CI&CEQ

Available on line at
Association of the Chemical Engineers of Serbia AChE
www.ache.org.rs/CICEQ
Chemical Industry & Chemical Engineering Quarterly 18 (4) 667–674 (2012) CI&CEQ

BJARNE SIVERTSEN
ALENA BARTONOVA

NILU-Norwegian Institute for Air Research, Kjeller, Norway

PROFESSIONAL PAPER

UDC 502.1:502.3

DOI 10.2298/CICEQ120110111S

AIR QUALITY MANAGEMENT PLANNING (AQMP)•

In most urban areas of the world, particulate matter (PM) levels pose severe problems, addressed in several policy areas (air quality, climate change, and human health). PM presents multiple challenges due to the multitude of its sources, spanning many sectors of economic activity as well as nature, and due to the complexity of atmospheric processes involved in its transport and secondary formation. For the authorities, the goal is to assure minimal impacts of atmospheric PM levels, in practice represented by compliance with existing regulations and standards. This may be achieved through an air quality management plan (AQMP). In Northern America and in parts of Europe, comprehensive research programs have guided development of AQMP over the last forty years. This cumulated experience can be utilized by others who face the same problems, but have yet to develop their own substantial research base. The main purpose of the AQMP development process is to establish an effective and sound basis for planning and management of air quality in a selected area. This type of planning will ensure that significant sources of impacts are identified and controlled in the most cost-effective manner. The choice of tools, methods and input information is often dictated by their availability, and should be evaluated against current best practices. Important elements of the AQMP are the identification of sources and development of a complete emission inventory, the development and operation of an air quality monitoring programme, and the development and application of atmospheric dispersion models. A major task is to collect the necessary input data. The development of the AQMP will take into account: Air Quality Management System (AQMS) requirements, operational and functional structure requirements, source identification through emission inventories, source reduction alternatives, which may be implemented, mechanisms for facilitating interdepartmental cooperation in order to assure that actions are being taken and institutional building and training requirements. This paper offers a practical guide through the different parts of the air quality management and planning procedures.

Keywords: air quality management; emissions; modelling; impact; training.

Urban air pollution is a serious problem worldwide. The gravity of the urban air pollution problem is largely attributed to the complex and multi-sectoral nature of everyday air polluting activities as well as the inadequate actions of governments. The lack of actions by governments is further due to poor information and weak understanding of the air pollution problems and, in addition, due to the lack of institutional capacity and coordination among government agencies in the various sectors contributing to air pollution.

In Europe and North America, air quality management is based on an ever-growing research basis that offers insight into all its elements. Over the course of the years, both theoretical requirements and practical tools became available for air quality managers to effectively address the challenges. These

Correspondence: B. Sivertsen, NILU-Norwegian Institute for Air Research, P.O. Box 100, NO-2027 Kjeller, Norway.
E-mail: bs@nilu.no
Paper received: 10 January, 2012
Paper revised: 9 June, 2012
Paper accepted: 24 July, 2012
•Part of this paper was presented at the Scientific Meeting Particulate Matter: Research and Management, 3rd WeBIOPATR Workshop & Conference, Belgrade, Serbia, 15-17 November, 2011.

experiences are translated into an Air Quality Management Plan (AQMP).

The AQMP describes the present state, and what could be done to ensure clean air in a city or region. It provides goals and objectives for a region and prescribes short- and long-term policies and controls to improve air quality. An early description of the planning process was given in the URBAIR project [1-8].

The objective of URBAIR was to develop Action Plans for air quality improvement in the four Asian cities that were studied. The action plans where to be based upon cost-benefit or cost-effectiveness analysis, so that the air quality could be improved to a certain target level at least cost. The concept combined air quality assessment based upon monitoring data and modelling of air pollution and exposure, assessment of the health damage (using dose-response relationships) and the related costs (based upon local cost data), analysis of control options and their costs, and prioritising the control measures through comparison of control costs and the related reduced health costs, choosing the measures with the highest benefit/cost ratio [7].

An AQMP thus sets a course of action that will attain air quality goals in a specified geographical area. It requires actions by government, business, industry, NGO's and the population, as its success will depend on support from all these segments. Examples of studies implementing the AQMP approach are, *e.g.*, [9-12]. This paper aims to provide a practical guide through the elements of the AQMP.

The AQMP process

AQMP is often based on results from a number of assessments, combined in an Air Quality Management System (AQMS). The AQMS depends on the following set of technical and analytical tasks:

- Creating an inventory of polluting activities and emissions.
- Monitoring air pollution and dispersion parameters.
- Calculating air pollution concentrations with dispersion models.
- Assessing exposure and damage.
- Estimating the effect of abatement and control measures.
- Establishing and improving air pollution regulations and policy measures.

These activities, and the institutions necessary to carry them out, constitute the prerequisites for establishing a functioning AQMS.

An AQMP describes the current state of air quality in an area, how it has been changing over recent years, and what could be done to ensure clean air. The development and implementation of an AQMP is a dynamic process involving the following six steps:

1. Goal setting.
2. Baseline air quality assessment.
3. Air quality management system (AQMS).
4. Intervention strategies.
5. Action plans implementation.
6. Evaluation and follow up.

The linkages between these steps are indicated in Figure 1.

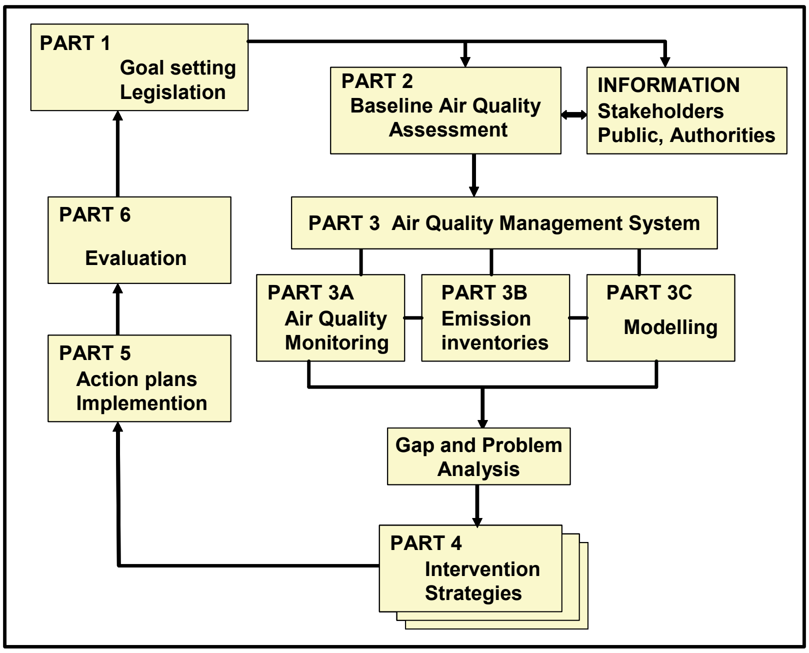

Figure 1. The AQMP six step process.

A typical complete description of the process was prepared as a draft implementation plan manual [13]. A baseline preliminary assessment was described under the EU air quality directives already in 1998 [14]. The content of the whole process, referring to the numbering used in Figure 1, is briefly given below.

Air quality goal setting

The setting of goals in the AQMP is usually made explicit in legislative or advisory instruments at appropriate management level, and may include:

- Identifying primary and secondary pollutants of concern: a) health related, b) environmental impact related and c) climate change related.
- Assessing urban or local issues such as urban air quality, local impact of industrial installations.
- Assessing regional issues: a) acid rain, b) regional ozone and c) transboundary problems.
- Global issues such as greenhouse gases and persistent organic pollutants.
- Indoor exposure.

Baseline air quality assessment

Information about past and current status (before any new pollution prevention measures are implemented) needs to be gathered from systematic monitoring or using a specific investigation. Inclusion of historical data is often an advantage; it allows assessing the temporal variability and trends, and provides additional perspectives.

The choice of method for the baseline assessment depends on available resources and tools. The baseline information should allow to assess levels of target pollutants in background areas (in areas not affected by major local sources), and in urban areas both under direct influence of sources (*e.g.*, near roads, near industrial installations) and in the background (*e.g.*, in areas somewhat removed from the main sources). This assessment should take into account temporal variations (*e.g.*, seasonal variability), and should be performed using a predetermined plan. In addition to using monitoring data, many methods are available for such assessments, including passive sampling, or dispersion or statistical modelling.

Emission inventories

The knowledge of sources and emissions is crucial as a basis for the planning process, and the following should be considered:

- Identifying air pollution sources on different levels: a) national, b) provincial, c) municipal and d) industries.
- Collection of data on production, consumption and emission factors for various sources: a) stationary sources, b) mobile sources and c) natural and biogenic sources.
- Preparation and use of emission models for estimating source data input into dispersion models.
- Estimation of trends in emissions and forecasting emissions based on different legislative and economic scenarios.

Monitoring air quality

An ambient air quality monitoring programme supplies input to the air quality assessment as well as input for developing and verifying the modelling tools used in planning. It may be necessary to develop a comprehensive monitoring network at the following levels: a) national level all scales, b) province level, c) municipal level and d) local city level and industrial impact areas.

The ambient air monitoring system should include:

- Quality assurance and quality control procedures.
- Methods to provide data to stakeholders/public.
- Meteorological data adequate for modelling and assessment purposes.
- Data on all pollutants relevant to different scales, sources and target issues.
- Air quality assessment methods and provision of statistics to satisfy reporting requirements including trend analyses.
- Methods to identify specific issues such as: a) hot spot areas and b) adverse exposure problems.
- Verification of compliance with goals, regulations and standards.

Modelling air quality

An air quality model is a mathematical technique that produces an estimation of ambient air quality characteristics of an air pollutant within a specified area.

Different types of models such as: a) dispersion models, b) impact models, c) economic models and d) cost/benefit analyses can be used in the estimation of ambient air quality. The application process has three steps:

- Developing and establishing relevant models for all parts of the air quality assessment.
- Verifying that urban and regional scale models for transport, dispersion and transformation have been made available and tested/verified against measurement data.
- Applying the models in order to: a) identify key sources, b) establish emission/ exposure relationship, c) future projections and impact assessment and d) evaluate the effect of control strategies and select

optimal abatement strategies in order to achieve air quality goals.

Identifying measures and control options

Once the current air quality has been assessed it may be necessary to identify actions and control options in order to reduce the pressure and impact on the environment. This part of the integrated AQMP may include but is not limited to:

- Establishment of detailed emission inventories as a basis for control options.
- Specification of control options related to national, regional and municipal requirements:
  - source and emission standards,
  - pollutants specific to national, regional and local technology control requirements,
  - health based needs for regulations and
  - economic incentives.
- Mobile source control requirements:
  - engine performance,
  - exhaust gas control and
  - fuel requirements.
- Specific priority area control requirements.
- Issue of legally enforceable operation permits.

Implementation

An implementation strategy is a plan to provide for the implementation, the maintenance, and the enforcement of desired environmental standards. The following tasks may need to be undertaken:

- Implementation strategy developed into an implementation plan by the relevant stakeholder.
- The implementation plan may include:
  a) identification of sources and areas of impact and concern,
  b) quantification of emission and air quality changes anticipated and
  c) emission limits and work practices which comprise the compliance strategy including how compliance will be determined in practice.
- Implementation measures may include among other options:
  - source specific emission regulations,
  - product related regulations,
  - mobile source engine and fuel performance regulations,
  - mobile source exhaust gas and evaporation loss control and
  - public transportation alternatives.
- Necessary institutional building, education and public awareness campaign.

The implementation plan must be enforceable, measurable, and transparent, listing reporting requirements, compliance dates and schedules.

Evaluation of changes and impact trends

In order to evaluate implementation of the plan in a given area, it may be necessary to:

- Establish expert institutions, perform training and provide instruments and tools.
- Evaluate the effect of measures and controls using measurements and models.
- Use different methods and tools in the evaluation such as:
  - source surveillance,
  - ambient air concentration monitoring downwind from the sources,
  - checking and updating control plans and modifying where necessary and
  - evaluating short term, medium and long term reduction measures and the impact on air quality of these measures.

Information to the public

If an AQMP is to be developed and successfully implemented, it must also be based on input from stakeholders including industry, numerous groups and individuals. Public consultation is an integral part of the AQMP development process, starting with informing the public and entering into a dialogue with stakeholders at the stage of initial assessment. However, communication with stakeholders regarding methods and results achieved is necessary in all the AQMP steps. Engaging in a public consultation process should preferably be a policy of the regulatory body.

Particulate matter and the AQMP process

Research basis for AQMP

Air quality management has been practiced somewhat differently in the U.S. and in Europe, reflecting the different legal and administrative systems in these two regions. An authoritative 2007 review [15] describes the air quality management theory and its scientific basis as it has been used in the US. In Figure 2 of [15], the author makes explicit the link between management and the scientific research basis. He provides a historical overview of air quality issues and how they have been dealt with in the air quality management. This review is complemented by a comprehensive 2008 review [16] of the elements of the AQMS, specifically for particulate matter. A full review of the research base has also been done in relation to the U.S. Environmental Protection Agency's periodic review of the national ambient air quality standards (NAAQS) for PM [17].

The European experience and practice of air quality management is linked to the United Nations Economic Commission for Europe Convention of

Long-Range Transboundary Air Pollution, and to the development of integrated assessment modelling using the Regional Air Pollution Information and Simulation model RAINS. In response to political demand, this model was further expanded to include greenhouse gas and air pollution interactions and synergies (GAINS) [18].

Overview of AQMS elements

Sources

Particulate Matter (PM) is emitted directly from 'primary' sources (primary PM) and is also formed in the atmosphere by reaction of precursor gases (secondary PM). Other common distinctions are natural/anthropogenic sources and combustion/non-combustion sources.

Normally, the largest contributions to anthropogenic PM emissions come from sectors such as the energy and industry sectors, with a relatively smaller contribution from road transport. The road transport sector contributes with vehicle exhaust particles, abrasion and resuspension of road dust. A significant contribution comes from fuel combustion in the residential sector.

The total ambient PM receives a contribution from a variety of natural sources, which vary widely from area to area and with time. These include sea salt (especially important in coastal regions), crustal material arising from natural erosion processes (especially important in dry regions), and biological material. Volcanic eruptions are an example of a natural source that may contribute to the total PM impact in a given area.

When undertaking AQMP related to PM, the emission estimates especially from non-combustion sources have a considerable degree of uncertainty. It is thus important to be able to estimate the contribution from "natural" sources.

PM assessment

In an early assessment phase it may be possible to estimate the relative importance of the different PM sources from measurement data using source apportionment techniques. In Europe, the air quality legislation requires all Member States to assess ambient concentrations of PM_{10} (PM with aerometric diameter less than 10 μm) throughout their territory. The assessment should be based on monitoring at a considerable number of sites and may be supplemented by modelling. The assessment has to be based on monitoring at a considerable number of sites and may be supplemented by modelling. Measurements of $PM_{2.5}$ at a limited number of sites are also required. Many Member States and Acceding Countries have substantially changed their existing networks in order to comply with the new requirements. There are now over one thousand PM_{10} stations in the EU plus the Acceding Countries, which measure concentrations in remote and rural areas, urban "background" areas and at "hot spots" (near road traffic and some industrial sources). The air quality directives also encourage assessment by modelling, especially for constructing maps of pollution levels. Measurements of $PM_{2.5}$ (PM with diameter less than 2.5 μm) at a limited number of sites are also required [19].

The assessment phase includes:

- Monitoring of air pollutants, using good network design procedures [20,21,22].
- Making inventories of pollution sources, their technology, activity, location and emissions.
- Assessing the spatial and temporal distribution of the pollutant concentrations and population exposure, using preferably atmospheric dispersion models.
- Determining the contributions from the various sources and source categories, using dispersion and receptor models (for methods review, see [17]).

Dispersion models and systems of models are at heart of this activity. Several studies have been published that document particular air quality models used as part of AQMS. Atmospheric dispersion modelling is not the only available approach (others include land use regression or other statistical techniques), but is perhaps the most commonly used. Two examples show the trend in their development.

In 2000, building on work done throughout the 1990s, Carruthers *et al.* [23] documented an AQMS based on dispersion modelling, applied for London, Belfast, and Neath/Talbot – Swansea, and show how this system can be used to evaluate emission reduction options.

In 2012, Carnevale *et al.* [24] summarized their work in Northern Italy. They applied a comprehensive modelling framework that couples atmospheric dispersion models with other modelling tools including neural networks and multi-objective optimization techniques in the GAMES evaluation tool for air quality planning policies at regional scale.

Intervention strategies

Developing scenarios for future development, and calculating the future projected air pollution development includes:

- Assessing the control options, (technical, economic, political feasibility) and costs.
- Calculating cost-benefit ratios for the options, as the basis for developing cost-effective control strategies.

- Identifying and developing Action plans for implementation of the control strategies, including financing and a time frame.
- Enforcing the policies and regulations needed to implement the strategies.

Cost-benefit analyses

Perhaps the most used way to identify the appropriate strategy for reducing air pollution is the cost benefit analysis (CBA). CBA is a highly interdisciplinary task, as it requires understanding of the whole chain of events, starting from emissions and the costs of abatement, through pollutant transport and fate, effects (health or environmental endpoints), impacts and their valuation. The CBA should provide a benefit-cost ratio based on monetarised costs and benefits, and be accompanied by a description of the non-monetarised items that also should be considered.

In addition to CBA, other methods are available to identify the most favourable emission reduction options, but in practice, CBA seems to be the most commonly used approach.

Example: PM and health

Impacts on human health from PM pollution have been recognized as one of the most serious environmental problems. Exposure information to PM is essential for policymakers to identify the potential risk group and to develop appropriate risk reduction measures. Epidemiological studies of PM routinely use concentrations measured with stationary outdoor monitors as surrogates for population exposure, and the epidemiologic associations between ambient concentrations and health effects depend on the correlation between ambient concentrations and exposure to ambient-generated PM [25].

The various potential health effects are defined by their “end-point”. Impacts may be morbidity, *i.e.*, can have impacts upon healthiness and well-being, or can be mortality, *i.e.*, can have fatal consequences. The CAFE CBA [26] was for PM impacts limited to mortality impacts as follows:

- Chronic mortality from PM.
- Infant mortality from PM.

To illustrate with examples, a summary statistics, mean and 95% confidence interval (2.5 to 97.5%) for assessment of PM mortality impacts, expressed either as deaths or Years of Life Lost (YOLL):

	Deaths per person µg/m3	YOLLs per person µg/m3
2.5 %	2.2 E-0.5	2.1 E-04
Mean	6.0 E-05	6.5 E-04
97.5 %	1.0 E-04	1.1 E-03

In a summary report concerning dose response functions [25] also indicated functions for mortality arising from chronic exposure to $PM_{2.5}$. It is important to note that these estimates can differ substantially from one location to another: also here, local data are essential. Overviews, methodologies and summaries of dose-response relationships are provided, *e.g.*, in [27-29].

A recent European research project [30] provides a comprehensive review of methods and results for assessment of impact of various health endpoints [31] and their valuation [32].

Effects and costs

Several methods of how to express deteriorated health due to environmental causes are available [33]. One of them, the environmental burden of disease, quantifies the amount of disease caused by environmental risks. Disease burden can be expressed in deaths, incidence or in Disability-Adjusted Life Years (DALY), and both indices can be assigned monetary value. The latter measure combines the burden due to death and disability in a single index. Using such an index permits the comparison of the burden due to various environmental risk factors with other risk factors or diseases.

Additional information required for the rational development of policies by the health sector and activities of other sectors which directly manage or influence the determinants of health includes:

- the effectiveness and cost-effectiveness of interventions,
- the availability of resources and
- the type of policy environment.

Surveillance,monitoring and information system

The AQMP should be followed up by monitoring and surveillance to be able to assess changes in air quality, and to monitor achievements of the goals. Information to the public, to authorities and others is important. Even in countries with long tradition in AQMP, providing information may require developing suitable institutions or training.

Establishing an Air Quality Information System for dissemination of air pollution data, especially when complemented by air quality predictions, gives the public and decision makers the opportunity to protect against high pollution. Long-term operation of an air pollution monitoring network allows following changes in air quality, in order to check if control strategies have the necessary effects so that air quality standards are not breached.

CONCLUDING REMARKS

Over the last 40 years, significant progress was made in understanding all aspects of air quality. The role of air quality as a determinant of quality of life and in the long run, of the economic development, is now widely recognized. Advances have been made in all aspects of atmospheric sciences, environmental health issues, and risk assessment, management and communication. From this accumulated research base, the practitioners of air quality management have been drawing experiences and developing practical approaches that are suited to situations where less information or local skills are available, as well as to those where research and policy for air quality have a long tradition of mutual support. This paper is based on this accumulated experience: it provides a practical guide to the principles and the necessary steps in development of AQMP, based on over 25 years of experience from similar work. Understanding of the research base and the main research findings underpins any successful action, but concrete methods and tools will always be specific to each location. Local implementations have to solve numerous challenges in all steps of the process, and have to critically assess the available resources, expertise, information and institutional system to select the tools most appropriate to each situation. A critical reasoning behind each choice and appropriate choice of communication strategies greatly improves the chances for the solutions to be accepted by all stakeholders. The authors hope that this short overview will be useful as a starting point, and as an initial check list.

REFERENCES

[1] K.E. Grønskei, F. Gram, L.O. Hagen, S. Larssen, H. Janssen, X. Olsthoorn, A.S. Giri, M.L. Sherstha, B. Sherstha URBAIR Urban Air Quality Management Strategies in Asia. Kathmandu Valley Report, Edited by J. Shah, T. Nagpal, The World Bank, Washington DC, 1997, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2010/02/01/000333037_20100201011702/Rendered/PDF/529060WP0URBAI10also0report0WTP3781.pdf (accessed February 2012)

[2] S. Larssen, F. Gram, I. Haugsbakk, URBAIR. Urban air quality management strategy in Asia. Kathmandu Valley city specific report, NILU Kjeller, 1995 (NILU OR, 55/95)

[3] S. Larssen, F. Gram, L.O. Hagen, H. Jansen, X. Olsthoorn, R. Aundhe, URBAIR. Urban air quality management strategy in Asia. Greater Bombay City specific report, Kjeller, NILU, 1995 (NILU OR, 56/95)

[4] S. Larssen, F. Gram, L.O. Hagen, H. Jansen, X. Olsthoorn, R. Lesaca, URBAIR. Urban air quality management strategy in Asia, Metro Manila City specific report, Kjeller, NILU, 1995 (NILU OR, 57/95)

[5] K.E. Grønskei, F. Gram, L.O. Hagen, S. Larssen, H. Jansen, X. Olsthoorn, URBAIR. Urban air quality management strategy in Asia. DKI Jakarta City specific report. Kjeller, NILU, 1996 (NILU OR, 19/96)

[6] S. Larssen, F. Gram, L.O. Hagen, H. Jansen, X Olsthoorn, R. Lesaca, URBAIR. Urban air quality management strategy in Asia, Metro Manila City specific report, Appendices, Kjeller, NILU, 1996 (NILU OR, 57/95)

[7] The World Bank, Urban air quality management strategy in Asia. Guidebook, Ed. by J.J. Shah, T. Negpal, C.J. Brandon, The World Bank, Washington DC, 1997, http://www-wds.worldbank.org/external/default/main?pagePK=64193027&piPK=64187937&theSitePK=523679&menuPK=64187510&searchMenuPK=64187283&siteName=WDS&entityID=000009265_3980312111305 (accessed February 2012)

[8] S. Larssen, K.E. Grønskei, M.C. Hanegraaf, H. Jansen, O.J. Kuik, J. Oosterhuis, URBAIR. Guidebook of urban air quality management strategy in Asia, Kjeller, NILU, 1995 (NILU OR, 64/95)

[9] B. Sivertsen, T. Bøhler, On-line Air Quality Management System for Urban Areas in Norway, In: Proceedings of the seminar "The air of our cities ... it's everybody's business", Paris, 2000, Marie de Paris, Environment, Fourth theme, Paris, 2000, paper D6, pp. 44-45 (NILU F 4/2000)

[10] B. Sivertsen, Application of urban air quality management tools in World Bank projects: Lessons from more than a decade of Norwegian experience, World Bank, Washington DC, 2007 (Air Quality Thematic Group BBL Series), NILU Kjeller, (NILU F 60/2007)

[11] B. Sivertsen, A. Dudek, Integrated air quality management in urban areas: simplified methods, presented at The 18th IUAPPA World Clean Air and Environmental Protection Congress in Brisbane, Australia, 9-13 September 2007, NILU Kjeller, (NILU F 20/2007)

[12] AirQUIS (2007), www.airquis.no (accessed February 2012)

[13] B. Sivertsen, AQA/AQMP project, Air Quality Management Plan, Draft Implementation Manual. NILU, Kjeller, 2007 (NILU OR 52/2007)

[14] R. Van Alst, L. Edwards, T. Pulles, E. De Saeger, M. Tombrou, D. Tønnesen, The Guidance Report on Preliminary Assessment under the EU air quality Directives, EEA, Copenhagen, 1998, http://www.eea.europa.eu/publications/TEC11a (accessed February 2012)

[15] J. Bachmann, J. Air Waste Manage. Assoc. **57** (2007) 652-697

[16] P.A. Solomon, P.K. Hopke, J. Froines and R. Scheffe, J. Air Waste Manage. Assoc. **58** (2008) S-3-S-92

[17] U.S. EPA Integrated Science Assessment for Particulate Matter (Final Report) http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=216546#Download (accessed 7 June 2012)

[18] M. Amann, I. Bertok, J. Borken.Kleefeld, J.Cofala, C. Heyes, L. Hoglund.Isaksson, Z. Klimont, B. Nguyen, M. Posch, P. Rafaj, R. Sandler, W. Schopp, F. Wagner, W. Winiwarter, Environ. Modelling Software 26 (2011) 1489-1501

[19] CAFE Working Group on Particulate Matter, Second Position Paper on Particulate Matter, Brussels, December

2004, http://ec.europa.eu/environment/archives/cafe/pdf/ /working_groups/2nd_position_paper_pm.pdf (accessed February 2012)

[20] US EPA, QA Handbook for Air Pollution Measurement Systems, Vol. II, Ambient Air Quality Monitoring Program, Publication No. EPA-454/B-08-003, Research Triangle Park, NC, 2008, http://www.epa.gov/ttnamti1/files/ambient/pm25/qa/QA-Handbook-Vol-II.pdf (accessed February 2012)

[21] B. Sivertsen, Chem. Ind. Chem. Eng. Q. **14**(3) (2008) 167−171

[22] EEA, Criteria for EUROAIRNET, The EEA Air Quality Monitoring and Information Network, EEA technical paper 12, Copenhagen, 1999, http://www.eea.europa.eu/publications/TEC12 (accessed February 2012)

[23] D.J. Carruthers, H.A. Edmunds, A.E. Lester, C.A. McHugh, R.J. Singles, Int. J. Environ. Pollut. **14** (2000): 364-374

[24] C. Carnevale, G. Finzi, G. Guariso, E. Pisoni, M. Volta, Environ. Modelling Software **34** (2012) 44-50

[25] C.A. Pope, M. Thun, M. Namboodiri, D. Dockery, J. Evans, F. Speizer. C. Heath, Am. J. Resp. Crit. Care Med. **151** (1995) 669-674

[26] M. Holland, F. Hurley, A. Hunt, P. Watkiss, Methodology Paper (Vol. 3) for Service Contract for carrying out cost-benefit analysis of air quality related issues, in particular in the clean air for Europe (CAFE) programme, ENV.C.1/ SER/ 2003/0027, 2005

[27] K. Barrett, B. Sivertsen, Dose-response in air pollution management. A review for application in AQMS, Kjeller, 2008 (NILU OR 15/2008)

[28] M.L. Cropper, N.B. Simon, A. Alberini, P.K. Sharma, The Health Effects of Air Pollution in Delhi, India. World Bank Development Research Group, Washington DC, 1997

[29] K. Aunan, X.-C. Pan, Sci. Total Environ. **329** (2004) 3-16

[30] HEIMTSA, www.heimtsa.eu (accessed February 2012)

[31] IOM, Final report on risk functions used in the case studies, Deliverable 3.1.2/3/4 (2011) http://www.heimtsa.eu/LinkClick.aspx?fileticket=a6n5dYwOWqU%3d&tabid=2937&mid=6403 (accessed February 2012)

[32] A. Hunt, S. Navrud, V. Maca, M. Scasny, Monetary values for health end points used in the HEIMTSA/INTARESE Common Case Study, Deliverable 4.2.1 (2011), http://www.heimtsa.eu/LinkClick.aspx?fileticket=Z79uJ1ZKuX8%3d&tabid=2937&mid=6403 (accessed February 2012)

[33] WHO, Quantifying environmental health impacts, Geneve, 2012, http://www.who.int/quantifying_ehimpacts/en/ (accessed February 2012).

BJARNE SIVERTSEN
ALENA BARTONOVA

NILU-Norwegian Institute for Air Research, Kjeller, Norway

STRUČNI RAD

UPRAVLJANJE KVALITETOM VAZDUHA (AQMP)

U većini gradova sveta, koncentracija suspendovanih čestica (PM) predstavlja ozbiljne probleme, koji se razmatraju u nekoliko oblasti (kvalitet vazduha, klimatske promene, ljudsko zdravlje). PM predstavljaju višestruki izazov zbog brojnih izvora, koji se prostiru kroz mnoge sektore ekonomskih aktivnosti, kao i kroz prirodu, zbog složenosti atmosferskih procesa obuhvaćenih njihovim transportom i sekundarnim formiranjem. Cilj vlasti je da uticaji koncentracija PM budu minimalne, u praksi to znači da su u saglasnosti sa posrojećim pravilima i standardima. U poslednjih četrdreset godina u Severnoj Americi i delovima Evrope sprovedeni su sveobuhvatni istraživački programi za razvoj AQMP. Napred navedena kumulativana iskustva mogu biti od korisiti i drugima koji se suočavaju sa istim problemima, ali tek treba da razviju sopstvenu bazu za istraživanje. Glavni cilj procesa razvoja AQMP je da uspostavi efikasanu i zdravu osnovu za planiranje i upravljanja kvalitetom vazduha u izabranoj oblasti. Ova vrsta planiranja će obezbediti da se identifikuju i kontrolišu značajni izvori uticaja na najisplativiji način. Izbor alata, metoda i ulaznih informacija je često diktiran njihovom raspoloživošću, i treba da bude vrednovan prema trenutno najboljim pravilima. Važni elementi AQMP su identifikacija izvora i razvoj kompletnog katastra emisija, razvoj i sprovođenje programa monitoringa kvalitata vazduha i primena atmosferskih disperzionih modela. Najvažniji zadatak je prikupljanje potrebnih ulaznih podataka. Razvoj AQMP će uzeti u obzir: zahteve za Sistem upravljanja kvalitetom vazduha (AQMS), strukturne operativne i funkcionalne zahteve, identifikaciju izvora kroz inventar emisija, aletrnative za smanjenje izvora, koje mogu biti implementirane, mehanizme za izgradnju međusekotrske kooperacije u cilju osiguranja akcija koje se preduzimaju i zahteve za izgradnju institucija i trening. Ovaj rad nudi praktičan vodič za različite delove procedura upravljanja i planiranja kvalitetom vazduha.

Ključne reči: Upravljanje kvalitetom vazduha, emisije, modelovanje, uticaj, trening.