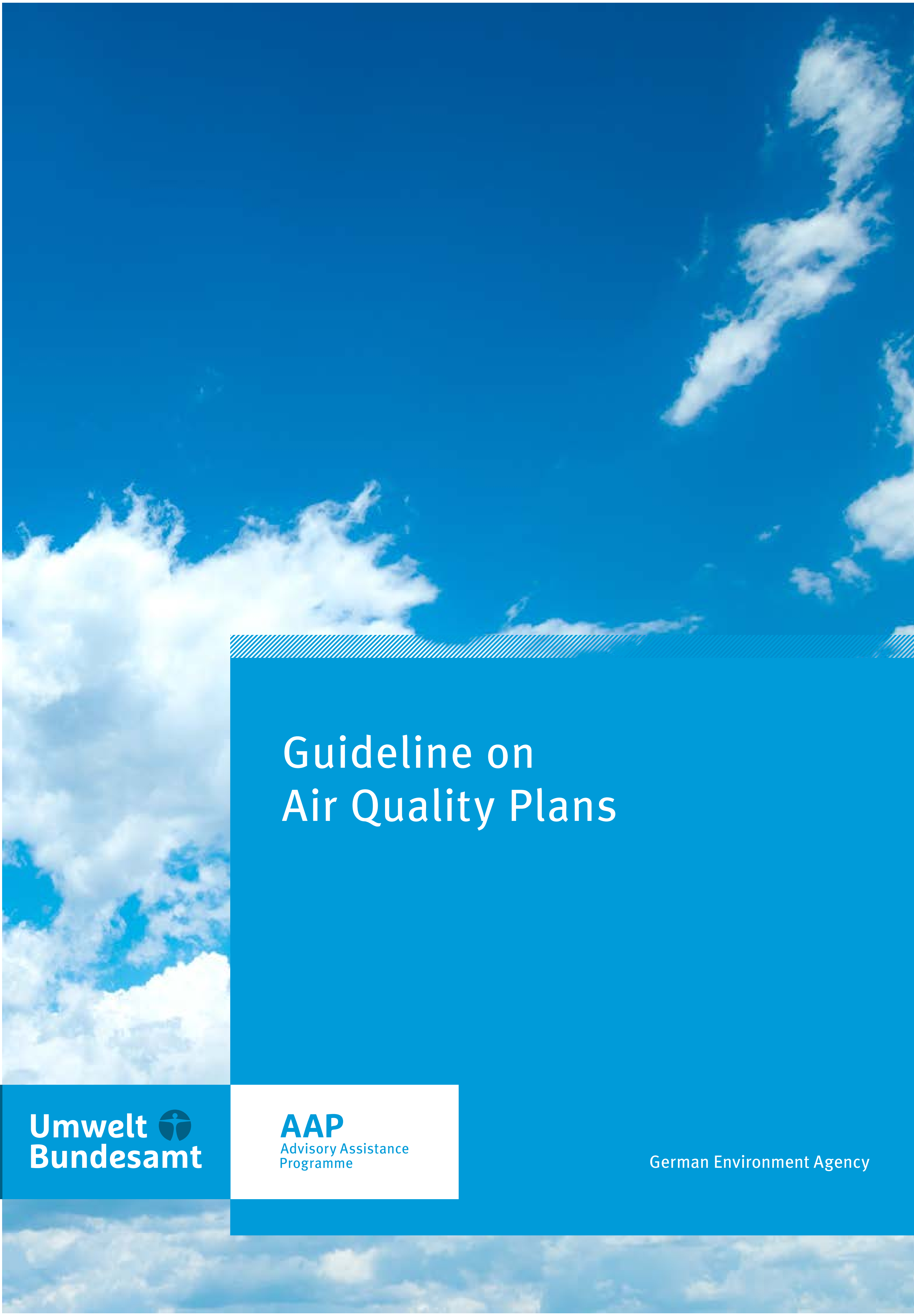

Guideline on Air Quality Plans

Umwelt Bundesamt

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Advisory Assistance Programme

German Environment Agency

Guideline on Air Quality Plans

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List of Abbreviations

AAP	Advisory Assistance Programme
ADT	Average daily vehicle
AQD	Air Quality Directive 2008/50/EC
AQP	Air quality plan
AUSTAL2000	German regular dispersion model within a plant permission procedure
BMUB	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety)
CO_2	Carbon dioxide
DPF	Diesel particulate filter
EEA	European Environment Agency
EURAD	Meso scale Chemical Transport Model System of University of Cologne and the Research Center Jülich
GIS	Geographical Information System
HBEFA	Handbook Emission Factors for Road Transport
LEZ	Low emission zone
MoEW	Bulgarian Ministry of Environment and Water
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
PM10	Particulate matter (diameter < 10 µm)
PM2.5	Particulate matter (diameter < 2.5 µm)
RIEW	Bulgarian Regional Inspectorates of Environment and Water
SELMA^{GIS}	GIS Based Dispersion Modeling System
SO_2	Sulphur dioxide
UBA	Umweltbundesamt (German Environment Agency)
VDI	Verein Deutscher Ingenieure (Association of German engineers)

Summary

The project “Transfer of knowledge for the implementation of Directive 2008/50/EC in Bulgaria: development, implementation, evaluation and adaptation of air quality plans and their measures” highlighted certain topics and discussed them with the Bulgarian Ministry of Environment and Water (MoEW), with regionally and locally responsible authorities, as well as with experts and scientists from universities. The objective was to critically accompany and support the improvement of air quality plans (AQPs) and their measures. In Bulgaria, more than 30 AQPs exist, in some cases revised for several times in the past ten years.

This guideline complements the discussions and the intensive workshop that took place in Bulgaria. It specifies important steps of the workflow that are the essential basis for a content-based AQP and it gives the corresponding references from the Directive 2008/50/EC on ambient air quality and cleaner air for Europe.

The methods of estimating emissions are described in the guideline, exemplified by the source sectors car transport and residential stationary combustion. The harmful effects of pollutant emissions from these sectors have to be the object of intensive consideration in the future and have to be taken into account by measures of emission reduction implemented in the AQPs. An extensive list of possible measures is added to this guideline and should be taken into consideration for each AQP.

To answer the relevant questions for estimating the effectiveness of measures and the need of additional methods of investigation related to such issues as emission inventory, sector-specific chemical transport modeling, including authorization procedures and public participation, building a network of the responsible institutions in Bulgaria with support from third parties as in this project was identified as urgently necessary.

Zusammenfassung

Im Projekt “Wissenstransfer zur Umsetzung der Richtlinie 2008/50/EG in Bulgarien: Entwicklung, Umsetzung, Bewertung und Anpassung von Luftqualitätsplänen und ihrer Maßnahmen” wurden bestimmte Fragestellungen herausgehoben und intensiver mit dem bulgarischen Umweltministerium, mit regional und lokal verantwortlichen Behörden sowie mit Gutachtern und Wissenschaftlern aus Universitäten besprochen. Ziel war die kritische Begleitung und Unterstützung zur Verbesserung von Luftreinhalteplänen und ihrer Maßnahmen. Über 30 Luftreinhaltepläne, die z. T. in den letzten 10 Jahren mehrfach überarbeitet wurden, existieren in Bulgarien.

Dieser Leitfaden ergänzt die zurückliegenden Diskussionen und den intensiven Workshop in Bulgarien. Er listet bedeutsame Arbeitsschritte auf, die essentielle Grundlage eines inhaltlich belastbaren Luftreinhalteplans sind, und verweist auf ihre zugehörigen Fundstellen in der Richtlinie über Luftqualität und saubere Luft für Europa (2008/50/EG).

Beispielhaft werden die Abschätzungsmethoden der Emissionen im Quellsektor Kfz-Verkehr und im Bereich des Hausbrands dargestellt. Die Schadstoffbelastungen durch diese Emissionen sind künftig verstärkt zu betrachten und mit Emissionsminderungsmaßnahmen in den Luftreinhalteplänen zu berücksichtigen. Eine umfangreiche Liste von möglichen Maßnahmen ist dem Leitfaden beigefügt und sollte Gegenstand der jeweiligen Abwägungen im Luftreinhalteplan sein.

Die Netzwerkbildung der verantwortlichen Institutionen in Bulgarien, mit Unterstützung von dritter Seite wie in diesem Projekt, in allen relevanten Fragestellungen wie der Emissionsermittlung, der Ausbreitungsrechnung für die verschiedenen Quellgruppen, inklusive Genehmigungsverfahren und der Einbindung der Öffentlichkeit, bei Abwägungsprozessen zur Ermittlung von effektiven Maßnahmen und bei der Nutzung weiterer Untersuchungsmethoden wurde als dringend notwendig erachtet.

1 Introduction

In the context of the German-Bulgarian bilateral cooperation, the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and the German Environment Agency (UBA) intended to assist Bulgaria in improving its knowledge base and capacities on air quality plans (AQPs) with a project.

The objective of the project "Transfer of knowledge for the implementation of Directive 2008/50/EC in Bulgaria: development, implementation, evaluation and adaptation of air quality plans and their measures" was the transfer of knowledge and the facilitation of relevant employees of the Bulgarian Ministry of Environment and Water (MoEW), the Bulgarian Regional Inspectorates of Environment and Water (RIEWs), and Bulgarian municipalities to improve existing AQPs, including

- collection and analysis of data,
- assessment of the current air quality situation in Bulgaria,
- selection of suitable air pollution control measures to improve air quality in different Bulgarian municipalities,
- assessment of emission reduction potentials,
- monitoring the implementation of mitigation measures,
- ex-ante and ex-post assessment of the effective mitigation measures and, thus, the success of air quality plans,
- adaptation of already planned measures.

One activity of the project was to develop this guideline. The guideline presents the main required topics to enhance and to produce reliable APQs.

Blue boxes

Important topics are presented in blue boxes.
Part of this guideline are cross references to relevant articles of the "DIRECTIVE 2008/50/EC on ambient air quality and cleaner air for Europe" (AQD), like "(Art. 23)".

Cross reference to reporting obligations

All obligations of the "DIRECTIVE 2008/50/EC on ambient air quality and cleaner air for Europe" are part of the reporting system laid out in Commission Decision 2004/461/EC for annual reporting on air quality assessment, updated in Commission Implementing Decision 2011/850/EU for exchange of information and reporting on ambient air quality.

2 AQPs – Systematic approach

The AQD describes two formal ways to reduce exceeding air quality levels:

- "Air quality plans should be developed for zones and agglomerations within which concentrations of pollutants in ambient air exceed the relevant air quality target values or limit values." (Art. 23),
- Action plans should be drawn up indicating the measures to be taken in the „short term where there is a risk of an exceedance of one or more alert thresholds in order to reduce that risk and to limit its duration" (Art. 24) (see Chapter 3.1.2).

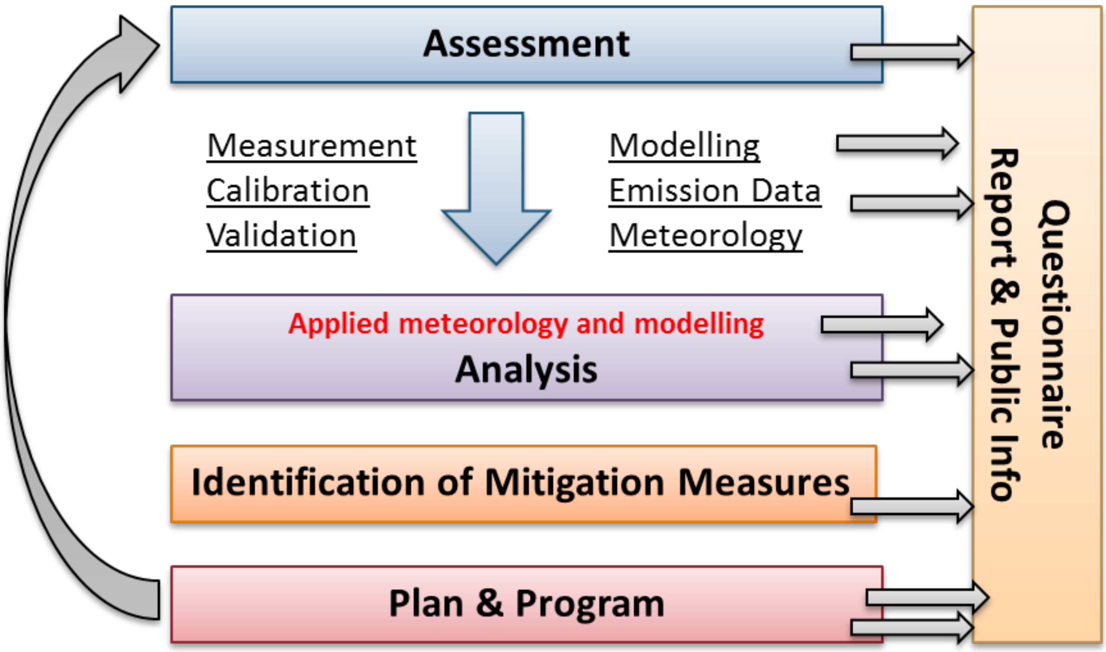
In Central Europe, AQPs are mostly developed to reduce the air quality level in a sustainable way. Continuously reduced emissions of industrial sources support this process. On the other hand, house heating and increasing traffic should be addressed, too. Therefore, the main focus of this guideline will be on AQP, not on action plans.

AQPs should describe the exceeding of limit values, the analysis, the discussion and the evaluation of measures, which can be undertaken in special time scales. This information must be submitted to the European Commission. For example, in an infringement procedure or in prolongation discussions, the European Commission will ask for reliable AQPs (Art. 27, 28).

The basis of all AQP activities to reduce the air pollution level should be a systematic workflow to develop an AQP, starting with an assessment, further detailed analysis and the development of plans and programs. After a time interval of typically 2 years, the effect of the measures must be evaluated by another round of assessment, analysis and modifying plans. This systematic approach is described in Figure 2.1. Part of the procedure is the reporting according to the AQD (Art. 27, 28). All steps of the workflow must be combined with information from the public by reports, free access of online monitoring data, round table etc. (Art. 26, Annex XVI).

Some measures may be implemented in an area by a Low Emission Zone (LEZ). A LEZ is located in a defined area in a municipality in which emission activities are restricted or prohibited to reduce the emission of air pollutants. The area and borders of the LEZ depend on the emission structure, population density, infrastructure and the effectiveness of mitigation measures. "Many cities in Europe use Low Emission Zones, Urban Road Tolls, Traffic Limited Zones and other Traffic Restrictions to improve air quality, reduce traffic congestion, and make historic city centers attractive to tourists." (www.urbanaccessregulations.eu).

Figure 2.1: Systematic approach for an AQP



Previous AQPs must be always the basis of the actual plan. The development of an AQP must be explained and documented step by step.

Action plans to combat alert situations in the case of actual exceeding of alert values are not the main topic of this guideline. The detailed assessment and analysis must be the same as in the case of an AQP. However, depending on reaction and information, the introduction of measures is special topic in an alert situation and is different and very complicated. A very well-organized management system with a lot of personnel would be needed. In our experience, it is a more sustainable way to reduce the emissions during the whole year based on an AQP instead of acting only in an alert situation.

The basic tasks to develop an AQP in a systematic way include several topics (Art. 23, Annex XV). An AQP report should describe how

- to collect the existing data,
- to identify the need of additional data,
- to start additional measurements,
- to add additional data,
- to check all input data,
- to calculate the air pollution level on the basis of these data,
- to use these data to propose some measures.

Figure 2.2 shows the workflow to develop an AQP. The detailed information and the results of all investigations must be part of the AQP.

Figure 2.2: Workflow to develop an AQP

1. Assessment by measurement and/or modeling
2. Checking the quality of the measurements

3. What are the sources of the pollution and how strong are they?
   Analysis of measurement results - in the case of exceeding limit values very intensive analysis. Count area and number of affected inhabitants.
4. Who is responsible and for how much?

5. Which mitigation measure can be used to reduce emissions?
7. Preparation of input data for the development of measures
8. Are measures sufficient for compliance? Check of the results of measures by modeling.

9. Choice of a (cost effective) measure
10. Implementation of the measure
11. Validation of the measures by measurements

Are the mitigation measures effective?
If not, start at the beginning of this workflow.

3 Basic requirements of AQPs

The basic requirements of AQPs are described in the following subchapters of Chapter 3 and are in accordance with the structure of the AQD Annex XV.

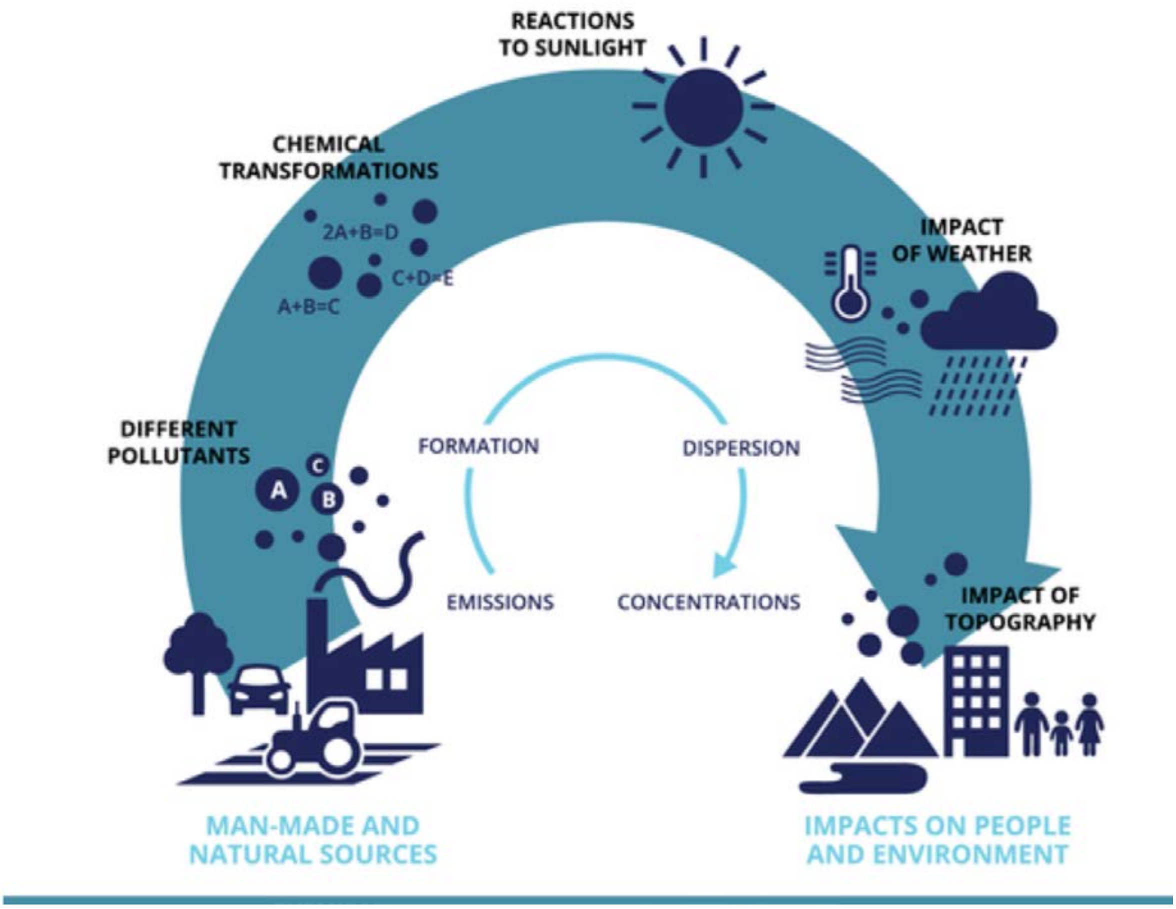
There is a need for local, regional and national AQPs caused by different pollution potential and abatement measures. The basic way, from emissions via dispersion and chemical transformation to exposure, is shown in Figure 3.1. The distance varies between some meters, in the case of traffic emissions, and a range of 1 km to more than 100 km. Therefore, an AQP has to distinguish between measures on a street scale, a local scale, an urban scale, a regional scale, a nationwide scale, a European scale and a global scale.

An AQP cares about reducing air pollution to protect human health. Nevertheless, the goal of AQPs can overlap with measures to protect flora and fauna, i.e., according to the Fauna-Flora-Habitat-Directive (92/43/EEC). Monitoring stations at rural background sites are needed in order to look at the protection of vegetation (Annex III B.2., Annex VII, Annex VIII, Annex XIII).

Remark: Natura 2000 areas

The protection of NATURA 2000 areas in relation to existing and new emissions is under discussion. All member states of the EU must find a solution. By now, there exists no homogenous management system. This topic may become more and more part of an AQP.

Figure 3.1: Schematic way from emission of air pollutants to impacts



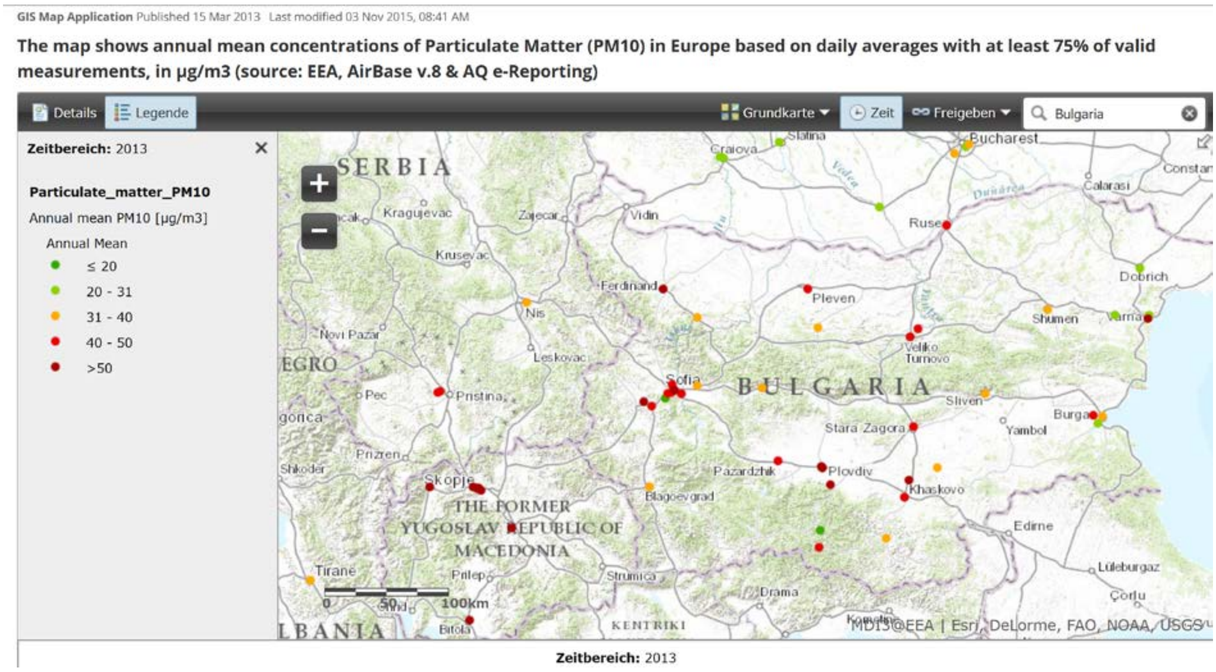
Source: http://www.eea.europa.eu/media/infographics/air-pollution-from-emissions-to-exposure/view

3.1 Current knowledge base

3.1.1 Annual data

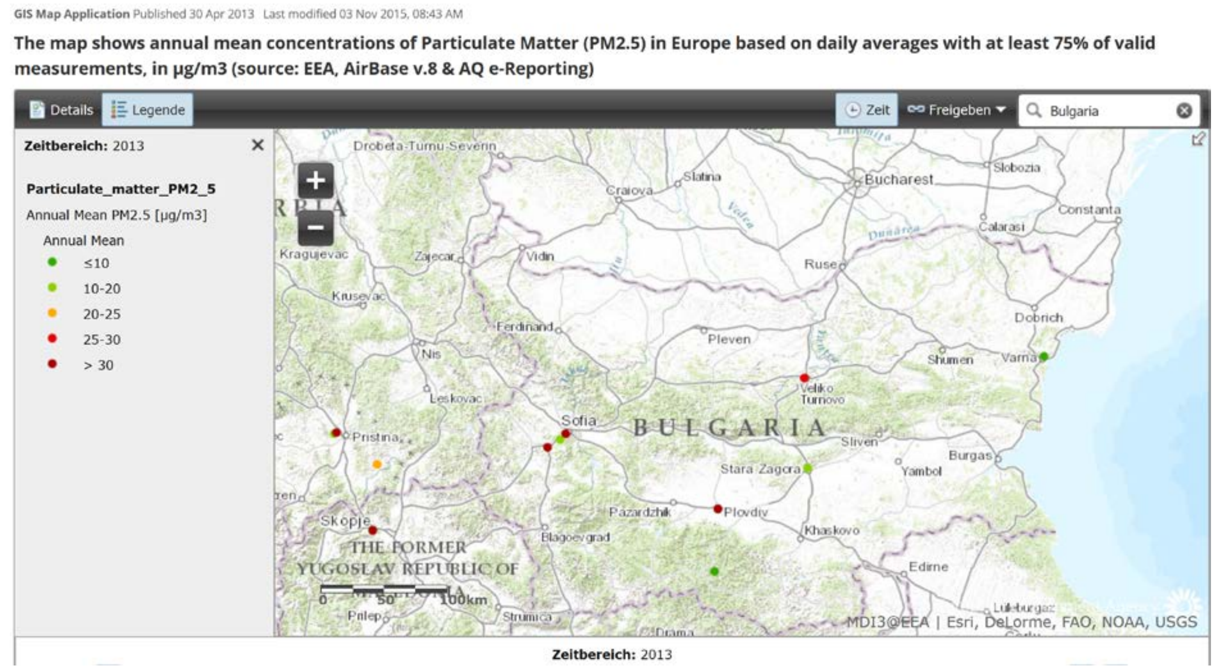
In Bulgaria, an air quality monitoring network is in operation. Measured values are saved in a national database, which is administered by the Executive Environment Agency (ExEA). MoEW, RIEWs, ExEA, and the municipalities involved have access to this database. All data that are reported to the European Environment Agency (EEA) are published in an EU web portal. The situation in Bulgaria in 2013 (last situation available) is published in Figure 3.2 to Figure 3.6 (source: http://www.eea.europa.eu/themes/air/air-quality/map/airbase/air-quality-statistics-at-reporting-stations, copy 7.3.2016). The annual mean and the exceeding situation of each pollutant are indicated by classified colors.

Figure 3.2: Map of PM10 measurement results in 2013



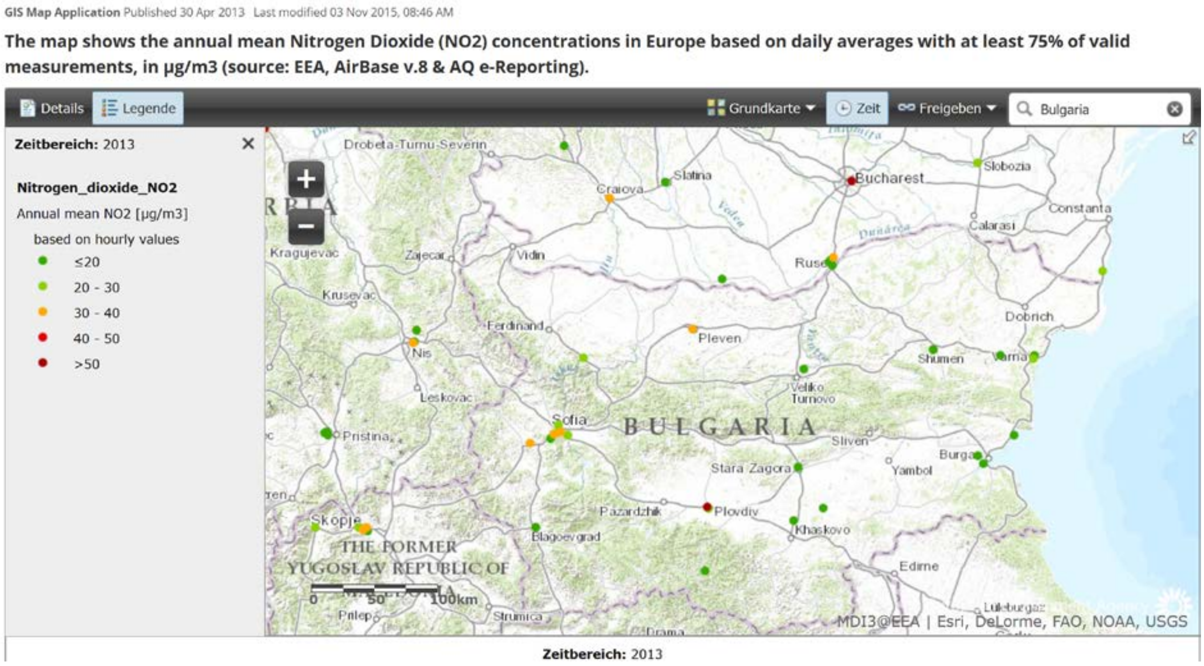
At most PM10-stations in Bulgaria, an exceedance of the PM10 limit value can be observed.

Figure 3.3: Map of PM2.5 measurement results in 2013



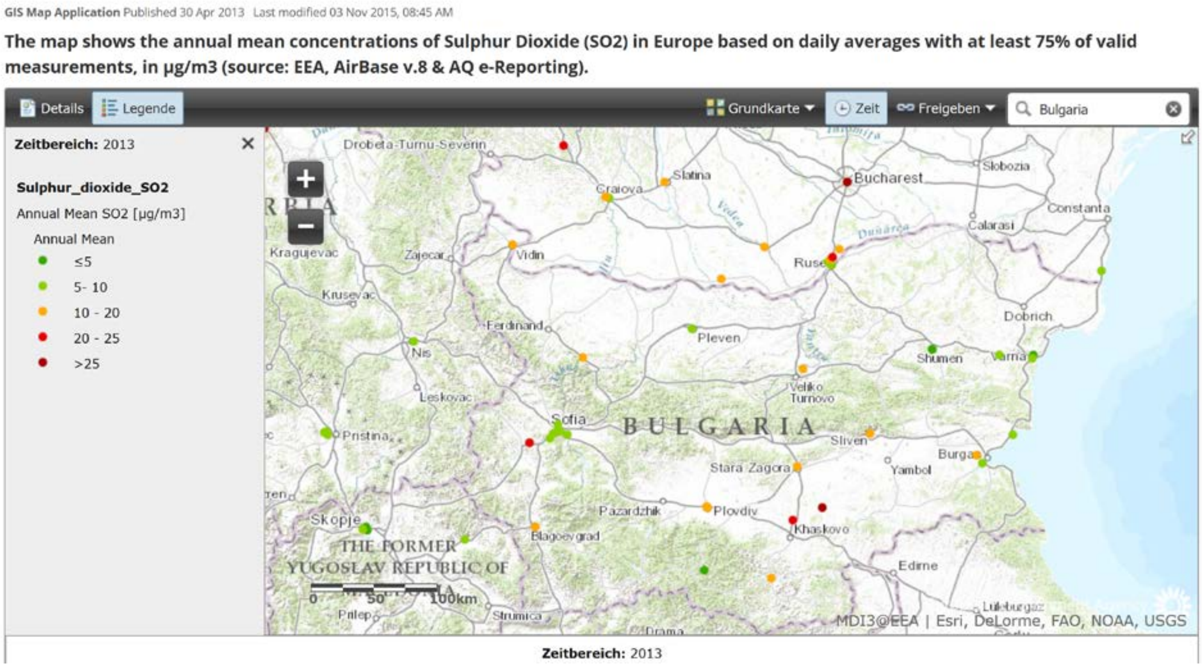
At most PM2.5-stations in Bulgaria, a high level of PM2.5 concentrations exists.

Figure 3.4: Map of NO_2 measurement results in 2013



At only one NO_2-station in Bulgaria, an exceedance of the (nitrogen dioxide) NO_2 limit value can be found.

Figure 3.5: Map of SO_2 measurement results in 2013



At few SO_2-stations in Bulgaria, an exceedance of the (sulphur dioxide) SO_2 limit value exists.

Bulgarian AQPs have to address at least these pollutants: PM10, PM2.5, NO_2, SO_2 and ozone. The other components of the AQD are not part of this report.

3.1.2 Short-term exposure

Another task is whether there is a perceptible risk for an excess of the alert thresholds for **SO_2 and NO_2**, which would require setting up **short-term actions plans** for areas where such risk exists (Art. 24). In order to assess that risk, it is suggested to evaluate the available air quality data series accordingly.

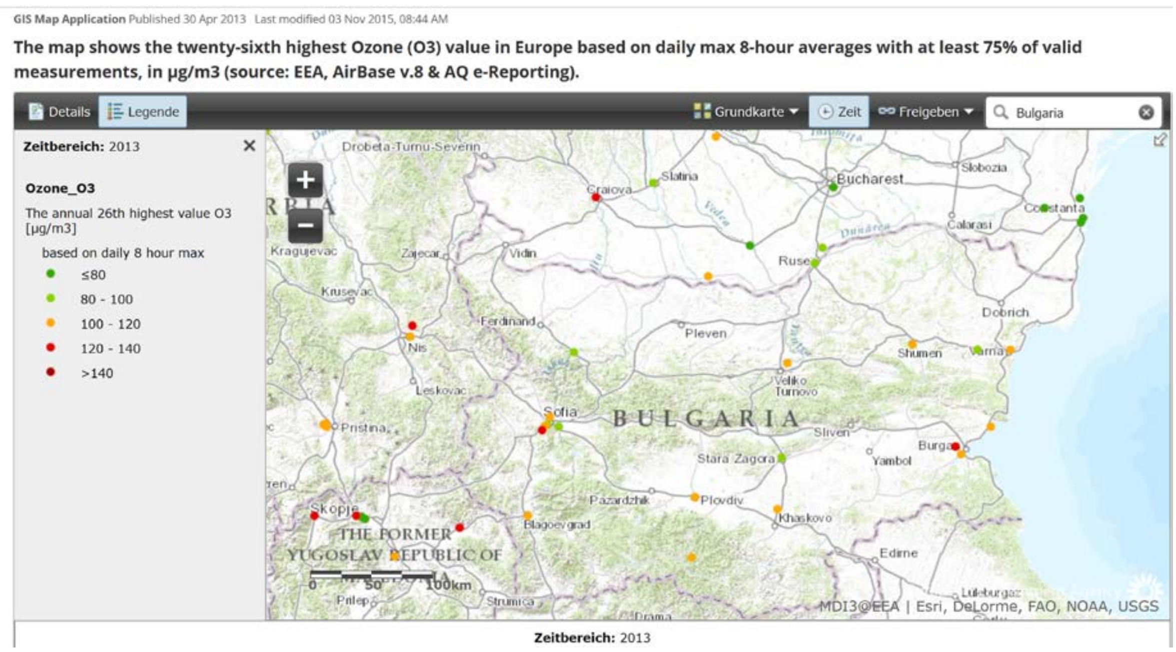
Given the short periods for which the alert thresholds are defined, air quality time series with an equivalent time resolution (1 hour) are required. The SO_2 time series should be examined for 3 h concentrations above a level of 500 µg/m³ (Annex XII A.). In Form 11, there is also a reporting obligation for1 h exceedances and their causes by the reason code in Table 2 (Commission Decision 2004/461/EC for annual reporting on air quality assessment, updated by Commission Implementing Decision 2011/850/EU for exchange of information and reporting on ambient air quality).

If so, the validity of such peaks should be checked by taking into account meteorological information, like wind speed, wind direction, vertical temperature profiles, radiation and radiation balance. Very often, the analysis reveals very poor (calm situation and temperature inversion) atmospheric dispersion conditions during the episodes. This typical smog situation can last several days.

Special wind direction and fumigation effects on nearby larger SO_2-emitters in the surrounding of the monitoring site could be also the cause of high short-term exposure. This situation can last several hours. Sometimes a transition to a typical smog situation can occur. Other pollution data series, like NO_2, CO or PM10, should always be checked for simultaneous time variation patterns. These pollutants might be emitted by the same potential sources. Dispersion modeling of the impact of large sources could also be helpful.

At few ozone monitoring stations in Bulgaria, high-level max 8-hour averages ozone occur. Information and alert threshold for ozone exist in Annex XII B.

Figure 3.6: Map of ozone measurement results in 2013



With regard to avoiding potential **ozone** alert threshold exceedances, the available ozone concentration series do not indicate a substantial risk of such exceedances. In Germany, disappointing experiences with ozone-related short-term actions exist, so it might not be an efficient instrument.

This judgment is reinforced by the messages of a guidance document of the Commission on short-term actions against ozone peaks, which can be summarized as follows (Art. 24):

- Cities and/or regions in Southern Europe could potentially reduce the risk or the severity of exceedances of the ozone alert threshold with short-term measures, where frequent recirculation of air masses due to topography and the influence of the sea can be observed.
- Short-term actions may require a regional-wide assessment and approach, where ozone and precursor transport account for a significant part of the observed ozone.
- Due to high natural VOC emissions in Southern Europe, emission reductions of VOC are relatively ineffective.

In conclusion, short-term actions are unlikely to be an effective instrument for Bulgaria. Hence, the limited resources on air quality management should instead be focused on long-term durable measures laid down in a national program for the whole country. Such a program is needed anyway because of Directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants and its proposed successor.

With regard to the abatement of exceedances of limit values, the arguments raised above against short-term actions can largely be applied to Bulgaria as well. As stated above for ozone, the limited resources on air quality management should instead be focused on long-term durable measures to attain the limit values for the other pollutants.

3.1.3 AQPs in Bulgaria

The described air quality situation of Bulgaria is the basis of the assessment. The identified agglomeration areas and heavy polluted areas determine the minimum number of monitoring stations. In the case of exceedances of an air quality limit, an AQP has to be prepared (Art. 23). In Bulgaria, more than 30 AQPs exist on the local level.

A major problem in South Eastern Europe in the field of air quality is the exceedance of PM10 limit values. Many municipalities with poor air quality have developed and implemented updated AQPs to reduce pollutants and achieve the established PM10 limit values. All of them meet format and content requirements of Directive 2008/50/EC, indicate the main sources of pollution and propose measures to reduce levels of PM10. These plans specify the following sectors contributing to pollution:

- domestic heating during the winter season, in some cases combined with additional influence of motorized transport (for the largest group of municipalities),
- distinct impact from the transport sector – the largest,
- distinct impact from the diffuse sources – some towns nearby large industrial areas,
- complex nature of pollution – only for some cities (includes domestic heating, transport, regional background level, diffuse sources (landfills, quarries, etc.) and industry, including power plants).

Municipalities implement part of the measures included in the AQPs, but the monitoring data after the update of the plans show that the action cannot be assessed as adequate. The reasons are:

- the degree of economic development of the country that determines the low level of use of environmentally friendly fuel types and more efficient combustion systems,
- failure to apply some of the necessary measures from the municipal AQPs due to lack of funds or other reasons.

The lack of sufficient AQP management capacity in municipalities to manage complex processes relates to the evaluation and implementation of measures to improve air quality.

3.2 AQP – Spatial levels

Basic spatial information should be included in the local, regional or national AQPs for improvement in ambient air quality according to Annex XV A.1. and 2.(b) of the AQD.

3.2.1 Local

Local AQPs describe the situation in a city, in a town or in heavy polluted industrial areas. The description of a pollution situation of one or more streets can also be part of local AQPs (Art. 23, Annex XV A.2.). The description should also be part of the public information (Annex XVI). In a systematic approach, based on the area of exceedance, the name of the region according to Annex XV A.1.(a) is a nice information but without substantial content. It is only part of reporting.

Local AQPs in Bulgaria

Currently the focus is on local plans. Exceedances of PM10 and in special cases SO_2 are mostly relevant. Up to now the Bulgarian monitoring stations document only a few areas with traffic induced air quality problems (exceedances of NO_2-limit value), which has to be investigated in more detail.

3.2.2 Regional

AQPs can be prepared if a typical homogeneous emission structure/air quality structure exists. This is most relevant for rural areas, mountain areas and coastal areas. The relevant components are PM and ozone.

3.2.3 National

AQPs should be prepared to introduce measures that are relevant for great parts of the national territory. Ozone can only be reduced by national measures abating VOC emissions. Some measures to control domestic heating, i.e., the nationwide use of coal and wood and the introduction of limit values for industrial facilities, also could be part of activities on the national level.

3.2.4 Name

The AQP has to describe the area of interest. In the case of local AQPs, a map of the city including legend and scale has to show the main emission sources (Annex XV A.1.).

3.3 Siting criteria of stations

The AQD contains in Section A. of Annex III some general criteria for ambient air quality assessment.

Annex III, Section B., provides macro scale siting criteria for sampling points, which define how sampling points shall be located in order check compliance with the air quality standards (i.e., in areas with the highest concentrations to which the population is exposed and in other areas which are representative of the exposure of the general population for the protection of human health or which are targeted at the protection of vegetation and natural ecosystems). Macro scale criteria also provide a basis for establishing the spatial representativeness of monitoring sites, so that they are representative of similar locations and not only in their immediate vicinity.

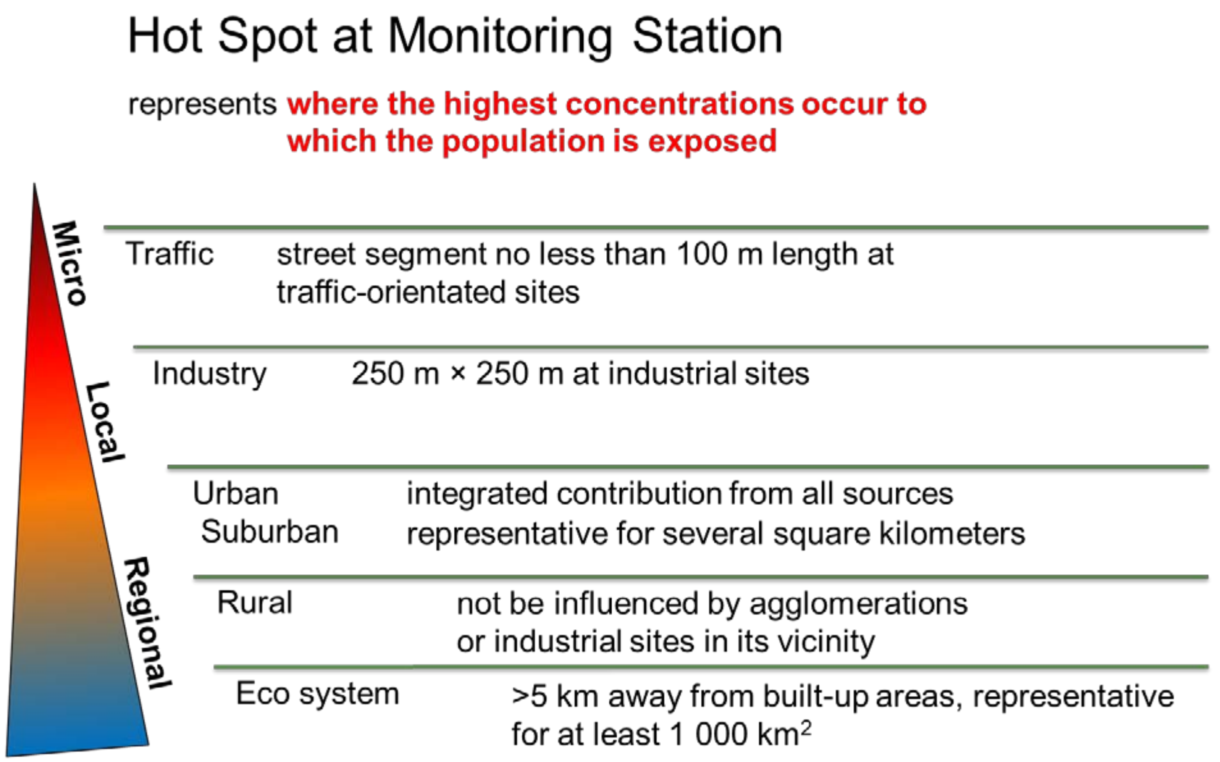
Annex III, Section C., provides micro scale siting criteria, which provide detailed guidelines for how sampling points shall be placed in relation to roads, buildings and other obstacles within the areas identified through the application of the macro scale criteria.

Annex III, Section D., requires that member states shall fully document the site selection procedures through photographs of the surrounding area and detailed maps. It also states that “sites shall be reviewed at regular intervals with repeated documentation.” (Annex III).

The scale of representativeness of a station is illustrated in Figure 3.7.

The graphic shows the spatial representativeness of a monitoring station according to the spatial scale.

Figure 3.7: Spatial scale relevant for the monitoring process



The text of the AQD Annex III D. underlines: “The site-selection procedures shall be fully documented at the classification stage by such means as compass-point photographs of the surrounding area and a detailed map. Sites shall be reviewed at regular intervals with repeated documentation to ensure that selection criteria remain valid over time.”

The EU-requirements to situate monitoring stations in cities consider the influence of the road traffic on air quality. The AQD specifies that the monitoring station in street canyons has to be situated at least 25 m away from the edge of a busy crossroad and must be representative of the air quality of a road section at least 100 m in length (Annex III C.). The highest concentrations are measured by monitoring stations that are situated in street canyons with buildings beside the street and much vehicle traffic. The air quality and air flow situation in a street canyon is illustrated in a schematic way by Figure 3.8. (source: Palmgren, 2003). The above roof wind system induces inside the street canyon an air flow vortex. This air flow determinates in combination with “traffic produced turbulence” (TPT) of the driving cars the air quality concentration at the monitoring stations 2 and 3 in Fig. 3.8. The vertical air flow vortex is important and causes higher concentrations at measurement position 2 than at position 3.

Furthermore, the monitoring station in street canyons has to be situated as illustrated in Figure 3.9 (Source Müller, VDI 3783 part 14) (see Annex III C.). The blue area in the sketch of Figure 3.9 indicates the area, in which the inlet of the monitoring station inside a street canyon has to be placed.

This blue area indicates the same area for receptor points of a micro scale dispersion model application like MISKAM.

Location of a traffic-oriented monitoring station

The location of a traffic-oriented monitoring station has to be discussed very intensively in regular time intervals regarding

- the location,
- the actual traffic situation by traffic counting, i.e., load of heavy duty vehicles, jams etc.,
- the distance to crossroads,
- the comparison with other stations,
- the comparison with model results

to enhance the reliability of traffic-oriented air pollution data.

All responsible persons should have an eyewitness of the location, and the air quality network must provide all information about the location. The site shall be reviewed at regular intervals (Annex III D.). There should be a comparison between the station inside the area of exceedances and other stations in the surroundings, maybe outside the involved municipality. Temporal passive sampler measurement nearby the continuous monitor can be very helpful to describe the concentration field. Sometimes a passive sampler can be more easily installed then a container of a monitor station on the pedestrian way.

Figure 3.8: Air flow and concentration profile inside a street canyon

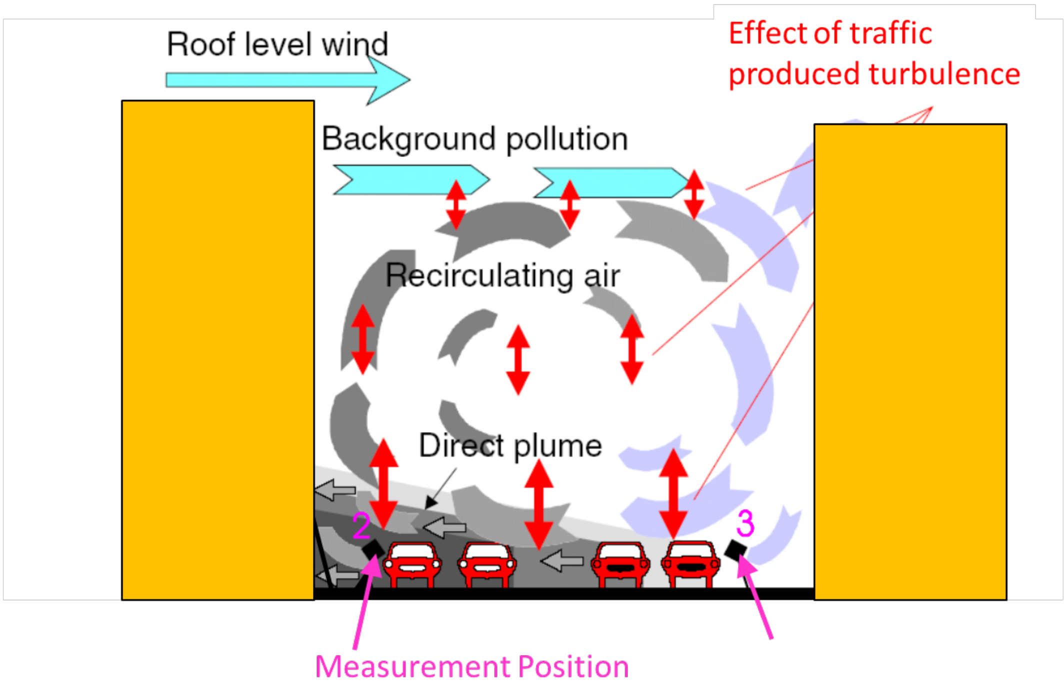
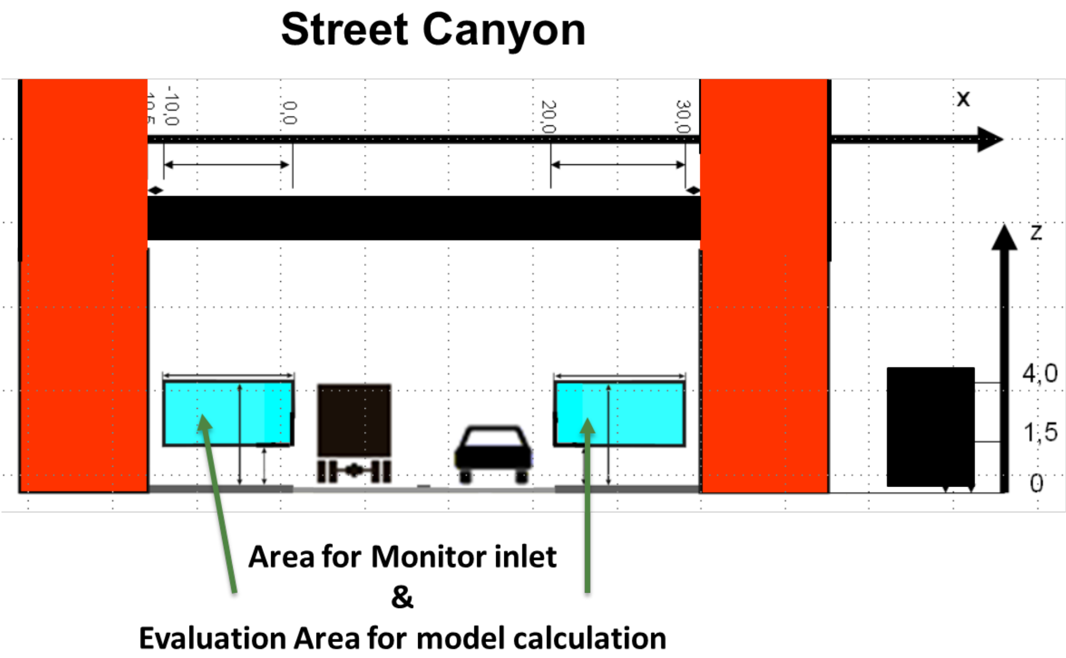


Figure 3.9: Monitor inlet area inside a street canyon (numbers indicate length in meter)



3.4 The monitoring strategy

The monitoring strategy should be checked in regular intervals. By now, very often only one station exists in a town and usually this station is situated in an area that is influenced by strong emission sources (e.g., industry, traffic or domestic heating). Then there is no chance to compare the data with the nearby suburban or rural environment. To identify the area of exceedances (Annex XV A.2.(b)) and to identify and evaluate measures, there is a need for a second comparable monitor station (Annex IV A.).

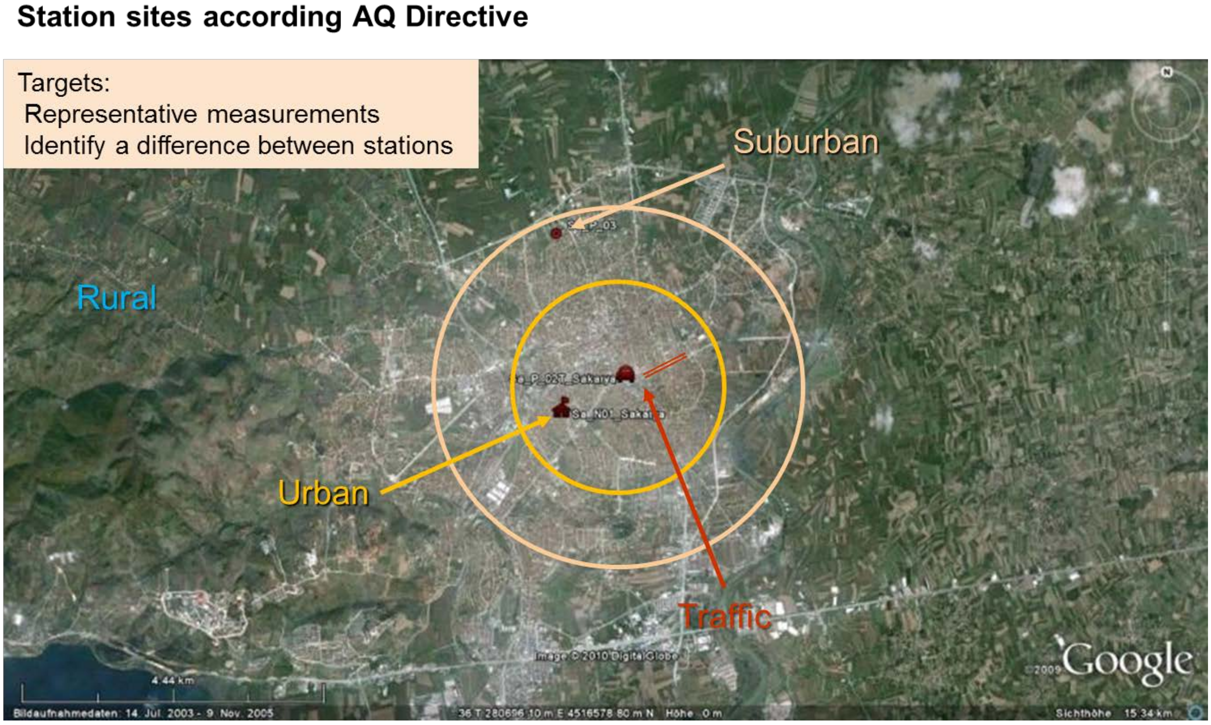
Bulgaria should develop a strategy to use new mobile stations to build up a pair of stations in order to identify the relevant sources in the case of traffic and industrial pollution. The monitoring strategy should be discussed and enhanced. There is a need to identify suburban and traffic sites.

Enhancement of monitoring strategy

By now, always only one station is located in the city center, but there is no information available about the concentration level in the suburban area or nearby the town. The existing rural stations are very often not suitable to describe the situation in a right way. This information is needed; otherwise, there is no chance to identify and to proof measures. A strategy to use temporarily mobile stations should be used.

An example of a reliable monitoring strategy is given in Figure 3.10 (source W. J. Müller based on google map). Inside the town and in the surrounding areas, monitoring stations are installed; therefore, the results can be compared and the additional load inside the town/street can be quantified. This is part of the analysis of the origin of high pollution levels (Annex III A.5, Annex IV A.). This information is also useful to fulfill the questionnaire reporting to the European Commission (Directive 2004/107/EC and Decision 2011/850/EU).

Figure 3.10: Example of a reliable monitoring strategy



A cross section of the concentration profile can be developed by dispersion calculation based on an emission inventory in combination with monitoring information, see Figure 3.11. This is a very impressive diagram that indicates and quantifies the parts of different source categories (Annex III A.6.(a)).

Name of used monitoring stations

Each monitoring station that is relevant to the AQP has to be described in detail to be able to make analysis in high quality (Annex III D., Annex XV A.1.). The following list has to be part of the description:

- map scale about 1:2000,
- geographical coordinates,
- photo of the surroundings to describe the structure of obstacles and the emission structure.

Free public internet access – Description of monitoring station

The description of the monitoring stations should be available via free public internet access on a website and should be updated in regular time intervals.

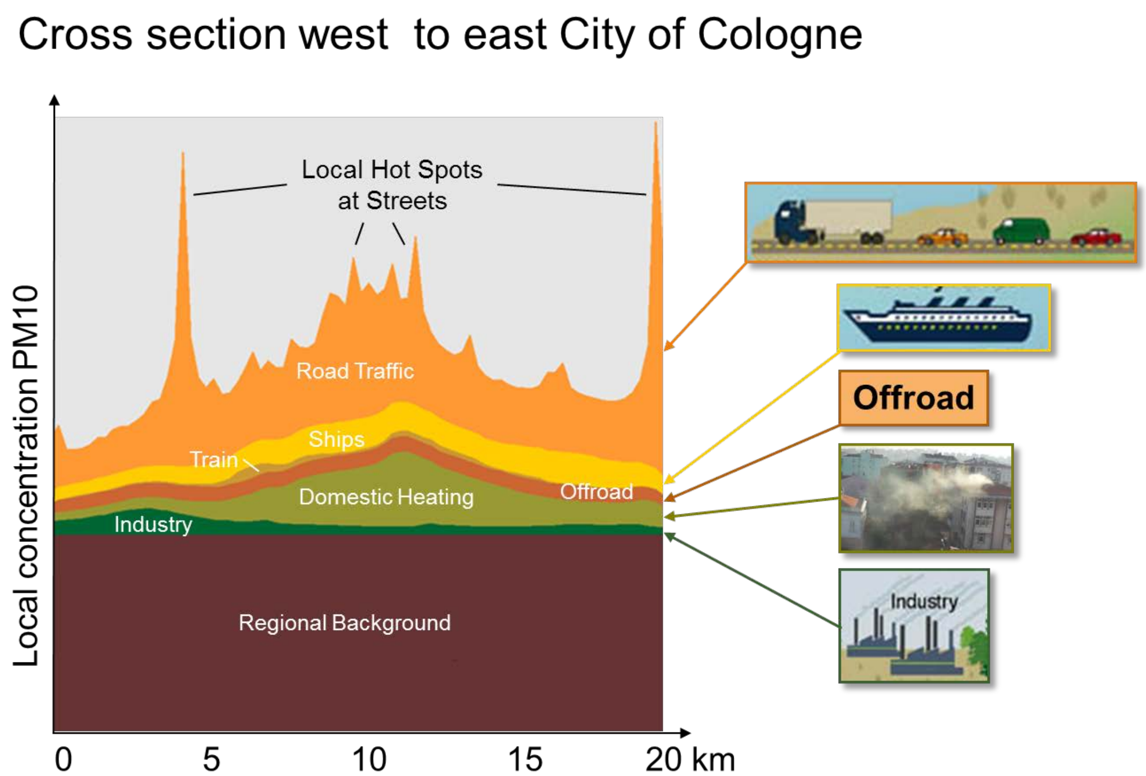
3.5 General information of an AQP

Type of zone (city, industrial or rural area)
An air quality relevant description of the area should be done.
Estimating the polluted area (km²) and the population exposed to the pollution (Annex XV A.2.(b)).
These data will be the result of many investigations based on different tools at the end.
Reliable meteorological data
Meteorological data can be observed at the air quality monitoring stations and are available from stations of the National Institute of Meteorology and Hydrology. These data are the basis to identify the circumstances and the origin of high concentrations of air pollutants (Annex I B., Annex XV A.5.). This is why the reliability of these data should be checked and the representativeness of these data should be proofed carefully. In special cases, additional wind measurements are needed to identify special wind field characteristics. The knowledge of the wind field should be one relevant parameter to develop and review a monitoring strategy and to identify most effective locations for monitoring stations. The data should be representative for the area, which also depends on the topographical structure (Annex XV A.2.(d)). The data should be suitable for dispersion calculation. It is useful to identify suitable and effective measures (Annex I C., Annex III 2.6.).

Check the reliability of AQP tools

The AQP has to describe and document the reliability of the tools to assess/estimate these topics.

Figure 3.11: Cross section of concentration profiles



Source: U. Hartmann

Check the reliability of meteorological data

The AQP must clarify
- the origin of meteorological data,
- the location of measurement of all parameters,
- an eyewitness of the location should be done,
- the time interval of measurement,
- the sensor system and follow up calculations, like mean wind direction,
- the spatial-temporal representativeness of these data,
- the usefulness of these data to analyze the exceedance of air quality levels,
- the usefulness and suitability for dispersion calculation,
- responsible persons for the reliability of the meteorological data.

Relevant data on topography and land use (Annex XV A.2.(d)).

Topography data in GIS format

The data should be available in GIS format. The surroundings of a traffic station should be described by building height data.

Sufficient information on the type of targets requiring protection in the zone
(Annex XV A.2.(e))
An AQP cares about reducing air pollution to protect human health. Nevertheless, the goal of AQPs can overlap with measures to protect flora and fauna, i.e., according to the Fauna-Flora-Habitat-Directive (92/43/EEC). Monitoring stations at rural background sites are needed in order to look at the protection of vegetation (Annex III B.2, Annex VII, Annex VIII, Annex XIII).

One indicator can be a map of land use and additional investigations on vegetation, i.e., describing the impact of nitrogen in relation to critical loads.

Natura 2000

The protection of NATURA 2000 areas in relation to existing and new emissions is under discussion. All member states of the EU must find a solution. By now, there exists no homogenous management system. This topic may become more and more part of an AQP.

Process flow of AQP

An AQP has to describe the process flow (Figure 3.12) (source W. J. Müller) of all relevant data.

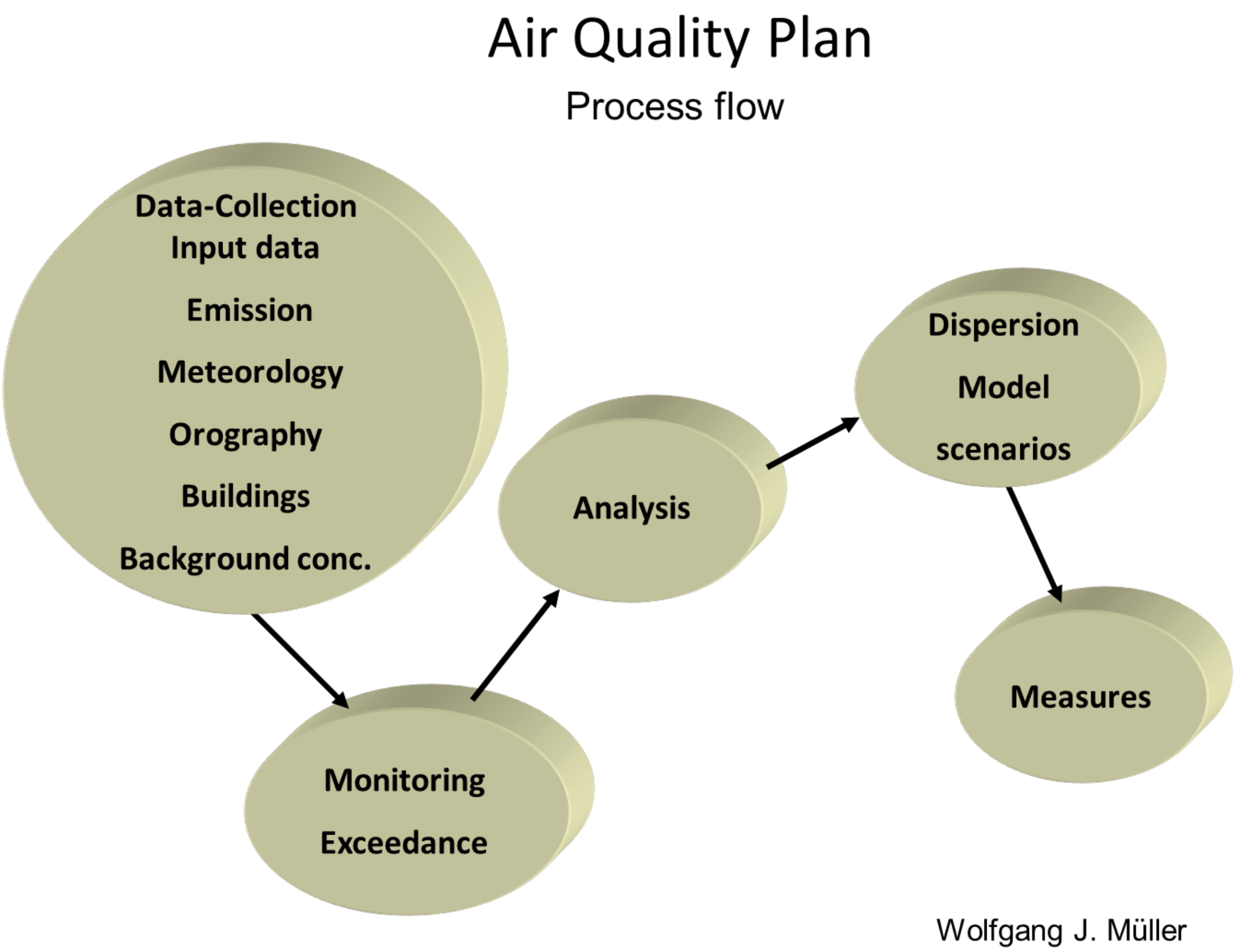
3.6 Responsible authorities

Names and addresses of persons who are responsible for the development and implementation of improvement of AQPs have to be listed. One institution and one person should be responsible for coordination in regular intervals (Annex XV A.3.).

Check previous plans

Previous plans and other investigations/reports concerning the air pollution level should be collected and be available in an archive to identify the origin or to describe the successful reduction procedures.

Figure 3.12: Process flow to develop an AQP



3.7 Nature and assessment of pollution

Part of the plan must be the timeline of concentrations observed over previous years (i.e., before the implementation of the improvement measures) (Annex XV A.4.).

Documentation of the location of monitoring stations

Any change in the location of the monitoring devices must be documented by a map, photo, etc. The reliability of previous data must be discussed.

Actual reports shall summarize the levels of exceedances of limit values, target values, long-term objectives, information thresholds and alert thresholds for the relevant averaging periods. That information shall be combined with a summary assessment of the effects of those exceedances. The reports may include, where appropriate, further information and assessments on forest protection as well as information on other pollutants for which monitoring provisions are specified in the AQD (Annex IV, Annex XVI).

Documentation of monitoring devices

The basis of all analysis must be reliable data, i.e., the calibration procedure and the lifetime of calibration gases have to be checked. These data must be documented. The data quality objectives (Annex 1) must be fulfilled.

Check carefully the quality of the air quality monitoring station:

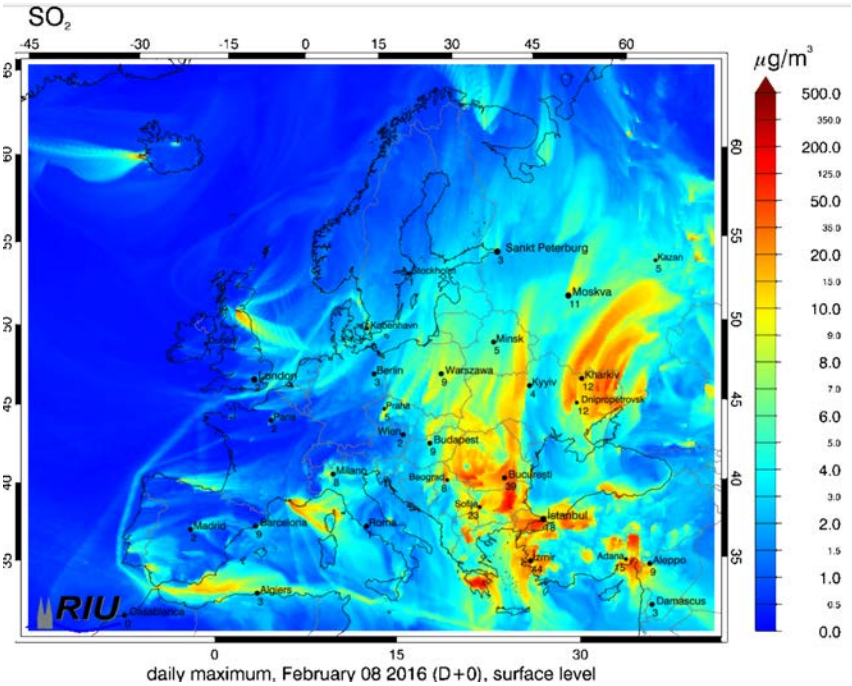
- Is the location of the monitoring station suitable?
- Are all quality requirements fulfilled?
- Is the location representative for regional or urban background or for hot spots like street canyons?

3.8 Origin of pollution

The origin of air pollution should be analyzed. All used tools should be documented and the results should be discussed. In this chapter, different tools to check the measurement data are described below (Annex XV A.4., Annex XV A.5.).

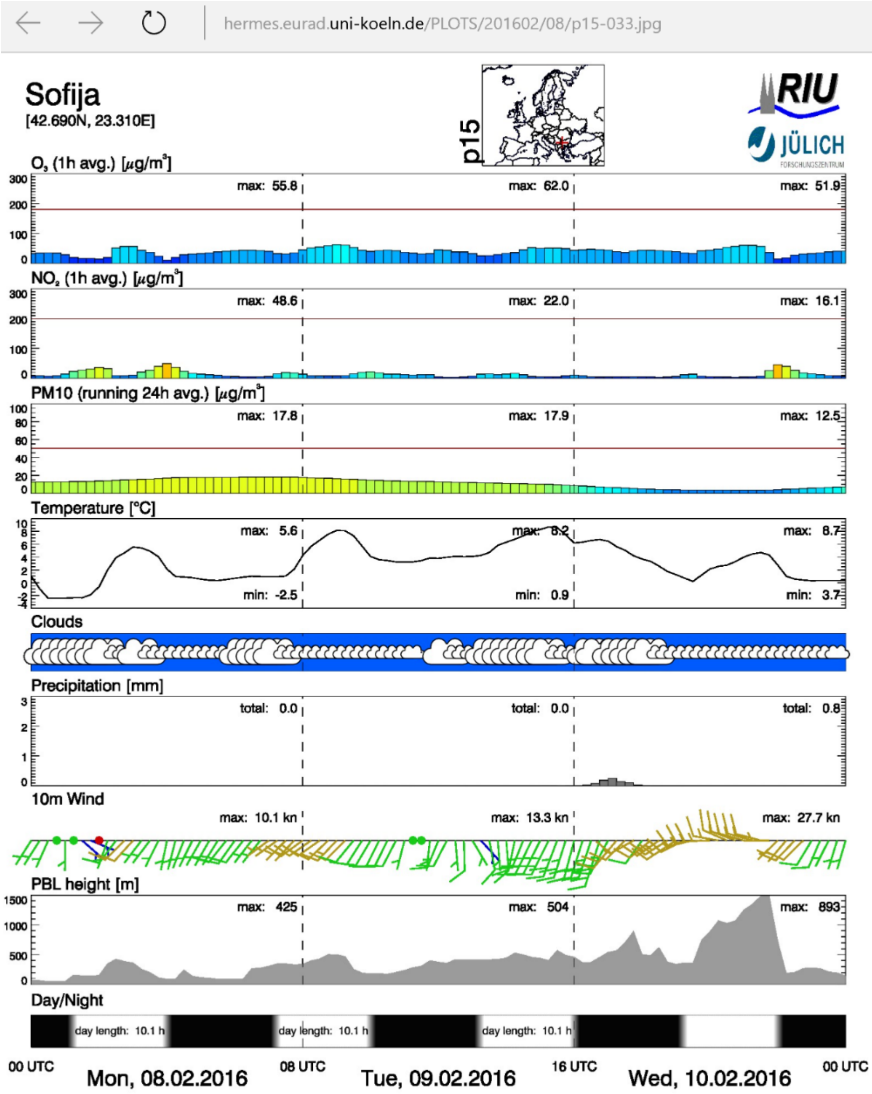
- For the European scale, current results of air quality modeling are available day by day. It is very useful to use this additional information to compare the monitoring network data with model results. To enhance the quality of monitoring time series, a comparison and analysis by independent model calculation of a recommended model system is very suitable (Annex XV A.5.). Long-term experience shows that the EURAD System is very useful. The system produces the current air quality situation every day (http://db.eurad.uni-koeln.de/en/forecast/eurad-im.php?domain=p15&year=2016&month=02&day=08&mode=0#euradim (see Figure 3.13) and the forecast of the pollution situation (http://db.eurad.uni-koeln.de/en/forecast/eurad-im.php). Furthermore, for some cities like Sofia, a Chemogram forecast is available (see Figure 3.14).

Figure 3.13: EURAD SO_2 forecast of daily maximum



- The knowledge of emission sources is a main topic to understand an episode with elevated concentrations of pollutants (Annex XV A.4., Annex XV A.5.).
  A list of the main emission sources responsible for pollution should be divided into industry, domestic heating and traffic. In some cases, additional sectors like livestock, mining activities, natural sources like wind erosion and Saharan dust events should be described.
  A description of the approach of the emission source inventory should be available. The total quantity of emissions from these sources (tons/year) should be listed. The origin of the data should be documented and checked for which level of spatial-temporal aggregation these data represent. It should be clarified, which emission level the used data represents, i.e., permit or mean level or unfavorable level for air quality. Furthermore, the diffusive emission sources should be described.
- Traffic related emissions should be calculated in a reliable, enhanced way. The use of the Handbook Emission Factors for Road Transport (HBEFA, see Chapter 4.1.2) is recommended.
- Domestic heating emissions dominate the air pollution level in great areas. The procedures to estimate the emissions should be described in detail. The portion of fresh and wet wood seems to be very high. Therefore, use of dry wood would be an effective measure.
- Information on pollution imported from other regions should be part of the AQP. The part of Saharan dust should be described. This should be also a part of the analysis of air quality time series in combination with meteorological time series (Annex XV A.5.(c), Annex XV A.6.(a)).

Figure 3.14: EURAD Chemogram for Sofia



3.9 Analysis of the current situation

- Details of those factors responsible for the exceedance (e.g., transport, including cross-border transport, formation of secondary pollutants in the atmosphere) must be described in the AQP (Annex XV A.6.(a)).
- The main analysis should be based on meteorological information to interpret the air pollution episode measurement timeline values. Some statistical procedures are available and should be used at any time. All used tools should be documented and the results should be discussed. In this project, the statistical analysis program "R" was implemented, introduced, trained and some examples were calculated together. All code instructions have been made available (https://www.r-project.org, 21.11.2015).
- Sometimes source apportionment procedures can support an additional understanding of the causes of exceedances (Annex IV A.).
- Very often dispersion modeling is used as a recommended tool (Annex IV A.).

Homemade exceedances

Very often the main problems are homemade:

- Local exceedances are caused by domestic heating using wood and coal (Analysis of the chemical content of PM10 and the levoglucosan (a tracer for biomass burning) concentration should be done).
- Exceedances are often caused by growing traffic.
- Industrial facilities are the origin of exceedances in only a few cases.

3.10 Details of mitigation measures or projects

Generally on local, regional and national levels, a strategy to reduce the emissions should be developed, i.e., by order or by incentives (less taxes). It is well known that social aspects should be a part of selecting an appropriate way to introduce effective mitigation measures.

Figure 3.15 (source Nagl, 2007) gives an impression of the structure of possible measures. These topics should be discussed in detail to develop a list of measures applicable for the special area. In the second step, the most effective measures should be identified. The relevant target of protection (human health and or vegetation/soil) should be identified. The timeline to implement measures must be reliable (Annex XV A.8.). A list of long-term measures should be developed (Annex XV A.9.).

Mitigation measures have to be documented in the AQP in detail and the effectiveness has to be quantified:

- Details of possible measures for the improvement of air quality should be listed.
- A listing and description of all the measures set out in the AQP should be done.
- Quantification and evaluation of mitigation measures by dispersion modeling has to be done.
- Identification of the most effective measures should be included.
- A timetable for implementation should also be included.

3.10.1 Format of the list of measures

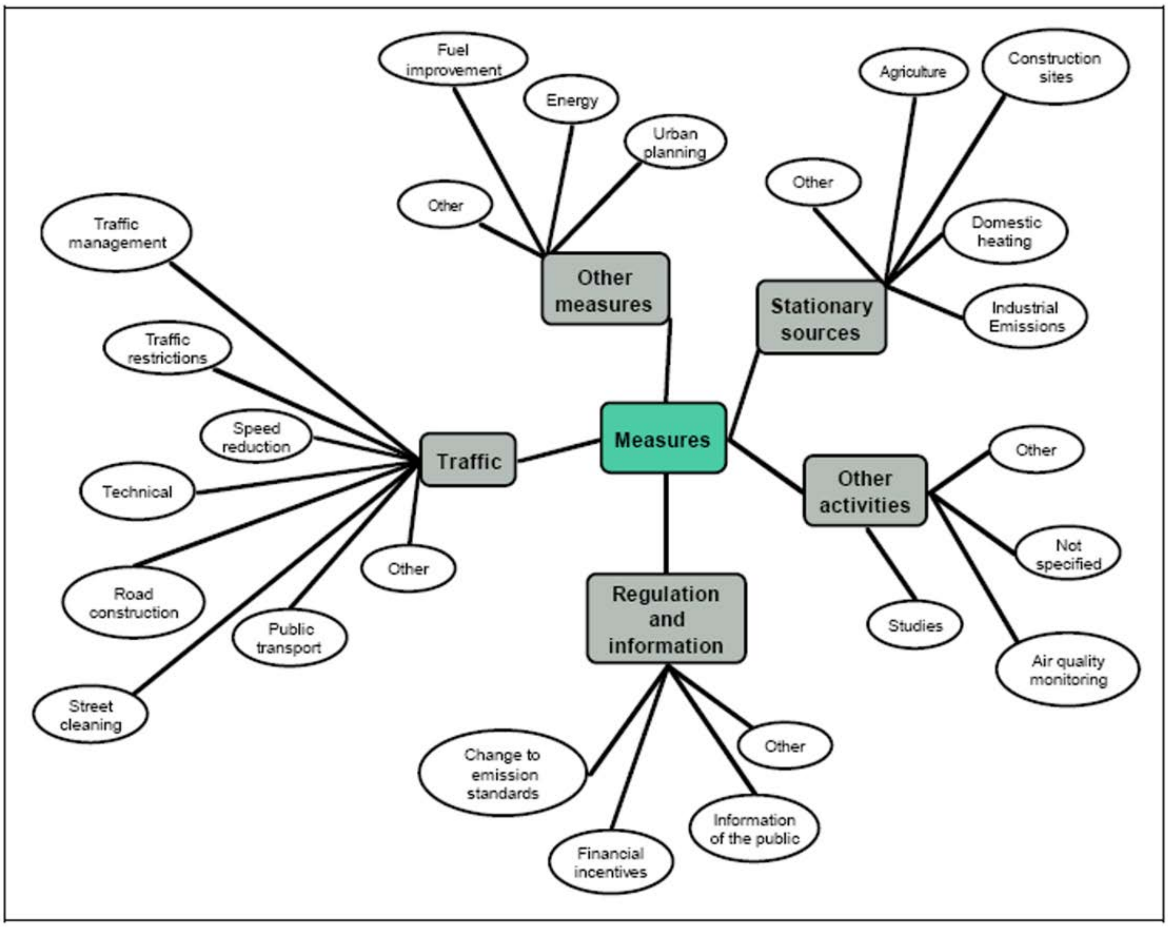
Chapter 8 presents a non-exhaustive list of possible measures in the transport and domestic heating sector. Measures regarding large industrial installations are not presented there because such action depends on the specific type of industry or plants, on the concrete condition of each plant and on the needs to be considered in the context of implementing the provisions of the Directive on industrial emissions.

The following format is recommended when describing the measures stipulated in the AQP:

- short headline with the essence of the action,
- time horizon for implementation,
- institution(s) in charge of the implementation,
- reduction potential: qualitative and quantitative, if possible, with figures of reduced emissions or pollution concentration,
- costs: at least rough estimation, if possible,
- short description of the context of the measure,
- objective of the action,
- implementation: concrete steps,
- environment impact: short description, if available.

The list of measures in Chapter 8 should be considered only as a provisional recommendation, which needs to be adapted to local boundary conditions, depending on feasibility, available resources, compliance gap and the extent to which measures have already been implemented in the past.

Figure 3.15: Structure of possible measures



3.10.2 Principles when selecting measures

- Measures should directly address the source of pollution.
- All sources should be addressed that have a relevant contribution to the exceedances.
- Measures should preferentially be applied to those sources contributing most to the exceedances.
- Cost efficiency should be taken into account when selecting and applying measures.
- Those measures should be selected that have maximum effect and least effort.
- Existing rights should be affected as little as possible.
- Public interests should be taken into account.

The following recommendations can be made when drafting the chapter on the extra long-term measures planned for the future:

- Do not hide weaknesses/data/knowledge gaps.
- Put the focus on justification, description and definition of measures.
- Try to be as concrete as possible.
- Use the templates of possible measures in Chapter 8 as orientation.
- If concrete action is not possible for the moment, stipulate a clear commitment for future scrutiny/study/investigation and subsequent decision on action.
- Add steps to improve emission databases/modeling or evaluation tools/required resources as measures.

The use of wet wood is a common problem. Promote the use of dry wood by

- training how to burn in a more effective way – to be done by municipality or engineers or fire brigade etc. (example: In Reutlingen, Germany, people can participate in voluntary courses to get an “oven-, stove- and boiler-license”),
- combining training with incentives like reduced wood price or taxes,
- education at school,
- involving chimney sweeper, fire brigade, engineers to increase the use of dry wood,
- changing of an order to deliver wet wood (national level),
- for special areas of a town, wood burning can be forbidden by the municipality (example: The city of Stuttgart, Germany, defines wood burning free areas).

On local, regional and national levels, a strategy to reduce the emissions should be developed by:

- changing an order regarding delivering wet wood (at local and national levels),
- incentives (less taxes) for cleaner fuels,
- incentives for more energy-effective and low emission stoves and boilers (example labelling: the label “Blue Angel” (https://www.blauer-engel.de/en) and the label “BeReal”, currently developed for pellet stoves and firewood stoves (www.bereal-project.eu)),
- development and introduction of a reliable procedure to check the effectiveness of ongoing implementation measures.

Research to enhance the burning process in typical Bulgarian ovens could be helpful to derive additional measures, which could be at low cost level.

3.11 Permit procedure

For introducing some measures, industrial facilities must be updated and this will be part of a permit procedure (Annex XV B.3.(a), Annex XV B.3.(g)). The permit procedure of industrial facilities should be checked. The needed dispersion calculation to describe the air pollution load in mean values and exceedances should be in accordance with the AQD limit values. The possibilities for applying a better dispersion model (e.g., AUSTAL2000) should be examined. Application of this model should be introduced and the staff should be trained to use this model system. The staff should build up a network to enhance their knowledge of using the system, e.g., carry out expert workshops annually. The same should be done for traffic emission calculation and dispersion calculation in street canyons.

3.12 Public Information

The access to actual online air pollution data should be enhanced. It should be an easy, user-friendly way to disseminate the information (Annex XVI).

A list of the documents, list of the publications, and works used to supplement information should be available for the public (Annex XV A.10.).

Information on all air pollution mitigation measures that have been considered to be implemented at appropriate local, regional or national levels aiming at the attainment of air quality objectives includes (Annex XV B.):

- reduction of emissions from stationary sources by ensuring that small and medium sized stationary combustion sources (including for biomass) are fitted with emission control equipment or replaced,
- reduction of emissions from vehicles through retrofitting with emission control equipment; the use of economic incentives to accelerate take-up should be considered,
- procurement by public authorities, in line with the handbook on environmental public procurement of road vehicles, fuels and combustion equipment to reduce emissions, including the purchase of:
  - new vehicles, including low emission vehicles,
  - cleaner vehicle transport services,
  - low emission stationary combustion sources,
  - low emission fuels for stationary and mobile sources,
- measures to limit transport emissions through traffic planning and management, including congestion pricing, differentiated parking fees or other economic incentives; establishing low emission zones,
- measures to encourage a shift of transport towards less polluting modes,
- ensuring that low emission fuels are used in small, medium and large scale stationary sources and in mobile sources,
- where appropriate, measures to protect the health of children or other sensitive groups.

Measures to reduce air pollution through the permit system under Directive 2008/1/EC, the National plans under Directive 2001/80/EC, and through the use of economic instruments such as taxes, charges or emission trading are quite common in some countries and could be a possible effective way.

All these topics should be thoroughly discussed. The local, regional and national authorities should develop a list/catalog of possible measures.

3.13 Sketch of a checklist for AQPs

Based on the detailed discussions on AQPs, the following sketch of a checklist was prepared, discussed and disseminated. The list is a simplified extract of the German VDI-Guidelines 3783 Sheets 13[1] and 14[2]. It will be useful to enhance the content and the quality of further AQPs in Bulgaria by checking the reports with this list.

Table 1: Checklist AQP

Basic input data	Yes/no, fulfilled , page no.
AQP contains an area description (area structure: plain, topography, barriers, street canyon)	
Is there a description of all input data, including the data source, the data validation and data analysis?	
Which chemical components are addressed?	
Air Quality situation, monitoring network	
Description of the monitoring station: siting of the station, photo category (urban, suburban, regional background) location on a map measured chemical components comparing these data with stations nearby analysis of data to identify causes of exceedances and sources	
Emission data	
Industry Source of data; Are input data suitable and reliable?	
House heating Description of the way for calculation; Are emission factors suitable?	
Traffic **Description of the traffic emission model** Description of input data: traffic volume emission factor reference year vehicle fleet [statistics of the EU emission standard for vehicle engines (Euro 1, Euro 2, etc.)]	

[1] VDI 3783 Part 13 (2010-01): „Environmental meteorology – Quality control concerning air quality forecast – Plant-related pollution control – Dispersion calculation according to TA Luft"

[2] VDI 3783 Part 14 (2013-08): "Environmental meteorology – Quality control concerning air quality forecast – Vehicle-related air pollution"

Basic input data	Yes/no, fulfilled , page no.
calculation method (HBEFA, COPERT Tier xx or other) traffic situation, level of service, jam slope of the road	
Discussion of results of traffic emission modeling	
Dispersion Modeling	
Is there a description of the dispersion models: name, scale (regional, industry and traffic scales), type (3D, Gauss particle model, version no.)?	
Terrain (plain, orography with digital elevation model); a digital elevation model has to be considered	
Meteorological input data: wind direction, wind velocity, stability class as time series or statistic, which location? Are the used data from a measurement station or modeled data? Are these data suitable for the purpose?	
Mitigation measures	
Does the AQP contain a list of possible measures on ▸ European ▸ national ▸ regional ▸ local levels? How effective are these measures? Cost/effectivity, timeline, proof?	
Are the mitigation measures well-founded by facts or by dispersion modeling of scenarios?	
Public information	
Does a procedure exist to inform the public? Does a procedure exist to change the behavior of the public in the case of domestic heating? Does a procedure exist to reduce the traffic-induced pollution?	
Quality Assurance, history, revision	
Is there a detailed revision of previous AQPs?	

4 Estimating emissions

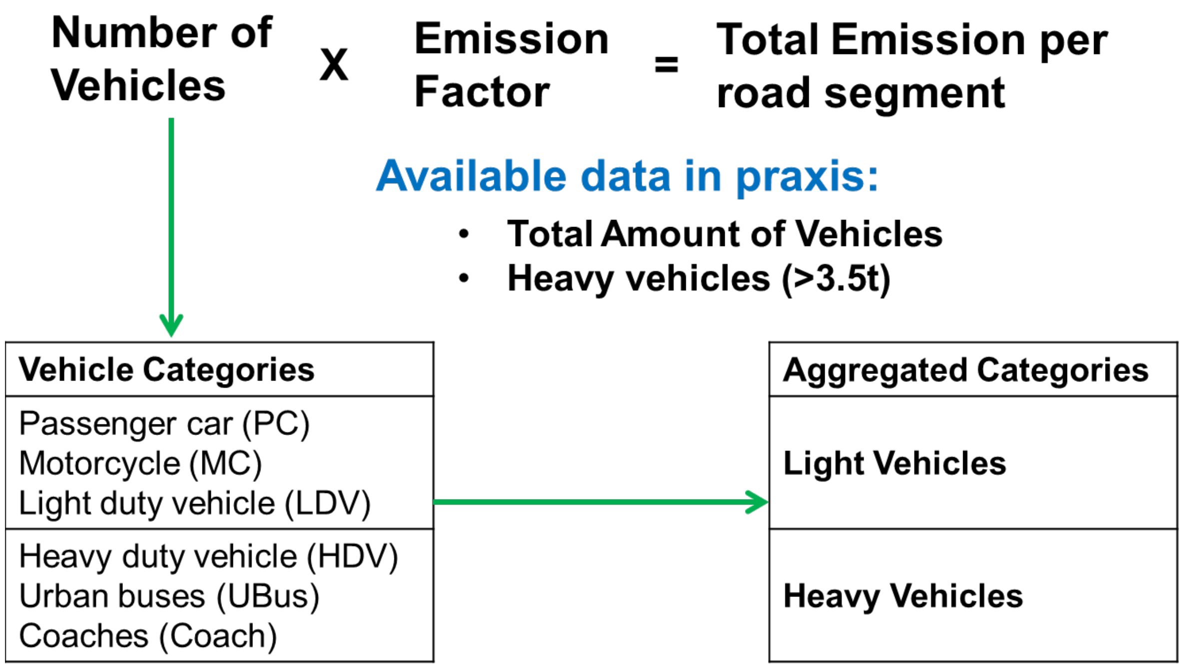
4.1 Road traffic emissions

In many European cities, the influence of road traffic emissions is one of the main causes of high NO_2 and PM10 concentration levels. Therefore, traffic emissions have to be calculated to consider them in dispersion modeling of AQPs. The simulation of road traffic emissions is required to quantify mitigation measures as well. The Commission Implementing Decision 2011/850/EU for exchange of information and reporting on ambient air quality requires detailed information (Annex II) about the input data, the method and the results of emission calculations, which are carried out below.

4.1.1 Calculating road emissions

The traffic emissions are determined from the number of vehicles and specific emission factors (see Figure 4.1). The emission factors are related to the engine type, emission concept and the driving behaviour of the car.

Figure 4.1: Calculation of road traffic emissions



The amount of traffic has to be collected by counters or simulated by traffic flow models. In praxis, only the amount of cars as a daily mean over the year and the share of heavy vehicles are collected. The share of vehicle categories (passenger cars, motorcycles, light duty vehicles, heavy duty vehicles, urban buses and coaches) are estimated out of generally accessible traffic statistics. Usually it requires too much effort to get the information about the engine type and the emission concept of the passing cars. The information about the engine type and emission concept is considered by using the adapted vehicle fleet (see Chapter 4.1.3).

4.1.2 Emission factor database

There are several emission factor databases that differ according to the details level of vehicle emission factors. In Europe, the most used emission databases are (http://www.ermes-group.eu/web/leading_EU_models):

- EMEP/EEA air pollutant mission inventory guidebook (http://www.eea.europa.eu/themes/air/emep-eea-air-pollutant-emission-inventory-guidebook),
- COPERT 4 (http://emisia.com/products/copert-4),
- Handbook Emission Factors for Road Transport, HBEFA (http://www.hbefa.net/e/index.html).

EMEP implements three different methods to estimate traffic emissions due to available input data. It is useful especially for emission inventory on the national level. EMEP is not useful to make detailed emission surveys in cities.

COPERT 4 is a software tool to calculate air pollutant and greenhouse gas emissions from road transport. COPERT emission factors are derived from a binomial regression analysis applied to a large dataset of vehicle measurements classified by vehicle type; they are classified per vehicle type and technology and are expressed as a function of the average speed of the vehicle. The COPERT 4 methodology is part of the EMEP/EEA air pollutant emission inventory guidebook for the calculation of air pollutant emissions and is consistent with the 2006 IPCC Guidelines for the calculation of greenhouse gas emissions. The use of a software tool to calculate road transport emissions allows for a transparent and standardized, hence consistent and comparable, data collecting and emissions reporting procedure, in accordance with the requirements of international conventions and protocols and EU legislation. COPERT considers information about the average speed of different street categories that have no traffic situation (e.g., stop-and-go, effects of traffic lights) implemented, in contrast to HBEFA.

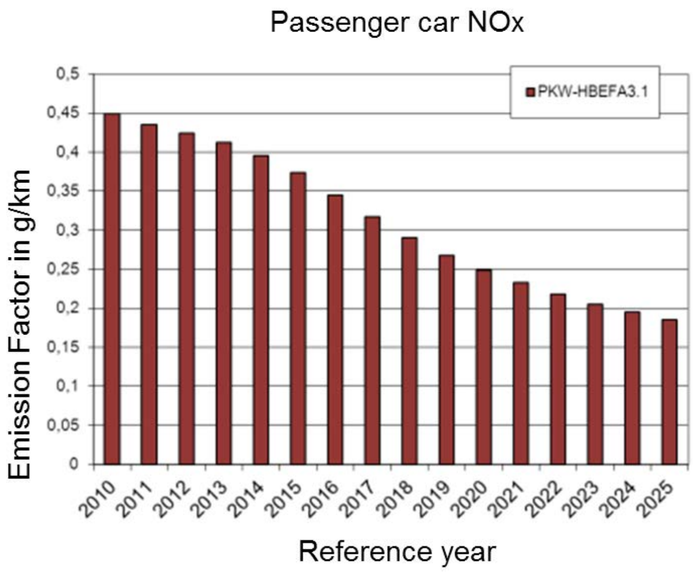
HBEFA, the Handbook Emission Factors for Road Transport, provides emission factors for all current vehicle categories (passenger cars, light duty vehicles, heavy duty vehicles, urban buses, coaches and motor cycles), each divided into different categories, for a wide variety of traffic situations. Emission factors for all regulated and the most important non-regulated pollutants as well as fuel consumption and carbon dioxide (CO_2) are included. The emission factors for HBEFA are generated by the model PHEM (Hausberger et al, 2009), which is a vehicle simulation tool capable of simulating vehicle hot and cold emissions for different driving cycles, gear shift strategies, vehicle loadings, road gradients and vehicle characteristics (mass, size, air resistance etc.). PHEM has been validated by emission measurements, both from light and heavy duty vehicles, in the laboratories (chassis and engine test bed) and on the road (with PEMS) and under different test conditions. HBEFA provides the largest range of traffic situations in comparison to other European emission factor databases. Therefore, HBEFA is predestined for detailed survey and quantify mitigation measures based on optimizing the traffic flow. In contrast to other European emission databases, HBEFA differs in emission factors due to the road slope, which is very important especially for cities with relevant topography.

In Germany, HBEFA is used for AQPs by consultants and governmental offices. This handbook is the actual basis of traffic emission calculations used for AQPs. HBEFA includes emission factors according to a range of generalized driving dynamics. In reality, there are driving dynamics, which are not described in the HBEFA. For this case, it could be necessary to measure the driving dynamic at relevant street sections to describe the driving cycle and the typical acceleration in a better way. These data are used in additional investigations by PHEM Method at the University of Graz to get emission factors with a better resolution.

4.1.3 Vehicle fleet: Adapting emission factors to national and local level

The emission factors of the databases represent a composition of emissions of each engine type (diesel, gasoline, natural gas, electric or hybrid engine) and emission concept (Euro 1, 2, 3, 4, 5 and 6). The vehicle fleet, which represents the portion of each engine type and emission concept, differs on the local level. Usually a vehicle fleet is derived from car inventory and/or fuel consumption on the national level or from detailed surveys on the regional or city levels. The vehicle fleet changes with time because modern vehicles with lower emissions substitute for old vehicles with high emissions. Therefore, the vehicle fleet is gradually becoming more modern and the emission factor is decreasing gradually (e.g., see Figure 4.2).

Figure 4.2: NO_X emission factors for passenger cars, HBEFA



4.1.4 Calculation and estimation problems of traffic emissions

Standardized measurements are made in laboratories to check that vehicles meet the official requirements for exhaust emissions. However, the official procedures currently used in Europe are not representative of real driving conditions. For certain pollutants, there is a significant difference between official emission measurements and vehicle performance on the road. Nitrogen oxides (NO_x), a major air pollutant that harms health and the environment, can be more than seven times higher under real world driving conditions for Euro 6 diesel passenger cars than in official tests. New vehicles similarly can emit up to 40 % more CO_2 than official measurements would indicate (Some information is given by EEA: http://www.eea.europa.eu/highlights/explaining-vehicle-emissions).

The EEA report outlines three main reasons for these discrepancies:

- an outdated test procedure used in Europe that does not reflect real-world driving conditions,
- permitted 'flexibilities' in the current testing procedures that allow manufacturers to optimize certain testing conditions and, thereby, achieve lower fuel consumption and CO_2 emission values,
- several in-use factors which are driver dependent (e.g., driving style) or independent (e.g., environmental conditions).

The existing emissions test procedure permits a number of flexibilities that can be used to minimize measured emissions.

4.1.5 Setting up a traffic volume database as an example

Apart from suitable emission factors, the intensity of the vehicle traffic has to be determined. This is mainly done by traffic counting in the relevant streets and by processing the counting data to get the average daily vehicle (ADT) and the share of heavy duty vehicles. For detailed surveys, the share of the light duty vehicles and the share of different weight classes of heavy duty vehicles could be collected. Additionally for the dispersion modeling, data has to be collected on the type of street (street canyon or not). In case of street canyons, the type of canyon has to be determined as well as the street width, the average height of the bordering buildings and the share of gaps between the buildings.

4.1.6 Objectives of traffic assessment

Traffic data are needed in order to calculate the emissions of pollutants from road traffic. For this purpose, traffic data should cover the type of road, the traffic volume, given as

- vehicles per 24 hours (ADT),
- the percentage of
    1. heavy duty vehicles (all vehicles with a weight > 3.5 t)

    Optionally:

    2. passenger cars
    3. motorcycles
    4. light duty vehicles
    5. heavy duty vehicles
    6. buses
    7. coaches,

traffic velocities and further qualitative information on traffic flow (steady flow, stop-and-go or perturbations, e.g., by traffic lights, etc.).

In order to get this information, traffic flow has to be examined and the number of vehicles has to be counted at representative sites. Counting traffic shows only the amount of traffic in selected road segments. For dispersion modeling in cities, traffic information for the entire road network is required. Therefore, the traffic information has to be applied to the road network manually or by using a traffic flow model.

4.1.7 General information on traffic data required

Calculation programs for the assessment of yearly emissions or the annual mean value of ambient air quality concentrations may require as input data traffic volumes for the “normal working day”, i.e., Tuesday, Wednesday or Thursday for any period, excluding holidays. The projections of this daily data on the whole year done by these assessment programs imply experience on weekly and annual distributions of traffic volume in Western Europe.

These programs still have not been updated for the traffic situation in Eastern European countries, as there is still not enough experience and data on weekly or annual traffic distributions available. In all urban areas, it is quite difficult and requires a lot of manpower to obtain the information on a 24-hour traffic volume for the “normal working day”, on the distribution of traffic over the hours of the day and especially on the share of different vehicle types.

In many countries in Western Europe, there is already some experience on typical characteristics for different types of roads in different urban situations. Many counting activities, therefore, can be replaced by calculated projections based on short-time sampling, which saves considerable time and money. Therefore, there is great interest in obtaining more information on typical traffic characteristics for standard traffic situations.

In Bulgaria, the traffic situation has been changing a lot during the last years and is still changing along with the transformation of the economic system. Thus, only few actual data are available even on the features of road traffic in towns and cities for “normal days”. Therefore, it is not possible at present to assess the amount of traffic by short-time counting actions and by calculated projections based on well-known time characteristics for daily traffic. It is necessary to get some more practical experience first on “how traffic runs” in Bulgaria. Consequently, traffic assessment in Bulgarian towns mainly must be founded on traffic counting actions over a period of at least 24 hours at well-chosen sites covering the most important part of the urban road network.

Additional sites of minor importance may be treated with counting actions covering the most representative hours of the day, if the 24-hour characteristics of the most important sites of the road network have been determined, thus allowing calculating projections.

Usually at most sites, the most representative hours consist of 3 hours in the morning, 2 hours at noon and 3 hours in the afternoon. In the inner cities, even 5 hours of traffic counting during the busiest period in the afternoon may be sufficient for valid projections.

It has to be mentioned that, e.g., in Germany, traffic counting is done mostly by the traffic administrations for serving their planning purposes and for gaining statistical data. If such data of the traffic administrations is available in Bulgaria for the area under investigation (this may, e.g., be the case for big cities like Sofia and Plovdiv) and if it is suitable, it should be used for the purposes of air quality management. If not, traffic counting and analysis of the data must be made to get a suitable base for assessment. The following explanations shall help to gather suitable data.

4.1.8 Planning and evaluating of traffic counting actions

Traffic assessment requires the following steps:

- Definition of the main road network and selection of appropriate sites for 24-hour counting and for short-time counting
  In order to get a realistic impression of the local situation, the first task in traffic assessment is to analyze the road network of the town and the main traffic flows by studies of maps, and even more importantly, by personal inspection of the sites. Using this information, the hierarchy of the road network and the importance of roads for air pollution have to be defined based on the following criteria:
    1. high traffic flow or
    2. medium traffic flow in combination with narrow street canyons.

  Based on the main road network, sites for the 24-hour counting actions have to be chosen covering all central positions in the road network and considering all important entries to the urban area. As these 24-hour sites constitute the backbone of all future traffic assessment, they have to be selected very carefully.

Further steps to be done:

- specification of the counting schedules (selection of the days and hours of counting),
- exact specification of the tasks for each counter involved in the action,
- design of the counting registration sheets and instructions to the staff,
- evaluation and control of the results of the 24-hour actions (separately for passenger cars, trucks, buses and trolleys and for every site, road section and direction of traffic flow) ,
- convert the data into suitable format and use it for emission and air quality assessment,
- definition of sectors in the road network and selection of the sites for short-time counting,
- definition of the counting schedules,
- exact definition of the tasks of each counter involved,
- design of the counting registration sheets and instructions to the staff,
- quality checks of traffic data,
- calculation of 24-hour projections, results for multipliers, recommendations,
- results on the composition of the vehicle fleet inside the town, taking account of the different types of trucks and buses.

Figure 4.3: Counting sheet – detailed version

Name of responsible	Site No.:	Name of Street:	Action:	
	Street segment direction:	Traffic direction (+lane):	Date:	1 h Period (norm): :00 - :00
Counting Intervals: Start(S =min) and End(E =min): S: E: ;S: E: ;S: E: ;S:				Sum(min):
Vehicle Types	axles	tyres / weight		
Passenger car	-	-		
Passenger car	-	-		
Passenger car	-	-		
Passenger car	-	-		
Passenger car	-	-		
Passenger car	-	-		
Passenger car	-	-		Sum:
Light duty vehicle	2	single tyres		Sum:
Small truck	2	twin tyres		Sum:
Medium truck	2	7,5 - 14 t		Sum:
Heavy truck	2	above 14 t		Sum:
Heavy Truck/ no Trailor	3			Sum:
Articulated lorry (or trailor)	4			Sum:
Articulated lorry (or trailor)	5 or more			Sum:
Buses	2			Sum:
Big Buses	3			Sum:
Trolley Buses	-			Sum:

4.2 Emissions from domestic heating

The following basic procedure on the estimation of the emissions from domestic heating is an example and was used in a Twinning Project for the case of Pernik. The procedure is explained in greater detail below.

The Commission Implementing Decision 2011/850/EU for exchange of information and reporting on ambient air quality requires detailed information (Annex II) about the input data, the method and the result of emission calculations, which are carried out below.

4.2.1 Estimation procedure

The estimation of the emissions from domestic heating, according to this procedure, includes several important simplifications and has the following basic steps (the order of the steps to do is variable and is not determined by the sequence presented below):

1. Estimation of the average gross heating power consumption during the heating season per m^2 living space in Watt/m^2, taking into consideration the energy sources used and the importance of emissions from domestic heating
   There are other types of indicators for the heating power consumption available, e.g., based on the volume of the living space in m^3, but the method based on m^2 living space seems to be easier to apply to the situation in Bulgaria because very few data about domestic heating and the characteristics of the apartments/buildings seem to be available. The estimation can be crosschecked with data on the amount of fuel locally used and the heating value of the fuel, as well as the average size of living space, if respective data are available.
   The relevant energy sources are coal, wood, natural gas or liquid pressurized gas (LPG), light fuel oil, electricity and district heat. The latter two sources of heat are not directly responsible for emissions at the houses/buildings. However, the knowledge of these figures may be relevant later for the planning of improvement measures, e.g., for estimating possible increases or decreases in the number of apartments heated by district heat or electricity, based on the future development of prices. If the price for district heat or electricity, e.g., will rise significantly, then a certain rate of residents may switch to fuels like coal or wood if these are cheaper and the residents have the technical possibility to switch.
   The estimation may be based on statistical values (annual statistical yearbook) or analysis of energy consumption per apartment, etc. The energy consumption depends on many variables such as type of energy source (coal, lignite, oil, gas), prices of fuel, income of the residents, technology of heating, type of combustion equipment, insulation of building, heating practice, mean temperature in the living space, etc. An appropriate estimation can only be done with knowledge of the local situation.
   For Pernik, a very low value of 50 W/m^2 as an average for the heating season was assumed in the Twinning Project, based on the assessment of the local situation. This may be significantly higher at other locations and may reach 100 or even 150 W/m^2 under different conditions.
2. Estimation of the average duration of heating in h/y
   This can be done based on the knowledge of the local climatic situation and heating practice. For the estimation, a heating period of 6 months (October to March) could be assumed. This may differ throughout Bulgaria. It could be checked by the temperature data sets of the nearby meteorological station of the National Weather Service. The heat consumption in W/m^2 and the duration of heating in h/y have to be considered together. For example, the heat consumption could be determined in a way that it is the average consumption during the whole heating season (averaging all the hours in the day, those in which heat is produced and those in which it is not).
3. Identification of areas of 1 km x 1 km in the city area (preferably according to the cell grid of a suitable map available and the residential districts) for summarizing the emissions from domestic heating
   Where the building structure is not homogeneous in this area, a smaller size may be chosen, e.g., 500 m x 500 m. Identifiers to the areas on a map for reference should be attached, e.g., consecutive numbers.

4. Estimation of the average size of the heated living space in m^2 per household in the apartments and houses in the areas, as well as the number of apartments and households
   Again, the estimated average heat consumption in W/m^2 should be considered together with the average heated living space. For the situation in Pernik, an average size of 60 m^2 per household was estimated.
5. Determination of the share of the different fuels in the chosen areas (how many households are using which source of heat)
6. Determining suitable emission factors for the different fuels
   The selection or choice of the best fitting emission factor is very important. Whereas the emission factors for light fuel oil and LPG or natural gas are in a small range of values or can, e.g., easily be deducted from the sulphur content (S content) in light fuel oil, this is not the case for coal and, to some extent, for firewood. Especially the SO_2 emissions of coal are varying with the S content and the absorbing characteristic of the ash. A certain part of the sulphur will always be chemically bound in the ash remaining in the oven, so that the SO_2 missions will be less than according to the average S content in case of full stoichiometric transformation to SO_2. The situation is even more difficult with regard to the emissions of TSP and PM10. The emissions depend on the technical characteristics of the oven and the combustion process, the ash content in the coal and the mechanical structure of the coal (e.g., briquettes may lead to lower dust emissions than bulk coal). In the ideal case, emission measurements of suitable quality and representativeness are available from typical combustion devices used in the area and from typical types of coal/firewood used (at least for TSP and SO_2). So far, such data seems to be unavailable for the Bulgarian situation. Alternatively, known emission factors for fuels from other origins may be used as a basis for estimation of suitable factors for the local situation. The emission factors are typically presented and used in kg emission/TeraJoule energy content (referring to the lower caloric value of the fuel, 1 TJ = 10^{12} Joule). Table 2 shows ranges of emission factors used in Germany for several typical fuels used in domestic heating.

Table 2: Emission factors for typical fuels

Fuel	Lower heating value of fuel Mj/kg resp. Mj/Nm3 (gas)	NO_x as NO_2 [kg/TJ]	SO_2 [kg/TJ	Lead [kg/TJ	TSP [kg/TJ
Light fuel oil, S 0,38-0,2 %	42,7	50	160 - 85	0,005	1,5
Natural gas	46 MJ/Nm3	42	0,5	0	0,03
Brown coal briquette, S content variable	18 - 20	80 - 100	100 - 900	0,0015 - 0,020	70 - 370
Hard coal, S content variable	28 - 32	35 - 65	350-600	0,1 - 0,84	6 - 630
Wood, natural, air dried	15	70	6	0,095	200

Additionally, Table 3 gives, for briquettes of several brown coal types used in Eastern Germany, results for emission factors of SO_2, NO_x and TSP from recent emission measurements, with some more detailed data on the coals. Brown coal is especially interesting for Bulgaria because brown coal is one of the major fuels available in the country from its own resources. But is has to be taken into account that some of the Bulgarian brown coals/lignites have a much higher ash content and lower heating value than the coals described in Table 3. For example, the coal from Pernik origin used for domestic heating has far more than 20 % ash content and a lower caloric value of up to about 17 MJ/kg. Therefore, the TSP emission is expected to be very high and was estimated, in absence of suitable measurement data, to 500 kg/TJ.

Table 3: Measured characteristic of different lignite used in Germany

Coal	Lower caloric value MJ/kg	Ash content %	Moisture content %	Sulphur content %	Total carbon content %
Lausitz 3	19	6	18	0,89	50,4
Stedten	20,1	11,3	18,6	2,91	49,8
salt coal	20,5	11,4	14,1	4,5	54,2
Profen 1	21,4	9,1	14,6	2,66	56,2
Profen 2	22,05	9,8	10	2,16	58,95
MIBRAG 1	20,36	15,6	12,4	2,84	53,4
Lausitz 1	20,40	5,3	11,4	0,64	56,4
MIBRAG 2	21,05	14,3	12, 3	2,74	55,6
Lausitz 2	20,45	6,7	12, 3	0,78	56,2
Bohemia	24,81	8,1	8,0	0,43	65,5
Baschkirien	19,51	19,4	9,4	0,68	50,4
Poland	19,69	7,7	15,3	0,49	54,0

Other guidance for PM10 emission factors for coal combustion can be found in the UK emission factors database recommended for estimation of emissions from domestic heating for local emission inventories (www.naei.org.uk/emissions/index.php). In that database, a value of 10.4 kg/ton of coal for PM10 is recommended with no distinction for the type of coal. This will result in higher emission factors for Bulgarian coal with low heating value than according to the German figures. For example, applied to the coal used in Pernik (lower caloric value of 17 MJ/kg, which is equivalent to 58,8 tons of coal/TJ), this results in a PM10 emission factor of 610 kg/TJ.

For the emissions from combustion of firewood, there is information available from the RAINS modeling system (www.iiasa.ac.at/~rains/PM/docs/documentation.html). For Eastern Europe, a twofold higher emission factor for emissions of domestic heating with firewood was estimated (480 kg/TJ) than for Western Europe. The reason for this higher value is not explained there, but it may be the result of differences in the average state of dryness of the wood used for domestic heating or differences in the combustion equipment.

The PM10 emissions can be derived from the TSP emissions by application of an average factor of 0.95. Depending on the special situation of combustion, the real factor may be somewhat lower or higher.

7. Computation of energy consumption and emissions for each area

   The results from the estimation of emissions should be summarized in a table by areas. An example of how this can be done is included in Table 4 to Table 6. The example is taken from the Twinning Project and concerns Pernik. It is best to include the whole computation in an Excel spreadsheet calculation. Then changes are easily possible. The table shows the complete results for all areas of a city and with all basic data including the emission factors used. Additionally, the average source height for each area is included.

8. Determination of the average emission source height in an area
The average emission height is a strong simplification of the real situation. It is needed for the dispersion modeling of the ambient air quality effect of the emissions from domestic heating. This height is an average approximation based on the typical number of stories of those buildings in the respective 1 km² area with emissions from domestic heating. Most important are the buildings with emission sources, which are really emitting in the period of investigation (the apartments with district heating or electricity heating are not needed for the determination of the average height of the emissions). The values can be found by multiplying the average number of stories with the typical height of a story (e.g., 2.6 m), plus a certain height for the roof and the chimney.

To show the different steps, an example for the application is shown in Table 4 to Table 6 (as mentioned above, the more appropriate way would be to implement the computations in an Excel spreadsheet).

Table 4: Example for calculation of domestic heating emissions – Basic information

Basic data apartments		
Avg_res_size heated	60	m²
En_consumption	55	W/m²
Avg_heating_hrs	4320	hrs

	Heating value	Fuel consumption
	MJ/kg	t/a
lignite	17	31010
wood	15	9372
oil	42.7	563
gas	46	588

PM10/TSP	0.95
Light fuel oil data	1 % S

Coal data
1 - 1.7 % S
25-30 % ash
1 TJ = 58.8 t of coal
42.7
46

Table 5: Example for calculation of domestic heating emissions – Emission factors

Emission factors			
Coal (lignite)		Dried wood	
NO_x [kg/TJ]	90	NO_x [kg/TJ]	70
SO_2 [kg/TJ]	600	SO_2 [kg/TJ]	6
Pb [g/TJ]	20	Pb [g/TJ]	95
TSP [kg/TJ]	500	TSP [kg/TJ]	500
PM10 [kg/TJ]	475	PM10 [kg/TJ]	475

Emission factors			
Oil		**Gas**	
NO_x [kg/TJ]	50.00	NO_x [kg/TJ]	42
SO_2 [kg/TJ]	470.00	SO_2 [kg/TJ]	0.5
Pb [g/TJ]	5.00	Pb [g/TJ]	0
TSP [kg/TJ]	1.50	TSP [kg/TJ]	0.03
PM10 [kg/TJ]	1.43	PM10 [kg/TJ]	0.0285

Table 6: Example for calculation of domestic heating emissions – Calculated emissions

Region #	NO_x kg/h	SO_2 kg/h	Pb g/h	TSP kg/h	PM10 kg/h	NO_2 kg/h	h [m]
1	0.64	3.70	0.24	3.61	3.43	0.41	8.5
2	0.45	2.36	0.21	2.66	2.53	0.29	6.2
...							
Sum: [kg/h]							
Sum: [t/a]							

4.2.2 Example for application

a) Identification of the different areas for estimation of the joint emissions from domestic heating
b) In a given area, the average size of an apartment may be 60 m^2.
c) The consumption of heating energy may be estimated to be 55 W/m^2.
d) The energy consumption during heating for the average apartment then is:

$60\ m^2 \times 55\ W/m^2 = 3300\ W$

The hourly energy consumption then is:
3300 Wh = 3300 Wh x 3600 sec/h = 11.88 MWsec = 11.88 MJ
= 11.88×10^{-6} TJ

e) The following computation shows the hourly emissions in case of use of the fuels indicated in bold font, with the emission factors (only examples from the range of possible factors) applied in the second column for the mentioned average apartment size:

Light fuel oil (S content 0.38 %):

NO_2:	50 kg/TJ	x 11.88×10^{-6} TJ =	0.000594 kg
SO_2:	160 kg/TJ	x 11.88×10^{-6} TJ =	0.0019 kg
PM10:	1.425 kg/TJ	x 11.88×10^{-6} TJ =	0.0000169 kg

Natural gas:

NO_2:	42 kg/TJ	x 11.88×10^{-6} TJ =	0.000499 kg
SO_2:	0.5 kg/TJ	x 11.88×10^{-6} TJ =	0.00000594 kg
PM10:	0.0285 kg/TJ	x 11.88×10^{-6} TJ =	negligible

Brown coal:

NO_2:	90 kg/TJ	x 11.88 x10^{-6} TJ =	0.00107 kg
SO_2:	900 kg/TJ	x 11.88 x10^{-6} TJ =	0.0107 kg
PM10:	211 kg/TJ	x 11.88 x10^{-6} TJ =	0.00251kg

Firewood:

NO_2:	70 kg/TJ	x 11.88 x10^{-6} TJ =	0.000832 kg
SO_2:	6 kg/TJ	x 11.88 x10^{-6} TJ =	0.000071kg
PM10:	190 kg/TJ	x 11.88 x10^{-6} TJ =	0.00226 kg

Based on the following share of apartments in a given area of 1 km x 1 km, the hourly emissions for, e.g., SO_2 can be estimated:

Total number of apartments is, e.g.: 1000, heating by fuel/type, numbers according to the following Table 7:

Table 7: Number of domestic heating devices according to fuel type

Heating by fuel	Type
400	Brown coal
50	Natural gas
100	Firewood
200	Light fuel oil
100	Electricity
150	District heating

Then the emissions of SO_2 per hour (supposed the heating takes place at the same time) are:

400 x 0.0107 + 50 x 0.00000594 + 100 x 0.000071 + 200 x 0.0019 kg/h =

4.28 + 0.000297 + 0.0071 + 0.38 = 4.67 kg

Under the assumption that the duration of the heating period is 6 months (or about 30 days/month x 24 hours/day x 6 months/year = 4320 hours/year) the annual emission of SO_2 in this 1 km^2 area may be estimated to

4320 x 4.67 = <u>20174</u> kg/a.

These emission data combined with the results of other grid cells can be used to identify measures and for dispersion calculations.

5 Atmospheric dispersion models

5.1 Dispersion modeling

All effective abatement strategies for the reduction of the air pollution level in an AQP are based on the knowledge of the current air quality in the region. Part of an AQP is an assessment report, which is usually based on air quality measurement data, supplemented by emission inventory and modeling and special indicative measurement campaigns where no permanent monitoring data are available.

Measurement data of air quality monitoring stations represent only a point in an area and a limited monitoring period (past to present). Dispersion models assist in providing spatial concentration information. Furthermore, it is possible to calculate concentrations for scenarios of mitigation measures for the future.

Dispersion calculations are needed for the

- analysis of source contribution,
- analysis of area of exceedance and exposure of population,
- analysis of effectiveness to avoid exceedances.

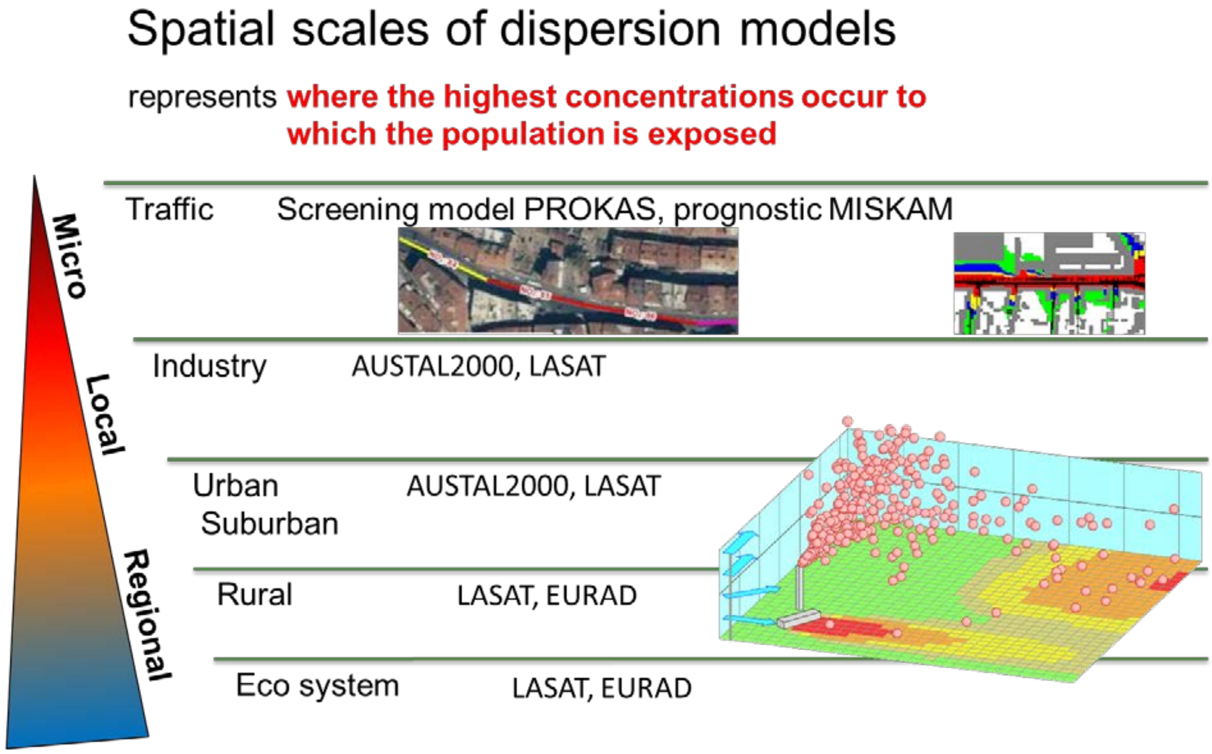
These are not only tasks to develop an AQP but also tasks in normal permit procedures.

Special tasks are:

- to identify hot spot monitoring locations by screening,
- to be a supplement of monitoring – check of monitoring data,
- to be an important part of quality assurance of air quality data,
- to identify the causes of high pollution level,
- to be part of reporting in the case of exceedances of limit values,
- to be an important part of permit procedures for industrial facilities, livestock and street planning,
- to look into the future,
- to plan mitigation measures,
- to check the effect of measures – cost/profit.

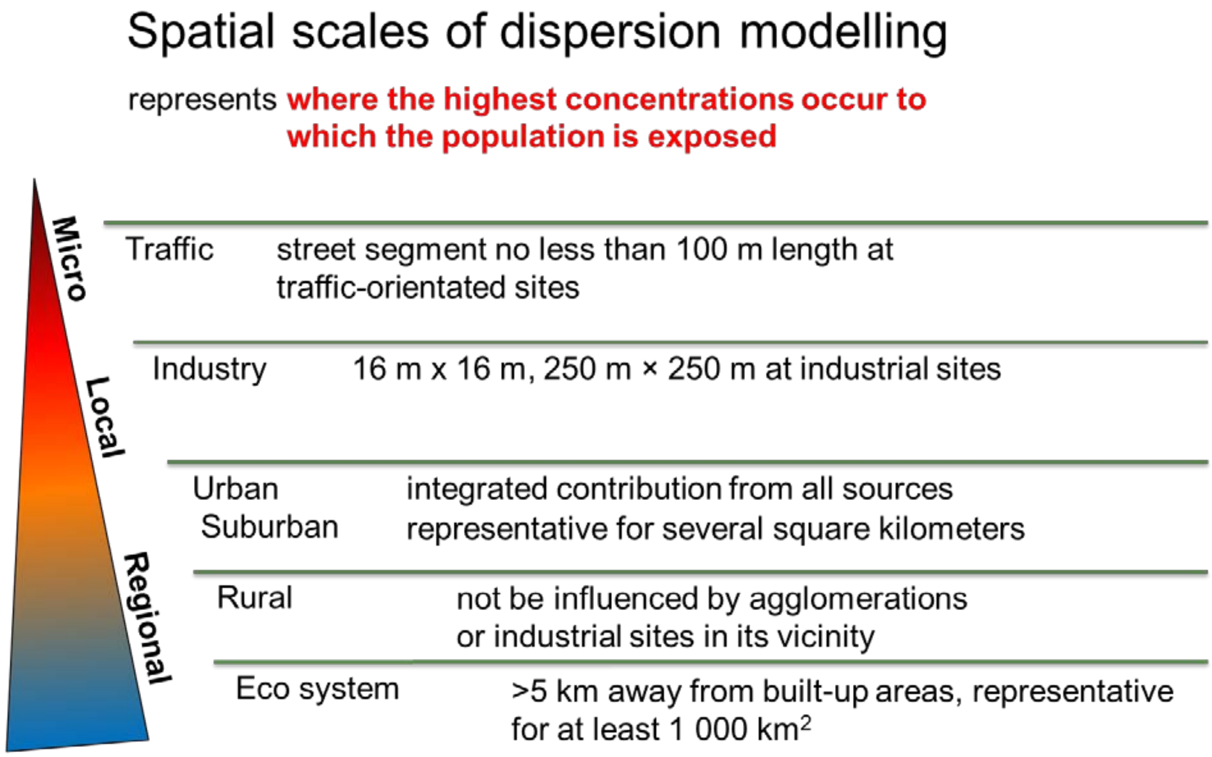
For different spatial scales, there is a need for different dispersion models. The list in Figure 5.1 gives an example of well-recommended, very often used, dispersion models in Germany (see also the spatial scale systematic for monitoring in Figure 3.7).

Figure 5.1: Different spatial scales need different dispersion models



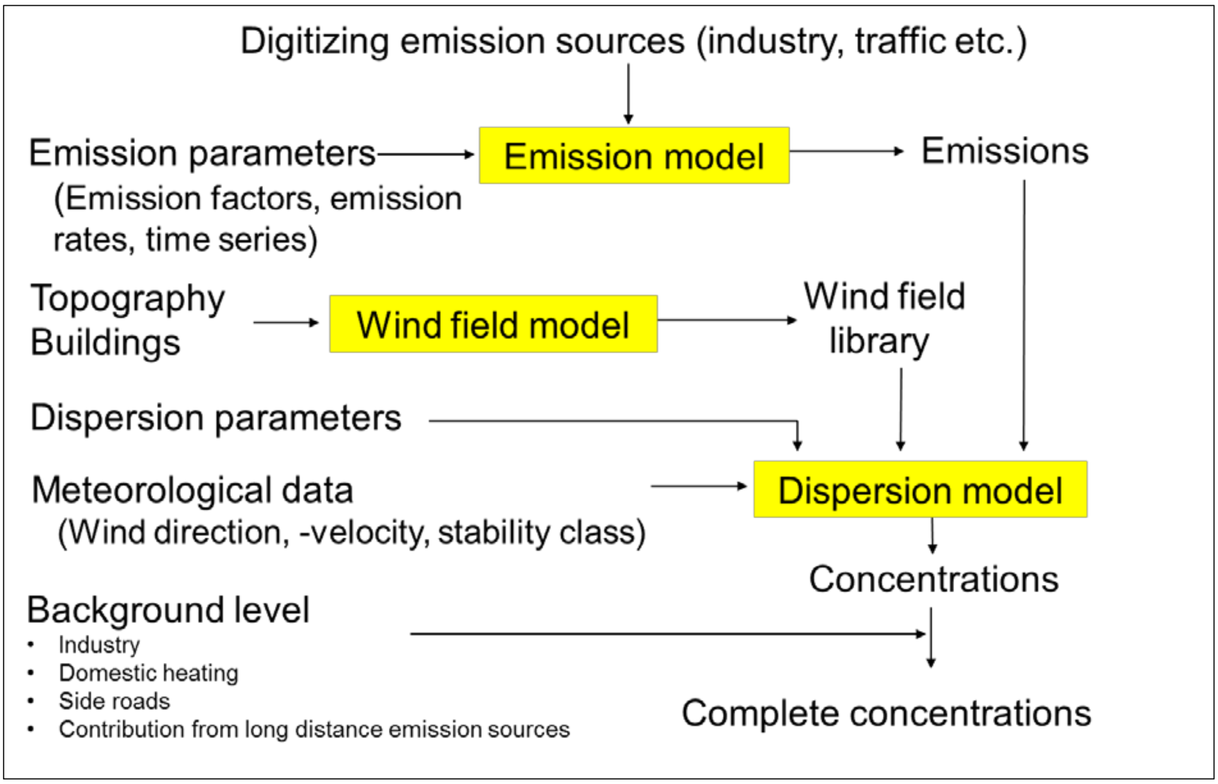
Dispersion models should describe the spatial extensions of hotspots, see Figure 5.2.

Figure 5.2: Spatial scales covered by dispersion calculation



Dispersion modeling includes different sub-models, which are shown in Figure 5.3. The main components are the emission model, the wind field model and the dispersion model as itself.

Figure 5.3: Emission, wind field and dispersion modeling scheme



Different emission, wind field and dispersion models are available on the market. The selection of an adequate model must take into account the local circumstances (e.g., orography, building, special meteorological phenomena, etc.) and the requirement of the input data. At first, the aim has to be defined. Do you need detailed information of the 3D concentration field in street canyons or is screening information sufficient? Do you want to analyze the air quality situation to define mitigation measures in an AQP? Depending on the aim, the resolution and the type of the model(s) have to be chosen.

Several dispersion models are used for AQPs. Dispersion models are mathematic software programs that are based on simple equations like Gaussian dispersion models or more sophisticated like Lagrangian particle models. The air quality specialist has to select the dispersion model that fits the circumstances of the AQP area. The model area for an AQP generally has many emission sources.

The Commission Implementing Decision 2011/850/EU for exchange of information and reporting on ambient air quality requires detailed information about the input data, the area, the model and the result of dispersion calculations, which are carried out below.

5.2 Micro scale dispersion models

Very often the highest concentrations occur in street canyons due to the reduced dispersion capabilities. Calculating concentrations in street canyons requires the calculation of the air flow between the buildings, which can be done by highly sophisticated models.

In practice, the workflow consists of two steps:

- For a whole town, the identification of hot spots and calculations may be done with a simplified screening model. Screening models can consider the building configurations of street canyons as parameters based on calculations of high sophisticated dispersion models. These calculations can be done by a screening-model system like SELMA^GIS^ PROKAS. The example of dispersion modeling in street canyons with the screening model SELMA^GIS^ PROKAS combined with urban background concentrations calculated by AUSTAL2000 shows the concentration field in the surroundings and inside of the city of Dresden (see Figure 5.4).
- A very detailed survey of the surroundings (area of about 500 m x 500 m) of hot spots/monitoring points will follow up with a high sophisticated dispersion model with an integrated wind flow model like MISKAM.

Figure 5.4: Example of dispersion modeling in street canyons with the screening model SELMA^GIS^ PROKAS combined with urban background concentrations calculated by AUSTAL2000

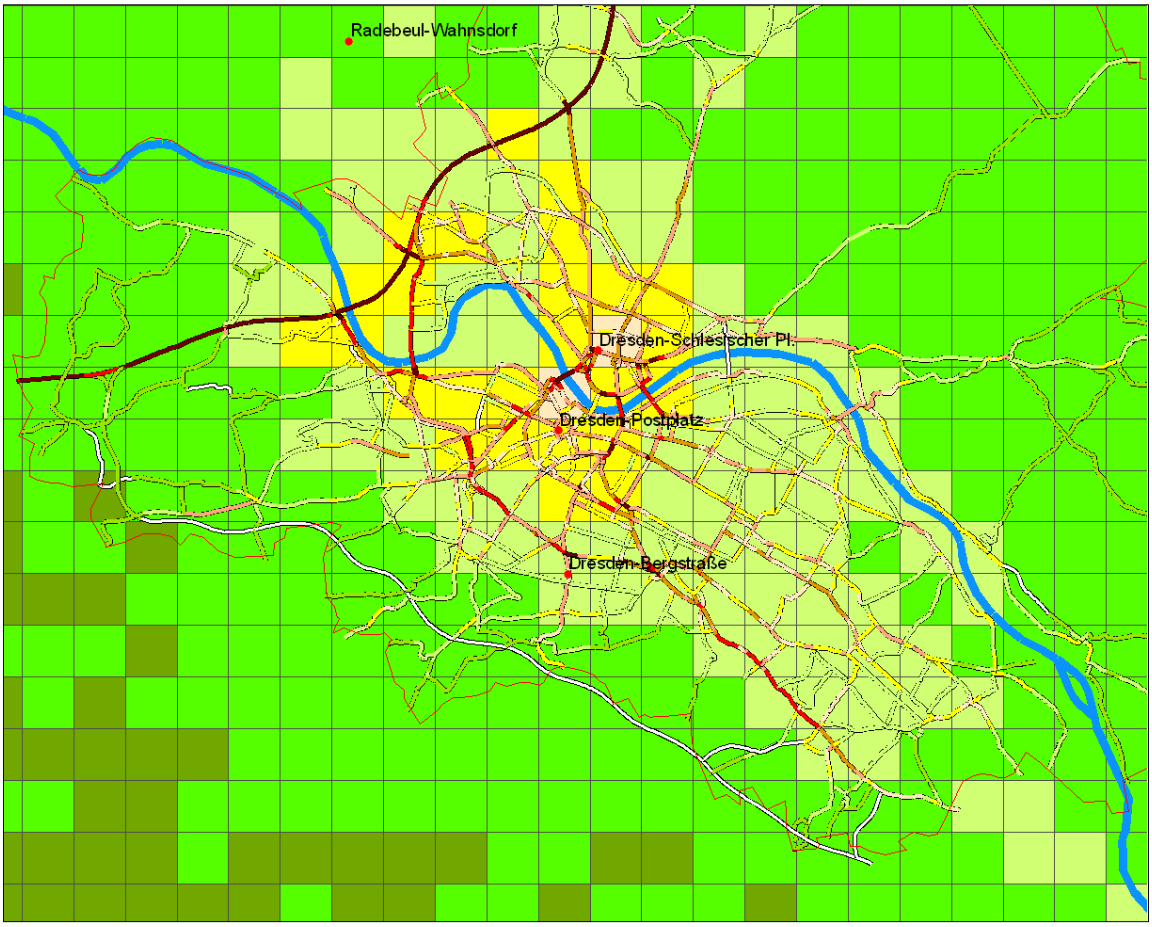
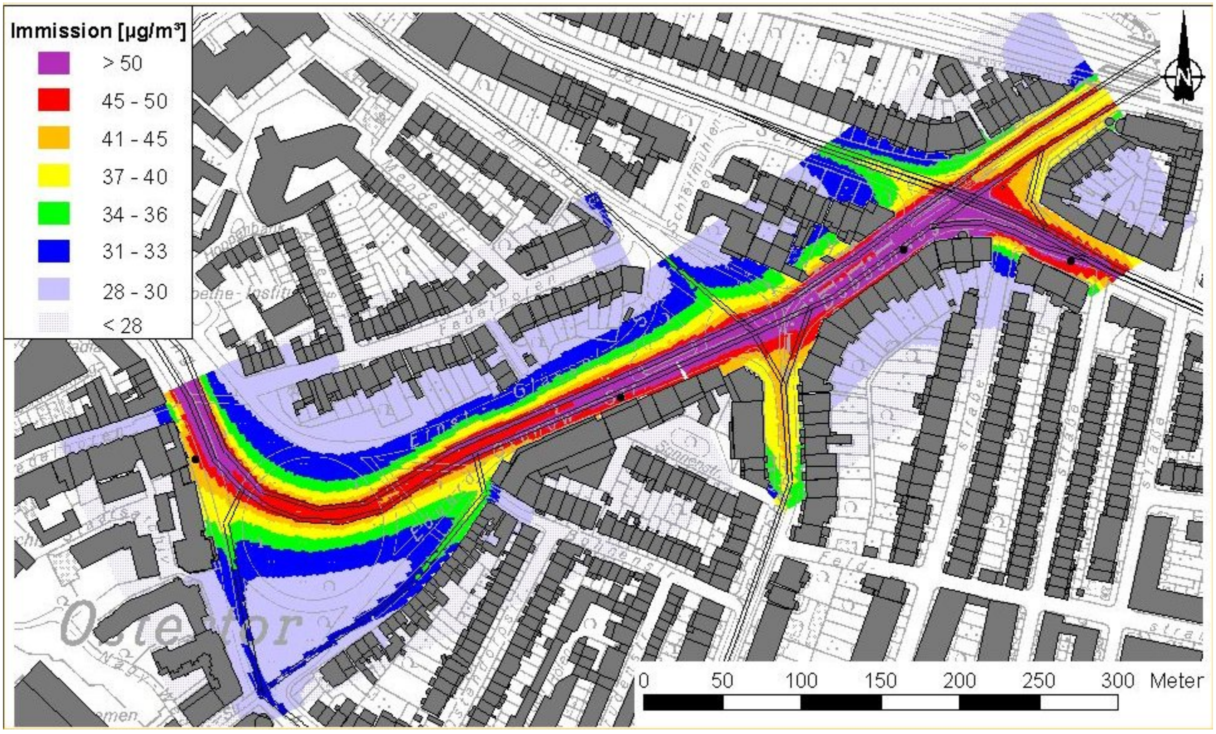


Figure 5.5: Example of dispersion modeling in a street canyon with the high sophisticated dispersion model MISKAM



5.3 Local scale model AUSTAL2000

In praxis, the calculations of the concentrations from domestic heating and industrial sources are done by local scale dispersion models like LASAT or AUSTAL2000.

The "Dispersion Calculation" of the Technical Instructions on Air Quality Control – TA Luft (https://www.umweltbundesamt.de/sites/default/files/medien/2008/dokumente/austal2000_en_0.pdf) describes the principle requirements of a dispersion model for permit/licensing purposes. But this system also can be used for other tasks.

The official software realization of the TA Luft model is AUSTAL2000. It is a free and open software (GNU License) and can be downloaded from the website www.austal2000.de in an English version.

The basis of AUSTAL2000 is the dispersion model system LASAT (www.janicke.de). This model system can be used for very complex situations.

There are great advantages to using a Langrange model instead of a Gaussian model system (see Figure 5.6).

A short summary of the features of the dispersion model AUSTAL2000 are listed below:

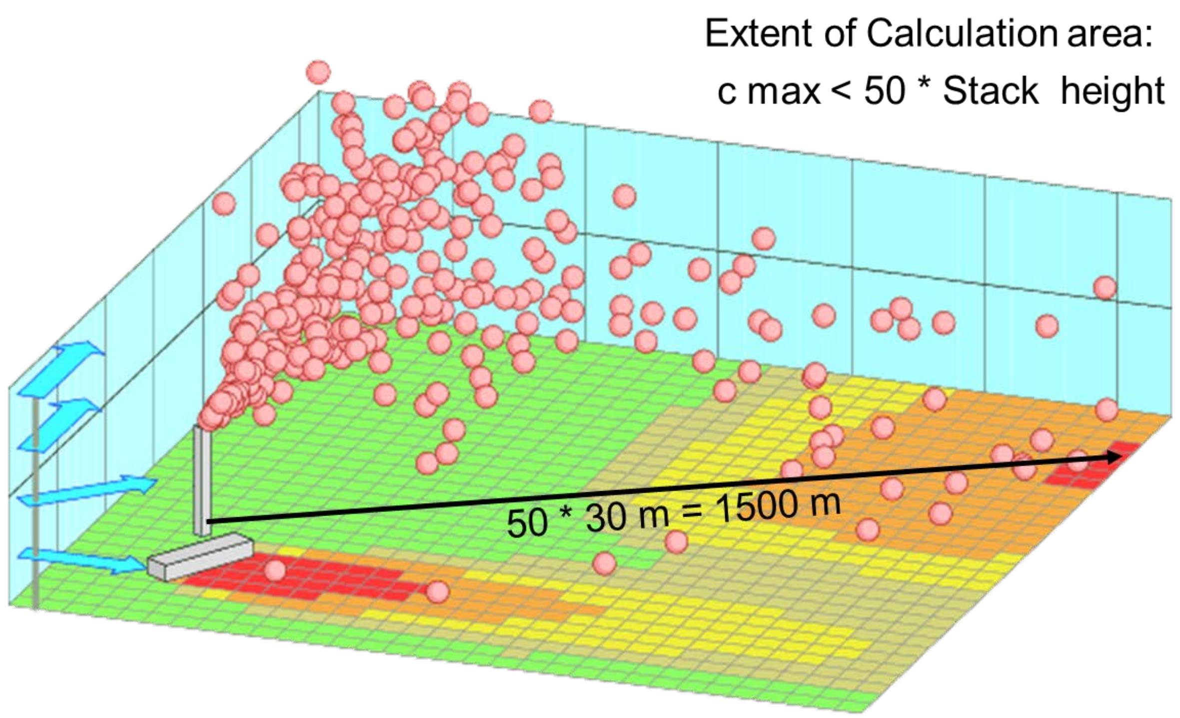
- calculation based on time series,
- calculation based on dispersion class statistics,
- contains parameters for all substances regulated by the AQD,
- point, line, area and volume sources,
- arbitrary number of sources,
- plume rise according to VDI Guideline,
- conversion NO to NO_2 according to VDI Guideline,
- deposition,
- gravitational settling of dust,

- results for a grid of receptor points,
- time series of the additional load at given receptor point,
- structured terrain,
- flow around buildings,
- automatic definition of nested calculations grids,
- verification according to Guideline VDI 3945 Part 3.

The Langrange model system does not have the basic restrictions of a Gaussian dispersion model. Until now, very simple and not well-documented dispersion models are very often the legal basis of permit procedures of industrial facilities. Often these simple models are unable to calculate the concentration levels according to the AQD. AUSTAL2000 could substitute these models.

Odor annoyance can also be calculated by AUSTAL2000. This model is part of the German odor annoyance system "GIRL".

Figure 5.6: Principle of dispersion calculation by Langrangian particle models



Quality checks for dispersion model usage

Although the application of the dispersion model is usually straightforward, quality assurance by an organized step-by-step check of the input data, the model usage and the according documentation turned out to be essential to enhance the quality of reports.

6 Other useful guidelines

Suitable guidelines concerning air quality and environmental meteorology topics have been developed by the German Commission on Air Pollution Prevention KRdL of VDI/DIN to support the state, see also Chapter 3.13. These whitepaper guidelines are available in English and German (http://www.vdi.eu/engineering/vdi_societies/commission-on-air-pollution-prevention-of-vdi-and-din/).

KRdL currently has published a total of 460 VDI Standards and DIN Standards.

7 Conclusion

As described earlier, all AQPs should be reviewed in regular time intervals.

In all countries, basically the same challenges exist to enhance the AQPs:

- need of further analysis of existing monitoring data to identify the causes of high-polluted episodes,
- comparison between monitoring data inside the city or town and nearby stations,
- description and calculation of the real traffic situations affecting the health of the inhabitants,
- suitable measures to reduce emissions from wood burning,
- in some areas, the use of coal for domestic heating is still a problem,
- information for the public and discussion and selection of suitable measures; communication of tasks and training and education at school should be done,
- application of emission and dispersion models should be introduced and the staff should be trained to use these model systems; the staff should build up a network to enhance their knowledge of using the systems, e.g., carry out expert workshops annually (This should be done for traffic emission calculation and dispersion calculation in street canyons and industrial facilities (also permit procedure) and domestic heating).

An example of a previous AQP report is available at the following link: www.lohmeyer.de/download/AirQualityPlan_Pernik_2002_Twinning_Project_BG99EN02.pdf. The AQP of Pernik from 2002 was the result of a Twinning Project – a joint project between MoEW and BMUB.

8 List of possible measures to improve urban air quality

The following list is based on experiences in several EU Twinning Projects. The main actor must be discussed and adapted to the situation of Bulgaria.

8.1 Measures in the transport sector

Table 8: Mitigation measures in the transport sector

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/ Medium/ High	Priority Low/ Medium/ High	Framework Conditions, Comments	Funding	Main Actor	Time Frame for Implementation
T1: Faster substitution of polluting vehicles by cleaner ones							
T11	Reduce emissions of the municipal vehicle fleet, in particular for buses and taxis (a) develop modernization program for buses, garbage collection, police, etc. (b) explore potential for retrofitting diesel vehicles with a diesel particulate filter (DPF) (c) set environmental criteria to be met by private bus service operators and taxis based on Euro emission standards; example for buses: set environmental criteria for the bus fleet operated by the companies; e.g., 1st stage Euro III & DPF, 2nd stage Euro IV, etc.;	Medium in urban areas, high on roads with high bus and taxi frequency	High	Due to the scarce budget of municipalities, funds need to be provided for the modernization of the bus fleet to ensure that ticket fares remain low in order to maintain or enhance the attractiveness of public transport; hence, investment cost cannot be financed from selling tickets; funding also might be needed for taxi drivers who cannot afford investments in better cars.		Ensure increase of funding: Ministries of Finance & Transport For practical implementation: municipalities	

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/ Medium/ High	Priority Low/ Medium/ High	Framework Conditions, Comments	Funding	Main Actor	Time Frame for Imple-mentation
	(d) set similar criteria for taxis: Euro 2 for petrol taxis, Euro 3 plus DPF for diesel						
T12	Emission-dependent vehicle taxation (based on Euro emission standards, DPF for Diesel): the tax law will be amended so that vehicles not meeting Euro 1 (later Euro 2) need to pay more, while those with Euro 3, 4 and better (and vehi-cles with DPF) pay less	Medium	High	In order to partly compensate the higher financial burden for the owners of older vehicles, which are often poor, ways will be ex-plored to combine the measure with a financial scrapping bonus for old vehicles (Euro 0), if new vehicles are purchased (Euro 4), if Diesel, then with DPF. The higher vehicle tax revenues could be used for this purpose.	Low	Ministries of Finance & Transport & Internal Af-fairs	
T13	Limited access to polluted urban zones for vehicles with high pollution: a zone in the city center of the town will be designated where pollution from traffic is highest and where ac-cess is prohibited by traffic signs for vehicles not meeting at least Euro 1 (or with first year of entering into ser-vice before 1993)	High in busy ur-ban roads	Medium	Enforcement requires labelling of vehicles by a national regulation; sufficient police staff to control the vehicle papers of driving ve-hicles and to check parked vehi-cles; exemptions needed for cases of financial hardship might be combined with a finan-cial scrapping bonus for owners of old vehicles		For creating the legal ba-sis: Minis-tries of Transport & Internal Af-fairs	Legal basis: NN Implementa-tion after a 2-year transition period

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/ Medium/ High	Priority Low/ Medium/ High	Framework Conditions, Comments	Funding	Main Actor	Time Frame for Imple-mentation
						For practical implemen-tation: mu-nicipality of the town	
T2: Shift of modal split towards cleaner means of transport							
T 21	Introduction/extension of zones with parking management in urban areas Zones will be designated or extended in town centers where a parking fee is raised.	Medium	High	Needs personnel or ticket ma-chines for collecting the parking fees; needs strict enforcement of park-ing traffic rules, plus penalties in order to avoid illegal parking elsewhere; fees need to be comparable with ticket fares of public transport in order for public transport to serve as an attractive alternative.	Parking fee reve-nues could be used for funding public transport	Municipali-ties	

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/ Medium/ High	Priority Low/ Medium/ High	Framework Conditions, Comments	Funding	Main Actor	Time Frame for Imple-mentation
T 22	Improve quality of public transport services. This includes - enhancing bus frequency and quality of the service - better passenger information about time tables - attractive ticket fares for commuters - tickets will be valid in all buses independent of the service operators - setting high quality standards for bus services as part of the service contract for private bus service operators - improvement of the combined use of public transport and road transport by setting up park/bike and ride facilities in the form of designated car parking areas at the city periphery with good connection to the bus network	Medium	High	Enhanced funding for public transport services is a precondition in order to account for the scarce financial resources of municipalities; cross funding from the revenues of parking management fees and vehicle taxes needs to be considered. Needs to be combined with the introduction of parking in town centers so that using public transport becomes more attractive	Consider cross funding from revenues of parking management, vehicle and fuel tax	Ensure increase of funding: Ministries of Finance & Transport For practical implementation: municipalities	

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/ Medium/ High	Priority Low/ Medium/ High	Framework Conditions, Comments	Funding	Main Actor	Time Frame for Imple-mentation
T 23	Cycling and walking in urban areas will be made more attractive. Municipal cycling strategies will be developed, including - setting up extra bicycle lanes where possible - setting up bicycle parking facilities, especially in front of public buildings like schools, offices, and at larger bus stations - encouraging the private sector to follow, in particular when constructing new office buildings, with the option to set mandatory minimum requirements of cycle parking facilities	Low on the short-term, but medium on a longer term	Medium	Extra budget lines are needed to ensure a continuous financial basis for the necessary investments; requires to shift priorities in traffic planning away from motor traffic; needs to be accompanied by information campaigns and long-term awareness raising among motorists		Municipalities, supported by Ministry of Transport	Start NN with a pilot concept, setting out concrete steps and funding needed for the next 5 years
T 24	Improvement of railroad infrastructure, aimed at providing more capacity and service quality for passenger rail transport	Medium	Medium			Ministries of Transport & Finance and municipalities	

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/ Medium/ High	Priority Low/ Medium/ High	Framework Conditions, Comments	Funding	Main Actor	Time Frame for Imple-mentation
T 25	Improving long- and medium-range freight transport capacities by rail: launch of a feasibility study to explore the potential, including the setting up of freight transport terminals as an interface between railroad freight trains and goods vehicles for local distribution/collection of freight	Medium	Long-term			Ministries of Transport & Finance and municipalities	
T3: Control growth in (road) transport demand							
T 31	Limitation of the motor traffic demand through better urban planning ("compact city") by (a) improving the legal planning framework by requiring an urban transport plan for larger towns (b) enhancing the administrative AQP activities on the municipal level to ensure that motor traffic demand is minimized when planning new dwellings, commercial buildings, shopping facilities, etc.	Low on the short-term, but medium on the long-term	High	Should be taken on fairly soon in order to steer the ongoing development of the business and service sector		Municipality and Ministry for Transport	

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/ Medium/ High	Priority Low/ Medium/ High	Framework Conditions, Comments	Funding	Main Actor	Time Frame for Imple-mentation
T 32	Gradual increase of the vehicle fuel tax	Low on the short-term, but medium on the long-term	High	Additional financial burden for poor small businesses; can be mitigated by spending the additional tax revenues for funding the purchase of cleaner and more fuel-efficient measures; should be combined with T12	Revenues should be spent primarily for funding measures under T2	Ministries of Trade & Industry & Transport and municipalities	
T4: Traffic management							
T 41	Planning and construction of bypass roads to keep long-distance (freight) traffic out of town centers	High in urban roads with high transit traffic	Medium	Should be concentrated on towns with high transit traffic This measure needs to be combined with a traffic ban for heavy duty vehicles, except those with a local destination. The risk that enhanced road capacities may attract more road traffic can be avoided by parallel reduction of urban road space and other measures in favour of clean modes of transport.	High	Municipalities and Ministry of Transport	

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/ Medium/ High	Priority Low/ Medium/ High	Framework Conditions, Comments	Funding	Main Actor	Time Frame for Imple-mentation
T 42	Development of routing concept for heavy goods vehicles in urban areas, possibly combined with a ban in other sensitive areas	High in the resi-dential areas with high freight vehicle traffic	Medium	Designate specific routes for easy access of commercial areas for heavy goods vehicles aimed at keeping unnecessary lorry traffic out of sensitive areas with high density of pedestrians and/or res-idents, where also a ban for such vehicles could be introduced Along the designated routes, the number of residents must be low. Truck bans in sensitive areas need proper enforcement by the police.	Low	Municipali-ties and Ministry of Transport	
T 43	Optimization of traffic flows in order to avoid traffic congestion (a) by prohibiting to stop or park on traffic lanes of important arterial roads (b) hampering traffic flows into con-gested areas through optimized traf-fic light coordination	Low	Long-term	(a) needs strict enforcement by the police; enhances the cacity of the road (b) needs high investment costs, only relevant for larger cities where a feasibility study could be launched	(a) Low (b) High	Municipali-ties	

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/ Medium/ High	Priority Low/ Medium/ High	Framework Conditions, Comments	Funding	Main Actor	Time Frame for Implementation
T 44	Speed limit (30 km/h) in urban main roads with high pollution and noise levels	Low for air quality, medium to high for noise	Short-term	Could be considered for narrow sections of the main road network with high frequency of pedestrians and density of residents, where also accident risk and noise levels are also high; needs enforcement by the police through regular speed measurements and redesign of road space (e.g., by designating road space for parking and/or pedestrians) in order to narrow the space for road traffic	Low	Municipalities and Ministry of Internal Affairs	
T5: Other measures							
T 51	Reducing the re-suspension of road dust from traffic by (a) making up the surface of the pavement and sideways to reduce deposition of soil on the road and subsequent re-suspension by road traffic	Medium	Medium	(a) Needs investments in making up pavement and sideway surfaces, where they are not yet sealed, so that soil is not being moved to the traffic lanes (e.g., by rain) with subsequent graining and re-suspension as fine dust into the air	(a) High	Municipalities	(a) setting up a long-term investment program within a defined time frame

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/ Medium/ High	Priority Low/ Medium/ High	Framework Conditions, Comments	Funding	Main Actor	Time Frame for Implementation
	(b) enhanced street cleaning with efficient equipment			(b) short term: enhance personnel resources for manual road cleaning; on the long-term, purchase of machinery that allows efficient road cleaning aimed at reducing re-suspension of PM10 Given the scarce financial resources of municipalities, a long-term funding concept should be developed to enhance the budgets for municipal road improvement and for road cleaning services.	(b) Medium with manual road cleaning		(b) enhanced manual cleaning and setting up of an investment program on road cleaning machinery within a defined time frame

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/ Medium/ High	Priority Low/ Medium/ High	Framework Conditions, Comments	Funding	Main Actor	Time Frame for Imple-mentation
T 52	Testing of vehicle emissions as part of the regular vehicle inspection	Medium	High	Enforcement of existing regulation on vehicle inspection will be strengthened. As an option, more frequent inspections could be required for older vehicles.	Medium for purchasing the requisite technical monitoring and testing equipment	Ministry of Transport	
T 53	Introduction of fuel tax discounts for cleaner fuels for - diesel fuel according to S content - petrol according to benzene content - for natural gas	Medium	High	Enhanced monitoring and control of fuel quality will be needed; the feasibility of this measure depends on supply structure, i.e., on the potential availability of cleaner fuels; given the need for increased tax revenues, any fuel dependent taxation scheme should be not result in overall tax reduction.	Neutral	Ministry of Finance	

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/ Medium/ High	Priority Low/ Medium/ High	Framework Conditions, Comments	Funding	Main Actor	Time Frame for Implementation
	Launch of a public information campaign on topics aimed at raising awareness on environment protection and control of air pollution from transport, including - information on the harmful effects of pollutant emissions from traffic - promoting clean transport means (public transport, cycling, walking) - promoting fuel-efficient driving	Medium on the long-term	High	There will be a focus on schools so that they integrate environmental issues in their curricula.	Low	Ministry of Education Municipalities	

8.2 Measures concerning small and medium combustion plants

Table 9: Measures concerning small and medium combustion plants

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/Medium /High	Priority Low/Medium /High	Framework Conditions, Comments	Cost Estimate	Main Actor	Time frame for Implementation
H1	Switch to cleaner fuels by substituting coal and heavy fuel oil by low-S-oil, natural gas and biogas A national program will be developed setting out concrete regulatory and economic measures (e.g., tax differential for different fuels depending on their environmental performance). As part of the program, the potential of biogas production will be assessed and the program be extended accordingly	High for PM, SO_2	Medium		Low for the development of the program	Development of the National Program: Ministry of Energy and municipalities	
H2	Investment in heat and power co-generation As a first step, a feasibility study could be launched on whether and how this could be realized, including a cost/benefit analysis	High for PM, SO_2, NO_x, PAH	High	See action EN 4. If realized, a considerable number of single heating systems running on pollution fuels like coal and wood could be substituted, which should result in a tangible drop of particle and SO_2 emissions		Ministry of Energy	

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/Medium /High	Priority Low/Medium /High	Framework Conditions, Comments	Cost Estimate	Main Actor	Time frame for Implementation
H3	Strengthening of the enforcement of the regulation on the prohibition of open fires and the burning of waste, garbage, etc., by enhancing the administrative capacities for inspection on local level; In addition, a public information campaign will be launched to raise awareness of the public and to change habits.	Medium in urban areas, high in the local environment for PM levels	High	Proper enforcement depends on sufficient local police forces. Hence, municipalities need to get the requisite resources to cope better with that task.	Low	Ministry of Internal Affairs and municipalities	
H4	Investigate the scope for drawing up a regulation setting emission limit values for small combustion units (< 1 MW) for new equipment and provisions for the operation of new and existing units, with the option of a gradual phasing out of old appliances with high emissions	High in residential areas	Medium	Given the huge quantities of pollutants emitted by these sources, standards for the emissions of new appliances, for the fuels to be used and for gradual replacement of older appliances are needed.	Low for developing the regulatory framework		

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/Medium /High	Priority Low/Medium /High	Framework Conditions, Comments	Cost Estimate	Main Actor	Time frame for Implementation
				As a long-term perspective, a scrappage scheme for old outdated equipment (e.g., > 25 years) should be set up, including economic incentives for the owners of high-polluting, ineffective units to buy new, cleaner equipment.			
H5	A new regulation could be drawn up ensuring regular inspection of the fuel to be allowed, of the performance and of the emissions of furnaces, boilers, burners and fire places	High in residential areas	High	The regulation ensures that inspectors can regularly control the status of small combustion units, including a simple check of exhaust emissions (CO-measurements and opacity measurements in the plume) and of the proper fuel type used in accordance with the technical standards set out in the regulation under action H4.	Labor costs for the additional personnel needed		

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/Medium /High	Priority Low/Medium /High	Framework Conditions, Comments	Cost Estimate	Main Actor	Time frame for Implementation
				As a starting point, fuels allowed to be used for house heating should be regulated (i.e., to exclude garbage and waste burning in stoves and ovens) and compliance should be controlled by the inspectors. The regulation should also determine the responsibility for the inspection of household combustion appliances. It is important that the competent authority in charge of the inspections is properly staffed.			
H6	Enhance the energy efficiency of new buildings by reviewing the existing regulatory framework and improve its enforcement and set up an investment program for increasing energy efficiency of existing buildings, starting with public premises	Low	Medium	As a starting point concerning the improvement of existing buildings, an energy audit could be performed to identify the energy saving potential. Energy contracting (i.e., investment in better energy efficiency by a contractor and revenue sharing with the proprietor) could help in starting the renovation of public buildings like schools, offices, etc.	Low, concerning the development of the program;	Ministry for reviewing the legislation and for drawing up the investment program;	

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/Medium /High	Priority Low/Medium /High	Framework Conditions, Comments	Cost Estimate	Main Actor	Time frame for Implementation
				This measure is also an objective of climate change policy.	costs for investments in energy efficiency to be estimated as part of the program development	Municipalities for the performance of the energy audit	
H7	Draft a regulation requiring temperature-regulated valves for radiators in buildings with central heating systems and multiple flats and offices	Low	Medium for air quality, high for climate change	As a starting point, this should be required for new buildings; it could also be part of action H6, resulting from the review of the regulatory framework	Low for drafting regulation 10 € plus costs for installation per radiator	Ministry, Municipalities for inspection	

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/Medium /High	Priority Low/Medium /High	Framework Conditions, Comments	Cost Estimate	Main Actor	Time frame for Implementation
H7	Draft a regulation introducing consumption-dependent billing in multi-flat houses with central heating	Low	Medium for air quality, high for climate change	As a precondition for consumption-dependent billing, the heat supplied by a radiator needs to be measured; hence, the regulation needs to stipulate instalment of heat meters at every radiator in buildings where individual flats and offices connected to a central heating system exist. As a starting point, this should be required for new buildings; it could also be part of action H6, resulting from the review of the regulatory framework.	Low for drafting regulation 10 € for the meter plus costs for installation per radiator		

No.	Measure / Activity / Project	Expected Effect on the Air Quality Low/Medium /High	Priority Low/Medium /High	Framework Conditions, Comments	Cost Estimate	Main Actor	Time frame for Implementation
H9	Promotion of clean renewable energy sources such as biogas, hydropower, wind power, photo-voltaic panels and solar panels for water heating	Low	Medium for air quality, high for climate change	As a starting point, investments in solar panels for water heating should be funded. As this is simple technology, such investments can be done easily by house owners. This activity should be an integral part of a climate change strategy. It could be part of the national program stipulated under activity H1. As an internationally recognized example for incentivizing the generation of clean electricity, the German Renewable Energy Sources Act could be used as an inspiration to boost the decentralized electricity or energy production.	Medium in the short-term, low in the long-term because of amortization due to saved energy consumption costs	Ministry of Energy	Funding concept for solar water heating panels; timing of national program to be compatible with climate change strategy (see also H1)
H10	Draft a regulation introducing energy efficiency labeling of electrical appliances in accordance with EU directive	Low	Low	This activity should be an integral part of the climate change strategy. It should be supplemented by a public information and awareness-raising program.	Low	Ministry of Trade & Industry	

9 Links

Austal2000 (description, download etc.) :
http://www.austal2000.de/en/home.html
COPERT:
http://www.emisia.com/copert/General.html
Deduce:
http://www.deducer.org/
EEA handbook:
http://www.eea.europa.eu/themes/air/emep-eea-air-pollutant-emission-inventory-guidebook
EEA map monitoring stations:
http://www.eea.europa.eu/themes/air/interactive/pm10-interpolated-maps
EURAD:
http://db.eurad.uni-koeln.de/en/index.php
Free data base for meteorological data:
http://www.wunderground.com
German Regulations:
http://www.plastep.eu/english/downloads/regulations/german-regulations/
HBEFA3.2:
http://www.hbefa.net/e/index.html
LASAT:
www.janicke.de
MISKAM
http://www.lohmeyer.de/en/content/software-sales-distribution/product-overview/winmiskam
OpenAir:
http://www.openair-project.org/
PROKAS:
http://www.lohmeyer.de/en/content/software-sales-distribution/product-overview/selma-gis
Statistic software R:
http://www.r-project.org/
VDI shop Flat rate: http://www.beuth.de/en/article/standards-flatrate-vdi
single guideline: http://www.beuth.de/cn/d29ya2Zsb3duYW1lPXNlYXJ-jaCZsYW5ndWFnZWlkPWVu.html

10 References

Directive 2004/461/EC: Commission Decision of 29 April 2004 laying down a questionnaire to be used for annual reporting on ambient air quality assessment under Council Directives 96/62/EC and 1999/30/EC and under Directives 2000/69/EC and 2002/3/EC of the European Parliament and of the Council
http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32004D0461 and
http://eur-lex.europa.eu/legal-content/BG/TXT/PDF/?uri=CELEX:32004D0461&from=EN (Bulgarian)

Directive 2008/50/EC: Directive of the European Parliament and Council of 21 May 2008 on ambient air quality and cleaner air for Europe
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:en:PDF and
http://eur-lex.europa.eu/legal-content/BG/TXT/HTML/?uri=OJ:L:2008:152:FULL&from=EN (Bulgarian)

Commission Implementing Decision of 12 December 2011 laying down rules for Directives 2004/107/EC and 2008/50/EC of the European Parliament and of the Council as regards the reciprocal exchange of information and reporting on ambient air quality (notified under document C(2011) 9068)
http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1463651916692&uri=CELEX:32011D0850 and
http://eur-lex.europa.eu/legal-content/BG/TXT/PDF/?uri=CELEX:32011D0850&from=EN (Bulgarian)

Fauna-Flora-Habitat-Directive 92/43/EWG: Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora
http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043 and
http://eur-lex.europa.eu/legal-content/BG/TXT/PDF/?uri=CELEX:31992L0043&from=BG (Bulgarian)

Hausberger et al. 2009: Hausberger S., Rexeis M., Zallinger M., Luz R.: Emission Factors from the Model PHEM for the HBEFA Version 3. Report Nr. I-20/2009 Haus-Em 33/08/679 from 07.12.2009

VDI-Guideline 3783 Part 13: Environmental meteorology, Quality control concerning air quality forecast. Plant- related pollution control, Dispersion Calculation according to TALuft, Berlin, Beuth Verlag 2010.
A Checklist for consultant reports is also available as a free download:
https://www.vdi.de/fileadmin/vdi_de/redakteur_dateien/krdl_dateien/KRdL-2/3783-13/Check%20list%20for%20the%20impact%20forecast.pdf

VDI-Guideline 3783 Part 14: Environmental meteorology Quality control concerning air pollution forecast Vehicle-related air pollutions, Berlin, Beuth Verlag2013.
A Checklist for consultant reports is also available as a free download:
https://www.vdi.de/fileadmin/vdi_de/redakteur_dateien/krdl_dateien/Checklist_3783-14.pdf

VDI-Guideline 3945 Part 3: Environmental meteorology, Atmospheric dispersion models, Particle model, Berlin, Beuth Verlag 2000.


Guideline on
Air Quality Plans