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Air Quality Management Strategy Planning Tool

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Preface

The Air Quality Management Strategy (AQMS) Planning Tool has been developed for the World Bank, and has been applied to major Asian cities in the URBAIR project. The framework has been established as a general tool for planning and can be applied to urban areas where information on emissions, meteorology, air quality and impacts are available or will be established.

Air Quality Management Strategy Planning Tool

The concept of Air Quality Management Strategy (AQMS)

The basic concept for an Air Quality Management Strategy contains the following main components:

- Air Quality Assessment;
- Environmental Damage Assessment;
- Abatement Options Assessment;
- Cost Benefit Analysis or Cost-effectiveness Analysis;
- Abatement Measures Selection (Action plan); and
- Optimum Control Strategy.

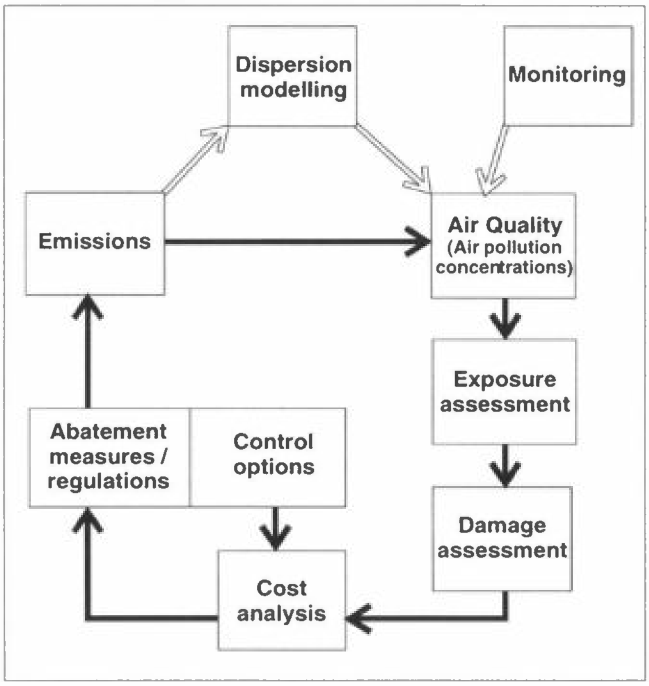
The Air Quality Assessment, Environmental Damage Assessment and Abatement Options Assessment provide input to the **Cost-benefit Analysis, or a Cost-effectiveness Analysis**, which is also based on established Air Quality Objectives (i.e. guidelines, standards) and Economic Objectives (i.e. reduction of damage costs). The analysis leads to an **Action Plan** containing abatement/control measures, for implementation in the short/medium/ long term. The final result of this analysis is an **Optimum Control Strategy**.

A successful AQMS requires the establishment/completion of an integrated system for continued air quality management. This system requires continuing activities on the urban scale in the following fields:

- inventory of air pollution activities and emissions;
- monitoring of air pollution and dispersion parameters;
- calculation of air pollution concentrations, by dispersion models;
- inventory of population, materials and urban development;
- calculation of the effect of abatement/control measures; and
- establishment/improvement of air pollution regulations.

These activities, and the institutions necessary to carry them out, constitutes the **System** for Air Quality Management that is a prerequisite for establishing the **Strategy** for Air Quality Management (AQMS).

The figure below represents a simple visualisation of the elements of the System for Air Quality Management, and the flow of information between them.



The process of developing an Air Quality Management Strategy (AQMS), for an urban area includes many steps. The most important of these are:

* identifying sources	emission inventory	Assessment
* quantifying sources		
* monitoring air pollution		
* assessing the exposure (impact) situation		
* identifying source - exposure relations	modeling	
* estimating the relative importance of various air pollution sources		
* assessing environmental damage		
* investigating short and long term control (abatement) options including urban planning needs		Control
* performing cost-benefit or cost-effectiveness analysis		
* developing a control strategy and an investment plan		
* developing institutions/regulations/enforcement		
* awareness raising		
* establishing an Air Quality Information System (AQIS)		Surveillance

As shown above, the AQMS consists of two main components, which are **assessment and control**. In parallel with the AQMS development, and to facilitate checking the effectiveness of the air pollution control actions, a third component is necessary, which is **surveillance** (monitoring).

The process of attaining acceptable urban air quality is dynamic and long term. As the urban areas develop, population, pollution sources and technology change. Throughout this process, it is very important to have an operating Air Quality Information System (AQIS), in order to:

- keep the authorities and the public well informed about the short-term and long-term AQ development
- assess the results of abatement measures, and thereby
- provide feed-back information to the abatement strategy process.

The following figures presents the elements of the System for Air Quality Management, and the flow of information between them.

Figure 1 shows the system for assessing the existing air pollution situation, which contains the following elements, and flow of information:

activity/emissions → concentrations/exposure (impact), by a combination of monitoring and dispersion modelling → comparison with air quality guidelines (or damage assessment).

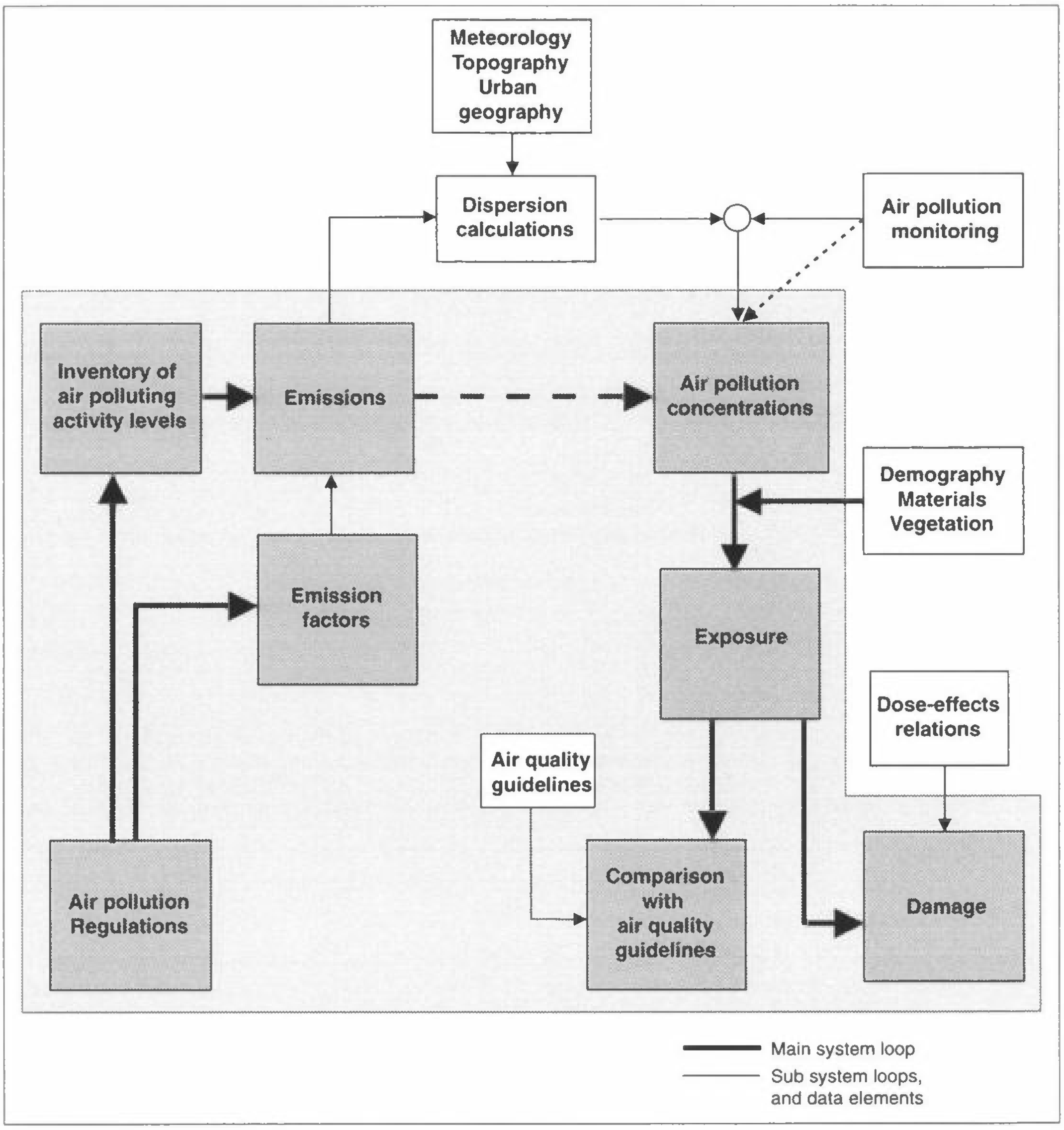


Figure 1: System for Assessment of existing Urban Air Quality situation.

Figure 2 presents the complete Air Quality Management System, when the loop is completed by a cost-benefit or cost-efficiency analysis, based on comparison between costs of abatement measures and the resulting reduced damage costs (or a quantification of improved air quality), resulting from the abatement measures.

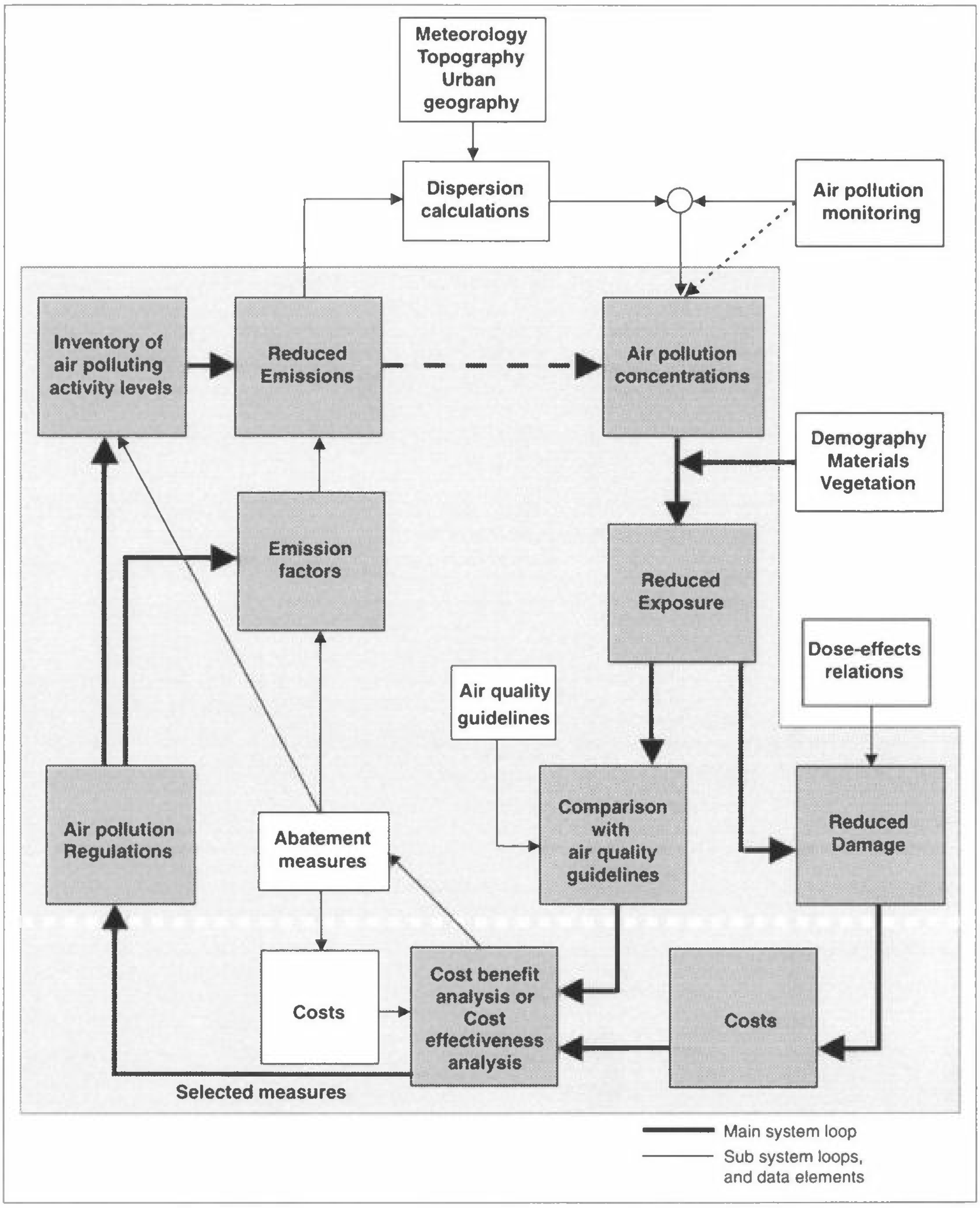


Figure 2: Complete system for Urban Air Quality Management.

The cost-benefit analysis is based on a comparison between abatement costs and reduced damage costs. An abatement strategy may be based on such a comparison of cost and benefits, or it may be based on the attainment of air quality/exposure goals, in the form of air quality guidelines. In the latter case a cost-effectiveness analysis should be performed, not a cost-benefit analysis. In both cases the abatement strategy should be based on analysis of cost of each abatement measure versus reduced damage costs, or versus a measure of air quality/exposure improvement.

In its most complete form, the System for Urban Air Quality Management requires manpower, skills and equipment in many institutions and several technological and scientific fields. This is a long term project. Only a few cities in the world have a system that is sufficiently complete to establish optimum control strategies. In megacities in developing countries, a build-up period of several years should be anticipated to establish a complete Air Quality Management System.

During this development period, intermediate strategies for controlling the present air pollution problems and their development must be developed. These intermediate strategies must be based on existing data, and additional information and data that can be acquired over one year or so. This database will not be complete, but the intermediate strategies should represent an optimum control strategy, given the data available.

The Action Plan will to the extent possible define actions that will support the development of an Air Quality Management Strategy, in three phases:

Phase 1: Immediate action.
Strategy for immediate control of the most urgent problems.

Phase 2: Intermediate action.
Strategy for control over an intermediate time scale (about 5 years), based on current development trends.

Phase 3: Long-term action.
Strategy for control over a long-time scale (more than 10 years), based on long-term projections.

In the following, the contents of the elements of the AQMS model system is visualized and described briefly.

The Emissions module (Figure 3):

Air polluting activities/sources/emissions

The AQM system emissions module provides an inventory of emissions of relevant air pollutants in the area, broken down by activity sector (e.g. traffic, industry). The emissions should be distributed geographically over the urban area based on the locations of industries and the major roads, and population distribution. Depending on the level of detail of activity data, emissions per sector can further be divided into emissions per process, technology, class of vehicles, or other factors, and as a function of time.

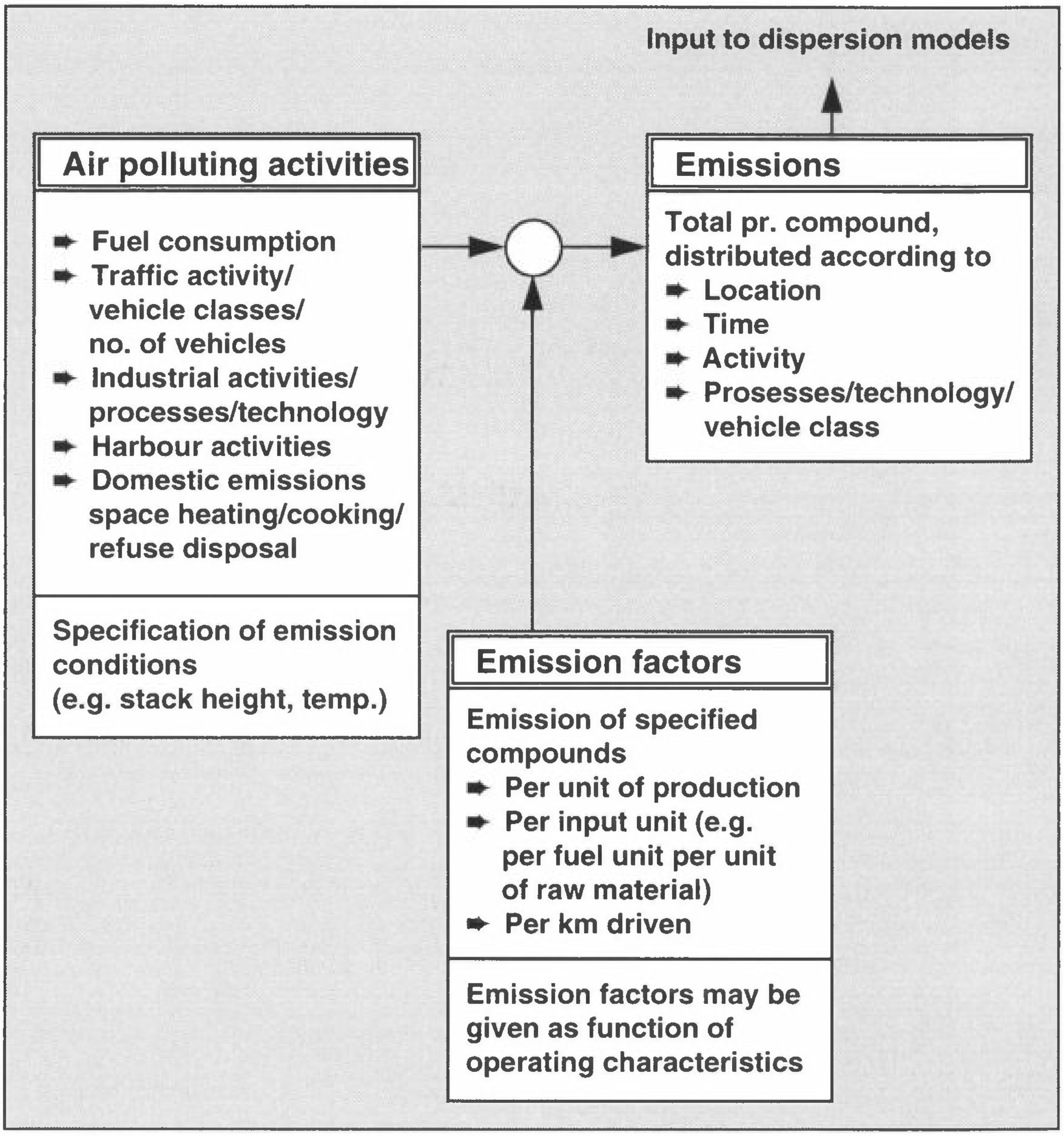
The input to this module is activity data and emission factors; the output is total and spatially distributed (gridded) emission amounts. The gridded emission distribution provides input to dispersion models for calculating air pollution concentrations in the urban area by time and location. It also provides a basis for calculating the effects of various specific abatement measures on air quality.

The emission's module must be computerized in the form of a database. Emission inventory databases are available.

Input data requirements include, as indicated in Figure 3:

- Fuel consumption:
  - various types and qualities of fuel
  - various processes (transport, domestic, industrial)
- Traffic activity:
  - various vehicle classes
  - traffic data on major roads
- Industrial sources:
  - type, location, production, emissions, emission conditions (stack height, temperature, etc.)
- Other sources:
  - refuse burning
  - harbour activities
  -
  -
- Population data:
  - geographic distribution within the urban area
- Emission factors:
  - amount emitted
    - per unit of production
    - per input unit (raw material)
    - per kilometer driven
    - per fuel unit

The emissions can be distributed geographically (e.g. within a 1 km x 1 km grid system), based on the location of sources, population distribution, and urban activity zones.



*Based upon:	Location of sources
	Population distribution (geographically)
	Urban geography: activity zones (industrial, residential, commercial)

Figure 3: The emissions module.

The Dispersion module (Figure 4):

Meteorology/dispersion conditions/dispersion models

The AQM system dispersion module provides the ability to calculate air pollution concentrations in the urban area as a function of time and location. For primary pollutants (i.e. non-reacting compounds) the module can calculate the contributions to the local concentrations from each activity/technology sector for which specific emission data are available.

The level of detail in the results from the dispersion calculations reflects of the level of detail in the input data, i. e. the emissions and meteorological/dispersion data.

The input data required for emission dispersion calculations include data on meteorology, topography and emission characteristics of the sources,as well as the emission data provided by the emission module.

The basic meteorological data are wind speed and direction, presented as time series (hourly averages) or as climatological statistics ("wind roses", annual or seasonal). Air temperature, and its variation at different altitudes are also important parameters.

Topographical data (height distribution, tye presence of sea, land, or vegetation) influence wind and dispersion conditions, and in turn potential pollution concentrations.

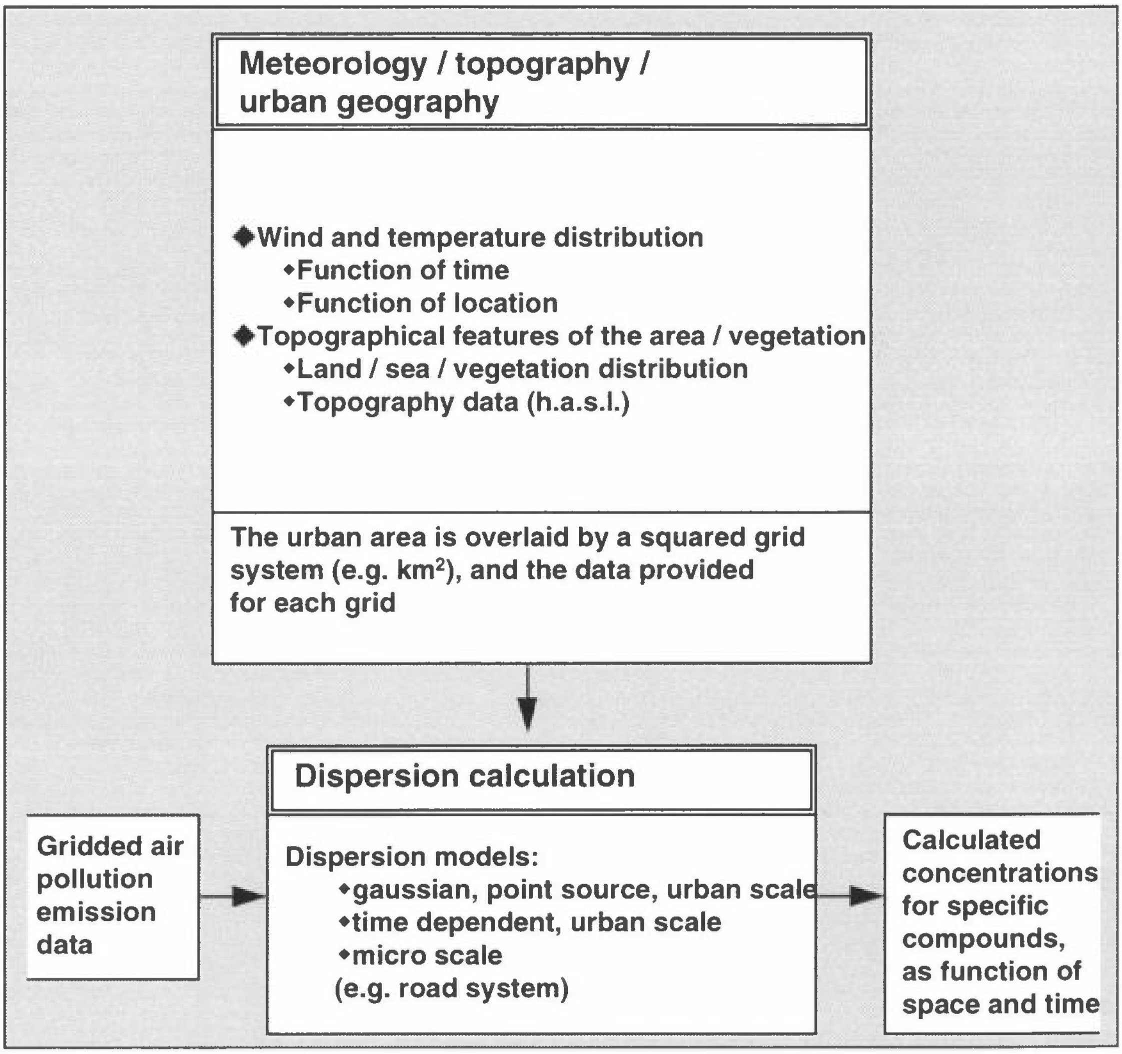


Figure 4: The dispersion module.

Exposure module (Figure 5):

Air pollution exposure assessment

The AQM system exposure module gives data on the impact of the air pollution on the population, on the materials and monuments, and on vegetation.

The exposure, or impact, is here defined as the product of the local air pollution concentration (e.g. within a grid square), and the amount of objects within that location (number of people, number of buildings of a certain material, etc.).

From such calculations it is possible to determine the number of people exposed to concentrations above a certain component's air quality guideline, where this occurs and how often. This provides a population exposure distribution for each studied compound for each abatement scenario.

The input to this calculation is mainly the measured or calculated distribution of pollution concentrations, and the population distribution.

The concentrations may be calculated as averages over various periods (annual, monthly, daily, hourly), depending upon the compound in question and the averaging time specified in the air quality standard or guideline. For compounds like sulphur dioxide (SO_2), ozone (O_3) and carbon monoxide (CO) with acute effects, hourly averages are important, while for compounds like TSP, lead (Pb) and persistent organic compounds, long-term averages (month, year) are of greater interest.

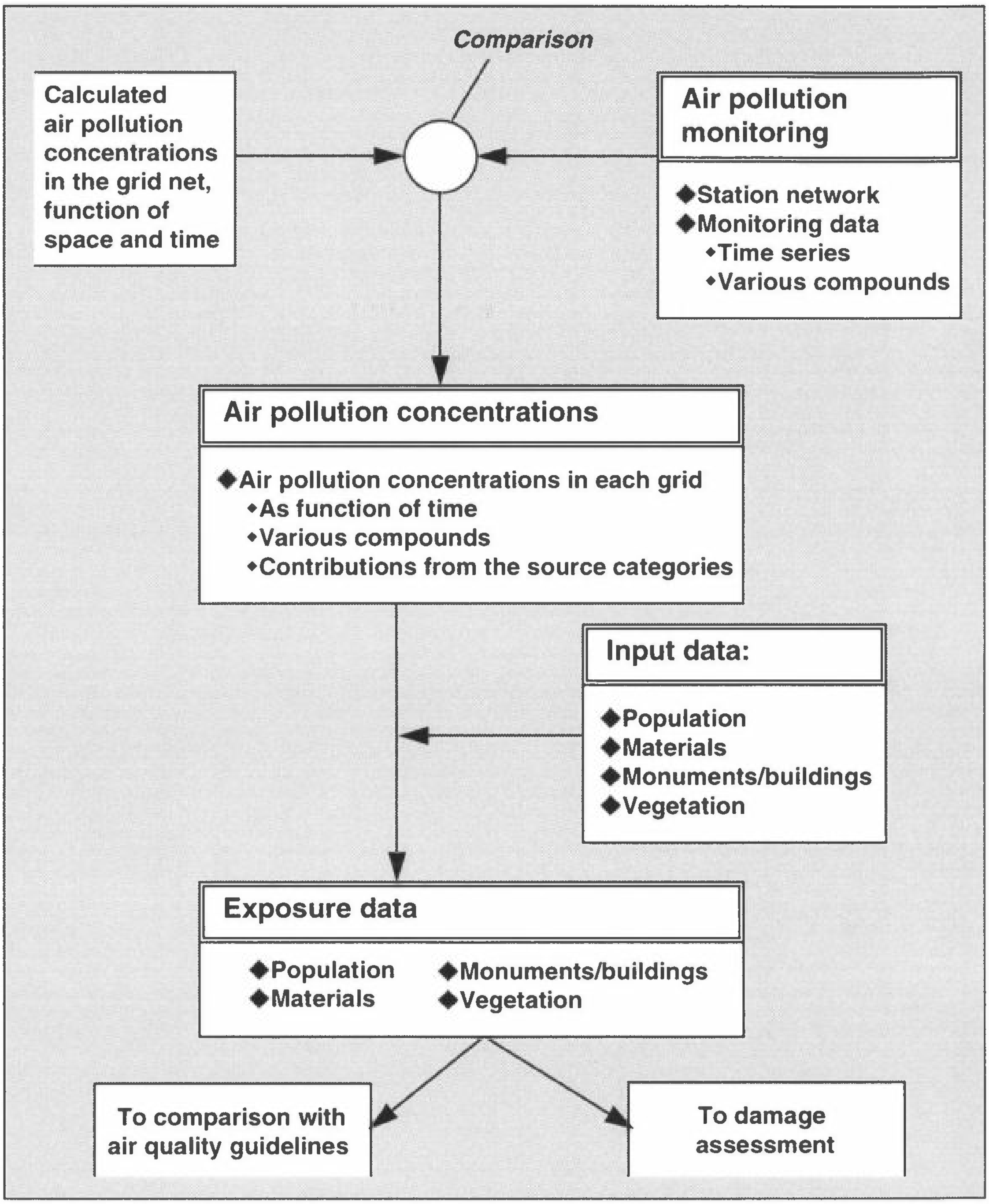


Figure 5: The exposure module.

Damage assessment module (Figure 6):

Categories of damage include:

- health;
- materials, buildings, monuments;
- vegetation.

For assessment of damage in physical term the following is needed:

- dose-effect relations;
- exposure distributions for people, objects, buildings, monuments and vegetation between isopleths.

For health damage, there are two types of dose-response relationships:

- non-specific, (restricted activity days (RAD), work loss days (WLD) and excess mortality (EM));
- disease-specific, (number of people with specific diseases attributed to air pollution).

For monetary assessment of damage, valuation is necessary. The following methods of valuing exist:

- loss of productivity;
- defensive or averting expenditures;
- based on willingness to pay: market-derived or not market derived

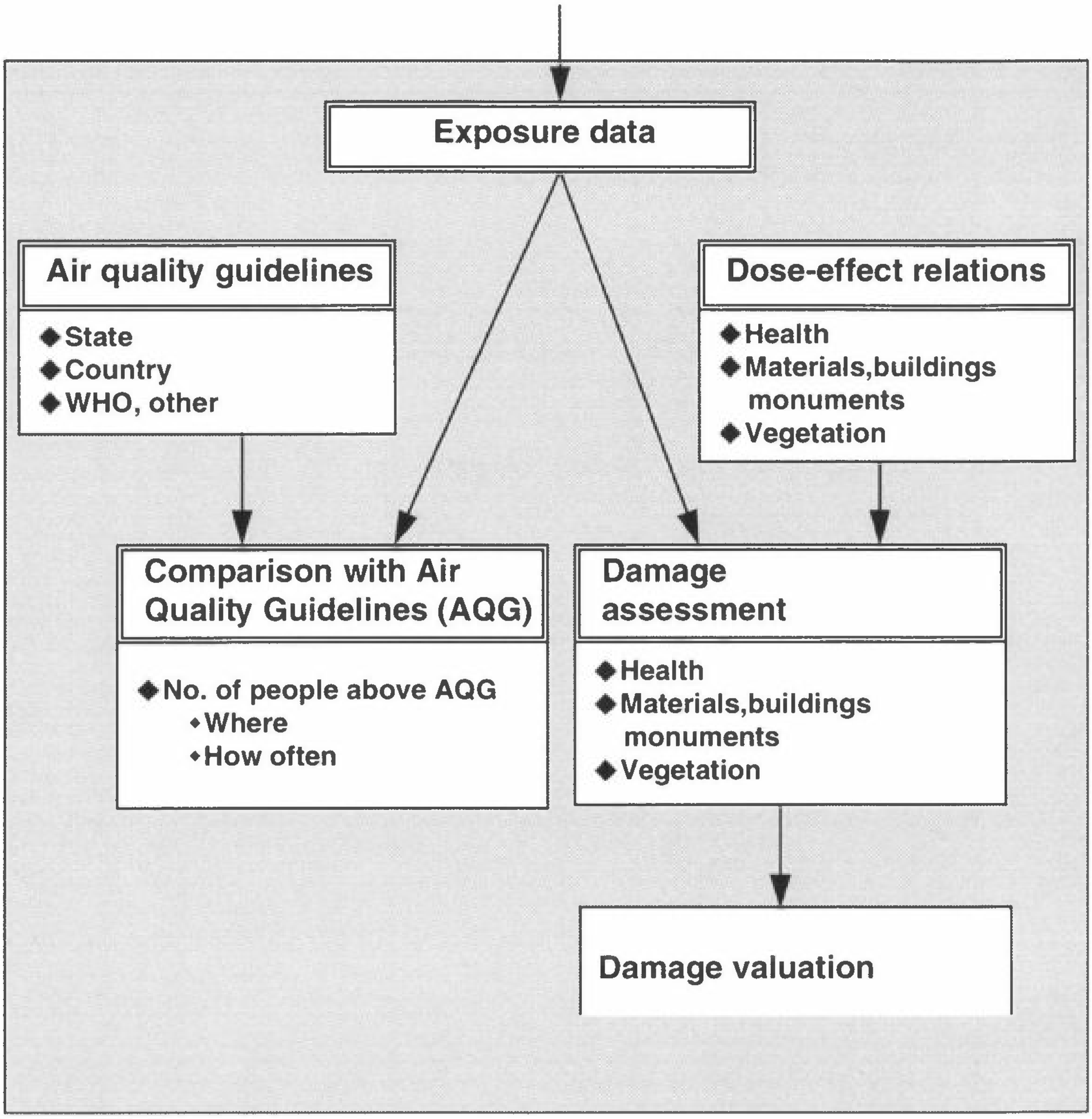


Figure 6: The damage assessment module.

Cost-Benefit and Cost-Effectiveness Analysis Module (Figure 7):

The reason for carrying out a CBA or CEA is to investigate whether a set of measures is desirable and to identify the best set of measures. In a CBA the costs of a set of measures is compared to the benefits; the reduced environmental damage in monetary terms. As the monetary estimation of reduced environmental damage is normally not accurate enough to compare to the measures' costs, a CEA can be used as an alternative. In a CEA no estimation is made of the benefit (expressed as monetized reduced environmental damage), but standards are set for emissions or concentrations, and from several of sets of measures the set is selected which both meets the standards and has the lowest costs.

Costs must be analysed in both CBAs and CEAs. This refers to investment costs and operation and maintenance (O & M) costs. In a CBA, the emissions reductions and concentration reductions that result from the measures must be calculated, and then an estimate of reduced environmental damage must be made in monetary terms. If the benefits exceed the costs, the set of measures is worthwhile.

In a CEA at least two sets of measures must be available. If two or more sets of measures meet the established standards, the lowest-costset of measures is selected.

An often debated topic concerning CBAs and CEAs is the discount rate. The discount rate serves to average the costs (and in CBAs also the benefits) over various years into one figure.

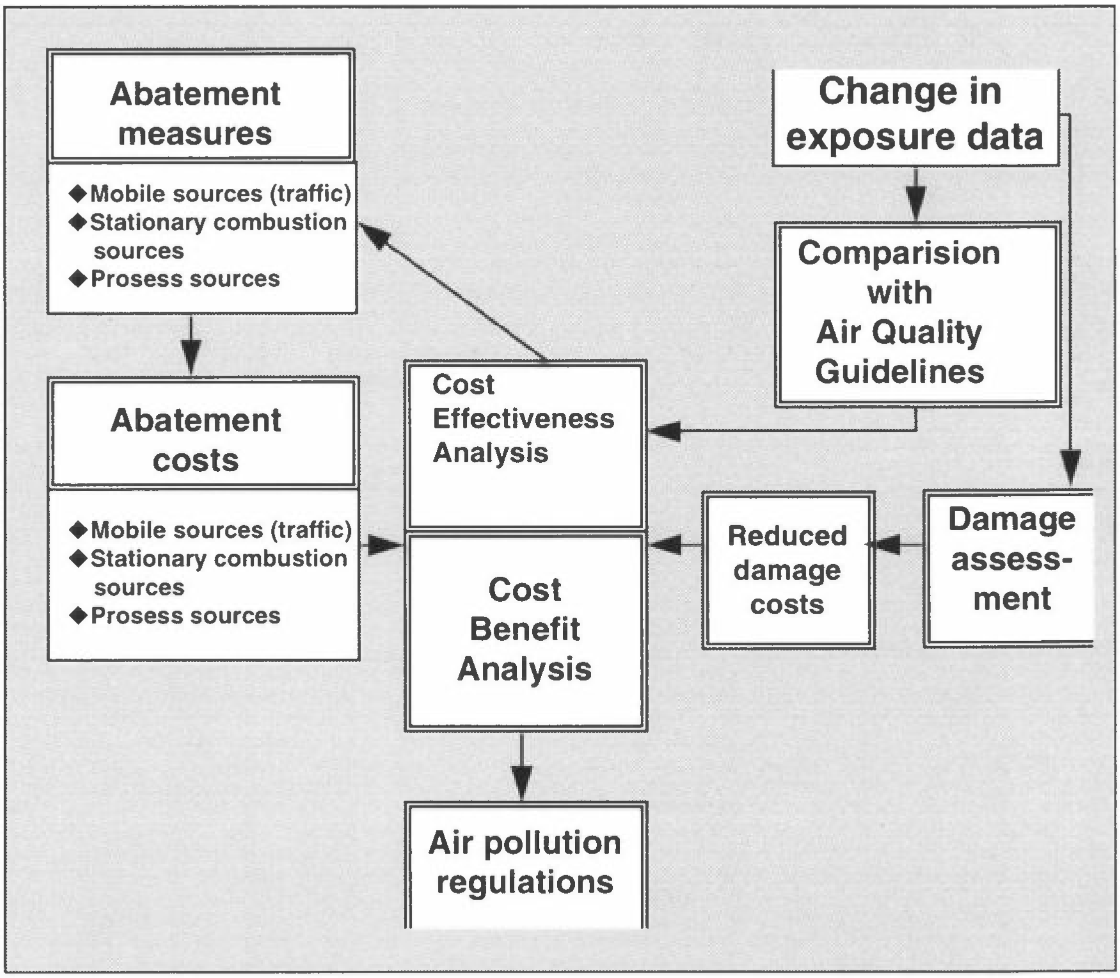


Figure 7: The cost-benefit analysis module.

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ABSTRACT
A concept for development of an Air Quality Management System and planning tool is described. The system contains modules for calculating emissions, dispersion and air quality, exposure and damage, costs of damage and control, and cost-benefit analysis.

NORWEGIAN TITLE

KEYWORDS		
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ABSTRACT (in Norwegian)

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