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Air Quality Management Planning (AQMP)

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Lecture

AIR QUALITY MANAGEMENT PLANNING (AQMP)

Presented at: The Third WeBIOPATR Workshop.
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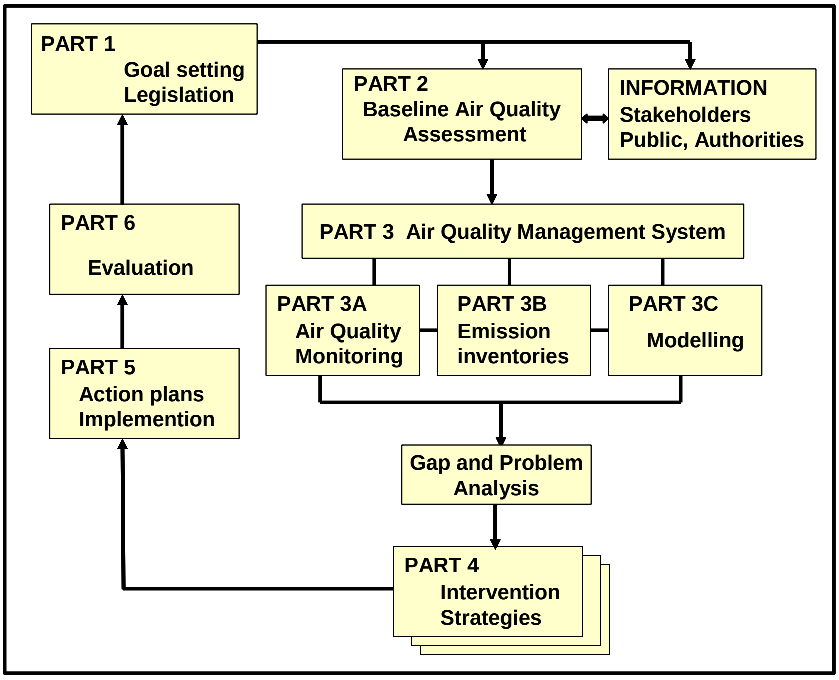
Bjarne Sivertsen



NILU F 24/2011

Air quality management planning (AQMP)

1 Abstract

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 is 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.
Major tasks in this work are 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.
This presentation will guide you through the different parts of the air quality management and planning procedures. In most large cities in the world particulate matter is often the main problem and represents a main challenge in the AQMP process.

2 Key words:

Air quality management, Emissions, Modelling, Impact, Training.

3 Introduction

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

The Air Quality Management Plan (AQMP) describes the present state of urban air quality and how it has been changing over recent years, and what could be done to ensure clean air quality in a region. It provides goals and objectives for a region and prescribes short- and long - term policies and controls to improve air quality. An early description of the planning process was described in the URBAIR project by NILU in 1996 [1].

The objective of the project was to develop Action Plans for air quality improvement in each of the four cities. The action plans where to be based upon cost/benefit or cost-effectiveness analysis, so that the air quality could be improved to a certain target level at least cost. The concept used in URBAIR was to combine air quality assessment based upon monitoring data and modelling of air pollution and exposure, assessment of the health damage (using dose-response relationships) and the related costs (based upon local cost data), analysis of control options and their costs, and prioritising the control measures through comparison of control costs and the related reduced health costs, choosing the ones with highest benefit/cost ratio [2].

An AQMP thus sets a course of action that will attain air quality goals in a specified geographical area. Several studies implementing the AQMP approach have been reported [3, 4, 5]. The AQMP requires actions by government, business, industry, NGO’s and the population, as its success will depend on support from all these segments.

4 Introduction to the AQMP Process

The Air Quality Management System (AQMS) used in the planning process depends on the following set of technical and analytical tasks:

- creating an inventory of polluting activities and emissions;
- monitoring air pollution and dispersion parameters;
- calculating air pollution concentrations with dispersion models;
- assessing exposure and damage;

- estimating the effect of abatement and control measures;
- establishing and improving air pollution regulations and policy measures.

These activities, and the institutions necessary to carry them out, constitute the prerequisites for establishing the AQMS. The air quality management system developed by NILU [6] has been installed and applied in several cities around the world.
An AQMP describes the current state of air quality in an area, how it has been changing over recent years, and what could be done to ensure clean air quality in a region. The development and implementation of an AQMP is a dynamic process involving the following six steps:

- Goal setting
- Baseline air quality assessment
- Air quality management system (AQMS)
- Intervention strategies
- Action plans implementation
- Evaluation and follow up

A typical complete description of the process was prepared as a draft implementation plan [7].

The linkages between these steps are indicated in Figure 1 below.

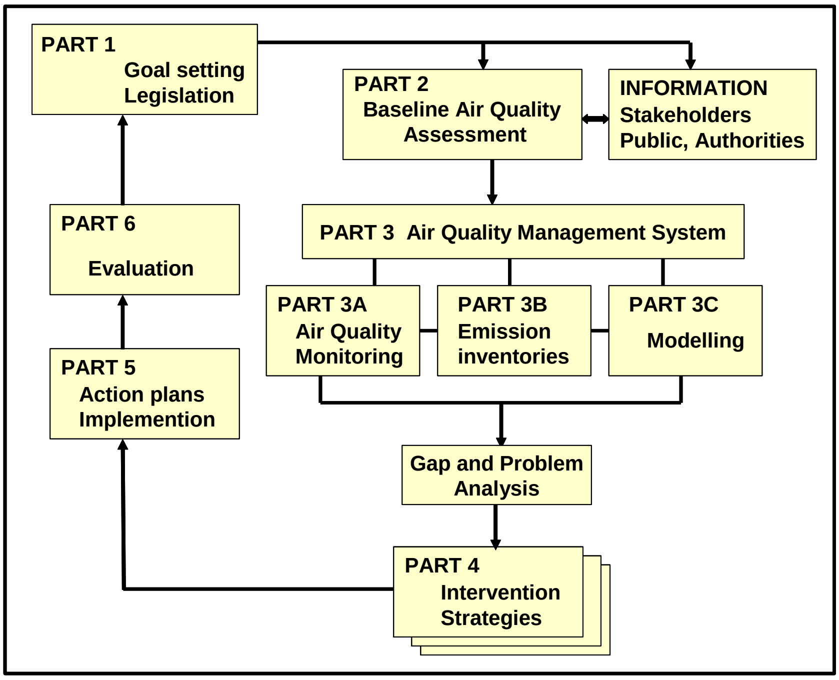


Figure 1: The AQMP process as presented in Steps 1 to 6.

The baseline preliminary assessment was described under the EU air quality directives already in 1998 [[8]]. The content of the whole process is briefly indicated in the following.

4.1 Air Quality goal setting

The setting of goals in the AQMP may include:

- Identifying primary and secondary pollutants of concern:

  a) health related b) environmental impact related

- Assessing regional issues

  a) acid rain b) regional ozone c) transboundary problems

- Global issues such as greenhouse gases and persistent organic pollutants
- Indoor exposure

4.2 Emission inventories

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

- Identifying air pollution sources on different levels;

  a) National b) Provincial c) Municipal d) Industries

- Collection of data on production, consumption and emission factors for various sources:

  a) stationary sources b) mobile sources c) natural and biogenic sources
- Preparation and use of emission models for estimating source data input into dispersion models
- Estimation of trends in emissions and forecasting emissions

4.3 Monitoring

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

This ambient air monitoring system should ensure that the following is prescribed in the development of the system:

- Quality assurance and quality control procedures
- Availability of data to stakeholders
- Adequate meteorological data are available
- Air quality assessment and provision of statistics and reporting requirements including trend analyses
- Inclusion of all relevant pollutants relevant to different scales and sources
- Identification of specific issues such as:

  a) hot spot areas b) adverse exposure problems
- Verification of compliance with goals, regulations and standards.

4.4 Modelling

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

Different types of models such as; a) dispersion models b) impact models c) economic models d) cost/benefit analyses can be used in the estimation of ambient air quality. An important part of the tools used in planning include:

- Developing and establishing relevant models for all parts of the air quality assessment;

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

4.5 Identify measures and control options

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

- Establishing detailed emission inventories as basis for control options
- Specifying controls related to National, Regional and Municipal requirements
  - source and emission standards
  - pollutants specific to National, Regional and local technology control requirements
  - health based needs for regulations
  - economic incentives
- Mobile source control requirements
  - engine performance
  - exhaust gas control
  - fuel requirements
- Specific priority area control requirements
- Issue of legally enforceable operation permits

4.6 Implementation

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

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

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

4.7 Evaluation of changes and impact trends

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

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

4.8 Information to the public

Public consultation should be an integral part of the AQMP development process, and it should preferably be a policy of the regulatory body.

If an AQMP is to be developed and implemented, it must be based on input from stakeholders including industry, numerous groups and individuals

5 Particulate matter and the AQMP process

5.1 Sources

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

Normally the largest contributions of PM_{10} emissions come from sectors such as the energy and industry sectors, with a relatively smaller contribution from road transport. The road transport sector contributes with both vehicle exhaust particles and resuspension of road dust.

When undertaking AQMP related to PM the emission estimates from non-combustion sources have a considerable degree of uncertainty. PM_{10} emissions are dominated by sectors including road transport, industry and fuel combustion in the residential sector. It is thus important to be able to estimate the contribution from “natural” sources. The total ambient particulate also comes from a variety of natural sources, which vary widely from area to area and with time. These include sea salt (especially important in coastal regions), crustal material arising from natural erosion processes (especially important in dry regions) and biological material. Volcanic eruptions are an example of a natural source that may contribute to the total PM impact in a given area.

5.2 PM assessment

In the early assessment phase it may be possible to estimate the relative importance of the different PM sources from measurement data using source apportionment techniques. In Europe the First Daughter Directive required all Member States to assess the ambient concentrations of PM_{10} throughout their territory. The assessment should be based on monitoring at a considerable number of sites and may be supplemented by modelling. Measurements of $PM_{2.5}$ at a limited number of sites are also required [9].

The assessment phase includes:

- Monitoring of air pollutants, using good network design procedures.
- Inventorying of pollution sources, their technology, location and emissions.
- Assessing the spatial and temporal distribution of the pollutant concentrations and population exposure, using dispersion models.
- Determining the contributions from the various sources and source categories, using dispersion and receptor models.

5.3 Intervention strategies

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

- Assessing the control options, (technical, economic, political feasibility) and costs.
- Calculating cost-benefit ratios for the options, as the basis for developing cost-effective control strategies.
- Implementing the control strategies, including financing and setting a time frame. Identifying and developing Action plans
- Enforcing the policies and regulations needed to implement the strategies.

At the end point it will be needed to evaluate the cost for each of the reduction measures implemented in order to reduce the burden of PM emissions on people and nature.

5.4 Cost-benefit analyses

5.4.1 Cost estimated actions

The Cost-benefit analyses (CBA) are a highly interdisciplinary task. The CBA should provide a benefit-cost ratio based on monetarised costs and benefits, and be accompanied by a description of the non-monetarised items that also should be considered [10].

5.4.2 PM and health

Impacts on human health from particulate matter (PM) pollution have been recognized as one of the most serious environmental problems. Exposure information to PM is essential for policymakers to identify the potential risk group and to develop appropriate risk reduction measures. Epidemiological studies of PM routinely use concentrations measured with stationary outdoor monitors as surrogates for population exposure, and the epidemiologic associations between ambient concentrations and health effects depend on the correlation between ambient concentrations and exposure to ambient-generated PM [11].

The various potential health effects are defined by their ‘end-point’. Impacts may be morbidity, i.e. can have impacts upon healthiness and well-being, or can be mortality, i.e. can have fatal consequences. The CAFÉ CBA [12] has for PM impacts limited itself to mortality impacts as follows:

- Chronic mortality from PM
- Infant mortality from PM

Below is shown a summary statistics, mean and 95% confidence interval (2.5% to 97.5%) for assessment of PM mortality impacts, expressed either as deaths or Years of Life Lost (YOLL).

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

In a summary report concerning dose response functions NILU [13] The following is proposed:

Increase in incidence = 6% / 10μg m^{-3} $PM_{2.5}$. (95% CI 2-11%)

The preferred unit of expression for this is as life years lost.

Coefficients derived for Beijing are found to compare with estimates for Delhi [14], but to be an order of magnitude lesser than the 6% coefficient estimated for Europe:

Increase in incidence = 0.6% / 10μg m^{-3} $PM_{2.5}$ Beijing
= 0.67% / 10μg m^{-3} $PM_{2.5}$ Delhi

For all cause mortality Aunan [15] estimated the following for PM_{10}:

Increase in incidence = 0.3 % per 10 µg/m^3 PM_{10}, China

There is a magnitude difference between Europe and China, which may lie in the fact that the case studies in each region examined different parts of the dose-response curve.

5.4.3 Effects and costs

The environmental burden of disease quantifies the amount of disease caused by environmental risks. Disease burden can be expressed in deaths, incidence or in Disability-Adjusted Life Years (DALY). The latter measure combines the burden due to death and disability in a single index. Using such an index permits the comparison of the burden due to various environmental risk factors with other risk factors or diseases.

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

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

5.5 Surveillance and monitoring

The air quality management plan should be followed up by monitoring and surveillance. Information to the public, to authorities and stakeholders is important. It may require developing institutions, institutional building and training.

Establishing an Air Quality Information System for dissemination of air pollution data giving the public and decision makers the opportunity to protect against high pollution. Long-term operation of the air pollution monitoring network, to follow the changes in the situation, to check if control strategies have the necessary effects so that air quality standards are not breached [[16]].

6 References

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Appendix A

Presentation


Air Quality
Management Planning
Bjarne Sivertsen, NILU
Presented at:
Third WeBIOPATR
Workshop.
Serbia 15 - 18
November 2011
DPSIR
AQMS
Emissions
Exposure
Measures
Effects
Concentration levels
Cost benefits
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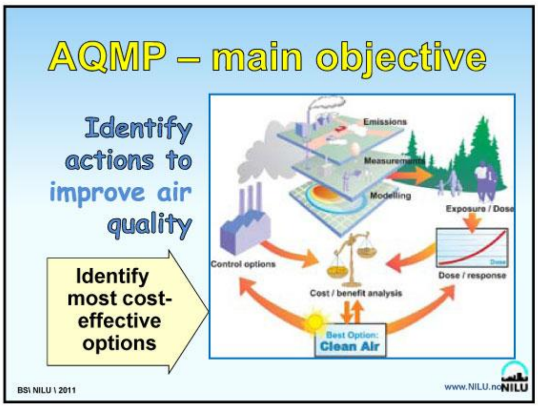
AQMP – main objective
Identify
actions to
improve air
quality
Identify
most cost-
effective
options
Emissions
Measurements
Modelling
Exposure / Dose
Control options
Dose / response
Cost / benefit analysis
Best Option:
Clean Air
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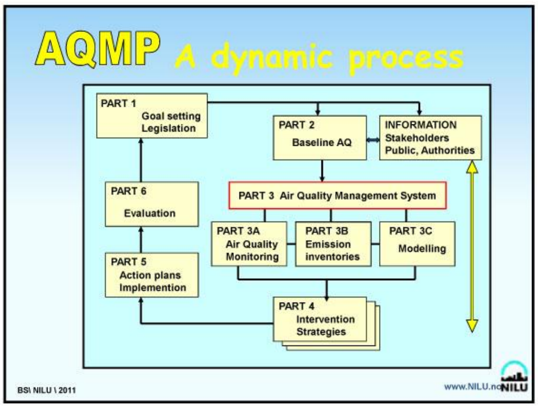
AQMP A dynamic process
PART 1
Goal setting
Legislation
PART 2
Baseline AQ
INFORMATION
Stakeholders
Public, Authorities
PART 6
Evaluation
PART 3 Air Quality Management System
PART 3A
Air Quality
Monitoring
PART 3B
Emission
inventories
PART 3C
Modelling
PART 5
Action plans
Implemention
PART 4
Intervention
Strategies
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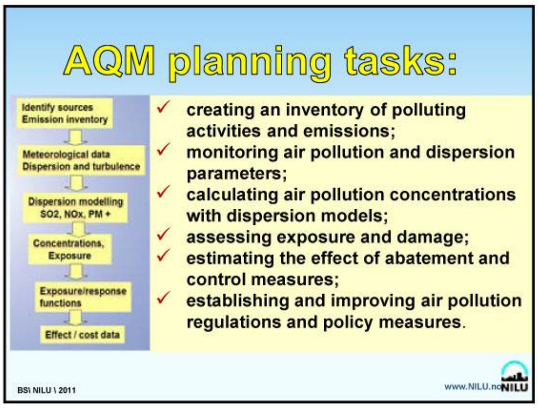
AQM planning tasks:
Identify sources
Emission inventory
Meteorological data
Dispersion and turbulence
Dispersion modelling
SO2, NOx, PM +
Concentrations,
Exposure
Exposure/response
functions
Effect / cost data
creating an inventory of polluting activities and emissions;
monitoring air pollution and dispersion 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.
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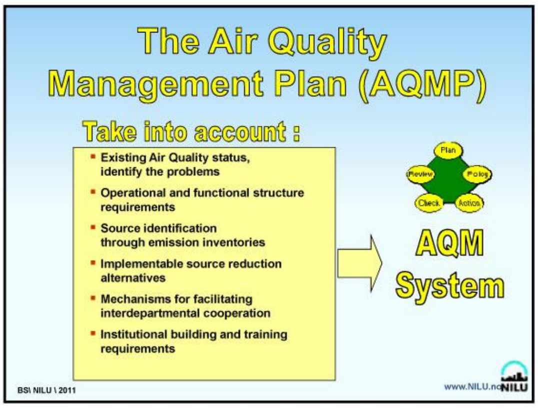
The Air Quality
Management Plan (AQMP)
Take into account :
Existing Air Quality status, identify the problems
Operational and functional structure requirements
Source identification through emission inventories
Implementable source reduction alternatives
Mechanisms for facilitating interdepartmental cooperation
Institutional building and training requirements
Plan
Review
Policy
Check
Action
AQM
System
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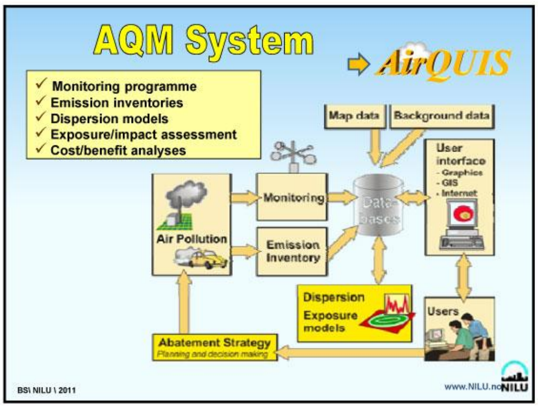
AQM System
AirQUIS
Monitoring programme
Emission inventories
Dispersion models
Exposure/impact assessment
Cost/benefit analyses
Map data
Background data
User interface
- Graphics
- GIS
- Internet
Monitoring
Data bases
Air Pollution
Emission Inventory
Dispersion
Exposure
models
Users
Abatement Strategy
Planning and decision making
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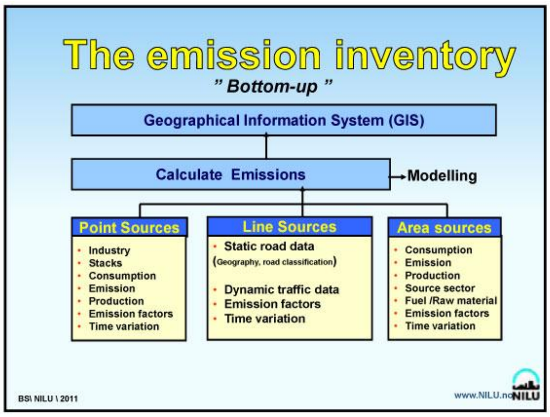
The emission inventory
" Bottom-up "
Geographical Information System (GIS)
Calculate Emissions
Modelling
Point Sources
Industry
Stacks
Consumption
Emission
Production
Emission factors
Time variation
Line Sources
Static road data
(Geography, road classification)
Dynamic traffic data
Emission factors
Time variation
Area sources
Consumption
Emission
Production
Source sector
Fuel /Raw material
Emission factors
Time variation
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Stacks around the world
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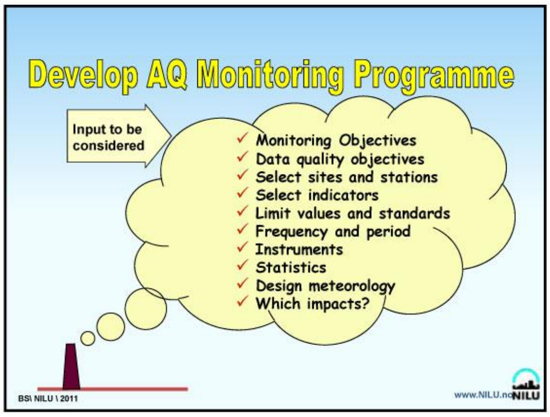
Develop AQ Monitoring Programme
Input to be considered
Monitoring Objectives
Data quality objectives
Select sites and stations
Select indicators
Limit values and standards
Frequency and period
Instruments
Statistics
Design meteorology
Which impacts?
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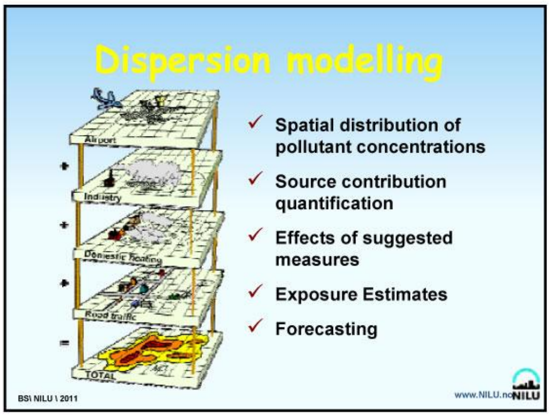
Dispersion modelling
Airport
Industry
Domestic heating
Road traffic
TOTAL
Spatial distribution of pollutant concentrations
Source contribution quantification
Effects of suggested measures
Exposure Estimates
Forecasting
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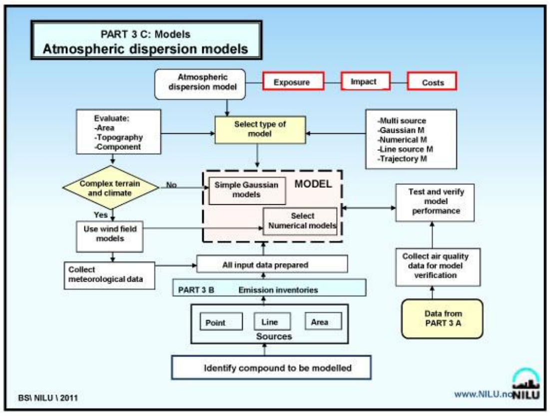
PART 3 C: Models
Atmospheric dispersion models
Atmospheric dispersion model
Exposure
Impact
Costs
Evaluate:
-Area
-Topography
-Component
Select type of model
-Multi source
-Gaussian M
-Numerical M
-Line source M
-Trajectory M
Complex terrain and climate
No
Yes
Simple Gaussian models
MODEL
Select Numerical 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
Point
Line
Area
Sources
Data from PART 3 A
Identify compound to be modelled
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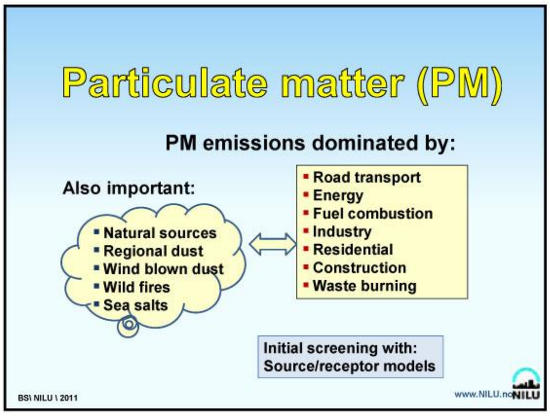
Particulate matter (PM)
PM emissions dominated by:
Also important:
Natural sources
Regional dust
Wind blown dust
Wild fires
Sea salts
Road transport
Energy
Fuel combustion
Industry
Residential
Construction
Waste burning
Initial screening with:
Source/receptor models
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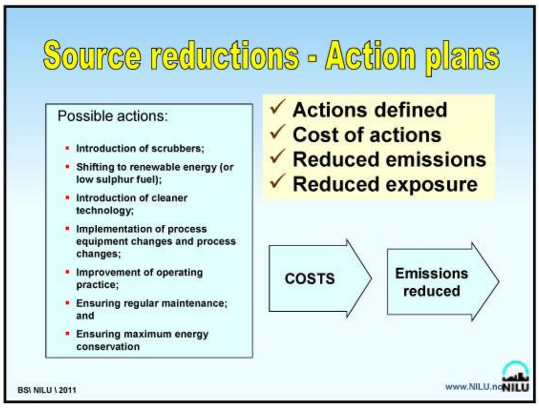
Source reductions - Action plans
Possible actions:
Introduction of scrubbers;
Shifting to renewable energy (or low sulphur fuel);
Introduction of cleaner technology;
Implementation of process equipment changes and process changes;
Improvement of operating practice;
Ensuring regular maintenance; and
Ensuring maximum energy conservation
✓ Actions defined
✓ Cost of actions
✓ Reduced emissions
✓ Reduced exposure
COSTS
Emissions reduced
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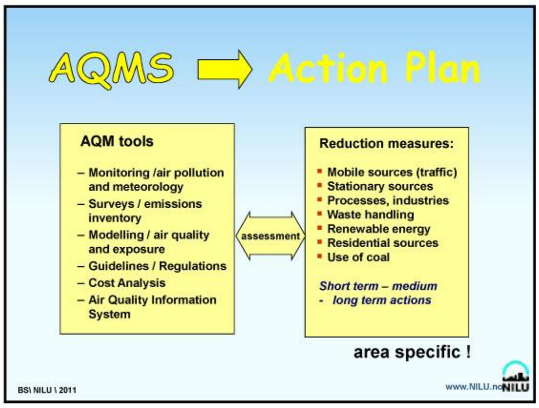
AQMS
Action Plan
AQM tools
– Monitoring /air pollution and meteorology
– Surveys / emissions inventory
– Modelling / air quality and exposure
– Guidelines / Regulations
– Cost Analysis
– Air Quality Information System
assessment
Reduction measures:
Mobile sources (traffic)
Stationary sources
Processes, industries
Waste handling
Renewable energy
Residential sources
Use of coal
Short term – medium
- long term actions
area specific !
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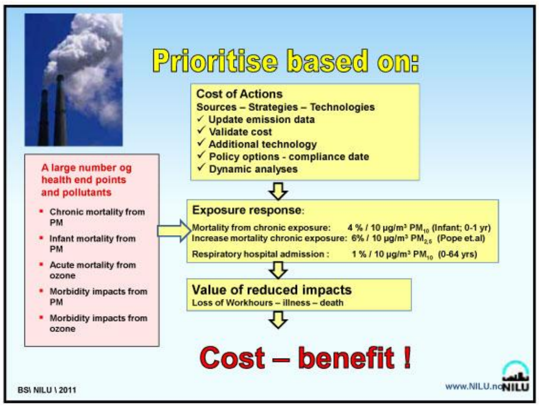
Prioritise based on:
Cost of Actions
Sources – Strategies – Technologies
✓ Update emission data
✓ Validate cost
✓ Additional technology
✓ Policy options - compliance date
✓ Dynamic analyses
A large number og health end points and pollutants
Chronic mortality from PM
Infant mortality from PM
Acute mortality from ozone
Morbidity impacts from PM
Morbidity impacts from ozone
Exposure response:
Mortality from chronic exposure: 4 % / 10 µg/m³ 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)
Value of reduced impacts
Loss of Workhours – illness – death
Cost – benefit !
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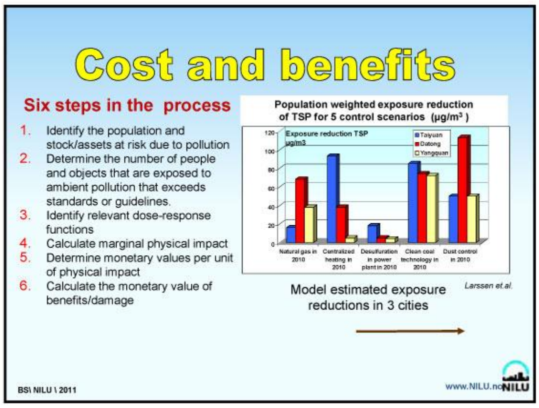
Cost and benefits
Six steps in the process
1. Identify the population and stock/assets at risk due to pollution
2. Determine the number of people and objects that are exposed to ambient pollution that exceeds standards or guidelines.
3. Identify relevant dose-response functions
4. Calculate marginal physical impact
5. Determine monetary values per unit of physical impact
6. Calculate the monetary value of benefits/damage
Population weighted exposure reduction of TSP for 5 control scenarios (µg/m³)
Exposure reduction TSP µg/m3
Taiyuan
Datong
Yangquan
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
Larssen et al.
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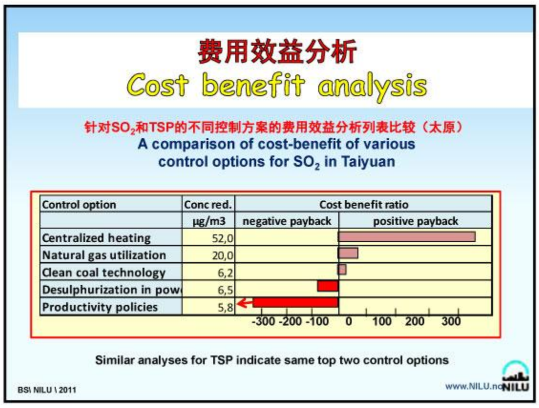
费用效益分析
Cost benefit analysis
针对SO_2和TSP的不同控制方案的费用效益分析列表比较（太原）
A comparison of cost-benefit of various control options for SO_2 in Taiyuan
Control option | Conc red. µg/m3 | Cost benefit ratio: negative payback | positive payback
Centralized heating | 52,0
Natural gas utilization | 20,0
Clean coal technology | 6,2
Desulphurization in pow | 6,5
Productivity policies | 5,8
-300 -200 -100 0 100 200 300
Similar analyses for TSP indicate same top two control options
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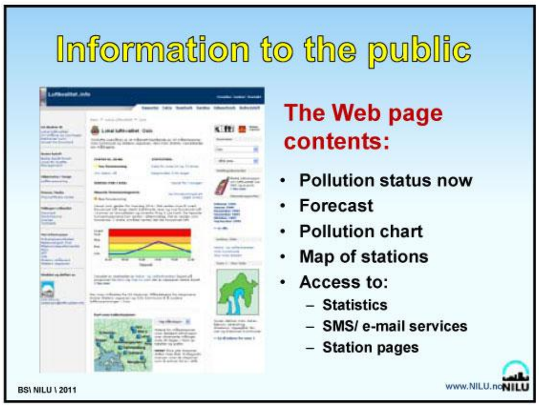
Information to the public
The Web page contents:
• Pollution status now
• Forecast
• Pollution chart
• Map of stations
• Access to:
– Statistics
– SMS/ e-mail services
– Station pages
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Organising the web portal
Public pages web portal
Admin pages
National
City
Station
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Capacity building
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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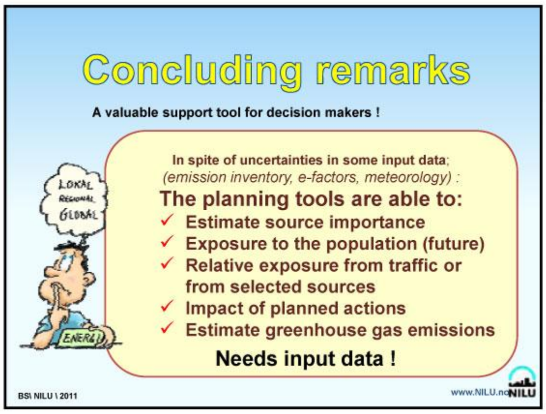
Concluding remarks
A valuable support tool for decision makers !
LOKAL
REGIONAL
GLOBAL
ENERGI
In spite of uncertainties in some input data;
(emission inventory, e-factors, meteorology) :
The planning tools are able to:
✓ Estimate source importance
✓ Exposure to the population (future)
✓ Relative exposure from traffic or from selected sources
✓ Impact of planned actions
✓ Estimate greenhouse gas emissions
Needs input data !
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Thank you !
Questions ???
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