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Technical Assistance for Improving Air Quality and Raising Public Awareness in Cities in Turkey - CITYAIR (in line with CAFE Directive)

Contract N° TR2017 ESOP MI A3 01/SER/01

Activity 1.3: Strategy Paper on Future Steps of Air Quality Management

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REPUBLIC OF TURKEY MINISTRY OF ENVIRONMENT AND URBANISATION

Environment and Climate Action Sector Operational Programme

CityAir cleaner air - better life

AESA CONSORTIUM

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Project Summary Information

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	Activity 1.3: Strategy Paper on Future Steps of Air Quality Management
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Submitted on:	29.11.2019

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Abbreviations

AQM	Air Quality Model
AQAD	Air Quality Assessment Division of MoEU
BAQAM	By-law on Ambient Air Quality Assessment and Management
CA	Contracting Authority (MoEU, General Directorate of EU and Foreign Relations)
CAAP	Clean Air Action Plan
CAFE	Directive 2008/50/EC on Cleaner Air For Europe
DGEUFR	General Directorate of EU and Foreign Relations
DGEM	General Directorate for Environmental Management
CLRTAP	Convention on Long-Range Transboundary Air Pollution
EF	Emission Factor
EU	European Union
HEY	Air Emission Management (Hava Emisyon Yönetim) Portal
IPPC	Integrated Pollution and Prevention Control
MAAP	Multi-Annual Action Programme
MoEU	Ministry of Environment and Urbanization
NAPEMS	National Air Pollution Management System
NAQMN	National Air Quality Monitoring Network
NEC	Directive 2001/81/EC on National Emission Ceilings
NO_x	Nitrogen oxides
NMVOCs	Non-methane volatile organic compounds
NH_3	Ammonia
OVI	Objectively Verifiable Indicator
$PM_{2,5}$	Fine Particulate Matter, size 2.5 μm
PR	6 Monthly Progress Report
RCAC	Regional Clean Air Center
RSHC	Refik Saydam Hıfzıssıhha Merkezi
SCM	Steering Committee Meeting
SO_2	Sulphur dioxide
SCM	Steering Committee Meeting
SNAP	Standardized Nomenclature for Air Pollutants
TAT	Technical Assistance Team
TFEIP	Task Force on Emission Inventory and Projections
ToR	Terms of Reference
TSMS	Turkish State Meteorological Service

1. Strategy Paper on Air Management

Air quality management is a complex procedure that requires the following steps (Figure 1): I) Establish Goals; ii) Develop Emission Inventories; iii) Develop Control Strategies; iv) Implement Programs, and v) Evaluate Improvements. At the heart of these steps lies the scientific research which provides essential context and input for further improve the strategies. Each of these steps and their relationships are provided in the following section.

1.1 Establish Goals:

Effective air quality management systems include setting specific goals or standards that can be quantified. A transparent process is required for understanding, acceptance and implementation of goals and standards. In Turkey, air quality management goals are set by the Turkish Ministry of Environment and Urbanization. It should be noted that these standards are in alignment with European standards . Since science continually evolves over time, air quality standarts also evolve. In order to stay in line with scientific and technical advances, periodic reviews of goals are important to enhance the continual improvement in air quality.

Goals and standards related to air quality management can take different forms, such as :

- acceptable level of air pollutants in the air (excluding air toxics);
- emission limits of a source (e.g., industrial facility or an emission point in the facility); and
- limit on the content of fuel (e.g., gasoline) or in a product (e.g., paint)

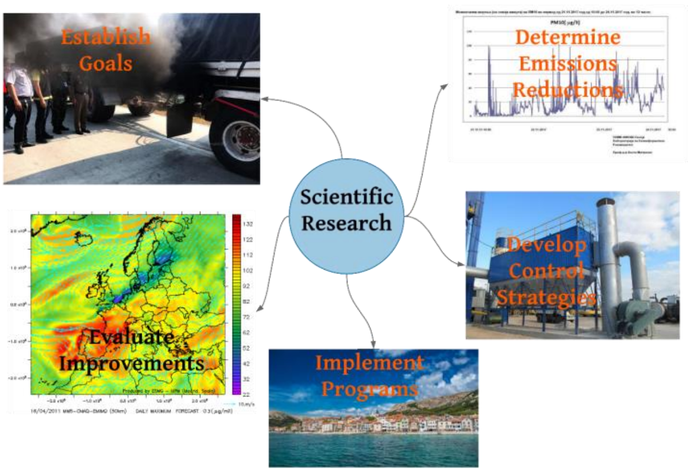


Figure 1. Steps of Effective Air Quality Management

1.2 Scientific Research

Scientific research provides an understanding of how pollutants are emitted to the atmosphere, transported and transformed in the air. It also involves the effect of air pollution on human health and the environment. As the topic is complex, continuous research activities are required. Scientific research is conducted by universities and research organizations. Although, a global effort is underway for better understanding of the complex structure of the air pollution problem, geographically local studies are also needed to further identify local differences as well as issues specific to local sources. For this reason, it is essential that institutions responsible for managing air quality be in close working relationship with researchers. Complex problems that decision-makers face should be investigated by university researchers.

1.3 Health Effects

Research has linked regulated air pollutants such as ozone and particulate matter (PM) to health problems. Detailed investigation is needed to further understand the role air pollution plays on health and disease and support the development of more sustainable and integrated air quality management strategies. The research goals include:

- Understand the link between health effects and exposure to individual pollutants.
- Understand air pollution emissions, exposures and health effects to air pollution from near sources such as highways, industry and provide solutions to reduce their impacts.
- Identify toxicity pathways and biological processes that lead to health effects from exposure to air pollutants.

1.4 Environmental Effects

Many ecosystems are under stress from climate change and air pollution. There is a strong need to understand the ecological impacts of air pollution. This in turn can provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. With climate change, science is critical to understanding and responding effectively to a changing climate with resiliency planning. The research goals include:

- Determination of the species that are at-risk species and the impact on ecosystems due to air pollution and climate change.
- Identify climate-sensitive stress factors, including pollutants.
- Assess vulnerabilities to ecosystems.
- Develop information and tools to evaluate air quality impacts on ecosystems and to mitigate climate change impacts on ecosystems.

More specifically, the responsibilities of an institution that manage air quality in a country includes the following :

- Develop and evaluate new and improved air measurement technologies and capabilities to enable effectively address air quality issues.
- Compile emissions data from designated sources to expand the emissions inventory and build a better understanding of atmospheric chemistry.
- Developed utilize scientifically sound modeling methods to quantify the impact of different emission sectors an air quality and develop and implement the necessary measures to improve air quality.

1.5 Steps for Better Air Quality Management

Air quality monitoring data is the first step in identifying problem areas and identify and implement related measures. For this purpose, high quality data are needed by decision-makers. Understanding possible sources of pollution such as industrial facilities, trasnportation, residential heating is critical to protect public health and environment from criteria air pollutants and other hazardous air pollutants regulated by Turkish Ministry of Environment and Urbanization. The Ministry is responsible to :

- Monitor compliance with the air quality standards
- Conduct emissions characterization research and develop emission inventories
- Identify effective pollution prevention and control strategies
- Use atmospheric modeling to develop Clean Air Action Plans.

1.5.1 Air Quality Monitoring

Air quality monitoring is an essential part of Air Quality Management Strategy (AQMS). First step in improving air quality is to determine the level of the problem. For this purpose, Turkish Ministry of Environment and Urbanization has setup a dense network of air quality monitoring system. Currently, there are over 300 air quality monitoring stations in Turkey measuring multiple pollutants. In 31 cities, where CityAir project is being implemented, there are 74 stations ; 24 of them have CO measurements ; 19 of them have O_3 measurements ; 10 of them have $PM_{2.5}$ measurements ; 73 of them have PM_{10} measurements ; and 69 of them have SO_2 measurements. Mainly PM and SO_2 measurements are available. As discussed in Activity Report 2.2, additional measurements data are needed for O_3.

It should be noted that measuring air quality data is important, however, detailed statistical analysis is also essential as to understand the status of air quality in each province. Trend analysis should be part of this analysis so that any improvement or deterioration can be detected and measures can be taken without any delay.

1.5.2 Emission Inventories

An emissions inventory is a process to account the amount of air pollutants discharged into the atmosphere for given geographical region in each time period. It is an essential component in determining the source of air pollution problem within a city using an air quality modeling framework. Details of the methodology proposed in this project is provided in Activity Report 1.6.

Additional measures need to be taken with respect to quantifying uncertainty in emissions estimation. Most of the emissions estimation is conducted using the following equation

$Emission\ = Activity\ \times Emission\ Factor$ (1)

In cases where Tier 2 and Tier 3 methods are used, the methodology is more complicated, however, even in those methods it all boils down to emission factors and activity data. Independent of the methodology used to estimate emissions for a sector, uncertainty needs to be quantified.

It is essential to differentiate between inherent variability and uncertainty. Variability is defined as inherent heterogeneity or diversity in a well-understood population. Variability can not be reduced through further measurement or study. Temporal variation in emissions from a power plant due to changes in fuel used can be given as an example. Uncertainty, on the other hand, represents lack of knowledge about a process, and can partly be reduced through further research. Sampling uncertainty, which arises from number of sample size or representability, can be listed as one of the important uncertainty sources.

There are analytical and numerical methods available for quantifying uncertainty in the mean emission estimates. Analytical solutions can be used under one or more of the following conditions; underlying distribution of a dataset is normal, variance is low or the sample size is large enough (e.g. >30). Analytical methods based on normality may lead to significant errors in the estimation of confidence intervals when following conditions are not valid. Numerical methods are flexible in terms of underlying distribution for estimating confidence intervals. Bootstrap simulation is one of the widely used numerical methods in quantifying confidence intervals based on random sampling error from parametric distributions.

Such an analysis by Alyuz (2019) for the Marmara region's facilities using NAPEMS study. Results of these analysis are provided in Figure 2. In this figure different parametric distributions are fitted to the empirical emission factor datasets. After assigning best fitting parametric distribution, Monte Carlo simulation is applied and Bootstrap method is applied. Then average EF and confidence intervals are calculated for each of in-situ EFs and given in Table 1.

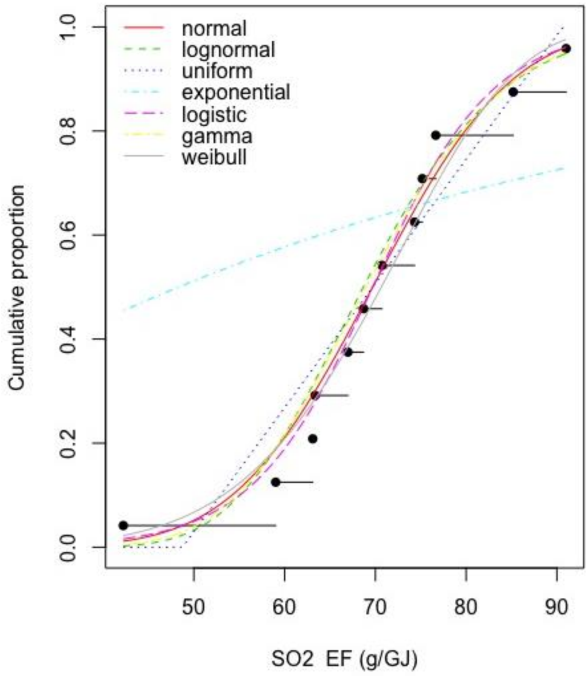


Figure 2. Uncertainty Analysis of SO2 Emission Factors

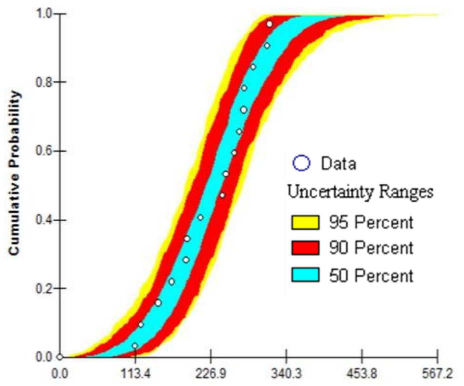
Table 1 Uncertainty analysis results for SO_2 EF of "1.A.1.a–10101–3.10" and comparisons with other studies

	In-situ Measurements	EMEP	EPA
Fitted distribution type	Weibull		
Mean (g/GJ)	229.2	1680	
95% CI (Lower, Upper) as g/GJ	191.8-265	330-5000	between 90 [3] and 569 [4] g/GJ
% Uncertainty (Lower, Upper)	16.3-15.6%	80.4-198%	
First parameter	252.77 [1]		
Second parameter	3.7 [2]		

[1] scale parameter (k) for Weibull parametric probability distribution function
[2] shape parameter (c) for Weibull parametric probability distribution function

[3] for uncontrolled external combustion of lignite with atmospheric fluidized bed technology for electricity generation (SCC is 10100316 and 10100317)
[4] for uncontrolled external combustion of lignite with other technologies for electricity generation (SCC is 10100311, 10100312, 10100313 or 10100314)

SO_2 EF is calculated from in-situ measurements as 229.2 g/GJ which is even below the 95% lower limit of EMEP (330 g/GJ) **Hata! Başvuru kaynağı bulunamadı.**, and less than EPA EF (569 g/GJ). Since almost all points fall into the 50% CI range in probability band of in-situ measurements given in 0a, Weibull distribution is appropriate for EFs derived from in-situ EFs.



(a)

Figure 3 Probability band of SO_2 EFs for "1A1a-10101-3.10" as cumulative distribution of Weibull distribution fitted to SO_2 EFs derived from in-situ measurements

Uncertainty analysis at Emission Factor level should be repeated for the activity data. Then uncertainty propagation should be conducted to estimate overall uncertainty in emission inventory.

1.6 Conclusions and Suggestions

Air Quality Management requires a detailed planning of the activities needed. These activities include selection of the correct methodology as well as choosing the right emission factor and activity data. In City Air project a detailed methodology is provided in Activity report 1.4. An important part of air quality strategy management is uncertainty and variability analysis. For this purpose, it is suggested that an uncertainty analysis, presented in this report, to be conducted for any emissions inventory study. Figure 4 summarizes the methodology to be used. As shown in this figure, first measurement for emission factors need to be quantified. In the next step probability distributions need to be fitted to determnine the underlying distribution for the uncertainty analysis. For this purpose, bootstap or monte carlo methods can be utilized. After quantifying the uncertainty in the emission factor dataset, similar methodology need to be conducted for the activity data.

When uncertainty ranges for emission factor and activity data are quantified, Taylor Series expansion or probabilistic methods can be used to propagate uncertainty in emissions inventories. Accurate decision making needs probabilistic data instead of point estimates. It is suggested such a probabilistic analysis to be included in the emission inventory analysis.

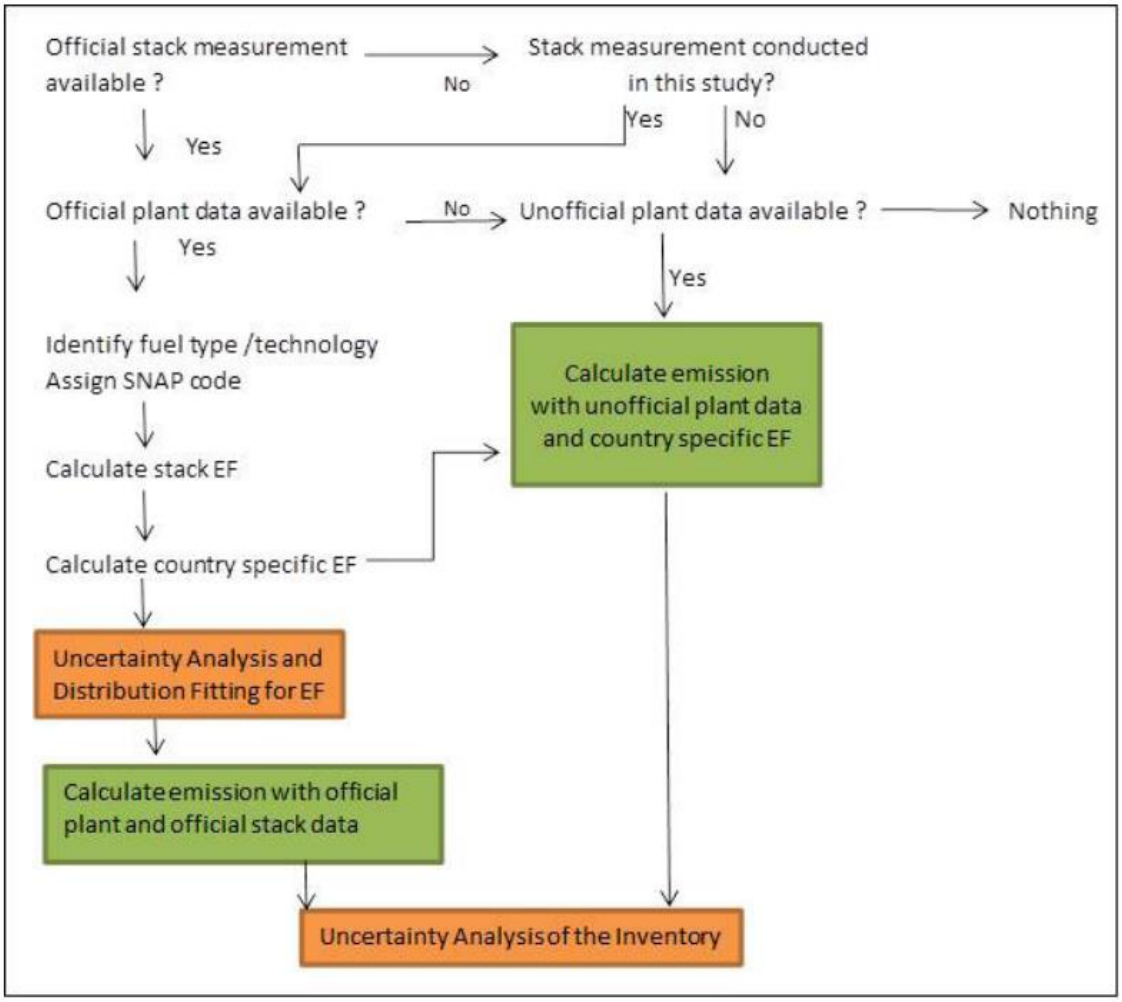


Figure 4 Algorithm for conducting uncertainty analysis

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