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Preparation of national emission reduction and ambient air quality assessment programmes

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Introduction

WHY HAVE A MANUAL?

The aim of the EU Environmental Policy is to reach acceptable levels of air quality that do not have negative impacts on or risks to the environment and/or health. Ambient air quality standards (limit values and target values) for pollutants are set according to their scientifically observed or estimated effects on (first and foremost) human health and/or on (second) the environment and are not based on the technological or economic feasibility of achieving them. Finally, the same standards apply in general throughout the EU. This principle of universality provides for only one exception; there are provisions for special areas (e.g. for nature conservation).

Air quality must be ensured by monitoring, restricting and preventing air pollution. The integrated approach of the EU Environmental Policy reflects on measures taken to reduce air pollution at one point or in one area, which should not lead to an increase in air pollution elsewhere, or to an increase in pollution of another environmental medium (based on the principles of Integrated Pollution Prevention and Control (IPPC)).

In order to continue to improve and protect their population's health and environment, the Baltic States face a significant challenge to introduce the related European Union air quality standards and requirements. To achieve this, a considerable change of system is needed as existing practices are historically based on different air quality standards and requirements.

Consequently, this manual has been developed to help staff from state institutions, municipalities, NGOs and consultancies that deal with air quality assessment issues, to improve their understanding of:

- the EU ambient air assessment principles (pollutants, limit values, thresholds etc.);
- principles and methods of ambient air monitoring system;
- modelling as an air quality management tool;
- principles and requirements of the air pollution reduction programmes;
- links to environmental permitting and EIA; and
- information flows and exchange.

This manual has been prepared as part of the *EuropeAid* project *Preparation of national emission reduction and ambient air quality assessment programmes,* which has also developed training programmes and provided direct assistance with air assessment development to the EPA, REPDs and municipalities. The project has been implemented by Estonian, Latvian & Lithuanian Environment (ELLE), in association with Cambridge Environmental Research Consultants (CERC) and Ecolas N.V.

WHO IS THIS MANUAL FOR?

This manual contains useful information for:

- ambient air quality assessment specialists at the EPA;
- environmental inspectors and specialists of EIA at the REPDs;
- environmental and planning specialists at regions and municipalities;
- enterprises and companies preparing applications for environmental permits (GINL, TIPK);
- project owners and companies preparing EIA and SEA;
- scientific and education institutions that carry research in ambient air quality; and
- the general public interested in ambient air quality issues.

Some information may be new to you, some you may already be aware of. In any case, this manual should help you put your knowledge and experience into perspective, and improve your success in application of the EU ambient air assessment principles and requirements.

HOW THE MANUAL IS STRUCTURED

This manual consists of this introduction plus five further sections with useful contacts which you can use to access more information.

Part I (Legal acts on ambient air quality assessment) gives an overview of the main legal issues, from the point of view of both EU legislation and national law. The manual provides information on useful links and resources as well as on legal acts related to ambient air quality assessment (such as the IPPC directive, NEC directive, LCP directive and EIA directive).

Part II (Description of main pollutants) provides information on the pollutants of concern from the EU perspective. It gives a detailed overview of the general characteristics, principal sources and main mitigation measures applicable to these pollutants.

Part III (Methods for ambient air quality assessment) presents different tools and methods that can be used for assessing ambient air quality. This includes ambient air quality monitoring, air quality modelling and other techniques, such as the compilation of emissions inventories and indicative measurement methods. The purpose of the Manual is to make you familiar with the methods that are available rather than teaching you how to apply them. Most often experts will be hired to do certain studies or assessments; the manual is mainly designed to help you evaluate the work of such experts.

Part IV (Air quality management) provides information on air quality action planning, which is an important aspect of the air quality management process, providing a practical opportunity for improving air quality in an area where assessment has highlighted problems. It also describes the most significant measures that can be implemented to improve air quality.

Part V (Information on the results of air quality assessment) gives a detailed overview of general provisions in the overarching legal acts on information to the public and requirements specifically designed for the assessment of ambient air quality. It explains also the role of different institutions involved in ambient air quality management.

1. Legal acts on ambient air quality assessment

1.1. EU legal acts on ambient air quality assessment

1.1.1. The Air Quality Framework Directive

The Air Quality Framework Directive (96/62/EC, September 1996) on ambient air quality assessment and management establishes the basic principles of a common strategy to define and set objectives for ambient air quality in order to avoid, prevent or reduce harmful effects on human health and the environment, assess ambient air quality in the Member States, inform the public, notably by means of alert thresholds[1], and improve air quality where it is unsatisfactory.

The European Parliament and the Council define limit values and alert thresholds for the following pollutants:

- sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead;
- benzene and carbon monoxide;
- ozone; and
- polycyclic aromatic hydrocarbons (PAH), cadmium, arsenic, nickel and mercury.

Ambient air quality must be monitored throughout the territory of the Member States. Different methods may be used for this: measuring, mathematical modelling, a combination of the two, or estimates. Assessment of this type is mandatory in built-up areas with more than 250,000 inhabitants, or in areas where concentrations are close to the limit values.

If the limit values are exceeded Member States must devise a programme for attaining them within a set deadline. The programme, which must be made available to the public, must contain at least the following information:

- the location where the pollution is excessive;
- the nature, and an assessment, of the pollution;
- the origin of the pollution.

Member States are required to draw up a list of the areas and conurbations where pollution levels exceed the limit values. Where the alert thresholds are crossed, Member States must inform the inhabitants and send the Commission any relevant information (recorded pollution level, duration of the alert, etc.). Where certain geographical areas and conurbations have pollution levels below the limit values, the Member States must maintain those levels below the said values.

[1] Alert threshold - a level above which there is a risk to human health from brief exposure and at which immediate steps must be taken by the Member States

1.1.2. The First Daughter Directive

Directive 1999/30/EC (April 1999) relates to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air. This is the first daughter Directive of the Framework Directive 96/62/EC.

Member States must take the measures necessary to ensure that concentrations of these pollutants in ambient air do not exceed the limit values in Table 1.1 or the alert thresholds in Table 1.2. For comparison against alert thresholds, locations representative of air quality over at least 100 km^2 or an entire zone or agglomeration, whichever is the smaller, should be considered.

Member States are to draw up a list of zones and agglomerations within which there is exceedence of the limit values. Within those zones and agglomerations they must take action to ensure that a plan or programme enabling the limit value to be achieved within the set deadline is drawn up or implemented.

Member States must ensure that measuring stations to supply data on concentrations of SO_2, NO_2, NO_x, lead and $PM_{2.5}$ are installed and operated, selecting the number and location of stations to be representative of mentioned substances concentrations in the State concerned, and inform the Commission of statistics relating to $PM_{2.5}$ and other substances measurements covering a 24-hour period during the year.

Table 1.1: Limit values established by the First Daughter Directive

Pollutant	**Averaging time**		**Limit value (µg/m^3)**	**Date to be met**
SO_2	1 hour average	Human health	350, not to be exceeded more than 24 times a calendar year	1st January 2005
	24 hour average	Human health	125, not to be exceeded more than 3 times a calendar year	1st January 2005
	Calendar year and winter	Ecosystems	20	18th July 2001
NO_2	1 hour average	Human health	200, not to be exceeded more than 18 times a calendar year	1st January 2010
	Annual average	Human health	40	1st January 2010
NO_x	Annual average	Ecosystems	30	19th July 2001
PM_{10}	24 hour average	Human health	50, not to be exceeded more than 35 times a calendar year	1st January 2005
	Annual average	Human health	40	1st January 2005

Lead	Annual average	Human health	0.5	1st January 2005
Indicative limit values[2]				
PM_{10}	24 hour average	Human health	50, not to be exceeded more than 7 times a calendar year	1st January 2010
	Annual average	Human health	20	1st January 2010

Table 1.2: Alert thresholds from the First Daughter Directive

Pollutant	Statistic	Limit value (µg/m^3)
SO_2	Measured over 3 consecutive hours	500
NO_2	Measured over 3 consecutive hours	400

The Directive lays down common methods and criteria for evaluating concentrations of those pollutants in ambient air on the basis of common methods and criteria, and gathering appropriate information on such concentrations in order to keep the public informed.

The Directive sets upper and lower assessment thresholds, which are fixed proportions of the limit values. Below the upper assessment threshold, a combination of measurements and modelling techniques may be used to assess air quality. Below the lower assessment threshold, modelling or objective estimation techniques alone may be used to assess air quality. These thresholds are also used to determine the minimum number of sampling points for each pollutant. Exceedences are to be determined on the basis of concentrations measured during the previous five years.

Up-to-date information on ambient concentrations of the pollutants must be routinely made to the public and to appropriate organisations, comparing the levels to the limit values and indicating any exceedence of the limit values and alert thresholds, as well as providing appropriate information on health effects.

1.1.3. The Second Daughter Directive

Directive 2000/69/EC (November 2000) relates to limit values for benzene and carbon monoxide in ambient air. This is the second daughter Directive of the Framework Directive 96/62/EC.

This Directive introduces limit values for benzene and carbon monoxide. The limit value for benzene is set at 5 µg/m^3 as from 1st January 2010, i.e. from 1st January 2006. the limit value will be decreased by 1 µg/m^3 every 12 months until 1st January 2010. The limit value for carbon monoxide is set at 10 mg/m^3 as from 1st January 2005. The Directive requires Member States to routinely inform the public of concentrations of these two substances in ambient air. The Member States had to comply with the Directive by no later than 13th December 2002.

[2] Reviewed by the "CAFÉ" Directive

Table 1.3: Limit values established by the Second Daughter Directive

Pollutant	**Averaging time**	**Receptor**	**Limit value**	**Date to be met**
Benzene	Annual average	Human health	5 µg/m^3	1st January 2010
CO	Maximum daily 8-hour mean	Human health	10 mg/m^3	1st January 2005

1.1.4. The Third Daughter Directive

Directive 2002/3/EC (February 2002) relates to ozone in ambient air. This is the third daughter Directive. Its purpose is to:

- set long-term objectives, target values for 2010, an alert threshold and an information threshold for concentrations of ozone in ambient air in the Community;
- establish common methods and criteria for assessing concentrations of ozone in ambient air;
- ensure that adequate information is obtained on ambient levels of ozone and that it is made available to the public;
- maintain or improve ambient air quality; and
- promote increased cooperation between the Member States in reducing ozone levels.

The long-term objectives set in the Directive comply with the World Health Organisation's guidelines on ozone in ambient air. Where target values are not met, Member States must draw up action plans to reduce ozone in ambient air. The Member States had to comply with the Directive by 9th September 2003.

Table 1.4: Target values established by the Third Daughter Directive

	Parameter	**Target value for 2010 (a)**
1. Target value for the protection of human health	Maximum daily 8-hour mean (b)	120 µg/m^3 not to be exceeded on more than 25 days per calendar year averaged over three years (c)
2. Target value for the protection of vegetation	AOT40, calculated from 1 hour values from May to July	18 000 µg/m^3.h averaged over five years (c)

(a) Compliance with target values will be assessed as of this date. That is, 2010 will be the first year for which the data are used in calculating compliance over the following three or five years, as appropriate.
(b) The maximum daily 8-hour mean concentration shall be selected by examining 8-hour running averages, calculated from hourly data and updated each hour. Each 8-hour average thus calculated shall be assigned to the day on which it ends, i.e. the first calculation period for any one day will be the period from 17:00 on the previous day to 01:00 on that day; the last calculation period for any one day will be the period from 16:00 to 24:00 on that day.

(c) If the three or five year averages cannot be determined on the basis of a full and consecutive set of annual data, the minimum annual data required for checking compliance with the target values will be as follows:

- for the target value for the protection of human health: valid data for one year; and
- for the target value for the protection of vegetation: valid data for three years.

The Directive sets also alert and information thresholds. The alert threshold for ozone is set for the protection of the general population. The information threshold is set to protect sensitive sections of the population.

Table 1.5: Information and alert thresholds established by the Third Daughter Directive

	Parameter	Threshold
Information threshold	1 hour average	180 µg/m3
Alert threshold	1 hour average(a)	240 µg/m3

(a) The exceedance of the threshold is to be measured or predicted for three consecutive hours.

1.1.5. The Fourth Daughter Directive

Directive 2004/107/EC (December 2004) relates to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons (PAH) in ambient air. This is the fourth daughter Directive.

This Directive is the final stage of the process launched by the framework Directive of recasting the European legislation on the presence of all above mentioned pollutants. Given that some substances involved (e.g. PAH) are human carcinogens and that there is no identifiable threshold below which they do not pose a risk to human health, the Directive applies the principle of lowest possible exposure to them. It does not set limit values for emissions of PAH, but uses benzo(a)pyrene as a marker for the carcinogenic risk of these pollutants and sets a target value for that substance, to be attained as far as possible. The Directive also determines methods and criteria for assessing concentrations and deposition of the substances in question and ensures that adequate information is obtained and made available to the public.

Table 1.6: Target values established by the Fourth Daughter Directive

Pollutant	Target value (1)
Arsenic	6 ng/m^3
Cadmium	5 ng/m^3
Nickel	20 ng/m^3
Benzo(a)pyrene	1 ng/m^3

(1) For the total content in the PM_{10} fraction averaged over a calendar year.

1.1.6. The “CAFÉ” Directive

Although at a proposal stage it is also worth mentioning the Directive of the European Parliament and of the Council on ambient air quality (September 2005). This proposal aims in particular to simplify and clarify the legislation on air quality. It merges into one act the Framework Directive and the first three daughter directives. It removes redundant and inessential procedures and simplifies the requirements relating to the presentation of reports thanks to the creation of an electronic database. Furthermore, this proposal strengthens the requirements for planning by the Member States in order to ensure that concentration limits of pollutants are complied with. It also provides for measures relating to fine particles ($PM_{2.5}$), in particular the establishment of a concentration cap in the most polluted regions, reduction targets to be achieved by 2020 and increased monitoring of this type of pollutant.

1.2. National legal acts on ambient air quality assessment and monitoring

European ambient air quality assessment and management is regulated by five key directives (see Section 1.1) that establish the framework of the ambient air assessment system and define limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead, ozone, benzene, carbon monoxide and several metals (arsenic, cadmium, mercury, nickel and PAH) in ambient air. All key elements of the directives have been transposed into the Lithuanian legal system.

The Law of the Republic of Lithuania No. VIII-1392 of 4th November 1999 on Ambient Air Protection sets priorities for ambient air quality management, principles of ambient air management and assessment. In addition it sets actions to be taken when limit values or threshold values are exceeded. In addition, it discusses aspects of air pollution management and environmental permitting.

A list of zones and agglomerations is defined by the Common Order of the MoE & MoH No. 470/581 "On Affirmation of List of Zones and Agglomerations for Assessment and Management of Ambient Air Quality" of 30th October 2000. It delineates Lithuania into two agglomerations (Vilnius and Kaunas) and one zone: the rest of Lithuania. The act transposes the requirements of the Framework Directive on Ambient Air.

Common Order of MoE & MoH No. 591/640 On Designation of Ambient Air Pollution Norms of 11th December 2001. This acts transposes requirements of the Framework, 1st and 2nd daughter directives and sets limit values and threshold values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead, ozone, benzene and carbon monoxide. In addition, it set requirements for the provision of information.

A list of pollutants that are assessed according to the EU criteria and their limit values is set by the Order of the Minister of Environment and Minister of Health Protection No. 471/582 of the 30th October 2000. It prescribes that limit values and thresholds should be assessed first for sulphur dioxide, nitrogen oxide, PM_{10}, suspended total particles, lead and ozone. The other pollutants to be assessed are benzene, carbon monoxide, cadmium, arsenic, nickel and mercury.

Ambient Air Assessment Rules describes principles for ambient air assessment. Ambient Air Assessment Rules transposes the requirements of the Council Directive 96/62/EC of 27th September 1996 on ambient air quality assessment and management, Council Directive 1999/30/EB of 22nd April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air and Directive 2000/69/EC of the European Parliament and Council of 16th November 2000 relating to limit values for benzene and carbon monoxide in ambient air. The programme has been set by the Order of the Minister 596 (2001.12.12), amended by Order No. 339 (2002.06.27).

Ambient Air Assessment Programme describes the aims, implementation and expected results of the implementation of the programme and its implementation plan.

The EPA is responsible for coordination of the implementation of the programme and for provision of methodological advice for state and municipal institutions responsible for the assessment of ambient air quality. The programme is a subject for annual revision and amendments. The programme has been adopted by the Order of the Minister No. 517 On Affirmation of the Ambient Air Quality Assessment Programme of 2003.10.23, amended by Order No. D1-30 of 17th January 2005.

Common Order of MoE & MoH No. 544/508 "On Affirmation of the ozone norms and assessment in the ambient air" of 17th October 2002 transposes the requirements of the 3rd Daughter Directive and sets norms and rules for ozone assessment in ambient air. It sets long term (2020) goals and short terms implementation plans for the ozone in zones and agglomerations. In addition, requirements for assessment of ozone and its precursors are provided and provisions for information and reporting are set.

The 4th Daughter Directive has been transposed by two legal acts: one legal act defines target values of the pollutants and the other legal act sets a procedure for their measurement (pollutant concentration is measured as annual average in total PM_{10} fraction) and assessment. Order of the Minister of Environment and Minister of Health D1-153/V-246, 2006.04.03 defines target values for arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air. The EPA is responsible for the organisation of measurements of these pollutants and for providing proposals on how to achieve compliance with these values by 31st December 2012. Order of the Minister of Environment No. D1-289 of 12th June 2006 on the Order of Assessment of arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air. This sets the requirements for zones and agglomerations, requirements for assessment of pollutants as well as the set of information that should be provided to the EC and public. The EPA is responsible for preliminary assessment of concentrations of arsenic, cadmium, nickel and benzo (a) pyrene in ambient air by 31st December 2006. At that time, the list of zones and agglomerations should be provided and an amendment proposed for the Ambient air quality assessment programme.

Access to information on ambient air quality by the public and concerned institutions is ensured through the order of the provision of information when alert or information thresholds are exceeded. Order of the Minister of Environment and Minister of Health No. D1-265/V-436 "On the Approval of the Order of Provision of the Information on the Ambient Air Pollution Levels Exceeding the Alert or Information Thresholds to the Public and Concerned Institutions" of 26th May 2005 defines the roles and actions of the responsible institutions.
Regional Environmental Departments should inform the public if the alert thresholds of SO_2, NO_2 or O_3 or theinformation threshold for O_3 are exceeded. The EPA, municipalities and Public Environmental Health Centres should react to the information and undertake the actions described.
Law on Environmental Monitoring of 20th November 1997, No. VIII-52, amended on 20060504 by Law No. VIII – 595 sets goals, structure and principles of implementation of environmental monitoring. Roles of state institutions, municipalities and enterprises are defined for state environmental monitoring, municipal monitoring and company level monitoring. In addition it prescribes principles of quality control/quality assurance and exchange and submission of

information. Ambient air monitoring is perceived as an integral part of environmental monitoring. Principles and rules of the municipal environmental monitoring are set in the Municipal Environmental Monitoring Regulation (Order No. D1- 436 of 16th August 2004). It describes rules for preparation and approval of municipal monitoring programmes as well as data collection and provision to the public.

1.3. Related legislation

1.3.1. Integrated pollution prevention and control

Ambient air quality monitoring and assessment are closely linked to the environmental permitting process.

Rules for integrated pollution prevention and control (IPPC) has been established by order No 80 of 27th February 2002 On Affirmation of Rules for Issuing, Renewal and Cancelling of Integrated Pollution Prevention and Control Permits (last amended of 29th June 2005, Order of the Minister No. D1 – 330). This legal act transposed the Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control. Application of the IPPC rules has been explained by a separate announcement of 7th September 2002 On Explanation of Application of the Rules of Issuing, Renewal, Cancelling of IPPC permits. Elaborations could be found at the web site of the Ministry of Environment.

The IPPC directive requires application of the best available technologies (BAT), which are based on BAT description ***Regulations for preparation of annotation for BAT*** information documents by technical working groups (Order of the Minister of Environment No 682 of 19th December 2003). It sets the structure of the annotation of BAT information document and a schedule for preparation of application of BAT for different sectors of industry.

Environmental permits for installations that do not fall under the rules of IPPC are issued following the rules of regulation ***LAND 32-99 On Order of Natural Resources use Permitting***, Definition of Usage and Pollution Limits by Order No 387 of the Minister of Environment of 30th November 1999. Amended 25th November 2003 by Order of the Minister No 590, the norms sets procedures and rules for permitting, for renewal, correction and cancelling of a permit as well as defining the structure of a permit. The norms provide templates for the permits and for the application to receive a permit. Part 3 of a permit describes requirements for pollutants emitted to ambient air from stationary sources and part 5.3 defines norms for allowed pollution to ambient air. This legal act is valid until 31st December 2008.

Reports on the implementation of IPPC directive are provided to the European Commission following the order approved by Ministerial Order No 630 of 10th December 2004. Lithuanian Environmental Protection Agency should collect, analyse information and report on the implementation of the directive to the European Commission. Regional Environmental Protection Departments should provide relevant information following the defined questionnaire. Reports for the EC should be provided every three years where the first report should be submitted for the reporting period of 1st January 2003 - 31st December 2005 in 9 months after the end of the reporting period. ***Data on pollution source and main emissions*** are provided according the rules set by the Order of the Minister of Environment 136 of 27th March 2002 On the Order of the Data Provisions on Pollution sources and their emitted Main Pollutants.

1.3.2. Environmental Impact Assessment

Reporting on impact to ambient air assessment is defined by Order of the Minister No. 64 of 25th January 2001 On regulation of Preparation, Definition of a Structure and Procedures for Approval of Environmental Impact on Ambient Air Assessment Report (amended on 16 October 2003 by Order No 509). The regulation sets requirements for the assessment of the impact to ambient air, structure of the report and procedure for approval. It also provides guidance on the preparation of ambient air pollution reduction programmes in case of unfavourable pollution distribution conditions.

The general principles of ***Environmental Impact Assessment*** are provided by the Law on Environmental Impact of 15th August 1996, No I-1495, amended 21st June 2005 and relevant legal acts.

1.3.3. National Emissions Ceilings

Directive 2001/81/EC of the European Parliament and of the Council of 23rd October 2001 set national emission ceilings for certain atmospheric pollutants. This Directive is part of the follow-up to the Commission's communication on a strategy to combat acidification, which sought to establish, for the first time, national emission ceilings for four pollutants: sulphur dioxide (SO_2); nitrogen oxides (NO_x); volatile organic compounds (VOC); and ammonia (NH_3), causing acidification, eutrophication and tropospheric ozone formation (also referred to as "bad ozone", present at low altitudes, as contrasted with stratospheric ozone), regardless of the sources of pollution.

2001/81/EC Directive on national emission ceilings for certain atmospheric pollutants was implemented in Lithuania on 25th September 2003 by the Order of the Minister of Environment No 468 On the approval of national emission ceilings for SO_2, NO_X, VOC and NH_3 emissions. The following national emission ceilings were set for Lithuania: for SO_2, 145 kt; for NO_x, 110 kt; for VOC, 92 kt; and for NH_3, 84 kt. It also gives provisions for National pollution limitation programme which should ensure that limits for the aforementioned pollutions will not be exceeded after 2010. The programme should set policies and measures and assess the impacts of these policies and measures.

Besides the implementation of European Directives, Lithuania is responsible for meeting the international requirements related to transboundary pollution. The Law on Ratification of the Protocol of 1979 Convention on Transboundary Air Pollution on European Monitoring and Assessment Programme long term funding (adopted 18th September 2003, No IX- 1740) ratifies the protocol, issued on 28th September 1984 in Geneva on cooperation programme on transboundary air pollution in Europe.

1.3.4. Large Combustion Installations

Directive 2001/80/EC on the limitation of emissions of certain pollutants into the air from large combustion plants was implemented in Lithuania by passing norms for pollution from large combustion plants and norms from the fuel combustion plants. They are set by regulation LAND 43 - 2001 (No. 486, 28th September 2001) amended by Order No. 712 of 24th December 2003. This order implements the requirement since 2004 to comply with SO_2 emission norms 1700 mg/Nm^3 for all installations using liquid fuels. From 1st January 2008, six times more stringent emission limits will be implemented for existing combustion plant.

Main requirements for waste incineration are set by the regulation LAND 19 – 99 approved by Ministerial order No 342 of 27th October 1999.

2. Description of main pollutants

This section gives a description of each of the main pollutants considered, including its effects on health, and a summary of the relevant sources.

More detailed information on emissions throughout Europe can be found on the EMEP web site.

2.1. SO_2, sources and mitigation principles

Sulphur dioxide (SO_2) is an acidic gas, which combines with water vapour in the atmosphere to produce acid rain. Both wet and dry deposition have been implicated in the damage and destruction of vegetation and in the degradation of soils, building materials and watercourses.

SO_2 in ambient air can also affect human health, particularly in those suffering from asthma and chronic lung diseases. Even moderate concentrations may result in a fall in lung function in asthmatics. Tightness in the chest and coughing occur at high levels, and lung function of asthmatics may be impaired to the extent that medical help is required. SO_2 pollution is considered more harmful when particulate and other pollution concentrations are high.

The principal source of this gas is the combustion of fossil fuels containing sulphur, mainly coal and petroleum products; this occurs mainly in power stations and also in some industrial plants. The decline in sulphur in diesel has greatly reduced emissions of SO_2 from the transport sector. As many power stations are now located away from urban areas, SO_2 emissions may affect air quality in both rural and urban areas. Significant SO_2 problems tend only to occur in areas in which coal or oil is still used in large amounts for domestic heating, in industry and in power stations.

Mitigation approaches include changes of the fuel used (e.g. coal or gas) or to the sulphur content in the fuel, or "end of pipe" abatement solutions, usually Flue Gas Desulphurisation (FGD).

More information on SO_2 in ambient air can be found in the Position paper on SO_2.

2.2. NO_2, sources and mitigation principles

Nitrogen oxides are formed during high temperature combustion processes from the oxidation of nitrogen in the air or fuel. A major source of nitrogen oxides (nitric oxide (NO) and nitrogen dioxide (NO_2), collectively known as NO_x) is road traffic, which is responsible for approximately half the emissions in Europe. NO and NO_2 concentrations are therefore greatest in urban areas where traffic is heaviest. Other important sources are caused by the combustion of fuels in power stations, heating plants and industrial processes.

NO_2 can irritate the lungs and lower resistance to respiratory infections such as influenza. Continued or frequent exposure to concentrations, that are typically much higher than those normally found in the ambient air, may cause increased incidence of acute respiratory illness in children.

Mitigation approaches include solutions to reduce traffic emissions or traffic flows and, for industrial sources, to change plant operating conditions.

More information on NO_2 in ambient air can be found in the Position paper on NO_2.

2.3. Lead, sources and mitigation principles

With the phasing out of anti-knock lead additives in petrol in most countries the principal source of particulate lead in air results from metal processing industries and waste incineration. The single largest industrial world-wide use of lead is in the manufacture of batteries.

Even small amounts of lead can be harmful, especially to infants and young children. In addition, lead taken in by the mother can interfere with the health of the unborn child. Exposure has also been linked to impaired mental function, visual-motor performance and neurological damage in children, and memory and attention span.

Successful mitigation has been achieved by reducing the amount of lead in petrol. For industrial sources, approaches include changes to plant operating conditions.

More information on lead in ambient air can be found in the Position paper on lead.

2.4. PM_{10} and $PM_{2.5}$, sources and mitigation principles

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. PM_{10} particles (the fraction of particulates in air of less than 10µm in size) are of major concern, as they are small enough to penetrate deep into the lungs and so potentially pose significant health risks. $PM_{2.5}$ particles are now thought to be an even greater health risk. Larger particles are not readily inhaled, and are removed relatively efficiently from the air by sedimentation.

PM_{10} and $PM_{2.5}$ in the atmosphere arise from two sources. The first is the direct emission of particulate matter into the atmosphere from a wide range of sources, including fuel combustion, (traffic, power generation and industrial), surface erosion, wind blown dust and mechanical break up in, for example, quarrying and construction sites. These are called 'primary' particulates. The second source is the formation of particulate matter in the atmosphere through the reactions of other pollutants such as sulphur dioxide, nitrogen oxides and ammonia to form solid sulphates and nitrates, as well as organic aerosols formed from the oxidation of VOCs.

Fine particles can be carried deep into the lungs where they can cause inflammation and a worsening of the condition of people with heart and lung diseases. In addition, they may carry surface-absorbed carcinogenic compounds into the lungs. Day to day variations in concentrations of particulates, measured as PM_{10} or $PM_{2.5}$, are associated with day-to-day variations of daily deaths, hospital admissions for respiratory and cardiovascular diseases and asthma symptoms.

Mitigation approaches include solutions to reduce traffic emissions. For industrial sources, plant operating conditions can be altered, or "end of pipe" abatement added, or fuel switched (e.g. coal to gas).

More information on PM_{10} in ambient air can be found in the Position paper on PM_{10}.

2.5. Benzene, sources and mitigation principles

Emissions of benzene are dominated by the road transport sector and arise predominantly from the evaporation and combustion of petroleum products. Other sources include the combustion of coal and wood for heating, and industrial processes, in particular the chemical industry where benzene is used in the manufacture of many important chemicals including those for the production of foams, fibres, detergents etc.

Mitigation approaches include solutions to reduce traffic emissions and to tackle industrial emissions.

Benzene is a genotoxic human carcinogen which has no absolutely safe level. Possible chronic health effects include cancer, central nervous system disorders, liver and kidney damage, reproductive disorders, and birth defects.

More information on benzene in ambient air can be found in the Position paper on benzene.

2.6. CO, sources and mitigation principles

Carbon monoxide (CO) is a toxic gas emitted into the atmosphere as a result of incompatible combustion processes, and is also formed by the oxidation of hydrocarbons and other organic compounds. In European urban areas, CO is produced almost entirely (90%) from road traffic emissions with much of the remainder arising from domestic and commercial boilers. It survives in the atmosphere for a period of approximately one month but is eventually oxidised to carbon dioxide (CO_2).

Mitigation approaches include solutions to reduce road traffic emissions.

CO prevents the normal transport of oxygen by the blood. This can lead to a significant reduction in the supply of oxygen to the heart, particularly in people suffering from heart disease.

More information on CO in ambient air can be found in the Position paper on CO.

2.7. Heavy metals: Arsenic; Cadmium; Nickel; and Mercury; sources and mitigation principles

Arsenic, cadmium and nickel are genotoxic human carcinogens for which no threshold for adverse effects on human health can be identified.

The main source of arsenic arises from coal combustion; emissions therefore arise from power production and industry. The main source of cadmium is in metal production and from waste incineration. The main sources of nickel are from the combustion of coal and heavy fuel oil in power plants and refining facilities.

The mercury present in the atmosphere exists in a relatively unreactive form. Although extremely toxic forms of mercury may occur, the main pathway for mercury to humans is through the food chain rather than by inhalation. Some forms of mercury poisoning cause damage to the brain and the central nervous system. Foetal and postnatal exposure can cause developmental problems in children.

The main sources of emissions are from the manufacture of chlorine, non-ferrous metal production, coal combustion and crematoria.

Heavy metals are generally emitted in particulate form; therefore mitigation is best actioned by reducing particulate emissions from processes and/or using fuels with lower heavy metal content.

More information on arsenic, cadmium and nickel in ambient air can be found in the Position paper on Arsenic; Cadmium and Nickel and on mercury – in the Position paper on Mercury

2.8. Ozone, sources and mitigation principles

Ozone (O_3), unlike the other pollutants mentioned, is not emitted directly into the atmosphere, but is a secondary pollutant produced by reaction between NO_2, hydrocarbons and sunlight, generally on regional or larger scales. Ozone levels are higher in rural areas than in urban areas; in these areas, higher levels of NO_x emitted from vehicles result in local destruction of ozone. Sunlight provides the energy to initiate ozone formation; consequently, high levels of ozone are generally observed during hot, still sunny, summertime weather.

Ozone irritates the airways of the lungs, increasing the symptoms of those suffering from asthma and lung diseases.

Ozone mitigation is achieved by reduction in emissions of VOC and NO_x at a regional, national and international scale. In Europe, this has led to a reduction in peak ozone levels but global increases in VOC and NO_x emissions are resulting in increases in the large scale background.

More information on ozone in ambient air can be found in the Ozone position paper.

2.9. Polycyclic Aromatic Hydrocarbons and mitigation principles

Polycyclic Aromatic Hydrocarbons (PAHs) are produced by the incomplete combustion of fuels from sources such as domestic coal and wood burning; they are also during wood treatment and are emitted by road traffic. The most volatile PAHs are emitted as gases, otherwise they form particles.

Although they are usually emitted in very small quantities, they are highly toxic or carcinogenic. They can cause lung and skin cancer, kidney dysfunction, and cause damage to the central nervous system, the respiratory tract and the immune system, among other effects. Therefore exposure to these pollutants should be as low as reasonably achievable.

Mitigation is best achieved by ensuring complete and efficient combustion of fossil fuels. Where this is not achievable, human exposure to combustion products should be minimised.

More information on PAH in ambient air can be found in the Position paper on PAH.

3. Methods for ambient air quality assessment

3.1. Ambient air quality measurements

Ambient Air quality monitoring at state level has been carried out in Lithuania since 1967. In the biggest cities and air pollution hot spots, concentrations of main pollutants and specific pollutants related to local industry were measured, in particular: total suspended particles; SO_2; CO; SO_4; formaldehyde; phenol; H_2S; NO_2; NO; heavy metals; and benz(a)pyrene. Between 1999 and 2004, monitoring stations were modernised and now the network covers 13 automatic air quality monitoring stations that continuously measure concentrations of NO_2, NO, NO_x, SO_2, CO, PM_{10}, $PM_{2.5}$, ozone, benzene and toluene, as well as meteorological parameters. Concentrations of total dust, polycyclic aromatic hydrocarbons and heavy metals are measured using semi-automatic measurement methods.

Background pollution in the country, influenced by trans-boundary pollution and general pollution in Lithuania, is analysed at background air monitoring stations. The first station was set up in Preila in 1980. Currently, background concentrations are measured by four measurement stations (Preila, Zemaitijos National Park, Aukstaitijos National Park and Dzukija National Park). Ozone, SO_2, NO_x, SO_4, heavy metals, nitrates and ammonium concentrations are measured there, except at Dzukija background station, where only ozone is measured. These stations also measure precipitation. The monitoring station in Preila follows the requirements of the European monitoring and evaluation programme (EMEP) and the Baltic Sea Environmental protection commission (HELCOM) programmes. The other stations follow an International Cooperation Programme on Integrated Monitoring of relatively natural ecosystems (ICP IM).

For ambient air quality assessment and management purposes Lithuania is divided into two agglomerations (Vilnius and Kaunas) and one zone (the rest of Lithuania). State monitoring stations are distributed as follows:

- one in Kaunas, focused on transport pollution;
- one in Panevezys, focused on transport pollution;
- one in Siauliai, focused on transport pollution;
- four in Vilnius (one focused on transport pollution, one on background city pollution and one located in a heavily populated urban territory);
- two in Klaipeda (one focused on transport, the other located in a heavily populated urban area);
- one in each of three industrial hotspots (Mazeikiai, Jonava, Kedainiai); and
- one in Naujoji Akmene (focused on city background pollution).

Distribution of the state monitoring stations are presented in the figure below.

Figure 3.1. Network of state ambient air monitoring stations in Lithuania

Kaunas municipal monitoring has been carried out since 1995 by an automatic ambient air quality monitoring system. Air quality monitoring stations are located at three places in Kaunas city: in a traffic pollution area; in a densely populated district; and in an area having high industrial pollution and intensive traffic. Besides that, Kaunas city has a mobile laboratory for *in situ* measurements. Air pollution monitoring data are processed and managed by a central computer and displayed on the web site www.kaunas.lt/aplinka. The data obtained are also used for air quality modelling.

Municipal monitoring helps to prevent mistakes in the development of economic, urban and transport systems in the city and save finances, as well as to protect public health and register dangerous concentrations of pollutants on a real time scale. There are attempts to ensure quality of data and to include the data in the national monitoring system.

Meteorological data are collected at 18 stations throughout the country. The stations are operated and meteorological and hydrological observations and forecasts made by the Lithuanian Hydrometeorological Service under the Ministry of Environment of the Republic of Lithuania.

Exchange of information and the information format follows the EU requirements. 2001/752/EC: Commission Decision of 17th October 2001 amending the Annexes to Council Decision 97/101/EC establishing a reciprocal exchange of information and data from networks and individual stations measuring ambient air pollution within the Member States sets the requirements for establishing a reciprocal exchange of information and data from networks and individual stations measuring ambient air pollution within the Member States. Decision 97/1001/EC lays down a system for reciprocal exchange of information and data on ambient air pollution and adapts the list of pollutants covered as well as requirements on additional information, validation and aggregation. The decision can be found here.

Example:

Table of content of the Guidance

Guidance on the Annexes to Decision 97/101/EC on Exchange of Information as revised by Decision 2001/752/EC elaborates parameters of measurements, information on network stations and measurement techniques, data validation process and quality assurance, and criteria for data aggregation. Guidance can be found here.

3.1.1. Measurement methods

Measurement methods for ambient air quality measurement are usually divided into two types: discontinuous methods; and continuous methods.

Discontinuous methods are mostly manual methods comprising two separate steps: on-site sampling and analysis in the laboratory. Continuous methods typically involve automatic equipment at a fixed site to carry out both sampling and analysis. However, these distinctions do not quite take account of the great variety of air quality measurement methods. “Discontinuous” measurement can be carried out with automatic equipment at the sampling site as well as in the laboratory. The employment of automatic sampling equipment, e.g. with several, independently and subsequently controllable receptors, allows continuous and uninterrupted measurements. Analysis can be carried out with automatic apparatus in the laboratory.

One specific example is the measurement of dust deposition. This is in principle a discontinuous, manual measurement method, but because of the length of the exposure time for a single measurement, one month without breaks, it is termed semi-continuous.

Continuous measurements have the advantage of providing temporally unbroken air monitoring. They are designed for stationary employment, but it is also possible to fit them in mobile monitoring laboratories. Since higher temporal than spatial variation is to be expected for air pollution in city areas with widely distributed pollutants, continuous measurements provide advantages for air quality monitoring. Expenditure for automatic continuous measurements is high; the measurement equipment is quite expensive and highly qualified personnel are needed for its operation. Therefore, to date, equipment for continuous ambient air quality measurements has been developed for only a limited number of substances.

Discontinuous, manual ambient air quality measurement methods are most useful for random sampling, and for covering many measuring sites within an examination area. The measurements apparatus can often be employed for the detection of several different substances. Finally, this topic covers the measurement of all those substances for which no automatic equipment is available.

3.1.2. Reference methods

The EU Framework Directive on Ambient Air Quality (Annex IX) specifies a reference method to be used for the measurement of each pollutant; Member States should use this method or another which produces results which are either demonstrated to correlate satisfactorily or to show a reasonably stable relationship when measurements are made in parallel with those obtained using the reference method.

Reference method for the analysis of sulphur dioxide:

ISO/FDIS 10498 (Standard in draft) Ambient air - determination of sulphur dioxide – ultraviolet fluorescence method.

Reference method for the analysis of nitrogen dioxide and oxides of nitrogen:

ISO 7996: 1985 Ambient air - determination of the mass concentrations of nitrogen oxides - chemiluminescence method. In Lithuania this method is legalised by LAND 51:2003 Ambient Air Measurement of nitrogen oxides mass concentration, chemiluminescence method (ISO 7996:1985).

Continuous monitoring methods cover various instrumental techniques. However, the chemiluminescence method is the recommended and most commonly used method. The instrument signals are continuously recorded at regular intervals and typically integrated to hourly means.

The technique is based on the gas phase chemiluminescence reaction of NO with O_3, which produces stimulated NO_2 emitting light (chemiluminescence) at a wavelength of about 1200 nm (ISO, 1985). The different types of chemiluminescence monitors measure NO_x and NO concentrations on the air, using a somewhat different design. The air sample passes a heated catalytic converter where NO_2 is reduced to NO. The signal from the air passing the converter gives the NO_x concentration, while the signal from the air drawn directly to the detector gives the NO concentration. NO_2 is determined from the difference between the two signals.

Reference method for the sampling of PM_{10}:

If a Member State decides to apply a method other than reference method, it should prove that the results achieved are similar or very close to each other. In such a case a correction factor is applied for the results achieved using non-reference methods so that the results are consistent with those obtained using the reference method.

LAND 62:2004 'Air Quality. Definition of a fraction of suspended particles PM_{10}. Reference method and method of measurements under natural conditions in order to show equivalence of the proposed method'.

Commercial manual and automatic instruments are available for monitoring TSP, PM_{10} and other particle size fractions in a timescale appropriate for checking compliance with the limit value. Monitoring must be undertaken by a method shown to be equivalent to the reference sampler or to one of the two transfer reference samplers, and which gives data with the appropriate time resolution to check compliance with the limit value. The CEN standard methodology should be used to check samplers against the reference sampler or equivalent reference samplers. In areas where monitoring is required, data capture over the year should be at least 75% for automatic methods and 90% of planned measurements for manual methods. Lower data capture may be acceptable in other areas. Where possible, laboratories undertaking monitoring should seek formal accreditation under EN45000 or Good Laboratory Practice, rather than more general quality standards such as EN ISO 9000.

Specifications of measurements of PM_{10} are described in the CEN 12341 standard, which describes the size of equipment and samples. It also describes how to take sample on the quarci sand filter in ambient temperature. PM_{10} mass is analysed gravimetrically. Filters are conditioned before and after the sampling at (20 ± 1°C) temperature and relative moisture conditions (50 ± 5 %) for 48 hours.

Reference method for the sampling of $PM_{2.5}$:

The CEN standard proposes to use a gravimetric analysis method as a reference method to measure $PM_{2.5}$. There are several difficulties once an appropriate measurement method is selected: it is impossible to create a primary calibration standard for $PM_{2.5}$, and losses of the particles could appear during sampling. This is even more crucial for $PM_{2.5}$ than in the case of PM_{10}.

Reference method for the analysis of lead:

The method for the sampling of lead is described in EN 12341 ' Air Quality – PM_{10} – procedure of measurements in place, showing how PM_{10} sampling methods matches reference methods. The basis of the method is collection of PM_{10} on a filter and definition of its mass.

ISO 9855: 1993 Ambient air - Determination of the particulate lead content of aerosols collected on filters. Atomic absorption spectroscopy method.

The reference method is described in an Annex of the directive 82/884/EEB which will be in power untill the limit value set in the EU directives is valid and until a reference method of PM_{10} is used.

Reference method for the analysis of CO:

The reference method for measurement of CO concentration is the nondispersial infrared spectrometric method, a standard of which is now under preparation by CEN, until the national standard base on the same principle can be used. In Lithuania the measurement method is defined by LAND 52:2003 Ambient Air. Carbon Monoxide measurements. Nondispersial infrared spectroscopic method.

Reference method for the analysis of benzene:

The reference method for the measurement of benzene will be the pumped sampling method on a sorbent cartridge followed by gas chromatographic determination, which is currently being standardised by CEN. In the absence of a CEN standardised method, Member States are allowed to use national standard methods based on the same measurement method.

Lithuania uses the LST ISO 16017 chromatographic method.

Reference method for the analysis of ozone:

The reference method of the current Directive is the UV absorption method. Analysis method: UV absorption method (ISO CD 13964); Calibration method: Reference UV photometer (ISO CD 13964, VDI 2468, p. 6).

LAND 60:2004, Air Quality. Analysis of ozone concentration in ambient air. Ultraviolet photometric method (ISO 13964:1998)" sets the legal basis for the application of ozone level analysis.

Sampling and analysis methods of arsenic, cadmium and nickel:

The reference method for measurement of arsenic, cadmium, nickel concentrations in ambient air as a standard is approved by European Standardization committee. The method is based on annual PM10 measurement equivalent according to EN 12341, which will be followed by sampling and analysis of samples by atomic absorption spectrometry or ICP MS methods. If European standards of Standardization committee does not exist, Member states are allowed to use national or ISO standards.

Directive 2004/107/EC of the European Parliament and of the Council of 15th December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air can be found here.

Reference method for analysis of polycyclic hydrocarbons:

The reference method for analysis of benzo(a)pyrene concentrations is under discussion at the European Standardization Committee. It is based on annual PM_{10} samples equivalent according to EN 12341. If the European Standardization Committee does not provide a standard on benzo(a)pyrene or other polycyclic hydrocarbons referred to in paragraph 8, article 4, Member States can apply national standards or ISO standards, for example ISO 12884.

Reference method for the analysis of mercury:

The reference method for measurement of mercury concentrations in ambient air is an automatic method based on the atomic absorption spectrometric method of atomic fluorescence spectrometry.

3.1.3. Equivalent measurements

Besides the reference measurement methods proposed by the directives for each pollutant, Member States are allowed to use whatever other method they choose, provided they can demonstrate that the method produces equivalent results or, for PM_{10}, shows a consistent relationship to the reference method. Equivalence is obtained if all of the data quality requirements established for each single pollutant and expressed in terms of accuracy, data coverage and data availability are respected. An important question is which methods are acceptable as non-reference methods. This matter has not yet been resolved and is not discussed here.

Requirements for equivalence of ambient air monitoring methods are elaborated in Guidance on Demonstration of equivalence of ambient air monitoring methods. The guidance was prepared by the EC Working Group and it describes principles and methodologies to be used for the demonstration of the equivalence of alternative (non-reference) measurement methods to the EN Standard methods. The principles and methodologies necessarily follows the general requirements laid down in Annex VIII (and similar Annexes on data-quality objectives in the other daughter directives). The document can be found here.

PM_{10} measurements
The EN 12341 standard refers to three different reference sampling devices: the Wide Range Aerosol Classifier (WRAC); the USEPA High Volume sampler (Sierra Andersen); and the Low Volume sampler (Kleinfiltergerät). The equivalence of whatever other sampling head with these reference devices can be established by using the procedure described in the EN 12341 standard.

Use of automated PM_{10} analysers
Automated analysers working on the oscillating microbalance, β-ray attenuation or the optical detection principle are of common and convenient use in monitoring networks. The use of a measurement principle that is different to the gravimetric method may however induce differences in the measurement results. This is particularly true if the air probe is heated during sampling; losses of volatile particles, such as ammonium nitrates in particular, may in some cases reach 50% of the particle mass. In that case the measurement results need to be corrected by a factor to produce results equivalent to the reference method. If the factor is not constant over the year or over the territory, different correction factors or even correction functions may have to be used. To judge whether the deviations are acceptable, the data-quality objectives in Annex VIII of the first Daughter Directive specify an accuracy of 25%.

Manual measurement methods
These measurement methods are based on the chemical analysis of samples or measurement of the weight of solid particles. Most frequently used are aspiration methods to measure gaseous pollutants, PM collection on a filter for measurement of the concentration of dust, heavy metals or benzo(a)pyrene. Physicochemical methods:

photometric; spectrophotometric; potentiometric; gaseous chromatographic methods; are also used. These methods are reliable, quite simple, relatively cheap, acceptable and analysis does not require complicated and expensive equipment. Photometric analysis is mostly used together with the potentiometric method for the measurement of single (vienkartine) concentrations and average daily concentrations of SO_2, NO_2, NO, H_2S, HCl, HF, NH_3 etc. in ambient air. Gas chromatographic methods are used to measure concentrations of organic substances.

Active and passive discontinuous methods are normally used for daily to monthly sampling. The manual discontinuous methods are relatively cheap and simple, but have several disadvantages including the need for manpower for sampling and analysis, the limited time resolution and the time delay until results are available. For daily measurements of NO_2, there are two active methods, the potassium iodide and the Saltzmann methods. Both methods can be operated on a 24-hour basis, although for the Saltzmann method, the recommended sampling time is shorter. These daily sampling methods are used in many European rural areas, for example in the EMEP programme. In some countries they are also the main monitoring method at urban background sites.

The potassium iodide method is based on the absorption of NO_2 on potassium iodide impregnated sintered glass filters (Ferm and Sjödin 1993). NO_2 is absorbed and reduced to nitrite by the iodide on the filter. The nitrite formed is extracted with deionised water and determined spectro-photometrically using the Griess method. The Saltzmann/modified Saltzmann method is based on the direct Griess reaction during sampling (ISO, 1981). A pink colour is produced during sampling. The intensity is measured spectro-photometrically (Mücke et al., 1995).

Methods approved for ambient air quality measurements in Lithuania are as follows:
- For dust (metals and polycyclic aromatic hydrocarbons, benzo(a)pyrene): gravimetric method described in LAND 26-98/M-06 Measurement of Dust (PM) Concentration
- For SO_2: photometric method described in LAND 25-98/M-05, “Measurement of Sulphur Dioxide concentration”
- For NO_2: photometric method described in LAND 24-98/M-04, “Measurement in nitrogen oxide concentration” and
- For CO: non-dispersial method described in LAND 52- 03, “Infrared spectroscopy”.

Automatic measurement methods
Currently the most widely applied measurement technique is based on physicochemical principals and treated electronically. In mobile laboratories these methods are very useful as they enable the measurement of ambient air quality at locations at which there is no continuous ambient air quality monitoring.

Optical measurements methods
Differential optical absorption spectroscopy (DOAS) measures gaseous pollutants across a distance of several hundred meters. DOAS instrumentation operates on a well-established scientific principle, the Beer-Lambert absorption law, which relates the quantity of light absorbed to the number of gas molecules in the light path. This

technology is used in instruments that can measure a number of different pollutants along a single light beam, which may be up to 800 meters long.

DOAS system has three major parts: an emitter, a receiver and an analyser. The emitter sends a beam of light to the receiver. The light beam contains a range of wavelengths, from ultraviolet to visible. Different pollutant molecules absorb light at different wavelengths along the path between the emitter and receiver. The receiver is connected to the analyser, which measures the intensity of the different wavelengths along the entire light path and converts this into concentrations for each of the gaseous pollutants being monitored.

DOAS is a technique that can be used for the measurement of a wide range of air pollution species. In the usual configuration, visible, non-laser light from a light source passes through a fixed path in the atmosphere, typically 100 to 1000m in length. At the end of this path, the light received is analysed in an optical-analyser system. The amount of a specific gaseous substance in the atmosphere is calculated following the principle of the Beer Lambert Law.

In commercial analysers, sophisticated signal processing is undertaken to account for interference and variability in atmospheric optical transmission conditions. Many species can be measured using the DOAS technique, but the most common configuration for ambient air monitoring is used to measure NO_2, SO_2, O_3 and benzene. Nitric oxide can be measured, but requires a different lamp type. At least one commercial DOAS instrument has EPA approval for the measurement of NO_2, SO_2 and O_3 provided that certain operational and calibration requirements are followed.

Many inter-comparison studies have demonstrated that DOAS can provide comparable NO_2 data to those measured using chemiluminescence point analysers, within the constraint that the DOAS analyser averages concentration measurements along the path length of measurement, rather than at a single point.

As with all air pollution analysers, DOAS instruments require regular calibration and other QA/QC checks to ensure reliable, high quality data.

Indicative measurements

Indicative measurements, which are generally less accurate than the reference method, may be implemented as an assessment method when ambient concentration levels for a given pollutant are lower than the upper assessment threshold. Indicative measurement techniques based on the use of a mobile laboratory (or any other mobile or transportable measurement platform) and manual measurement methods, such as the diffusive sampling technique in particular, are of particular interest, because of their relatively low cost and their simple operation in comparison with fixed monitoring stations. This method is a good screening method for the definition of areas, with a high concentration of pollutants. Monitoring is then carried out using a more accurate automatic technique to show formal compliance with the EU standards.

An example of methods used in the UK can be found here.

Indicative measurement methods may also include on-line automated methods used for compliance monitoring, when implemented with a lower degree of accuracy.

Application of passive solvents
A passive solvent is a little tube partly filled with solvent which absorbs pollutants without additional inflation of air. The time of exposure varies from several days to several weeks or months. The tube is then closed and sent to the laboratory for chemical analysis. This method is especially suitable for the assessment of dispersion of pollution across a large area over a long time period.

In Lithuania ambient air quality measurement using passive solvents is carried out based on the standards sets by the Lithuanian Standardization Department:

Lithuanian Standard LST EN 13528-1 “Ambient Air Quality. Diffusive samples for the determination of concentration of gases and vapours. Requirements and sampling methods. Part 1. General requirements”.

Lithuanian Standard LST EN 13528-2 “Ambient Air Quality. Diffusive samples for the determination of concentration of gases and vapours. Requirements and sampling methods. Part 2. Special requirements and test methods”.

Lithuanian Standard LST EN 13528-3 “Ambient Air Quality. Diffusive samples for the determination of concentration of gases and vapours. Requirements and sampling methods. Part 3. Guide for selection, use and maintenance’.

These standards are transposed CEN standards. They have a different approach to that used for chemiluminescence measurement in that they were not specifically written to support the EU legislation, and so are not obligatory, and they do not go into a similar level of detail as to how measurements should be made. The scope of these standards includes samplers for NO_2, NO, SO_2,
NH_3, formaldehyde, ozone, and volatile organic compounds.

A survey of NO2 concentrations using passive diffusion tubes operated by local authorities throughout the UK aimed at:

- o Identifying high concentrations of gaseous pollutants (NO2, SO2, VOC) that may warrant more detailed investigation;
- o Determination of the spatial variation of gaseous pollutant concentrations in the country; and
- o Determination of trends in gaseous pollutant concentrations over a number of years.

The survey commenced in 1993, and currently comprises over 1300 sites operated by more than 300 local authorities. Up to December 2000, each authority operated 4 sites, including one kerbside location (1 to 5 metres from a busy road), one intermediate site (20 to 30 metres away from a busy road) and two background sites (in residential areas, and more than 50 metres from a busy road). From January 2001, sampling at intermediate sites has been discontinued and kerbside sites have been renamed as roadside sites to be consistent with the site classification system used for automatic monitoring. Hence, since January 2000, most authorities now operate 2roadside sites and 2 urban background sites.

Tubes are supplied and analysed by a variety of analytical laboratories, and exposed over 4 or 5 week periods. Data are collated and processed centrally by netcen. Detailed information on the monitoring sites and measured data can be found at www.airquality.co.uk. Annual network reports are published (Loader, 2002) and a 5- year summary has been prepared (Stevenson, 2001)

A similar procedure is adopted for the NO2 diffusion tube data except that the provisional data are not collected automatically but on manually returned forms from the many network participants. The initial screening is undertaken manually and the provisional data are updated to the Archive every 3-months. These provisional data are then ratified annually to produce the final ratified dataset for the year, using the procedures outlined in Section 4.9.5. This ratified data set then overwrites and updates the Archive once per year, approximately 6-months after the year end. All data provided in this report have undergone quality assurance and quality control checking and are therefore regarded as ratified.

Use of mobile laboratory

The methodology allows the evaluation of the maximum concentration in zones during a period corresponding to the averaging time set for each limit value. The goal for the use of a mobile laboratory could be, for example, measurements of pollution levels to evaluate whether or not the concentration of pollutants exceeds limit values. Mobile laboratories or other movable measurement stations are used for measurements in fixed measurement locations by means of installing measurement equipment there.

3.1.4. Quality assurance and quality control

The key concern of the EU directives is to ensure coherent and uniform assessment of ambient air quality in all Member States. The 3rd article of the Framework Directive and Annex VIII of the First Daughter directive present a list of provisions that would ensure better quality of air quality data. These provisions comprise the following:

- o Criteria for network establishment and selection of sampling points (ID1 VI and VII annexes);
- o Data-quality objectives for the compilation of results of air quality assessment (ID1 VIII annexes);
- o Standardised reference measurement methods or equivalent methods (ID1 IX annexes);
- o Certification of equipment (FD 3 article);
- o National assessment laboratory (FD 3 article);

- Accreditation of laboratories (FD 3 article); and
- Coordination of a comparison at national and EU level (BD 3 article).

A guide for automatic ambient air quality control systems was prepared on the basis of EU standard EN 17025:2000, requirements of the EU directives 1999/30/EB, 2000/63/EB and 2002/03/EB and taking into account the current circumstances and administrative system of the Lithuanian environmental protection system.

The Lithuanian automatic ambient air quality control system consists of monitoring stations under the supervision of the EPA: stationary stations, reference stations, calibration and sampling laboratory, maintenance workshops and data storing and analysis centre as well as local measurement stations, set in certain districts and densely inhabited territories.

The prepared guide for quality assurance is a preliminary proposal which will enable a high quality of work. The content of the guide is as follows:

- Procedures for quality management;
- Structure of quality management;
- Lists of quality management; and
- Instructions for quality management (standardised procedures for activities).

Under harmonisation of European law all Member States shall set the same rules to ensure quality of measurements and enabling the comparison of results throughout the EU.

QA/QC of air quality monitoring data

In order to make a reliable assessment of air quality from measured data, it is essential that the data be of sufficient quality. The overall aim of any quality assurance programme should be to ensure that the measurement data fulfil the aims and objectives of the monitoring programme.

The aims and objectives of these networks may differ slightly, but the following general objectives will apply in most cases:

- Meeting statutory requirements;
- Providing necessary information on air quality for the public, regulators and/or the scientific community;
- Providing information for local authority air quality review and assessment;
- Identifying long term trends on air pollutant concentrations; and
- Assessment of policy effectiveness.

Quality assurance refers to the overall management of the process involved in obtaining the data; whilst quality control refers to the activities undertaken to check and optimise data accuracy and precision after collection. Hence, quality assurance relates to the measurement process, whilst quality control is concerned primarily with outputs.

Example: This section provides an example on QA/QC activities in relation to the both the automatic NO_2 monitoring data and the diffusion tube data based on UK experience

QA/QC activities for automatic air monitoring networks
There will, inevitably, be differences in the detailed QA/QC activities undertaken in each network supplying data. However, this section provides a general overview of activities which will be applied to all networks, perhaps to a greater or lesser extent, depending on the specific objective of the monitoring undertaken.

Quality assurance activities include:

- Network design;
- Station siting;
- Instrument selection;
- Instrument calibration;
- Instrument service and repair;
- Operations manual;
- Operator training; and
- Correct operation of the on-site equipment.

Quality control activities include:

- Information management;
- Data ratification; and
- Quality circle review and feedback.

It is important that all factors that may affect the quality of the data be considered. For example, the sample inlet line to the gas monitor needs to be inert and have no, or a negligible effect on the gases monitored. The sample line needs to be carefully designed, cleaned and maintained and regularly tested for its integrity.

Quality assurance
The design of the Automatic Monitoring Network and information on general station sitting is provided in the Automatic Urban Monitoring Network Site Operator's Manual (AEA Technology, 1998). In recent years, new sites have been added to ensure that the network conforms to the network design and monitoring criteria specified in the Air Quality Framework Directive and subsequent Daughter Directives (96/62/EC, 1999/30/EC, 2000/69/EC, 2002/3/EC). A classification system for UK air quality monitoring site locations has been devised and is presented in the Report on Nitrogen Dioxide in the United Kingdom. The locations of all monitoring sites have been classified according to this system.

The Site Operator's Manual provides information on the procedures adopted in the network for instrument service and repair and much general background information about the network. All site operators have a copy of the manual and are trained by the network QA/QC Unit on all of the network operation procedures.

Instrument selection
All of the automatic NO_2 data presented in this report have been obtained from chemiluminescence analysers. Provided that the operational and QA/QC requirements discussed in this section are followed, measurements from chemiluminescence analysers should be robust and reliable.

Calibration
In the national network and in the majority of local networks a 3-stage approach to calibration is adopted:

- daily span and zero check with the analysers internal gas source (permeation tube for NO_2 analysers;
- weekly or 2-weekly manual calibration with certified calibration gas cylinder; and
- 6-monthly site audit check with an independent gas standard to check the calibration of the analyser and the stability of the on-site gas cylinder.

The daily auto-calibration is used only to rapidly identify any possible analyser faults that may require attention. The gas from internal permeation devices is not considered sufficiently stable or reliable to be considered as a calibration source.

The weekly or two-weekly manual calibrations with accredited gas standards provide the main calibration data to scale the analyser output to correct concentration units for the gas species being monitored. Detailed records are kept for all calibrations undertaken and, during the calibration visits, any consumables (such as filters etc) are replaced and the general fabric of the site inspected.

A major tool for quality assurance checking in the national networks is the detailed site, instrument, calibration gas and operator audit carried out at 6-monthly intervals. A single independent body visits every site in the network to undertake a full site check. All analysers on site are checked. In relation to the NO_2 analyser, the following checks are undertaken:

- linearity;
- noise;
- response time;
- leaks and flow check;
- converter efficiency, and
- analyser calibration.

The sample inlet, manifold system and on-site gas calibration standards are also checked to ensure correct operation of the full measurement system. The bodies undertaking these tests have the appropriate UKAS accreditation and a UKAS certificate of calibration is produced documenting the results of the checks.

These quality assurance tasks ensure, as far as possible, that data collected from the analysers are correct and accurate at the time of collection. However, there may be faults and problems that only become apparent when a large time series of data or calibrations are examined together. The Quality Control system therefore provides a further check on the data.

Quality control
Quality control of air pollution data is the process of checking, accepting, rejecting or adjusting the data, on the basis of all available information. This operation is usually referred to as data ratification and is generally carried out on 3 or 6-month data blocks, or annually, so that a reasonable amount of data and several calibrations are available to assess consistency and long-term performance. The ratification procedure consists of collating all of the available data, calibration records, service records and any other information relevant to analyser or site operation. All of this information, together with meteorological data and information from other analysers or other sites may be used in the ratification process. An important principle of the data ratification procedures is that data are always retained unless there is a specific reason for rejection.

The final task of ratification, within the national automatic network, is to hold a quality circle to identify any generic issues arising from the data ratification process and to use these as a basis for recommendations to improve network performance.

Diffusion tubes
Diffusion tube data in the UK Nitrogen Dioxide Diffusion Tube Network undergo similar QA/QC procedures with the same aims as those for the automatic data, but with differences appropriate to the method.

The monitoring sites are classified using the same system as for the automatic sites, although all diffusion tube sites are now either roadside or urban background. All monitoring locations selected by local authorities are checked from maps and photographs supplied. A manual for the survey (AEA Technology, 2003) has been prepared and can be found here.

Data are manually checked as they are received from the local authorities on a monthly basis. Any problems identified at this stage are discussed with the local authority concerned.

Two quality assurance schemes are operated to control analytical laboratories contributing data to the network. The Health and Safety Executive operates a laboratory proficiency test scheme as part of the Workplace Analytical Scheme for Proficiency (WASP) scheme and, in addition, a field inter-calibration of diffusion tubes from all laboratories takes place annually. The latest report has been published (AEA Technology, 2002).

At the end of each calendar year, the dataset is checked in its entirety and also fed back to the local authorities for final checking and any additional comments on their own data. When these checks have been completed, the data are formally ratified.

Provisional and ratified data
Data from the UK national air quality monitoring networks are marked as "provisional" or "ratified" depending on what stage they are at in the process of ratification. When data are first collected from the analyser on site, they are scaled with calibration data from the last calibration. In many cases, this will produce satisfactory data, with problems only arising if the instrument is unstable or drifting rapidly. The data are then automatically screened using computer algorithms to highlight suspect data, but no data are deleted at this stage. This process occurs in real time and all data that are not marked as suspect are sent to the National Air Quality Information Archive within about 1 hour of being collected. Data sent to the archive at this stage are marked as provisional.

All of the provisional data, together with all the identified suspect data, then undergo full ratification, as described in Section "Quality control" (see above) in 3-month blocks. As part of the ratification process, the suspect data may be reinstated if deemed to be genuine.

Following the ratification process, the fully ratified dataset are re-sent to the Air Quality Archive (in 3-monthly blocks, 3 months in arrears) and the provisional data are overwritten with the ratified data.

3.1.5. Future developments relating to European standardisation

One of the elements of the European Air Quality legislation is a set of written standards that are currently being produced by the European Centre for Standardisation (CEN). These are designed to ensure that all Member States are making their measurements with the required level of accuracy, and Member States must follow these standards unless they can demonstrate that their own methods give equivalent results.

A Community-wide procedure for the exchange of information and data on ambient air quality in the European Community is established by the Council Decision 97/101/EC. The decision introduces a reciprocal exchange of information and data relating to the networks and stations set up in the Member States to measure air pollution and the air quality measurements taken by those stations. The information exchange relates to the pollutants listed in Annex I of Directive 96/62/EC. The Annexes of the Decision were amended by Commision Decision 2001/752/EC. A Guidance report on the Annexes to Decision 97/101/EC on Exchange of Information as revised by Decision 2001/752/EC is now available. Also a report on the implementation of Decision 97/101/EC has been prepared as foreseen in Article 8 of the Decision.

Further reference to the Guidance on Ambient Air Assessment under the EU Air Quality Directives, Final Draft is found here.

3.2. Modelling

3.2.1. Air quality models and their application

An air quality model uses mathematical and numerical techniques to simulate the physical and chemical processes that affect air pollutants as they disperse and react in the atmosphere. Using inputs of meteorological data and source information such as emission rates and stack height, models are used to calculate the resulting pollutant concentrations for comparison against air quality limit values.

Models are important in air quality management as they can be used both to identify source contributions to air quality problems and to assist in the design of effective strategies to improve air quality. For example, air quality models are used during the industrial permitting process to check whether or not a new process will lead to an exceedence of the limit values and, if so, determine appropriate mitigation. Air quality models are also used to predict future pollutant concentrations from all of the different types of sources, for example in an urban area, before and after the application of mitigation measures or the addition of a proposed development.

Models vary from screening models to detailed models that make use of up-to-date understanding of the atmospheric boundary layer, known as 'new-generation' models. This document does not deal with screening models, as their use is generally straightforward and self-explanatory. These include such models as the UK Design Manual for Roads and Bridges (DMRB) screening model, which is a spreadsheet based screening tool for road traffic sources. For industrial sources, examples include ADMS-Screen, a screening version of the new-generation industrial air quality model ADMS 3, and SCREEN3, a screening version of the "old-generation" Gaussian air quality model ISC3. More information on different models can be found in the Model Documentation System of the European Topic Centre on Air and Climate Change. This system contains basic key words and descriptions for each of the atmospheric dispersion models that have been submitted to this database.

Steady state Gaussian plume models are the most commonly used for detailed air quality assessments, both for modelling emissions from industrial processes and for the assessment of the air quality experienced in urban areas. Gaussian plume models simulate continuous emissions, and their output is based on a normal distribution of pollutant. The mean concentration decreases with distance from the source, and the spread of pollutant is determined by the stability of the atmospheric boundary layer. An example of such a Gaussian model is ISC3.

More recently, new-generation Gaussian plume models have been developed that take account of a more up-to-date and sophisticated understanding of the atmopheric boundary layer (atmospheric boundary layer is the lowest layer of the earth's atmosphere, usually up to 3,300 feet, or one kilometre, from the earth's surface, where the wind is influenced by the friction of the earth's surface and the objects on it). Examples include Aermod and the ADMS suite of models. The two main features of these new-generation models are that:

- The **atmospheric boundary layer** properties are described by two parameters: the boundary layer depth; and the Monin-Obukhov length, rather than in terms of the single parameter Pasquill-Gifford stability class; and
- Dispersion under **convective meteorological conditions** uses a skewed Gaussian concentration distribution, shown by validation studies to be a better representation than a symmetric Gaussian expression.

Industrial models are those used to model the impact of existing and proposed industrial installations. Current and future air quality can be assessed with respect to the air quality limit values. Typical applications include:

- IPPC authorisations;
- stack height determination;
- odour modelling;
- environmental impact assessments; and
- assessments for safety and emergency planning.

An example of an industrial modelling study is given in the report of the Elektrenai Power Plant study.

Urban scale models are those used for assessing and dealing with air quality problems across a region, city or town, from the street scale up to the regional scale, taking into account the whole range of relevant emission sources: traffic; industrial; commercial and domestic heating and other less well spatially-defined sources. As data management becomes an issue when dealing with multiple sources, such models often have links to GIS and emissions inventories. An example of an urban modelling study is given in the report of the Panevežys study.

3.2.2. Criteria for model selection

A list of models that have been or can be used in Lithuania can be found here.

For any particular study, a model capable of taking into account all relevant emissions sources should be used. This usually means that the model should be able to include line (major road), area (minor road, domestic heating, and other spatially indistinct sources) and point (industrial stack) sources, depending on the nature of the assessment.

The following criteria may be useful in selecting an air quality model.

- The model should be "user-friendly" with a graphical user interface of a "Windows®" or equivalent type.
- The model should be able to consider a sufficient number of industrial sources, including point, area and volume sources, and road sources in the case of the urban scale model.
- The model should provide output on a local scale, up to around 50km, with a high output grid resolution, ideally at least 10m.
- The model should be able to calculate wet and dry deposition as well as concentration output.
- The model should be able to include the effects of complex terrain on dispersion using various digital terrain data formats, including parameterisation of surface roughness.

- It should be possible to define the variation of emission parameters and rates with time, i.e. hour-to-hour, day-to-day and month-to-month variation.
- The model should be a so-called "new generation" model with respect to the parameterisation of the boundary layer, i.e. including Monin-Obukhov length scale and boundary layer scaling. The model should be able to describe dispersion under all types of atmospheric stability conditions in the atmospheric boundary layer.
- The model should be able to accept, as a minimum, standard hourly sequential meteorological data without the need for any further meteorological measurements. Standard meteorological parameters are assumed to be surface temperature, wind speed and direction, cloud cover, precipitation. The model should ideally also be able to accept more advanced meteorological parameters such as heat flux, Monin-Obukhov length, boundary layer height and solar radiation.
- The model should include NO_x chemistry in order to calculate concentrations of NO_2 for direct comparison against NO_2 limit values.
- The output should be able to be displayed in graphical form as contour plots on a map covering the area of interest. The output must also be exportable for other purposes, e.g. as text files for further processing in spreadsheets.
- It should be possible to output results from the model for direct comparison with the EU limit values, i.e. in percentile format with the full range of averaging times, including for example daily averages and rolling 24-hour averages, without requiring the use of factors to determine the values for different averaging times.
- The model should include the impacts of plume rise and buildings on dispersion of industrial pollutants.
- The software supplier should provide validation papers to demonstrate the performance of the software proposed, including examples of the application of the model and comparison between simulated and measured results.

3.2.3. Pollution sources and pollutants

Pollution sources commonly required to be included in air quality modelling studies are as follows.

3.2.3.1 Industrial sources

The most common and arguably most significant industrial sources are stacks, which are suitable for representation as point sources with a vertical emission. However, some industrial sources, such as open tanks with volatile emissions, or fugitive emissions (see below), are more appropriately represented as area or volume sources. Some emissions may have a horizontal velocity component, and so require representation as jet sources.

The most common pollutants emitted in significant quantities are those resulting from combustion of fossil fuels, i.e. NO_x, CO and possibly SO_2 and PM_{10}, depending on the fuel. However, depending on the process exhausting through the modelled stack, a wide range of pollutants could require assessment, not limited to Volatile Organic Compounds such as benzene, or heavy metals such as lead.

Fugitive emissions may be caused by leakages from industrial plant as well as from dusty activities such as open-case mining or quarrying, the loading/unloading of freight, or activities at landfill sites. Such sources are most likely to be relevant for emissions of VOCs and PM_{10}. Fugitive emissions are difficult to quantify; they are usually best treated as area or volume sources with an estimated annual emission rate.

3.2.3.2 Road and associated sources

Although a range of pollutants is associated with vehicle emissions, for example CO, SO_2, benzene and lead (where used as a fuel additive), the most significant pollutants for road sources are NO_x and PM_{10}, since these are the pollutants which are of most concern in urban areas.

Other sources associated with road sources are those used to represent traffic congestion, usually by the addition of extra road links to represent traffic queues, and car parks, which are represented either by area or volume sources.

Benzene is the significant pollutant emitted from petrol stations, which are usually represented by area sources covering the forecourt area.

3.2.3.3 Other transport sources

Other transport sources, such as those representing emissions from railways, ships or airports, are usually either represented in a similar way to road sources, or as area or volume sources, depending on the detail of the information available to represent them. Some models have the capability of representing aircraft emissions as jet sources following a landing and take-off (LTO) sequence.

3.2.3.4 Spatially indistinct sources

The above source groups can be spatially defined, i.e. associated with a particular location. Other emissions, such as those from heating of domestic or commercial premises, or from a network of minor roads, are best included in the model by aggregating them onto a grid, say 1km by 1km, across the area to be modelled.

3.2.4. Meteorological data and their influence

Meteorological data are required as input to an air quality model in order to simulate the physical and processes that affect air pollutants as they disperse in the atmospheric boundary layer.

The meteorological parameters required for a new-generation air quality model are:

- Wind speed and direction, to account for the transport and mixing of pollutants; and
- Temperature, cloud cover and/or solar radiation, to provide information concerning atmospheric stability.

For particular types of assessment, the following additional parameters may also be required:

- Precipitation for use in wet deposition calculations; and
- Relative humidity for use in plume visibility assessments.

The meteorological data chosen should be representative of the meteorological conditions across the area being modelled. Thus the location of the meteorological site and its distance from the modelled region, whether it is coastal or inland, whether near to complex terrain, are all important factors.

Although statistical meteorological datasets are available, the use of hourly sequential data is preferable so as to ensure capture of extreme conditions that may only occur very occasionally.

As wind speed and direction data are more widely available, wind roses can be useful tools for summarising the wind characteristics of a site for comparison with those from a potential source of meteorological data.

Meteorological data should be taken from a site with a full dataset. For example, the UK Environment Agency insists on at least 90% data capture.

Note that, for the purpose of verification of the model set-up for urban scale modelling, the year of meteorological data used should be the same as that of the modelled emissions and as the year of background data used (see later).

For industrial studies, it is often required to consider the results from the use of more than one year of meteorological data, in order to allow for inter-year variability. For example, the UK Environment Agency requires the use of at least four years of meteorological data.

3.2.5. Input data

Meteorological data has already been covered in Section 3.2.4. The other possible inputs to air quality models are discussed below.

Some of the data required for input to an air quality model depends on the model to be used and the application it is to be used for.

A parameter is used in air quality modelling to represent the physical characteristics of the area under consideration. A length scale parameter called the surface roughness length is used to characterise the study area in terms of the effects it will have on wind speed and turbulence, which are key factors in modelling. In some models, a variable surface roughness can be set up across the study area.

Care should be taken in any air quality modelling study to ensure sufficient output grid resolution and that sensitive receptors, either for human health or sensitive ecosystems, are included as necessary. In an industrial study, a useful rule of thumb provided by the UK Environment Agency is to use a grid resolution of not more than 1.5 times the height of the lowest stack to be modelled. In an urban scale study, the resolution required will depend on the scenario under investigation and on other factors such as the detail of the emissions data.

Further the input data required specifically for **an industrial study** are described. For more information about modelling an industrial site, please refer to the Elektrenai Power Plant case study.

The required data for such a study are as follows; these data are required for each scenario to be considered.

- Plan of the site with the local grid marked on it, including the locations and dimensions of on-site buildings and sources to be modelled;
- Source parameters including location, stack height and internal diameter at emission point, plus any other relevant information concerning the release (vertical or horizontal release, presence of a rain cover etc);
- Operating times or variations in emission parameters throughout a typical year for each source;
- Emissions data for each source including:
  - Emission rate of each pollutant (note that typical and maximum emissions may be required to model long- and short-term concentrations, respectively);
  - Emission temperature; and
  - Velocity and/or volume flow rate of total emission, including the conditions for which these parameters are quoted, such as temperature, oxygen content and water content.

Other data may also optionally be required if relevant to the study:

- The percentage by volume of the emitted NO_x that is NO_2, required if NO_x chemistry is to be included to calculate concentrations of NO_2[3];
- Local terrain data, should the surrounding area be hilly;
- Data concerning wet and dry deposition velocities; and/or
- Plume water content, required for a plume visibility assessment.

Input data required specifically for an urban scale study

[3] For more information on NO_x chemistry, see later section on background data.

For more information about modelling an industrial site, please refer to the Panevežys case study.

In urban areas, the significant amount of heat emitted by buildings and traffic warms the air within and above a city or large town. This is known as the urban heat island and its effect is to prevent the atmosphere from becoming very stable. In general, the larger the area the more heat is generated and the stronger the effect becomes. In new-generation models, the stability of the atmosphere is represented by the Monin-Obukhov parameter, L_{MO}, which has the dimension of length, and the height of the boundary layer, h. Values of these parameters corresponding approximately to the Pasquill-Gifford stability categories are shown in Table 3.1. Note that there is no exact correspondence, since many different values of h and L_{MO} may correspond to one Pasquill-Gifford category.

Table 3.1: Meteorological parameters that may be used to represent Pasquill-Gifford categories

Wind speed, U (m/s)	L_{MO} (m)	$1/L_{MO}$ (m^{-1})	h (m)	h/L_{MO}	P-G category
1	-2	-0.5	1300	-650	A
2	-10	-0.1	900	-90	B
5	-100	-0.01	850	-8.5	C
5	∞	0	800	0	D
3	100	0.01	400	4	E
2	20	0.05	100	5	F
1	5	0.2	100	20	G

The effect of the urban heat island is that, in stable conditions the Monin-Obukhov length will never fall below some minimum value; the larger the city, the larger the minimum value. In some models, this limit value can be set, where appropriate, to give a more accurate representation of the stability of the boundary layer.

Spatially accurate data are required to model the important local emissions sources explicitly. These may include some or all of the following.

For **road traffic**, the following data are required for each road:

- Annual average daily total (AADT) traffic flow. The flows may be automatic or manual counts, or traffic model output;
- Breakdown of traffic type, at least into light and heavy duty vehicles[4];
- Average traffic speed;
- Road width; and
- Street canyon height, where appropriate[5].

For detailed modelling, where there are areas of congested traffic, bus stops or other situations where traffic is slowed, data should be obtained as to the timing, location

[4] Note that a suitable "route type" reflecting the further breakdown of traffic type by year (technology) and engine size will be required. Such a route type will be developed

[5] A street canyon height should be included where there are buildings both sides of a road section that rise to a height greater than half the road width.

and length of queues. Sufficient data will also be required from which to derive hourly time-varying factors for traffic emissions, to be applied for a typical weekday, Saturday and Sunday; automated 24-hour traffic count data could be used to derive these profiles. The date, time and location at which the traffic counts were made should be noted. A GIS shape file of the road network is also useful, and can be digitised from suitable map data.

Note that a route type for road sources has been derived for Lithuania and is available from the EPA; see the Panevežys case study. This gives information about the vehicle age and engine size breakdown in the country, for the derivation of emission factors for traffic on a typical road.

Railway data, where relevant, should be in a similar form to road traffic data, with the railway network digitised and passenger and freight train movement data combined with emission factors for each engine type.

For **industrial source data,** the requirements are given above. However, note that detailed site data, such as multiple buildings data, are not required to be included in an urban scale study. If emissions data are not available for any industrial sources, then they can be derived from fuel use or other activity data. Petrol stations and boilers should be included here.

Other emissions will be required on a 1 km by 1 km grid basis, such as heating of domestic and commercial premises and emissions from the minor road network, which to be derived from population and fuel use data.

An emissions inventory for the whole of Lithuania is available from the EPA in the form of 1 km by 1 km gridded emissions; see the Panevežys case study. However, this should be used with caution and with understanding of the way in which it has been compiled.

Emissions data for an urban scale study are required to be appropriate for the base year to be modelled; see Section 3.2.7 on model verification. Sufficient information is also required concerning assumptions to be made in updating the emissions to any future years to be modelled, for example 2010, for comparison with limit values to be achieved by this year. These may include:

- Traffic growth factors, by which to multiply traffic flows;
- Information concerning the closure or addition of any sources of emissions; and/or
- Information concerning any significant trends, for example in terms of changes in fuel use.

Background data

For direct comparison against air quality limit values, the total concentration of the pollutant being modelled must be calculated. This means that some estimation of "background" concentration of that pollutant must be taken into account.

In an industrial modelling study, usually the only sources being modelled explicitly are the on-site industrial sources. This means that the background concentration should take account of pollution from all other sources in the area and further afield, representative of the modelled area. Note that as the industrial emissions being modelled will often be implicitly included in these estimates of background concentration, there will be an element of double counting where they are included in the total pollutant concentration.

In an urban scale modelling study, care must be taken that the background concentration takes account of all of the sources of pollution that are not included in the model, without double counting those that are. For example, if all local sources are included in the model, rural background concentration data should be used. However, if only a few major roads are included in the model, an urban background concentration is more appropriate.

If the background concentration is a long-term, for example annual, average, then the UK Environment Agency recommends that double the long-term value be added to short-term concentrations, for example the 99.79^{th} percentile of hourly average concentrations for NO_x. Some models allow hourly average background data to be included in the model, if available, and this is a more accurate way of taking background concentrations into account, although even more care should be taken with potential double counting.

The background data used for an urban scale study should be for the same year as the meteorological date.

NO_x chemistry

NO_x comprises NO and NO_2, and only NO_2 poses a threat to human health, although note that there are NO_x objectives for the protection of vegetation and ecosystems.

A proportion of the emitted NO_x will be in the form of NO_2 and a further proportion will be converted to NO_2 during the time spent in the atmosphere. For direct comparison against the objectives, total concentrations of NO_2 are required.

Ideally, the model used should have the capability of taking into account the reactions between NO, NO and ozone. In this case, hourly average background concentrations of these three pollutants must be input to the model. This is especially important for urban scale studies, as the relationship between NO_x and NO_2 concentrations is non-linear. Alternatively there is a range of methods for calculating NO_2 concentrations from NO_x concentrations.

3.2.6. Processing and interpretation of model output

In any air quality study, concentrations should ideally be output from the model using appropriate averaging times for direct comparison against air quality limit values, such as annual averages or the appropriate percentiles. The maximum model-calculated values can then be tabulated and directly compared against the limit values.

In an industrial study, the reported values are usually the maximum values occurring outside the site boundary of the industrial site under consideration; within the site boundary, less stringent occupational health standards will usually apply.

It is also useful to provide results as contour maps of concentration; these can be superimposed on digital base mapping, which is the best way to show how impacts vary over the surrounding area. This is the main form of presentation of results for urban scale studies, as the distribution of concentrations is very important in such studies. Any exceedences can be highlighted by producing contours of the relevant limit values in a different colour to show the extent of the exceedences.

Model output may sometimes need to be processed further before the presentation of results, for example to add background concentrations or convert NO_x to NO_2 concentrations. In some models, only annual average values can be output, which then need to be processed to estimate short-term values before they can be compared against limit values.

3.2.7. Accuracy of dispersion models and validation of the model

It is useful to understand the difference between **validation** of a model and **verification** of a particular model set-up.

Validation refers to the general comparison of modelled results against monitoring data, usually in the form of standard datasets, carried out by the model developers to check the model algorithms. Before using any air quality model, it should be confirmed that the model has undergone extensive validation for the purpose for which it is intended to be used.

Verification of the particular model set-up is a comparison of model output against local monitoring data at the locations of each monitor, carried out by the model user, usually for an urban scale study rather than an industrial study. The main purpose of the verification is to check that the emissions data and other input parameters accurately represent the modelled area. Meteorological and background data must be for the same year as the monitoring data and any null data should be removed from the monitoring and modelled data before making the comparison.

Discrepancies between modelled and measured concentrations may be due to a number of different reasons, including but not limited to:

- Incorrect or inaccurate representation of monitor locations in the model, with respect to modelled sources;
- Unreliable monitoring data, or monitoring data with low data capture;
- Traffic flow uncertainties, including estimates of speeds, total flows and proportions of vehicle types;
- Poor emission estimates for vehicles and other sources such as domestic heating and industrial stacks;
- Poor estimates of background concentrations;
- Poor choice of meteorological data; and
- Poor choice of model input parameters such as surface roughness length and minimum Monin-Obukhov length.

The model inputs should be adjusted until reasonable agreement is obtained, whilst allowing for any effects on the monitoring data that may not readily be represented by the model.

An accuracy of a factor of two is often quoted for air quality models. When representative data are input to a well-validated model, the accuracy should be significantly higher than this and annual average modelled and monitored data can often agree within 10%. This more than fulfils the requirements of the First Daughter Directive, which states that, for modeling, an accuracy of 30% is required for annual averages and an accuracy of 50 to 60% is required for short-term averages. When the pairs of modelled and monitored data are plotted against one another, a good spread of data points should be achieved above and below the modelled = monitored line for the range of concentrations experienced across the study area.

3.3. Application of the emission data (inventory data)

It is necessary to have quantitative information on emissions (emission estimates) and their sources in order to carry out trends analysis, regional and local scale air quality modelling, regulatory impact assessment and human exposure modelling.

Emission estimates are collected together into inventories or databases which usually also contain supporting data on, for example: the locations of the sources of emissions; results of emission measurements (when available); emission factors; capacity, production or activity rates in the various source sectors; operating conditions; methods of measurement or estimation, etc.
Emission inventories may contain data on three types of sources:

- Point sources: emission estimates are provided on an individual plant or emission outlet (stack) usually in conjunction with data on location, capacity or throughput, operating conditions, etc.
- Area sources: smaller or more diffuse sources of pollution are provided on an area basis either for administrative areas, such as counties, regions etc, or for regular grids (for example the EMEP 50x50 km grid).
- Line sources: in some inventories, vehicle emissions from road transport, railways, inland navigation, shipping or aviation, etc are provided for sections along the line of the road, railway-track, sea-lane, etc.

However, in some inventories all of the data may be provided on an area basis: region, country, sub-region, etc.

Emission inventories are also necessary due to a number of international and EU requirements such as the Convention on Long Range Transboundary Air Pollution (LRTAP) and its subsequent Protocols, the United Nations Framework Convention on Climate Change (UNFCC), the Council Decision 99/296/EC on a Monitoring Mechanism of Community CO_2 and other Greenhouse Gas Emissions, the IPPC Directive (96/61/EC, European Pollutant Emission Register (EPER)), the large combustion plants Directive (2001/88/EC), the National Emissions Ceilings Directive (2001/81/EC) etc. Some of these require the set up of an inventory of the total emissions of a certain pollutant from all sources, while others require only the emissions from certain sources, e.g. large combustion plant.

3.3.1. Principles of identification of emission sources

The term ‘relevant source’ can be defined in different ways depending on the context. On the national level a source or group of sources may be termed ‘relevant’ if they contribute to a large extent to the total annual emissions. The same applies in principle on the regional scale; however, sources being almost insignificant at the national scale may be highly relevant for a particular region, if the total emission level of this region is low but dominated by the source under consideration. On the local scale flue gas concentrations can become at least as important as the annual emission from freight. Thus, sources with low annual emissions and minor importance for the national or regional balance may be relevant if high concentrations of the flue gas directly influence the emission situation, for example due to low stack heights.

Following these definitions the identification of relevant sources can be done in principle by ranking the sources according to their emissions on the different levels of consideration. However, this would require a complete database or at least a database with a comparable degree of completion for all sources. Obviously, this is not the case for all pollutants.
The data gaps can be closed partly by additional statements about the probability that a source may be relevant. This probability can be assessed by estimating the uncertainty of the basic data followed by calculation of the possible emission range.

3.3.2. Database of the emission inventory

In order to streamline the methodology for emission inventories among the Member States, the European Commission provided guidance through the EMEP/CORINAIR Emission Inventory Guidebooks and developed a software tool for emission inventory (CollectER), which is completely in line with the EMEP/ CORINAIR guidelines.

CollectER (Collect Emission Register) is a tool designed to help National Reference Centres on Air Emissions to collect the relevant air emission data in a national emission inventory for delivery to the European Commission and to international conventions.

The program CollectER includes data collection (activity data of area and point sources, emission factors, emissions) and the storage of these data in an emission inventory (bottom up as well top down) following the national territorial split and enabling reporting of national air emissions.
The database stores root data, input data to be collected and calculated emissions. Root data define the basic dimensions of the inventory and are based on international data delivery requirements and formats. The user is allowed to enter new pollutants and to specify specific fuels within the predefined fuel groups. Input data to be collected cover direct emissions from point sources as well as activity rates (fuel use, land surface area, number of inhabitants, number of livestock etc.).

The database contains three groups of pollutants: acidifying pollutants, ozone precursors, greenhouse gases (SO_2, NO_x, NH_3, CH_4, NMVOC, CO, CO_2, CH_4, N_2O, HFCs, PFCs and SF_6); heavy metals (HM) and persistent organic pollutants (POP).

Activities that cause emissions are classified using the Selected Nomenclature for Air Pollution (SNAP). This nomenclature has three levels: sectors, subsectors and basic emission generating activities. Each SNAP can be used with both area and point sources. In the case of Lithuania, only 17 point sources (the largest industrial facilities in the country) are considered.

Point sources, mainly large emitters that can be attributed to a specific location, are defined by their geographical coordinates, emission generating activities and other specific data. If the plant or company delivers measured emission data, these data can be stored in the database as “direct emissions”. This is the case for the emission inventory of Lithuania.

Area sources, all other stationary and mobile sources, that are too small and/or dispersed over larger areas, are defined as totals over a certain territory. Area sources will always be described by an activity rate and emissions are calculated using emission factors.

An emission factor is a coefficient that relates emissions to activity rates. It is therefore expressed as an emission per unit of activity. Emission factors are often based on a sample of measurement data, on a mass balance (e.g. CO_2 and SO_2). In many cases they are averaged values derived to represent the typical range of technologies and/or fuels applied within a certain activity.

An activity rate is defined as information on the intensity of a human activity resulting in emissions. In activities where combustion is involved, activity data should be expressed as total amount of fuel burned. For other sources different activity rate units can be used or defined. The user has considerable freedom in selecting the activity rate units to make optimal use of available statistical information. National prescribed methods for emission estimation should always be used whenever available because these normally take into account specific issues that account for the local situation. Relevant sources that can be consulted for emission factor based emission inventory in case the national prescribed methods are insufficient, are:

- EMEP-CORINAIR Emission Inventory Guidebook;
- Emission factor handbook US-EPA AP-42.

3.3.3. Assessment methods according to the groups of pollution sources

This section aims at the requirements for emission inventories for local assessment (e.g. within the framework of permitting or EIA for an industrial facility), for urban air quality assessment and for regional/national air quality assessment. While the first has to be much more detailed, the latter will only have detail for the 'relevant' sources (sources with high emissions; e.g. point sources with significant emissions like power plants or refineries, network of main roads etc.) while the other sources are aggregated into grids.

3.3.3.1 Local air quality assessment

This mainly deals with the inventory required for the assessment of the impact of a single industrial facility within the framework of, for example, permitting or EIA. The emission inventory should cover point and non-point sources and consider all significant pollutants and emissions. Significant pollutants are pollutants that are either emitted in substantial quantities or pollutants that present a potential danger to human health (acute toxicity, carcinogenicity etc.). Significant emissions are likely from a number of different processes. As well as defined (stack) releases, industrial processes may also give rise to fugitive emissions. This is particularly relevant to emissions of VOC, benzene, particles and lead. Fugitive emissions generally arise at ground level, for example from chemical storage and handling plant, quarries and some metal refining activities, and are more difficult to quantify using simple methods.

Stack emissions parameters can be taken either from emission measurements (preferred option) or from estimation methods, such as the ones currently used for the yearly reporting of emissions to the Regional Environmental Protection Agencies. The register kept by the Regional Environmental Protection Agencies is an important source of information.

Emission factors can be used to calculate annual emissions from activity data such as fuel consumption, production, or consumption statistics. Emission factors can be based on one or several sets of measurement from similar processes and can be very generalised (such as an average for coal combustion in boilers) or highly specific (such as coal combustion in a tangential grate boiler).
The use of emission factors often requires a detailed knowledge of a process and it is important to consider the 'appropriateness' or 'relevance' of an emissions factor before applying it. Additionally, some emission factors are more robust than others, depending on how they were derived and how much test data was available, and this should be taken into account when considering the accuracy of emissions estimated from emission factors.

Emission factors have been used as fundamental tools for air quality management for a considerable time. Data from source-specific emission tests or continuous emission monitors are usually preferred for estimating emissions because the data provides the best representation of the tested source's emissions. However, test data from individual sources are not always available and, even then, they may not reflect the variability of actual emissions over a prolonged period of time. Thus, emission factors are frequently used for estimating emissions, in spite of their limitations.

Fugitive emissions may also give rise to significant emissions for some large processes or storage facilities. This is particularly relevant to emissions of VOC, benzene, particles and lead. Emissions can be calculated from mass balances or loss inventories for products or feedstock compiled by the operators. Where the fugitive emissions are from a process and the release is not product or feedstock loss then it can only be estimated using emission factors and activity data.
As a rule of thumb, emission inventory for local air quality assessment should cover all point and non-point sources in an industrial facility that make up 95% of the total emissions of a certain pollutant.

3.3.3.2 Urban air quality assessment

Emission inventory for urban air quality assessment should focus on the significant sources. These significant sources will be different for different local authorities and even for different areas within a local authority. In the majority of cases, road transport and stationary large point sources and non-point sources are likely to be the most common problems. In addition but probably in more isolated cases residential areas burning coal or solid fuel, large ship ports or airports may need detailed assessments. In many cases a complete inventory is inappropriate and time consuming. However, where exceedences are likely to result as a cumulative result of a large number of different sources then a more complete inventory is recommended. Details on the emission inventory for stationary large point and non-point sources have been provided under the chapter on local assessment.

For emissions from road transport one should differentiate between major roads and background road data. Hot exhaust emissions from traffic on major roads will be assessed in detail, while background road data will be generalised. Background road data include hot exhaust emissions from traffic on minor roads as well as cold start and evaporative emissions and tyre and brake wear.
Hot exhaust emissions from traffic on major roads are also estimated using an emission factor approach, where emission factors are depending on vehicle type (car/truck/bus; engine size; diesel/gasoline/LPG), vehicle age and vehicle speed. Required activity data are the traffic flow (annual average daily traffic flow, AADT) and the traffic split (% of trucks and buses). Detailed assessment will involve some form of modelling, requiring high quality traffic flow and link location information. It is very important for detailed assessments that the data used is representative of the specific likely traffic flow, speed and type characterisation for the links being considered. The use of average or aggregate factors for flow or traffic composition should be avoided. Possible slow speeds during congestion and the likely impact of bus stops and steep hills should be incorporated, if possible. Activity data for the detailed assessment may be generated either from traffic counting data or from traffic models.

Roads that are not being assessed in detail will include minor roads as well as rural or more distant major roads. Minor roads will usually carry comparatively small amounts of traffic that are less likely to give rise to an exceedence of Air Quality Objectives in their own right. A busy urban road will typically be surrounded by smaller residential/access roads. Data describing traffic flows on minor roads is likely to be sparse, and this means that traffic will usually need to be estimated on the basis of fairly crude surrogate statistics. The objective is to compile an area source type grid (usually of 1 x 1 km resolution) of the roads that are not being assessed in detail. This grid will represent the emissions from hot exhausts from the network of roads not included in road link and junction assessments. This grid needs to be based on the best available data (traffic count data, traffic models or estimates).

Cold start and trip-end hot soak emissions are usually estimated on the basis of trips as these emissions can be considered as an additional emission resulting from a cold engine at the beginning of each trip for cold start, and the evaporative component from hot engines. The important spatial entity to estimate is the trip starts and the trip ends. There are three possible sources of data describing the density of vehicle trip ends over a study area: data from a traffic model, data from a travel survey and estimates. Particular consideration should be given to temporal patterns; the morning peak period will see a lot of 'starts' in suburban areas, with a corresponding concentration of starts in the centre of towns in the PM peak (and vice-versa for trip ends). These 'cold start' emissions would be important if many of the car journeys in an area were short trips.

Estimating emissions from brake and tyre wear should be done on the basis of vehicle-kilometres by type of vehicle. This component can be added to the major road link estimates using specific emission factors. Alternatively it can be calculated more generally by adding all vehicle-kilometre data into 1 x 1 km grid squares (road links and minor roads) for each basic vehicle type (cars, LGV, HGV, buses/coaches) and applying an emission factor to these vehicle-kilometres. Emission factors for fugitive

PM_{10} from brake and tyre wear and re-suspended road dust are subject to a great degree of uncertainty. These factors are expressed per kilometre travelled, or as a percentage of the total PM_{10} emission, and need therefore to be associated with vehicle-kilometre data for the road under study.

Besides industrial facilities and road transport, emissions may also arise from low level domestic and commercial combustion. For SO_2 and PM_{10}, in areas that are particularly associated with the domestic combustion of high solid or high sulphur liquid fuel, it is important to fully assess the impact of these sources. For other pollutants it is unlikely that emissions from low-level domestic and commercial combustion will contribute a significant quantity of emissions and will not warrant detailed treatment. Where it is likely that there will be significant emissions from domestic or commercial sources then a Detailed Assessment of the spatial emissions must be done. This should be at least at a 1 x 1 km emission map of domestic and commercial solid/liquid burning. Using local knowledge and maps, the areas in which solid or high sulphur liquid is burned (estates, commercial areas etc) should be highlighted. In some cases, coal or other solid fuel sales data may be available. It is important to attribute these sales to the point of use, which is potentially different from point of sale. Sometimes it is not possible to obtain sales or consumption data. In these cases estimates can be made based on the defined extent of solid/liquid fuel consumption population on a 1 x 1 km grid square basis and assumptions about the energy demand per capita either for the country as a whole or from local data.

In some cases it may be necessary to estimate specific sources in more detail depending on their significance. In the case of PM_{10}, wind-blown dust, sea salt, fugitive emissions from activities such as quarrying and bulk materials handling etc. may form a significant component of ambient PM_{10} levels in some areas.

3.3.3.3 Regional/national air quality assessment

Regional/national air quality modelling is performed to calculate ambient air concentrations on a larger scale (several tens of km^2), excluding local effects of smaller point sources and smaller roads. This means that only the very large industrial facilities (large power plants, district heating plants, important industrial facilities) and the main road network (highways and national roads) will be considered in detail. All other emissions are aggregated into a 1x1 km grid. The emission inventory largely coincides with the CollectER database which is drawn up by the Ministry of Environment on a yearly basis.

In the case of Lithuania, CollectER only considers 17 large industrial facilities, the emissions from which are put in separately into the database. These 17 facilities, characterised by high emissions and high stacks, may influence air quality over a broad area. Besides (petro)chemical plants and a cement factory, most of these industrial plants are power plants or district heating plants.
For the road emissions, only the hot exhaust emissions from highways and major national roads (high traffic density) are to be put into the inventory explicitly. All other emissions are to be gridded on a 1x1 km level.

4. Air quality management

4.1. Principles and requirements of air quality management

The Air Quality Framework Directive establishes the need for air quality management programmes, to assess air quality and to improve air quality where it is unsatisfactory.

An assessment of air quality is the first step in the air quality management process. Assessment can be carried out using ambient air quality monitoring, air quality modelling or other techniques, such as the compilation of emissions inventories and indicative measurement methods.

When reporting the assessment, information must be provided as to the methods used, the data and information sources and the results, in particular the location and extent of any area over which limit values are exceeded, together with the population exposure. Where possible, maps of concentration distributions should be compiled.

Whatever assessment methods are used, Member States have a responsibility to ensure that up-to-date ambient concentrations of pollutants in air are made available to the public, as well as to other stakeholders

In the UK, local authorities have a responsibility to carry out air quality assessment for their area. First of all, an **Updating and Screening Assessment** is carried out to identify any changes since previous assessment. This Assessment includes an explanation of the conclusion reached as to whether or not the local authority should proceed further. If necessary, a **Detailed Assessment** is carried out for those pollutants and locations identified as requiring further work. If they do not have to proceed to a Detailed Assessment, local authorities have a responsibility to produce an annual air quality **Progress Report**. This is intended to check if there have been any changes to the air quality, and includes a report of any monitoring data recorded over the previous year.

Under the EU Air Quality Framework Directive, where limit values are exceeded, Member States must devise a programme for attaining the air quality limit values within a set deadline. This programme must be made available to the public and contain information concerning the location of high levels of pollution, an assessment of the problem and its origin. The information to be included in local, national or regional programmes for improvement in ambient air quality is given in Annex IV of the above mentioned Directive.

The UK legislation requires local authorities to designate an **Air Quality Management Area** (AQMA) for any areas where air quality limit values are not being achieved, or are not likely to be achieved by the relevant date. Where a local authority has designated an AQMA, it has a responsibility to produce an action plan setting out the measures the authority intends to introduce in order to achieve the air quality limit values, together with timescales for implementation of the measures.

The development of air quality action plans is an important aspect of the air quality management process, providing a practical opportunity for improving air quality in an area where assessment has highlighted problems. Action taken at the local level can often be the most cost-effective way of tackling localised air quality problems.

An air quality action plan should include:

- quantification of the source contributions to the predicted exceedences of the objectives, as this will allow the action plan measures to be effectively targeted;
- evidence that all available options have been considered on the grounds of cost-effectiveness and feasibility;
- clear timescales in which the stakeholders propose to implement the measures included in the plan;
- quantification of the expected impacts of the proposed measures and, where possible, an indication as to whether the measures will be sufficient to meet the air quality limit values; and
- the way in which the plan will be monitored and evaluated.

By the time the stage of compiling an action plan is reached, the main sources of the air pollution, such as road transport, industry or domestic sources, should already have been identified through air quality assessment. The options and measures available to improve local air quality should be carefully assessed, ensuring that the measures to be included in the plan are cost-effective and fit for purpose, taking into account the contribution of pollution from the different sources.

Care should be taken to consider the wider environmental, economic and social consequences of each option. In many cases, measures taken to improve air quality will have a positive impact in other ways; for example, traffic control strategies may improve air quality, reduce noise and benefit pedestrians. In other cases, negative impacts may be associated with some air quality measures; re-routing traffic away from an congested area, for example, might increase congestion and pollution elsewhere.

The cost-effectiveness of each proposed measure should be calculated, showing that the costs of implementing various options have been considered before a decision has been reached as to whether it is cost-effective to implement any particular measure. Note that doing nothing is not always a cost-free option, as there might be indirect costs involved, such as health impacts on the local community.

It should be clear which stakeholders are responsible for helping to work towards achieving the objectives. A timetable should be included showing by when each of the measures will be implemented.

4.2. Possible mitigation measures

A number of measures, including planning, technological, economic, mechanical and policy measures, can be implemented to improve air quality. Given the predominant air quality issues in most Member States, the most significant measures are likely to be industrial including power generation, transport and land use planning measures. Mitigation with regard to the key air quality pollutants is briefly discussed with regard to each pollutant in Chapter 2. Here some further discussion is presented.

The UK National Society for Clean Air (NSCA) guidance: 'Air Quality Action Plans: Interim Guidance for Local Authorities' sets out useful examples and their contributions.

4.2.1. Industrial emissions

For industrial sources, the mitigation options available fall into two main categories: abatement and fuel switching. For example, Flue Gas Desulphurisation (FGD) can be used to abate SO_2 emissions, and filtration systems reduce PM_{10} emissions. Switching from coal to gas can significantly reduce both SO_2 and PM_{10} emissions.

Operators must use the Best Available Techniques (BAT) to ensure that pollution is minimised. This regime allows the regulator and operators to work together over the long term to reduce atmospheric pollution to a minimum. Integrated Pollution Prevention and Control (IPPC) aims to prevent emissions and, where that is not practicable, reduce them to acceptable levels. The regulator will be enforcing IPPC to protect the environment as a whole.

BAT Reference Documents (BREFs) for a range of industrial processes are available from the European IPPC Bureau.

4.2.2. Road transport

Road transport is a major source of local air pollution, particularly in towns and cities, accounting for over half of the total emissions of NO_x and PM_{10} in urban areas; these are the pollutants for which the limit values are hardest to achieve. In the UK, this is demonstrated by the significant number of AQMAs that have been designated in respect of NO_2 and, to a lesser extene, PM_{10}.

Cutting road transport emissions is therefore a key part of air quality management. Mitigation measures can be applied at different levels.

National level transport initiatives include measures to reduce vehicle emissions and improve fuels, and tax-based measures that encourage the supply and use of cleaner fuels and the purchase of more environmentally-friendly vehicles. New vehicle standards can be backed up by emissions tests.

A wide variety of measures that can be applied at a local level, and some examples are described here.

Traffic, or certain types of vehicle, can be prohibited or restricted from entering certain roads. An extreme version of this is a Low Emission Zone (LEZ), where only vehicles meeting specified emission standards are permitted to enter areas of high pollution in towns or cities. An LEZ may deliver additional benefits by reducing traffic noise and overall traffic volumes. However, care should be taken, as more polluting vehicles may be diverted elsewhere.

"Park and ride" schemes can be used to reduce the volume of traffic in a city centre. Such schemes can be accompanied by measures such as reductions in town centre parking, bus priority measures or pedestrianisation. Park and ride is unlikely to affect town centre traffic levels, and may simply add to the amount of traffic entering the town.

In the UK, local authorities are responsible for putting together a local travel plan; a package of measures designed to reduce car dependency by supporting more sustainable forms of travel and improving safety. Such plans can help to improve local air quality.

4.2.3. Land use planning

The land use planning system is integral to improving air quality, but the links between air quality and land use planning policies must be understand fully if the planning system is to successfully contribute to achievement of the air quality limit values.

Land use planning can be used to promote more sustainable transport choices for people and for freight; to promote accessibility to jobs, shopping, leisure facilities and services by public transport, walking and cycling; and reducing the need to travel, especially by car.

Some planning decisions have an obvious significant impact on air quality, for example: a new factory or power station in an area where air quality is already poor; or a development which might result in a significant increase in transport emissions.

Where a proposed development is likely to have a significant impact on air quality, close co-operation is required between the planning authority and those organizations responsible for air quality management. The air quality impact will be particularly important where the development could itself result in exceedences of the air quality limit values or where it is proposed within or next to an area where there are exceedences. There may be many individual small planning applications which separately might not have a significant impact on air quality but which together may have a significant impact.

5. Information on the results of air quality assessment

5.1. Legal basis

There are a number of legal acts that set procedures and content of the provisions of the information on air quality measurements and assessment. It combines both – general provisions in the overarching legal acts on information to the public and requirements specifically designed for the assessment of ambient air quality.

Policy on the provision of environmental information to the public has been developed following the Aahrus convention[6] that was signed in Denmark in 1998 and ratified by Lithuania in 2001. The United Nations Economic Commission for Europe (UNECE) Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters was adopted on 25th June 1998 in the Danish city of Aarhus (Århus) at the Fourth Ministerial Conference as part of the "Environment for Europe" process. It entered into force on 30th October 2001. The "Århus Convention" is an international agreement which lays down a set of basic rules to promote citizens' involvement in environmental matters and improve enforcement of environmental law. It grants the public access to environmental information, provides for participation in environmental decision-making, and allows the public to seek judicial redress when environmental law is infringed, including breaches of the two previous rights.

The Aarhus Convention establishes a number of rights of the public (individuals and their associations) with regard to the environment. The Parties to the Convention are required to make the necessary provisions so that public authorities (at national, regional or local level) will contribute to these rights to become effective. The Convention provides for:

- the right of everyone to receive environmental information that is held by public authorities ("access to environmental information"). This can include information on the state of the environment, but also on policies or measures taken, or on the state of human health and safety where this can be affected by the state of the environment. Applicants are entitled to obtain this information within one month of the request and without having to say why they require it. In addition, public authorities are obliged, under the Convention, to actively disseminate environmental information in their possession;
- the right to participate in environmental decision-making. Arrangements are to be made by public authorities to enable the public affected and environmental non-governmental organisations to comment on, for example, proposals for projects affecting the environment, or plans and programmes relating to the environment, these comments to be taken into due account in decision-making, and information to be provided on the final decisions and the reasons for it ("public participation in environmental decision-making"); and

[6] Convention of United Nations on access to information, public participation in decision making and access to justice in environmental matters

- the right to review procedures to challenge public decisions that have been made without respecting the two aforementioned rights or environmental law in general ("access to justice").

All EU governments signed up to the Convention, as did the European Union, and the EC is a Party to the Convention since May 2005 (for more information see here). By signing the Århus Convention in 1998, the EU committed itself to transposing it into EU law. Two Directives concerning access to environmental information (Directive 2003/4/EC) and public participation in environmental decision-making (Directive 2003/35/EC) in EU Member States were adopted earlier in 2003.

In 2003, two directives concerning the first and second "pillar" of the Aarhus Convention were adopted (they were to be implemented in the national law of the EU Member States by 14th February and 25th June 2005 respectively):

- Directive 2003/4/EC of the European Parliament and of the Council of 28th January 2003 on public access to environmental information and repealing Council Directive 90/313/EEC[7]; and
- Directive 2003/35/EC of the European Parliament and of the Council of 26th May 2003 providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment and amending with regard to public participation and access to justice Council Directives 85/337/EEC and 96/61/EC[8]. These Directives also contain provisions on access to justice.

These two Directives provide for an EU-wide harmonised framework for public access to environmental information and public participation in environmental decision-making, which is fully in line with the ambitious standards of the Århus Convention. Member States are required to introduce the provisions of these two Directives into their national legal systems by 2005 at the latest.

The "legislative package" adopted by the Commission today covers those aspects of the Århus Convention that are not dealt with by the two aforementioned Directives or by earlier relevant legislation.

More specific provisions for the public to access information on the environment in Europe are set in The Decision on conclusion of the Aarhus Convention, adopted by the EC on 17th February 2005 (Decision 2005/370/EC).

On 24th October 2003 the Commission adopted further legislative proposals to align Community legislation with the requirements of the Aarhus Convention which contained, next to the proposal for a Decision to ratify the Convention:

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[7] Directive 2003/4/EC of the European Parliament and of the council on public access to environmental information and repealing Council Directive 90/313/EEC

[8] European Parliament and of the Council providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment and amending with regard to public participation and access to justice Council directives 85/337/EEC and 96/61/EC)

- a Proposal for a Directive of the European Parliament and of the Council on access to justice in environmental matters [COM(2003) 624]; and
- a Proposal for a Regulation of the European Parliament and of the Council on the application of the provisions of the Aarhus Convention on Access to information, Public Participation in Decision-making and Access to Justice in Environmental Matters to EC institutions and bodies [COM(2003) 622]. An agreement between the European Parliament and the Council has been reached in conciliation on 2nd May 2006. This will still need to be formally adopted by both institutions. Following its publication, the Regulation will apply after nine months. Details on the legislative procedure can be found here.

The Proposal for a Regulation on the application of its provisions to EC institutions and bodies took into account existing provisions in these matters, namely Regulation (EC) No 1049/2001 of the European Parliament and of the Council of 30th May 2001 regarding public access to European Parliament, Council and Commission documents, as well as the "general principles and minimum standards for the consultation of interested parties" set by the Commission in its Communication of 11th December 2002 [COM(2002)704], in application since 1st January 2003.

Regulation of the European Council on establishment of Regulation (EEC) No 1210/90 of 7th May 1990 on the establishment of the European Environment Agency (EEA) and the European environment information and observation network (Î) EIONET 1210/90EEC. The EEA is a key EU body dedicated to providing sound independent environmental information to help its members and the EU make informed decisions about integrating environmental considerations into policy and moving towards sustainability. The Agency also serves as an information resource for those involved in the coordination of environmental policy in the EU Director General Environment, Eurostat, JRC, UNEP, WHO, United States EPA and OECD. The EEA aims to establish and coordinate the European environment information and observation network (Eionet), based on an infrastructure for collection, analysis, assessment and management of data shared with European Commission services, EEA member countries and international organisations, agreements and conventions.

The requirements of the former directive have been transposed in the Governmental Resolution No. 338 ‘On the order of the reporting to the EC on implementation of environmental law’ 7th April 2004, (amended 27th March 2006, No. 0299). Standardisation requirements of the reporting to the EU is required by the Directives 91/692/EEC.

The implementation procedure of the WHO Charter on Transport, Environment and Health was approved by the Order No. V-564/D1-339/3-312 of the Ministers of Health, Environment, Transport of the Republic of Lithuania on 11th July 2005. This Order regulates that it is mandatory to follow the principles and orientations laid down in the Charter on Transport, Environment and Health (further referred to as Charter) when elaborating the strategic documents relating to transport, health and environment, planning measures for their implementation and taking decisions as regards the development of transport, planning of territories, investment programmes as well as the use of the European Regional Development and Cohesion Funds.

Lithuanian Governmental Regulation No. 198 on the Submission of Environmental Information to Public 21st February 2005 [9] transposes requirements of the EU directives 2003/4/EC on public access to environmental information and Directive 2003/35/EC on public participation in respect of the drawing up of certain plans and programmes relating to the environment. This governmental Regulation sets the procedure on how the information should be provided by the national and municipal institutions to the public. This Governmental Resolution has amended Governmental Resolution No 175, 22nd October 1999 (Žin., 1999, Nr. 90-2660).

An order of the Minister of Environment No 273 4th July 2000 (amended by Order No 401, September 1st) has set rules of storing, provision of information following public request and public service in the Ministry of Environment'. This Order transpose the Governmental Resolution on the 'Order of the public service in public sector and other institutions' No. 1491, 25th September 2002, (Žin., 2002, Nr.94-4105).

The order on the Public Service in the Ministry of Environment[10] was approved by the Ministerial Order No. 624, 6th December 2002. State and municipal institutions shall prepare and maintain a list of environmental information at their disposal (List of information about the environment).

An order of the Ministry of Environment No. 248 on the Actions to be undertaken in Case of Emergency and Accidents and Management of the Ravage Made 20th May 2003[11] describes the procedures on the activities of the institutions to be taken in case of emergency and accidents. The roles of the Ministry of Environment, Environmental Protection Agency, States Environmental Protection Inspectorate, State Hydrometeorological Service are described.

Information on concentrations of sulphur dioxide, nitrogen dioxide, particulate matter, benzene, carbon monoxide and ozone in ambient air is actively disseminated to the public via the internet (on the EPA's web site) and updated in accordance with the requirements of the relevant daughter directive. Unlike most of the other case study countries, Lithuania monitors lead on a monthly basis (i.e. more frequently than required by the first daughter directive) and disseminates this information on the EPA's web site.

9 Order for provision of information about environment for public in the Republic of Lithuania.
[10] Order for provision of services for the public in the ministry
[11] This order of the Minister of Environment was amended on 29 December 2004 by order No. D1-704

5.2. Public information

Governmental institutions shall inform the public about the **exceedence of the limit value of ambient air pollutants**. The Lithuanian public is informed via radio, TV and press in a case of an exceedence or in the case of environmental accidents (e.g. the case of peat bogs wild fire in summer 2002, or Curonian Lagoon, spring 2006). There has not yet been an exceedence of the ozone alert threshold, but the public information threshold has been exceeded.

The State Environmental Public Health Centre at the Ministry of Health has information on air pollution effects on health. The orders on how to inform public and interested institutions when alert thresholds or information thresholds are exceeded are set in Order No. D1-265/V-436 of 26th May 2005. It describes actions to be taken by institutions involved, such as the Regional Environmental Protection Departments, EPA, Public Health centres in the districts, State Environmental Public Health Centre, municipalities when providing information on exceedence of SO_2 and/or NO_2 alert thresholds and exceedence of ozone (O_3) information or alert threshold. This information focuses on the effects for vulnerable/sensitive members of the population.

When an **exceedence of an alert threshold** does occur, Regional Environmental Protection Departments are responsible for recording the exceedence and information relating to the responsible institutions and the EPA is responsible for distribution of information (according to the procedure set in the legal acts). The information will be shown on the EPA's web site and the EPA will pass on the alert message to the Ministry of Environment's public information division who in turn will pass it on to the mass media. Responsible institutions should provide the following details, as a minimum, to the public when the alert threshold for SO_2, NO_x, are exceeded:

- the date, hour and place of the occurrence and the reasons for the occurrence, where known;
- any forecasts of changes in concentrations (improvement, stabilisation, or deterioration), together with the reasons for those changes;
- the geographical area concerned;
- the duration of the occurrence;
- the type of population potentially sensitive to the occurrence; and
- the precautions to be taken by the sensitive population concerned.

The Ministry of Environment and Environmental Protection Agency provide information for the public on regular basis. The main source of detailed and up-to-date information on air pollution can be found on the EPA's web site. A variety of options are available:

(1) Real time air quality measurement data from all air quality measurement stations.

(2) A daily bulletin with information on air quality measurements. Processed daily measurement data are provided for particulate matter (daily average), carbon monoxide (maximum 8 hour average), sulphur dioxide (daily average and maximum one hour average), nitrogen dioxide (maximum one hour

average) and ozone (maximum one hour average and maximum eight hour average).

(3) Historic air quality data. The EPA collects and stores historical data. Approximately two years of historical automatic measurements data are now available on line. The data on air quality for previous years is available on the EPA's archive, but only in hard copy format.

(4) Reports. The EPA produces annual air quality reviews. These are available on their web site for the years 1998 to 2001. The Annual Report on the Environmental Status also includes data on air quality, as well as the other environmental sectors. For example, the 2002 annual report featured a report describing how concentrations of PM_{10} in certain parts of Vilnius had exceeded limit values during the winter, when the wind speed was very low, due to winter sanding. The feature included graphs explaining the correlation of the hourly concentrations of PM_{10} and wind speed. The annual report is available on the internet. Hard copies are available; members of the public can purchase them from the Ministry of Environment.

It is also possible to telephone the Ministry of Environment's Public Information Division (+370 52 366 3659) and the EPA's Air Quality Division (+370 52 727 827/9) to request further information, but there is no recorded telephone service on current levels of air pollutants.

The Lithuanian EPA's web site contains very detailed information on air quality in the form of graphs and tables to show the pollutant levels. The limit values are marked in red, thus it is very clear to see when the exceedence occurred and the level of the exceedence. Since the majority of information is actively disseminated only through the medium of the EPA's web site, this can of course cause difficulties for persons without internet access seeking information.

5.3. Role of the institutions involved in ambient air quality assessment

The department of public information and public service of the Ministry of Environment provides information on the work of the Ministry, news and environmental problems for the public and media on a regular basis. To serve this purpose press releases are prepared and media conferences organised. Information is provided in the Ministerial web site.

The public information division under the Department of public information and public service provides information to the public by phone and to those visiting in person.

The EPA is responsible for ambient air quality monitoring and assessment at a national level and also for the provision of information to the public.

Municipalities collect and maintain information on environment and ambient air in their territories. Each municipality should have an order of provision of information on the environment to the public and a list of information on the environment available in the Municipalities.

The ambient air assessment programme (approved by Ministerial Order No. 517M 23rd October 2003 amended by Minisgterial Order no D1-30, 17th January 2005 sets ambient air quality management objectives, measures for their implementation and a schedule for implementation, as well as naming responsible institutions for the implementation of each measure. The programme covers measures for the period of 2003 to 2008.

The EPA is responsible for reporting directly to the EC through the Central Data Repositorium. In addition, the EPA provides information for WHO through the Public Environmental Health Centre and Eurostat through the Lithuanian Statistics Department.

5.4. Inter-institutional exchange of the information (ICISEM)

In order to ensure effective standardised inter-institutional exchange of data, data quality, security and management, and to facilitate reporting to the EU and national institutions and public, the Integrated Computerised Information System for Environmental Management (ICISEM) has been established in the Ministry of Environment.

The goal, data submitters and receivers, management of gathered and developed data, organisation of the system etc. are set in regulation (currently under preparation, to be adopted by the end of 2006) of the ICISEM. The Information management department at the Ministry of Environment is responsible for ICISEM operation.

The regulation states that the supervisor (lt: valdytojas) of the ICISEM is the Ministry of Environment and the manager (lt: tvarkytojas) is the EPA, which receives or gathers data from different services and institutions. The EPA is the main submitter of data. Data is submitted to the ICISEM from other institutions related to the environmental monitoring, such as the Regional Environmental Protection Departments, State Environmental Protection Inspection, Lithuanian Geological Service, Lithuanian Hydrometeorological Service and others.

The information is submitted to the Lithuanian organisations responsible for the management of environmental quality, analysis and submission of the information, and decision making, EU and international organisations that use information on the quality of Lithuanian Environment, Scientific research institutions, consultants and experts who develop environmental impact assessment, as well as to the public.

The ICISEM is based on an Oracle Database and receives data from existing data bases in different sectors of the environment, e.g. ENVI, ISMA, GeoEnviron, Geolis and other information systems.

Ambient air monitoring information is among the subsystems developed under the ICISEM. The other subsystems are surface water, radiation, chemical substances and industrial pollution to ambient air and water.

The EPA is responsible for preparation of queries with a queries generator, information collection, training of users, submission of metadata, and submission of data to the public on the internet.

In the follow up of the development of ICISEM between 2008 and 2011, additional subsystems, such as meteorological data, dangerous chemical substances, management of extreme situation and other will be added to the integral system.