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DRAFT GUIDELINES FOR DEVELOPING NATIONAL STRATEGIES TO USE AIR QUALITY MONITORING AS AN ENVIRONMENTAL POLICY TOOL

Note by the secretariat[1]

Summary

The present document contains draft guidelines to facilitate the implementation of the sub-task "1.1 Review of developments in environmental monitoring and assessment at the national and international levels" of the work programme of the Working Group. It is based on the *Draft strategy for the use of air quality monitoring as an environmental policy tool in countries of Eastern Europe, Caucasus and Central Asia*, which was discussed at a workshop on the interaction between air quality monitoring and air protection strategies in countries of Eastern Europe, Caucasus and Central Asia held on 11 June 2007 in Geneva. The document reflects comments and proposals made by the Working Group at its eighth session (ECE/CEP/AC.10/2007/2, paras. 24 and 25).

The Working Group may take it as basis when preparing the Guidelines at its tenth session, for submission to the Committee on Environmental Policy for approval.

[1] Prepared with the assistance by Mr. Vladislav Bizek, consultant to the secretariat.

CONTENTS

I. INTRODUCTION

1. The present Guidelines were prepared in response to the invitation of the Sixth Ministerial Conference "Environment for Europe" (Belgrade, October 2007) to the United Nations Economic Commission for Europe (UNECE) "to continue its efforts, in cooperation with EEA and other partners, to make monitoring effective instrument in environmental policymaking in countries of Eastern Europe, Caucasus and Central Asia and South-Eastern Europe". They were also a response to the subsequent decision
by the UNECE Committee on Environmental Policy that its Working Group on Environmental Monitoring and Assessment should complete guidelines "to help interested countries in developing national strategies for the use of air quality monitoring as environmental policy tool".

2. The aim of these Guidelines is to provide guidance to countries of Eastern Europe, Caucasus, Central Asia and South-Eastern Europe (hereinafter "the target countries") as in terms of heir revising their air quality monitoring programmes to help make monitoring a practical tool for environmental policy, especially for target-setting, for the development of pollution abatements strategies and for assessing progress in achieving policy targets and the effectiveness of abatement measures. Minimization of health and environmental effects of air pollution is recognized as a main policy objective (see box 1).

Box 1: Health and environmental impacts of air pollution

Concerning health impacts, currently in the European Union (EU) there is a loss in statistical life expectancy of over eight months due to particulate matter (PM) in the air, equivalent to 3.6 million life years lost annually.
Source: *Communication from the Commission to the Council and the European Parliament: Thematic Strategy on air pollution, COM (2005) 446final.*

There are serious risks to health from exposure to PM and ground-level ozone (O_3) in many cities of developed and developing countries. It is possible to derive a quantitative relationship between the pollution levels and specific health outcomes (increased mortality or morbidity). This allows invaluable insights into the health improvements that could be expected if air pollution were reduced. Even relatively low concentrations of air pollutants have been related to a range of adverse health effects. Poor indoor air quality may pose a risk to the health of over half of the world's population. In homes where biomass fuels and coal are used for cooking and heating, PM levels may be 10–50 times higher than the guideline values.
Source: *World Health Organization (WHO) 2005 Air Quality Guidelines.*

Current exposure to PM from anthropogenic sources leads to an average loss of 8.6 months of life expectancy in Europe. The total number of premature deaths amounts to about 348,000 in 25 EU Member States (EU-25). In addition, some 100,000 hospital admissions per year can be attributed to exposure.
Source: *Health Risks of Particulate Matter from Trans-boundary Air Pollution, WHO Regional Office for Europe (WHO-Europe), 2006.*

It is estimated that some 21,000 premature deaths per year are associated with ozone exceeding 70 $\mu g/m^3$ measured as a maximum daily 8-hour average in the EU-25. Ozone is also associated with 14,000 respiratory hospital admissions annually in the EU-25.
Source: *Health Risks of Ozone from Long-range Trans-boundary Air Pollution, WHO-Europe 2008.*

3. While the present Guidelines focus on target countries as a group they take into account country specifics such as geographic conditions, the diversity of national economies and established practices for setting monitoring networks, practices and procedures.

4. The Guidelines are based on the assessment of the situation with air quality monitoring in the target countries made by the Working Group and the evaluations contained in the country environmental performance reviews (EPRs) prepared under the UNECE EPR programme. The document reflects relevant experiences gained in the EU and the United States of America where coherent systems of air quality assessment and management have been developed and implemented. They also take into account relevant international activities, requirements, guidance documents and recommendations, especially those developed under the Convention on Long-range Transboundary Air Pollution (CLRTAP), the Global Atmospheric Watch Programme of the World Meteorological Organization (WMO-GAW), the World Health Organization (WHO), the International Standardization Organization (ISO) and the Global Atmospheric Pollution Forum (GAP Forum).

II. LINKING AIR QUALITY MONITORING TO ENVIRONMENTAL POLICY DEVELOPMENT

5. To minimize the negative health and environmental effects of air pollution, those target countries that have not yet done so should develop strategies to establish comprehensive air quality assessment and management systems (see box 2) with a focus on priority pollutants, particularly PM_{10} (and $PM_{2.5}$), ground-level ozone, sulphur dioxide (SO_2) and nitrogen oxides (NO_x)[2]. Within it, a realistic approach to enhancing monitoring (focusing on both ambient air quality monitoring and emissions monitoring) should be developed.

6. The air quality assessment and management system should include a clearly defined institutional setting, including one central competent authority responsible for the coordination of all activities within this system (see box 2).

7. The main message of this document is that air quality monitoring systems should become an integral part of national air quality assessment and management systems and should therefore be designed, developed and interpreted in a broader policy and scientific context (see box 2).

8. As a part of the air quality assessment and management system, a well-developed air quality monitoring system is a basic precondition for priority and target-setting, for the preparation of instruments and measures as well as for the assessment of their effectiveness. In addition, air quality monitoring can also be used as an "early warning" and scientific instrument to better understand complex environmental systems and their developments before starting regulation.

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[2] It should be taken into account that two of priority pollutants are either fully (ground-level ozone) or partially (secondary particles – inorganic or organic aerosols) created via precursors (nitrogen oxides, volatile organic compounds (VOCs), sulphur dioxide and ammonia (NH_3)), which makes assessment of the relations between emissions and air quality difficult in comparison to other pollutants that are being emitted directly into the air.

A. Integrating air quality monitoring data with emission inventories

9. An effective air quality assessment and management system, as a part of environmental policy formulation and implementation, should fit the DPSIR (driving force-pressure-state-impact-response) framework. Especially the relation between emissions (pressure) and ambient air quality (state) is of the utmost importance (bearing in mind that in the case of ground-level ozone and secondary particles, the relation between ambient air concentrations and the emissions of precursors is very complex).

Box 2: Basic elements of air quality assessment and management system

Institutional framework
(a) Central competent authority responsible for air quality issues (generally, the ministry of the environment), which coordinates activities of all relevant authorities and institutions;
(b) Relevant public administration institutions at the national, regional and local levels;
(c) Supporting institutions (mainly a hydrometeorological service).

Policy-level document setting:
(a) Objectives;
(b) Priorities;
(c) Targets.

Regulatory and other instruments
(a) Standards (ambient air limit values, emission limit values, emission ceilings, fuel standards, product standards);
(b) Technical requirements (operation of emission sources, measurement of emissions by operators, monitoring protocols, etc.);
(c) Economic and market-based instruments (pollution charges, product charges, taxation, emission trading, incentives, etc.);
(d) Voluntary instruments (ISO 14 000, eco-labelling, codes of conduct, voluntary agreements etc.);
(e) Information instruments (public information and awareness raising, environmental education).

Monitoring and information management
(a) Operation of a core air quality monitoring system (including its coordination with local and specialized monitoring networks and supporting activities);
(b) Development of emission inventories and projections (including scenario analysis);
(c) Air quality modelling (including scenario analysis);
(d) Assessment of effects on human health and the environment;
(e) Operation of air quality information system (including public information);
(f) Reporting.

Operational level setting
(a) Permitting including environmental impact assessment (EIA)/environmental expertise, strategic environmental assessment (SEA) and life-cycle assessment (LCA);
(b) Regional approach (zoning, planning);
(c) Application of instruments/implementation of measures;
(d) Enforcement (inspection);
(e) Feedback mechanisms (mechanisms to update policy and technical levels).

Source: *UNECE.*

10. Target countries that have not yet done so should:

(a) Update the mechanisms to create and operate national emission inventories on a regular basis; these inventories should cover the most important priority pollutants which are being regulated;

(b) Include the assessment of emissions from mobile sources (mainly road transport, but also non-road mobile machinery) and small stationary sources (mainly decentralized local heating and small businesses) into emission inventories;

(c) Apply the *EMEP/CORINAIR*[3] *Air Emissions Inventory Guidebook* as the methodological tool[4],

(d) Use, in addition, the GAP Forum's *Air Pollutant Emission Inventory Preparation Manual*, together with its associated software (an Excel-based workbook) as a practical tool for preparing emission inventories[5];

(e) Arrange for the preparation of emission projections for selected pollutants on a regular basis (these projections should at least cover those priority pollutants which are being regulated);

(f) Coordinate preparation of emission inventories and projections for "classic" air pollutants (mainly PM, SO_2, NO_X, VOCs and NH_3) with the preparation of emission inventories and projections for greenhouse gases (GHGs).

B. Integrating air quality monitoring data with modelling activities

11. It is recommended that target countries that have not yet done so to develop or implement existing modelling tools extrapolating the monitoring data to cover all territories where the compliance with the standards is required and correlating the air quality monitoring data with the emissions from specific sources.

12. As a first step, past and actual situations should be assessed by appropriate models (e.g. processing of time series of monitoring data) to define background for setting targets. Suitable policies and measures should be proposed to achieve them. As a second step, modelling should be carried out to predict future developments in air quality and to check both whether the proposed targets are technically and economically achievable and whether the policies and measures are likely to achieve them.

[3] Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP)/Core Inventory of Air Emissions (CORINAIR).
[4] The last version (2007) available at: www.eea.europa.eu/publications/EMEPCORINAIR5; new version is upcoming.
[5] Version 2.2 (October 2008) available for free download at: www.sei.se/gapforum/tools.php.

13. It is recommended to use dispersion and/or chemical transport models (e.g. EMEP[6], TM5[7] or CAMx[8]) and complex "scenario analysis" models developed by IIASA[9] (e.g. RAINS[10] or GAINS[11]) which attempt to cover the whole DPSIR cycle and are a very important policymaking tool.

14. Those target countries that are covered by the IIASA GAINS Europe model are still recommended to work with this tool actively, as it enables not only the calculation of emission inventories and emission projections but also the assessment of impacts of air pollution on human health and ecosystems for various policy scenarios, including the cost assessment. Other target countries are recommended to contact IIASA to check the possibility of being included among the "GAINS countries" (either under GAINS Europe or GAINS Asia).

C. Integrating air quality monitoring data with the assessment of health and environmental effects

15. The Guidelines for Reporting on the Monitoring and Modelling of Air Pollution Effects[12] offer guidance for estimating and reporting monitoring and modelling data on effects of air pollution to human health and the environment (e.g. forests, waters, vegetation, ecosystems and materials), including quantification of those effects. Their application will help to establish a scientific basis for dose-effect relationships and, where possible, to evaluate economically the benefits for the environment and human health resulting from emission reductions. The Guidelines address effects of acidifying pollutants, nutrient nitrogen, ozone, heavy metals and persistent organic pollutants (POPs). Technical details for monitoring are specified in the technical manuals of the International Cooperative Programmes (ICPs) of the Working Group on Effects.

D. Integrating air quality monitoring data with the results of remote sensing

16. Data obtained from remote sensing may play very important role in air quality assessment, especially in the case of large space scales, as they provide complementary data to that obtained via ground-level monitoring. It can be applied in conjunction with dispersion modelling for the tracking of very dynamic phenomena, such as, transported air pollution.

17. Experiences could be taken into account with the development by the European Space Agency (ESA) and the EEA of the "Integrated Air Quality Platform for Europe" service, part of the ESA GMES (Global Monitoring for the Environment and Security) PROMOTE (Protocol Monitoring for the GMES Service Element) project. Its aim is to provide end-users information

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[6] Available at: www.emep.int/OpenSource/index.html.
[7] Global Chemistry Transport Model (TM5). Available at: www.phys.uu.nl/~tm5 .
[8] Comprehensive Air Quality Model with extensions (CAMx). Available at: www.camx.com.
[9] International Institute for Applied System Analysis.
[10] 'Regional Air Pollution Information and Simulation (RAINS) model. Available at: www.iiasa.ac.at/Research/TAP/rains_europe/intro.html.
[11] Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model. Available at: http://gains.iiasa.ac.at.
[12] Developed by the Working Group on Effects of the CLRTAP Executive Body (ECE/EB.AIR/WG.1/2008/16/Rev.1). Available at: www.unece.org/env/lrtap/ExecutiveBody/welcome.26.html.

about air quality. It is currently providing forecasts for up to 72 hours at a resolution of 50 km. The service includes data on O_3, NO_2 and PM (the sum of all particles suspended in air, including dust, smoke, pollen, etc.)[13].

E. Integrating air quality monitoring with other monitoring networks

18. It is recommended that the target countries consider preparing and implementing integrated monitoring strategies which would create a framework for coordination of specialized monitoring networks (e.g. air, water, soil, forests, biodiversity, noise and waste).

F. Revising air quality standards and harmonizing them with international standards and guidelines

19. Current air quality standards should be updated or discontinued and new ones set by the central-level competent authority responsible for the coordination of national air quality assessment and management systems. Where a ministry of health is responsible for setting national air quality standards, the same central-level competent authority should participate actively in the process of air quality standards updating and setting.

20. The WHO Air Quality Guidelines values may be taken into consideration when revising and setting new air quality standards. Nevertheless, as certain WHO values (especially annual mean values for PM_{10} and $PM_{2.5}$) are hardly achievable for many countries, it is recommended that the target countries consider the approach that has been developed and implemented either in the EU or in the United States of America. The differences between the EU and the United States approaches are described in detail in box 3. A comparison between the air quality limits in the EU and the United States of America is made in the recent UNECE study[14]. Due to practical reasons, a step-wise approach is recommended, in any case with a sufficient transition period.

21. In the first phase, the assessment of an existing set of national air quality standards should be carried out to decide which ones should remain in place (taking into account their role in permitting procedures like environmental expertise and setting emission limits) and which ones should be updated and or replaced.

22. In the second phase, selected air quality standards should be introduced or updated for priority pollutants: mainly PM (PM_{10} in any case), ground-level ozone, SO_2 and NO_2. New or revised standards for other pollutants – CO, lead and benzene – could be added if found appropriate. It is also recommended that alert thresholds for sulphur dioxide, nitrogen dioxide and ground-level ozone and information threshold for ozone be introduced.

23. In the third phase, new or revised standards for other pollutants – $PM_{2.5}$ (if not introduced earlier), heavy metals (As, Cd and Ni) and PAHs (benzo(a)pyrene) – could be added depending on their impact on air quality in particular target country and limit values for the protection of vegetation (secondary standards) could be introduced as well, if not in place.

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[13] Details are available at: www.esa.int.

[14] *Adaptation of Monitoring Networks in Eastern Europe, Caucasus and Central Asia: Air Quality Monitoring* (2006) (ECE/CEP/AC.10/2006/3). Available at: www.unece.org/env/europe/monitoring.

Box 3: Major differences between the European Union and the United States air quality standards

These differences are as follows:

(a) The United States basic set of standards (criteria pollutants[15]) does not include benzene, arsenic (As), nickel (Ni), cadmium (Cd) and benzo(a)pyrene;
(b) The EU limit values are more stringent (in absolute values) than the US ones, with the exception of $PM_{2.5}$;
(c) The United States compliance criteria are often more stringent than the EU ones (in the case of short-term limit values);
(d) The United States compliance timing is more flexible than that in the EU (where the same flat deadlines are set for all Member States);
(e) Averaging periods are different in certain cases;
(f) The United States secondary standards (limit values for the protection of vegetation, ecosystems) cover more pollutants than the EU standards[16] (and take into account visibility and protection of man-made materials);
(g) The EU approach distinguishes between limit values[17] and target values[18] and more complicated standards are applied in the case of ground-level ozone (target value and long-term objectives) and $PM_{2.5}$ (average exposure indicator, national exposure reduction target, exposure reduction obligation, target value and limit value).
(h) In the EU, ambient air quality standards for certain pollutants (PM_{10}, sulphur dioxide, nitrogen dioxide and nitrogen oxides, lead, benzene and carbon monoxide) are legally binding and are to be (or were to be) complied with by given deadlines (2005 or 2010) throughout the whole territory of all Member States. In the case of ground-level ozone, heavy metals (As, Cd and Ni) and polycyclic aromatic hydrocarbons (PAHs) expressed as benzo(a)pyrene, the target values set should be complied with by a given deadline (2013) in the case that all necessary measures not entailing excessive costs are taken. In the case of $PM_{2.5}$, the targets have been introduced in a more complex way: exposure reduction target (to be met by 2020), exposure concentration obligation (to be met by 2015), target value (to be met by 1 January 2010) and limit values (to be met by 1 January 2015 and 1 January 2020).
(i) In the United States of America, the country is divided into three categories (attainment areas, non-attainment areas and unclassifiable areas). For the non-attainment areas, the compliance deadlines for criteria pollutants (sulphur dioxide, nitrogen oxides, ozone, lead, carbon monoxide, PM_{10} and $PM_{2.5}$) are differentiated in accordance with the pollution levels (marginal, moderate, serious or severe).

Source: *Comparison of EU Air Quality Pollution Policies and Legislation with Other Countries. Study 1. Review of the Implications for the Competitiveness of European Industry*. *January 2004. AEA Technology Environment and Metroeconomica for the European Commission.*

[15] Sulphur dioxide, nitrogen dioxide, carbon monoxide, lead, ozone, PM_{10} and $PM_{2.5}$.
[16] Fixed level to be attained within a given period and not to be exceeded once attained.
[17] Fixed level to be attained where possible over a given period.
[18] Critical levels for the protection of vegetations for sulphur dioxide and nitrogen oxides, target value and long-term objective for protection of vegetation for ground-level ozone.

24. The step-wise EU-like approach (e.g. average exposure indicator, national exposure reduction target, exposure reduction obligation, target value and limit value) is recommended to be followed in the case of $PM_{2.5}$ (the United States standard of 15 $\mu g/m^3$ for annual average concentration seems to be too stringent even for the EU Member States).

25. In updating their current air quality standards and developing new ones, the target countries may use relevant background information (e.g. health impact studies, cost-benefit analyses) available at the international level (e.g. EMEP[19], WHO[20], EEA[21] and the United States Environmental Protection Agency[22]).

26. The target countries should also decide on compliance deadlines for their updated or newly introduced ambient air quality standards (following, for instance, the EU more flat approach or the US more flexible approach). Without compliance deadlines, these standards would remain at the level of statements without any real power.

G. Target-setting

27. Detailed analysis of available air quality monitoring data (supported by modelling as far as possible) and of available emission data is a necessary precondition for sound target-setting (setting the baseline).

28. In general, targets should be constructed under the SMART (Specific, Measurable, Achievable, Realistic, Timely) concept and structured as main targets (e.g. air quality targets and emission reduction targets) and complementary technical targets (e.g. development of air quality monitoring networks, institutional settings, mechanisms for preparation of emission inventories and development of emission projections etc).

29. Main targets in the field of air quality should always include the priority pollutants: PM_{10} (and $PM_{2.5}$), ground-level ozone, sulphur dioxide and nitrogen dioxide.

30. Main targets in the field of air quality and emission reduction should be mutually coordinated and focused on minimization of health effects (PM and ground-level ozone) and environmental effects (acidification, eutrophication, ground-level ozone). As a result, the following priority air pollutants “on the emission side” are recommended to any target country:

(a) Dust[23] (primary emissions);

(b) Sulphur dioxide (precursor of secondary particles, acidifying agent);

(c) Nitrogen oxides (precursors of ground-level ozone and of secondary particles, acidifying and eutrophication agent);

[19] http://www.emep.int.
[20] http://www.who.int/topics/air_pollution.
[21] http://www.eea.europa.eu/themes/air.
[22] http://www.epa.gov/epahome/learn.htm#air.
[23] Emissions of heavy metals and of polycyclic aromatic hydrocarbons are related with the emissions of primary particles (dust).

(d) Volatile organic compounds (precursors of ground-level ozone and secondary particles);

(e) Ammonium (precursor of secondary particles, eutrophication and acidification agent).

31. A particular target country may add other main targets based on its specific conditions.

32. It is recommended that coordination of air quality targets and emission reduction targets be carried out using relevant modelling techniques (e.g. the GAINS model).

33. Complementary technical targets should be coordinated with the main targets (especially as for timing) to create conditions both for setting the main targets and for the assessment of compliance.

34. Setting the targets, both country-specific issues (e.g. geographic conditions, state-of-the-environment, environmental commitments at the international level and general policy trends) and economic assessment of achievability should be taken into account.

35. Reasonable timing of targets is recommended strongly following a prioritization of problems based on detailed analysis. A step-wise and flexible approach to the timing of compliance with targets is recommended as well.

36. For the assessment of compliance with the targets, the role of air quality monitoring is crucial.

H. Integration of air quality monitoring, assessment and management with climate change

37. It has been found[24] that certain air pollutants (e.g. PM, ground-level ozone) have considerable effects on the climate and there are many complex interactions between air pollutants and GHGs. Bearing in mind that the major part of both air pollutants and GHGs is generated by the same anthropogenic activities (e.g. energy, transport), the co-benefits of an integrated approach to the air quality assessment and management and climate change mitigation (reduction of GHG emissions) are evident.

38. The target countries are recommended to coordinate the development of their air quality assessment and management strategies with the development of climate change mitigation strategies to make use of the application of the co-benefit ("one measure – two effects") approach.

[24] Main conclusions of the conference Air Pollution and Climate Change: Developing a framework for integrated co-benefits strategies, Stockholm, 17–19 September 2008 (www.sei.se/gapforum).

I. Better use of air quality monitoring data

(i) Permitting

39. All target countries have introduced permitting procedures for activities which may have an impact on air quality. In this respect, results of air quality monitoring, preferably in combination with modelling (or at least expert assessment), are necessary to decide on the location of a new potentially polluting activity or in the case of a substantial change of existing activity which may cause an increase in emissions. Results of air quality monitoring are used during the process of EIA or environmental expertise as a baseline for an air dispersion study which should estimate the incremental concentration of pollutants caused by the implementation of the project assessed.

40. The target countries are recommended to extend the use of air quality monitoring data in combination with modelling tools in permitting processes.

(ii) Compliance with ambient air quality standards

41. Once ambient air quality standards are adopted, reliable air quality monitoring data are the most relevant way how to monitor compliance[25]. Nevertheless, due to the costs it is not possible to monitor all pollutants for which some kind of regulation (e.g. emission limit values) is in place. In any case, priority pollutants should be monitored in ambient air for which air quality standards have been set or updated. The national legislation should clearly impose responsibilities on the actors responsible for monitoring of specific sets of standards together with technical requirements for monitoring networks.

(iii) Reporting

42. It is recommended to the target countries to include air quality data in their national state-of-the-environment reports. As national environmental reports are produced for policymakers as well as for the public, the data on air quality should be accompanied by detailed interpretation of that data. Such interpretation should cover at least the following issues:

(a) Population living in areas with increased concentrations of pollutants;

(b) Areas of environmental importance (e.g. national parks or other protected areas) with increased pollution levels;

(c) Potential risks for human health and for the environment;

(d) Origin of air pollution (both sectoral and territorial distribution of emission sources);

(e) Impact of meteorological conditions;

[25] In the case of lower concentrations, the results of monitoring may be supplemented or even replaced by modelling or expert assessment.

(f) Trends in air pollution;

(g) Policies applied and measures taken.

43. This information cannot be made available in full without monitoring, modelling and emission inventory results.

44. When preparing state-of-the-environment reports, the application of indicators[26] is recommended strongly to the target countries.

45. Besides the state-of-the-environment reports, those target countries that do not do it yet are recommended to regularly prepare and publish easily accessible specialized reports on air quality. These should include not only the air quality monitoring data together with their detailed interpretation, but also relevant emission data. International developments in air quality reporting[27] are recommended to be taken into account.

(iv) Public information and warning: urgent actions

46. In the case of certain pollutants (mainly PM, ground-level ozone, SO_2 and NO_X), increased concentrations may lead to immediate health risk for sensitive groups or even for population as a whole. If so, public should be duly informed or warned. The role of reliable air quality monitoring system is clear and very important in such a case. Air quality monitoring systems should be able not only to detect such situations immediately, but also to predict them (on the basis of meteorological predictions). In addition, short-term plans, prepared and adopted by the respective competent authority, should be implemented in such cases. These may include restrictions on traffic or specific stationary sources of pollution.

47. It is recommended that target countries introduce (if not introduced earlier) alert thresholds for sulphur dioxide, nitrogen dioxide and ground-level ozone and information threshold for ozone. In addition, it is recommended that they consider the introduction of alert threshold for PM_{10}.

(v) International targets

48. At present, there is no explicit international quantitative target for the target countries in terms of compliance with binding ambient air quality standards. On the “emission side”, the quantitative targets are in place for those target countries that have ratified respective CLRTAP protocols.

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[26] *Environmental Indicators and Indicator-based Assessment Reports – Eastern Europe, Caucasus and Central Asia*. Geneva and New York, 2007. Sales No. E 07.II.E.9. The English version of this publication is available online at www.unece.org/env/documents/2007/ece/ece.belgrade.conf.2007.inf.6.e.pdf, and the Russian version at www.unece.org/env/documents/2007/ece/ece.belgrade.conf.2007.inf.6.r.pdf.

[27] See, for instance, *City annual air quality reports. A proposal for a reporting format*. DCMR/AIRPARIF. November 2006 (http://citeair.rec.org/downloads/Products/CityAnnualAirQualityReports.pdf).

III. MODERNIZING AND UPGRADING NATIONAL AIR QUALITY MONITORING NETWORKS AND INFORMATION SYSTEMS

49. Within the framework of the development of national air quality assessment and management systems, the target countries are recommended to prepare and implement their national programmes for modernization and upgrading of their air quality monitoring networks and air quality data management and information systems. The main objective of these programmes is to create modern systems that respond to the information and policymaking needs of the target countries and operate on the basis of best available techniques, methodologies and good practices available in the UNECE region.

50. Development of a complete national core air quality monitoring network as a part of air quality assessment and management system (see box 2) should be the main specific target of these programmes. The following issues should be covered by these programmes:

(a) Sampling points, their location and densities;

(b) Parameters measured;

(c) Technical capacities, particularly automated measurements;

(d) Reliability of measurements and analyses;

(e) Data management;

(f) Publication of data including for the general public;

(g) Mobilization of funds from various domestic and external sources.

(h) A step-wise approach is recommended taking into account financial and technical possibilities of particular target countries.

A. Sampling points, their location and densities

51. It is recommended that the target countries observe the following guidance related to the siting and equipment of sampling points:

(a) Sampling points should be sited in such a way as to provide data on the concentrations of pollutants both in highly populated areas (impact on human health) and in rural areas that are not highly influenced by anthropogenic pollution (impact on vegetation and ecosystems);

(b) Siting of sampling points is given by the type of station (e.g. traffic, industrial or background), the type of area (e.g. urban, suburban or rural) and the characterization of area (e.g. residential, commercial, industrial, agricultural or natural);

(c) In general, sampling points should be sited in such a way to avoid measuring very small micro-environments and to be representative for air quality monitoring in their reasonable vicinity, which is different for different types of stations and areas (from hundreds of square metres in the case of traffic or industrial sites to thousands of square kilometres in the case of stations targeted at obtaining the information related to the protection of vegetation);

(d) Sampling points targeted at obtaining the information related to the protection of vegetation should be located more than 20 km from agglomerations (250,000 or more inhabitants) or more than 5 km from other built-up areas, industrial installations or major motorways (with more than 50,000 vehicles per day);

(e) From the micro-scale point of view, sampling points should be located in such a way as to ensure unrestricted flow of air around the inlet, obviously in the height between 1.5 m and 4 m;

(f) In general, minimum number of sampling points in populated areas should be set depending on – besides the number of population – typical concentrations of relevant pollutants (in the case of lower concentrations, this number could be reduced);

(g) In the case of stations targeted at obtaining the information related to protection of vegetation, at least one sampling point per 20,000–40,000 km^2 is recommended for smaller countries depending on typical concentrations of pollutants;

(h) Additional sampling points should be established to measure pollution related to the important point sources of emissions.

52. In the case of PM (PM_{10} and $PM_{2.5}$ sampling points), the minimum number of sampling points should be higher than that for other pollutants. In the case of ground-level ozone, minimum numbers of sampling points can be slightly lower than those for other pollutants, but 50 per cent of ozone sampling points should measure nitrogen dioxide and at least one sampling point per country for measuring ozone precursors (VOCs) should be in place. In the case of heavy metals (As, Cd and Ni) and benzo(a)pyrene, one background sampling point should be installed every 100,000 km^2 in the case of smaller countries.

53. In the case of large target countries with a low density of population, the numbers of sampling points sited outside highly populated areas could be lower than that proposed in paragraphs 52(g) and 53.

B. Parameters measured

54. It is recommended that target countries monitor, generally, a core set of priority pollutants for which standards have been or will be set or updated (namely PM_{10}, ground-level ozone, sulphur dioxide and nitrogen dioxide as well as carbon monoxide, benzene, lead, where appropriate), at least in the biggest cities and highly populated agglomerations. In addition, it is recommended that the target countries, where it has not yet been done, start monitoring, at least at selected monitoring stations, $PM_{2.5}$, heavy metals (As, Cd, Ni) and PAHs (benzo(a)pyrene).

55. In target countries where it has not been done yet, besides the concentration of pollutants, meteorological parameters should be measured at least at selected stations, representative with respect to monitoring data assessment, as the relation between emissions and air quality cannot be interpreted without having relevant meteorological data. Data on wind velocity and direction, temperature 10 m and 2 m above terrain, relative air humidity, atmospheric pressure, precipitation amount and global radiation is necessary for the interpretation of ambient air quality measurements. At selected representative stations, precipitation quality (chemical composition) and atmospheric deposition should be monitored as well.

C. Technical capacities, particularly automated measurements

56. For the establishment of a national core air quality monitoring network, the stepwise introduction of automated monitoring stations is recommended (starting with the biggest cities and highly populated agglomerations and continuing “top down”). A national core air quality monitoring network based on automated stations could be supplemented by manual monitoring stations and by “passive monitoring devices” (diffusion tubes). In addition, mobile monitoring stations could be applied to provide supplementary data in a flexible way.

D. Reliability of measurements and analyses

57. Application of internationally recognized reference sampling and measurement methods is recommended to the target countries. ISO is standardizing tools for air quality characterization of ambient air, in particular measurement methods for air pollutants[28] and for meteorological parameters, measurement planning, procedures for quality assurance/quality control (QA/QC) and methods for the evaluation of results, including the determination of uncertainty. ISO also outlines the general principles to be taken into account when assessing the accuracy of measurement methods and results[29]. EU relevant standards could be another option[30]. Data quality objectives are recommended to be defined by three variables: uncertainty, minimum data capture and minimum time coverage.[31]

58. The technical recommendations presented in paragraphs 52 to 57 are based, among others, on the current practice in the European Union and are mainly related to the establishment of national core air quality monitoring networks. The *EMEP Manual for Sampling and Chemical Analyses*[32] could be another source of information for the target countries but it should be taken into account that the EMEP network of stations is intended to supplement national air quality monitoring networks.

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[28] Twenty-one ambient atmospheres standards/projects of TC 146/SC 3 and 11 general standards and/or guides of TC 146/SC 4 (www.iso.org).

[29] *1993 Guide to the Expression of Uncertainty of Measurements* and guidance for the accuracy of the measurement and for testing laboratories (ISO 5725-1-8:1994-1998 and ISO 17025:2005) (www.iso.org).

[30] See the Directive 2008/50/EC of the European Parliament and of the Council on ambient air quality and cleaner air for Europe.

[31] In the EU legislation, for instance, different values of some of these variables are set for particular pollutants: Uncertainty of fixed measurement is 15 per cent for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, carbon monoxide and ozone while 25 per cent for benzene and particulate matter. Minimum data coverage is 90 per cent. Minimum time coverage is 90 per cent for industrial sites and 35 per cent for background sites.

[32] Available at www.nilu.no/projects/ccc/qa/index.htm.

E. Data management

59. It is recommended that a national air quality information system, as a subsystem of the national air quality assessment and management system, should be established/updated to implement the following main tasks:

(a) Collection of data on air quality (e.g. core network, specialized networks and mobile stations);

(b) Processing of the data (quality control);

(c) Modelling of concentration fields of pollutants;

(d) Assessment and modelling of trends in air quality;

(e) Assessment of health and environmental effects;

(f) Reporting (both national and international);

(g) Providing information to the public.

(h) The air quality information system should be closely linked operationally with:

(i) Compliance assessment (exceedance of limit values or other relevant standards);

(j) Collection of data on emissions (emission cadastre/inventory);

(k) Preparation of emission projections.

60. National air quality information systems are recommended to be established preferably within those authorized institutions that operate the national core air quality monitoring network (mostly hydrometeorological services). In the case that such institutions are not related to the competent authority responsible for air quality assessment and management, other arrangement should be applied (e.g. environmental agency or the competent authority itself). Such arrangement should include data exchange based on an inter-agency agreement.

F. Cost estimates

61. The recommended step-wise top-down approach to the upgrade of air quality monitoring system (starting with the most populated areas) may allow to the target countries to optimize the needs of air quality assessment and management with economic conditions.

62. The (investment) cost of one fully equipped automated monitoring station (for meteorological data, PM_{10}, $PM_{2.5}$, sulphur dioxide, nitrogen dioxide and nitrogen oxides, carbon monoxide and ozone) could be estimated between $140,000 and $190,000. Annual operational cost of such a station could be between $20,000 and $50,000. In the case of specialized stations

or stations without meteorological data measurement could be less expensive (less than $120,000).

63. Additional costs (analytical laboratories and staff) must be expected for monitoring data management and the operation of the whole air quality information system.

64. Detailed cost estimates for the monitoring of PM (PM_{10} and or $PM_{2.5}$) in countries of Eastern Europe, Caucasus and Central Asia were published by WHO Regional Office for Europe[33].

G. Mobilization of funds from various domestic and external sources

65. The expenditures related to modernizing and upgrading national air quality monitoring systems (core systems) as well as to national air quality information systems are to be funded from the State budget.

66. Additional sources could be found in public (regional and municipal) budgets to support supplementary monitoring activities (regional or municipal networks).

67. Optionally, private companies could bear a part of the costs related to the modernizing of and upgrading air quality monitoring system, either voluntarily (promoting their corporate social responsibility) or through legal requirements (mandatory self-monitoring stations included in the State monitoring system).

68. It is also recommended to the target countries to participate in certain international activities to be qualified for financial support from external sources (e.g. trust funds under CLRTAP).

IV. IMPROVING COORDINATION OF NATIONAL AIR QUALITY MONITORING PROGRAMMES

69. Air quality monitoring networks and/or individual monitoring stations (groups of stations) may be operated by different institutions, e.g. hydrometeorological services, environmental inspectorates, sanitary/health inspections, territorial authorities, municipal authorities, enterprises or specialized companies. Due to different reasons (e.g. location of monitoring stations, monitoring frequencies), the results often differ in scope of pollutants monitored, in parameters of measurements, in the timing of measurements, in data treatments as well as in the quality of data and information obtained.

70. It is recommended that the authorized institution (preferably the one which operates the national core air quality monitoring network) have the power to coordinate all air quality monitoring activities in the country. This power should be accompanied by certain responsibilities with regard to data management (e.g. data flow, data validation and comparison) and support services, including the operation of reference laboratories, the organization of inter-calibration exercises, the publication of manuals and the organization of expert training.

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[33] *Framework Plan for the Development of Monitoring of Particulate Matter in EECCA*, WHO-Europe 2006 (www.europe.who.int/Document/E88565.pdf).

71. In the case that such an authorized institution does not report to the Ministry of Environment, the coordination power should be given to the Ministry of Environment.

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