F 7/2010

Air Quality Monitoring and Management

Seminar

Burgas, Bulgaria 26-27 May 2010

Bjarne Sivertsen, Leif Marsteen and Claudia Hak

Norsk institutt for luftforskning
Norwegian Institute for Air Research
NILU

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Seminar

1 Introduction

The objective of this seminar is to present the total air quality management planning system. The different elements of the air quality monitoring and management system will be presented based on internationally accepted standards through a 2 day seminar. The participants should be practitioners and experts from environmental monitoring institutes as well as stakeholders and people interested in air pollution issues.

The seminar is being presented as lectures over two days covering monitoring and sampling methods and equipment, EU legislation and directives, WHO guidelines and EU legislation, key air quality parameters, methods of data collection, validation, analysis and reporting and air quality planning.

The schedule for the presentations are presented in Appendix A and a summary of the topics in the following:

Day 1: Wednesday 26 May 2010

09:15 Air quality management
10:30 Monitoring programme design
11:30 Instrumentation; monitoring and sampling
13:30 Monitoring and sampling, network operation
14:30 Quality systems, QA/QC

Day 2: Thursday 27 May 2010

09:00 Air quality legislation
10:00 Legislation Bulgaria (by Municipality)
10:45 Air quality assessment and reporting
13:15 Results from the screening study, Burgas
14:15 Data dissemination
14:45 Air quality management planning
15:30 Summary, conclusions and discussions
16:00 End of Seminar

The transparencies used during the course are presented in Appendix B.

2 Air quality management

An air quality management plan must within the domain of the relevant national department, province or municipality seek to:

- Give effect, in respect of air quality, and relate to National Environmental Management Plans;
- Improve air quality;
- Identify and reduce the negative impact on human health and the environment of poor air quality
- Address the effects of emissions from the use of fossil fuels in residential applications;
- Address the effects of emissions from industrial sources;
- Address the effects of emissions from any point or non-point source also other than the ones stated above;
- Implement the nation's obligations in respect of international agreements and
- Give effect to best practice in air quality management;

The Air Quality Management Plan (AQMP) should also describe how the relevant national department, province or municipality would comply with such other requirements as may be prescribed.

The main purpose of the AQMP development process is to establish an effective and sound basis for planning and management of air quality in the selected area. This type of planning will ensure that significant sources of impacts are identified and controlled in a most cost-effective manner. The best air quality management tools and practices may be used in order to assure the most adequate solutions. The ultimate goal will thus be to assure that health effects and impact on building materials and the environment will be avoided in the future.

The development of the AQMP will take into account:

- Air Quality Management System (AQMS) requirements
- Operational and functional structure requirements
- Source identification through emission inventories
- Source reduction alternatives, which may be implemented
- Mechanisms for facilitating interdepartmental cooperation in order to assure that actions are being taken
- Institutional building and training requirements

Important elements of the AQMP are the identification of sources and development of a complete emission inventory, the development and operations of an air quality monitoring programme and the development and application of dispersion models.

A major task in this work is to collect the necessary input data. The programme starts with preliminary assessments based on available data and the identification of zones into which the country will be divided. We assume that the setting of standards and regulations is already available.

3 Monitoring programme design

The typical approach to network design involves placing monitoring stations or sampling points at carefully selected representative locations, chosen on the basis of required data and known emission/dispersion patterns of the pollutants under study. This scientific approach will produce a cost effective air quality monitoring programme. Sites must be carefully selected if measured data are to be useful. Moreover, modelling and other objective assessment techniques may need to be utilized to “fill in the gaps” in any such monitoring strategy.

Another consideration in the basic approach to network design is the scale of the air pollution problem:

- The air pollution is of predominantly local origin. The network is then concentrated to within the urban area. (e.g NO_2, SO_2, PM_{10}, CO, benzene)
- There is a significant regional contribution to the problem and more emphasis will be on the regional part. (e.g. Ozone, PM).

The design of the air quality monitoring programme will depend upon the measuring strategy, which again depends on the objectives of the monitoring, and the pollutants to be assessed. For the relevant air quality parameters or selected indicators the concentration of pollutants and associated averaging time need to be specified. Specifications are also needed on where, how, and how often measurements should be taken.

In the initial design phase we will have to evaluate:

- The variation of pollutant concentrations in space and time;
- The availability of supplementary information;
- The accuracy of the estimate, that is required.

It may be possible to derive, in quantitative terms, a measuring strategy from this information

The number of monitoring stations and the indicators to be measured at each station in the final permanent network may then be decided upon based on the results of the screening study as well as on knowledge of sources and prevailing winds.

Once the objective of air sampling is well-defined and some preliminary result of the screening study is available, a certain operational sequence has to be followed. A best possible definition of the air pollution problem together with an analysis of available personnel, budget and equipment represent the basis for decision on the following questions:

1. What spatial density of sampling stations is required?
2. How many sampling stations are needed?
3. Where should the stations be located?
4. What kind of equipment should be used?
5. How many samples are needed, during what period?
6. What should be the sampling (averaging) time and frequency?
7. What additional background information is needed:

- Meteorology,
- Topography,
- Population density,

- Emission sources and emission rates,
- Effects and impacts.

8. What is the best way to obtain the data (configuration of sensors and stations)?
9. How shall the data be accessible, communicated, processed and used?

4 Air quality legislation

Ambient standards define targets for air quality management and establish the permissible amount or concentration of a particular substance in or property of discharges to the atmosphere, based on what a particular receiving environment can tolerate without significant deterioration.

The relevant laws, regulations, standards and guidelines will be used as mechanisms to obtain information on atmospheric impacts, which in turn will be used to evaluate predicted impacts against the ambient standards.

Part of the development of the air quality management programme includes training, institutional building and information management.

Air quality management education should be integrated in all education programmes, at all levels, in all curricula and disciplines of formal and non-formal education in the national qualification framework.

The EU limit values specify for most of the compounds a certain number of hours or days when the limit value may be exceeded. The Directives also clearly specify the proportion of valid data needed as well as margin of tolerance. A summary of limit values is presented in the Table below.

Pollutant	Averaging time	Limit- and Guidelines Values	
		EU[1] 1)	WHO
Sulphur Dioxide (SO_2)	1 hour	350 (24 x)	500 (10 min)
	24 hours	125 (3 x)	50 *
	Year	-	-
Nitrogen Dioxide (NO_2)	1 hour	200 (18 x)	200
	Year	40	40
Ozone (O_3)	1 hour	-	150-200
	8 hours	120 *)	120
Carbon Monoxide (CO)	1 hour	-	30 000
	8 hours	10 000	10 000
Particles < 10 µm (PM10)	24 hours	50 (35 x)	(150) 50
	Year	40	(50) 20
Particles < 2,5 µm PM2,5)	24 hours	-	(75) 25
	Year	25	(25) 10
Benzene	Year	5	-
Lead (Pb)	Year	0,5	0.5-1,0

[1] Ref: EU limit values for protection of human health (2008/50/EC). (n x) not to be exceeded more than n times.

More details concerning EU limit values are presented in Appendix B.
The EU Directives also specify lower and upper threshold values which indicate levels at which air quality assessment and measurements has to be undertaken.

The development of information dissemination systems could be important elements in the awareness campaigns initiated for air quality management planning, together with training of the provincial environmental departments. The campaigns should be implemented by the local government for general air pollution, and the provincial environmental departments for hazardous and industrial emissions.

5 Instrumentation; monitoring and sampling

Instruments for measurements of air pollutants may vary strongly in complexity and price from the simplest passive sampler to the most advanced and most often expensive automatic remote sampling system based upon light absorption spectroscopy of various kinds. The following Table indicates four typical types of instruments, their abilities and prices.

Different types of instruments, their abilities and price.

Instrument type	Type of data collected	Data availability	Typical averaging time	Typical price (US $)
Passive sampler	Manual, in situ	After lab analyses	1-30 days	10
Sequential sampler	Manual /semi-automatic , in situ	After lab analyses	24 h	1 000
Monitors	Automatic Continuous, in situ	Directly, on-line	1h	>10 000
Remote monitoring	Automatic/Continuous, path integrated (space)	Directly, on-line	<1 min	>100 000

Relatively simple equipment is usually adequate to determine background levels (for some indicators), to check Air Quality Guideline values or to observe trends. Also for undertaking simple screening studies, passive samplers may be adequate. However, for complete determination of regional air pollution distributions, relative source impacts, hot spot identification and operation of warning systems more complex and advanced monitoring systems are needed. Also when data are needed for model verification and performance expensive monitoring systems are usually needed.

The instruments most often applied to measure the main air pollution indicators are automatic monitors. These instruments are developed by several different providers, but they all should be using so called reference methods for analysing the air. Methods and instruments for measuring continuous air pollutants must be carefully selected, evaluated and standardised. Several factors must be considered:

- *Specific*, i.e. respond to the pollutant of interest in the presence of other substances,
- *Sensitive* and range from the lowest to the highest concentration expected,

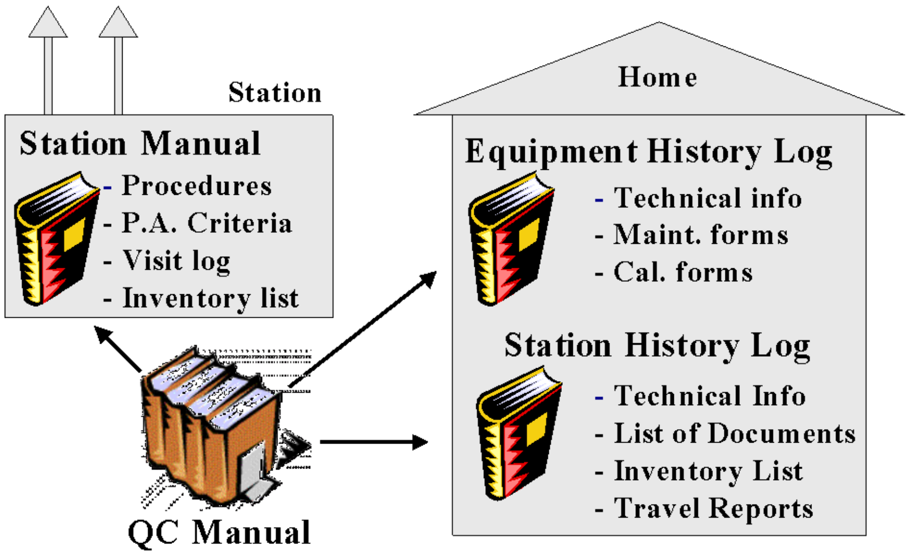
* *Stable*, i.e. remain unaltered during the sampling interval between sampling and analysis,
* *Precise, accurate* and representative for the true pollutant concentration in the atmosphere where the sample is obtained,
* Adequate for the *sampling time* required,
* *Reliable and feasible* relative to man power resources, maintenance cost and needs,
* Zero drift and calibration (at least for a few days to ensure reliable data),
* Response time short enough to record accurately rapid changes in pollution concentration,
* Ambient temperature and humidity shall not influence the concentration measurements,
* Maintenance time and cost should allow instruments to operate continuously over long periods with minimum downtime,
* Data output should be considered in relation to computer capacity or reading and processing.

If one considers the typical air concentrations of some pollutants of interest in air pollution studies, it is seen that as we go from background to urban atmosphere, the concentration for the most common pollutants increases roughly by a factor 1000. In the next step from urban to emission we see another factor of about 1000. The specified range for the given instrument has therefore to be selected based on the purpose of the measurements.

The measurement reference methods as specified by the European Union was given in the EU Council Directive 1999/30/EC. A brief summary of these reference methods is presented in the course.

6 Monitoring and sampling, network operation

As a basis for operating the air monitoring system all quality system documentation should be compiled into a Quality Manual. When installing quality documentation at a measurement station, copies will be made from relevant documents in the Quality Manual. The documentation at the measurement station is compiled into a Station Manual. The manual includes all Standard Operation Procedures (SOPs), forms and other documentation used at that particular station. At “home” a history log is compiled for each measurement instrument. The history log will include remarks on maintenance, repairs, etc. as well as service and calibration reports. The figure below shows the conceptual design of the quality documentation.



The Quality Manual and distributed documentation.

The content of the SOPs will be based on the instruction manuals delivered with the instruments. References will be made to the instruction manuals as necessary. The aim is to provide easy to read "cookbooks" that secure unified operation of instruments by all operators. All operations that may influence the quality of the measurement results should be covered by SOPs. A specific form in which the operator documents his or her work shall accompany all SOPs. The forms are stored in the history log for later reference.

The following SOPs should be available:

- SOPs on installation, operation and maintenance of instruments
- SOPs on calibration of instruments and gas cylinders
- SOPs/guidance documents on fault finding and trouble shooting
- Action limits specific for each type of instrument
- SOP on data validation
- Description of measurement methods
- Description of traceability in calibrations

7 Quality systems

In ambient and emission air quality measurement systems, the Quality System is concerned with all activities that contribute to the quality of the measurements. The aim of the Quality System is to assure that the results meet the predefined standards of quality. To produce results of known and sufficient quality there is a whole range of tasks to be performed such as periodic status checking, maintenance, calibrations, data evaluation and so on. Failure to perform all or some of these tasks will decrease the data quality.

The Quality System shall assure that:

- Data is reliable for its intended use (fulfils the Data Quality Objectives).

- Data has known quality (fulfils the performance standards).
- Data from different sites can be compared.
- The receiver of the measurement results (management, public, etc.) has confidence in the results.

The quality terms relevant for Quality Assurance/Quality Control (QA/QC) procedures and criteria can be defined as follows (ISO 8402, 1994):

- Quality is the totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs.
- Quality Assurance involves the management of the entire process which includes all the planned and systematic activities which are needed to assure and demonstrate the predefined quality of data, to provide adequate confidence that an entity will fulfil requirements for quality.
- Quality Control comprises the operational techniques and activities that are undertaken to fulfil the requirements for quality.

The Quality Assurance activities cover all the pre-measurement phases, ranging from definition of data quality objectives to equipment and site selection and personnel training. The Quality Control activities cover all operational work such as routine maintenance, calibration, data collection, data validation and data reporting. For emission inventories and modelling it may cover activities such as entering or editing emission data in the emission inventory, running models and reporting results. In addition to Quality Assurance and Quality Control, a third activity called Quality Assessment is usually implemented in the Quality System. The Quality Assessment provides for a periodic external audit of the Quality System and the operational activities. Quality Assurance, Quality Control and Quality Assessment will all be parts of the Quality Plan. They have to be operational and co-ordinated and must be considered as necessary parts of any Air Quality Management System.

7.1 The Quality organisation

A modern integrated Air Quality Management System (AQMS) is a complex system. It may cover very different activities such as instrument maintenance, data collection, emission inventories, running models, data reporting and audits. People working on the system will range from technicians maintaining instruments to planners running air quality models. In addition the AQMS can span several industries and geographical areas.

The quality organisation will typically include the following functions/people:

- Operators focused on Quality Control
- The Quality Manager focused on Quality Assurance
- The Reference Laboratory focused on Quality Assurance and Quality Assessment

The operators run instruments, computer systems and models. They report status on quality matters to the Quality Manager. The Quality Manager has the overall responsibility for the Quality System within the measurement network. It is the responsibility of the Quality Manager to assure that the operators are running the AQMS in compliance with the requirements of the Quality System. The Quality Manager will report any requests for changes or updates in the quality documentation to the Reference Laboratory. The Quality Manager will be responsible for initiating training programs.

A workshop/calibration laboratory will be responsible for service, repair and calibration of instruments. The calibration laboratory will ensure that the measurement instruments are in good working order and calibrated with traceability to the Reference laboratory.

7.2 The Reference Laboratory

Article 3 of the Framework directive calls for the designation of bodies responsible for ensuring accuracy of measurements etc. This implies the appointment of a Reference Laboratory. The Reference Laboratory will be responsible for administration and maintenance of the Quality System. This typically includes preparing new procedures and updating the quality documentation. The Reference Laboratory will also maintain the reference calibration standards. The reference standards will represent the highest level of calibration in the country. The Reference laboratory will provide traceability to the reference standards to all measurement instruments in the monitoring network. This can be accomplished either by having the Reference Laboratory calibrating all calibration materials used in the nework or if the network has a suitable calibration laboratory only calibrating their reference standards.

The Reference Laboratory will perform audits in the measurement network to assess the actual quality of the measurements. Based on the results of the audits the Reference Laboratory will advise the network operators on how to improve the data quality. A yearly data quality assessment report will be submitted to the authorities.

The Reference Laboratory will participate in international intercomparison tests to verify its competence and to establish international traceability. It will also participate in international working groups such as the group of National Air Quality Reference Laboratories in Europe (AQUILA) to get exchange information and to harmonise the quality work with other countries.

7.3 The Quality documentation

To ensure unified operation across the AQMS, a documented quality system is necessary. The Quality System will be documented in the Quality Manual. The Quality Manual will consist of two main parts:

- Quality Assurance - Management level.
- Quality Control - The daily work.

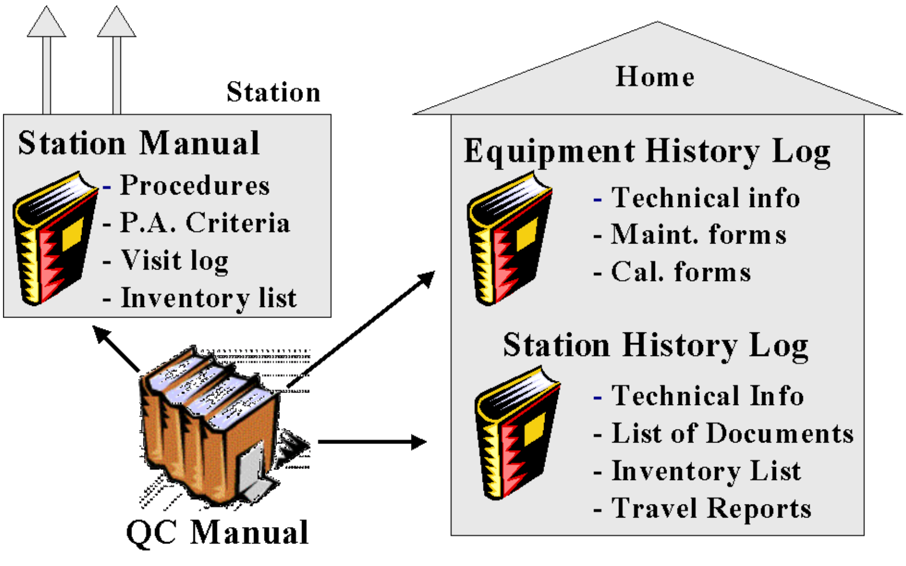
The Quality Assurance part of the Quality Manual will include a description of:

- The overall objective of the Quality system.
- How responsibilities, tasks and functions are shared between the parties involved in the quality work.
- The Data Quality Objectives (DQO) based on the intended use of the data.
- Instrument performance standards and criteria (performance acceptance criteria) based on the DQOs.
- Quality System audits.
- Training programs for operators.
- Document handling and document version control

The performance standard/criteria related to air (and emissions) monitoring are based upon the setting of Data Quality Objectives (DQO). The performance acceptance criteria related to monitoring are then set so that the DQOs specified are fulfilled.

To keep the measurement instruments within the limits of the performance acceptance criteria it is necessary to operate them (maintain, calibrate, service, repair, etc.) according to certain procedures. The computer systems, covering data collection, database maintenance and use of the modelling tools has to be operated according to certain procedures too. These procedures, called Standard Operations Procedures (SOPs), are collected in the Quality Control part of the Quality Manual.

The figure below shows the conceptual design of the quality documentation.



The Quality Manual and distributed documentation

The Quality Control part of the Quality Manual will include procedures on:

- Maintenance of measurement instruments
- Calibration of measurement instruments
- Data collection
- Data validation
- Computer and data systems maintenance
- Quality System audits
- Training

Each SOP will be documented in a specific form. The form will be completed by the operator during the execution of the SOP and stored systematically for later reference.

A station manual is kept at the station containing documents necessary for operating that specific station. At home all equipment and the shelter itself will have a history log book where notes and documentation on the equipment is stored. The main documentation at a site is:

- Standard Operations Procedure (SOP) for each instrument at the site
- A form for each SOP to document the procedure
- Performance Acceptance Criteria specific to the instrumentation at the site

8 Air quality assessment and reporting

In general it is always necessary to perform standardized statistical analysis in order to assess air quality trends, changes in emissions or impact from specific types or groups of sources. The severity of the air pollution problem or the air quality should be specified relative to air quality guideline (AQG) values, standards or predefined levels of classification (e.g. good, moderate, unhealthy or hazardous).

The number of hours and days, or percentage of time when the air pollution concentrations have exceeded AQG values should be presented. This will also need minimum requirements of data base completeness. Long-term averages (annual or seasonal) should be presented relative to AQG.

Before undertaking statistical evaluations the data should be presented and validated based upon a form of time series. These data must be evaluated logically to correct for drift in instruments, and eliminate data that are identified to be including errors. It is also important that the data are checked with other relevant information.

Different use of the data collected and different presentations are needed for the different users. Data presentations have been produced to meet the requirements from:

- Specialists on air pollution,
- Policy makers and
- The public.

The ***specialist*** often needs a tool that gives easy access to the data with the ability to treat these data in different ways. The specialist also wants to apply the data and prepare his own way of presenting results graphically.

The ***policy makers*** need presentations that illustrate the conclusions that the specialist has drawn from the information available. This is usually best done through a graphical presentation.

The ***public*** needs information on the general state of the environment. The type of information that is needed is more general than that of the policy maker. It often needs to cover environmental issues that are of special concern to the public. This could be the air quality that is expected to occur in the urban area on this specific day. This information could be given as a short term forecast or based upon actual on-line data.

9 Data dissemination

Data dissemination and information to the public is an important tool in raising public awareness. Data can be prepared and distributed from databases in many different ways to meet the needs of the users. Data presentation systems are often based on the air quality management system. Several applications have also been designed for use directly in Internet presentations, WAP (Wireless Application Protocol) solutions, SMS (Short Message Service) and MMS (Multimedia Messaging Solution) services. Several projects have been designed for utilizing such services and also in international research programmes like EU-Information Society of Tomorrow e.g. through the APNEE (www.apnee.org) project where links to several Web pages in Europe may be found.

10 Air quality management planning (AQMP)

Optimal abatement strategies have been developed based on air quality measurements combined with models, dose response functions and effect/cost estimates. These approaches have produced a list of the most cost effective actions that could be implemented in selected cities in Europe and Asia.

The AQMP approaches have been performed to assist in the design and implementation of policies, based on monitoring, and management in order to restore the air quality in large urban areas. Its goal was to identify the components of a general action plan to manage and control air pollution. Abatement measures in the plan were categorized according to cost-effectiveness, as well as the time required implementing them and when they would become effective.

The air quality management strategy planning system (AQMS) contains the following main components:

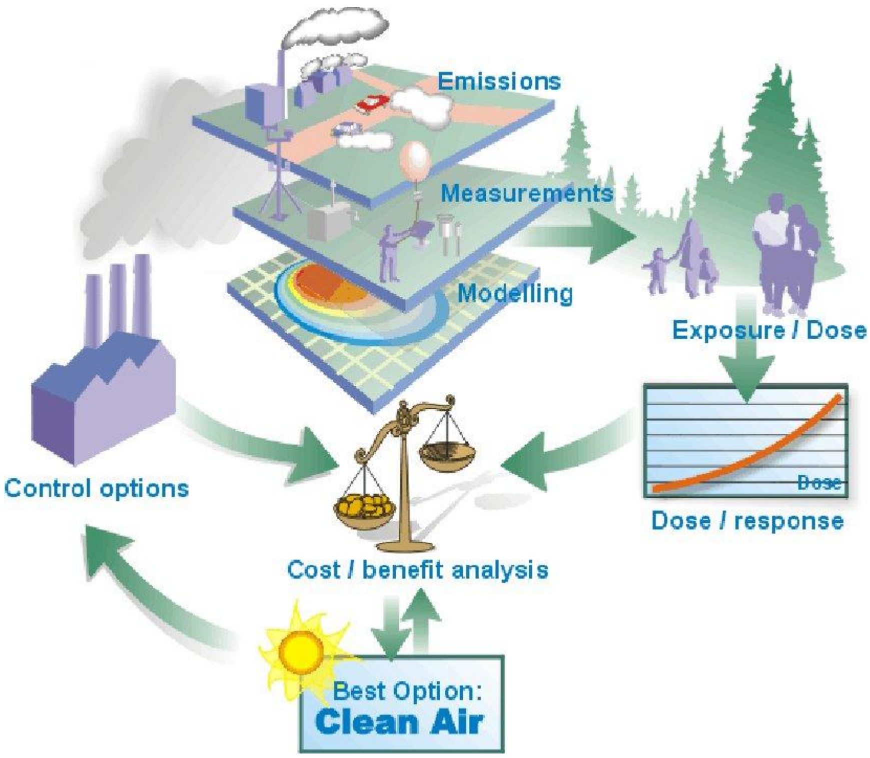
- Air quality assessment
- Environmental damage assessment
- Abatement options assessment
- Cost-benefit or cost-effectiveness analyses
- Abatement measures
- Optimum control strategy

Assessment: Air quality assessment, environmental damage assessment and abatement options assessment provide input to the cost analysis, which is also based on established air quality objectives (e.g. air quality standards) and economic objectives (e.g. reduction of damage costs). The analysis leads to an Action Plan containing abatement and control measures for implementation in the short, medium, and long term. The goal of this analysis is an optimum control strategy.

The AQMS depends on the following set of technical and analytical tasks, which can be undertaken by the relevant air quality authorities:

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

These activities, and the institutions necessary to carry them out, constitute the prerequisites for establishing the AQMS as illustrated in the Figure below.



The elements of an optimal abatement strategy planning system.

Action plans and implementation: Categories of “actions” include the following:
- Technical abatement measures;
- Improvements of the factual database (e.g. emission inventory, monitoring, etc.);
- Institutional strengthening;
- Implementing an investment plan;
- Awareness raising and environmental education.

Monitoring: A third essential component of AQMS is continued monitoring, or surveillance. Monitoring is essential to assessing the effectiveness of air pollution control actions. The goal of an Air Quality Information System (AQIS) is, through thorough monitoring, to keep authorities, major polluters and the public informed on the short- and long-term changes in air quality, thereby helping to raise awareness; and to assess the results of abatement measures, thereby providing feedback to the abatement strategy. This part of the AQMS will also include institutional building and training in order to assure sustainability in the system established in the area or region in question.

A system for air quality management requires activities in the following fields:
- Inventorying of air pollution activities and emissions
- Monitoring of air pollution, meteorology and dispersion
- Calculation of air pollution concentrations, by dispersion models
- Inventorying of population, materials and urban development
- Calculation of the effect of abatement/control measures
- Establishing/improving air pollution regulations

The implementation of plans and strategies for air quality improvements is done through the use of policy instruments by ministries, regulatory agencies, law enforcers and other institutions. Indeed, some of these institutions may well be the same institutions as those, which must be in place to carry out the AQMS analysis described above, which ideally is the basis for the plans and strategies. Thus, the existence of relevant institutions, and an organisational institution structure, is part of the basis for AQMS work.

Different levels of government - national, regional and local - have different roles and responsibilities in the environmental sphere. Air quality standards or guidelines are usually set at the national level, although local governments may have the legal right to impose stricter regulations. National governments usually assume the responsibility for scientific research and environmental education, while local governments develop and enforce regulations and policy measures to control local pollution levels.

Institutional arrangements, laws and regulations are important parts of an AQMS. Some countries have their own political and administrative hierarchies and technical expertise that affect institutions, laws and regulations related to air pollution control. Some examples of NILU applied AQMS procedures are being presented in Appendix B based on project undertaken in China, (such as

Guangzhou, and the Shanxi province) and in Vietnam. One of the experiences from these studies is pointing at the importance of clarity in the organisational structures and the division and description of responsibilities and "lines-of-command".

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World Health Organization (2005) WHO air quality guidelines global update 2005 Report on a Working Group meeting, Bonn, Germany, 18-20 October 2005. Copenhagen, WHO Regional Office for Europe (EUR/05/5046029). URL: http://www.euro.who.int/Document/E87950.pdf

Appendix A

Contents of the seminar

Day 1: Wednesday 26 May 2010

Morning

09:00 Welcome
Introduction

09:15 Air quality management
Sources
Monitoring
Air quality assessment
Modelling
Data dissemination
Abatement planning

10:15 Break

10:30 Monitoring programme design
Objectives
Design the programme
Air quality indicators
Operational sequence
Meteorological data
The mobile station

11:30 Instrumentation; monitoring and sampling
Fields of application
Measurement principles and standard measurement methods
Data logging and data collection
Operational costs
Procurement, installation and start-up of measurement stations
Commercially available instruments and data collection systems

12:30 LUNCH

Afternoon

13:30 Monitoring and sampling, network operation
Routine operation, site visits
Preventive maintenance
Calibrations, service and repairs
Data validation

14:30 Quality systems, QA/QC
Quality Assurance, Quality Control and Quality Assessment
References to EU directives, tasks of The National Reference Laboratory
Requirements for traceability in calibrations, nationwide and internationally

Intercomparison exercises and demonstration of measurement capabilities
Quality manual overview, examples of procedures
Accreditation and references to ISO 17025

15:30 Questions and Discussions
16:00 End of day 1

Day 2: Thursday 27 May 2010

Morning
09:00 Air quality legislation
Guidelines and limit values
WHO guidelines
EU Directives
Framework directives
Daughter directives
Limit values and standards

10:00 Legislation Bulgaria (by Municipality)

10:30 Break

10:45 Air quality assessment and reporting
Statistics
Air quality and meteorology
Exceeding limit values
Possible impacts (health and nature)
Designing the AQ report

11:45 Questions and discussions

12:15 LUNCH

Afternoon day 2

13:15 Results from the screening study, Burgas
The sampling programme
Passive sampling, results
PM sampling in situ
General aspects of the air quality

14:15 Data dissemination
Requirements for data dissemination with references to EU directives
Different information channels, Web, e-mail, SMS, radio, TV
Information adapted to different audiences, public, experts, decision makers

Information content, online data, historical data, warnings, forecasting, reports,
Reporting to the European Commission
Live example (internet connection required)

14:45 Air quality management planning
Models
Emission inventories (point, area, line-sources)
Concentration distribution and exposure
Impact assessment
Abatement strategies
Action plans – future air –scenario evaluation

15:30 Summary, conclusions and discussions

16:00 End of Seminar

Appendix B

The transparencies used during the presentations

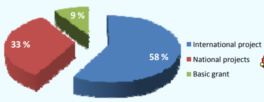
The Norwegian institute for Air Research

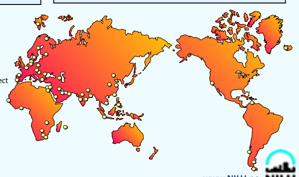
NILU

Making a difference for the environment

Founded in 1969
Independent foundation from 1986
Annual turnover 184 MNOK (24 MEuro)

192 employees
56 scientists with a PhD
Offices in 4 countries





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Seminar schedule

AQM Burgas 26 - 27 May 2010

Day 1, 26 May 2010
1 Air quality management
2 Monitoring programme design
3 Instrumentation; monitoring and sampling
4 Monitoring and sampling, network operation
5 Quality systems

Day 2, 27 May 2010
6 Air quality legislation
Legislation Bulgaria
7 Air quality assessment and reporting
8 Results from screening study Burgas
9 Data dissemination
10 Air quality management planning
11 Summary, conclusions and discussions

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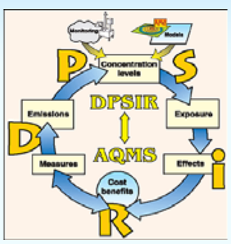
Air Quality Management

Introduction

Bjarne Sivertsen, NILU



Sources
Monitoring
Air quality assessment
Modelling
Data dissemination
Abatement planning

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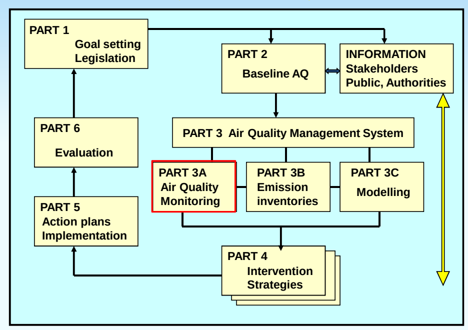
AQMP *A dynamic process*



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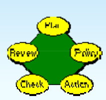
The Air Quality Management Plan (AQMP)

Take into account :

- Existing Air Quality status, identify the problems
- Operational and functional structure requirements
- Source identification through emission inventories
- Implementable source reduction alternatives
- Mechanisms for facilitating interdepartmental cooperation
- Institutional building and training requirements



AQM System

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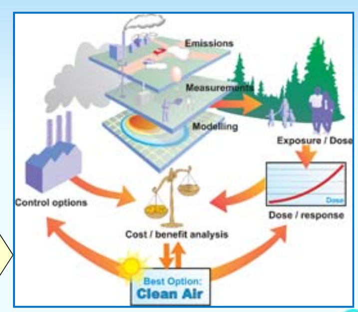
AQMS – main objective:

Identify actions to improve air quality



Identify most cost-effective options

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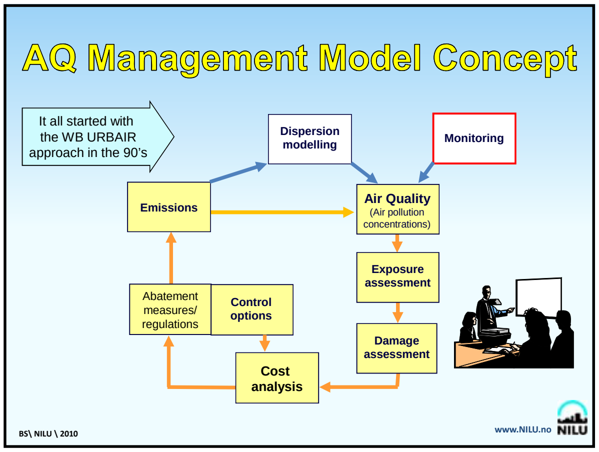
AQ Management Model Concept
It all started with the WB URBAIR approach in the 90's
Dispersion modelling
Monitoring
Emissions
Air Quality (Air pollution concentrations)
Exposure assessment
Abatement measures/ regulations
Control options
Damage assessment
Cost analysis
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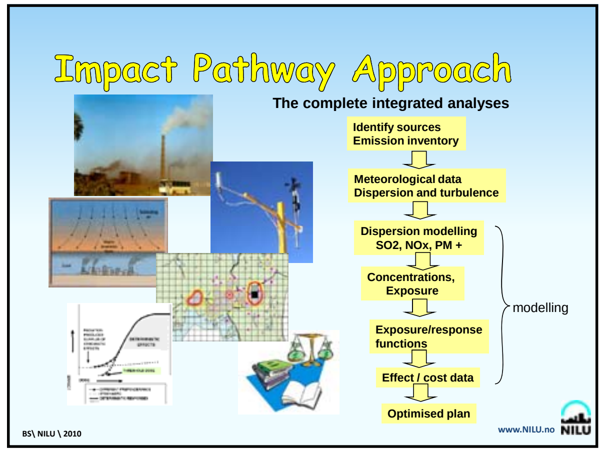
Impact Pathway Approach
The complete integrated analyses
Identify sources Emission inventory
Meteorological data Dispersion and turbulence
Dispersion modelling SO2, NOx, PM +
Concentrations, Exposure
Exposure/response functions
Effect / cost data
Optimised plan
modelling
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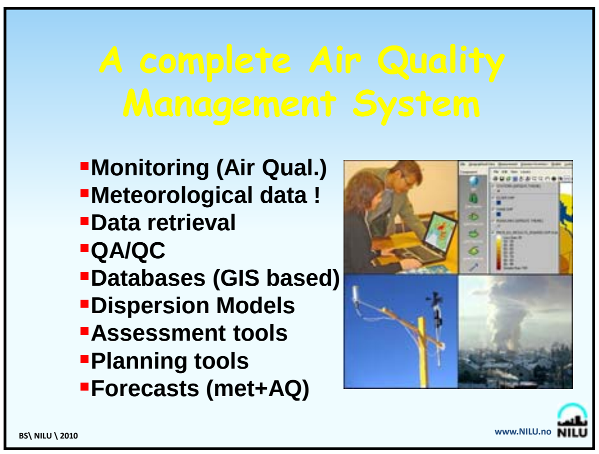
A complete Air Quality Management System
Monitoring (Air Qual.)
Meteorological data !
Data retrieval
QA/QC
Databases (GIS based)
Dispersion Models
Assessment tools
Planning tools
Forecasts (met+AQ)
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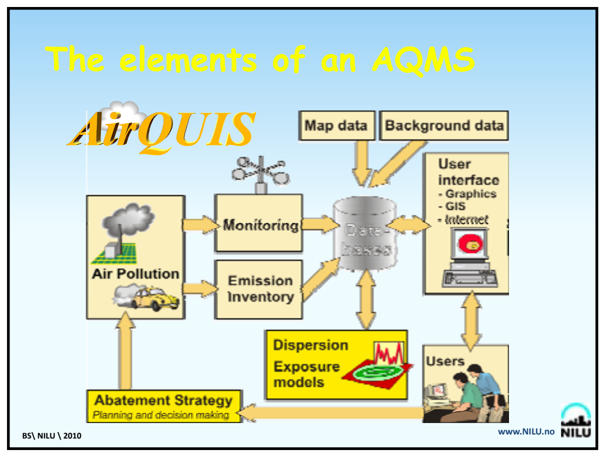
The elements of an AQMS
AirQUIS
Map data
Background data
User interface
- Graphics
- GIS
- Internet
Air Pollution
Monitoring
Emission Inventory
Data bases
Dispersion Exposure models
Users
Abatement Strategy
Planning and decision making
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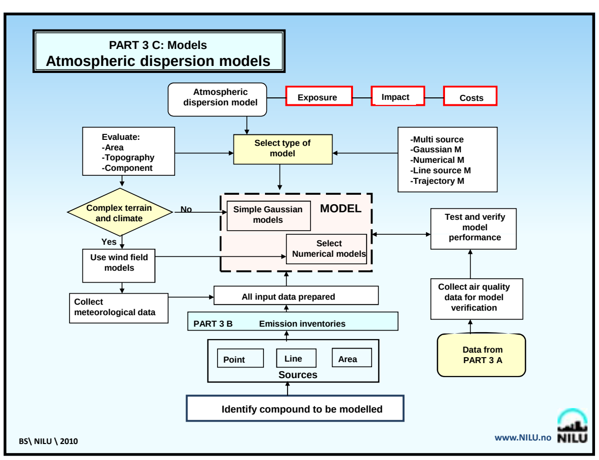
PART 3 C: Models
Atmospheric dispersion models
Atmospheric dispersion model
Exposure
Impact
Costs
Evaluate: -Area -Topography -Component
Select type of model
-Multi source -Gaussian M -Numerical M -Line source M -Trajectory M
Complex terrain and climate
No
Yes
Simple Gaussian models
MODEL
Select Numerical models
Test and verify model performance
Use wind field models
Collect meteorological data
All input data prepared
Collect air quality data for model verification
PART 3 B
Emission inventories
Point
Line
Area
Sources
Data from PART 3 A
Identify compound to be modelled
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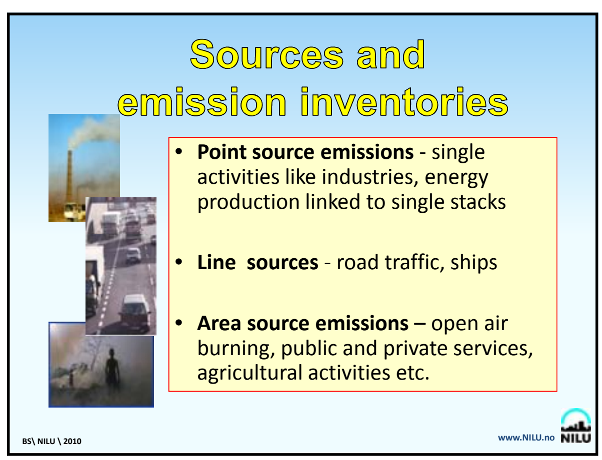
Sources and emission inventories
Point source emissions - single activities like industries, energy production linked to single stacks
Line sources - road traffic, ships
Area source emissions – open air burning, public and private services, agricultural activities etc.
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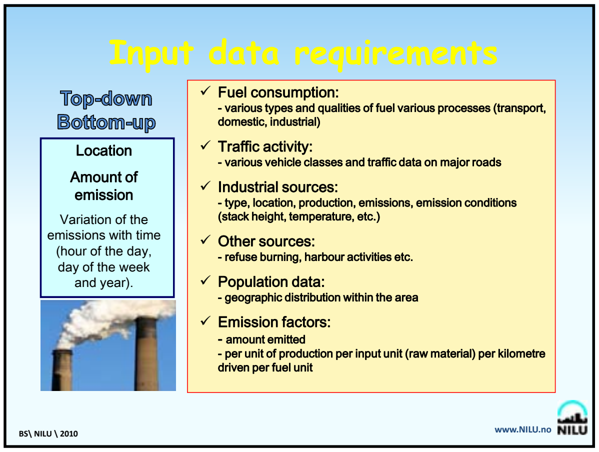
Input data requirements
Top-down
Bottom-up
Location
Amount of emission
Variation of the emissions with time (hour of the day, day of the week and year).
✓ Fuel consumption:
- various types and qualities of fuel various processes (transport, domestic, industrial)
✓ Traffic activity:
- various vehicle classes and traffic data on major roads
✓ Industrial sources:
- type, location, production, emissions, emission conditions (stack height, temperature, etc.)
✓ Other sources:
- refuse burning, harbour activities etc.
✓ Population data:
- geographic distribution within the area
✓ Emission factors:
- amount emitted
- per unit of production per input unit (raw material) per kilometre driven per fuel unit
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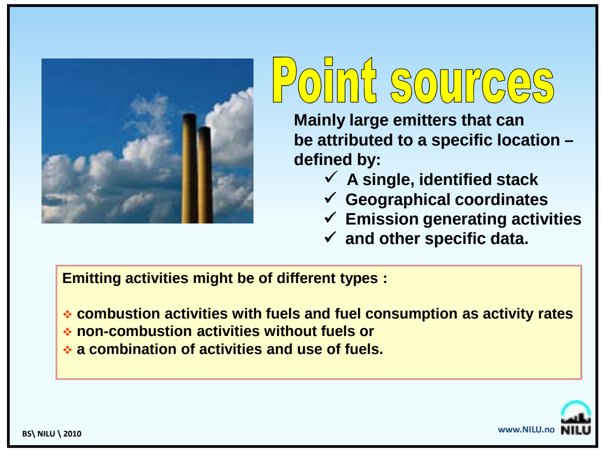
Point sources
Mainly large emitters that can be attributed to a specific location – defined by:
✓ A single, identified stack
✓ Geographical coordinates
✓ Emission generating activities
✓ and other specific data.
Emitting activities might be of different types :
combustion activities with fuels and fuel consumption as activity rates
non-combustion activities without fuels or
a combination of activities and use of fuels.
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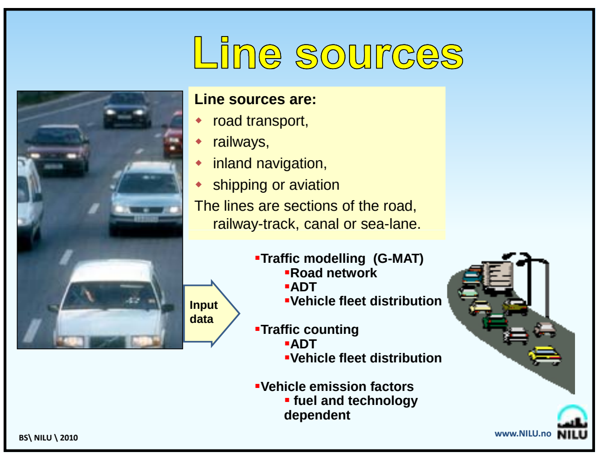
Line sources
Line sources are:
road transport,
railways,
inland navigation,
shipping or aviation
The lines are sections of the road, railway-track, canal or sea-lane.
Input data
Traffic modelling (G-MAT)
Road network
ADT
Vehicle fleet distribution
Traffic counting
ADT
Vehicle fleet distribution
Vehicle emission factors
fuel and technology dependent
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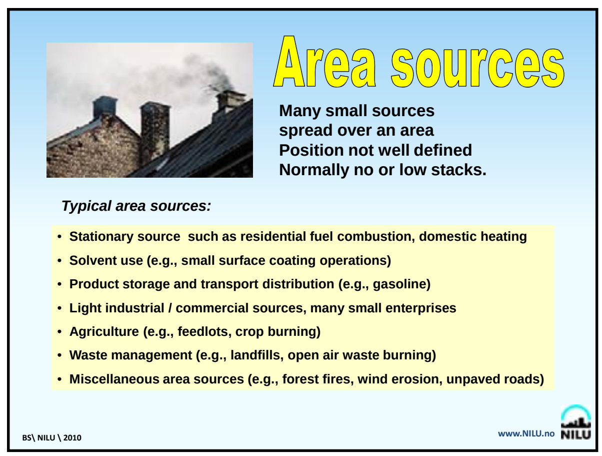
Area sources
Many small sources spread over an area
Position not well defined
Normally no or low stacks.
Typical area sources:
Stationary source such as residential fuel combustion, domestic heating
Solvent use (e.g., small surface coating operations)
Product storage and transport distribution (e.g., gasoline)
Light industrial / commercial sources, many small enterprises
Agriculture (e.g., feedlots, crop burning)
Waste management (e.g., landfills, open air waste burning)
Miscellaneous area sources (e.g., forest fires, wind erosion, unpaved roads)
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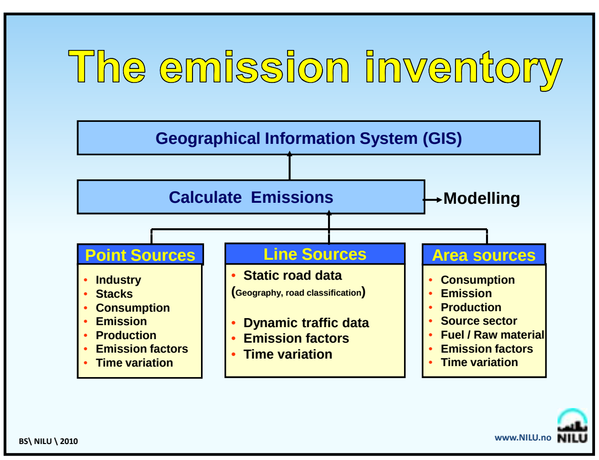
The emission inventory
Geographical Information System (GIS)
Calculate Emissions
Modelling
Point Sources
Industry
Stacks
Consumption
Emission
Production
Emission factors
Time variation
Line Sources
Static road data
(Geography, road classification)
Dynamic traffic data
Emission factors
Time variation
Area sources
Consumption
Emission
Production
Source sector
Fuel / Raw material
Emission factors
Time variation
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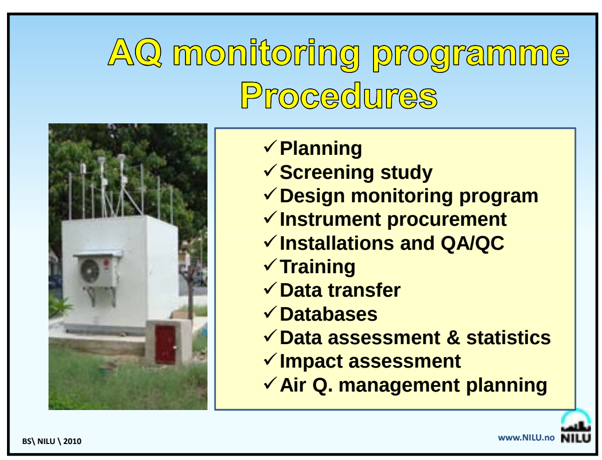
AQ monitoring programme
Procedures
✓Planning
✓Screening study
✓Design monitoring program
✓Instrument procurement
✓Installations and QA/QC
✓Training
✓Data transfer
✓Databases
✓Data assessment & statistics
✓Impact assessment
✓Air Q. management planning
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Air Pollution Indicators

First priority pollutants

- SO_2 (Sulphur dioxide)
- NO_2 (Nitrogen dioxide)
- PM_{10} (Particles with aerodynamic diameter < 10 micrometer)
- Pb (lead)

Limit values developed for other indicators:

- CO (Carbon monoxide)
- Ozone
- Benzene
- $PM_{2,5}$

PAH (BaP)

BTX

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Instruments

instrument procurement

SO_2	➡	fluorescent signal exciting SO_2 with UV
NO, NO_2	➡	chemiluminiscent reaction NO/O
O_3	➡	UV absorption analyser
CO	➡	non-dispersive infrared photometer

Reference instruments !

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Installation and start-up

- Instrument procurement
- Instrument selections
- Factory Acceptance Test
- Transport of shelter to site
- Installation of equipment inside shelter
- Testing of equipment and telecommunication
- Start-up of systems
- Site Acceptance Test
- Training

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Dispersion modelling

- ✓ Spatial distribution of pollutant concentrations
- ✓ Source contribution quantification
- ✓ Effects of suggested measures
- ✓ Exposure Estimates
- ✓ Forecasting

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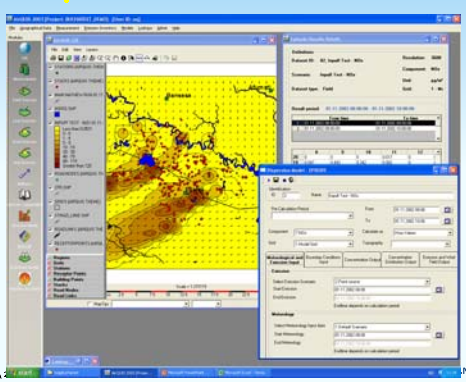
Dispersion Models



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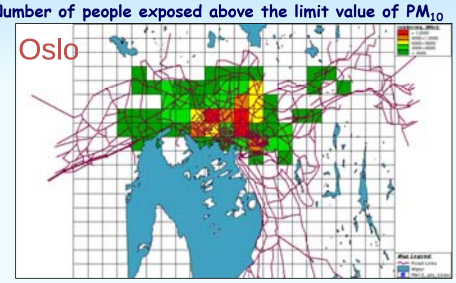
Exposure assessment

Links population data to concentration fields

Number of people exposed above the limit value of PM_{10}



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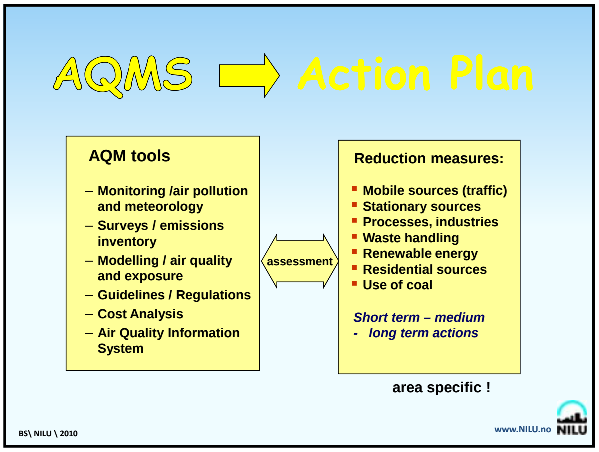
AQMS Action Plan
AQM tools
– Monitoring /air pollution and meteorology
– Surveys / emissions inventory
– Modelling / air quality and exposure
– Guidelines / Regulations
– Cost Analysis
– Air Quality Information System
assessment
Reduction measures:
Mobile sources (traffic)
Stationary sources
Processes, industries
Waste handling
Renewable energy
Residential sources
Use of coal
Short term – medium
- long term actions
area specific !
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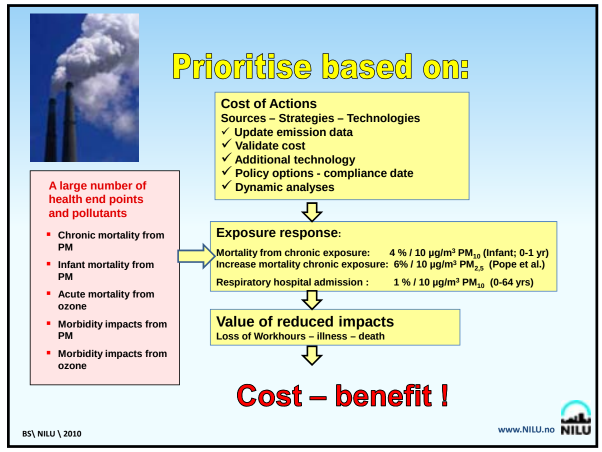
Prioritise based on:
Cost of Actions
Sources – Strategies – Technologies
✓ Update emission data
✓ Validate cost
✓ Additional technology
✓ Policy options - compliance date
✓ Dynamic analyses
A large number of health end points and pollutants
Chronic mortality from PM
Infant mortality from PM
Acute mortality from ozone
Morbidity impacts from PM
Morbidity impacts from ozone
Exposure response:
Mortality from chronic exposure: 4 % / 10 μg/m³ PM10 (Infant; 0-1 yr)
Increase mortality chronic exposure: 6% / 10 μg/m³ PM2.5 (Pope et al.)
Respiratory hospital admission : 1 % / 10 μg/m³ PM10 (0-64 yrs)
Value of reduced impacts
Loss of Workhours – illness – death
Cost – benefit !
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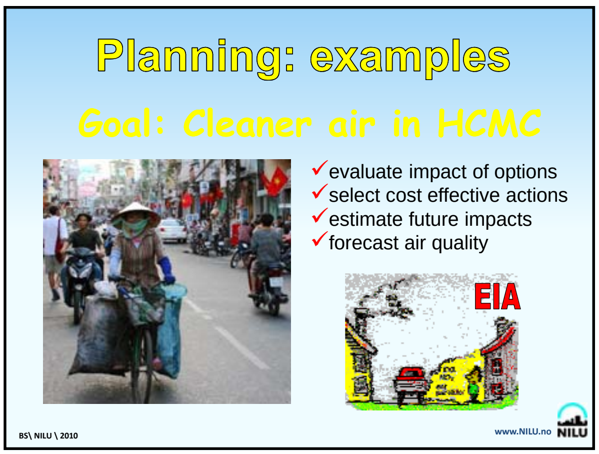
Planning: examples
Goal: Cleaner air in HCMC
✓evaluate impact of options
✓select cost effective actions
✓estimate future impacts
✓forecast air quality
EIA
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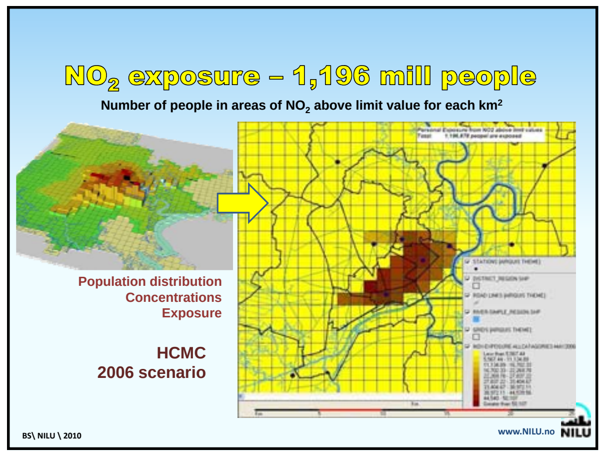
NO2 exposure – 1,196 mill people
Number of people in areas of NO2 above limit value for each km²
Population distribution
Concentrations
Exposure
HCMC
2006 scenario
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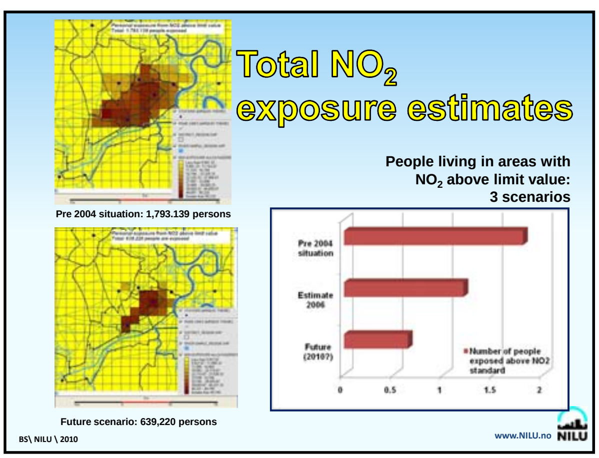
Total NO2 exposure estimates
Pre 2004 situation: 1,793.139 persons
People living in areas with NO2 above limit value: 3 scenarios
Pre 2004 situation
Estimate 2006
Future (2010?)
Number of people exposed above NO2 standard
0
0.5
1
1.5
2
Future scenario: 639,220 persons
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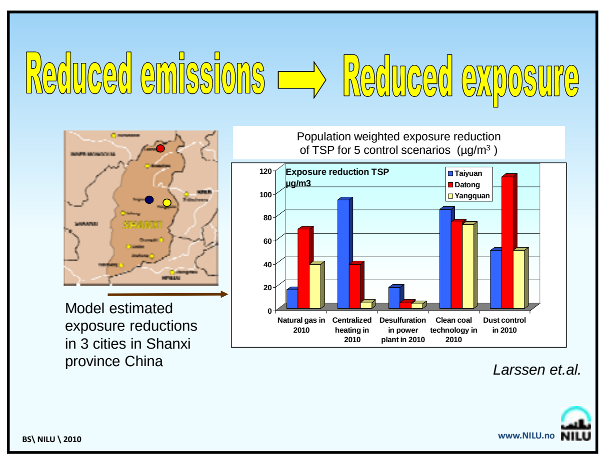
Reduced emissions Reduced exposure
Population weighted exposure reduction of TSP for 5 control scenarios (μg/m³)
Exposure reduction TSP μg/m3
Taiyuan
Datong
Yangquan
120
100
80
60
40
20
0
Natural gas in 2010
Centralized heating in 2010
Desulfuration in power plant in 2010
Clean coal technology in 2010
Dust control in 2010
Model estimated exposure reductions in 3 cities in Shanxi province China
Larssen et.al.
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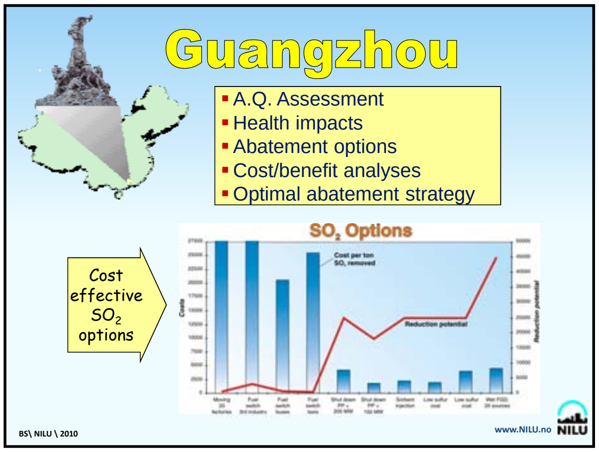
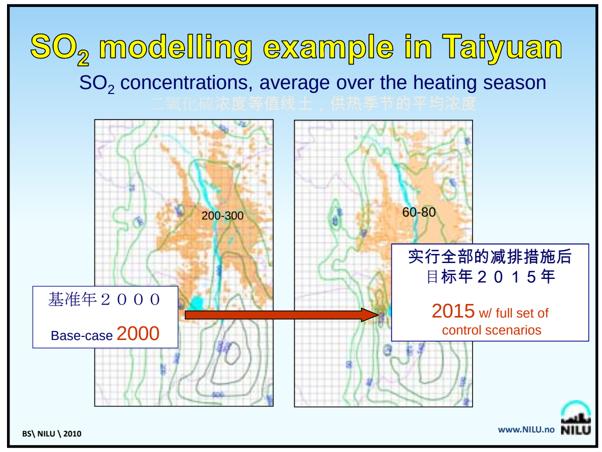
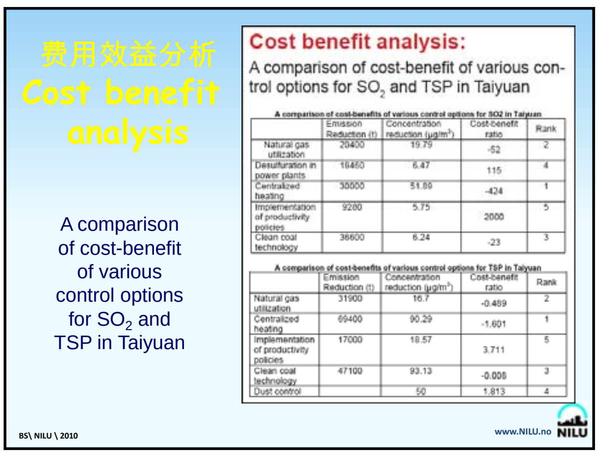




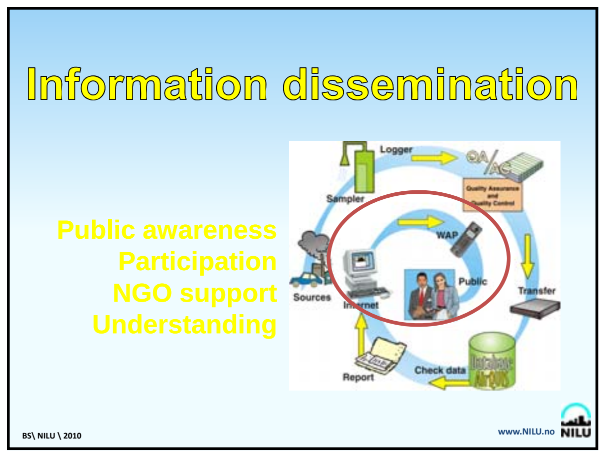


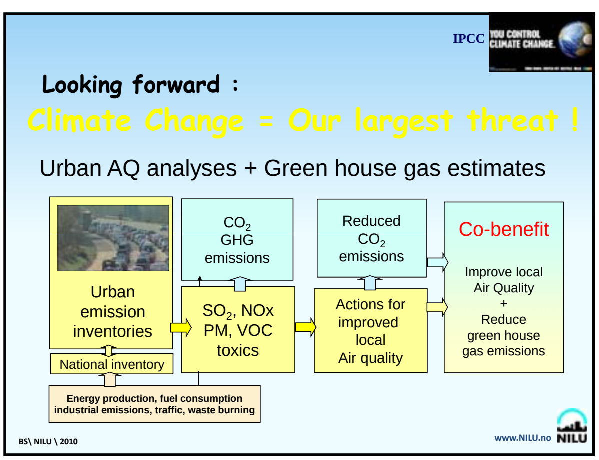
A comparison of cost-benefits of various control options for SO2 in Taiyuan

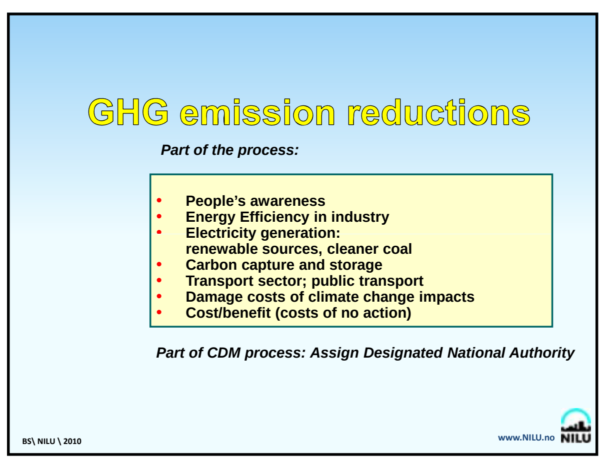
	Emission Reduction (t)	Concentration reduction (μg/m³)	Cost-benefit ratio	Rank
Natural gas utilization	20400	19.79	-52	2
Desulfuration in power plants	18460	6.47	115	4
Centralized heating	30000	51.89	-424	1
Implementation of productivity policies	9280	5.75	2000	5
Clean coal technology	36600	6.24	-23	3

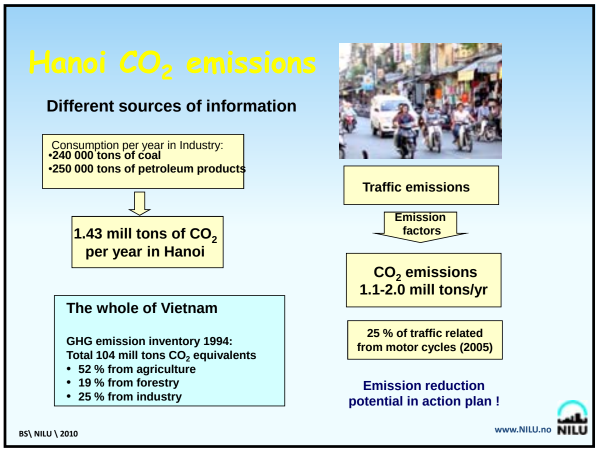
A comparison of cost-benefits of various control options for TSP in Taiyuan

	Emission Reduction (t)	Concentration reduction (μg/m³)	Cost-benefit ratio	Rank
Natural gas utilization	31900	16.7	-0.489	2
Centralized heating	69400	90.29	-1.601	1
Implementation of productivity policies	17000	18.57	3.711	5
Clean coal technology	47100	93.13	-0.008	3
Dust control		50	1.813	4








Hanoi CO_2 emissions
Different sources of information
Consumption per year in Industry:
•240 000 tons of coal
•250 000 tons of petroleum products
1.43 mill tons of CO_2 per year in Hanoi
The whole of Vietnam
GHG emission inventory 1994:
Total 104 mill tons CO_2 equivalents
• 52 % from agriculture
• 19 % from forestry
• 25 % from industry
Traffic emissions
Emission factors
CO_2 emissions 1.1-2.0 mill tons/yr
25 % of traffic related from motor cycles (2005)
Emission reduction potential in action plan !
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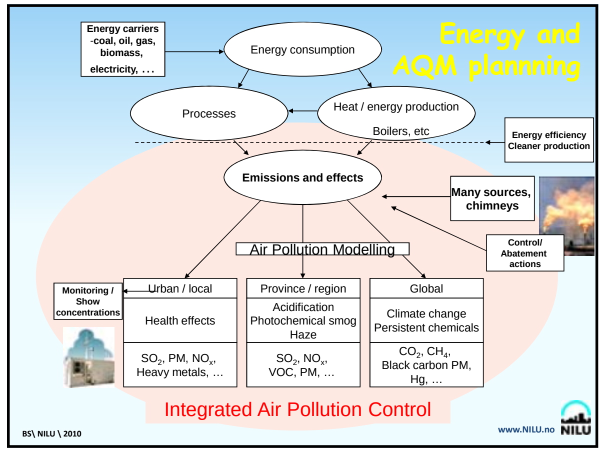
Energy and AQM plannning
Energy carriers -coal, oil, gas, biomass, electricity, …
Energy consumption
Processes
Heat / energy production
Boilers, etc
Energy efficiency Cleaner production
Emissions and effects
Many sources, chimneys
Control/ Abatement actions
Air Pollution Modelling
Monitoring / Show concentrations
Urban / local
Health effects
SO_2, PM, NO_x, Heavy metals, …
Province / region
Acidification Photochemical smog Haze
SO_2, NO_x, VOC, PM, …
Global
Climate change Persistent chemicals
CO_2, CH_4, Black carbon PM, Hg, …
Integrated Air Pollution Control
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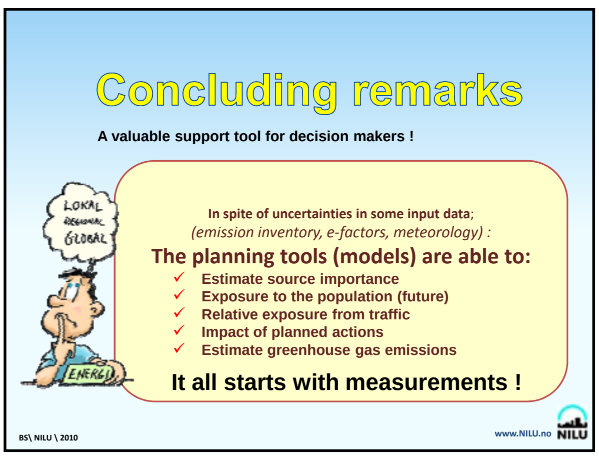
Concluding remarks
A valuable support tool for decision makers !
LOKAL
REGIONAL
GLOBAL
ENERGI
In spite of uncertainties in some input data;
(emission inventory, e-factors, meteorology) :
The planning tools (models) are able to:
✓ Estimate source importance
✓ Exposure to the population (future)
✓ Relative exposure from traffic
✓ Impact of planned actions
✓ Estimate greenhouse gas emissions
It all starts with measurements !
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Thank you !
Questions ???
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Air Quality Monitoring
Programme Design
Bjarne Sivertsen, NILU
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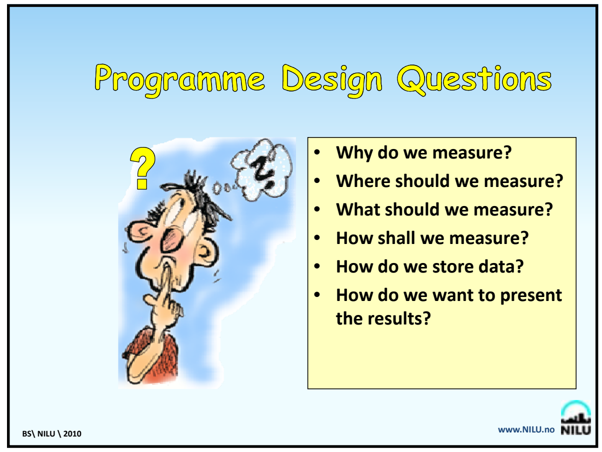
Programme Design Questions
• Why do we measure?
• Where should we measure?
• What should we measure?
• How shall we measure?
• How do we store data?
• How do we want to present the results?
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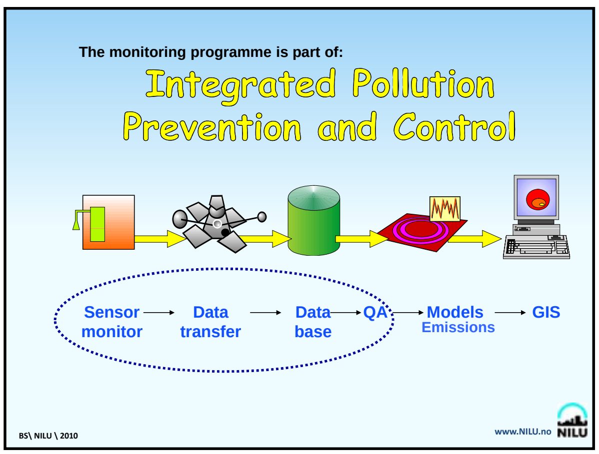
The monitoring programme is part of:
Integrated Pollution
Prevention and Control
Sensor monitor
Data transfer
Data base
QA
Models
Emissions
GIS
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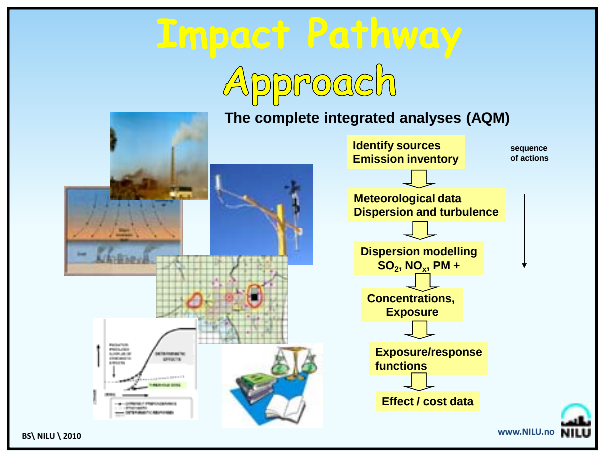
Impact Pathway
Approach
The complete integrated analyses (AQM)
Identify sources
Emission inventory
sequence of actions
Meteorological data
Dispersion and turbulence
Dispersion modelling
SO2, NOx, PM +
Concentrations, Exposure
Exposure/response functions
Effect / cost data
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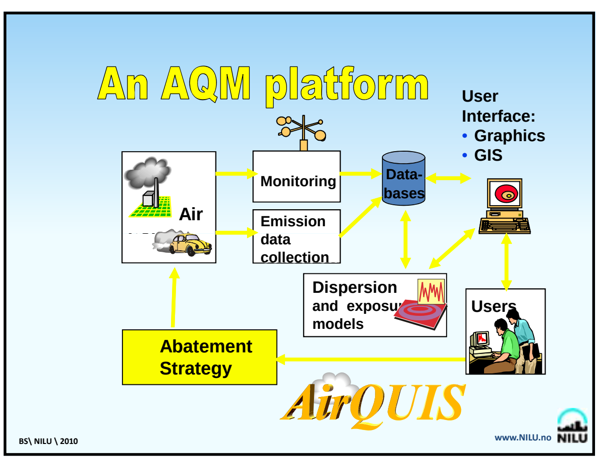
An AQM platform
User Interface:
• Graphics
• GIS
Air
Monitoring
Emission data collection
Data-bases
Dispersion and exposure models
Users
Abatement Strategy
AirQUIS
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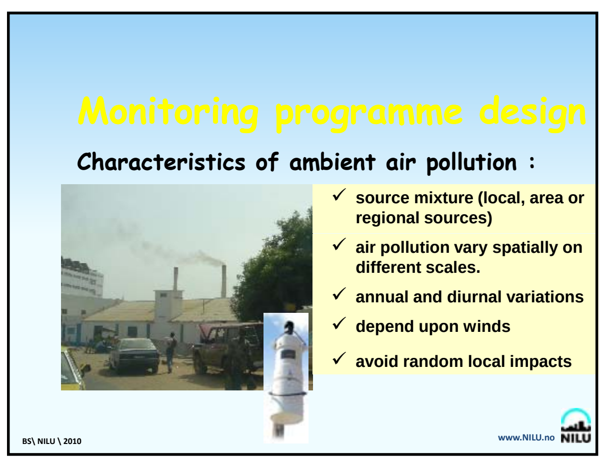
Monitoring programme design
Characteristics of ambient air pollution :
✓ source mixture (local, area or regional sources)
✓ air pollution vary spatially on different scales.
✓ annual and diurnal variations
✓ depend upon winds
✓ avoid random local impacts
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Air Quality Monitoring

Input to be considered

- ✓ Monitoring Objectives
- ✓ Data quality objectives
- ✓ Select sites and stations
- ✓ Select indicators
- ✓ Limit values and standards
- ✓ Frequency and period
- ✓ Instruments
- ✓ Statistics
- ✓ Design meteorology
- ✓ Which impacts?

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Monitoring objectives

- Individual sources
- Impact from outside
- Inform the public
- Warning
- Forecasts

- ✓ Mapping the air quality, current levels, baseline;
- ✓ To judge compliance with ambient air quality standards;
- ✓ To observe pollution trends throughout the region;
- ✓ To evaluate progress made towards meeting standards;
- ✓ To provide a data base for research evaluation of effects;
- ✓ A database for urban, land-use, and transportation planning;
- ✓ Basis for development and evaluation of abatement strategies;
- ✓ Data as input to and development and validation of models;
- ✓ To activate emergency control procedures that prevent or alleviate air pollution episodes.

Influence on design !

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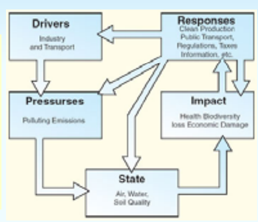
What shall we measure:

Air Quality Indicators

Identified to:

- provide a general picture,
- be easy to interpret,
- respond to changes,
- provide international comparisons,
- be able to show trends over time.



respond to DPSIR

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Air Pollution Indicators

First priority pollutants
(USEPA: Criteria pollutants)

- SO_2 (Sulphur dioxide)
- NO_2 (Nitrogen dioxide)
- PM_{10} (Particles with aerodynamic diameter < 10 micrometer)
- Pb (lead)

Limit values developed for other indicators:

- CO (Carbon monoxide)
- Ozone
- Benzene
- $PM_{2,5}$

PAH (BaP)

BTX

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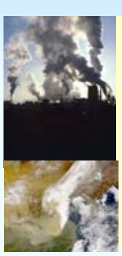
Which pollutants?

Scale of air pollution problem



- The air pollution is of predominantly local origin.
- Network concentrated in the urban area; (e.g NO_2, SO_2, PM_{10}, CO, benzene)
- Significant regional contribution; (emphasis on e.g. Ozone, PM).
- Large-scale phenomena, smog episodes in Europe or the Asian dust cloud (e.g. PM)
- Avoid local impacts (temporary impacts)

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AQ Limits and Guidelines

Pollutant	Averaging time	Limit- and Guidelines Values	
		EU 1)	WHO
Sulphur Dioxide (SO_2)	1 hour	350 (24 x)	500 (10 min)
	24 hours	125 (3 x)	50 *
	Year	-	-
Nitrogen Dioxide (NO_2)	1 hour	200 (18 x)	200
	Year	40	40-50
Ozone (O_3)	1 hour	-	150-200
	8 hours	120 *)	120
Carbon Monoxide (CO)	1 hour	-	30 000
	8 hours	10 000	10 000
Particles <10 µm (PM10)	24 hours	50 (35 x)	(150) 50
	Year	40	(50) 20
Particles < 2,5 µm PM2,5)	24 hours	-	(75) 25
	Year	25	(25) 10
Benzene	Year	5	-
Lead (Pb)	Year	0,5	0.5-1,0

1) Ref: EU Limit values for protection of human health (2008/50/EC)
(n x) not to be exceeded more than n times
**) not to be exceeded more than 25 days per year (aver over 3 years)*
WHO guideline values 2005 in ( ) are WHO interim target values (IT2)

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QA/QC system

to assure a predefined quality of all data

1. Quality Assurance
2. Quality Control
3. Quality Assessment

Define objectives ⇨ Follow-up controls ⇨ Verify Audit

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Quality Assurance in Monitoring planning

All planned and systematic activities which are needed to assure and demonstrate the predefined quality of data

1) Monitoring Objectives
Determine use of data, e.g. monitoring of trends

2) Data Quality Objectives
Determine necessary data quality to fulfil the Monitoring Objectives

3) Equipment selection
Results must fulfil the DQO. Select best measuring practice

4) Site selection
Must be representative for the Monitoring Objectives

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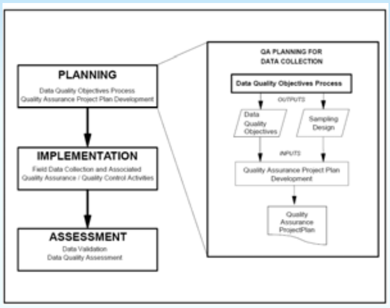
DQO part of the QA/QC process

QA

QC

QA



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Data quality objectives (DQO)

In Europe the objectives that guide the quantification of DQOs, are defined such as to:

- ✓ Enable comparison of air quality across Europe,
- ✓ Enable detection of the trend over a reasonable time period in air quality in Europe, as well as in each area where stations are located,
- ✓ Enable the assessments of exposure.

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Data quality objectives

EU

For air quality assessment	Sulphur dioxide, nitrogen dioxide and oxides of nitrogen and carbon monoxide	Benzene	Particulate matter (PM_{10}/$PM_{2.5}$) and lead	Ozone and related NO and NO_2
Fixed measurements (¹)				
Uncertainty	15 %	25 %	25 %	15 %
Minimum data capture	90 %	90 %	90 %	90 % during summer 75 % during winter
Minimum time coverage:				
— urban background and traffic	—	35 % (²)	—	—
— industrial sites	—	90 %	—	—
Indicative measurements				
Uncertainty	25 %	30 %	50 %	30 %
Minimum data capture	90 %	90 %	90 %	90 %
Minimum time coverage	14 % (⁴)	14 % (³)	14 % (⁴)	> 10 % during summer
Modelling uncertainty:				
Hourly	50 %	—	—	50 %
Eight-hour averages	50 %	—	—	50 %
Daily averages	50 %	—	not yet defined	—
Annual averages	30 %	50 %	50 %	—
Objective estimation Uncertainty	75 %	100 %	100 %	75 %

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A summary of DQOs

Monitoring programme/ *Monitoring objective*	Compounds	Accuracy	Precision	Data time coverage
EU Regulatory Monitoring 1) *Detect non-compliance with directives*	SO_2, NO_2 PM, Pb	15% 2) 25% 2)		90% annual "
EMEP *Provide basis for control of models*		15-25% 3)		90% annual
WMO-GAW *Detect trends over short term (5 years)*	Examples: O_3 NO_2 $PM_{2.5}$	15% or 3 ppb 20% or 50 ppt 0,05+5% M	10% or 1 ppb 10% or 25 ppt 10%	80% monthly " 90% monthly

1) Minimum DQOs. Final approval of the directive (EC 97/0266(SYN)) is pending (as of July 1998).
2) Combined accuracy and precision.
3) Total "uncertainty (combined accuracy and precision) for sampling and analysis combined). Dependent upon compound.

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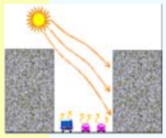
Where do we locate sites?

- Regional background
  - 3 km < x < 50 km from built up areas
- Urban background
  - in cities (1 km scale)
  - away from local sources (streets, industries etc.)
- Traffic impacts
  - curbside, along streets
- Industrial pollution
  - downwind from industries



Types of Monitoring Stations

Classification system:

Type of area	Description	Type of station
Urban	Continuously built-up area	Traffic
Suburban	Largely built-up area: continuous settlement of detached buildings mixed with non-urbanized areas	Industrial Background :
Rural	Areas that not fulfil the criteria for urban/suburban areas	- Near city - Regional - Remote

Area of representativity of station classes (typical values)

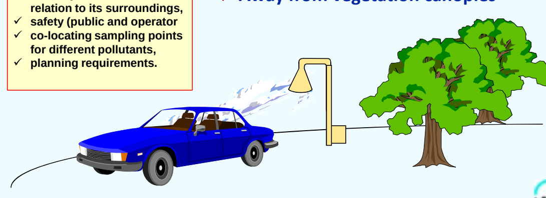
Station class	Radius of area
Traffic stations	<10-15 m
Industrial stations	10-1000 m
Background stations:	
- Urban background	0,1-1 km
- Near-city background	1 - 10 km
- Regional stations	25-150 km
- Remote stations	200-500 km

Air intake design - Location

Take into account:

- ✓ interfering sources,
- ✓ security,
- ✓ access,
- ✓ availability of electrical power and telephone,
- ✓ visibility of the site in relation to its surroundings,
- ✓ safety (public and operator
- ✓ co-locating sampling points for different pollutants,
- ✓ planning requirements.

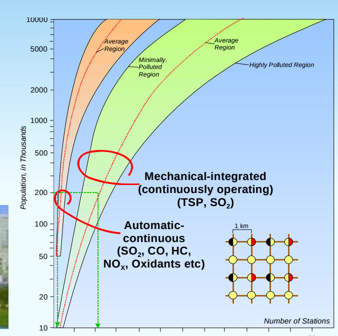
- Same height above ground
- Avoid buildings
- Away from local sources
- Away from vegetation canopies



Number of sites needed depends upon several factors:

- Types of data needed,
- Mean values and averaging times,
- Frequency distributions,
- Geographical distributions,
- Population density and distribution,
- Meteorology and climatology of the area,
- Topography and size of area,
- Location and distribution of industrial areas.

Number of monitoring sites needed in an urban area



Minimum numbers of sampling points for fixed measurement SO_2, NO_2, particulate matter and lead in

AMBIENT AIR

fixed measurement to assess compliance with limit values for the protection of human health and alert thresholds (EU Directives)

urban areas

Population of agglomeration or zone (thousands)	If maximum concentrations exceed the upper assessment threshold (¹)		If maximum concentrations are between the upper and lower assessment thresholds	
	Pollutants except PM	PM (¹) (sum of PM_{10} and $PM_{2,5}$)	Pollutants except PM	PM (¹) (sum of PM_{10} and $PM_{2,5}$)
0-249	1	2	1	1
250-499	2	3	1	2
500-749	2	3	1	2
750-999	3	4	1	2
1 000-1 499	4	6	2	3
1 500-1 999	5	7	2	3
2 000-2 749	6	8	3	4
2 750-3 749	7	10	3	4
3 750-4 749	8	11	3	6
4 750-5 999	9	13	4	6
≥ 6 000	10	15	4	7

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Minimum numbers of sampling points for fixed measurements of

Ozone in AMBIENT AIR

fixed measurement to assess compliance with target values long-term objectives and alert thresholds where measurements are the only info (EU Directives)

Population (× 1 000)	Agglomerations (urban and suburban) (¹)	Other zones (suburban and rural) (¹)	Rural background
< 250		1	1 station/50 000 km² as an average density over all zones per country (²)
< 500	1	2	
< 1 000	2	2	
< 1 500	3	3	
< 2 000	3	4	
< 2 750	4	5	
< 3 750	5	6	
> 3 750	One additional station per 2 million inhabitants	One additional station per 2 million inhabitants	

(¹) At least 1 station in suburban areas, where the highest exposure of the population is likely to occur. In agglomerations at least 50 % of the stations shall be located in suburban areas.
(²) 1 station per 25 000 km² for complex terrain is recommended.

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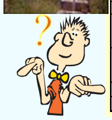
Sampling frequency and sampling time



Pollutant/ Indicator	Unit	Sample resolution	Average needed
Carbon monoxide	mg/m3	Hourly average	Hourly, 8-hour running average, annual max
Nitrogen dioxide	µg/m3	Hourly average	Daily average Annual average Frequency distribution
Ozone	µg/m3	Hourly average	Hourly, 8-hour running average, annual max
Particulate matter	µg/m3	Daily average	Daily average Annual average Frequency distribution.
Sulphur dioxide	µg/m3	Hourly average	Daily average Annual average Frequency distribution.
Lead	µg/m3	Annual average	Annual average
Benzene	µg/m3	Annual average	Annual average

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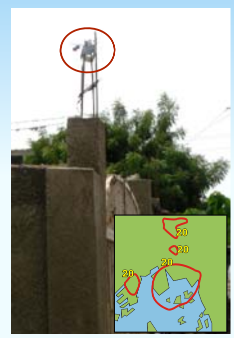
Siting studies

- ✓ Define site locations
- ✓ Evaluate sources and possible impact
- ✓ Perform simple "model estimates"

- Investigate the area
- Select relevant indicators
- Complete report covering
  - Instruments
  - Sites
  - Components



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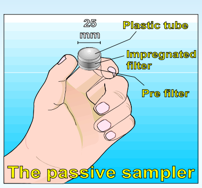
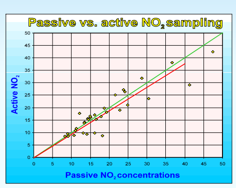
Passive samplers for screening studies





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Screening study Burgas

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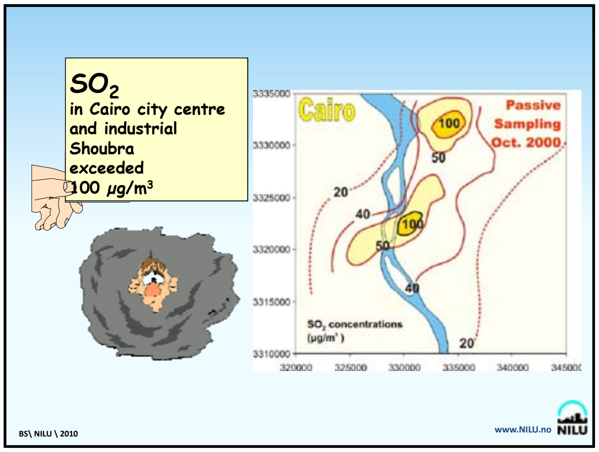
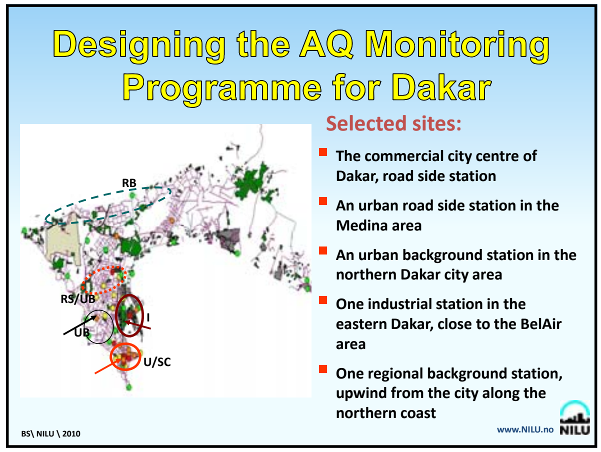
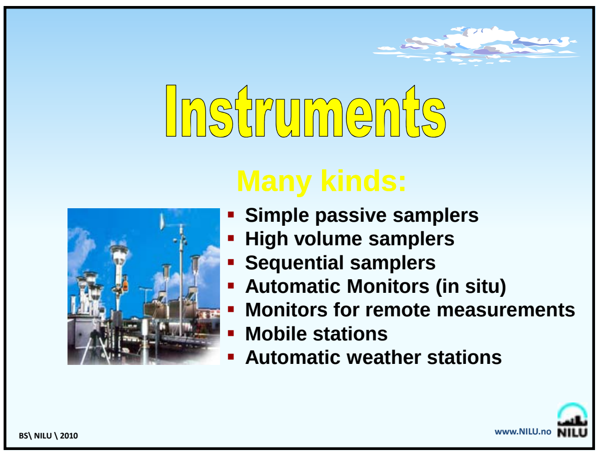
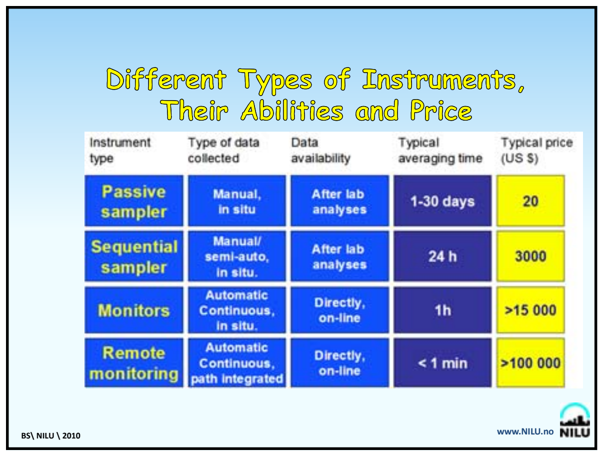
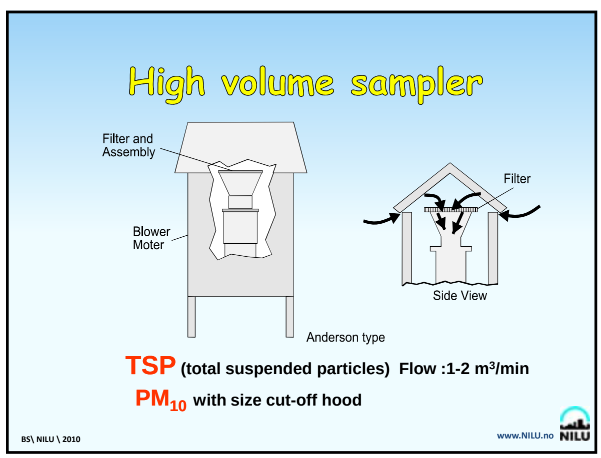








Instrument type	Type of data collected	Data availability	Typical averaging time	Typical price (US $)
Passive sampler	Manual, in situ	After lab analyses	1-30 days	20
Sequential sampler	Manual/ semi-auto, in situ.	After lab analyses	24 h	3000
Monitors	Automatic Continuous, in situ.	Directly, on-line	1h	>15 000
Remote monitoring	Automatic Continuous, path integrated	Directly, on-line	< 1 min	>100 000



Air quality Gas Monitors

SO_2	➡	fluorescent signal exiting SO_2 with UV
NO, NO_2	➡	chemiluminescent reaction NO/O
O_3	➡	UV absorption analyser
CO	➡	non-dispersive infrared photometer

Reference instruments !

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Additional instruments

- PM $_{10}$: ➡ Measurement on filter tape using the principles of beta attenuation
- PM $_{10}$: ➡ TEOM (Tapered element oscillating microbalance) particulate mass collected on a filter
- HC : ➡ Gas Chromatograph (GC) with Flame Ionization Detector (FID)
- VOC: ➡ Collected in canister for GC analyses
- BTEX ➡ Monitor Photo Ionization Detector (PID) as the sensing element.

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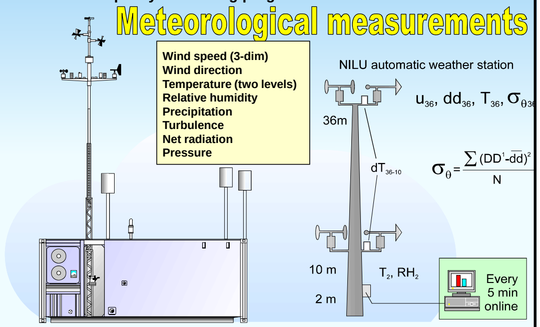
All air quality monitoring programmes include

Meteorological measurements



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Meteorological station

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Objectives

⇓

Requirements

⇓

Permanent network !

Should map:

1. Highest concentrations and hotspots;
2. Representative concentrations in areas of high population density;
3. Impact from significant sources or source categories;
4. General background concentration levels.

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A typical monitoring station

QA/QC !

Urban background site in HCMC

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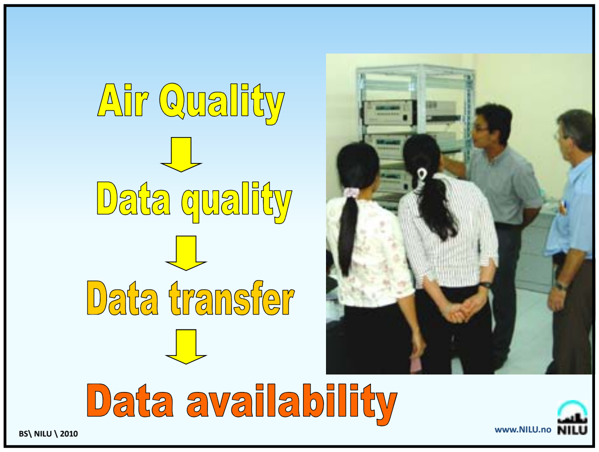
Air Quality
Data quality
Data transfer
Data availability
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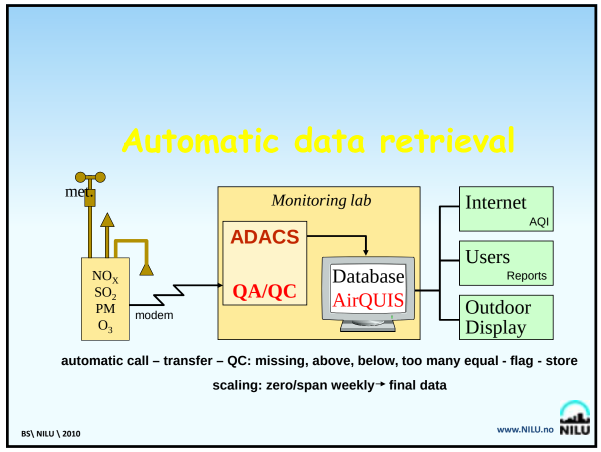
Automatic data retrieval
met.
NO_X
SO_2
PM
O_3
modem
Monitoring lab
ADACS
QA/QC
Database
AirQUIS
Internet
AQI
Users
Reports
Outdoor
Display
automatic call – transfer – QC: missing, above, below, too many equal - flag - store
scaling: zero/span weekly→ final data
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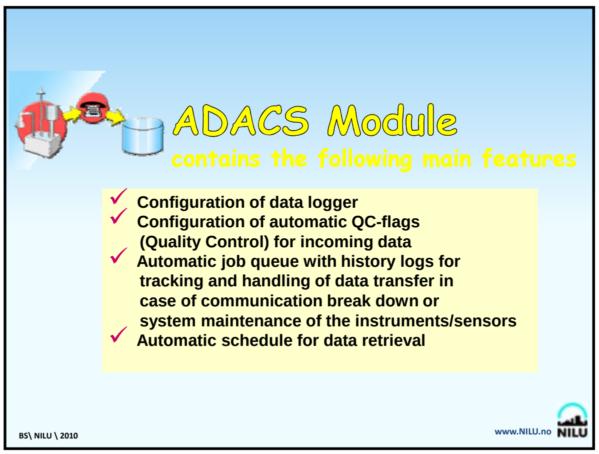
ADACS Module
contains the following main features
Configuration of data logger
Configuration of automatic QC-flags (Quality Control) for incoming data
Automatic job queue with history logs for tracking and handling of data transfer in case of communication break down or system maintenance of the instruments/sensors
Automatic schedule for data retrieval
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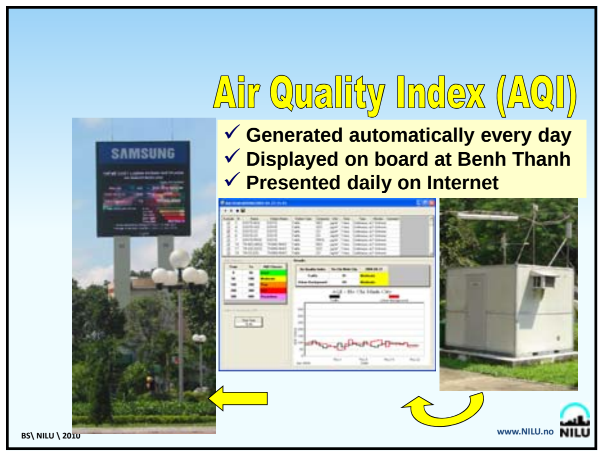
Air Quality Index (AQI)
Generated automatically every day
Displayed on board at Benh Thanh
Presented daily on Internet
SAMSUNG
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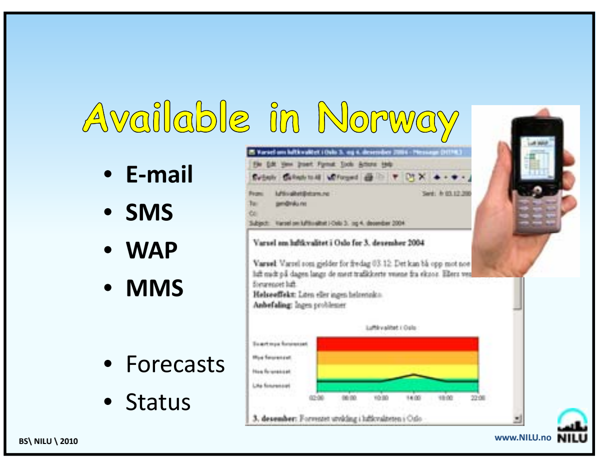
Available in Norway
E-mail
SMS
WAP
MMS
Forecasts
Status
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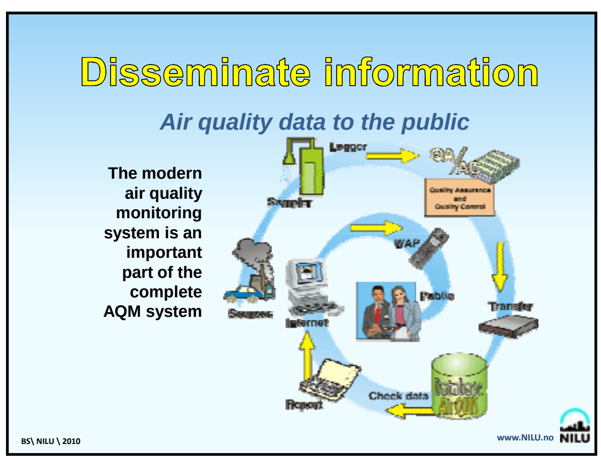
Disseminate information
Air quality data to the public
The modern air quality monitoring system is an important part of the complete AQM system
Logger
Sampler
QA/QC
Quality Assurance and Quality Control
WAP
Public
Sources
Internet
Transfer
Report
Check data
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No-2027 Kjeller
Norway
Fax: +4763898050
E-mail: nilu@nilu.no
BS\ NILU \ 2010
www.NILU.no
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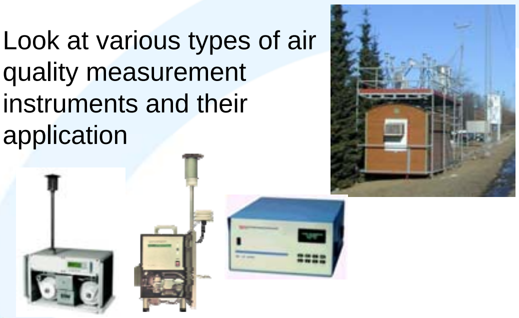
Monitoring and Sampling Instrumentation

Burgas, Bulgaria
26-28 May 2010

Leif Marsteen
NILU

Purpose of presentation

Look at various types of air quality measurement instruments and their application



Equipment selection

1. Monitoring Objectives
   - Why measure? Trends, warnings, compliance
2. Site selection
   - Must be representative for Monitoring Objectives
3. Data quality objectives
   - Determine data quality necessary to fulfil the Monitoring Objectives
4. Equipment selection
   - Results must fulfil the Data Quality Objectives Select best measuring practice

Equipment selection

- Example

1. Monitoring Objectives
   - Compliance with Directive 2008/50/EC
2. Site selection
   - Road side, Nitrogen dioxides (ref. directive)
3. Data Quality Objectives
   - Maximum 15 % uncertainty (ref. directive)
4. Other considerations
   - Warning/Information to the public (ref. directive)
5. Equipment selection
   - Automatic NO_x analyser (ref. directive)

EU Directive 2008/50/EC

on ambient air quality and cleaner air for Europe

- Covers SO_2, NO_x, Pb, PM_{10}, $PM_{2.5}$, Benzene, CO, O_3
- Defines Data Quality Objectives
  - Uncertainty, data capture, time coverage
- Defines measurement methods
  - Reference method, or any method that is tested
  - Refers to CEN standards for equivalence testing
- Requires public to be informed

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF

Testing analysers

- Is analyser within the uncertainty specified in the air quality directive?
- Done by a test house, e.g. TÜV
- According to CEN standard
- Done once and after design changes
- Test is valid in all EU countries

Ask for test report before buying

CEN standards

- Describes measurement methods
- Describes test procedure (equivalence testing)

Component	Measurement method	Reference to standard
NO, NOx, NO2	Automatic Chemiluninecsence	CEN/EN142111, Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence
SO2	Automatic Ultraviolet fluorescence	CEN/EN14212, Standard method for the measurement of the concentration of sulphur dioxide by ultraviolet fluorescence
O3	Automatic Ultraviolet photometry	CEN/EN14625, Standard method for the measurement of the concentration of ozone by ultraviolet photometry
CO	Automatic Nondispersive infrared spectroscopy	CEN/EN14626, Standard method for the measurement of the concentration of carbon monoxide by nondispersive infrared spectroscopy
BTX	Automatic, GC	CEN/EN14662, Ambient air quality - Reference method for measurement of benzene concentrations

http://www.cen.eu/cen/Products/Pages/default.aspx

Air Quality Instrumentation

Two basic types:

- Manual samplers
- Automatic analysers

Horiba
Gas analyser

Thermo
PM Beta gauge

Thermo
PM High vol

Manual samplers
When to use

- Detect several components
  - Chemical analysis
- Components not detectable by analysers
  - No automatic detection method
  - Low concentrations
- Trend analysis
  - Modest diurnal variation
  - Detect long term changes
  - Typical at background sites

Manual samplers

- Samples air or particulates on a filter, 24 hours
- Determination of mass, PM_{10} and $PM_{2.5}$
- Multicomponent chemical analysis
- Relatively cheap to buy and maintain
- Labour intensive, daily filter change
- Sequential sampler automatic filter change
  - 14 days maintenance period
- Passive sampler, 2 – 4 weeks exposure
- Rain fall/dust fall samplers, 4 weeks

Manual samplers
Some more types

- Low volume sampler
  - Road side and urban background sites
  - 1,0 - 2,3 m^3/h, 24 hrs
- High volume sampler
  - Background sites
  - 30 m^3/h, 24 hrs
- Evacuated canisters
  - 1 min (grab sampling), 1-24 hrs

Leckel

Digitel

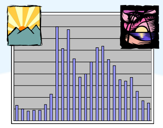
Sampler inlets

- Separate large particles from smaller
- Typically PM_{10}, $PM_{2.5}$ and PM_1
  - PM_x = Particle size less than x µm

USEPA standard
PM_{10} with $PM_{2.5}$ cyclone
Flow rate 1 m^3/h

EN12341 standard
PM_{10}/$PM_{2.5}$ interchangeable nozzles
Flow rate: 2,3 m^3/h

Automatic analysers
When to use



- Document diurnal variations
  - Rush hours, human activity
- Pinpoint pollution sources
  - Together with wind speed/direction/stability
- Air pollution information/warning to the public
  - Radio, TV, Internet, SMS

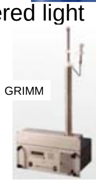
Requires high time resolution, usually 1 hour or 30 minutes

Automatic analysers

- Continuous analysis at the site
- Local or remote sensing techniques
- Data usually stored in an external data logger
- Automatic data transfer to center
- Usually only one parameter per instrument
- Expensive to buy
- Expensive to maintain
- Not easy to repair

Automatic analysers
Some types

- Gasous
  - NO_x, CO, SO_2, H_2S, O_3, nMHC, BTEX
  - One analyser for each component
- Particulates
  - Principles: Beta gauge, TEOM, scattered light
  - PM_{10}, $PM_{2.5}$, PM_1
  - Same inlets as samplers



Automatic analysers
Meteorology

Meteorological sensors:

- MetOne
- Young
- Gill
- Skye

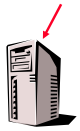
Parameters:

- Wind speed and direction, Rain fall, Temperature, RH, BP, Net radiation

Data logging and collection

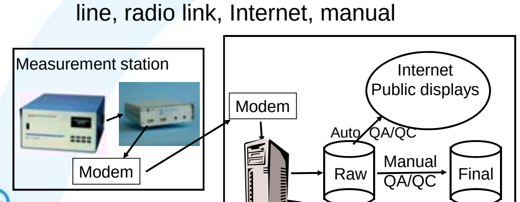
- Continuous analysis at site
- Data stored in a data logger
- Automatic data transfer to center

Data logger



Data transfer

- Center calls data logger automatically
  - Once every hour or more often
- Transfer techniques:
  - Public telephone lines,GSM/GPRS, leased line, radio link, Internet, manual

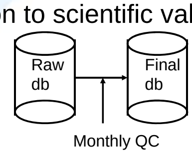


Data storage
Automatic quality control on raw data

- Some tests performed on raw data
  - Data integrity – Correct components?
  - Missing data - Call station again
  - Statistics on missing stations and data
  - Conversion to scientific values
- Daily reports on network status
- Alarms to operators on malfunctions etc.

Data storage
Final quality control

- Typically monthly (manual)
- Performed on raw data
- Data validation, removing not valid data
- Flag data as OK or not
- Conversion to scientific values (SI units)



Shelter

Stand alone instruments

- No shelter required

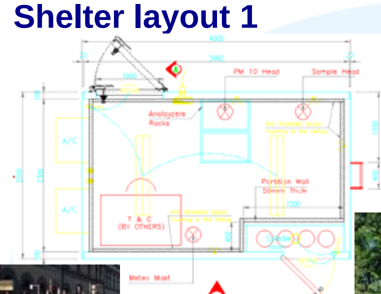
Delicate instruments

- Shelter required

Shelter requirements

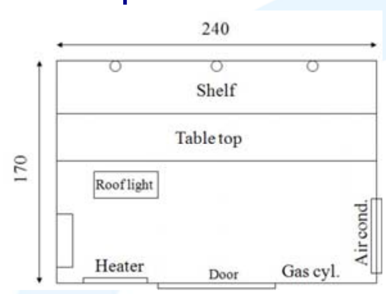
- Easy access
  - Inspections, repairs - '24 hours'
  - Heavy loads - Car parking nearby
- Protection against
  - Theft and damage – Install fence, lock
  - Sunshine - No windows
  - Outdoor environment - Air conditioned
- Data communication line
- Benches or racks for instruments
- No smoking, clean workplace

Shelter layout 1



Types:
- Fixed
- On wheels
  - Towable
- On truck

Shelter layout 2
a simpler solution



Shelters can be made locally

Important:
Leak tight around inlets through roof

Summary
Instrument selection

1. What is the purpose of monitoring?
2. What shall you measure?
3. Select a representative site
4. What is the required data quality?
5. Determine data averaging time
6. Select equipment

Always keep it as simple as possible!

Procurement of equipment

- Decide on turnkey installation or not
  - Will you install anything yourself?
- Use as few suppliers as possible
  - Narrows responsibility
- Include instrument specifications in tender
  - Use internet to find them
- Require FAT and SAT
  - FAT = Factory Acceptance Test
    System test before shipping to site
  - SAT = Site Acceptance Test
    System test after installation at site
  - No pay unless SAT is successfull

Installation at site

- Electrical power
- Telephone line or GSM
- Concrete pad necessary?
- Fence and lock necessary?
  - Install in secure areas if possible, school, university, police/fire station, etc.
- Meteorological tower with guy wires

Shelter Surroundings

- Inlets approx 1.5 m above rooftop
  - Prevents resuspension of dust from roof
  - Easy access during cleaning
- Free sight to the pollution source, e.g. road
- Avoid:
  - Trees and constructions close to shelter/ met. tower
  - Dusty ground - resuspension (PM_{10})
  - Vent outlets, e.g. shelter air condition

Laboratory requirments

- Workshop
  - Repair and maintenance of instruments
- Calibration facilities
  - Calibration of instruments
- Chemical lab facilities
  - Preparation of filters
  - Post analysis of filters

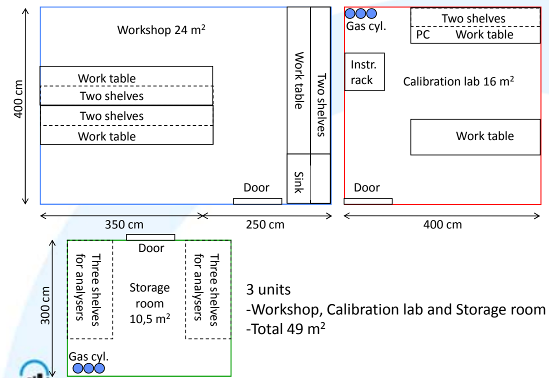
Workshop

- Tools
- Spare parts, gas cylinders, instruments
- Repair parts
- Consumables
- Storage room

Calibration lab

- High concentration reference gases
- Dilution unit
- Zero air generator
- Flow calibrator
- Calibrate analysers
  - After repair and yearly service
- Calibrate gas cylinders
  - Before use and every 3 months

Workshop and Calibration lab with storage room layout



3 units
-Workshop, Calibration lab and Storage room
-Total 49 m²

Chemical lab

- Clean room - Filter handling
- Balance - Filter weighing
- Ion chromatograph - Analysis of anions and cations in precipitation
- ICPMS - Metal analysis
- GC – PAH analysis

Adresses

Gas and PM analysers:
- http://www.teledyne-api.com/
- http://www.synspec.nl/
- http://www.thermo.com/
- http://www.environnement-sa.com/
- http://www.recordum.com/
- http://www.grimm-aerosol.de/
- http://www.tsi.com/
- http://www.horiba.com/
- http://www.opsis.se/

PM samplers:
- http://www.digitel-ag.com/
- http://www.leckel.de/
- http://www.derenda.de/
- http://www.airmetrics.com/

Noise analysers:
- http://www.bksv.com/

Shelters:
- http://www.ekto.com/

Meteorology sensors:
- http://www.metone.com/
- http://www.gill.co.uk/
- http://www.kippzonen.com/
- http://www.lsi-lastem.it/
- http://www.skyeinstruments.com/
- http://www.vaisala.com/

Gas cylinders:
- http://www.airliquide.com/
- http://www.lindegas.com/
- http://www.nmi.nl/
- http://www.scottgas.com/
- http://www.nist.gov/

Data collection:
- http://www.iseo.fr/
- http://www.emcslo.com/
- http://www.ecotech.com/
- http://www.environnement-sa.com/
- http://www.nilu.no/

Thank you

Air Quality Monitoring Network Operation

Burgas, Bulgaria
26-28 May 2010

Leif Marsteen
NILU

Purpose of presentation

Look at how an air quality monitoring network is operated

Purpose of network operation

Collect data of required quality for its intended use

HOW?

Is it information or just numbers?

Network operation

Daily:
- Check measurement data from home

Periodicly (e.g. weekly):
- Test instruments at station

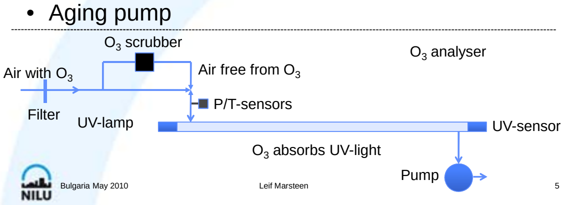
Monthly:
- Prepare data report

Three/six-monthly:
- Perform preventive maintenance on instruments

Yearly (or more often):
- Calibrate instruments

What affects instruments?

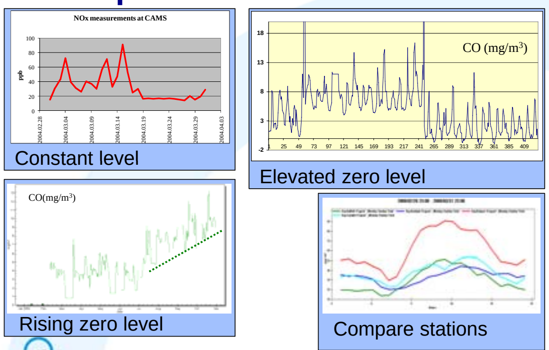
- Indoor temperature and humidity
- Dirt buildup in tubes, valves, inlets, manifold
- Saturation of scrubbers, converters, filters
- Clogged filters, valves, junctions, orifices
- Leaks in junctions, O-rings, valves
- Aging pump



Check measurement data from home

- Look for strange data
- Unstable or noisy values?
- Values not as expected for particular station?
- Compare neighbouring stations, same trend?
- Constant levels, e.g. many hours of zeros?
- Spikes, sudden drops, values below zero?
- Rising/elevated zero level?
- Values never close to zero at night?

Suspicious data



Constant level

Elevated zero level

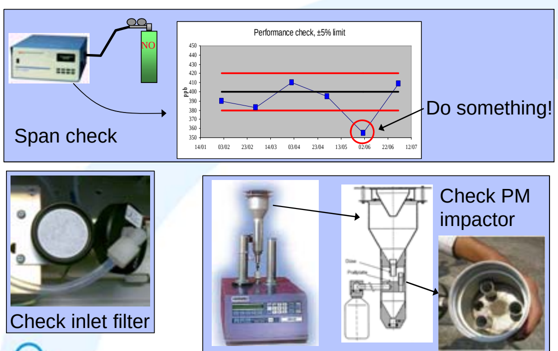
Rising zero level

Compare stations

Periodic check at station

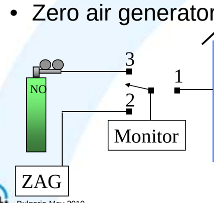
- Record instrument status
- Test analysers (zero/span check)
- Adjust analysers (lamps, gain, etc.)
- Change sample filters on samplers
- Change inlet filters on gas analysers
- Clean gas inlet manifold
- Clean PM impactors

Checks at station



Zero/span check equipment

- Zero/span checks are performed to:
  - Verify instrument response
  - Calculate scale factors for adjustment of measurement data
- ”Normal” concentration gas cylinders
- Zero air generator



Monitor connected to:
1. Inlet – normal operation
2. ZAG – Check zero level
3. Gas – Check span level

Regular maintenance

Valid data requires maintained instruments

- Change consumables regularly
- Clean air inlets and manifolds
- Clean outdoor sensors and inlets
- Check instrument status
- Maintain air condition
- Keep station tidy
- Look at data every day

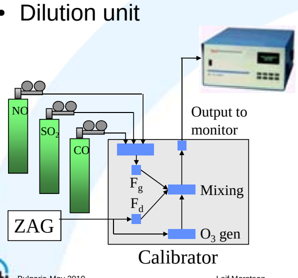
No instrument will run without problems but maintenance will prevent some of them

Preventive maintenance

- According to instrument manuals
- Calibrate analysers
- Calibrate gas cylinders
- Change lamps, scrubbers, valves
- Rebuild pumps
- Leak check analyser

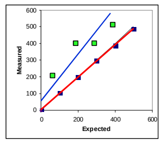
Yearly linearity check on gas analysers

- High concentration reference gas cylinders
- Zero air generator
- Dilution unit



$$OGC = C_{cyl} * \frac{F_g}{F_g + F_d}$$

OGC = Output Gas Concentration
C_{cyl} = Gas Cylinder Concentration
F_g = Gas flow rate
F_d = Dilution air flow rate



Possible services to client

- Network operation – all included
- Yearly service and calibration of analysers
- Periodic / preventive maintenance
- Calibration of gas cylinders
- Data reporting

Network operation services

- Client owns instruments
  - Contractor runs network for a fixed sum
  - Sum covers either:
    1. Everything, hours, transport, spare parts, repairs
    2. Hours only, rest paid by Client
- Client rents instruments
  - Contractor runs network for a fixed sum
  - Sum covers everything

Thank you

Quality Systems

Burgas, Bulgaria
26-28 May 2010

Leif Marsteen
NILU

QA/QC - Where does it all begin?

With the instruments!

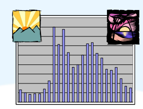
Quality Control / Quality Assurance

Is it information or is it just numbers?

A quality system will increase the information in the numbers

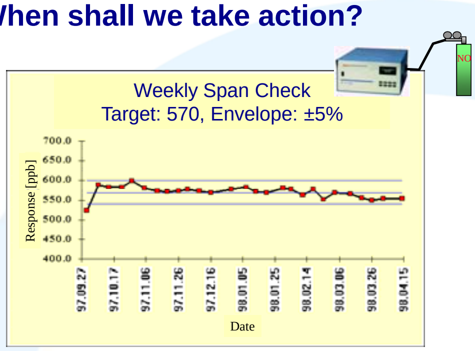
Instrumentation requirements

- Close follow up
- Performance testing
- Preventive maintenance
- Calibrations
- Repairs



We want unified instrument operation

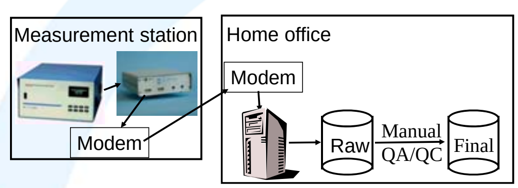
When shall we take action?



We want unified evaluation of test results

How do we validate data?

- Continuous analysers generate results on the fly
- Data collected by a data logger
- Data transfered to data center, e.g. every hour
- Automatic data validation, invalid data flagged
- Data transfer to final data base after manual data validation



We want unified evaluation of measurement data

Which tools do we have?

- Data collection software
  - Collect data from stations automatically and manually
- Statistical and graphing software
  - Evaluate collected data
- Manual call to stations from home
  - Get current status
- Instruction and technical manuals
  - Guidance on maintenance, calibrations and repairs
- Calibration systems
  - Test and adjust analysers

We want unified use of tools

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How do we get

- Unified instrument operation
- Unified evaluation of test results
- Unified evaluation of measurement data
- Unified use of tools

We introduce a quality system!

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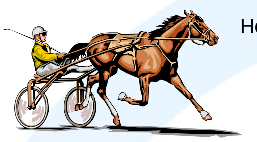
What is quality?

It depends on your needs



Horse racing - Speed

Farming - Strength

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Why QA/QC systems?

CONTRA
- Increased costs
- Conservative
  - Resists changes
  - Too much to update
- Extra paper work
  - No time to do the job!
- Too many documents
  - Impossible to learn

Myths or reality?

PRO
- Operations documented
- Results documented
- Transparency
- Easy training
  - Documentation exists
- Competitive edge

Reliable results with known quality

We want information not only numbers

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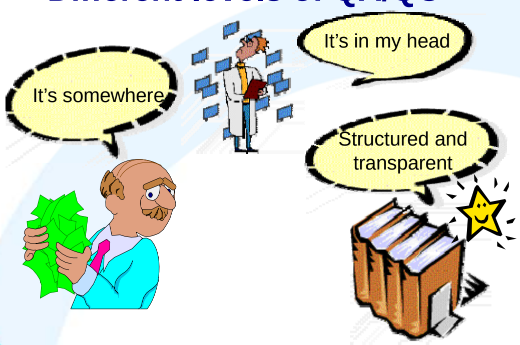
Different levels of QA/QC



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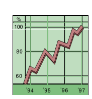
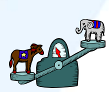
Elements of the quality system

Quality Assurance



Quality Control



Quality Assessment

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Quality Assurance

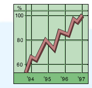
All planned and systematic activities which are needed to assure and demonstrate the predefined quality of data

(ISO 8402, 1994)

Described in the Quality Assurance Plan

Client's assurance that Contractor is in control

Quality Control



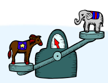
Operational techniques and activities that are undertaken to fulfil the quality requirements
(ISO 8402, 1994)

- Calibration and maintenance plan
- Standard Operations Procedures (SOPs)
  - Describes how to perform and document all operations
  - Maintenance, calibration, repairs, data validation, etc.
- All operations are documented in forms
- All forms are stored for later reference

No SOP !

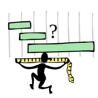
Makes operations traceable for Client

Quality Assessment



Determining the actual quality of the data and if the data fulfils the Data Quality Objectives

- Audit performed by an independent institution
- System Audit: Inspection of QA/QC plan and documents
- Performance Audit: Instruments are checked at the station using an independent calibration standard



Client's assurance that the Contractor is actually following his own procedures

Legal background for QA/QC systems

- EU directive (2008/50/EC)
- Defines responsibilities
- Defines measurement methods and refers to CEN
- Requires a QA/QC system and refers to ISO17025

Article 3 – Responsibilities

EU directive (2008/50/EC)

Member States shall designate at the appropriate levels the competent authorities and bodies responsible for the following:

(a) assessment of ambient air quality;

(b) approval of measurement systems (methods, equipment, networks and laboratories);

(c) ensuring the accuracy of measurements;

(d) analysis of assessment methods;

(e) coordination on their territory if Community-wide quality assurance programmes are being organised by the Commission;

(f) cooperation with the other Member States and the Commission.

The Reference Laboratory

- Implements Article 3 requirements
- Appointed by the national authority
  - E.g. by the Environmental agency
- Legally responsible for the quality assurance of measurements in their Member State
- Participates in AQUILA meetings (The European Association of Air Quality Reference Laboratories)

Roles of the Reference Lab

- Implementing a quality system in the laboratory
- Approving measurement systems (instruments, laboratories, networks)
- Ensuring the traceability of the measurements at national level, by providing/certifying reference materials to networks
- Organizing intercomp./round robin tests at national level
- Participating in EC QA/QC programmes (intercomp.)
- Exchanging information through the organisation of training sessions, workshops, conferences and guidance documents

ANNEX I - DATA QUALITY OBJECTIVES

EU directive (2008/50/EC)

C. Quality assurance for ambient air quality assessment: data validation

1. To ensure accuracy of measurements and compliance with the data quality objectives laid down in Section A, the appropriate competent authorities and bodies designated pursuant to Article 3 shall ensure the following:

— that all measurements undertaken in relation to the assessment of ambient air quality pursuant to Articles 6 and 9 are traceable in accordance with the requirements set out in Section 5.6.2.2 of the ISO/IEC 17025:2005,

— that institutions operating networks and individual stations have an established quality assurance and quality control system which provides for regular maintenance to assure the accuracy of measuring devices,

— that a quality assurance/quality control process is established for the process of data collection and reporting and that institutions appointed for this task actively participate in the related Community-wide quality assurance programmes,

Reference to measurement methods

EU directive (2008/50/EC)

- CEN develops standards (documents)
  - Measurement methods and QC measures
  - Laboratories must follow the standards
- ISO 17025 describes the quality organisation
  - Used by laboratories to develop quality systems
  - Used by accreditation bodies when auditing labs

Some CEN standards

Component	Measurement method	Reference to standard
NO, NOx, NO2	Automatic Chemiluninecsence	CEN/EN142111, Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence
SO2	Automatic Ultraviolet fluorescence	CEN/EN14212, Standard method for the measurement of the concentration of sulphur dioxide by ultraviolet fluorescence
O3	Automatic Ultraviolet photometry	CEN/EN14625, Standard method for the measurement of the concentration of ozone by ultraviolet photometry
CO	Automatic Nondispersive infrared spectroscopy	CEN/EN14626, Standard method for the measurement of the concentration of carbon monoxide by nondispersive infrared spectroscopy
BTX	Automatic, GC	CEN/EN14662, Ambient air quality - Reference method for measurement of benzene concentrations

Quality system requirements

- Management requirements
- Technical requirements

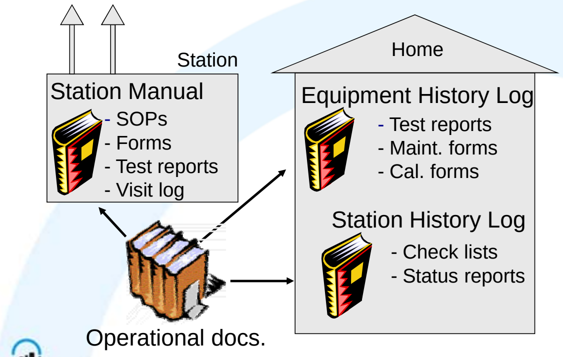
- Requirements found in:

  EN ISO 17025:2005 General requirements for the competence of testing and calibration laboratories

Quality Manual - Example

- Organisation and responsibilities
- Measurement traceability
- Measurement methods
- Task schedules
- Action criteria
- Standard Operating Procedures (SOPs)
- Training
- Internal audits
- Document management system

Manuals used in the network



Proofing of quality system

Accreditation

- Acceptance by an accreditation body
- Assures that your operation is according to ISO 17025

Most countries have an accreditaion body

- UKAS in England
- DPA in Albania
- NA in Norway

The quality organisation

- Department of environment
- National reference laboratorium
- Calibration laboratories
- Many participants
- Network owner Local authorities,Road administration
- Network operator

Tasks and responsibilities

Network operator - Reference lab

Task	NO	RL
Measurement network design	X	X
Select monitoring sites	X	
Select instruments	X	
Maintain monitoring sites	X	
Calibrate instruments and gas cyl.	X	X
Data validation, collection and storage	X	
Maintain the central data base		X
Provide traceability		X
Maintain the national reference std.		X
Maintain the quality system		X
Audits, once a year		X

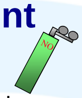
Reference lab services

- Measurement network design
  - Components, methods, locations
- Calibration
  - Certify new cylinders and recertify old
- Central data base
  - Storage area for national data
- Training
- Audits

Services- Provide traceability

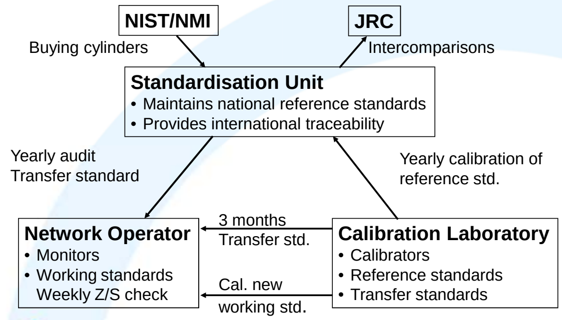
- Calibrate gas cylinder that is used to adjust analyser at the station
- All analysers in all networks will be adjusted according to the same reference
- Measurements from different stations and networks can be compared

Gas calibration equipment



- Gas calibrator with
  - National reference standard gas cylinders
  - NO, SO_2, CO, H_2S, BTEX, nMHC, HC
- Analysers for
  - NO, SO_2, CO, H_2S, BTEX, nMHC, HC, O_3
- Procedure
  - Calibrate analyser
  - Measure secondary standard gas cylinder
- Ozon calibrator

Traceability – Gas monitors



Flow calibration equipment

- Flow calibrators
- Calibration of
  - Samplers
  - PM analysers
  - Gas calibrators

Services – QA/QC system

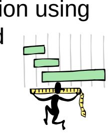
- Adapting QA/QC system to networks
- Based on ISO 17025 standard
  - Organisation and responsibilities
  - Network traceability
  - Measurement methods
  - Task schedules
  - Action criteria
  - Standard Operations Procedures (SOPs)
  - Training
  - Document management system

Services - Training

- Using the QA/QC system
- Documenting network operation
- How to maintain traceability
- Calibration of analysers
- Data validation
- Reporting data to the central data base

Services - Audits

- Determining the actual quality of the data
- System Audit
  - Inspection of QA/QC plan and documents
- Performance Audit
  - Instruments are checked at the station using an independent calibration standard
- Aim is to improve data quality
  - No ”police” but cooperation



Summary

The Reference lab can offer

- Help on network design
- Certification of gas cylinders
- Traceability in calibrations
- Quality system development
- Training
- Audits

Adresses

Accreditation bodies:

- http://www.albanianaccreditation.gov.al/
- http://www.ukas.com/
- http://www.akkreditert.no/en/

AQUILA and JRC:

- http://ies.jrc.ec.europa.eu/aquila-homepage.html

CEN

- http://www.cen.eu/

ISO

- http://www.iso.org

EU directive (2008/50/EC)

- http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF

Thank you

Air Quality Legislation

Bjarne Sivertsen, NILU

Guidelines and limit values
WHO guidelines
EU Directives
Framework directives
Daughter directives
Limit values and standards
Monitoring mechanism
CO_2 and GHG emissions

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Guidelines ⟺ Standards

Guidelines (WHO):

- Provide basis for protecting public health
- Background information
- Not intended to be standards

Standards or Limit values:

- Level of Air Quality adopted by regulatory authorities
- Enforceable

Concentration + Averaging time

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Air pollutants to be taken into consideration

IN THE ASSESSMENT AND MANAGEMENT OF AMBIENT AIR QUALITY

Pollutants governed by the Directives:
1. Sulphur dioxide
2. Nitrogen dioxide
3. Fine particulate matter such as soot
4. Suspended particulate matter
5. Lead
6. Ozone

II. Other air pollutants
7. Benzene
8. Carbon monoxide
9. Poly-aromatic hydrocarbons
10. Cadmium
11. Arsenic
12. Nickel
13. Mercury

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AQ Limits and Guidelines

Pollutant	Averaging time	Limit- and Guidelines Values	
		EU 1)	WHO
Sulphur Dioxide (SO_2)	1 hour	350 (24 x)	500 (10 min)
	24 hours	125 (3 x)	50 *
	Year	-	-
Nitrogen Dioxide (NO_2)	1 hour	200 (18 x)	200
	Year	40	40
Ozone (O_3)	1 hour	-	150-200
	8 hours	120 *)	120
Carbon Monoxide (CO)	1 hour	-	30 000
	8 hours	10 000	10 000
Particles <10 µm (PM10)	24 hours	50 (35 x)	(150) 50
	Year	40	(50) 20
Particles < 2,5 µm PM2,5)	24 hours	-	(75) 25
	Year	25	(25) 10
Benzene	Year	5	-
Lead (Pb)	Year	0,5	0.5-1,0

1) Ref: EU Limit values for protection of human health (2008/50/EC)
(n x) not to be exceeded more than n times
**) not to be exceeded more than 25 days per year (aver over 3 years)*
WHO guideline values 2005 in ( ) are WHO interim target values (IT2)

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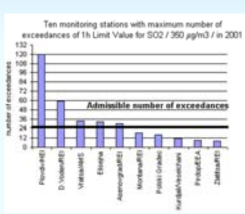
Limit values Bulgaria

1 Jan 2000:
Three new Regulations were enforced by the Ministry of Environment and Water and the Ministry of Health, developing the air quality legislation,.
➡ Transpose the EU Directives: - 96/62/EC, 92/72/EC, 99/30/EC

Bulgaria is received a final written warning for its failure to comply with limit values for sulphur dioxide. In June 2009, the Commission sent Bulgaria a first written warning about the measures in place to meet limit values.



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EU air quality Directives

Framework D:	**(96/62/EEC)**	
Daughter D:	**(1999/30/EC)**	**NO_x, SO_2, PM_{10} and Pb (first DD)**
	(2000/69/EC)	**CO, Benzene**
	(82/884/EEC)	**Pb**
	(2002/389/EEC)	**Ozone**
Council Dir:	**(94/C/216/04)**	**Assessment**
	(93/389/EEC)	**Monitoring CO_2 and GHG**
	(2004/107/EC)	**As, Cd, Hg, Ni, PAH**

World Health Organisation (WHO) Guidelines

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EU limit values

✓The EU limit values specify for most of the compounds a certain number of hours or days when the limit value may be exceeded.

✓The Directives clearly specify the proportion of valid data needed as well as margin of tolerance.

✓The EU Directives also specify lower and upper threshold values which indicate levels at which air quality assessment and measurements has to be undertaken

EU Air Quality Directive

EU Directives 1996-2004, summarized 2008 D)
Quality Limit values (µg/m³)

Averaging time	1 h	24 h	annual
SO_2	350 (24)	125 (3)	20*
NO_2	200 (8)	-	40
PM10 2005		50 (25)	30
Pb			0.5

* related to ecosystems *D) Directive 2008/50/EC, 21 May 2008*

(n) = number of exceedings permitted per year

Sulphur dioxide

Time period		Limit value (µg/m³)
1-hour average value,	24 times (99,3 perc)	350
24-hour average value	99 percentile	125
Yearly average value (critical level vegetation)		20

The yearly average value (calendar year average + average October 1 - March 31) is for areas outside agglomerations and other built-up parts.

DD (1999/30/EC)

Nitrogen dioxide

Time period	Limit value (µg/m³)
1-hour average value, 18 times (99,5 perc)	200
Yearly average value	40
Yearly average value (ecosystem)	30

The yearly average value of 30 µg/m³ applies for $NO+NO_2$. Applies outside of agglomerations and other built-up parts as well as in transition areas. The other two values apply everywhere from January 1, 2010.

Particulate matter

Measured as PM_{10} = max. diameter 10 µm, or as $PM_{2,5}$ = max. diameter 2,5 µm.

Time period	Limit value(µg/m³)
PM10:	
24-hour average value, (90 percentile)	50
Yearly average value	40
PM 2,5:	
Annual average (from 2010)	25
Annual average (from 2015)	20

The 90 percentile of the 24-hour average value means that the value may be exceeded at the most 35 times a year.

PM10 already in force since *January 1, 2005*

Lead

The yearly average limit value of

0,5 µg/m³

is applicable everywhere and takes effect from January 1, 2010 in industrial zones from January 1, 2005 elsewhere.

Directive 2004/107/EC

Arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air

Target values for arsenic, cadmium, nickel and benzo(a)pyrene:

Arsenic	**6 ng/m³**
Cadmium	**5 ng/m³**
Nickel	**20 ng/m³**
Benzo(a)pyrene	**1 ng/m³**

For the total content in the PM_{10} fraction averaged over a calendar year

Point sources
For the assessment the number of sampling points for fixed measurement should be determined taking into account emission densities, distribution patterns of ambient air pollution and potential exposure of the population.
Apply BAT as defined by Article 2(11) of Directive 96/61/EC

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Benzene

	Averaging period	*Limit value*	*Margin of tolerance*	*Date by which limit value is to be met*
Limit value for the protection of human health	Calendar year	5µg/m³	5µg/m³ on 13 December 2002, reducing on 1 January 2006 and every 12 months thereafter by 1 µg/m³ to reach 0 by 1 January 2010	1 January 2010

	Annual Average
Upper assessment threshold	70% of limit value (3.5 µg/m³)
Lower assessment threshold	40% of limit value (2 µg/m³)

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Sites and techniques

When limit values and alert thresholds are set, criteria and techniques shall be established for:
(a) the measurement to be used in implementing the legislation
- the location of the sampling points,
- the minimum number of sampling points,
- the reference measurement and sampling techniques;

(b) the use of other techniques for assessing ambient air quality, particularly modelling:
- spatial resolution for modelling and objective assessment methods,
- reference modelling techniques.

These criteria and techniques shall be established in respect of each pollutant according to the size of agglomerations or to the levels of pollutants in the zones examined.

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Responsibilities and actions

Ambient Air Quality Assessment and Management Directive

(Framework Directive 96/62/EC + Daughter Directives)

local authorities are responsible for:
- Periodic reviews and assessment of air quality
- Preparation of action plans

CD 94/C/216/04) Assessment

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Air Quality Assessment

Preliminary Air Quality Assessment

Assessment regime
Assessment criteria
Sampling points
Reference methods

- ✓ Define zones & agglomerations
- ✓ Evaluate sampling sites and methods
- ✓ Collect air quality data
- ✓ Evaluate quality and representativity
- ✓ Assess air quality
- ✓ Collect emission data
- ✓ Collect meteorological data
- ✓ Prepare and run models
- ✓ Present modelling results
- ✓ Present total AQ assessment

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EU Directive

Article 6:

Assessment requirements

– **divide territory into zones**
– **levels of pollution within each zone**

Member States are required to:
- ✓ **divide their territory into zones – whereby an agglomeration is a special type of zone - based on the results of the preliminary assessment**
- ✓ **perform ongoing assessment requirements related to the levels of pollution within the zones**

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EU Directive

Article 5:

Identify levels of air pollution*) within zones

- Undertake representative measurements
- Evaluate and use existing data
- Perform surveys of air the pollution situation
- Present an assessment of the air quality

*) SO_2, NO_2, PM_{10}, Pb

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EU Directive

Article 2:

Assessment

"Any method used to measure, calculate, predict or estimate the level of a pollutant in ambient air"

- preliminary air quality measurements
- air emission inventories
- air pollution modelling

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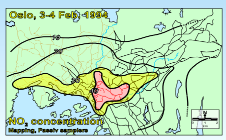
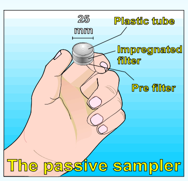
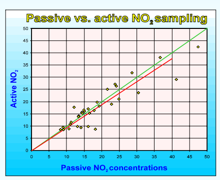
Indicative measurements

- Less accurate than the reference methods
- Mobile laboratory
- Grab samples
- Passive samples (low cost)







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Assessment Tools

Measurements:

- Methods and uncertainties
- Representative location (siting)
- Limited time coverage

Emission inventories:

- Incomplete data
- Improve input data
- Evaluate emission factors

Models

- Prepare relevant models
- Prepare input data
- Emissions and meteorology
- Uncertainties
- Verify models?

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Assessment output included

In local, regional or national programmes for improvement in the ambient air quality

1. Localization of excess pollution
   - region
   - city (map)
   - measuring station (map, geographical coordinates).
2. General information
   - type of zone (city, industrial or rural area)
   - estimate of the polluted area (km²) and of the population exposed to the pollution
   - useful climatic data
   - relevant data on topography
   - sufficient information on the type of targets requiring protection in the zone.
3. Responsible authorities

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Classification of monitoring stations

Station classes		*Relevant for exposure of* Popula-tion	Mate-rials	Eco-systems
Traffic stations (TRA)	Street type Traffic volume Traffic speed	x	(x)	
Industrial stations (IND)	Type of area	x	x	x
Urban backgr. stations (URB)	Location (geogr) within the city Type of zone	x	x	(x)
Near city backgr. stations (NCB)		x	x	x
Regional (rural background) stations (REG)		x	(x)	x
Remote stations (REM)				x

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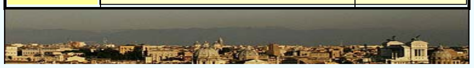
Types of Monitoring Stations

Classification system:

Type of area	Description	Type of station
Urban	Continuously built-up area	Traffic
Suburban	Largely built-up area: continuous settlement of detached buildings mixed with non-urbanized areas	Industrial Background :
Rural	Areas that not fulfil the criteria for urban/suburban areas	- Near city - Regional - Remote



Minimum numbers of sampling points for fixed measurement SO_2, NO_2 , particulate matter and lead in

AMBIENT AIR

fixed measurement to assess compliance with limit values for the protection of human health and alert thresholds (EU Directives)

urban areas

Population of agglomeration or zone (thousands)	If maximum concentrations exceed the upper assessment threshold (¹)		If maximum concentrations are between the upper and lower assessment thresholds	
	Pollutants except PM	PM (²) (sum of PM_{10} and $PM_{2,5}$)	Pollutants except PM	PM (²) (sum of PM_{10} and $PM_{2,5}$)
0-249	1	2	1	1
250-499	2	3	1	2
500-749	2	3	1	2
750-999	3	4	1	2
1 000-1 499	4	6	2	3
1 500-1 999	5	7	2	3
2 000-2 749	6	8	3	4
2 750-3 749	7	10	3	4
3 750-4 749	8	11	3	6
4 750-5 999	9	13	4	6
≥ 6 000	10	15	4	7

Upper and Lower Assessment Thresholds

Exceedances of upper and lower assessment thresholds must be determined on the basis of concentrations during the previous five years where sufficient data are available.

Regime 1

Non compliance

Measurements models source invent. needed

Limit value

Upper Assessment threshold

Measurements needed

Lower Assessment

Indicative measurements

UAT:

SO_2 : 60 % (24-h aver.): 75 µg/m3
60 % winter limit conc.

NO_2 : 70 % (1-h aver.): 140 µg/m3
80% annual limit

PM_{10} : 60 % (24-h aver.): 30 µg/m3
70% annual limit

Pb (lead) : 70 % annual limit

Assessment requirements

Regime 1 (> UAT):
High quality monitoring mandatory (+models)

Regime 2 (LAT – UAT) :
Measurments mandatory, fewer, less intensive, other sources

Regime 3 < LAT) :
a) Agglomeration : one measurement site combined with modeling, indicative measurements
b) Zones: Modelling, indicative measurements

Assessment requirements

Maximum pollution level in agglomeration or zone	Assessment Requirements*
Regime 1: Greater than the upper assessment threshold	High quality measurement is mandatory. Data from measurement may be supplemented by information from other sources, including air quality modelling.
Regime 2: Less than the upper assessment threshold but greater than the lower assessment threshold	Measurement is mandatory, but fewer measurements may be needed, or less intensive methods may be used, provided that measurement data are supplemented by reliable information from other sources.
Regime 3: Less than the lower assessment threshold	
a. In agglomerations, only for pollutants for which an alert threshold has been set	At least one measuring site is required per agglomeration, combined with modelling, objective estimation, indicative measurements.
b. In non-agglomeration zones for all pollutants and in all types of zone for pollutants for which no alert threshold has been set	Modelling, objective estimation, and indicative measurements alone are sufficient.

Margins of tolerance

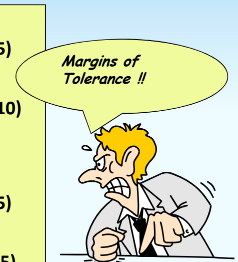
SO_2 : + 150 µg/m³ (1-h aver.)
(1 Jan 2001 – 1 Jan 2005)

NO_2 : + 50 % (1-h aver.)
***(1 Jan 2001 – 1 Jan 2010)**

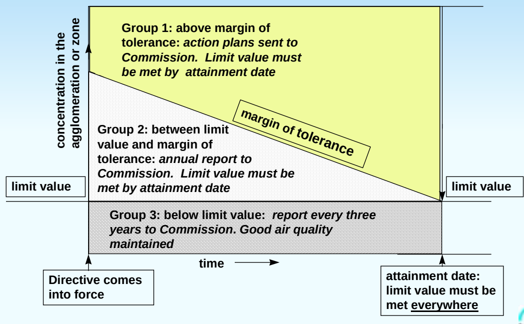
+ 50 % (annual aver.) *

PM_{10} : + 50 % (24-h aver.)
(1 Jan 2001 – 1 Jan 2005)

+ 20 % (annual aver.)
(1 Jan 2001 – 1 Jan 2005)



Margin of tolerance



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Action plans

- Member States shall draw up action plans indicating the measures to be taken in the short term where there is a risk of the limit values and/or alert thresholds being exceeded, in order to reduce that risk and to limit the duration of such an occurrence.
- Such plans may, depending on the individual case, provide for measures to control and, where necessary, suspend activities, including motor-vehicle traffic, which contribute to the limit values being exceeded.

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Anthropogenic CO_2 and other greenhouse gases (GHG)

The monitoring mechanism for anthropogenic CO_2 and other greenhouse gases was established in June 1993, following the adoption of Council Decision 93/389/EEC, by the Council of Environment Ministers.

This was revised in April 1999, (Council Decision 99/296/EC) to allow for the updating of the monitoring process in line with the inventory requirements incorporated into the Kyoto Protocol .

Almost all Member states compiled a complete inventory for CO_2, CH_4 and N_2O emissions for the full period from 1990 to 1999.

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Greenhouse gas emission estimates

Council Directive: 93/389/EEC

GHG:
Carbon dioxide (CO_2)
Methane (CH_4)
Nitrous Oxide (N_2O)
Hydrofluorocarbons (HFCs)
Perfluorocarbons (PFCs)
Sulphur Hexafluoride (SF_6)

For each site for which emissions are calculated:
- Activity data;
- Emission factors;
- Oxidation factors;
- Total emissions; and
- Uncertainty.

The verifier shall prepare a report on the validation process stating whether the report pursuant to Article 14(3) is satisfactory. This report shall specify all issues relevant to the work carried out

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Area of representativity of station classes (typical values)

Station class	Radius of area
Traffic stations (TRF)	<10-15 m
Industrial stations (IND)	10-100 m
Urban background stations (URB)	100 m-2 km
Near-city background stations (NCB)	2-10 km
Regional stations (REG)	25-150 km
Remote stations (REM)	200-500 km

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Selection of monitoring areas and stations for EUROAIRNET

For population exposure

Type of area	Criteria: Area selection	Criteria: Station selection
Agglomerations		
>0.5 mill	All cities	All stations (up to 20 stations) All station categories represented in the city
0.25-0.5 mill	At least 25% of the cities	High, medium and low levels of industrialization
0.05-0.25 mill	At least 10% of the cities	High, medium and low levels of industrialization
Rural areas	At least 50% of the areas with population density >2	One station to represent each of the selected areas.
Industrial areas outside cities	All areas with air pollu tion above the WHO AQ Guidelines	All existing monitoring stations in these areas.

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Selection of compound and indicators to be included in EUROAIRNET

	Population exposure	Materials exposure	Ecosystems exposure
Priority 1	Air 1h : SO_2, NO_2, NO_x, O_3 1h or 24h : PM_{10}, $PM_{2,5}$ 24h or longer : Pb	Air: SO_2, O_3, NO_2, temp. relative humidity. Precip.: mm, pH Materials: steel panels	Air: 1h : O_3, VOC* 24h : SO_2, SO_4, NO_2 Precip.: 24h : SO_4, NO_3, NH_4, Ca, pH, (H^+)
Priority 2	1h : CO 1h or 24h : SPM (or TSP), BS 24 h or longer : Benzene, PAH, Cd, As, Ni, Hg	Air: HNO_3 (gas). Precip.: Cl^-, SO_4, NO_2 Materials: zinc	Air: VOC, NO_x
Priority 3	Other compounds	Materials: copper, calcareous stone	UV radiation?

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Air Quality EU-directives for PM_{10}, Pb ($\mu g/m^3$) (Council Directive 1999/30/EC of 22 April 1999), Daughter directives for benzene ($\mu g/m^3$) and CO (mg/m^3) (COM (1998) 591 final)

Compound	PM_{10}	PM_{10}	Pb	Pb	Benzen	CO
Date for meeting the limit	01.01.10	01.01.10	01.01.05	01.01.10	01.01.10	01.01.05
Averaging time	24 timer	Calendar year	Calendar year	Calendar year	Calendar year	8 timer
Limit value for health impact (nr exceed/yr.)			0,5	0,5 (1,0 from 01.01.05)	5*	10
Guideline value for health impact	50 (7 x))	20				
Tolerance margin health		10 (50% 01.01.05)	0,5 (100%)		5 (100%)	5 (50%)
Upper assment threshold (UAT) (exceed/yr)	30 (7)	14	0,35		3,5	7
UAT Ecosystem						
UAT vegetation						
Lower AT Health (ex. per year)	20 (7)	10	0,25		2	5
LAT ecosystem						
LAT vegetation						

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Air Quality EU-directives for SO_2 and NO_2

Compound	SO_2	SO_2	SO_2	NO_2	NO_2
Date meeting the limit	01.01.05	01.01.05	19.07.01	01.01.10	01.01.10
Averaging time	1 hour	24 hours	winter-half year	hour	Calendar year
Limit value for health impact (nr exceed/yr)	350 (24 times)	125 (3 times)		200 (18 times)	40
Limit value, ecosystem			20		
Limit value vegetation					
Tolerance margin health	150 (+43%)			100 (50%)	20 (50%)
Limit value for warning (3 consec. hrs)	500			400	
Upper assm. T. (no. Exceed per year)		75 (3 times)		140 (18)	32
UAT Ecosystem			12 Winter		
Lower AT Health (ex. per year)		50 (3)		100 (18)	26
LAT ecosystem			8 (winter)		
LAT vegetation					

(Council Directive 1999/30/EC of 22 April 1999),

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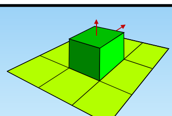
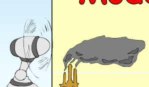


A Q Modelling

Model input



- source characteristics / emission data
- area characteristics
- measurement data air quality
- meteorological data
- dispersion coefficients
- dry & wet removal
- receptor point locations / grid

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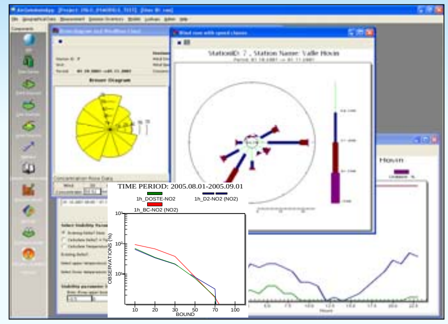
Air Quality Assessment and reporting

Bjarne Sivertsen & Claudia Hak, NILU

Statistics
Air quality and meteorology
Exceeding limit values
Possible impacts (health and nature)
Designing the AQ report

Air Quality assessment using Management software



AirQUIS

QA/QC

Selected indicators

- SO_2 (Sulphur dioxide)
- NO_2 (Nitrogen dioxide)
- PM_{10} (Particles with aerodyn. diametre < 10 microns)
- $PM_{2,5}$ (< 2.5 microns)
- Ozone
- Benzene (BTX)
- CO (carbon monoxide)

AQ Limits and Guidelines

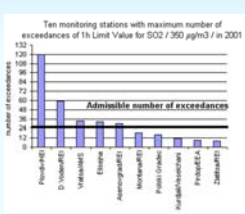
Pollutant	Averaging time	Limit- and Guidelines Values	
		EU 1)	WHO
Sulphur Dioxide (SO_2)	1 hour	350 (24 x)	500 (10 min)
	24 hours	125 (3 x)	50 *
	Year	-	-
Nitrogen Dioxide (NO_2)	1 hour	200 (18 x)	200
	Year	40	40
Ozone (O_3)	1 hour	-	150-200
	8 hours	120 *)	120
Carbon Monoxide (CO)	1 hour	-	30 000
	8 hours	10 000	10 000
Particles <10 µm (PM10)	24 hours	50 (35 x)	(150) 50
	Year	40	(50) 20
Particles < 2,5 µm PM2,5)	24 hours	-	(75) 25
	Year	25	(25) 10
Benzene	Year	5	-
Lead (Pb)	Year	0,5	0.5-1,0

1) Ref: EU Limit values for protection of human health (2008/50/EC)
(n x) not to be exceeded more than n times
**) not to be exceeded more than 25 days per year (aver over 3 years)*
WHO guideline values 2005 in ( ) are WHO interim target values (IT2)

Limit values Bulgaria

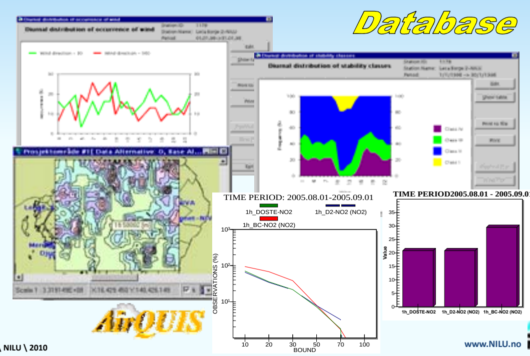
1 Jan 2000:
Three new Regulations of the Ministry of Environment and Water and the Ministry of Health, developing the air quality legislation, were enforced. Transpose the EU Directives: - 96/62/EC, 92/72/EC, 99/30/EC

Bulgaria is received a final written warning for its failure to comply with limit values for sulphur dioxide. In June 2009, the Commission sent Bulgaria a first written warning about the measures in place to meet limit values.

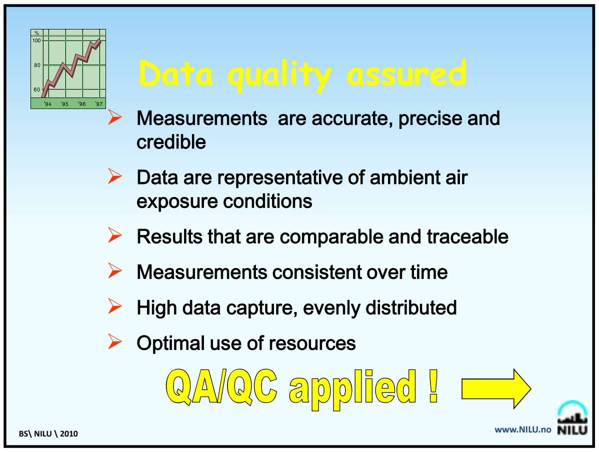


Data Statistics

Database



AirQUIS


Data quality assured
Measurements are accurate, precise and credible
Data are representative of ambient air exposure conditions
Results that are comparable and traceable
Measurements consistent over time
High data capture, evenly distributed
Optimal use of resources
QA/QC applied !
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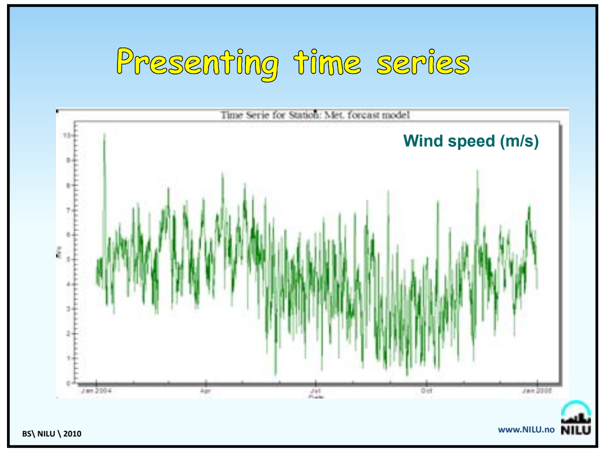
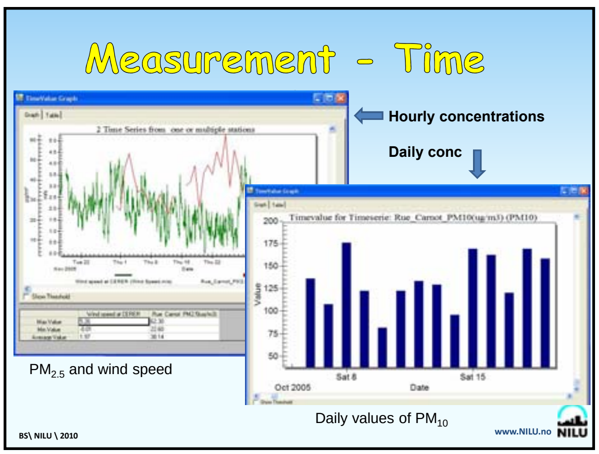
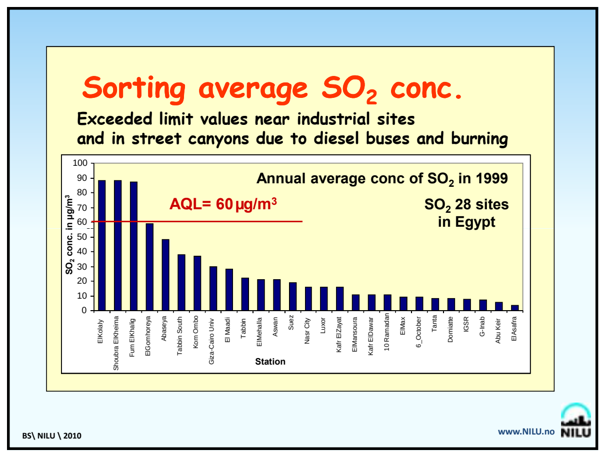
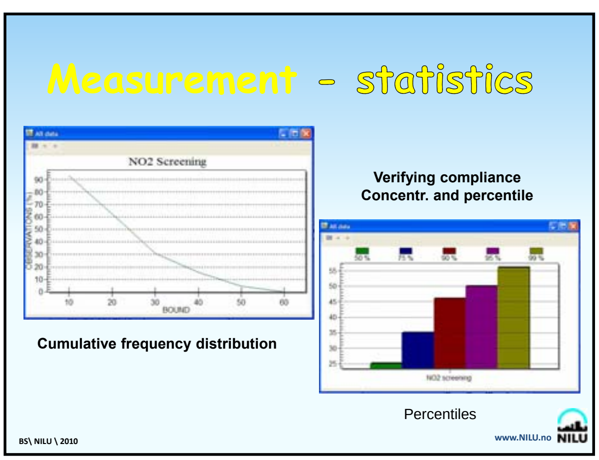
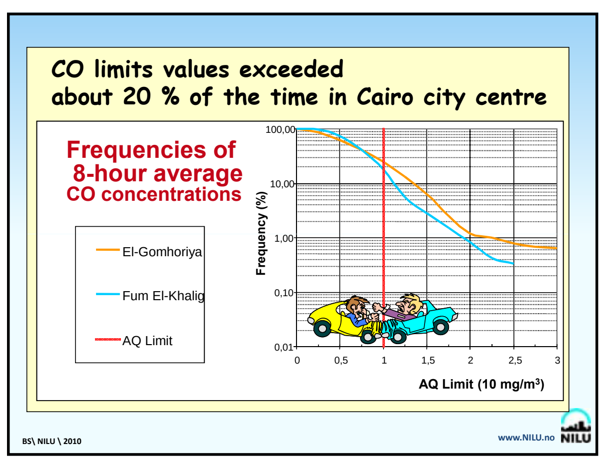
NILU

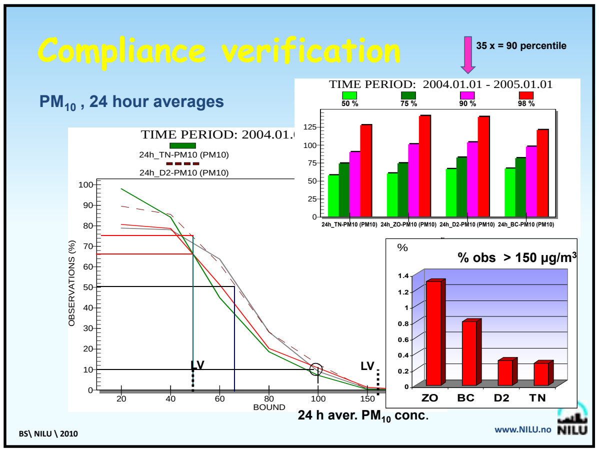

Presenting time series
Time Serie for Station: Met. forcast model
Wind speed (m/s)
BS\ NILU \ 2010
www.NILU.no
NILU

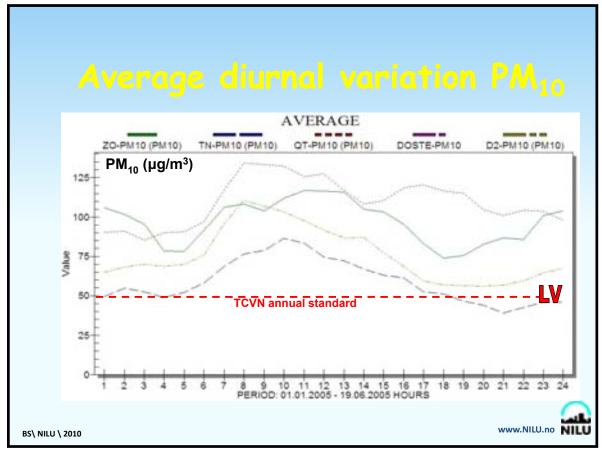

Measurement - Time
Hourly concentrations
Daily conc
2 Time Series from one or multiple stations
Timevalue for Timeserie: Rue_Carnot_PM10(ug/m3) (PM10)
PM2.5 and wind speed
Daily values of PM10
BS\ NILU \ 2010
www.NILU.no
NILU

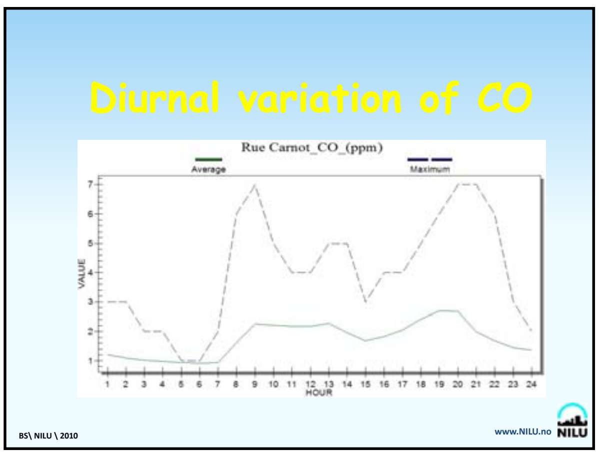

Sorting average SO2 conc.
Exceeded limit values near industrial sites
and in street canyons due to diesel buses and burning
Annual average conc of SO2 in 1999
AQL= 60 µg/m³
SO2 28 sites
in Egypt
SO2 conc. in µg/m³
Station
BS\ NILU \ 2010
www.NILU.no
NILU

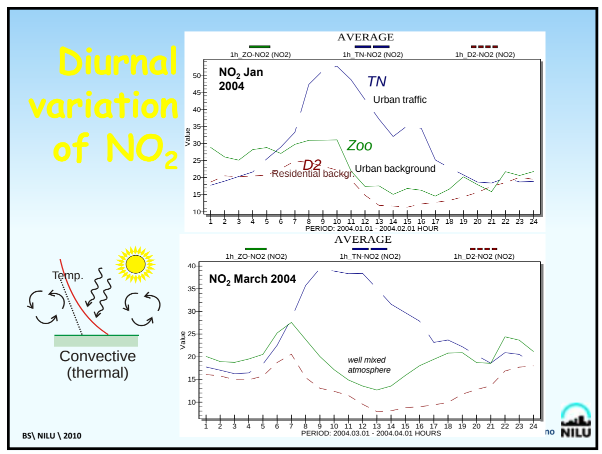

Measurement - statistics
NO2 Screening
Verifying compliance
Concentr. and percentile
Cumulative frequency distribution
Percentiles
BS\ NILU \ 2010
www.NILU.no
NILU

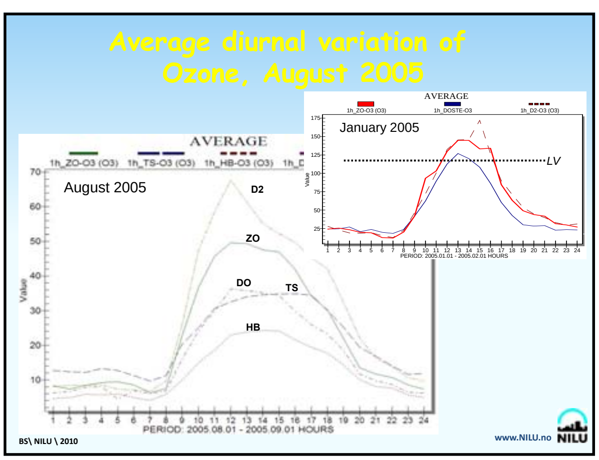

CO limits values exceeded
about 20 % of the time in Cairo city centre
Frequencies of
8-hour average
CO concentrations
El-Gomhoriya
Fum El-Khalig
AQ Limit
Frequency (%)
AQ Limit (10 mg/m³)
BS\ NILU \ 2010
www.NILU.no
NILU

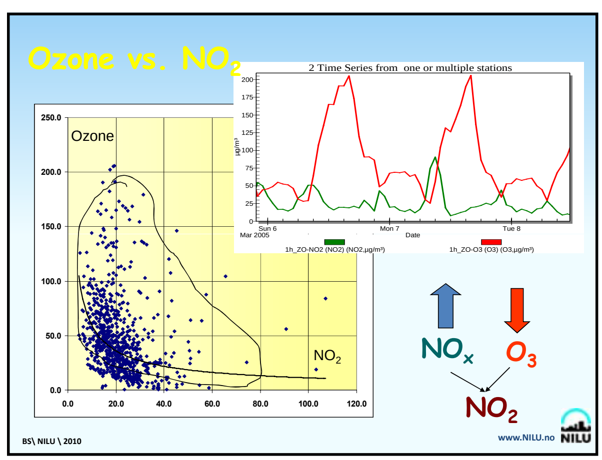

Compliance verification
35 x = 90 percentile
PM10 , 24 hour averages
TIME PERIOD: 2004.01.01 - 2005.01.01
50 %
75 %
90 %
98 %
% obs > 150 µg/m3
ZO
BC
D2
TN
LV
24 h aver. PM10 conc.
BS\ NILU \ 2010
www.NILU.no
NILU

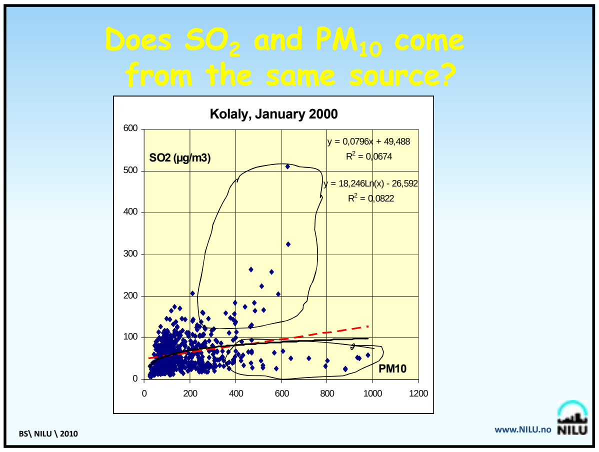

Average diurnal variation PM10
AVERAGE
PM10 (µg/m3)
TCVN annual standard
LV
BS\ NILU \ 2010
www.NILU.no
NILU

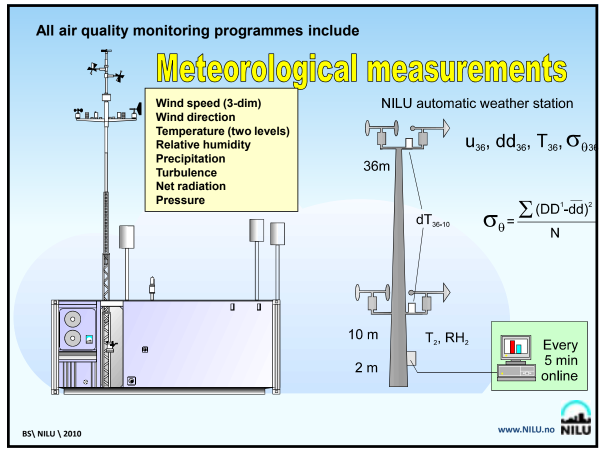

Diurnal variation of CO
Rue Carnot_CO_(ppm)
Average
Maximum
HOUR
BS\ NILU \ 2010
www.NILU.no
NILU

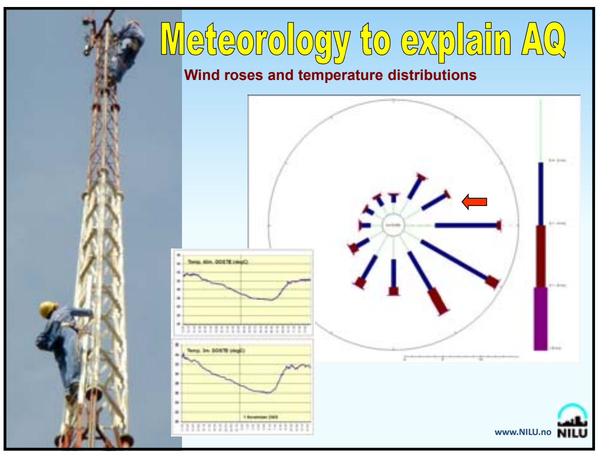

Diurnal variation of NO2
AVERAGE
NO2 Jan 2004
TN
Urban traffic
Zoo
D2
Residential backgr.
Urban background
NO2 March 2004
well mixed atmosphere
Temp.
Convective (thermal)
BS\ NILU \ 2010
NILU

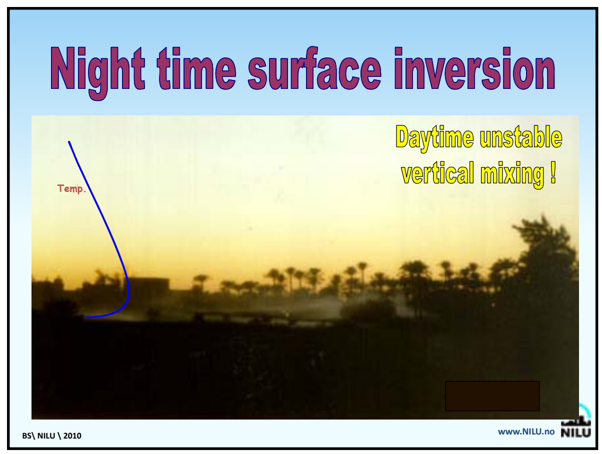

Average diurnal variation of Ozone, August 2005
AVERAGE
August 2005
D2
ZO
DO
TS
HB
January 2005
LV
BS\ NILU \ 2010
www.NILU.no
NILU

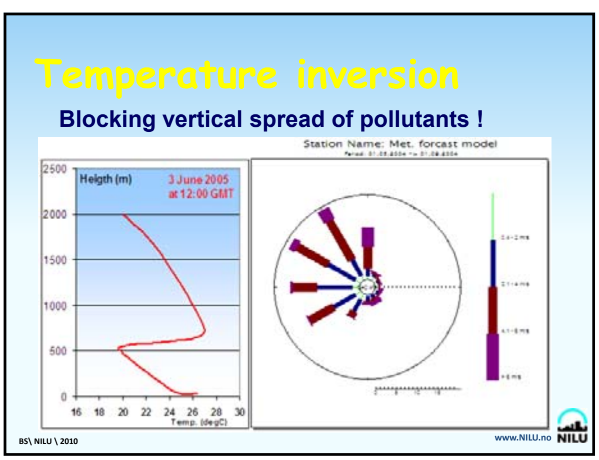

Ozone vs. NO2
2 Time Series from one or multiple stations
Ozone
NO2
NOx
O3
NO2
BS\ NILU \ 2010
www.NILU.no
NILU

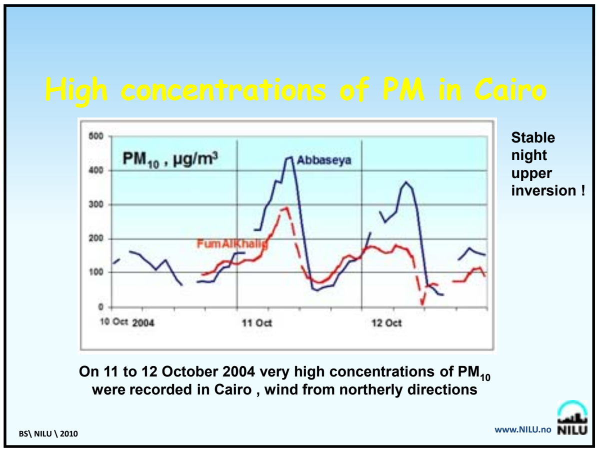

Does SO2 and PM10 come from the same source?
Kolaly, January 2000
SO2 (µg/m3)
y = 0,0796x + 49,488
R2 = 0,0674
y = 18,246Ln(x) - 26,592
R2 = 0,0822
PM10
BS\ NILU \ 2010
www.NILU.no
NILU

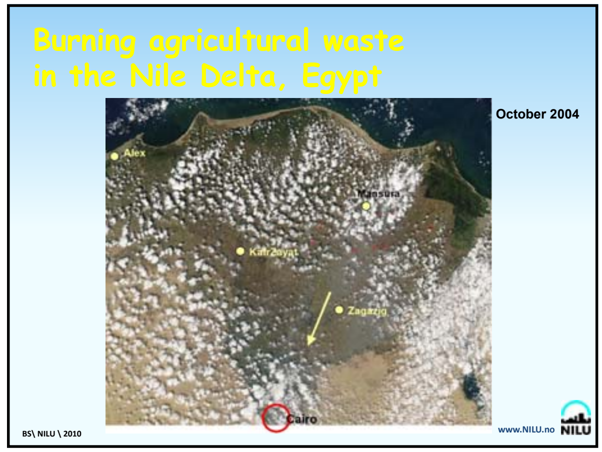

All air quality monitoring programmes include
Meteorological measurements
Wind speed (3-dim)
Wind direction
Temperature (two levels)
Relative humidity
Precipitation
Turbulence
Net radiation
Pressure
NILU automatic weather station
36m
10 m
2 m
Every 5 min online
BS\ NILU \ 2010
www.NILU.no
NILU

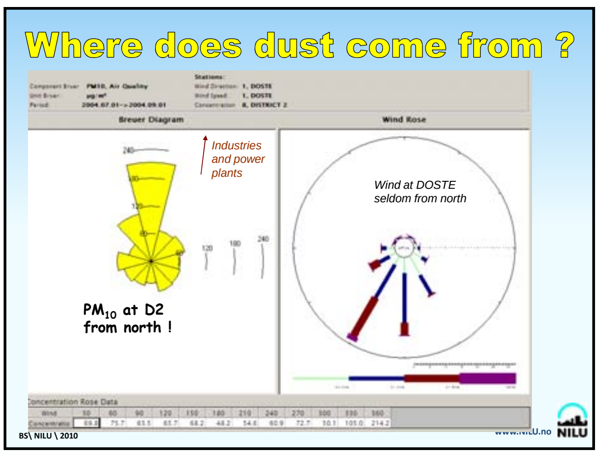

Meteorology to explain AQ
Wind roses and temperature distributions
www.NILU.no
NILU


Night time surface inversion
Daytime unstable vertical mixing !
Temp.
BS\ NILU \ 2010
www.NILU.no
NILU


Temperature inversion
Blocking vertical spread of pollutants !
Station Name: Met. forcast model
Heigth (m)
3 June 2005 at 12:00 GMT
Temp. (degC)
BS\ NILU \ 2010
www.NILU.no
NILU


High concentrations of PM in Cairo
PM10 , µg/m3
Abbaseya
FumAlKhalig
500
400
300
200
100
0
10 Oct 2004
11 Oct
12 Oct
Stable night upper inversion !
On 11 to 12 October 2004 very high concentrations of PM10 were recorded in Cairo , wind from northerly directions
BS\ NILU \ 2010
www.NILU.no
NILU


Burning agricultural waste in the Nile Delta, Egypt
October 2004
Alex
Mansura
Kafr Zayat
Zagazig
Cairo
BS\ NILU \ 2010
www.NILU.no
NILU


Where does dust come from ?
Breuer Diagram
Wind Rose
Industries and power plants
Wind at DOSTE seldom from north
PM10 at D2 from north !
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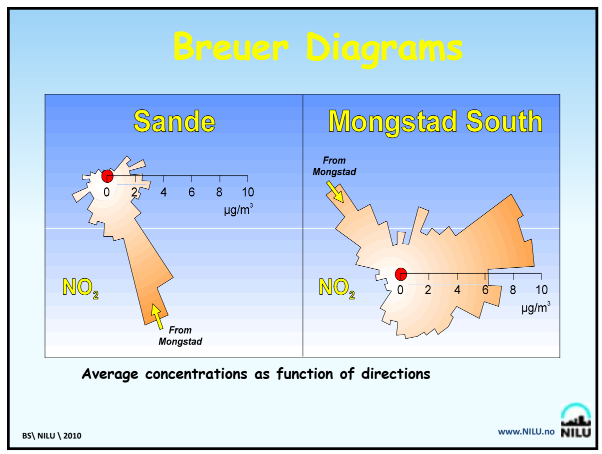
Breuer Diagrams
Sande
Mongstad South
NO2
NO2
0 2 4 6 8 10
µg/m3
From Mongstad
From Mongstad
Average concentrations as function of directions
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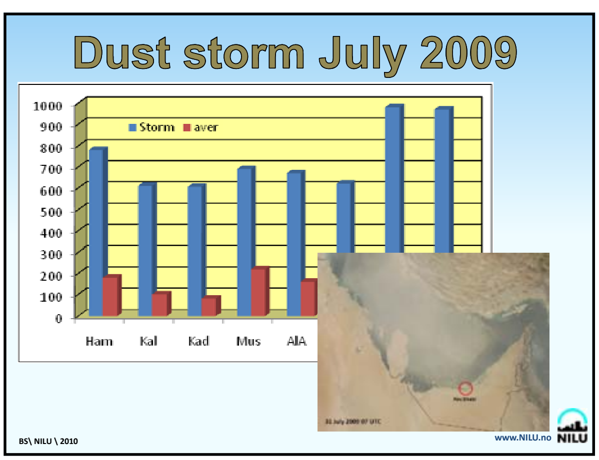
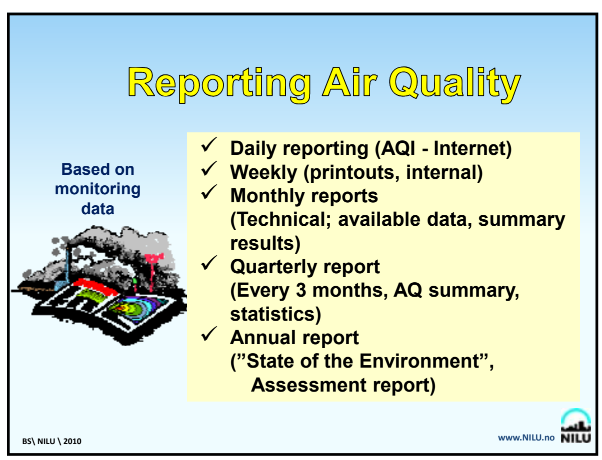

Dust storm July 2009
Storm
aver
1000
900
800
700
600
500
400
300
200
100
0
Ham
Kal
Kad
Mus
AIA
BS\ NILU \ 2010
www.NILU.no
NILU


Reporting Air Quality
Based on monitoring data
✓ Daily reporting (AQI - Internet)
✓ Weekly (printouts, internal)
✓ Monthly reports (Technical; available data, summary results)
✓ Quarterly report (Every 3 months, AQ summary, statistics)
✓ Annual report ("State of the Environment", Assessment report)
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www.NILU.no
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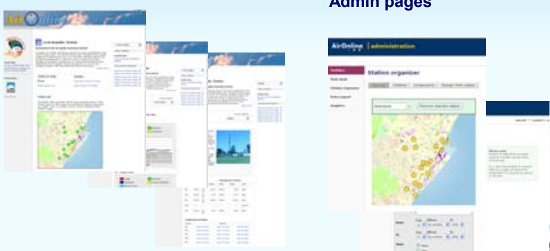
Daily reports

Based on AQ Web pages

Public pages

Admin pages



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Web info "on-line"

Based on simplified presentations

AQI = Air Quality Index

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*...air quality conditions are:*	*...as symbolized by this color:*
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

The AQI = index for reporting daily air quality:
- how clean or polluted is the air,
- Indicate associated health concerns you should be aware of.

$$AQI = \frac{\text{Pollutant concentration}}{\text{Pollutant limit value}} \times 100$$

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Monthly Reports

Summary
Introduction
Objectives and AQ standards
Data Capture
Presentation of measurements
Meteorology
- Wind rose
- Average wind speed per wind sector
- Diurnal variation of wind directions
- Temperature, rel. humidity and pressure.

Ambient air quality
Statistical evaluation
- Cumulative frequency distribution
- Percentiles

Diurnal variation
Concentration roses (Breuer diagram)
Discussions/news
Conclusions

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Data capture

Include:
- •Sites with map
- •Data quality
- •Data availability
- •Explain errors
- •Simple statistics

Data availability per site and parameter %

No.	Station Name	Parameter									
		SO_2	NO_2	CO	O_3	PM_{10}	H_2S	CH_4	BETX	Met.	Noise
1	Hamdan Street	87.8	96.3	68.6	---	99.4	---	0	0	100	66.6
2	Khadejah School	66.5	66.9	---	67.5	67.1	67.5	0	---	67.5	67.5
3	Khalifa School	99.6	94.3	---	100	74.5	99.1	0	---	100	33.8
4	Mussafah	100	92.7	---	---	99.6	100	0	---	100	0
5	Baniyas School	96.9	99.4	---	100	100	93.3	0	---	93.5	100
6	Al Ain Islamic Institute	94	0	---	100	99.7	91.4	0	---	99	100
7	Al Ain Street	0	85.4	83.2	---	99.9	---	0	98	100	100
8	Bida Zayed	93	0	---	0	99.3	97.9	0	---	97.1	100
9	Gayathi School	90.5	100	---	73.8	100	98.2	0	---	98	100
10	Liwa Oasis	92.4	78.7	---	98.2	100	---	0	---	100	100

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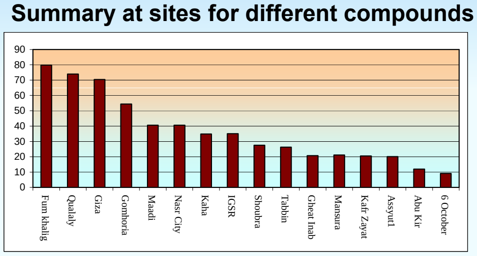
Average concentrations

Summary at sites for different compounds



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A monthly summary

- How good were the data?
- What was the critical pollutant ?
- Any specific episode?
- This month compared to earlier

Discussions and conclusions

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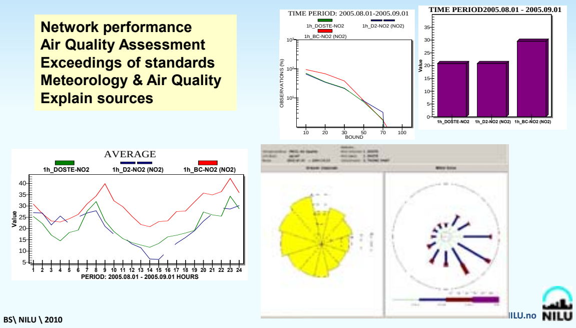
Quarterly reports

Network performance
Air Quality Assessment
Exceedings of standards
Meteorology & Air Quality
Explain sources



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The monitoring programme

	Parameters								
	Site	SO2	NOx	NO2	PM10	PM2,5	O3	CO	Benz
1	Bd.Republique	X	X	X	X	X	X	X	
2	Medina		X	X	X			X	
3	HLM4	X	X	X	X		X		
4	BelAir	X	X	X	X	X			X
5	Yoff		X	X	X		X		

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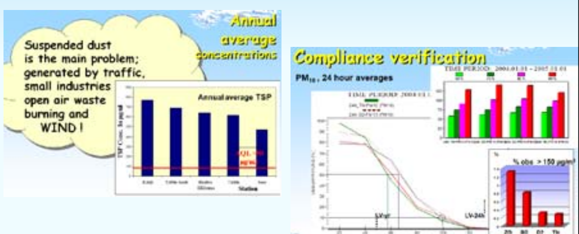
Explain the air quality

Select parameters and statistics that illustrate the main features



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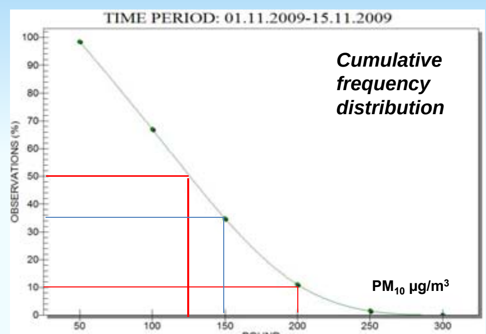
Frequencies and exceedings



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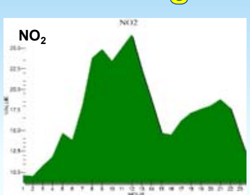
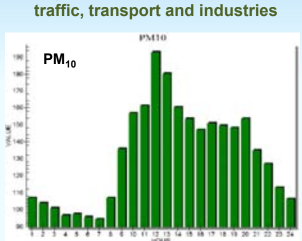
Average diurnal variation



Can it explain the impact from traffic/industry ?

Daytime impact from activities: traffic, transport and industries



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Annual report

State of the environment

1	Introduction
2	Prevailing winds
3	The main features of air pollution in Dakar
4	Suspended dust in the air, PM_{10}
4.1	Annual average PM_{10} concentrations
4.2	Monthly average concentrations
4.3	Sand storm levels-episodes?
4.4	Exceedings of PM_{10} standards
5	Gaseous pollutants
5.1	Ozone concentrations
5.2	SO_2 and NO_2 concentrations
5.3	CO concentrations in streets
5.4	VOC-Benzene
6.	The main air pollution problems in Dakar

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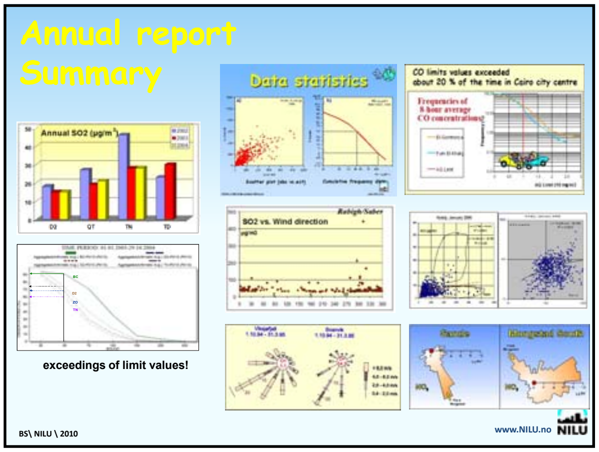
Annual report
Summary
Data statistics
Annual SO2 (µg/m³)
exceedings of limit values!
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www.NILU.no
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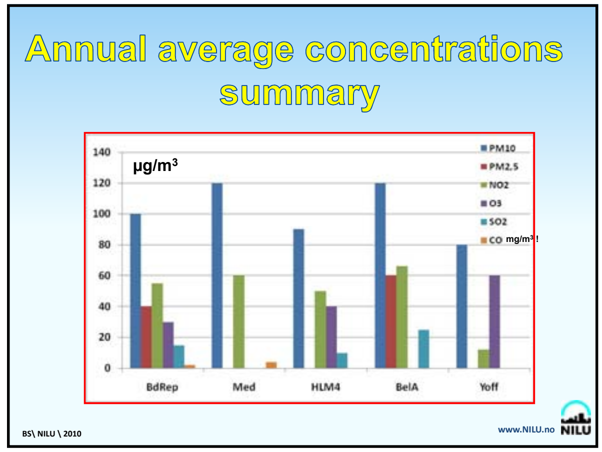
Annual average concentrations summary
µg/m³
PM10
PM2.5
NO2
O3
SO2
CO mg/m³
BdRep
Med
HLM4
BelA
Yoff
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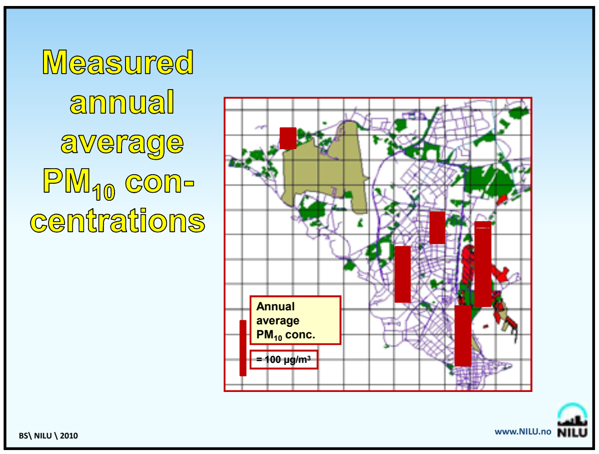
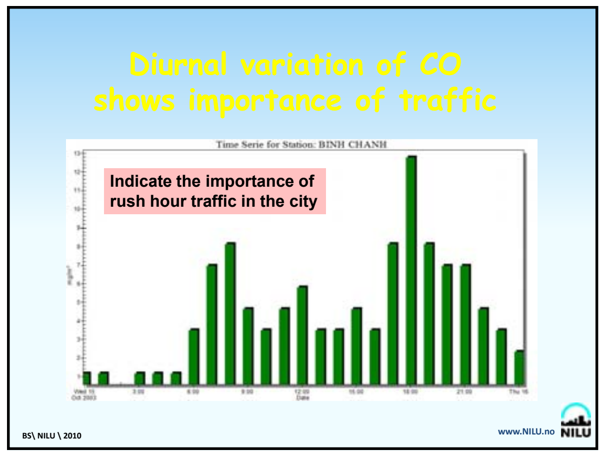
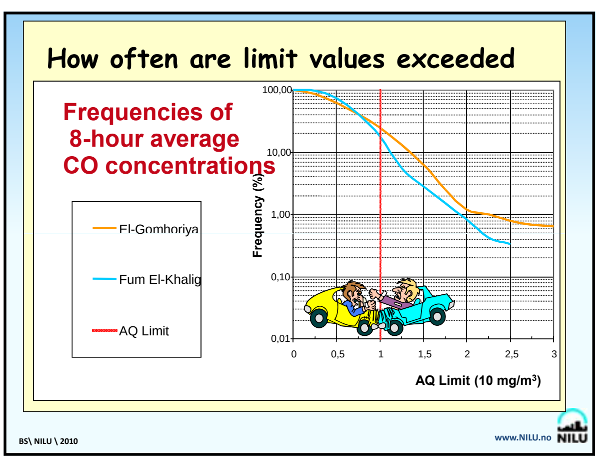
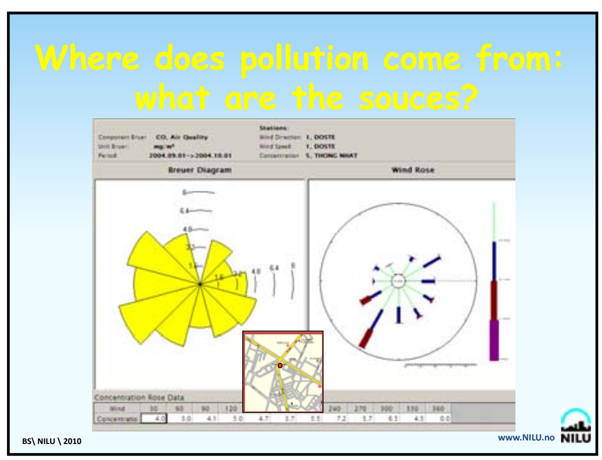
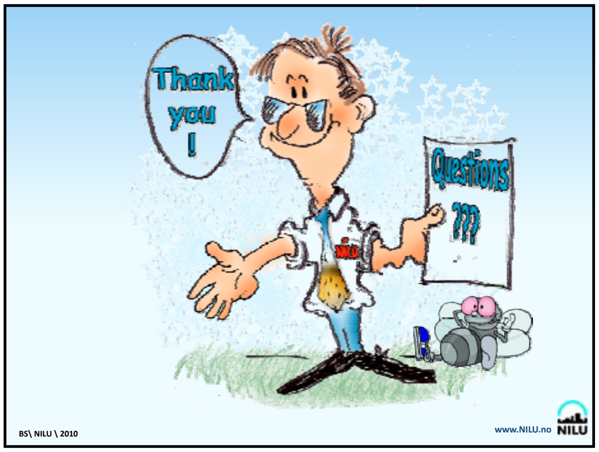

Measured annual average PM10 con-centrations
Annual average PM10 conc.
= 100 µg/m³
BS\ NILU \ 2010
www.NILU.no
NILU


Diurnal variation of CO shows importance of traffic
Time Serie for Station: BINH CHANH
Indicate the importance of rush hour traffic in the city
BS\ NILU \ 2010
www.NILU.no
NILU


How often are limit values exceeded
Frequencies of 8-hour average CO concentrations
El-Gomhoriya
Fum El-Khalig
AQ Limit
Frequency (%)
AQ Limit (10 mg/m³)
BS\ NILU \ 2010
www.NILU.no
NILU


Where does pollution come from: what are the souces?
Breuer Diagram
Wind Rose
BS\ NILU \ 2010
www.NILU.no
NILU


Thank you !
Questions ???
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www.NILU.no


Norwegian Institute for Air Research
www.nilu.no
NILU
POBox 100
No-2027 Kjeller
Norway
Fax: +4763898050
E-mail:
nilu@nilu.no
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Results from the screening study, Burgas

Burgas, Bulgaria
26-28 May 2010

Claudia Hak
NILU

Sampling programme

Screening → investigation of great number of 'something'

31 sites representative for background, traffic, industrial influence, etc

Passive samplers exposed for 10 days

Screening study

Passive samplers (diffusion) for NO_2, SO_2, O_3, PM and VOC at 31 sites in Burgas and surroundings

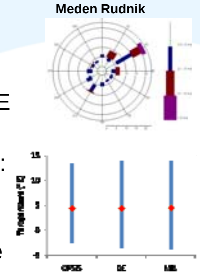
Active sampling (pumped) of PM_{10} in Burgas and VOC close to refinery

Representativity of results

Winter conditions!

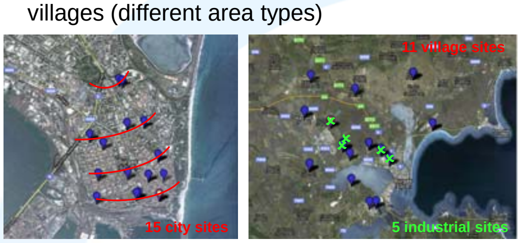
- sampling in March 2010
- transition wind regime: N, NE
- winter meteorological conditions → winter sources: residential heating

→ Screening study results representative for wintertime



Sampling sites

31 sampling sites in Burgas and surrounding villages (different area types)

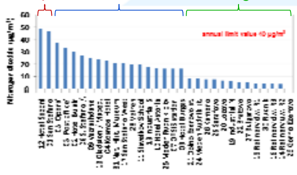


Limit and guideline values

	Effect	Averaging period	Bulgaria (standards)	EU (limit values)	WHO (guidelines)
SO_2	**Effect (SO_2)**	**Averaging period**	**Bulgaria (standards)**	**EU (limit values)**	**WHO (guidelines)**
	Health	10 min			500 $\mu g/m^3$
	Health	1 hour	350 $\mu g/m^3$ (1)	350 $\mu g/m^3$ (1)	
	Alarm thresh.	3 hours	500 $\mu g/m^3$	500 $\mu g/m^3$	
	Health	24 hours	125 $\mu g/m^3$ (1)	125 $\mu g/m^3$ (2)	20 $\mu g/m^3$
	Ecosystem	Calendar year and winter	20 $\mu g/m^3$	20 $\mu g/m^3$	
NO_2	**Effect (NO_2)**	**Averaging period**	**Bulgaria (standards)**	**EU (limit values)**	**WHO (guidelines)**
	Health	1 hour	200 $\mu g/m^3$ (1)	200 $\mu g/m^3$ (1)	200 $\mu g/m^3$
	Health	1 year	40 $\mu g/m^3$	40 $\mu g/m^3$	40 $\mu g/m^3$
PM_{10}	**Effect (PM_{10})**	**Averaging period**	**Bulgaria (standards)**	**EU (limit values)**	**WHO (guidelines)**
	Health	24 hours*	50 $\mu g/m^3$ (1)	50 $\mu g/m^3$ (2)	50 $\mu g/m^3$
	Health	1 year	30 $\mu g/m^3$	40 $\mu g/m^3$	20 $\mu g/m^3$
$PM_{2.5}$	**Effect ($PM_{2.5}$)**	**Averaging period**	**Bulgaria (standards)**	**EU (limit values)**	**WHO (guidelines)**
	Health	24 hours*	-	-	25 $\mu g/m^3$
	Health	1 year	-	-	10 $\mu g/m^3$
O_3	**Effect (O_3)**	**Averaging period**	**Bulgaria (standards)**	**EU (limit values)**	**WHO (guidelines)**
	Alarm thresh.	1 hour	240 $\mu g/m^3$	240 $\mu g/m^3$	
	Health	1 hour	180 $\mu g/m^3$	180 $\mu g/m^3$	
	Health	8 hours*		120 $\mu g/m^3$	100 $\mu g/m^3$
C_6H_6	**Effect (VOC)**	**Averaging period**	**Bulgaria (standards)**	**EU (limit values)**	**WHO (guidelines)**
	benzene				
	Health	1 year	5 $\mu g/m^3$	5 $\mu g/m^3$	

NO_2 concentration levels

hot spot urban villages



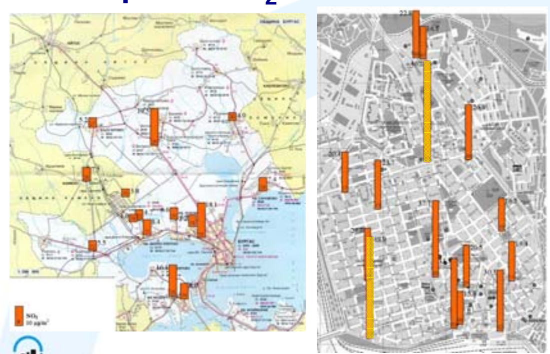
10 day average

- annual LV exceeded at traffic hot spots
- urban background ~16 µg/m³
- villages 6-8 µg/m³

☞ Exceedance of annual LV expected at traffic hot spot sites within Burgas

Bulgaria May 2010 Claudia Hak 7

Spatial NO_2 distribution



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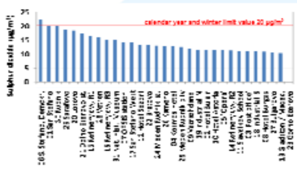
SO_2 concentration levels

Rather homogeneous distribution in and around Burgas



10 day average

- annual LV for protection of ecosystems slightly exceeded at three sites
- major source - refinery
- traffic, residential heating (coal)

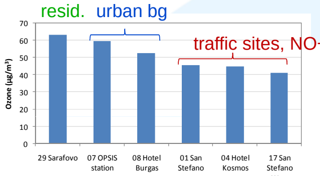
☞ Exceedance of 1 h or 24 h LV (health) may happen occasionally under unfavourable meteorological conditions

Bulgaria May 2010 Claudia Hak 9

Spatial SO_2 distribution

Bulgaria May 2010 Claudia Hak 10

O_3 concentration levels



10 day average

- O_3 limit values defined for 1 h and 8 h averaging periods
- No exceedances expected during wintertime

☞ Presumably exceedances during summertime
VOC + NO_x + sunlight → O_3

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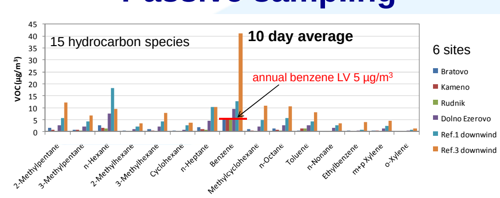
VOC concentration levels – Passive sampling



- Highest levels of all compounds downwind of refinery
- Styrene < d.l.
- Dolno Ezerovo – villlage with highest concentrations
- Benzene conc. close to annual LV

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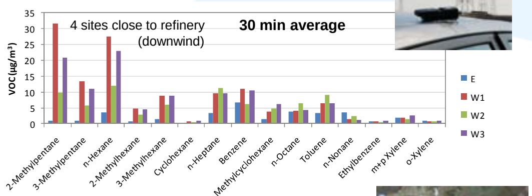
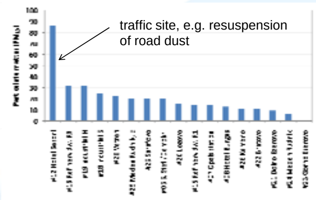
VOC concentration levels – Active sampling



- Sampled air from different areas of refinery
- Styrene < d.l. → no styrene source
- mainly alkanes (no LV)
- aromatic compounds (benzene, toluene)

Bulgaria May 2010 Claudia Hak 13

Passive PM_{10} sampling



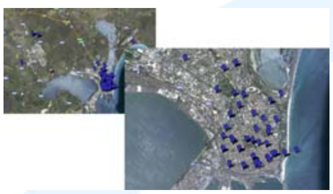
10 day average

- Passive samplers in villages and some sites in Burgas
- Higher PM levels at industrially influenced sites and traffic sites

☞ Rather homogeneous distribution of PM levels

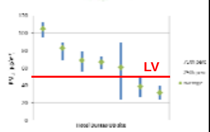
Bulgaria May 2010 Claudia Hak 14

Active PM_{10} sampling



- Short-term (15 min) in-situ sampling
- 60 samples at 47 different sites

- Sampling up to > 1 day at an UB site
- PM_{10} concentrations above 24 h LV most of the time



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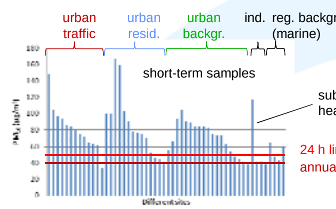
PM_{10} in different areas



- High regional background level > 45 µg/m³
- \+ traffic
- \+ resid. heating

Concentrations!

Composition?

☞ Exceedance of 24 h and annual LV happened for short-term samples at all sites. Annual LV likely to be exceeded.

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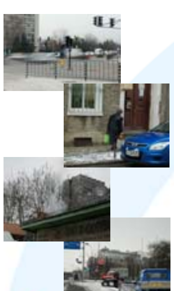
General aspects of the air quality



traffic main source for NO_2 (year-round source)

residential heating applying wood combustion stoves important PM and C_6H_6 source in winter

PM_{10} level in hot spot areas and city centre high; may represent a health problem (combustion particles)

Ventilation conditions play important role regarding PM levels

Bulgaria May 2010 Claudia Hak 17

Summary

Air pollution in Burgas related to traffic, residential heating, a regional background (PM) and in some areas industry

Suspended particulate matter poses main air pollution problem

Nitrogen dioxide levels high at traffic hot spots

Sulphur dioxide homogeneously distributed in the region

Benzene levels in villages close to refinery may exceed annual LV

Bulgaria May 2010 Claudia Hak 18

Thank you

Data Dissemination

Burgas, Bulgaria
26-27 May 2010

Leif Marsteen & Bjarne Sivertsen
NILU

Data transport

Information distribution

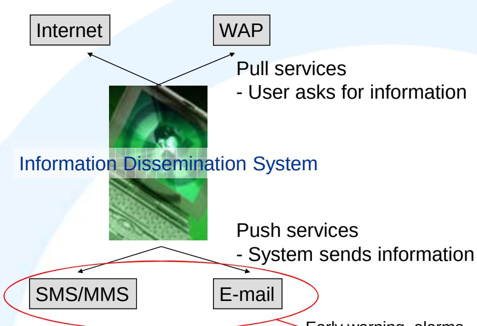
Relevant for:

- Informing the public
- Informing governmental organisations
- Informing non-expert decision makers
- Supporting the operators of Environmental Management Systems

Legal background

- Directive 2003/4/EC on public access to environmental information
- Directive 2008/50/EC on ambient air quality and cleaner air for Europe
  - The public shall be informed

Information channels



Challenges

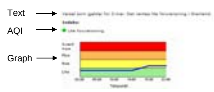
- Present data that is both scientifically correct and being understood by the audience
- Audience: Scientists, decision-makers, public
- Requires different presentation techniques
- Public pages: Keep it simple!
- Simple graphs, color coding, pollution classes, Air Quality Index, not numbers

Requirements

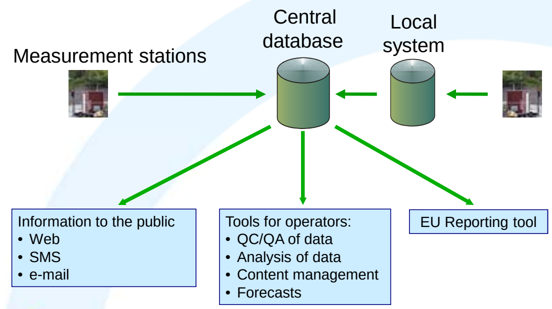
Pollution level
- Little
- Some
- A lot
- Very much

Content
- Health related information
- Effect descriptions for non-experts

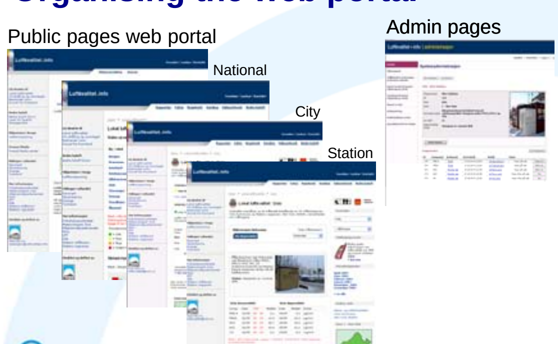
Technical
- Professional databases
- Powerful processing
- Automatic QA/QC
- Efficient data exchange



Integrated system



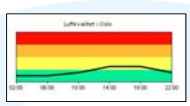
Organising the web portal



Administrative pages

- Contents management
  - Add stations
  - Add/remove parameters at station
  - Edit information
  - Update forecasts
- Data quality control
  - Data validation
  - Data discrimination, flagging

Public pages



- Forecasts
- Health warnings/recommendations
- On-line data
- Statistics
- Compliance views
- Facts on air pollution and regulations
- Service for SMS and e-mail

National page

Contents:
- List of cities
- Status air pollution level
- On-line data
- News

City page

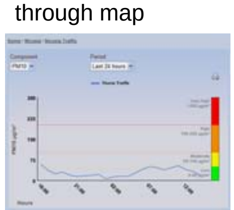
Contents:
- Pollution status now
- Forecast
- Pollution chart
- Map of stations
- Access to:
  - Statistics
  - SMS/ e-mail services
  - Station pages

Station page

Contents:
- Station description
- On-line data
- Historical data
- Compare data from different stations

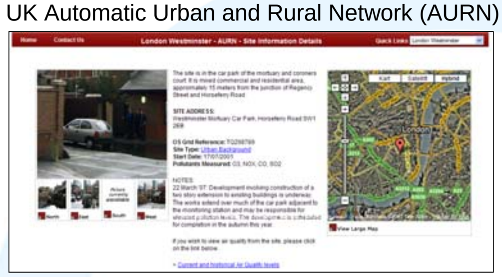
More examples, Cyprus

Access to details through map

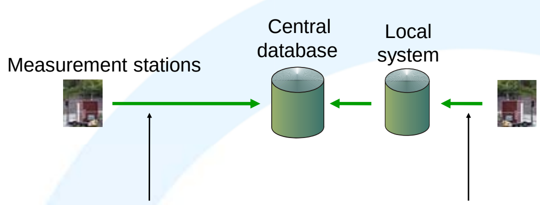


Google Map as added information

UK Automatic Urban and Rural Network (AURN)



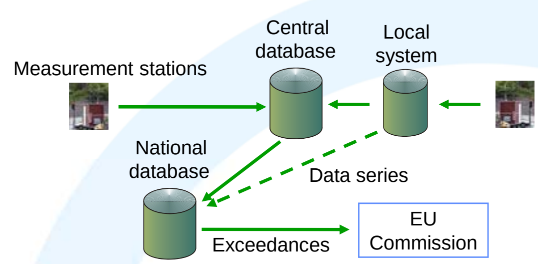
Data collection and validation



Centralised data collection:
Data validation tools available in admin pages

Local data collection:
Data validation is done locally

National data base



Stores data from stations that shall report data to the EU Commission

Possible services to client

- Develop web solution
- Maintain web portal and central data base
- Maintain national data base

Summary

- Information to the public is required
- Via Web, SMS, WAP
- Forecasts
- On-line data
- Historical data
- Data reporting to the Commission

Adresses

Public air quality web portals:

- http://www.luftkvalitet.info/
- http://www.airquality.co.uk/archive/index.php
- http://www.lanuv.nrw.de/luft/immissionen/aktluftqual/eu_luft_akt.htm
- http://www.airquality.dli.mlsi.gov.cy/
- http://www.casadata.org/Reports/AlbertaMap.asp
- http://www.bv-aurnsiteinfo.co.uk/
- http://www.eea.europa.eu/

Thank you

Air Quality Management Planning
Bjarne Sivertsen, NILU
Models
Emission inventories
(point, area, line-sources)
Concentration distribution and exposure
Impact assessment
Abatement strategies
Action plans – future air – scenario evaluation
Clean Air
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www.NILU.no
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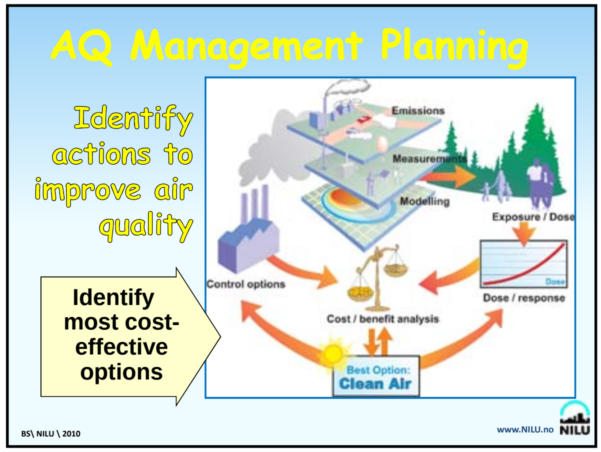
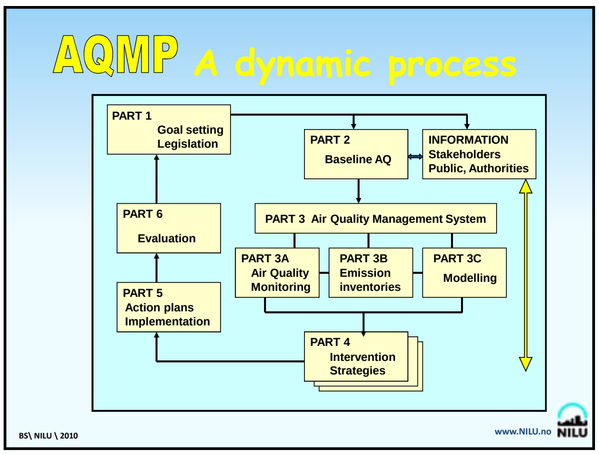


AQ Management Planning
Identify actions to improve air quality
Identify most cost-effective options
Emissions
Measurements
Modelling
Exposure / Dose
Control options
Dose / response
Cost / benefit analysis
Best Option:
Clean Air
BS\ NILU \ 2010
www.NILU.no
NILU



AQMP A dynamic process
PART 1
Goal setting
Legislation
PART 2
Baseline AQ
INFORMATION
Stakeholders
Public, Authorities
PART 6
Evaluation
PART 3 Air Quality Management System
PART 3A
Air Quality Monitoring
PART 3B
Emission inventories
PART 3C
Modelling
PART 5
Action plans
Implementation
PART 4
Intervention Strategies
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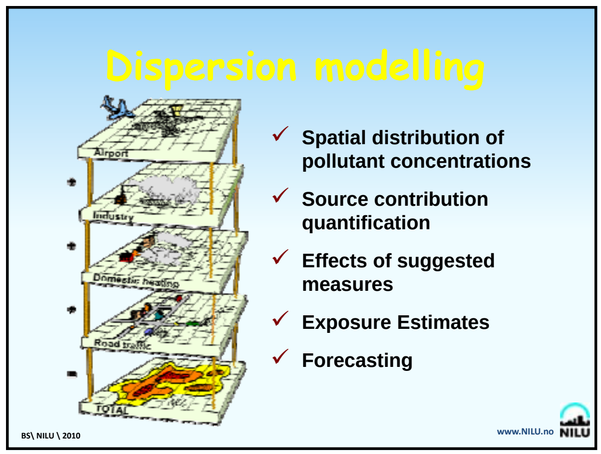

Dispersion modelling
Airport
Industry
Domestic heating
Road traffic
TOTAL
Spatial distribution of pollutant concentrations
Source contribution quantification
Effects of suggested measures
Exposure Estimates
Forecasting
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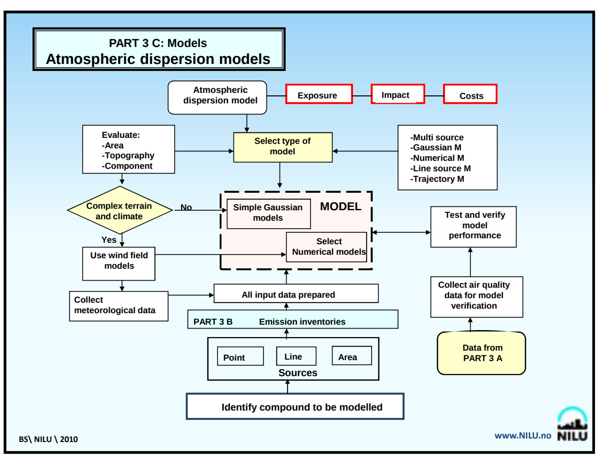

PART 3 C: Models
Atmospheric dispersion models
Atmospheric dispersion model
Exposure
Impact
Costs
Evaluate:
-Area
-Topography
-Component
Select type of model
-Multi source
-Gaussian M
-Numerical M
-Line source M
-Trajectory M
Complex terrain and climate
No
Yes
Simple Gaussian models
MODEL
Select Numerical models
Test and verify model performance
Use wind field models
Collect meteorological data
All input data prepared
Collect air quality data for model verification
PART 3 B
Emission inventories
Data from PART 3 A
Point
Line
Area
Sources
Identify compound to be modelled
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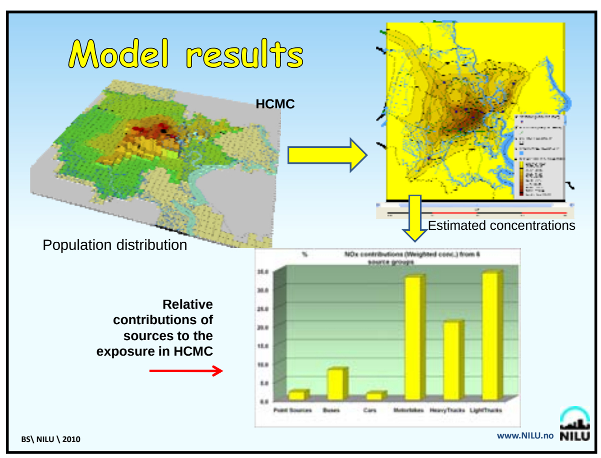

Model results
HCMC
Population distribution
Estimated concentrations
Relative contributions of sources to the exposure in HCMC
Point Sources
Buses
Cars
Motorbikes
HeavyTrucks
LightTrucks
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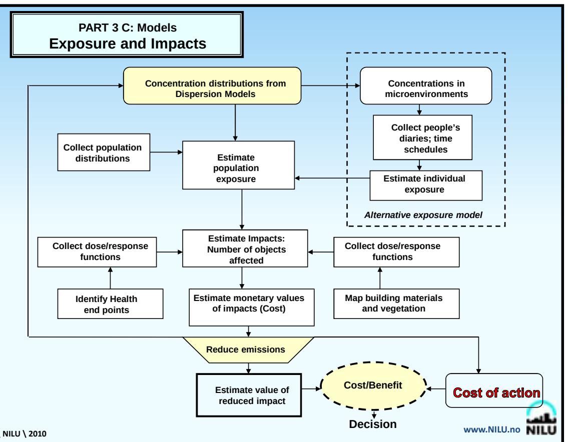

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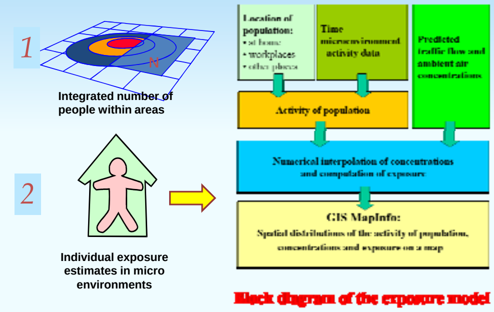
Exposure estimates



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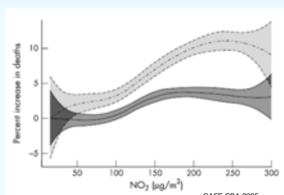
Estimate dose/response

A large number of health end points and pollutants

- Chronic mortality from PM
- Infant mortality from PM
- Acute mortality from ozone
- Morbidity impacts from PM
- Morbidity impacts from ozone
- Bronchitis
- Asthmas
- Acute respiratory diseases, PM, NO_x
- Hospital admissions
- Reduced working days

Dose/response functions



CAFE CBA 2005

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Exposure response relationships for PM

Meta-analyses; time series morbidity study in China

Health end point	Diseases	% per µg/m³ PM_{10}	s.e.
Hospital admission	Resp dis.	0.12	0.02
	Cardiov. Dis.	0.07	0.02
New cases	Chronic Bronchitis	0.48	0.04

Aunan & Pan, 2004

EU Cost Benefit Analyses (CAFÉ CBA 2005)

Mortality from chronic exposure :	4 % / 10 µg/m³ PM_{10} (Infant; 0-1 yr)
Increase mortality chronic exposure:	6% / 10 µg/m³ $PM_{2,5}$ (Pope et al.)
Respiratory hospital admission :	1 % / 10 µg/m³ PM_{10} (0-64 yrs)

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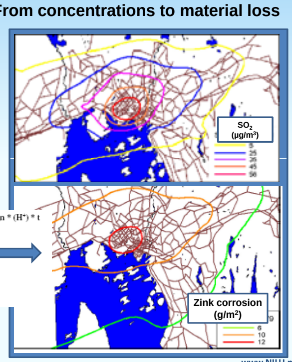
Environmental load

From concentrations to material loss

Mass loss model

$$ML = a * (SO_2)^b * (O_3)^c * RH * \exp[d\,(T-10)] * t^e + f * regn * (H^+) * t$$

- ML = vekttap (Mass Loss) i g/m² dag
- SO_2 = svoveldioksid i µg/m³
- O_3 = ozon i µg/ m³
- RH = relativ fuktighet i prosent
- T = temperatur i °C
- Regn = nedbør i meter
- H+ = hydrogen ionekonsentrasjonen mg/l



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Next step:

Intervention strategies

Aims and targets

- Improve air quality
- Reduce negative impact on human health
- Achieve acceptable air quality
- Reduce negative impact on the environment

Tasks:

1. Assess control options, their feasibility (technical, economic, political) and their costs.
2. Calculate cost-benefit ratios for options, find best control strategies.
3. Implement control strategies,
4. Enforce policies and regulations needed to implement strategies.

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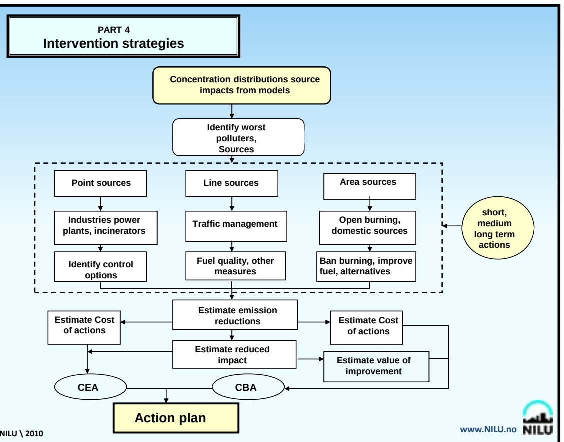

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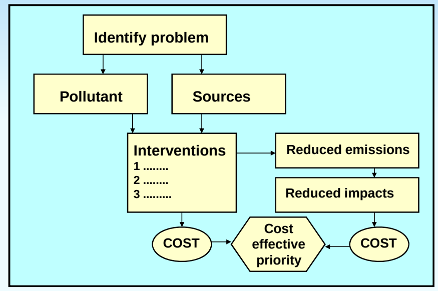
Intervention strategies

Summary:



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Source reductions - Action plans

Possible actions:

- Introduction of scrubbers;
- Shifting to renewable energy (or low sulphur fuel);
- Introduction of cleaner technology;
- Implementation of process equipment changes and process changes;
- Improvement of operating practice;
- Ensuring regular maintenance; and
- Ensuring maximum energy conservation

✓ Actions defined
✓ Cost of actions
✓ Reduced emissions
✓ Reduced exposure

COSTS → Emissions reduced

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Listing possible activities

✓ Combustion
✓ Petroleum industry
✓ Coal gasification
✓ Metallurgical industry
✓ Mineral processing ind
✓ Organic industry
✓ Incineration process
✓ Waste handling
✓ Wood and paper
✓ Animal products

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Possible strategies - compounds

Particulate control
- Mechanical collectors (dust cyclones, multicyclones)
- Electrostatic precipitators
- Bag houses
- Particulate scrubbers

NOx control
- Low NOx burners
- Selective catalytic reduction (SCR)
- Selective non-catalytic reduction (SNCR)
- NOx scrubbers
- Exhaust gas re-circulation
- Catalytic converter (also for VOC control)

VOC abatement
- Adsorption systems, such as activated carbon
- Flares
- Thermal oxidizers
- Catalytic oxidizers
- Bio filters
- Absorption (scrubbing)
- Cryogenic condensers

Acid Gas/SO2 control
- Wet scrubbers
- Dry scrubbers
- Flue gas desulphurisation

Mercury control
- Sorbent Injection Technology
- Electro-Catalytic Oxidation (ECO)
- K-Fuel

Area dependent !

✓ Industry
✓ Domestic fuel burning
✓ Mine tailings
✓ Transport
✓ Regional air movements
✓ Wildfires and
✓ prescribed burning

Other smaller sources that contribute to pollution include:

- Landfills
- Waste treatment works
- Agriculture
- Large scale construction
- Tyre burning

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Short and long term interventions

Emission Reduction Strategies

Short-term (1-2 years):
These include actions that can be taken immediately to reduce emissions and generally involve minimal disruption or would have a major benefit. Examples include: more efficient industrial operating practices; switching to cleaner fuel; vehicle emissions testing.

Medium-term (3-5 years):
These include strategies which require a measure of planning before they can be implemented.

Long-term (> 5 years):
These are interventions that require major changes either socially or require huge investment. Examples include: promotion of public transportation; education campaigns.

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Reduce emissions - mobile sources

- ✓ Assess the vehicle fleet; vehicle numbers, type, age and fuel usage.
- ✓ Ensure the integration of air quality into town planning and future road developments.
- ✓ Introduce effective transportation measures to reduce air pollution
- ✓ Include traffic calming (speed humps, roundabouts, traffic islands, traffic light synchronisation etc.)
- ✓ Provide alternative transportation measures to reduce single-occupancy vehicles.
- ✓ Development regular emissions testing on all vehicles
- ✓ Create public awareness of motor vehicle related emissions impacts
- ✓ Disseminate information on pollution concentrations measured in the city.

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Cost/benefit procedure

1 Identify the population and stock/assets at risk due to pollution
All the residents of a polluted area, or a fraction thereof,
The stock-at-risk refers to the area exposed

2. Determine the number of people and objects that are exposed to ambient pollution that exceeds standards or guidelines.

3. Identify relevant dose-response functions
Health impacts may directly be correlated to the concentration
Different concentrations result in differing degrees of symptoms.

4. Calculate marginal physical impact
Multiply population-at-risk and/or the stock-at-risk with the impact

5. Determine monetary values per unit of physical impact
Impacts on e.g. crop production valued with market prices.
Health and ecological impacts more complex relations.

6. Calculate the monetary value of benefits/damage
Change in air pollution impact multiplied with the monetary unit values.

Prioritise: Cost of actions vs. value of improvement

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Prioritise Cost of Actions

Input from Stakeholders and Industries

Sources – Strategies - Technologies

- ✓ Update emission data
- ✓ Validate cost with recent installations
- ✓ Expand with additional technology
- ✓ Policy options - compliance date
- ✓ Dynamic analyses

Estimated costs (US$) per ton reduced in a specific area					
	NOx	SOx	PM_{10}	CO	HC
Low	5	1000	400	5	200
High	175000	167000	389000	38000	27000
Average	43900	52400	92500	26300	6300

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Cost of Reduced Impacts

Possible health end points and pollutants
- Chronic mortality from PM
- Infant mortality from PM
- Acute mortality from ozone
- Morbidity impacts from PM
- Morbidity impacts from ozone

Europe

Mortality	Median value	Mean value
Infant mortality	€1,500,000/death	€4,000,000/death
Value of statistical life	€980,000/death	€2,000,000/death
Value of a life year	€52,000/year	€120,000/year

Morbidity	low	central	high
Chronic bronchitis	€120,000/case	€190,000/case	€250,000/case
Respiratory/cardiac hospital admissions		€2,000/admission	
Primary care consultations		€53/consultation	
Restricted activity day (stay in bed)		€130/day	
Minor restricted activity day		€38/day	
Use of respiratory medication		€1/day	
Symptom days		€38/day	

CAFE CBA 2005

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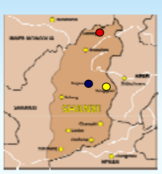
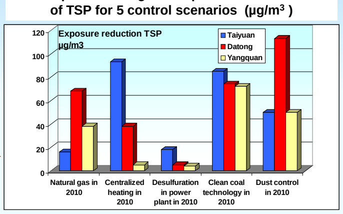
Reduced emissions ⇨ Reduced exposure



Model estimated exposure reductions in 3 cities in Shanxi province China

Population weighted exposure reduction of TSP for 5 control scenarios (μg/m³)



Larssen et.al.

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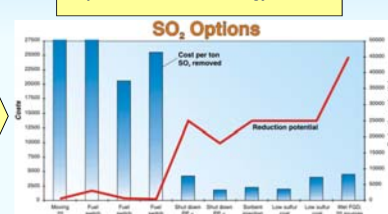
Cost effective SO_2 options

- A.Q. Assessment
- Health impacts
- Abatement options
- Cost/benefit analyses
- Optimal abatement strategy

Cost effective SO_2 options



Interventions

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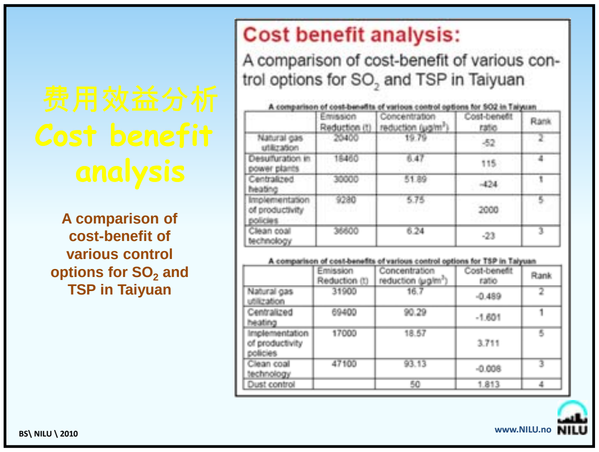
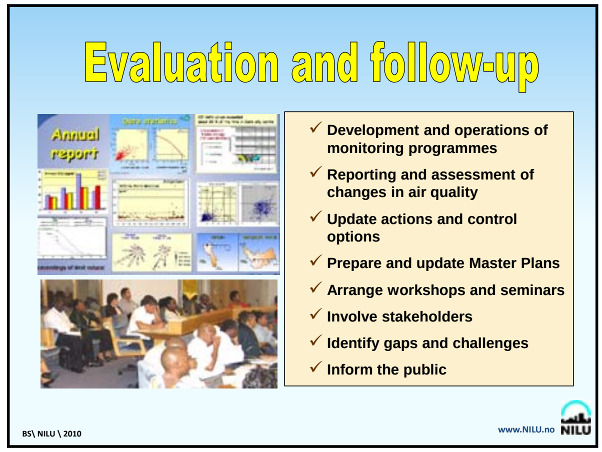


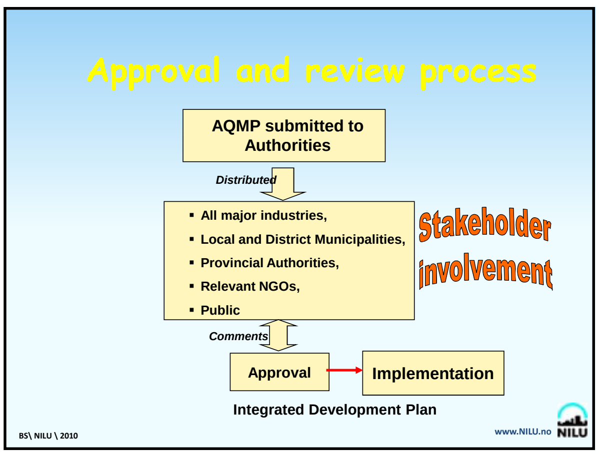
A comparison of cost-benefits of various control options for SO2 in Taiyuan

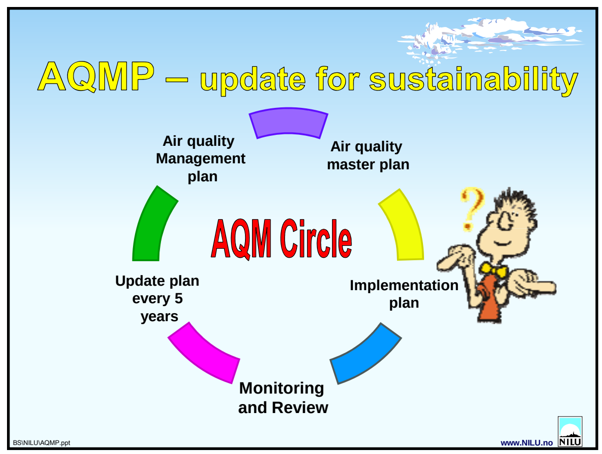
	Emission Reduction (t)	Concentration reduction (μg/m³)	Cost-benefit ratio	Rank
Natural gas utilization	20400	19.79	-52	2
Desulfuration in power plants	18460	6.47	115	4
Centralized heating	30000	51.89	-424	1
Implementation of productivity policies	9280	5.75	2000	5
Clean coal technology	36600	6.24	-23	3

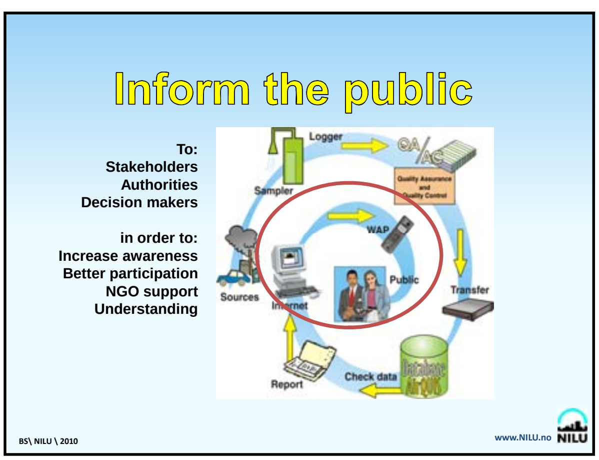
A comparison of cost-benefits of various control options for TSP in Taiyuan

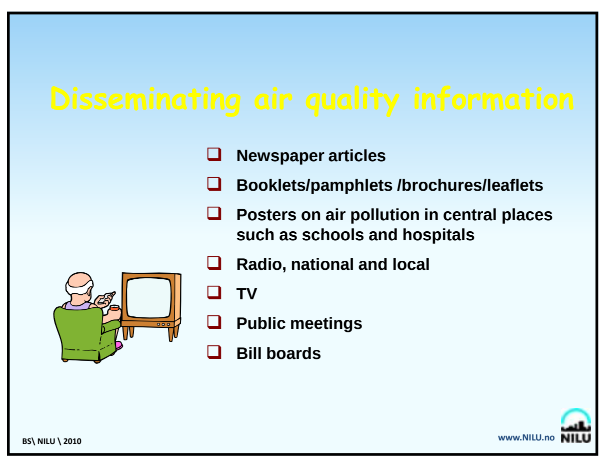
	Emission Reduction (t)	Concentration reduction (μg/m³)	Cost-benefit ratio	Rank
Natural gas utilization	31900	16.7	-0.489	2
Centralized heating	69400	90.29	-1.601	1
Implementation of productivity policies	17000	18.57	3.711	5
Clean coal technology	47100	93.13	-0.008	3
Dust control		50	1.813	4







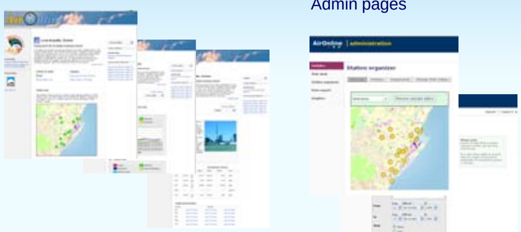




Web solutions for dissemination of ambient air quality

Public pages

Admin pages



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Capacity building and training

AQMS – an expert system

- **Need institutional building and training**
- **Understanding the issues, local and global**
- **Tools and equipment**
- **Assure sustainability!**

Future needs and priorities

Tools – Policy – Actions – Follow-up

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Training needs assessment

***Topics identified for one training programme*:**

- **Introduction to Air Quality Management planning;**
- **Monitoring and modelling skills;**
- **Presentation of the Implementation Manual;**
- **Presentation of the Air Quality management regulations**
- **Discuss Air Quality management regulations;**

Developing experts requires training on:

AQMS

Monitoring **Modelling** **Cost/benefit** **Assessment** **QA/QC**

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