council on ambient air quality and cleaner air for Europe.

ISO/IEC EN-12341: "Ambient air. Standard gravimetric measurement method for the determination of the PM_{10} or $PM_{2.5}$ mass concentration of suspended particulate matter".

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Theodosi C., Grivas G., Zarmpas P., Chaloulakou A., Mihalopoulos N. (2011) Atmos Chem Phys, 11: 11895-11911.

Deliverables & Milestones

Milestones M1 and M2 were achieved on time (Table 6). A number of **technical problems** have been encountered during the field measurement campaigns (mainly instruments malfunction and loss of electric power during sampling). Nevertheless, quality and sufficient quantity of data was secured by extending the measurement period. The most significant loss of data occurred during the VGA campaign, where one of the two PM_{10} samplers did not function for 2/3 of the measurement period, resulting in limited data on PM_{10} mass concentrations and filters available for ions and elements' analysis. A longer measurement period was implemented in the winter campaign, in order to achieve an adequate number of samples for the consequent application of source apportionment models in Action 3. Despite the drawbacks in the realization of the field sampling campaigns, they were completed one month earlier to the initial planning. **Deliverable D6** was completed without any problems three months in advance, on April 2012.

Milestone M3, related to the analysis of the PM samples for chemical characterization, was achieved with a delay of six months. The main reason for this **delay**, apart from the heavy load of chemical analyses needed to be performed, was that XRF and AAS analysis for the determination of major and trace elements in PM was conducted on the same filters. XRF, which is a non-destructive technique, was performed by AUTH. Following AUTH analysis, the filters were transported to NCSR "D", where AAS analysis was conducted. These logistics were necessary in order to avoid collecting duplicate Teflon filter samples for these analyses. Similarly to Milestone M3, **Deliverable D7** was completed with a delay of six months on April 2013. Due to the delay in chemical characterization of PM samples, the application of source apportionment techniques to the ACEPT-AIR datasets (**Action 3**) was postponed until the input data were fully available. This caused a deviation from the foreseen time-schedule for Action 3 as well (see section 5.1.2) but with no significant effect on the overall successful completion of the project.

Deliverables D6 and D7 are attached to the present Report, along with ACEPT-AIR Database (in Microsoft Office Access).

Continuation after the end of project: The developed Database contains unique information on PM chemical speciation for three characteristic Greek urban environments. ACEPT-AIR Database has been **distributed to the project stakeholders** and is already **used by the Ministry** of Environment, Energy and Climate Change for Air Pollution Mapping, a major project undertaken by the Ministry during the last years. **PM monitoring** is a major activity for both NCSR "D" and AUTH. NCSR "D" maintains GAW-DEM station, where PM_{10} and $PM_{2.5}$ mass concentrations along with other particle parameters are measured on a continuous basis throughout the year. In addition, UTH has obtained significant experience in PM sampling through the implementation of ACEPT-AIR project. The Sequential PM sampler purchased by UTH for the project is currently being used in the framework of **doctorate and master theses**. It is thus expected that new data on chemical speciation will be available in the course of the following decade through the project partners' research and other activities. Moreover, given that the partners have developed and maintain a very good collaboration with key stakeholders in their respective regions, the national, regional and local authorities will continue to take advantage of all new data obtained as well as of the expertise gained by ACEPT-AIR partners.

Table 6. List of Deliverables and Milestones for Action 2. Foreseen and actual dates of completion are also shown.

Completion of Deliverables	**Foreseen date**	**Actual date**
D6. PM_{10} and $PM_{2.5}$ concentration databases for the three urban areas (AMA,TMA and VGA)	31/07/2012	30/04/2012
D7. PM_{10} and $PM_{2.5}$ chemical composition databases for the three urban areas (AMA,TMA and VGA)	31/10/2012	30/04/2013
Achievement of Milestones	**Foreseen date**	**Actual date**
M1. Collection of historical data sets and quality control assurance	02/2011	02/2011
M2. Completion of sampling campaign	05/2012	04/2012
M3. Completion of chemical analysis	08/2012	03/2013

Complementary actions outside LIFE: The high level of expertise of NCSR "D" in PM measurements, documented as well by PM_{10} accreditation and related QA/QC procedures, has been pivotal to the co-ordination of an Inter-comparison exercise for PM_{10} samplers, organized under the auspices of IAEA and the Regional European project RER/2/005. The Inter-comparison was followed by a workshop with the participation of 12 organizations from 9 European countries and resulted in the enhancement of QA/QC procedures among National Environmental authorities in the Balkan Region, including some Greek organizations (National Technical University of Athens, University of Patras) and project stakeholders (Ministry of Environment, Energy and Climate Change)**.**

In addition, NCSR "D" co-ordinated a Proficiency Test exercise for the analysis of PM elemental content, again under the auspices of IAEA and the Regional European project RER/1/008. NCSR "D" undertook the samples' preparation (by the use of two Certified Reference Materials) and analysis and reporting of results. In total 18 laboratories from 13 countries participated. Five analytical techniques (XRF/EDXRF, PIXE, ICP-MS, AAS and INAA) were assessed with respect to the determination of particles elemental content.

5.1.2. Action 3. Application of state of the art source apportionment techniques based on the developed databases and receptor modelling

Action 3 started on November 2010 and was completed on December 2013 (Table 2). In the framework of this Action, the main **emission sources** affecting PM concentration levels at the three studied cities were identified and their **contributions** were quantified. Both historical data and data collected during ACEPT-AIR project were used in the analysis in order to examine temporal and spatial variability. Action 3 was performed by **NCSR "D"** (Action leader) and **AUTH.**

Application of receptor modelling

Source apportionment of PM_{10} and $PM_{2.5}$ concentrations measured at AMA, TMA and VGA has been performed by two widely used receptor models: **Positive Matrix Factorization (PMF)** and **Chemical Mass Balance (CMB)**. The PMF model applied was PMF2 (two-way PMF) (Paatero, 2004), while for CMB modelling an optimized CMB procedure was applied, the Robotic CMB (RCMB), which has been developed by AUTH (Argyropoulos & Samara, 2010).

Source apportionment analysis was performed on the **PM_{10} and $PM_{2.5}$ data** collected during **ACEPT-AIR project** at two sites in AMA (AP and NS), two sites in TMA (UT and UB) and one site in VGA. In addition **historical data** collected at three urban sites in Athens during 2002 and a traffic site in Thessaloniki during 2007 were also analyzed. These historical data allowed for an assessment of the long term temporal variability of source chemical composition and strength. In the case of CMB modelling, **source profiles** were also used as input data. These chemical profiles have been obtained through emission source measurements (for primary anthropogenic sources), SPECIATE Database on PM source profiles developed by the U.S. Environmental Protection Agency (for marine aerosol) and theoretical profiles based on stoichiometry (for secondary aerosol formation).

Major sources and their contributions to PM concentration levels

The identified factors by PMF were attributed to emission sources based on their chemical profile and contribution time series (i.e. seasonality etc.). The obtained **chemical profiles** for PM_{10} and $PM_{2.5}$ corresponding to the **best PMF solution** for each city are provided in Deliverable D8 "The chemical profile and respective contribution of aerosol sources on each region (AMA, TMA, GVA) in the $PM_{2.5}$ and PM_{10} fractions" (ANNEX III).

The major contributing source to **PM_{10} concentrations** at Agia Paraskevi (AP) and Nea Smyrni (NS) urban background sites in **AMA** was Biomass burning (Figure 10), with the relative contribution in NS reaching more than 40%. Mineral dust and Secondary sulfate & organics also contributed significantly to the PM_{10} mass concentration, especially in AP, indicating the more suburban character of this site with respect to NS site. Primary anthropogenic sources (vehicle exhaust and non-exhaust emissions and oil combustion) presented a much higher contribution in NS, while sea salt concentration was similar between the two sites and accounted for 7 – 10% of total PM_{10} mass. Biomass burning and Secondary sulfate & organics were the main **contributing sources in $PM_{2.5}$,** with the former prevailing in NS and the latter in AP, again highlighting the more suburban character of AP site. Traffic (vehicle exhaust and non-exhaust emissions) accounted for 18% and 16% of $PM_{2.5}$ mass in NS and AP respectively, while oil combustion had a lower share (6 and 3%). Sea salt presented

much lower concentration in relation to the PM_{10} size fraction indicating that this natural source mainly affects coarse particles.

At the **urban background site** (UB) in **TMA**, the major contributing sources were Biomass burning (24% and 36% for PM_{10} and $PM_{2.5}$, respectively), Secondary sulfate & organics (24% and 33%) and Secondary nitrate & organics (25% and 20%) (Figure 10). Traffic contribution (exhaust and non-exhaust emissions) was similar to the concentrations estimated for the Athens urban background sites. Natural contributions (Mineral dust and Sea salt) were found lower in Thessaloniki, due to the topography and climate of the region (such as higher humidity which does not promote soil dust resuspension). At the **urban traffic site** (UT) the main contributing source was vehicle exhaust (29% and 34% for PM_{10} and $PM_{2.5}$, respectively), with mean contribution reaching more than 15 and 10 μg m^{-3} for PM_{10} and $PM_{2.5}$, respectively.

At **Volos Greater Area (VGA)** the major contributing sources to PM_{10} were Biomass burning (20%), Mineral dust (18%), Secondary sulfate & organics (18%) and Secondary nitrate & organics (18%). Oil combustion also contributed significantly to the PM_{10} mass concentration (12%) (Figure 10). Traffic contribution was lower than in Athens and Thessaloniki which are the two major urban centres in Greece and present much higher urbanization and traffic density. Sea salt contributed mainly to PM_{10} and accounted for 2% of its mass. Secondary nitrate and Mineral dust were also related to coarse particles. The main contributing sources to $PM_{2.5}$ were Oil combustion (33%), Biomass burning (23%) and Secondary sulfate & organics (19%).

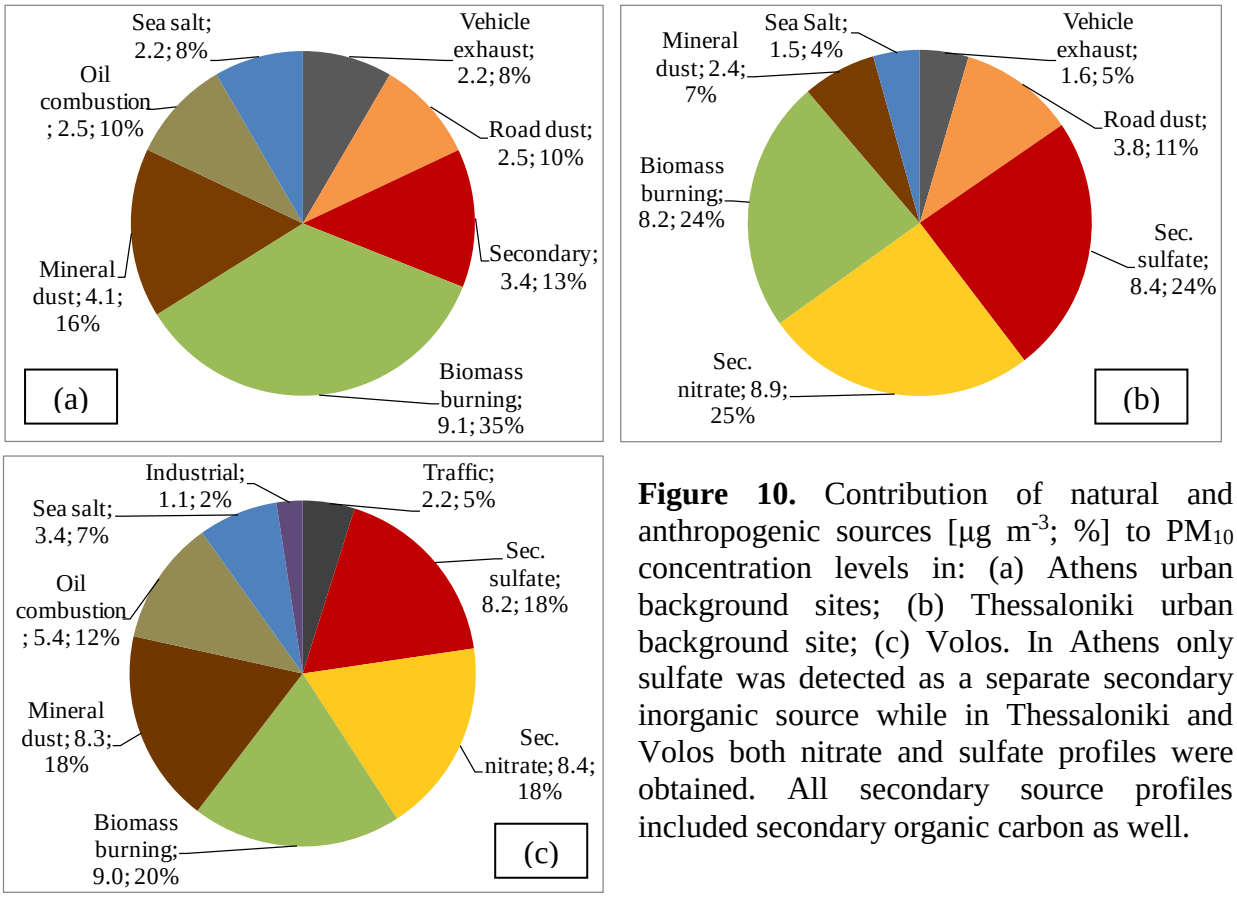

Figure 10. Contribution of natural and anthropogenic sources [μg m^{-3}; %] to PM_{10} concentration levels in: (a) Athens urban background sites; (b) Thessaloniki urban background site; (c) Volos. In Athens only sulfate was detected as a separate secondary inorganic source while in Thessaloniki and Volos both nitrate and sulfate profiles were obtained. All secondary source profiles included secondary organic carbon as well.

Comparison of PMF and CMB results provided useful additional information of PM emission sources, as well as insight into the advantages and limitations of each model. The contribution of traffic to PM concentrations was accounted for differently by the two models mainly due to the absence of a Mineral dust profile in CMB modelling. Mineral dust was probably attributed to Road dust in that case. In addition, the Vehicle exhaust profile used in CMB is characteristic of fresh exhaust emissions, while the obtained PMF profiles correspond to aged exhaust particles. Secondary sulphate & organics presented very similar results in both models, highlighting the need to use theoretical secondary species chemical profiles in CMB modelling. The Biomass burning profile obtained by PMF presented significant contribution from ammonium and nitrate, which were negligible in the CMB profiles. Ammonium nitrate was mostly measured during cold season when the low temperatures favour its presence in the particle phase. Since biomass burning activity was more intense during that period as well (probably for residential heating), the PMF Biomass burning profile reflected the interaction inside the urban atmosphere of typical biomass burning species (such as K^+ and OC) with secondary aerosol related to other anthropogenic activities (such as nitrate). These differences in CMB and PMF profiles highlight the changes in source profiles from the emission point to the receptor. Sea salt contribution was generally higher in PMF due to the presence of other non sea-salt species in its profile (such as EC, V, Ni or other metals), which may be attributed to shipping emissions or harbour activities apportioned together with sea salt aerosol. A characteristic example is the sea salt contribution calculated by PMF in Volos which is equal to the sum of contributions from fresh and aged sea salt along with emissions from scrap handling in Volos harbour. Low contributing sources (below 1%) were not identified by PMF, while when included in CMB source profiles, they were quantified (e.g. tire and /or waste burning or oil combustion in the case of Thessaloniki).

Temporal variation in source chemical composition and strength

Temporal variation was assessed both in the short and the long term. With respect to **seasonal variability**, Biomass burning presented the highest seasonal dependence (Figures 11 and 12). Specifically, Biomass burning mostly contributed during cold season probably due to its use for residential heating, reaching up to 22 μg m^{-3} in the densely populated NS and 20 μg m^{-3} in Volos. In Thessaloniki Biomass burning contributions were slightly higher in warm season and may be attributed to forest fires affecting the region. Traffic (exhaust and non-exhaust emissions) seasonal pattern varied between cities and even for different sites in the same city. The contribution of the non-exhaust component (road dust) was often larger in the warm season when dry weather conditions promoted dust resuspension. Similarly the mineral dust source was more intense during spring and summer months (Figures 11 and 12). Secondary aerosol formation did not show significant seasonal variability, except for nitrate which was mainly found during cold season. Nitrate formation is favored in winter due to low temperature and higher humidity while in the summer it volatilizes easily due to higher temperatures (Chow et al., 2005). Oil combustion was contributing more during cold season which may be related to central residential heating emissions. Sea salt contribution exhibited high seasonality with different patterns depending on the geography of each site and the prevailing wind directions during each season. Higher sea salt concentrations were observed during winter in Athens and Volos and during summer in Thessaloniki.

Analysis of long term variability in Athens indicated considerable change in emission source strengths over the last decade (2002-2012). All anthropogenic sources (traffic, oil combustion, secondary aerosol formation) exhibited significant decrease (in the range -55% to -90% depending on the source) while natural source contributions remained relatively stable. The only exception was Biomass burning which showed a much higher contribution in 2012 (1.6

and 3.0 times higher for $PM_{2.5}$ and PM_{10}, respectively) and was probably related to residential heating as discussed above. An additional source profile corresponding to Industrial emissions has been detected for the 2002 database. This source was absent in the ACEPT-AIR data analysis, suggesting that industrial activity contributed less than1% during that period. Comparison of source apportionment results for 2007 and 2012 in the UT site in Thessaloniki demonstrated much lower variability in source strength during this 5-year period. Nevertheless Biomass burning was significantly increased in 2012 again pointing towards extensive use of biomass burning during the last years. The results clearly demonstrate the effective reduction in emissions during the last decades due to control measures and technological development allowing for cleaner energy and production processes. On the other hand, they may also reflect the effects of the financial crisis in Greece during these years.

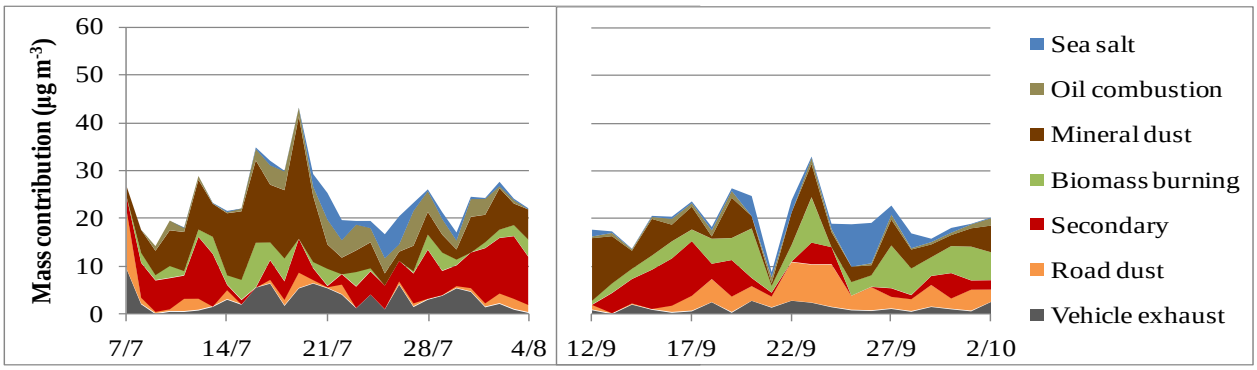

Figure 11. Variability of daily contributions (µg m^{-3}) of the different sources to PM_{10} concentrations during warm season in AP site (AMA).

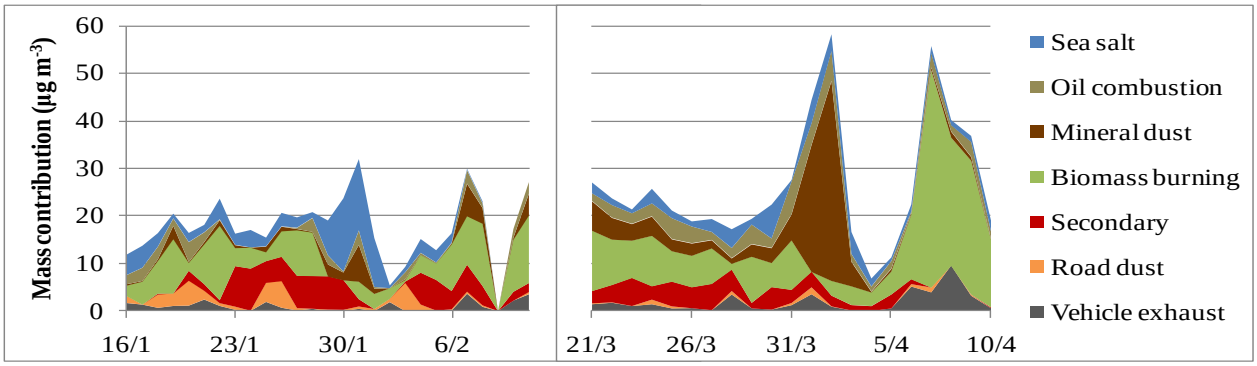

Figure 12. Variability of daily contributions (µg m^{-3}) of the different sources to PM_{10} concentrations during cold season in AP site (AMA).

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Deliverables & Milestones

Milestone M4 was achieved with a delay of one month (Table 7). **Milestone M5** and **Deliverables D8** and **D9** were completed with a significant delay of 1 year (Table 7). The main cause for this **deviation from the foreseen time-schedule** was the delay observed in the completion of Action 2, and in particular the chemical speciation data used as input in source

apportionment models. The final chemical composition database was available on April 2013 and application of source apportionment models on ACEPT-AIR data was concluded by the end of 2013. Even though the problems presented in the realization of Action 2 (described above in 5.1.1) caused a significant delay in the completion of Action3, they also provided the opportunity to conduct a road dust collection campaign in Athens. No experimental data on road dust chemical profile existed for this city and the initial planning was to use profiles obtained from Thessaloniki. NCSR "D" decided to organize the road dust campaign in Athens while waiting for the completion of chemical analysis of ACEPT-AIR samples. The observed delay in completion of Deliverables and Milestones of Action 3 did not affect significantly the overall successful completion of the project. Deliverables D8 and D9 are attached to the present Report.

Table 7. List of Deliverables and Milestones for Action 3. Foreseen and actual dates of completion are also shown.

Completion of Deliverables	**Foreseen date**	**Actual date**
D8. The chemical profile and respective contribution of aerosol sources on each region (AMA, TMA, GVA) in the $PM_{2.5}$ and PM_{10} fractions	31/01/2013	31/12/2013
D9. The temporal variation in source chemical composition and strength	31/01/2013	31/12/2013
Achievement of Milestones	**Foreseen date**	**Actual date**
M4. Completion of PMF and CMB application on historical data sets	02/2012	03/2012
M5. Completion of PMF and CMB application on new data sets	11/2012	11/2013

Continuation after the end of project: Source apportionment results provide an insight into the major emission sources affecting air quality and may be a valuable tool in **control measures prioritization**. ACEPT-AIR results have been already communicated to the **Ministry of Environment, Energy and Climate Change**, as well as the **regional authorities** which have been following the project as key stakeholders. In addition, the output of Action 3 has been used in the development of ACEPT-AIR Policy Tool. NCSR "D" and AUTH are expected to produce new source apportionment results every 5-10 years when emission sources and relevant strengths are expected to show significant changes. The updated results will be incorporated into the Tool database and will be available to all interested parties.

Complementary actions outside LIFE: The capacity for source apportionment techniques to serve as useful instruments for advancing Air Quality management in the EU has been highlighted in the FAIRMODE (Forum for Air quality Modelling) initiative. NCSR "D" and AUTH have been participating in FAIRMODE meetings since 2012, representing the scientific community in Greece applying those techniques and using them in demonstration projects like ACEPT-AIR. In addition, in the framework of FAIRMODE two inter-comparison exercises on source apportionment models have been organized by the Joint Research Centre (JRC), with the participation of both NCSR "D" and AUTH. The inter-comparison results were presented during two FAIRMODE workshops (2013 and 2014) and several receptor modelling issues have been extensively discussed.

5.1.3. Action 4. Construction of emission inventories

Action 4 started on September 2010, one month earlier than foreseen in the initial planning and was completed on February 2014, according to schedule (Table 2). In the framework of this Action a comprehensive **emission inventory for anthropogenic and natural sources** was constructed for the three areas of interest (AMA, TMA and VGA) and for the years 2000-2013, along with future projections. Action 4 was performed by **TUC** (Action leader) and **AXON.**

The **anthropogenic emission sources** included Road transport, Industry, Residential/ commercial activities, Navigation, Aviation and Railways. The **pollutants considered** were: PM, nitrogen oxides (NOx), Non-Methane Volatile Organic Compounds (NMVOCs), sulphur oxides (SOx) and carbon oxide (CO). For **Road transportation** two categories were taken into account: a) exhaust emissions (resulting from the fuel combustion in the vehicles engines) and b) emissions resulting from tyre, brake and road surface wear. The **Industrial sector** inventory includes emissions from fuel combustion and emissions related to the actual industrial production processes. The **National Technical University of Athens (NTUA)** has been subcontracted for this inventory. NTUA maintains a detailed database of all the high emission industrial plants in Greece, including energy power plants. The **Residential / commercial sector** relates to non-industrial (stationary) combustion processes such as residential activities in households and in institutional and commercial buildings. Emissions from **Navigation, Aviation** and **Railways** were calculated according to the EMEP/CORINAIR methodology.

The natural emission sources estimated were **Windblown dust** (WB) emissions from agricultural and vacant lands and S**ea salt** by waves breaking at the **Sea Shore**-surf zone (SS_SS) and from the bursting of bubbles from oceanic whitecaps - **Open Ocean** (SS_OO). Emissions of BVOCs (**Biogenic Volatile Organic Compounds**) from vegetation during photosynthesis, plant respiration and vaporization from stores within the plant tissue, precursor to PM, were also estimated.

Details on the methodology applied for the estimation of emissions for each source category are provided in Deliverable D10 "Emission inventories for the three urban areas (AMA, TMA, GVA), for anthropogenic and natural sources, for the past decade (2000-2010)". In addition, emissions of anthropogenic and natural sources were temporally and spatially disaggregated. Details on the disaggregation methodology are provided in Deliverable D11 "Spatial and temporal disaggregation of emissions for the past decade (2000-2010)".

Emissions from anthropogenic sources

Road transport was found to be the major source of atmospheric pollution. Despite the increase of the population of circulating vehicles, the fleet renovation with less polluting vehicles has lead to substantial decreases in NOx, NMVOC and PM emissions. Considerable reduction of SO_2 emissions was observed after 2010 and may be attributed to the improvement of the fuels characteristics (i.e. the reduction of their sulphur content). The results for the period 2000-2010 suggested that PM_{10} and NOx concentrations are strongly associated with road traffic emissions. Industrial emissions presented a considerable decrease for all pollutants in 2009 and 2010, stabilized in the years 2011-2012 and slightly increased in 2013. Residential/commercial sector emissions exhibited significant decreases throughout the years 2010-2013. All these decreased emissions in the industrial and residential/commercial sectors are associated with the economic crisis. Navigation air pollutants emissions in 2013 were decreased in comparison to the last years but were higher (26%) than the emissions in

2000. Aviation emissions increased by 84% since 1990 with an average annual increase rate of approximately 4%. Emissions from anthropogenic sources were also temporally and spatially disaggregated. An example of spatial disaggregation of road transport emissions in Thessaloniki is shown in Figure 13.

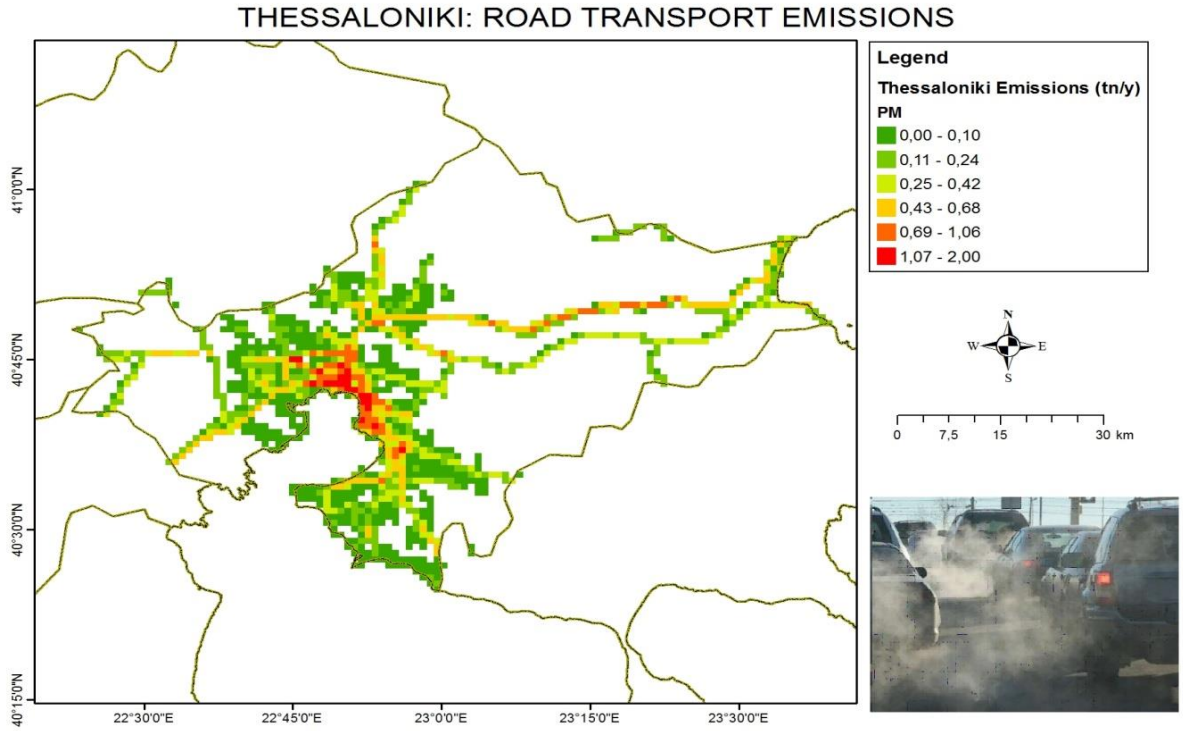

Figure 13. Spatial distribution of PM road traffic emissions in the TMA.

Emissions from natural sources

Emissions from natural sources were significant, especially in the case of coarse particles (around 65 Gg per year for AMA; 6 Gg per year for TMA, 5 Gg per year for GVA). The most significant natural source was the sea surface, with mean contributions to total PM over AMA, TMA and GVA equal to 37%, 10% and 44% for $PM_{2.5}$ and 85%, 65% and 84% for $PM_{2.5\text{-}10}$. Windblown dust accounted for a relatively small fraction of total natural PM emissions in AMA, TMA and GVA (~8%; ~9%; ~8%). In addition, BVOCs emissions accounted for approximately 1%, 16% and 4% of total PM emitted from the AMA, TMA and VGA, respectively. Except for AMA natural PM emissions have increased during 2000-2010 whereas their relative contribution to total PM_{10} emissions has increased in all areas (from 0.9% in AMA to 88% in VGA) (Figure 14). Natural BVOCs emissions during the period 2010-2013 were enhanced compared to 2000-2010 whereas natural PM emissions were decreased. No significant seasonal variation was observed in the natural PM emissions, while BVOCs emissions were increased during the warm period due to the enhanced solar radiation and temperature.

Future emission projections

Future fuel consumption scenarios were examined as provided by the Centre of Renewable Energy Sources (CRES) and national reports. The projections were performed for the years 2015 and 2020. According to these fuel consumption scenarios, in 2015, an increase of the

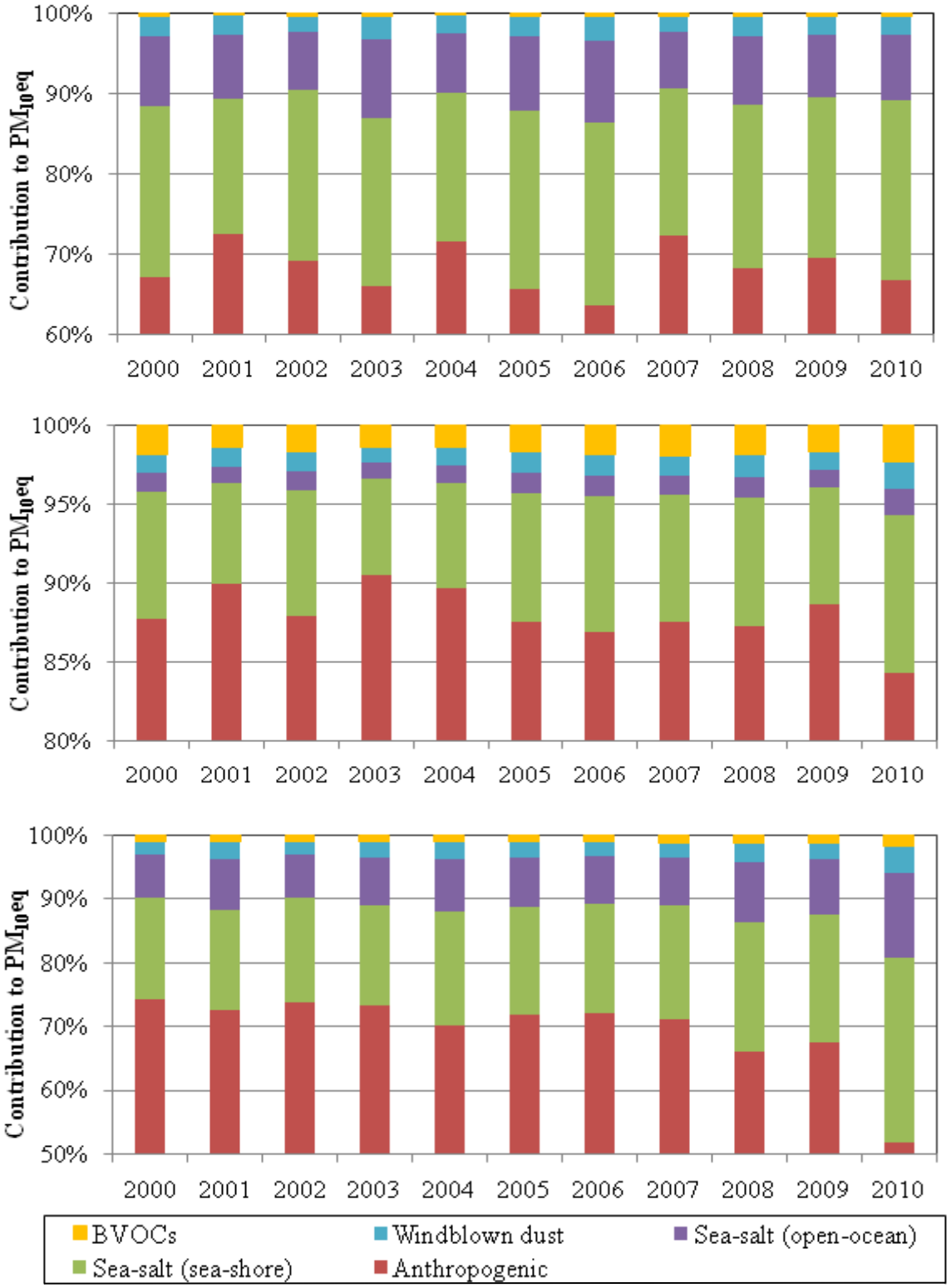

Figure 14. Contribution from natural sources to total annual primary and secondary particle emissions (PM_{10}) in AMA (top), TMA (middle) and VGA (low) for the period 2000-2010.

order of 10% is anticipated for transportation emissions. The corresponding changes in 2020 are expected to be of the order of 30% for transportation emissions. For residential and commercial emissions, the corresponding increases are expected to be 5 and 15% for 2015

and 2020 respectively. Finally, industrial emissions are expected to present a constant increase regarding natural sources, the projected changes in temperature, precipitation and land use are expected to enhance windblown dust emissions.

References

EMEP/CORINAIR, Emission Inventory Guidebook (2009) Technical Report No 9, European Environmental Agency, http://reports.eea.eu.int/EMEPCORINAIR4/en.

Deliverables & Milestones

All **Milestones** and **Deliverables** of Action 4 were achieved according to the foreseen time schedule (Table 7). No major problems were encountered in this Action. Deliverables D10 – D13 are attached to the present Report.

Continuation after the end of project: The emission inventories compiled for the years 2010-2013 have been used in the development of **ACEPT-AIR Policy Tool**. TUC and AXON will **update the Tool's database** with emission inventories for the years to come, as they become available either from the **National Emission Inventories** submitted in the framework of Greece's environmental reporting obligations to the European Environmental Agency and the United Nations Economic Commission for Europe, or from newly compiled inventories by the two project partners.

Table 8. List of Deliverables and Milestones for Action 4. Foreseen and actual dates of completion are also shown.

Completion of Deliverables	**Foreseen date**	**Actual date**
D10. Emission inventories for the three urban areas (AMA, TMA, GVA), for anthropogenic and natural sources, for the past decade (2000-2010)	31/08/2012	31/08/2012
D11. Spatial and temporal disaggregation of emissions for the past decade (2000-2010)	30/11/2012	30/11/2012
D12. Emission inventories for the three urban areas (AMA, TMA, GVA), for anthropogenic and natural sources, for 2010-2013 and projections for the future	28/02/2014	28/02/2014
D13. Spatial and temporal disaggregation of emissions, for 2010-2013 and projections for the future	28/02/2014	28/02/2014
Achievement of Milestones	**Foreseen date**	**Actual date**
M6. Completion of data collection	02/2012	02/2012
M7. Completion of data processing and analysis and of models application (compilation of emission inventories) for the past decade (2000-2010)	08/2012	08/2012
M8. Completion of spatial and temporal disaggregation of emissions for the past decade (2000-2010)	11/2012	11/2012
M9. Completion of data processing and analysis and of models application (compilation of emission inventories) for 2010-2013 and projections for the future	02/2014	02/2014
M10. Completion of spatial and temporal disaggregation of emissions for 2010-2013 and projections for the future	02/2014	02/2014

5.1.4. Action 5. An operational platform for the Control PM concentrations Policy Tool

Action 5 started on March 2011 and was completed on May 2013, according to the foreseen time schedule (Table 2). In the framework of this Action the **Operational Platform (OP) of ACEPT-AIR Policy Tool** was developed. The OP was constructed in such a way as to include all available data on PM concentrations and source contributions (based on emission inventories and receptor modelling) for the three studied areas: Athens, Thessaloniki and Volos. All these data were used by ACEPT-AIR Policy Tool in order to assess **trends in concentrations and emissions** in the course of the years, as well as to **calculate changes** in PM concentration levels related to **control measures** or specific conditions leading to emission reductions or increases. The development of ACEPT-AIR Polity Tool Operational Platform was performed by **AXON** (Action leader) with the collaboration of all project partners.

Design of OP modules

The design of the Operational Platform modules was carefully planned by all ACEPT-AIR partners in order to ensure a functional, user friendly Policy Tool. The **main issues** were summarized by AXON in the form of a questionnaire which was circulated to all partners and were: (1) Which should be the specific functional possibilities of the OP; (2) Which are the specific air pollutants concentration and emissions levels that will be inserted; (3) Should other kind of data be used as well; What will be the time resolution of the input data; (4) Will historical data be used and for which period for each area; (5) Which will be the structure and the format of input data; In which form should the final results (output) be presented; (6) Will future projections be made? (7) Which assumptions and scenarios should be examined; (8) What possibilities of intervention to the Policy Tool's databases and scenarios should be allowed to partners and end-users.

The general concepts and functionalities of the Policy Tool were also discussed during the 1st Informative Meeting with stakeholders, held in Athens on 14/12/2011.

The interaction between project partners as well as the feedback obtained by stakeholders during the 1st Informative Meeting led to the identification of the **main objectives** of the Policy Tool:

- Complete overview of the PM concentrations measured and calculated emissions at the three studied areas;
- Estimation and direct presentation of the effects of specific interventions on PM concentrations in selected Greek regions;
- Access in relative information described in scientific papers and other material published in the international press.

According to the above mentioned objective, the **structure** of the Tool's Operational Platform was determined. The final OP design included three interconnected yet clearly separated parts ('3-tier approach'):

- the Database and programming related to manage it;
- the Business Logic ('Business Tier') that includes the code referring to the update and calculations to be performed;
- the Presentation Interface.

Development of OP modules

Following the finalization of OP design, AXON proceeded to the development of the different modules, as described below:

Development of Input Databases: **PM and gaseous pollutant concentration** data obtained from all stations of the National Network of Air Quality Monitoring as well as from the Municipality of Thessaloniki network have been incorporated into the Policy Tool database. In addition to air pollutants' concentration data, the Policy Tool includes **emission source data**. Specifically, relative contribution of emission sources to PM concentration levels for different regions, particle fractions (PM_{10} or $PM_{2.5}$) and years are provided. These data correspond to previous source apportionment studies of ACEPT-AIR partners, as well to the results obtained by receptor modelling in the framework of Action 3. Moreover, the emission inventory data collected and analyzed in the framework of Action 4 have been incorporated and are presented with respect to: Distribution of emission sources for each pollutant and emissions' time series, spatial allocation and daily variations. Emission source data are also used by the OP calculation code in order to quantify changes in PM concentrations due to variation in emission source strengths, as described below.

Development of the Calculation Code: ACEPT-AIR Policy Tool **calculation code** was based on the assumption that the increase or decrease in PM concentration (ΔC) caused by a specific source (i.e. traffic, residential heating or industrial activities) is proportional to the respective **increase or decrease of this source's emission rate** (tons/year). This assumption has been proven to be reasonable in the case of traffic emissions that have been the main anthropogenic PM source in Athens Metropolitan Area during the last decades (Progiou and & Ziomas, 2011). Since source apportionment results from Action 3 have demonstrated that **secondary aerosol formation** may constitute a major PM source, changes in PM concentrations were also related to changes in emissions of precursor gaseous pollutants: sulfur dioxide (SO_2), nitrogen oxides (NOx), ammonia (NH_3) and mon-methane volatile organic compounds (NMVOCs). Aerosol formation potential factors (Table 9) have been used in order to quantify the emissions of different secondary pollutants based on the relevant emissions of precursor gases, according to the methodology presented by de Leeuw (2002). During the initial testing of ACEPT-AIT Policy Tool its has been acknowledged that PM concentration changes over a long period (such as 10 years) could be the result of changes in local emissions as well as an increase or decrease of the **background concentration** over these years. For that reason, an additional change in PM concentration ($\Delta C_{background}$) may be included in the calculation algorithm, if the user considers that it is relevant. Based on the above, the general equation used in the calculation code is presented below:

$$\Delta C = C_{new} - C_{old} = C_{old} \cdot [\sum_{i=1}^{n} (\Delta PE_i \cdot SA_i) + \sum_{j=1}^{k} (\Delta SE_j \cdot SA_j)] + \Delta C_{background} \quad (1)$$

where: C_{new} and C_{old} are the initial and final (after emission changes) PM concentrations [μg m^{-3}]; n is the number of primary PM sources and k is the number of sources of gaseous precursors; PE are the PM emissions from primary sources and ΔPE are the respective reductions/increases expressed as a fraction of the initial emission rate; SE are the emissions of gaseous precursors and ΔSE are the respective reductions/increases expressed as a fraction of the initial emission rate; SA is the relative contributions of the specific source to the total PM concentration, as quantified by receptor modeling; $\Delta C_{background}$ is the estimated change in the background concentration.

Table 9. Aerosol formation potential factors used in the calculation code of ACEPT-AIR Policy Tool (de Leeuw, 2002).

Precursor gas	Aerosol formation potential
SO_2	0.54
NOx	0.88
NH_3	0.64
NMVOCs	0.02

Development of the Presentation Interface: Special attention has been given in the development of the presentation interface, since this interface is the main **communication medium** between the user and the developed Policy Tool. The Interface has been designed in a way to be user friendly, easy to handle and operational at the same time.

Testing of OP modules

The functionality of the different OP modules was **tested by means of historical data** available from: (i) the measurements of the National Monitoring Network (NMN), (ii) emission inventories developed by AXON and TUC and (iii) source apportionment studies conducted in the past by NCSR "D" and AUTH. During this stage the format of data presentation and the relevant selection categories available to the user were decided. In addition, the **calculation code was tested by running trial scenarios** for Athens and Thessaloniki, where source apportionment results from previous years were available. Mean PM_{10} concentration, calculated from all the NMN stations of the Athens Metropolitan Area, for the 2012 was reproduced with input data: (i) the corresponding PM_{10} concentration in 2002, (ii) source apportionment results for 2002, (iii) emission rate changes between 2002 and 2012, as quantified by emission inventories and (iv) the change in background concentration between 2002 and 2012, obtained from Finokalia station, a remote coastal site in the North-East of the island of Crete. This site is characterized as natural background and may be considered representative of the background conditions of the Eastern Mediterranean area (Gerasopoulos et al., 2006). Similarly, mean PM_{10} concentration measured by the Municipality of Thessaloniki on 2012 was reproduced with input data: (i) the corresponding PM_{10} concentration in 2007, (ii) source apportionment results for 2007, (iii) emission rate changes between 2007 and 2012, as quantified by emission inventories and (iv) the change in background concentration between 2007 and 2012, obtained again from Finokalia station. The calculated concentrations were **20% higher** in the Athens case study and **8% lower** in the Thessaloniki case study. The results were considered very promising considering the uncertainties involved in the calculations (e.g. source apportionment in Athens for 2002 was performed for a site different than the NMN stations where PM concentrations were measured).

Integration of OP modules and completion of OP development

The developed OP modules were integrated into the ACEPT-AIR Policy Tool. The final **Tool functions** were divided into three main categories:

- Data Presentation where the stored data (emissions, graphics, scientific publications etc) can be presented in different ways;

- Scenarios Build-up where the stored emissions data can be processed taking into account certain scenarios in order to forecast potential future concentrations changes/trends;
- DataBase where the tool databases can be accessed in order to see, update, delete or add new data.

A detailed **Application guide and manual for the ACEPT-AIR Policy Tool** has been developed which includes: Installation guidelines, Description of all the functions of the Operational Platform and Working examples that assist end users to understand and take advantage of all the features of the developed Policy Tool. The developed Policy Tool was demonstrated during the 2nd Informative Meeting for stakeholders, held in Thessaloniki on 22/02/2013. According to the feedback obtained during the meeting, some changes mostly related to the Presentation Interface have been performed, leading to the **final version of ACEPT-AIR Policy Tool**. The Policy Tool and its Application guide and manual have been provided to all stakeholders.

References

Gerasopoulos E., Kouvarakis G., Babasakalis P., Vrekoussis M., Putaud J.-P., Mihalopoulos N. (2006) Atmos. Environ., 40: 4679–4690.
de Leeuw F.A.A.M. (2002) Environ. Sci. Policy, 5: 135–145.
Progiou A.G., Ziomas I.C. (2011) Sci. Total Environ., 410-411: 1–7.

Deliverables & Milestones

All Milestones and Deliverables of Action 5 were achieved according to the foreseen time schedule with no major problems (Table 10). ACEPT-AIR OP (Deliverable D14) and its Application guide and manual (Deliverable D15) are attached to the present Report.

Table 10. List of Deliverables and Milestones for Action 5. Foreseen and actual dates of completion are also shown.

Completion of Deliverables	**Foreseen date**	**Actual date**
D14. Operational Platform (OP) for the "ACEPT-AIR" Policy tool	28/02/2013	28/02/2013
D15. Application guide and manual for the OP	30/09/2013	30/09/2013
Achievement of Milestones	**Foreseen date**	**Actual date**
M11. Development of OP modules (database, integration of source apportionment)	08/2012	08/2012
M12. Testing of OP modules by means of historical data	12/2012	12/2012
M13. Integration of modules and completion of the OP development	02/2013	02/2013

Continuation after the end of project: The Operational Platform of ACEPT-AIR Policy Tool has been designed in such a way as to allow end users to access its database and **update** the relevant input data (on PM concentrations or emissions). AXON and NCSR "D" have committed to providing all necessary **support to end users**, related either to the use of the Tool or its update. The ACEPT-AIR Tool support scheme has been planned in the framework of Action 12 "After-life communication & continuation plan".

5.1.5. Action 6. Development and application of a two-way direct interaction process with stakeholders

Action 6 started with a delay of one month on February 2011 and was completed at the end of the project, on August 2014 (Table 2). In the framework of this Action, a two-way direct **interaction** process with **key stakeholders** was developed and implemented, with the purpose of **communicating** the project outcome, obtaining **feedback** and promoting the use of **ACEPT-AIT Policy Tool** by local, regional and national authorities. The Action was coordinated by **AUTH** (Action leader) and all project partners were actively involved.

The **key stakeholders** of the project were local, regional and national authorities at the studied areas:

- The Ministry of Environment, Energy and Climate Change (MEECC)
- The Coalition of 21 Local Authorities of North and East Athens, encompassing at least one third of the Athens Metropolitan area
- The Municipality of Thessaloniki
- The Regional Unit of Magnesia and Sporades (former Prefecture of Magnesia)
- The association of Motor Vehicles Importers – Representatives.

During the project implementation, several **other stakeholders** were involved and participated in the project informative events: The Municipalities of Galatsi, Marousi, N.Ionia, Chalandri and Keratsini-Drapetsona in Athens Metropolitan Area and the Municipality of Delta in Thessaloniki Metropolitan Area, the Directorate of Environment and Spatial Planning of Central Macedonia, the Directorate of Development of the Regional Unit of Pieria, the Hellenic Statistical Authority, the Organization of Planning and Environmental Protection of Thessaloniki, Volos Port Authority S.A., AGET Cement Industry, the Pan-Hellenic Network of Ecological Organization (PANDIKO), the Regional Unit of Agria, FREE RECYCLE company for electrical appliances recycling, the Public Power Corporation S.A. and Technical Chamber of Greece

Information activities

During the course of the project implementation, NCSR "D", AUTH and UTH were in close **communication with the local and regional authorities** in their respective areas providing them with updates on the progress of the project and obtaining feedback. NCSR "D" and AXON also communicated on a regular basis with the Ministry of Environment, Energy and Climate Change (MEECC), discussing key issues and specific management needs in relation to the application of an integrated environmental policy for ambient air quality. Apart from these informal communications, ACEPT-AIR team organized three **Informative Events** with the participation of all project stakeholders and other interested parties. The minutes of each Event were sent to all interested participants. During all meetings and Informative Events **views and needs** of stakeholders were recorded, providing valuable material for the development of the Policy tool.

The **1st Informative Event** was organized in collaboration with the Coalition of 21 Local Authorities of North and East Athens. The event was held on **14/12/ 2011**, at the Municipality of Chalandri, in **Athens**, with a total of 42 participants (Figure 15). Representatives of the Ministry of Environment, Energy and Climate Change, a number of Municipalities of the wider Athens area, the Municipality of Thessaloniki, the Prefecture of Magnesia, FREE RECYCLE company and local press have attended. In addition, Mrs. G. Valaoras,

representative of ASTRALE Monitoring Team, and Prof. A. Chaloulakou, member of the external evaluation team, were among the participants. ACEPT-AIR partners presented the main objectives and actions of the project, as well as initial results from the summer measurement campaign and the compilation of emission inventories. The presentations were followed by a live discussion between ACEPT-AIR team and stakeholders, regarding the results presented as well as the stakeholders' role during the implementation of the project.

Figure 15. Photos from the Informative Events for stakeholders held in Chalandri, Athens on December 2011 (left) and in Volos on 4/4/2013 (right).

The **2nd Informative Event** was held at the Municipality of **Thessaloniki** on **5/4/2013**, with a total of 84 participants (Figure 16). Apart from representatives of key stakeholders, other Municipalities in the Thessaloniki Metropolitan Area, the Public Power Corporation S.A., the 15th Primary School of Evosmos, the Directorate of Environment and Spatial Planning of Central Macedonia, the Directorate of Development of the Regional Unit of Pieria, the Organization of Planning and Environmental Protection of Thessaloniki and the Hellenic Statistical Authority attended. The event was advertized through several press releases in the local press and online information platforms. ACEPT-AIR partners provided an update on the progress achieved, including: the final outcome of the measurement campaigns and chemical characterization of PM in the three studied cities, the developed ACEPT-AIR Database, Emission inventories compilation and the results from the application of source apportionment techniques. In addition, Dr. M. Petrakakis from the Municipality of Thessaloniki presented data on the evolution of PM concentrations in Thessaloniki before and after the financial crisis. The presentation of results was followed by a demonstration of the Operational Platform of ACEPT-AIT Policy Tool by Dr. Eleftheriadis (NCSR "D") and Dr. Progiou (AXON). The Event closed with a discussion among participants regarding details on the results presented, as well as ways of effective use of the project outcome after its completion

The **3rd Informative Event** was held in **Volos** on **4/4/2014**, with the participation of key stakeholders only (Figure 15). This event was dedicated to the training of stakeholders in the use of ACEPT-AIR Policy Tool. Prior to the event and by the end of 2013 all stakeholders had in their procession an initial version of **ACEPT-AIR Policy Tool (installed by project partners)** and relevant **Training Material**. The objectives of the 3rd Informative Event were to record **feedback** on the functionalities of the Tool, possible problems or suggestions and to provide **formal training** on the Tool after the hand-on experience stakeholders had already

gained by using it for the past few months. Among the topics discussed during the Event were the methodologies applied for the development of the Tool's calculation code and the included databases on concentrations and emission strengths. Dr. Eleftheriadis (NCSR "D") demonstrated in detail all the functionalities of the Tool, discussing as well on the different emission scenarios that may be applied and the best ways to make use of the Tool's outcome with respect to environmental management and development of effective control strategies. Based on the comments received at this last event, the **final version of ACEPT-AIR Policy Tool** was developed at the end of July 2014.

Figure 16. Photos from the Informative Event for stakeholders held in Thessaloniki on 5/4/2013.

Active participation of stakeholders in the project implementation

During the field measurement campaigns, NCSR "D" and AUTH have had the opportunity to collaborate closely with the Ministry of Environment, Energy and Climate Change, the Coalition of 21 Local Authorities of North and East Athens and the Municipality of Thessaloniki. All three stakeholders assisted in site selection / preparation issues and were constantly held informed of the progress of the measurement campaigns. In addition, NCSR "D" has contacted the Coalition of 21 Local Authorities of North and East Athens to examine the possibility of organizing short-term measurements at a number of municipalities. There was increased interest by the part of the municipalities and Mobilab was employed in order to conduct measurement in as many sites as possible (as described above in 5.1.1).

Deliverables & Milestones

In general, **Milestones and Deliverables** of Action 6 were achieved according to the foreseen time schedule with no major problems (Table 11). Some small **delays** in the realization of the Informative Events were mainly due to the **availability of stakeholders** since an effort was made to ensure maximum participation at all events. Deliverable D17 was updated on April 2014, after the 3rd Informative Event, in order to include the minutes from this event as well. Deliverables D16 (Training material for stakeholders), D17 (Minutes, invitations, lists of participants and photos for the informative Events) and D18 (The final updated version of ACEPT-AIR Policy Tool) are attached to the present Report.

Continuation after the end of project: In the course of the project, ACEPT-AIR partners in Athens, Thessaloniki and Volos have developed a close and fruitful collaboration with the

local, regional and national authorities. The adoption of ACEPT-AIR Policy Tool by these authorities ensures the use of ACEPT-AIR project outcome after the project end. The project partners will maintain the communication with these key stakeholders, providing support in the application of the Policy Tool as well as updated databases on concentrations and source strengths, to be used in the Tool and for air pollution mapping and management. ACEPT-AIR provided the valuable opportunity to project partners to demonstrate their capacity with respect to provision of data and scientific expertise to the relevant authorities. The active involvement of stakeholders throughout the project implementation is a promising start for a continuous collaboration after the end of the project. Nevertheless there is a concern, in view of the economic and political crisis Greece is currently facing, that the personnel and other budget cuts inflicted may result to partial neglect of certain social and political aspects, such as the protection of the environment and public health. ACEPT-AIR team will continue to promote these issues and to provide all available information and know-how in order to assist national, regional and local authorities towards the planning and implementation of effective environment strategies.

Table 11. List of Deliverables and Milestones for Action 6. Foreseen and actual dates of completion are also shown.

Completion of Deliverables	**Foreseen date**	**Actual date**
D16. Training material composed for the stakeholders' seminars	31/08/2013	31/08/2013
D17. Minutes of the views and comments expressed in the framework of the interaction process with stakeholders	30/09/2013	31/04/2014
D18. Updated version of the developed tool platform, based on the stakeholders' feedback	31/07/2014	31/07/2014
Achievement of Milestones	**Foreseen date**	**Actual date**
M14. Installation of the "ACEPT-AIR" Policy tool and all other necessary infrastructure across the Urban Regions and particularly at the three pilot zones	12/2013	12/2013
M15. Organization of informative and training seminars, intended only for stakeholders	12/2011 12/2012 12/2013	12/2011 04/2013 04/2014

Complementary actions outside LIFE: During ACEPT-AIR measurement campaigns, a number of municipalities in Athens Metropolitan Area expressed an interest in acquiring and **installing PM monitoring equipment** in their regions. NCSR "D" discussed with them on the possibilities and resources needed. The Municipality of N. Ionia finally purchased a sequential PM sampler which was installed with the assistance NCSR "D" personnel. NCSR "D" continues to provide support to the Municipality in relation to sample weighing and data analysis.

5.1.6. Action 7. Active application of the developed policy tool

Action 7 started on October 2011 and was completed with a delay of one month at the end of the project, on August 2014 (Table 2). In the framework of this Action **an active application of the developed Policy Tool** was performed, in order to **verify** its operational **utility** at an early stage, to provide stakeholders and other interested parties with **initial results** regarding the effectiveness of specific control measures and to **demonstrate** to local, regional and national authorities the **usefulness** of the "ACEPT-AIR" Policy tool and its cost-effective approach towards developing an integrated environmental policy.

Application of emission control scenarios

Application of the ACEPT-AIR Policy tool included **quantitative tests**, where reductions of major sources as a result of corresponding measures/scenarios were used as input to the OP, and the results were assessed (Figures 17 and 18). The measures considered were targeting reductions to the relevant anthropogenic sources where reductions are possible such as : Traffic exhaust and non-exhaust emissions, emissions from biomass burning for residential heating, fuel combustion from industrial and all non-traffic sources (shipping, commercial sector, residential heating) and industrial emissions. As a measure of the efficiency of a general emission reduction in all anthropogenic sources it was calculated that a **20% reduction in emissions** resulted in a **16% to 19% reduction of PM_{10}** depending on the urban area (receptor) where the lowest effect was observed in the urban background sites and the highest at the central traffic sites. A **wealth of information** can be derived from the Policy Tool outcome, regarding the effectiveness of mitigation measures. Areas where dense traffic is the major source of PM_{10} and in our case Thessaloniki central areas are such an example, a 20% reduction of traffic emissions alone can reduce concentrations by 13 %. On the contrary the same traffic reduction in Athens suburban areas can only provide a 4% reduction of PM concentrations. In the latter the major source is biomass burning for residential heating and emphasis should be given by authorities to limit the effects of this pollution source.

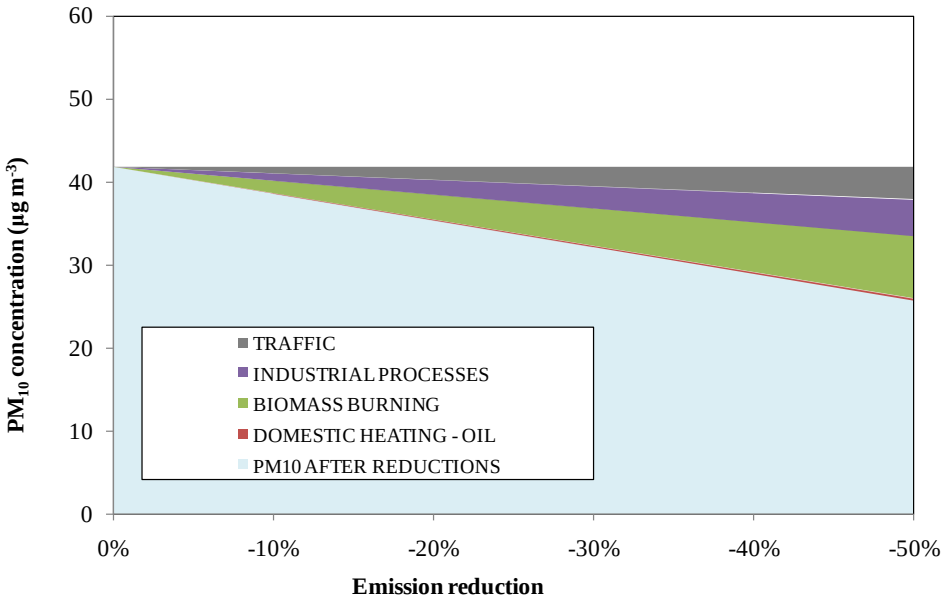

Figure 17. The cumulative result to PM_{10} concentrations at an urban site in Athens of emission reductions in each displayed source was calculated by the ACEPT AIR tool.

Proposed mitigation measures for reduction of PM concentrations

Measures proposed by ACEPT-AIR for Greek cities based on PM speciation and source apportionment obtained during 2011-2012 and the most efficient reductions achievable as calculated from the ACEPT-AIR Policy Tool are summarized at Table 12 below.

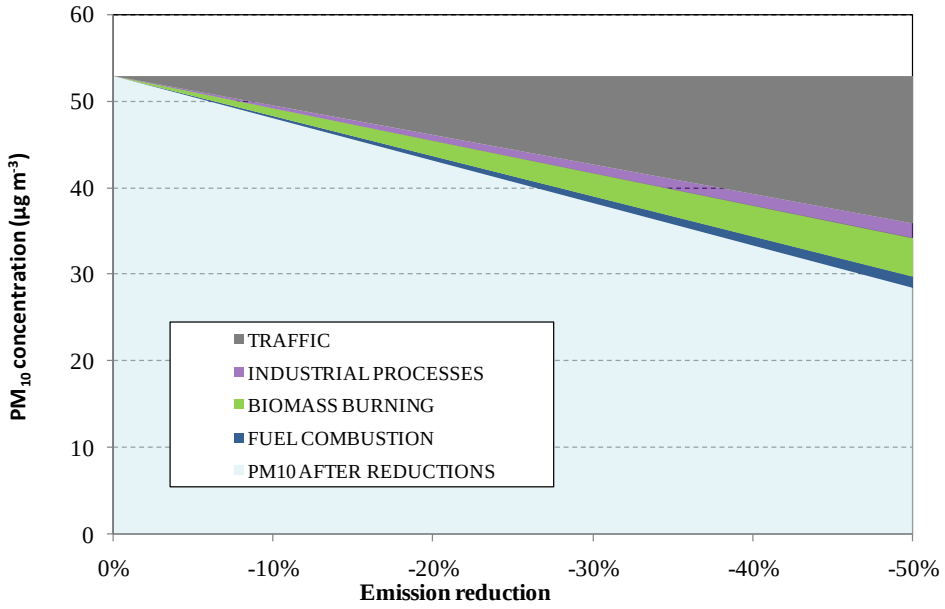

Figure 18. The cumulative result to PM_{10} concentrations at Thessaloniki traffic impacted site of emission reductions in each displayed source was calculated by the ACEPT AIR tool.

Table 12. Proposed measured for the reduction of PM concentration in Greek cities.

Road traffic	
Low emission zones (LEZ)	Expand and prioritize the recently (2012) implemented free access for Euro 5 or newer technology vehicles emitting less than 140 g/km or hybrids in the "green ring".
Parking	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	Tandem use of sweeping and, more importantly, water washing, especially during dry periods of the year.
Promoting low-carbon and low-NOx vehicles and new technology vehicles	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. Incentives for installation of particle filters in heavy duty commercial vehicles.
Expand public transport Network	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).
Reducing road transportation for	Creating a terminal outside the Athens Metropolitan

goods	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 fleet	Subsidies for increasing the share of hybrid, natural gas and new technology private vehicles and taxis.
Reduced fares of public transport	Reduced fares for public transport during intensive Sahara dust intrusions or forecasted intense pollution episodes
Improving public fleet	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	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	
Combat the illegal trade of adulterated fuel	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	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	Impose high standards for fuels and increase inspections to facilities.
Stricter legislation for harbour	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.
Precursors of secondary particles	
Reduce precursors of secondary particles, mainly SO_2	Expansion of Greek natural gas system in order to link more cities and industries to the system.
Reduce trans-boundary pollution due to the use of fossil fuels in large industrial facilities and power plants in European developing countries	Policy makers must intensify efforts for resolving problems of trans-boundary pollution in Europe, by providing support and incentives to developing countries to turn towards cleaner fuels and production processes.
Biomass burning	
Reduction of low efficiency wood burning for residential heating	Introduction of natural gas and renewable energy sources; Improvement of the thermal behaviour of residential buildings; Promotion of energy efficiency appliances and heating equipment; News bulletins advising for reduction in wood burning during forecasted atmospheric stagnation periods; Information material and training of citizens regarding the negative health impact of uncontrolled biomass burning.
Local population bad practices	
Environmental education and awareness raising	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.

Deliverables & Milestones

Milestone M16 was achieved according to the foreseen time schedule (Table 13). The Operational Platform of ACEPT-AIR Tool was completed by the end of February 2013 and the initial application of the Policy Tool was completed a year later (February 2014). Nevertheless Deliverables D19 and D20 were finalized with a **delay** of 5 months in order to take into account the comments of the external evaluators as expressed in the Plenary Meeting held in Athens on 17 and 18/3/2014. This delay did not affect the successful implementation of the project. The development of a simplified algorithm that relates PM emissions and concentrations in the air is a challenging work, given the complexity of the processes involved (such as primary and secondary aerosol formation etc.). In this context, the feedback and suggestions of external evaluators who are considered experts in the field was essential towards the development of a reliable Policy Tool. Deliverable D19 and D20 are attached to the present Report.

Table 13. List of Deliverables and Milestones for Action 7. Foreseen and actual dates of completion are also shown.

Completion of Deliverables	**Foreseen date**	**Actual date**
D19. PM concentration reductions in relation to the implementation of specific measures / scenarios, apportioned to changes in different source categories	31/03/2014	31/08/2014
D20. Proposed measures for the attainment of required PM concentration reductions	31/03/2014	31/08/2014
Achievement of Milestones	**Foreseen date**	**Actual date**
M16. Initial application of the "ACEPT-AIR" Policy Tool, to estimate relationships between PM concentration reductions and the implementation of specific measures	02/2014	02/2014

Continuation after the end of project: The continuous application of ACEPT-AIR Policy Tool is a major objective of the project. Among target users are the relevant authorities and policy makers as well as other interested parties, such as private companies who need to assess the effectiveness of new technologies for emission control. The large publicity achieved through a well planned dissemination scheme is expected to help towards the adoption of the Policy Tool by different stakeholder groups. In addition, the continuous support of ACEPT-AIR partners to the Tool end users (in terms of specific functionalities of the Tool as well as updating of input databases) and the existing collaborations with the national, regional and local authorities will further promote the use of the Policy Tool in the future.

5.1.7. Action 10. Monitoring of Project progress

Action 10 started on March 2011 and was completed at the end of the project on August 2014 according to schedule (Table 2). In the framework of this Action the general **progress** of the project implementation was **monitored** though a committee of external evaluators. The Action was coordinated by **NCSR "D"** (Action leader) and all project partners were actively involved. The **external evaluators committee** comprised of three experts in the field: Prof. Roy Harrison (University of Birmingham, UK), Dr. Xavier Querol (CSIC, Spain) and Prof. Archontoula Chaloulakou (NTUA, Greece).

Amendment of Action 10

During the preparation of the Inception report, the project's Management Board and Steering Committees reviewed the monitoring scheme described in the initial proposal and concluded that both the methods employed and expected results were not clear and feasible in certain cases. For this reason, an **amendment of Action 10** was proposed and included in the Inception Report (Annex X) submitted on 4/4/2011. The amendment was accepted by the E.C. on 27/7/2011.

According to the amended monitoring scheme, the external consultants were sent all **Reports** submitted to the E.C. in order to follow the project progress. In addition, they participated in two **plenary meetings**, at the beginning (end of the 1st year) and towards the end of the project. Based on the reports and personal communication with the Project Manager and the Steering Committee, the three experts evaluated the project progress in relation to the initial situation, objectives and expected results.

Dr. X. Querol and Prof. R. Harrison participated in the **3rd plenary meeting** on **4/11/2011** in **Athens** and had the opportunity to meet and discuss with all partners (Figure 19). Prof. Chaloulakou visited NCSR "D" on a later date (**13/1/2012**) and discussed in detail with the Project Manager and Scientific Secretary. Following the meetings, the three external evaluators have prepared and submitted to the Project Manager their **1st evaluation report**, summarizing their comments and suggestions. The reports were forwarded to all beneficiaries for further study. There was a general consensus regarding the satisfactory progress achieved. A number of **interesting points** were put forward by the evaluators relating to the analysis of chemical speciation data, the contribution of secondary aerosol and in particular organic carbon, the application of receptor modeling and the contribution of African dust and forest fires to PM levels.

Dr. X. Querol and Prof. R. Harrison also participated in the **7th plenary meeting** on **17-18/3/2014** in **Athens** (Figure 19). Following the meeting, the two external evaluators prepared and submitted to the Project Manager their **2nd evaluation report**. Both evaluators expressed their approval of the methodological approaches used in ACEPT-AIR Polity Tool. They also commented on the results of the source apportionment (SA) analysis which constitute a major part of the Tool's input data and affect greatly its output. They both agreed that some refinement was needed on the SA results especially since two different receptor models (PMF and CMB) were used. Based on these comments, NCSR "D" and AUTH repeated the source apportionment analysis, which lead to two significant **improvements in the Tool calculation code**: (i) the contribution of secondary organic aerosol was considered in the calculation code of the Tool and (ii) source profiles for secondary inorganic and organic aerosol were used in CMB modeling, providing contribution estimates for these sources as well in agreement with PMF modeling.

Figure 19. Photos from the visit of external evaluators during the 3rd and 7th Plenary Meetings, in Athens on 4/11/2011 (left) and 17-18/3/2014 (right), respectively.

Deliverables & Milestones

All **Milestones and Deliverables** of Action 10 were achieved prior to the foreseen time schedule (Table 14). Prof. Chaloulakou withdrew from the external evaluators committee during the 2nd year of the project implementation due to personal circumstances. The implementation of Action 10 continued with no major problems with the remaining two evaluators. Deliverables D28 refers to the two Evaluation reports. The first one has been submitted along with the Mid-term Report and the second one is attached to the present Report.

Table 14. List of Deliverables and Milestones for Action 8. Foreseen and actual dates of completion are also shown.

Completion of Deliverables	**Foreseen date**	**Actual date**
D28. Documented efficiency quantified in the two evaluation reports	30/11/2014	30/04/2014
Achievement of Milestones	**Foreseen date**	**Actual date**
M26. Publication of two evaluation reports (attached in Mid-term and Final project report respectively)	10/1012 11/2014	06/2012 04/2014

Continuation after the end of project: The participation of Dr. Querol and Prof. Harrison in the ACEPT-AIR evaluation committee has enhanced the collaboration between the project partners and the University of Birmingham and CSIC research groups. ACEPT-AIR project partners have and continue to benefit from this interaction and exchange of expertise.

5.1.8. Action 11. Action plan formulation for PM reduction

Action 11 started on February 2013 and was completed at the end of the project on August 2014 with a 6 month delay (Table 2). In the framework of this Action a comprehensive **characterization of air quality** in relation to particulate matter at the three studied areas was performed. In addition, the application of ACEPT-AIR Policy Tool along with the outcome of source apportionment analysis was used in order to develop a **specific set of measures and policies** for each area, in line with the concentration reductions required by Directive 2008/50/EC. The Action was coordinated by **NCSR "D"** (Action leader) and all project partners were actively involved.

Characterization of air quality in relation to particulate matter

The **PM_{10} and $PM_{2.5}$ concentrations** in Athens Metropolitan Area (AMA), Thessaloniki Metropolitan Area (TMA) and the city of Volos have been studied in detail with respect to concentration levels, chemical composition and quantitative source apportionment analysis by receptor modelling. The **threshold limits** of both $PM_{2.5}$ and PM_{10} were not exceeded in the suburban areas of the Athens, Thessaloniki and Volos but this is not a result that should lead to complacency towards effective mitigation measures for the reduction of air pollution in this large urban area. The concentrations were much higher in the traffic impacted central areas with fewer but yet emerging **exceedances** (Figure 20). The levels of $PM_{2.5}$ in AMA stations were below the target value of 25 μg m^{-3} at urban background sites and close to the target value at urban traffic stations. In spite of the decreasing trend of PM concentrations more efforts has to be made, in order to attain the WHO guidelines, and to prevent future exceedances under the economic recovery and less favourable meteorological scenarios.

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.

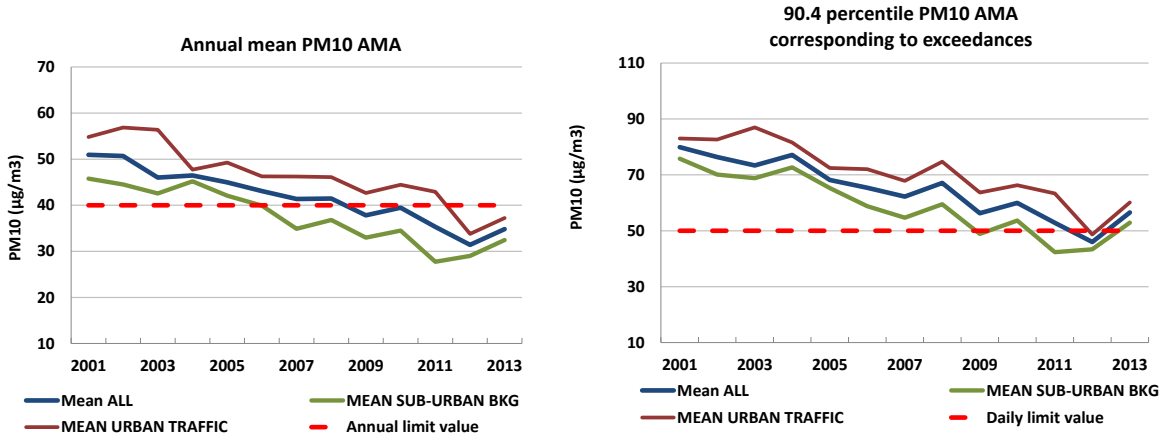

Figure 20. PM_{10} concentration long-term trend analysis for the AMA stations of the National Monitoring Network (ALL) and separately for urban traffic and sub-urban background (SUB-URBAN BKG) stations: Mean annual values (left) and 90.4 percentile values (right) which corresponds to the concentration of the top 35 days per year.

One interesting observation here 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, it is observed at considerably higher concentrations 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, also 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 area. Nevertheless **exceedances still persist** in central and other traffic impacted areas. 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. During 2011-2012 the current dataset shows 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 in comparison to 7% in PM_{10} and 11% in $PM_{2.5}$ during 2002. **Traffic emissions** from vehicle exhaust and non exhaust origins remains 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. 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 bellow 10% for $PM_{2.5}$).

Apart from anthropogenic sources, not insignificant contributions were also calculated for **Natural sources**, especially for the PM_{10} size fraction, highlighting the presence of high natural background levels in Greece. **Sea salt** accounted for 8%, 4% and 7% at urban background sites in Athens, Thessaloniki and Volos. The respective relative contributions for **Mineral dust** were 16%, 7% and 18%. A significant natural source affecting mainly Southern Greece is the **long range transport of African dust**. The contribution of African dust in PM_{10} concentrations was estimated for all three cities, based on the methodology proposed by Escudero et al. (2007) and adopted by EC (2011). The average contribution of African dust to PM_{10} concentrations during the ACEPT-AIR campaigns was estimated equal to 1.85 μg m-3 in Athens, 0.57 μg m-3 in Thessaloniki and 0.37 μg m-3 in Volos. The respective relative contributions were equal to 6.6%, 1.6% and 0.8%.

Guidelines for Action Plan formulation

The objective of integrating the outcome of ACEPT-AIR project into the environmental Directorates followed by Greek authorities has led to the compilation of a set of control measures, to be used as Guidelines for the formulation of a national Action Plan for the reduction of pollution from particulate matter. The interaction with project key stakeholders constituted a significant part of the process. The initial objective was to acquire a clear image of the current environmental policies followed in Greece. Detailed information was provided by the Ministry of Environment, Energy and Climate Change which is responsible for air quality monitoring and management. Following the documentation of current situation, with respect to concentrations, emission sources and control strategies, ACEPT-AIR project results and experience gained were used for the compilation of a set of control measures, to be used as Guidelines for the formulation of Action Plans for the reduction of pollution from particulate matter.

ACEPT-AIR project outcome highlight the need to develop targeted control measures in the future in order to achieve further reductions of particulate matter concentrations in the air. Three general emission sources have been identified as the main contributors to increased PM concentrations and exceedances of the EU air quality standards: Road traffic, Biomass burning and Secondary aerosol production by gaseous precursors (nitrogen and sulfur oxides and volatile organic compounds). Based on the project results and the consultation process with key stakeholders, and mainly the Greek Ministry for the Environment, Energy and Climate Change, a set of control measures has been developed and provided as guidelines for the preparation of a National Air Quality Plan. These measured have been endorsed by the National, Regional and Local authorities of the three cities (Athens, Thessaloniki and Volos), as documented in the letters submitted as Annex in the present Report.

References

EC (2011) Commission Staff Working Paper on establishing guidelines for demonstration and subtraction of exceedances attributable to natural sources under the Directive 2008/50/EC on ambient air quality and cleaner air for Europe, Brussels.

Escudero M., Querol X., PeyJ., Alastuey A., Pérez N., Ferreira F., Alonso S., Rodríguez S., Cuevas E. (2007) Atmos. Environ., 41: 5516–5524.

Deliverables & Milestones

Deliverable D29 was completed according to the foreseen time schedule (Table 15). **Milestone M27** and **Deliverable D30** were achieved with a **delay** of 6 months due to enhancement made on ACEPT-AIR Policy Tool after the suggestions made by the external evaluators committee (as described above in 5.1.8). This delay did not affect the successful completion of the project. Deliverables D29 and D30 are attached to the present Report.

Table 15. List of Deliverables and Milestones for Action 11. Foreseen and actual dates of completion are also shown.

Completion of Deliverables	Foreseen date	Actual date
D29. Characterization of air quality in relation to particulate matter at the three areas studied and contribution of natural sources to exceedance events	28/02/2014	28/02/2014
D30. Mitigation measures and policies for the control of particulate pollution	28/02/2014	31/08/2014

Achievement of Milestones	Foreseen date	Actual date
M27. Publication of Guidelines for effective action plan formulation for the three urban areas, containing a detailed description of the PM concentration levels, the natural and anthropogenic sources controlling them, mitigation measures and policies in order to achieve the limit values and concentration reductions required by Directive 2008/50/EC, as well as the reduction potential for $PM_{2.5}$ concentrations.	02/2014	08/2014

Continuation after the end of project: The Control measures / Guidelines for Action Plan formulation have been developed in close collaboration with the relevant authorities in order to ensure official approval and subsequent inclusion of these guidelines in the formulation of the National Action Plan. Letters of endorsement have been received by all key stakeholders, representing the National, Regional and Local authorities in the three cities.

5.2. Dissemination actions

5.2.1. Objectives

The objective of the dissemination plan developed in the framework of ACEPT-AIR project was to **convey the key aspirations and results** of the project and **raise awareness** towards particulate air pollution and emissions control. The **target audience** included policy makers, professional groups, general population groups, as well as the scientific community, given that all the above play or have the potential to play a major role in air quality management. Two **Actions (8 and 9)** were dedicated to dissemination and included a variety of information activities, as described below. **Action 6** was also designed to disseminate the project outcome to key stakeholders but was considered as part of the technical work since it included a two-way interaction between project partners and stakeholders. The feedback obtained in the framework of this Action was fully exploited and resulted in the final version of the ACEPT-AIR Policy Tool, designed in line with stakeholders' needs and aims.

5.2.2. Action 8. Organization of an Open Forum and an International Conference

Action 8 started on June 2011 and was completed on July 2014 according to schedule (Table 2). In the framework of this Action an **Open Forum** for key stakeholders and an **International Conference** were organized. The Action was coordinated by **UTH** (Action leader) and all project partners were actively involved.

Open Forum for key stakeholders

The **Open Forum** for key stakeholders was organized in **Volos** on **3/4/2014**, with a total of 26 participants from local and regional authorities, industry and NGOs. Among the **participants** were representatives from the Municipality of Thessaloniki, the Regional Unit of Magnesia and Sporades, Volos Port Authority S.A., the Labor Union of AGET Cement Industry, the Pan-Hellenic Network of Ecological Organization (PANDIKO), the Regional Unit of Agria,

the Technical Chamber of Greece, the Natural history Museum of Volos and the Environmental Education Center of Makrinitsa (Figure 21).

Figure 21. Photos from the Open Forum held in Volos on 3/4/2014.

The Forum opened with **presentations by members of ACEPT-AIR team** on long term trends of particulate air pollution in Greece, the objectives and outcome of ACEPT-AIR project and a demonstration of the possibilities offered by ACEPT-AIR Policy tool for emissions management and control. Following the presentations, stakeholders with different incentives and interests, from both the public and private sector, were able to **exchange views**, knowledge and experience and highlight different aspects of the issue of air quality management. The event was covered by the **local press** and a number of articles were published the next day.

International Conference

The **ACEPT-AIR International Conference** was held in Skiathos island on 3/7/2014, as a nest event to "Protection and Restoration of the Environment PREXII" international conference, in an effort to attract larger participation from the international scientific community. In total **19 papers** were included in the LIFE 09 “ACEPT-AIR” Conference and were presented in **3 sessions** (Figure 22). Among them, 8 presentations were held by members of the consortium of ACEPT-AIR project and 4 presentations were held by other LIFE project beneficiaries (PM3, AIRUSE, MAPEC and MED PARTCILES). Several **experts in the field of air pollution** have accepted ACEPT-AIR invitation and presented their recent research activities, such as Prof. N. Mihalopoulos (University of Crete, Greece), Dr. T. Moreno (Institute of Environmental Assessment and Water Research, IDAEA-CSID, Spain), Dr. K. Sega (Institute for Medical Research and Occupational Health, Croatia), Dr. G. Engling (National Tsing Hua University, Taiwan), Dr. O. Popovicheva (Lomonosov Moscow State University, Russia).

Deliverables & Milestones

All **Milestones and Deliverables** of Action 8 were achieved according or prior to the foreseen time schedule with no major problems (Table 16). Deliverables D21 and D22 are attached to the present Report.

Figure 22. Photos from the International Conference held in Skiathos island on 3/7/2014.

Continuation after the end of project: The minutes of the Open Forum and the proceedings of the International Conference have been published in ACEPT-AIR project website in order to further promote the ACEPT-AIR objectives and outcome after the end of the project and trigger exchange of views among policy makers, scientists and other interested parties.

Table 16. List of Deliverables and Milestones for Action 8. Foreseen and actual dates of completion are also shown.

Completion of Deliverables	**Foreseen date**	**Actual date**
D21. Minutes of the open forum organized in a Report form	31/07/2014	31/05/2014
D22. Proceedings of the international conference	31/08/2014	31/08/2014
Achievement of Milestones	**Foreseen date**	**Actual date**
M17. Organization of the open forum (Quantification of participation among stakeholders invited)	07/2014	04/2014
M18. Publication of the forum's outcomes on the project's web site	08/2014	05/2014
M19. Organization of the international conference (Extent of participation of foreign expert groups)	08/2014	08/2014

5.2.3. Action 9. Dissemination and mobilization of society

Action 9 started on January 2011 and was completed at the end of the project on August 2014 according to schedule (Table 2). In the framework of this Action several **information activities** targeted for the general public were realized, with the aim to publicize the project objectives and results and **mobilize local societies** towards air quality, reduction of emissions and the adoption of environmentally friendly lifestyle and practices. The Action was coordinated by **UTH** (Action leader) and all project partners were actively involved. A short description of the different dissemination activities is provided below.

Erection of notice boards: 4 informative boards describing the project objectives and outcome were prepared and were displayed at centrally located sites in the three studied cities

(Athens, Thessaloniki and Volos). In Athens two notice boards were placed outside the Environmental Radioactivity Laboratory in NCSR "D" and at the NCSR "D" measurement station (Figure 23). In Thessaloniki a notice board was installed at the Ionos Dragoumi Air Pollution Monitoring Station of the Municipality of Thessaloniki. In Volos a notice board was placed at the Department of Planning and Regional Development of the University of Thessaly. The **initial target** of **3 noticed boards** has been achieved.

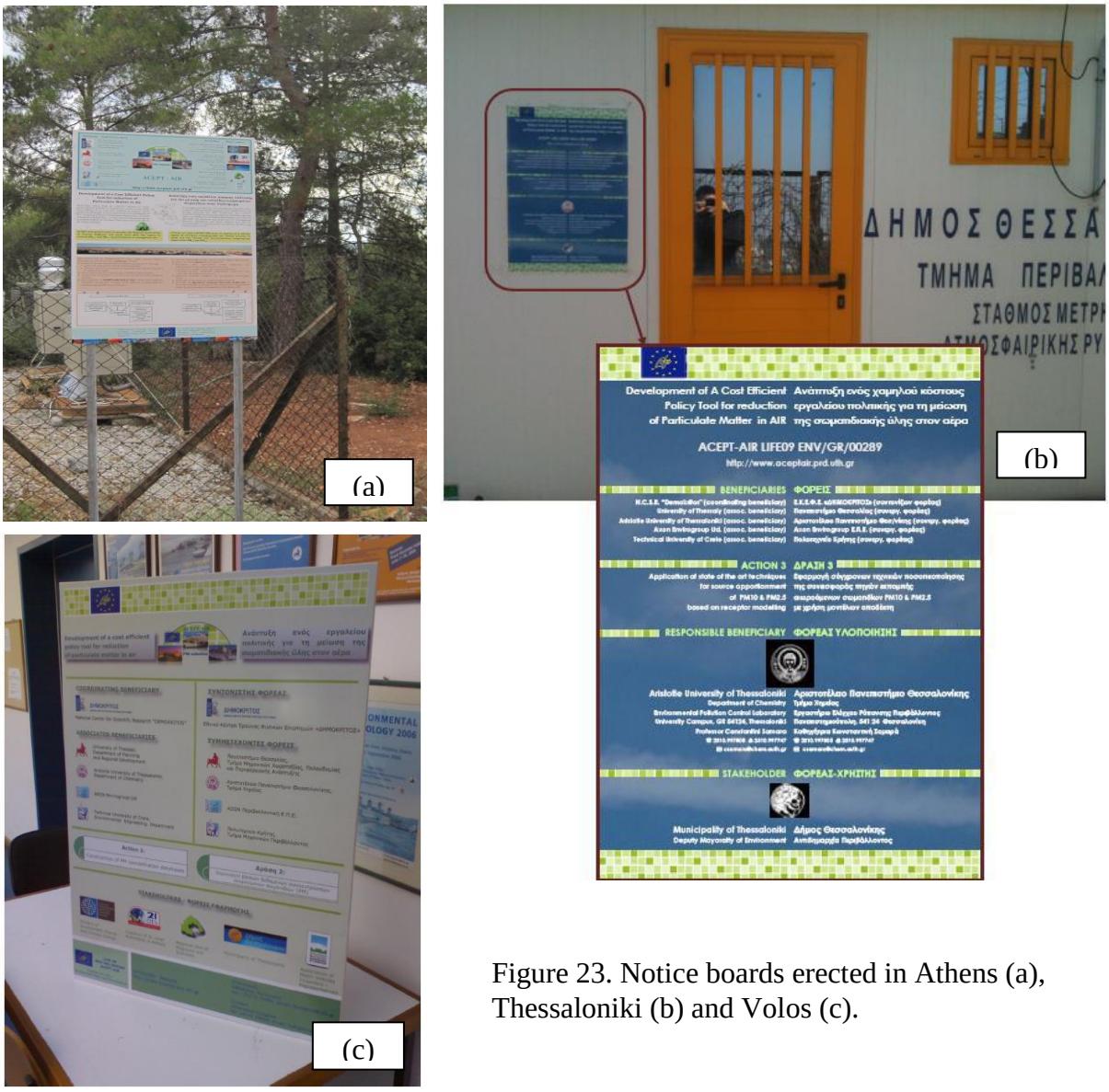

Figure 23. Notice boards erected in Athens (a), Thessaloniki (b) and Volos (c).

Life logo: Stickers with the LIFE logo were placed in all equipment purchased in the framework of the project. In addition the LIFE logo was used in all material produced for the project and the LIFE flag was used in all ACEPT-AIR events.

Press releases and articles: A number of press releases were issued by ACEPT-AIR project team in order to advertise the project implementation and the realization of measurement campaigns in Athens, Thessaloniki and Volos (in total **3 press releases**) and the Informative Events and the Open Forum targeted to stakeholders (in total **9 press releases**). In addition **8 newspaper articles** and **6 internet articles** were published in the national and local press in the framework of the project. The articles included results from the measurements conducted

in the studied cities as well as comments of ACEPT-AIR team members on the effects of PM pollution and the project objectives and outcome with respect to major emission sources and air quality management. The **initial target** of **2** press releases, **4** general public articles in national and local press, **2** specialised press articles and **5** internet articles has been reached.

Radio interview: 1 radio interview was organized to communicate the project outcome, as foreseen in the Grant Agreement. Mr G. Proias (UTH) was interviewed by Mrs. Kekatou at ERT - ERA radio station (101.2 FM) on 9/3/2012 regarding the scope of the project and actions involved, as well as initial results from the measurement campaigns in Volos.

Informative material (leaflets, brochure and DVD): Three informative **leaflets** were produced during the project implementation (in Greek and English). The first leaflet advertised the project objectives, while the second and third leaflet presented results from PM measurements and source apportionment. A **brochure** was also produced (in Greek and English) advertising the project aims and outcome, with special focus on the developed Policy Tool. A **DVD** was prepared, containing information on all project actions and relevant results, as well as educational material on PM pollution and general guidelines for the reduction of emissions and the protection of public health. The DVD was produced in Greek since it was intended for the local general public in Athens, Thessaloniki and Volos. In total **5,000** copies of the leaflets, **400** copies of the brochure and **167** DVDs were distributed. The initial target was **300** copies for the leaflets and **100** copies for the brochure.

Seminars for secondary education teachers: Secondary education teachers' seminars were organized in Volos (17-18/4/2013), Thessaloniki (16-17/12/2013) and Athens (27-28/1/2014), with a participation of **19, 31 and 60 teachers** at each city respectively (Figure 24). The seminars focused on particulate air pollution, their sources and effects, as well as monitoring and modelling methodologies. Discussion between participants, lecturers and other members of ACEPT-AIR team followed the presentations. The participants were provided with a booklet containing **Educational Material** composed specifically for the seminars and a certificate of participation.

Figure 24. Photos from the teachers' seminars organized in Volos (left) and Thessaloniki (right).

Website: The project website (**www.aceptair.prd.uth.gr**) is on air from January 2011 and is frequently updated. It contains detailed information on the project objectives, actions and

results. All information is in Greek and English. The website will remain functioning for at least 5 years after the completion of ACEPT-AIR project. Around **3,000 visitors** were recorded on a monthly basis at the last months of the project (**target** value **120 visitors** per month). A public profile of ACEPT-AIR project was also created at social networking media (Facebook) with the view to enhance interaction with the general public.

Layman's report: A Layman's report has been published (both in Greek and English) providing an overall description of the project objectives and actions as well as its major results and achievements. The report is available in electronic format from the project website. In addition **50 copies** have been distributed to the general public, as foreseen in the Grant Agreement.

Technical publications: **5 papers** were published in international scientific journals, as foreseen in the Grant Agreement. In addition, ACEPT-AIR team members participated in **19** international and national **conferences** communicating the project results to the international scientific community through oral or poster presentations.

Deliverables & Milestones

All **Milestones and Deliverables** of Action 9 were achieved according or prior to the foreseen time schedule with no major problems (Table 17). The only **problems encountered** relate to the organization of **seminars for secondary education teachers**, which was **delayed due to low participation**. UTH initially contacted the Directions of Secondary Education in all three cities. A low level of interest was observed especially in Athens and Thessaloniki, probably related to the large number of teachers' seminars advertised each month as well as the teachers' strikes during 2013. A more direct form of communication was employed at a second stage in order to increase participation. The seminars were advertized to the relevant Teachers' Societies (such as Chemistry or Physics), while Directions of schools in the areas where ACEPT-AIR measurement campaigns were performed were also contacted. The seminars were organized with a total of **110 participants**, a number considered satisfactory with respect to the **initial target of 120 participants**. Very positive feedback was obtained from the participating teachers, despite the initial low interest. Deliverables D23 - D27 are attached to the present Report.

Table 17. List of Deliverables and Milestones for Action 9. Foreseen and actual dates of completion are also shown.

Completion of Deliverables	Foreseen date	Actual date
D23. Informative and dissemination material: • Informative notice boards, in Athens, Thessaloniki and Volos • Articles in the local and national press • Informative leaflets and DVDs	30/06/2014	30/06/2014
D24. Informative material composed for the teachers' seminars	31/08/2012	31/08/2012
D25 .The project website	28/02/2011	31/01/2011
D26. A Layman's report	30/06/2014	30/06/2014
D27. Technical publications in international journals and proceedings of international conferences	31/08/2014	31/08/2014

Achievement of Milestones	Foreseen date	Actual date
M20. Creation of the project website	02/2011	01/2011
M21. Information material	08/2011	08/2011
M22. Organization of teachers' seminars (quantification of participation in relation to initial target)	08/2012	04/2013 12/2013 01/2014
M23. Publication of articles in local and national press and quantification of the extent of their reach	06/2014	06/2014
M24. Preparation of the "layman's report	06/2014	06/2014
M25. Technical papers accepted for publication in international journals and / or presentation in international conferences	08/2014	08/2014

Continuation after the end of project: ACEPT-AIR notice boards remain erected at the three cities, while the project website will continue functioning for at least 5 years after the project end. A number of technical publications are being prepared to be submitted to international journals, further publicising the project results. In addition, ACEPT-AIR team members will present key outcome in conferences, workshops and other networking events. During a workshop organized by LIFE AIRUSE project on "Quantitative methods for evaluating daily contributions of African dust to ambient PMx levels over Europe during dust outbreaks" (Barcelona, Spain, 27-28/4/2015), ACEPT-AIR Project Manager, Dr. Eleftheriadis, presented results from on Saharan dust contribution during the ACEPT-AIR measurement campaigns.

Complementary actions outside LIFE: ACEPT-AIR team members have been promoting air quality management and effective emission control strategies, which are key concepts of ACEPT-AIR project as well, through relevant presentations:

- The Project Manager Dr. K. Eleftheriadias gave a speech at the opening session of the Conference EcoTexnologia 2011, held at NCSR "D" on 12/3/2011, related with "The effects of PM in the environmental pollution and public health".
- Prof. C. Samara (AUTH) gave a speech during the opening session of the 21st Hellenic Conference on Chemistry (Thessaloniki, 9-12/12/2011) entitled "Airborne Particulate Matter: Chemical composition and bioactivity".

In addition, the Project Manager was participated in the following networking and outreaching events in order to communicate the project results:

- Briefing for Policy Makers Event on "Health Effects of Air Pollution", Brussels, 31/1/2013: The event was organized by the European Commission, the World Health Organization Regional Office for Europe, and the Health Effects Institute (U.S.A.). The Coordinator of ACEPT-AIR considered that this was an opportunity to communicate the results of the project to key stakeholders and get first reactions from the outcome of the review of the EU Air policy and the Year of Air and the package of measures considered by the European Parliament and the Council.
- 3rd AirMonTech Workshop "Current and Future Urban Air Quality Monitoring", Duisburg, 4 - 5/3/2013: The project progress and the Introduction of the Policy Tool were presented to an audience of Air Pollution Health Effects specialists, at the FP7 Research Project focusing on Air Pollution Monitoring Technologies for Urban areas. The ACEPT-AIR presentation, entitled "Policy Tool for Reduction of PM in Air", is available at the

following link: http://www.airmontech.eu/fileadmin/airmontech/user/2013-presentations/10_Eleftheriadis.pdf

5.2.4. Action 12. After-life communication & continuation plan

Action 12 started on July 2013 (Table 2). In the framework of this Action an **After-Life communication & continuation plan** was developed in order to secure the exploitation of the project outcome after its completion. The Action was coordinated by **UTH** (Action leader) and was performed in collaboration with NCSR "D".

The **main aspects** of the After-Life communication & continuation plan which aspires to ensure the sustainability of the project outcome and further promote its objectives are:

- A modified project website including key strategies and experience gained through ACEPT-AIR project. The website will be operating for a minimum of 5 years. A link to the modified ACEPT-AIR website from the Coalition of 21 Local Authorities of North and East Athens webpage has been created, further enhancing the visibility of ACEPT-AIR key messages.
- Submission of new proposals for the continuous funding of NCSR "D" and AUTH research groups in an effort to produce updated source apportionment results in the future. NCSR "D" and AUTH are already collaborating in the framework of other projects and initiatives such as FAIRMODE and have submitted together new research proposals. NCSR "D" is participating in a new LIFE project, AIRUSE, which will provide information on the contribution of natural sources to PM concentration levels in Athens. Source apportionment on new datasets will be also performed. AIRUSE outcome is expected to be very useful with respect to changes in emissions sources and relevant strengths during the beginning of the financial crisis in Greece (ACEPT-AIR campaigns) and the years to follow. All the available results from AIRUSE or other future projects will be used to update the Policy Tool databases and will be made available to the relevant national, regional and local authorities.
- AXON and TUC have committed to updating the emission inventories of the Policy Tool whenever they have new available data.
- A technical support desk has been created for ACEPT-AIR Tool users. Two members of NCSR "D" team (S. Vratolis, permanent staff of NCSR "D" and E. Diapouli) have been assigned to run the help desk which will be maintained for a minimum of 5 years. All stakeholders involved have been given the relevant contact information.
- ACEPT-AIR Policy Tool manual has been published in the project modified website in order to attract additional end users. A contact link to NCSR "D" is included in case there is an interest to obtain the Policy Tool.
- Demonstration of ACEPT-AIR Policy Tool and the project results by the Project Manager or other ACEPT-AIR team members in workshops, conferences etc. Enhanced visibility of the project objectives and outcome may attract new users as well as new collaborations that will assist towards the continuation of work done in the framework of ACEPT-AIR and the production of new data.

Deliverables & Milestones

Deliverables D31 and **D32** were completed according to the foreseen time schedule (Table 18). **Milestones** for this Action refer to indicators of progress to be assessed after the end of the project. Deliverables D31 and D32 are attached to the present Report.

Table 18. List of Deliverables and Milestones for Action 12. Foreseen and actual dates of completion are also shown.

Completion of Deliverables	**Foreseen date**	**Actual date**
D31. Publication of After-Life Communication plan	31/08/2014	31/08/2014
D32. Adoption of a modified project website of key strategies by key stakeholder	31/08/2014	31/08/2014
Achievement of Milestones	**Foreseen date**	**Actual date**
Sustainability of target audience		
Stakeholders participation in the development of respective strategies they could effectively employ in their respective fields of operation to contribute into PM reduction		
Continual public response through the access of information on the website		
The rate of number of visitors over time being kept at similar levels as during the projects development		
Friendly environmental policy making in the development of new industries		
Introduction of key legislation for existing and new industries to demonstrate steps or strategies they will employ in controlling emissions		

5.3 Evaluation of Project Implementation

5.3.1. Methodological approaches

The methods applied in the framework of the project are widely used in the field of air pollution. **PM sampling and mass determination** was performed according to reference methods ISO/IEC EN-12341 and ISO/IEC EN-14907. All **analytical methods** for chemical speciation are also used by the world scientific community, as documented in the relevant references provided. **Receptor modelling** and **emission inventories** are also common methodological approaches for PM source apportionment. The capacity of NCSR "D" and AUTH in applying receptor models is documented by their participation in the FAIRMODE (Forum for Air quality Modelling) community. The use of two different receptor models (PMF and CMB) was resource-consuming both in terms of number of PM samples and work time for chemical analysis and model application. Nevertheless it was considered important to include both models since they are the most commonly used in receptor modelling, while they may provide insight into different aspects of source apportionment, as discussed in Deliverable D8 of Action 3. The compilation of emission inventories was also based on state-of-the-art methodologies. Both source apportionment approaches (receptor modelling and emission inventories) were used in the ACEPT-AIR Policy Tool calculation code which relates ambient PM concentrations with emission strengths for the various natural and anthropogenic, primary or secondary sources.

A critical part of the project was the development of **ACEPT-AIR Policy Tool** and in particular of its calculation algorithm. The challenge was to develop a simple mathematical formula which does not require complex input data but is still able to capture the major effects of the different atmospheric processes affecting PM concentration levels. The applicability of the Tool for long-term air quality management has allowed for yearly trend analysis and estimates, which are not affected by daily meteorology and seasonal variability. In that way input data were reduced to mean yearly concentrations, emission strengths and source contributions. The positive comments received from the external evaluators, whose expertise in the field is significant, regarding the methodological approach used in the development of the Tool provided ACEPT-AIR team with confidence for the validity of the calculations. The effectiveness of the Tool in estimating PM concentrations based on emission strengths and source contribution data was further assessed quantitatively through the use of historical data, as described in 5.1.4. The results of this initial application of the Tool were very promising and indicated that the developed Policy Tool may provide reliable estimates of the changes of mean yearly PM concentrations due to increases or decreases in specific emission sources.

5.3.2. Achievement of objectives

The project implementation has been considered successful in terms of achieving not only the general aims but also the specific objectives set for each Action. A detailed presentation of the foreseen and obtained results for each Action is provided in Table 19.

Table 19. Assessment of obtained results in relation to foreseen objectives in the Gran Agreement.

Task	Foreseen in the revised proposal	Evaluation of achievement
Action 1: Project Management		
Preparation of submission of **5 Reports** to the EC	Submission of 5 Reports	All Reports have been accepted by the EC, excluding the present Report which is now submitted.
Action 2: Construction of PM concentration databases		
ACEPT-AIR Database containing: (i) Historical data; (ii) PM_{10} and $PM_{2.5}$ concentrations and chemical characterization obtained from the measurement campaigns in 2 sites at AMA, 2 sites at TMA and 1 site in VGA	PM_{10} and $PM_{2.5}$ concentration and chemical composition databases for the three urban areas (AMA,TMA and VGA)	The developed Database contains all the information foreseen in the initial proposal as well as historical data which may be useful for long-term trend analysis. The inclusion of all concentration data obtained in the framework of the project in one Database makes the data easily accessible to end users.
Action 3: Application of state of the art source apportionment techniques based on the developed databases and receptor modelling		
Source apportionment by **two receptor models** (PMF and CMB) have provided source profiles and respective contributions to PM_{10} and $PM_{2.5}$ concentrations at the 5 sites where measurements were conducted. Temporal variation has been examined with respect to seasonal variability and long-term changes based on historical data.	Chemical profile and respective contribution of aerosol sources on each region (AMA, TMA, GVA) in the $PM_{2.5}$ and PM_{10} fractions Temporal variation in source chemical composition and strength	All the tasks foreseen have been completed. The application of two different models allowed for comparison of results and provided insight into the advantages and disadvantages of each model.
Action 4: Construction of emission inventories		
Emission inventories for the three urban areas (AMA, TMA, GVA), for anthropogenic and natural sources, for the years 2000-2013 and future projections Spatial and temporal disaggregation of emissions	6 Emission inventories corresponding to 3 urban areas (AMA, TMA, GVA) and two types of emissions, from anthropogenic and natural sources. Spatial and temporal disaggregation of emissions	All deliverables foreseen for this Action have been completed. State-of-the-art methodologies have been applied for the compilation of emission inventories and the disaggregation of emissions.

Table 19 (continued). Assessment of obtained results in relation to foreseen objectives in the Gran Agreement.

Task	Foreseen in the revised proposal	Evaluation of achievement
Action 5: An operational platform for the Control PM concentrations Policy Tool		
The **Operational Platform** of the Tool has been developed A **manual** has been compiled for the Tool end users	Operational Platform (OP) for the ACEPT-AIR Policy tool and Application guide and manual	The functionality of the Operational Platform has been tested by means of historical data with very good results. A guide and manual has been produced and distributed to stakeholders along with the Policy Tool.
Action 6: Development and application of a two-way direct interaction process with stakeholders		
3 Informative Events have been organized for stakeholders. Minutes and list of participants from all three events are submitted as Deliverables. Training material was produced and distributed during the 3rd event which was dedicated to stakeholders' training on the Policy Tool. The final version of ACEPT-AIR Policy Tool has been completed.	Training material for the stakeholders' seminars Minutes of the views and comments expressed in the framework of the interaction process with stakeholders Updated version of the Tool platform, based on stakeholders' feedback	The Informative Events organized were considered successful both in terms of participation and of interest shown by stakeholders. Live discussions followed the presentations, as documented in the minutes of the events. The training material prepared for stakeholders summarizes the lessons learnt from the project implementation and is expected to further assist local and national authorities in the application of the Policy Tool and the development of cost-effective mitigation strategies. The final version of the Policy Tool has been adjusted based on stakeholders suggestions.
Action 7: Active application of the developed policy tool		
The initial application of the Policy Tool has provided PM concentration reductions based on specific emission control scenarios. These results were used in the development of **mitigation measures** proposed to stakeholders	PM concentration reductions in relation to the implementation of specific measures / scenarios, apportioned to changes in different source categories Proposed measures for the attainment of required PM concentration reductions.	The initial application of the Policy Tool has been successful. Concentrations and emissions trend analysis has shown that PM levels have been reduced during the last decade due to mitigation strategies. The application of the Policy Tool has provided evidence for prioritization of future control measures for further reductions. These results are expected to be used by the relevant authorities in the development of cost-effective environmental policies.
Action 8: Organization of an Open Forum and an International Conference		
Both events have been organized. The **Forum**'s minutes and the **Conference**'s proceedings are published in ACEPT-AIR website.	Open Forum and publication of the forum's outcomes on the project's web site International conference	The Open Forum was held in Volos with **26 participants** from regional and local authorities, NGOs and private sector. In total **19 papers** were included in the ACEPT-AIR Conference, with **7** works from **foreign research groups**.

Table 19 (continued). Assessment of obtained results in relation to foreseen objectives in the Gran Agreement.

Task	Foreseen in the revised proposal	Evaluation of achievement
Action 9: Dissemination and mobilization of society		
All **dissemination activities** foreseen have been realized, as described in detail in section 5.2.3.	Informative notice boards; Press articles; Informative leaflets and DVDs; Informative material for teachers' seminars; The project website; A Layman's report; Technical publications to scientific journals and conferences	The target numbers for dissemination have been either achieved or surpassed (e.g. copies of leaflets and other informative material, press articles, notice boards etc.). It was difficult to find contacts in the school Directions and advertise the seminars Participation in the teachers' seminars was slightly lower than expected since. Nevertheless there was increased interest by the participants during the seminars.
Action 10: Monitoring of project progress		
Two evaluation reports have been submitted by the external evaluators.	Documented efficiency quantified in the two evaluation reports	The amended description of this Action, submitted in the Inception Report, has allowed for a clear monitoring plan for the project progress. The external evaluators' comments and suggestions have been documented and were very useful for the implementation of the project.
Action 11: Action plan formulation for PM reduction		
The data collected during the project provided a comprehensive **characterization of PM pollution** and respective sources in the 3 cities. These data along with the initial application of the Policy Tool resulted in a **set of mitigation measures** to be used in action plan formulation.	Characterization of air quality in relation to PM at the three areas studies and contribution of natural sources to exceedance events Mitigation measures and policies for the control of PM	The outcome of Action 11 represents the general experience gained through ACEPT-AIR project communicated to stakeholders. The endorsement by national, regional and local authorities of the project outcome (documented by their letters after the end of the project) provides evidence that the Action plan guidelines developed by ACEPT-AIR will be used in future air quality management schemes and environmental strategies.
Action 12: After-life communication & continuation plan		
An after-Life plan has been developed. The project website has been modified to include all key results and has been linked to the website of the 21 OTA.	Publication of After-Life Communication plan Adoption of a modified project website by key stakeholder	The outcome of this Action will only be visible in the future. The developed after-Life plan and the modified website which will be functioning for at least 5 years after the end of the project are expected to ensure sustainability of target audience and continuous exploitation of the project outcome.

5.4 Analysis of long-term benefits

Environmental benefits: The project can improve the **effectiveness of National, Regional and Local policies** on ambient air quality by providing the means to prioritize emission control measures and take informed decisions based quantified PM reductions. The general objectives of ACEPT-AIR project are in line with the requirements of **Directive 2008/50/EC** for formulation of air quality plans and reductions of PM concentration levels, as well as **WHO** Guidelines on ambient PM concentrations and the protection of public health. The project has provided the relevant Greek authorities with a **comprehensive characterization** of PM_{10} and $PM_{2.5}$ pollution and corresponding emission sources in three characteristic urban areas in Greece. It has also developed a set of **mitigation measures** based on the data collected during the project as well as the application of ACEPT-AIR policy Tool, which can be used for the formulation of a national Action Plan. Moreover, **ACEPT-AIR Policy Tool** has been provided to the authorities, along with support training material. The project stakeholders have been already trained in the use of the Tool and ACEPT-AIR partners will continue to provide any support needed to end users. The **direct environmental benefits** of the project relate to resource savings from the implementation of cost-effective environmental policies and reductions of PM concentrations leading to attainment of air quality standards. These benefits cannot be seen immediately since they require the implementation of the proposed measures for an adequate time period (at least one year) in order to document the effect on PM concentration levels.

Long-term benefits and sustainability: The long-term benefits of this project include:

- A Polity Tool provided to policy makers for cost-effective air quality management: The Tool can be easily updated with new concentration and emission strength data in order to provide valid estimates for the following decades.
- Long-term resource savings by the implementation of cost-effective environmental strategies
- Strong partnership between authorities and other stakeholders with ACEPT-AIR partners, leading to continuous transfer of expertise
- Motivation of national authorities and stakeholders to enhance their current air quality policies
- High visibility of mitigation measures proposed in the guidelines for Action Plan formulation issued by the project
- Mobilization and education of local populations with respect to particulate air pollution, sources and effects as well as control strategies, including adoption of environmentally friendly practices in everyday life
- New business and employment opportunities in the area of air pollution mitigation
- Long-term health benefits for the local populations due to the improvement of ambient air quality by the implementation of effective emission control measures
- Cost savings from reductions in hospitalizations and work absences due to air pollution health effects
- Air pollution monitoring actions by local authorities and stakeholders motivated by their involvement in the project. The Coalition of 21 Local Authorities of North and East Athens, the Municipality of Thessaloniki and the Municipality of N. Ionia in Athens have already undertaken or intensified their monitoring activities.
- New data on PM concentrations and chemical speciation and on source apportionment provided by project partners. NCSR "D", AUTH, AXON and TUC have already committed to providing new data and updating the Policy Tool's databases.

Replicability, demonstration, transferability, cooperation: ACEPT-AIR Policy Tool may be applied to other regions as well. The software is provided free of charge to interested end users and is easy to use, which may be drivers for its more extensive application in the future. Nevertheless it requires input databases characteristic of the application region. PM concentration data are easily accessible from national monitoring networks. Emission strength and source contribution data require more resources and greater expertise to be obtained. ACEPT-AIR partners cannot supply these data for other areas of interest but will provide any support needed for the application of the Tool when the required input data are available. The Policy Tool may be useful also to private companies for the assessment of effectiveness of new technological solution on emission control with respect to ambient PM concentration levels. The high visibility of the project outcome and the demonstration of ACEPT-AIR Policy Tool may assist towards the mobilization of the general public to adopt control measures (such as reduction of the use of fireplaces for residential heating, more extensive use of public transportation) and to put pressure on the relevant authorities to implement effective mitigation strategies. Air quality management needs both policy makers and local populations / stakeholders in order to be successful. In this framework the dissemination plan of ACEPT-AIR project included all the above target groups.

Best Practice lessons: Several best practice methods for source apportionment have been used, including two types of receptor models (PMF and CMB) and emission inventories. The combination of these methods provided an added value to the project outcome and allowed for the association of PM concentrations with emission strengths used in the calculation code of ACEPT-AIR Tool. Application of the tool by policy makers may provide an assessment of the existing best practice measures and may indicate a need for adjustments for a more cost-efficient environmental policy.

Innovation and demonstration value: ACEPT-AIR Policy Tool is an innovative software that relates PM concentrations with emission strengths and provides estimates of changes in PM concentrations based on emission scenarios. The functionality of the Tool has been demonstrated to local stakeholders as well as abroad during networking events with international participation. The major innovative aspect of the Tool is its simple calculation code which does not require complex input data and detailed temporal variability of parameters.

Long term indicators of the project success: Future assessment of the project success may be quantified based on the following long term indicators:

- Adoption of control measures proposed by ACEPT-AIR project by National, Regional or Local authorities
- Sustainability of ACEPT-AIR Policy Tool in terms of its use by policy makers and updating of its databases
- Decrease of PM concentration levels and attainment of EU air quality standards
- Continuous exchange of experience and know-how between project partners and key stakeholders
- New data on emission strengths and source contributions
- Application of ACEPT-AIR Policy Tool in other regions.

6. Comments on the financial report

6.1. Summary of Costs Incurred

PROJECT COSTS INCURRED				
	Cost category	Budget according to the grant agreement	Costs incurred within the project duration	%
1.	Personnel	1,254,065.73	1,268,175.16	101.13%
2.	Travel	98,307.20	84,280.52	85.73%
3.	External assistance	76,000.00	75,792.45	99.72%
4.	Durables: total non-depreciated cost	45,780.30	45,347.05	99.05%
	- *Infrastructure sub-tot.*			
	- *Equipment sub-tot.*			
	- *Prototypes sub-tot.*	45,780.30	45,347.05	99.05%
5.	Consumables			
6.	Other costs	84,462.14	80,793.80	99.66%
7.	Overheads	65,714.78	56,159.59	85.46%
	TOTAL	**107,599.70**	**107.194.58**	**99.62%**

There has been no official amendment to the Budget of the GA but according to the Response letter of Joakim Capitao (28/11/2012):
"The changes proposed in the budget and listed below seem acceptable. Please note, however, that the eligibility of costs will be assessed at the time of the final payment. You should also note that the reference budget remains the one in the signed grant agreement and that, therefore, the impact of any other modifications needed in the future on the margin of flexibility of 10% / 30.000 € provided by the Common Provisions will need to be evaluated cumulatively.
Personnel: increased from 1.207.256 € to 1.248.085 €.
Travel: decreased from 126.267 € to 100.307 €.
External assistance: decreased from 83.500 € to 74.500 €.
Consumables: increased from 96.800 € to 98.800 €.
Other costs: increased from 51.617 € to 55.072 €."

6.2. Accounting system

Every beneficiary has a unique code and record for every project except for AXON. Every cost referring to the project is checked by the financial manager of the project and the accounting office of every beneficiary for its legality and eligibility.

The timesheets used for the time recording system were manually completed and signed by the responsible for the project for every beneficiary and the staff member, except for AUTH which uses a computerized recording system.

Every invoice contains a stamp with the details of the project that show the link to the LIFE+ project.

6.3. Partnership arrangements (if relevant)

The financial transactions between the coordinating beneficiary and the associated beneficiaries have been done through a bank transaction. The financial reporting is implemented by the associated beneficiaries themselves.

6.4. Auditor's report/declaration

Organization Name:	NEXIA EUROSTATUS A.E. CERTIFIED AUDITORS
Company's Reg. No.:	141
Address:	Head Office: 34, Frantzi Amvrosiou Street, 11745, Athens, Greece Branch: 108, Kallistratous Street, 15771, Athens, Greece
Name of the auditor:	Charalambides Antonios
Auditor’s Reg. No.:	18041

6.5 Summary of costs per action

Action no.	Short name of action	1. Personnel	2. Travel and subsistence	3. External assistance	4.b Equipment	6. Consumables	7. Other costs	TOTAL
1	**Project Management**	141.812,00 €	8.010,00 €	0,00 €	0,00 €	0,00 €	0,00 €	**149.822,00 €**
2	**PM2.5 and PM10 concentration databases**	130.169,00 €	17.533,00 €	0,00 €	43.062,00 €	69.721,00 €	4.886,00 €	**265.371,00 €**
3	**Source Apportionment application**	68.280,00 €	5.140,00 €	20.000,00 €	0,00 €	0,00 €	3.629,00 €	**97.049,00 €**
4	**Emission inventories**	123.786,00 €	3.337,00 €	13.489,45 €	0,00 €	0,00 €	4.200,00 €	**144.812,45 €**
5	**Development of Policy/management Tool**	115.551,00 €	0,00 €	29.000,00 €	2.285,05 €	0,00 €	1.629,00 €	**148.465,05 €**
6	**Demonstration of Policy/management Tool to stakeholders**	99.794,00 €	0,00 €	0,00 €	0,00 €	692,00 €	543,00 €	**101.029,00 €**
7	**Application of Operational version of the Policy Tool to the selected areas**	71.431,00 €	3.337,00 €	0,00 €	0,00 €	1.296,00 €	573,00 €	**76.637,00 €**
8	**Dissemination to public and private bodies**	144.333,00 €	33.441,00 €	2.494,00 €	0,00 €	1.048,80 €	17.372,59 €	**198.689,39 €**
9	**Dissemination and mobilization of society**	218.706,00 €	10.146,00 €	0,00 €	0,00 €	8.036,00 €	19.670,00 €	**256.558,00 €**
10	**Progress Monitoring**	90.235,00 €	3.336,52 €	10.809,00 €	0,00 €	0,00 €	2.171,00 €	**106.551,52 €**
11	**Action plan formulation for PM reduction**	64.078,16 €	0,00 €	0,00 €	0,00 €	0,00 €	1.486,00 €	**65.564,16 €**
Overheads								**107.194,58 €**
	TOTAL	1.268.175,16 €	84.280,52 €	75.792,45 €	45.347,05 €	80.793,80 €	56.159,59 €	**1.717.743,15 €**

7. Annexes

7.1 Administrative annexes

Administrative Annex: List of personnel employed in the project

The Partnership agreement has been submitted with the Inception report (Annex IV of Inception Report).

7.2 Technical annexes

List of abbreviations

Letters of endorsement for the ACEPT-AIR Life+09 ENV/GR/000289 Program

Deliverable D6. PM_{10} and $PM_{2.5}$ concentration databases for the three urban areas (AMA, TMA and VGA)

Deliverable D7. PM_{10} and $PM_{2.5}$ chemical composition databases for the three urban areas (AMA, TMA and VGA)

Deliverable D8. The chemical profile and respective contribution of aerosol sources on each region (AMA, TMA, GVA) in the $PM_{2.5}$ and PM_{10} fractions

Deliverable D9. The temporal variation in source chemical composition and strength

Deliverable D10. Emission inventories for the three urban areas (AMA, TMA, GVA), for anthropogenic and natural sources, for the past decade (2000-2010)

Deliverable D11. Spatial and temporal disaggregation of emissions for the past decade (2000-2010)

Deliverable D12. Emission inventories for the three urban areas (AMA, TMA, GVA), for anthropogenic and natural sources, for 2010-2013 and projections for the future

Deliverable D13. Spatial and temporal disaggregation of emissions, for 2010-2013 and projections for the future

Deliverable D14. Operational Platform (OP) for the "ACEPT-AIR" Policy tool

Deliverable D15. Application guide and manual for the OP

Deliverable D16. Training material composed for the stakeholders' seminars

Deliverable D17. Minutes of the views and comments expressed in the framework of the interaction process with stakeholders

Deliverable D18. Updated version of the developed tool platform, based on the stakeholders' feedback

Deliverable D19. PM concentration reductions in relation to the implementation of specific measures / scenarios, apportioned to changes in different source categories

Deliverable D20. Proposed measures for the attainment of required PM concentration reductions

Deliverable D28. Documented efficiency quantified in the two evaluation reports

Deliverable D29. Characterization of air quality in relation to particulate matter at the three areas studied and contribution of natural sources to exceedance events

Deliverable D30. Mitigation measures and policies for the control of particulate pollution

7.3 Dissemination annexes

7.3.1 Layman's report

Deliverable D26. A "layman's report"

7.3.2 After-LIFE Communication plan

Deliverable D31. Publication of After-Life Communication plan

Deliverable D32. Adoption of a modified project website of key strategies by key stakeholder

7.3.3 Other dissemination annexes

Deliverable D21. Minutes of the open forum organized in a Report form

Deliverable D22. Proceedings of the international conference

Deliverable D23. Informative and dissemination material

Deliverable D24. Informative material composed for the teachers' seminars

Deliverable D25. The project website

Deliverable D27. Technical publications in international journals and proceedings of international conferences

ACEPT-AIR project photos

7.4 Final table of indicators

Final table of indicators

8. Financial report and annexes

Standard Payment Request and Beneficiary's Certificate

Consolidated Cost Statement for the Project

Financial Statement of the Individual Beneficiary

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Auditor's report and Annexes