NILU F 11/2006
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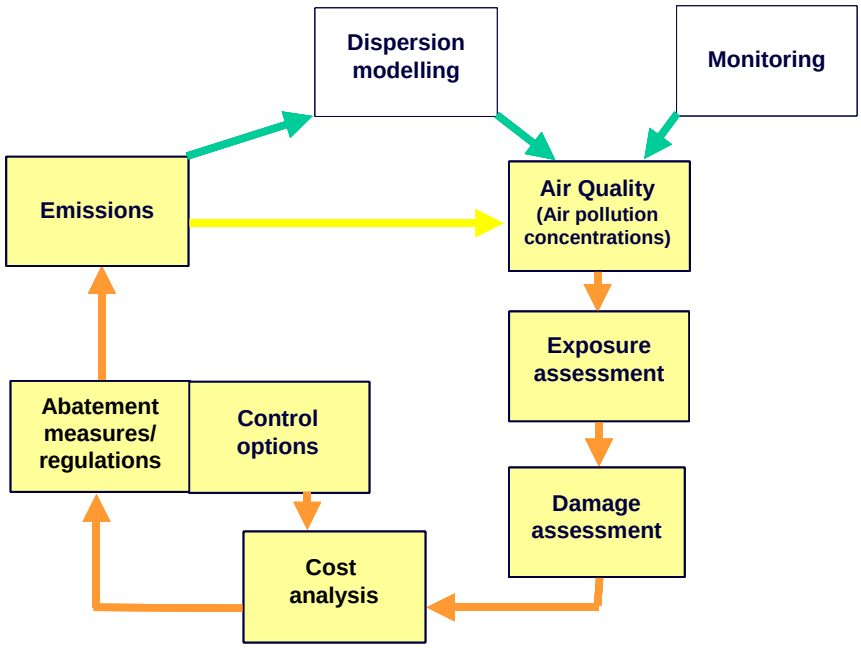
Date: Sept. 2006

The World Bank

## Hanoi Urban Transport and Development Project
## Air Quality Management Sub-component

# Air Quality Management System for Hanoi;
**Monitoring, Databases, Emissions, Models and Organisation.**

*Bjarne Sivertsen*




## Presentations at a Seminar
## Hanoi 14 September 2006

NILU Norwegian Institute for Air Research, www.NILU.no

# Air Quality Management System for Hanoi

## Introduction

The seminar presented a summary of the air quality management system needed to perform air quality planning in urban areas such as Hanoi. Presentations included the basic platform established for the air quality databases, emission inventories as well as the air pollution modelling. The future applications of the system used for air quality planning was presented based on results from other cities in Asia.

The NILU developed AirQUIS platform has been used world wide for air quality assessment and planning. Some of the examples used in the seminar were based on the application of AirQUIS. Future solutions for Hanoi were presented and at the ends we also included a presentation of organisational set-up and operations of the air quality management system as well as some input to the institutional framework and involvement of relevant agencies.

## Air Quality Monitoring

Five fixed air quality monitoring stations are being operated by 4 operators and by four different types of instruments in Hanoi. It has been stated that: “The management of monitoring stations and monitoring activities is not concentrated at one organization, management responsibilities are vested in many different organizations, and their cooperation is not effective. Technical infrastructure is lagging behind while the investment is still limited and spread; labour resource is wastefully used “.

The present situation was presented as a background for a proposed future network of air quality monitoring stations. Data from this network will then in the future represent the basis for air quality assessment and planning. The presentation may also represent a background for further discussions in Hanoi.

## Emission inventories

Hanoi’s vehicle fleet is the second largest in Vietnam, after Ho Chi Minh City (ADB, 2002). The number of vehicles has been increasing steadily during the last few years. As of 2002 Shah and Saikawa estimated that there were about 1.3 million motorcycles in Hanoi. Later estimates presented by Khaliquzzaman have indicated 1.66 million motorcycles and almost 170 000 other vehicles in Hanoi.

A GIS based system for the emission inventory data should be established at DONREH. These emission data should further be prepared to work directly as input to the dispersion models for Hanoi. NILU has considered the use of the AirQUIS emission inventory module or similar systems for updating the emission inventory for Hanoi in the future. The tools and templates for collecting emission data will be presented in the seminar.

The AirQUIS emission module includes templates for import of source data and emission data as well as a modern emission inventory database with emission models. The emission data are normally divided into:

- Point sources (stacks, industries, power plants)
- Line sources (traffic)
- Area sources (domestic burning, diffuse traffic etc.)

## Dispersion models

Air pollution dispersion models will have to be added to the system in Hanoi. This will enable concentration estimates, evaluation of different source's relative importance to the total exposure, impact assessment and to perform optimal abatement planning. Models and model applications was briefly introduced in the seminar. For implementation in Hanoi it will be necessary to perform further training and practical work with atmospheric dispersion models.

## Assessment and planning

When the necessary input data such as air quality, meteorology and emission inventories are in place in one integrated database it will be possible to use the GIS based system for air quality assessment optimal abatement planning. The background and some results from other studies was presented in the seminar.

## Institutional arrangements

The organisation of air quality management in Hanoi will be a challenge, and was presented and discussed during the seminar. In order to implement the total Air Quality Management Component in Hanoi NILU has suggested that Hanoi should base the development on the decisions already made by the People Committee Decisions on institutional arrangements (158/2005/QD-UB for the establishment of CENMA and 2370/QD-UBND dated May 22, 2006 for the establishment of a Steering Committee. Decision No.101/2003/QDU from August 2003 identified DONREH as the key stakeholder. We will have to specify other agencies that should cooperate with DONREH.

The tasks and work to be undertaken as part of the AQM work in Hanoi may represent the basis for identifying a group of institutions and their role in the future Air Quality Management if Hanoi.

# Agenda for the seminar

## Held in Hanoi,
## Thursday 14 September 2006

| Time (hr) | Topic | Lecturer |
|---|---|---|
| 09:00 | Welcome, presentation from DONREH | Mr Vu Van Hau / Mr Dang Duong Binh |
| 09:15 | Hanoi Urban Transport and Development Project, The Air Quality Management Component | Mr Duong Quoc Vinh |
| 09:30 | An integrated air quality management system for Hanoi, introduction to the different components | Mr. Bjarne Sivertsen |
| 10:15 | Coffee break | |
| 10:30 | The air quality monitoring system, monitoring design, data needed, site and equipment selection | Mr. Bjarne Sivertsen |
| 11:30 | Air quality data retrieval, QA/QC and databases. A proposed future system for Hanoi. | Mr. The N Thanh |
| 12:00 | Lunch break | |
| 13:30 | Emission inventories and modelling in Hanoi, (Input- output – examples)<br>The use of templates for collecting input data – data and information needed | Mr. Bjarne Sivertsen<br>Dr Agnes V. Dudek |
| 14:30 | Introduction to models, how do they work<br>Model applications (Asia) | Mr. Bjarne Sivertsen |
| 15:00 | Coffee break | |
| 15:15 | Understanding air pollution, future applications, Air Quality Management and abatement strategies presented based on examples from other cities in Asia | Mr. Bjarne Sivertsen |
| 16:15 | Using the system and data dissemination systems in Hanoi including issues to be covered during this Mission and further. Input to discussions | Intro by<br>Mr The N Thanh<br>Mr B Sivertsen |
| 15:45 | The organisation of Air Quality Management in Hanoi. Proposals, plans and initiatives from DONREH. | DONREH representative |
| 16:30 | Questions, discussions and summaries<br>Final statements | all |

## References

Sivertsen B. (1997) An on-line monitoring, surveillance and planning system for air quality. Presented at the 10th regional IUAPPA conference, Istanbul, Turkey, 23-26 September 1997. Kjeller (NILU F 12/97)

Sivertsen, B. (1999) On-line Air Quality Monitoring Systems used in Optimal Abatement Strategy Planning. Presented at the Int. Conf. on Environmental Management, Health and Sustainable Development, Alexandria, Egypt, 22-25 March 1999. Kjeller (NILU F 7/99).

Sivertsen, B. and Bøhler, T. (2000) On-line Air Quality Management System for Urban Areas in Norway. Presented at the seminar "The air of our cities ... it's everybody's business", Paris, 16-18 February 2000. In: *Proceedings. Paris, Marie de Paris, Environment. Fourth theme, paper D6*, pp. 44-45.

Sivertsen, B. (2000) Understanding air quality measurements. Kjeller (NILU TR 4/2000).

Sivertsen, B. and Thanh, T.N. (2004) Ho Chi Minh City Environmental Improvement Project. Air Quality Monitoring Component. Mission 4, April 2004; Status report (QR7-9), Data assessment and training. Kjeller (NILU OR 51/2004).

Sivertsen, B., Thanh, T.N., Le, K.V. and Vo, D.T. (2004) The air quality monitoring and management system for HCMC, Vietnam, Presented at the Better Air Quality Conference, Agra, India, December 2004.
URL: http://www.cleanairnet.org/baq2004/1527/article-59135.html

Sivertsen, B. (2005) Ho Chi Minh City Environmental Improvement Project. Air Quality Monitoring and Reference Laboratory. MR-1. Reference laboratory; planning and design. Kjeller, NILU (OR 58/2005).

Sivertsen, B. (2005) An air quality monitoring and management system for Hanoi. Presented at the World Bank meeting in Hanoi, 26 February 2005. (NILU FF 7/2005).

Sivertsen, B. (2006a) Air quality monitoring programme for Dakar, Result of the design study. Kjeller (NILU OR 37/2006).

Sivertsen B. and The N. T. (2006a) Support for the Review of Air Quality Management Sub-component for the Hanoi Urban Transport and Development Project, Inception report. Kjeller. (NILU OR 60/2006).

Sivertsen B. and The N. T. (2006b) Support for the Review of Air Quality Management Sub-component for the Hanoi Urban Transport and Development Project, Final report. Kjeller. (NILU OR 78/2006).

Sivertsen B. (2006b) Air Quality Management System for Hanoi; Monitoring, Databases, Emissions, Models and Organisation. Kjeller. (NILU F 11/2006).

## Norwegian Institute for Air Research

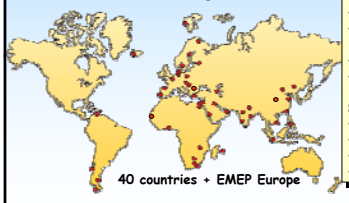
- Founded in 1969
- Independent foundation from 1986
- Annual turnover
- 20 mill US$

140 employees
- 80 scientists
- 45 PhD scientists
- Accreditated laboratories

**Some major NILU clients:**
- UN Economic Commission for Europe
- European Environment Agency/Topic Centre for Air Quality
- European Commission
- World Bank
- World Meteorological Organisation
- World Health Organization (WHO)
- UNEP
- The European Bank for Reconstruction and Development
- ERWDA, UAE
- Nordic Development Bank

**Selected development projects:**
- Guangzhou S & T Commission (China)
- Egypt Environment Affairs Agency
- Department of Mines, Botswana
- HCMC HEPA/DONRE (AQMS)

International Assignments






## The World Bank

Hanoi Urban Transport and Development Project

# Air Quality Management Sub-component

*Bjarne Sivertsen*
*The Nguyen Thanh*

**Norwegian Institute for Air Research (NILU)**



## Content of the workshop

A: An integrated AQM system

*Coffee----------*

B: The air quality monitoring system

C: Air quality data retrieval, QA/QC and databases, A proposed future system for Hanoi .

*Lunch break----------*

D: Emission inventories and modelling in Hanoi, (Input- output – examples)

E: Introduction to models, applications in Asia and in Hanoi

*Coffee break----------*

F: Understanding air pollution, Air Quality assessment and management

G: Organisation of Air Quality Management in Hanoi; proposals, plans and initiatives presented by DONREH.

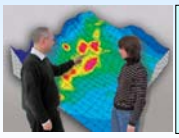
H: Future AQM application and organisation in Hanoi. Input to discussions.

Questions, discussions and summaries



## The Mission & Objectives

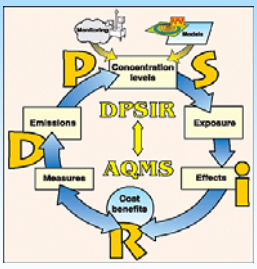
- ✓ Review existing air quality data and management programmes ,
- ✓ Review existing vehicular emission control strategy,
- ✓ Institution analyses for sustainable air quality management,
- ✓ Share experience with other cities in Asia



- Emissions sources,
- Ambient air monitoring; QA/QC,
- Impacts of air pollutants,
- AQM studies for the city of Hanoi,
- Institutional framework



## Integrated AQM system for Hanoi




**AQ Hanoi:**

- Drivers
- Pressures
- Status
- Impact
- Responses



## NILU support includes

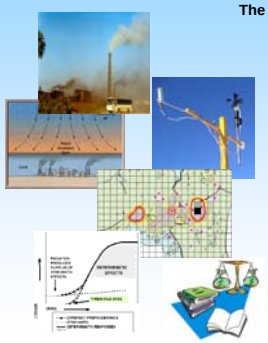
- ✓ Review current organisational set-up
- ✓ Assess and evaluate present AQ monitoring system
- ✓ Review sites, instruments and retrieval system
- ✓ Design and modify the Air Quality monitoring and management programme
- ✓ Advice data retrieval and QA/QC
- ✓ Review databases and assessment system
- ✓ Collect input data for modelling
- ✓ Institutional building and training

*more funds available*

- ✓ Install AQ management platform (AirQUIS)
- ✓ Continue emission data and inventory for modelling
- ✓ Perform assessment and management
- ✓ Data and information dissemination through Internet application
- ✓ Institutional building and training

## Impact Pathway Approach

The complete integrated analyses



Identify sources
Emission inventory

Meteorological data
Dispersion and turbulence

Dispersion modelling
SOx, NOx, PM

Concentrations,
Exposure

Exposure/response
functions

Effect / cost data



## AQ Management Model Concept

Developed by
NILU for WB
from 1992

Dispersion
modelling

Monitoring

Emissions

Air Quality
(Air pollution
concentrations)

Exposure
assessment

Abatement
measures/
regulations

Control
options

Damage
assessment

Cost
analysis



## The elements of an AQMS

AirQUIS

Map data

Background data

User
interface
- Graphics
- GIS
- Internet

Air Pollution

Monitoring

Emission
Inventory

Dispersion
Exposure
models

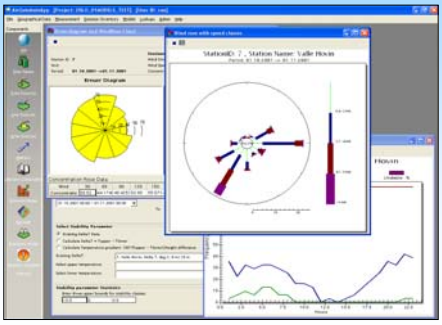
Users

Abatement Strategy
Planning and decision making



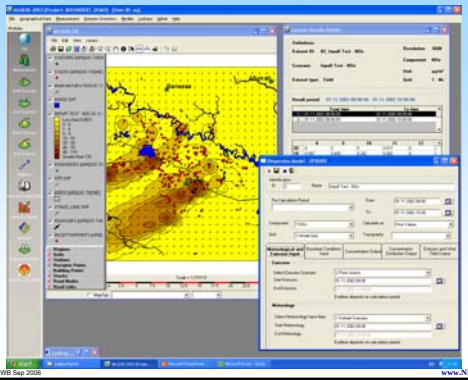
## Management software using monitoring data

AirQUIS





## Dispersion Models





## Emission Data Base

Geographical Information System (GIS)

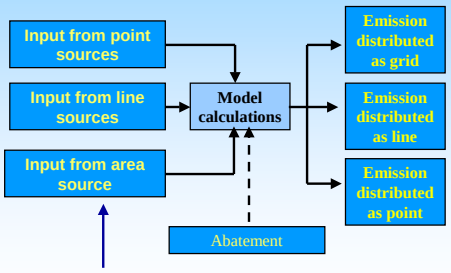
Calculation of Emission → Modeling

**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

## Emission Model




Excel templates for data collections



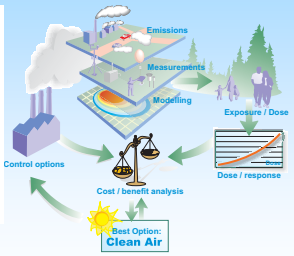
## Applications

- Environment impact assessment
- Air Quality management
- A.Q. forecasting and early warning
- Optimal abatement strategies
- A.Q. information systems



## A complete Air Quality Management System for Hanoi

- ✓For Assessment and planning
- ✓Check impact of regulations
- ✓Optimal abatement
- ✓Identify Cost-effective future measures




most cost-effective options



## Presenting Air Quality information to people


- Providing clear, understandable data to decision makers is key to effective air quality management, but it is not the ultimate goal.
- The ultimate goal is to motivate action – get reduction – protect public health and the environment.
- There are numerous options for effectively presenting the data
  - Find what is effective for your audience – decision makers or the public.
  - Match the presentation method to the goal
  - You do NOT need to start from scratch
- The public is a key player in air quality management and communicating effectively with them has many benefits, but does require planning.



## Air online

Web for Vietnam (National)

Adm tools password

Public pages

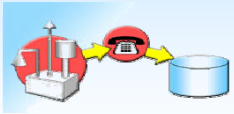
DONREH
MONREH



The World Bank

# Air Quality Management

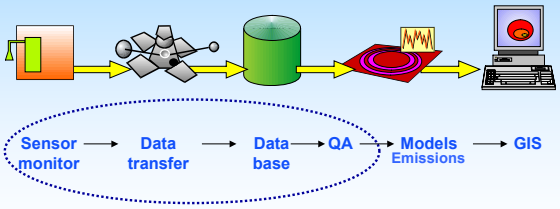
## Air Quality Monitoring Design -Equipment - Data



*Bjarne Sivertsen, Norwegian Institute for Air Research (NILU)*



## Integrated Pollution Prevention and Control



Sensor monitor → Data transfer → Data base → QA → Models Emissions → GIS



## The Monitoring Programme Design

- 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?



## 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



## 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?



## 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 !**

# Quality Assurance

**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



# 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




# Air Pollution Indicators


**First priority pollutants**

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

PAH (BaP)

BTX

**Limit values developed for other indicators:**

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



# AQ Guidelines and Standards

| Pollutant | Averaging Time | WHO (µg/m³) | TCVN-2005 (µg/m³) |
|---|---|---|---|
| $SO_2$ | Annual Avg. | 50 | 50 |
| | 24 Hours | 125 | 125 |
| | 1 Hour | 500 (10min) | - |
| CO | 8 Hours | 10 000 | 10 000 |
| | 1 Hour | 30 000 | 30 000 |
| $NO_2$ | Annual Avg. | 40 | 40 |
| | 24 Hours | - | - |
| | 1 Hour | 200 | 200 |
| $O_3$ | 8 Hours | 120 | 80 *(24 h)* |
| | 1 Hour | - | 120 |
| PM10 | Annual Avg. | 20 | 50 |
| | 24 Hours | 50 | 150 |
| Pb | Annual | 0.5 | |



# Types of Monitoring Stations

**Classification system:**

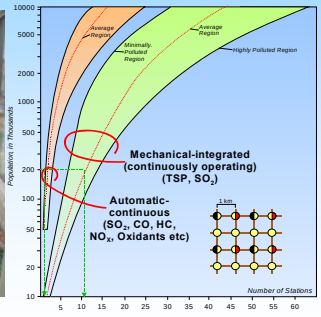
| Type of area | Description | Type of station |
|---|---|---|
| Urban | Continuously built-up area | Traffic |
| Suburban | Largely built-up area: continuous settlement of detached buildings mixed with non-urbanized areas | Industrial<br>Background : |
| Rural | Areas that not fulfil the criteria for urban/suburban areas | - Near city<br>- Regional<br>- 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 backgr. | 1 - 10 km |
| - Regional stations | 25-150 km |
| - Remote stations | 200-500 km |

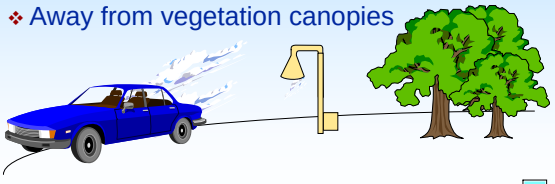
## Number of monitoring sites needed in an urban area






## Sampler Location

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





## Siting studies

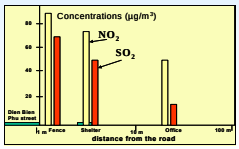
- ✓ Define site locations
- ✓ Evaluate sources and possible impact
- ✓ Perform simple "model estimates"

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




## Passive sampling

In HCMC 14-25 Nov 2002 + May 2005


| Measurement site | $SO_2$ (µg/m³) | $NO_2$ (µg/m³) |
|---|---|---|
| Zoo, Quan 1 | 21 | 28 |
| Zoo at fence | 30 | - |
| Tan San Hoa | 32 | 36 |
| Nguyen van Troi str | 35 | 81 |
| Tu Duc | 39 | 30 |
| Quan 2 PC build | 72 | 18 |
| Quan 2 at gate | 23 | 24 |
| ThongNat Hospital | - | - |
| Software city | 26 | 25 |
| Software city gate | - | 31 |
| Road 14 | 72 | 91 |
| Binh Chanh educ. | 25 | 58 |
| Hong Bang | 50 | 63 |
| DOSTE fence | 67 | 86 |
| DOSTE shelter | 48 | 72 |
| DOSTE office | 14 | 49 |
| Liberty 1 hotel, 4.floor | 51 | 79 |
| Liberty1 hotel, entrance | 40 | 54 |
| Tran Hung Dao str. City centre | 62 | 44 |
| Nguyen Tat Thahn, Quan1 | 67 | 89 |



## Sites and Locations

Traffic and road side stations

DOSTE

Binh Chanh

Thong Nhat

Hong Bang



## Urban background and residential sites

Zoo, D1

District 2

Tan Son Hoa

Quang Trung

Thu Duc (res/ind)

# Instruments

## Many kinds:

- Simple passive samplers
- High volume samplers
- Sequential samplers
- Automatic Monitors (in situ)
- Monitors for remote measurements
- Mobile stations
- Automatic weather stations



# 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 | 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 |



# Simple instruments for $PM_{10}$ and $PM_{2.5}$

Minivol sampler

Kleinfilter
SEQ sampler

Dust track



# Air quality Monitors

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

Reference instruments !

$PM_{10}$ : ➡ Measurement on filter tape using the principles of beta attenuation



# 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

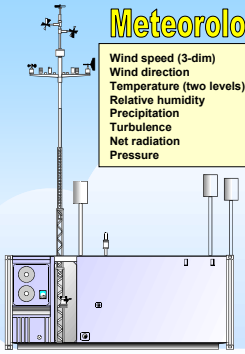
BTEX ➡ Monitor Photo Ionization Detector (PID) as the sensing element.



All air quality monitoring programmes include

# Meteorological measurements

Wind speed (3-dim)
Wind direction
Temperature (two levels)
Relative humidity
Precipitation
Turbulence
Net radiation
Pressure



## Meteorological station


## 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.



## A typical monitoring station


Urban background site in HCMC



## AQ monitoring Programme in Hanoi


DONREH (Pham Van Dong Street), since 2002 – need repair and calibration.

DONREH (334 Nguyen Trai Street), since 2000 - repaired May 2006.

CEETIA (Giai Phong Street), since 1999. broken

CTET (282 Lac Long Quan Street), since 2001 .

HydroMet (Nguyen Chi Thanh Street), since 2004 in operation



## A.Q monitoring sites in Hanoi




Hanoi need to upgrade:

## QA/QC system

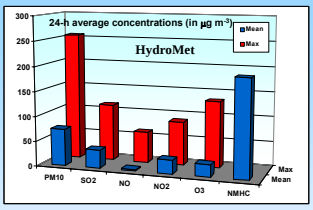
**to assure a predefined quality of all data**

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

Define objectives ⇨ Follow-up controls ⇨ Verify Audit

## Air Quality
⬇
## Data quality
⬇
## Quality assessment
⬇
## The right decisions






## Air Quality measured in Hanoi

**Measured August 2005 (JICA)**

| Compound | Concentrations (µg/m³) Range | Average | Maximum | Comment |
|---|---|---|---|---|
| $SO_2$ | 119 – 181 | 142 | 304 | Autom. monitor |
| $SO_2$ | 21 – 92 | 52 | 196 | Manual sample |
| $NO_2$ | 21 – 67 | 36 | 98 | Manual sample |
| Ozone | 22 – 70 | 40 | 84 | Sample |
| $PM_{10}$ | 36 – 191 | 97 | 191 | Filter sample |
| $PM_{2.5}$ | 19 – 171 | 67 | 171 | Fiter sample |
| TSP | 120 – 537 | 271 | 537 | Filter sample |
| NH3 | 10 - 55 | 32 | 91 | Manual sample |




## Air Quality Index (AQI)

- ✓ Generated automatically every day
- ✓ Displayed on board at Benh Thanh
- ✓ Presented daily on Internet





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Norwegian Institute for Air Research

The World Bank

# Air Quality Management

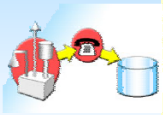
## Database – QA/QC – future AQM

*The Nguyen Thanh*
*Bjarne Sivertsen*

Norwegian Institute for
Air Research (NILU)



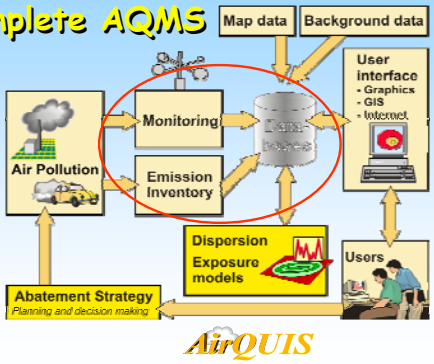
## Proposal for a future Air Quality Management System in Hanoi



- Monitoring sites
- Indicator selection
- Instrumentation
- QA/QC system
- Automatic data retrieval
- Centralised database system
- Data statistics
- Air Qualitty assessment
- Information dissemination

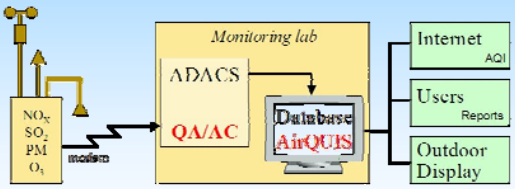


## Part of the complete AQMS



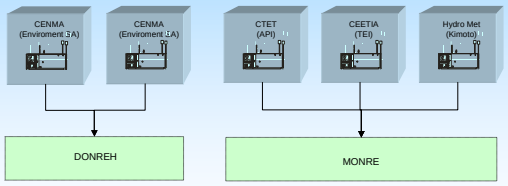



## Automatic data retrieval





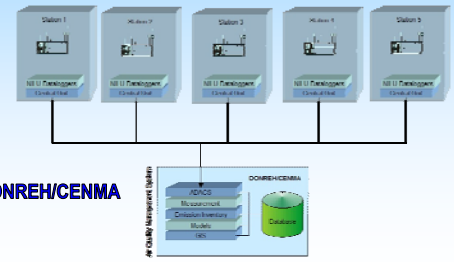

## Current situation for air quality measurement in Hanoi






## Phase I – Integrate and Centralise

- ✓ Integrate 5 existing automatic measurement stations into One Centralized Measurement Network
- ✓ One Centralized Air Quality Management System (AQMS)



## Phase II

Repair and upgrade the 5 existing automatic measurement stations
Establish agreement for maintaining the instruments

in good operational conditions

| Owner | Location | To be fixed |
|---|---|---|
| DONREH | Pham Van Dong Str. | $SO_2$ monitor need repair, $O_3$ monitor need calibration and maintenance, CO monitor looks strange, $PM_{10}$-monitor (filters), NO/NO$_x$-monitor, modem, instrument-filters, radiation-meter Wind speed too low, need maintenance Logbooks not in use, upgrade QA/QC , check calibration gases |
| DONREH | 334 Nguyen Trai Str. | Only 3 out of a total of 11 parameters is working properly. The station needs a complete overhaul. No calibration gases are available! |
| CEETIA | 55 Giai Phong Str. | The station is totally shut down since 2005. Needs total upgrading, repair and calibration. |
| CEETIA | Street level (mobile) | Not evaluated |
| Hydro Met - | 62 Nguyen Chi Thanh Str | All calibration automatic, instrument provider checks once a year. NO/NOx and $O_3$ monitor not working; need repair $PM_{10}$-monitor? Check! |

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## Quality Assurance

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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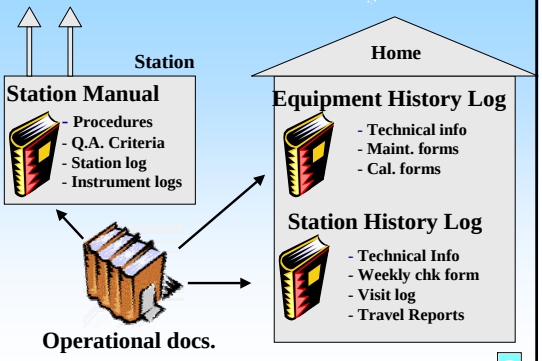
## Manuals used in the network

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## Phase III - New measurement stations

- ✓ Invest 3 new DONREH automatic measurement stations based on screening study and site selection study
- ✓ Integrate 3 new DONREH automatic measurement stations into the centralized Air Quality Management System

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## Critical succes factors

- Budgets and funds for development
- Training for operating and maintaining instruments and stations
- Annual budgets for consumables and spare parts
- Maintenance agreement with local instrument supplier
- Upgrade the QA/QC system and perform training
- Training in understanding Air Quality Management
- Training in using the Air Quality Management System
- Emission inventory with collected source information
- DONREH provides an organisation for supporting and handling the Air Quality Management System for Hanoi

*Training and institutional building !*

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## Outcome of the proposal

- ✓ One Centralised Measurement Network
- ✓ One Centralised Air Quality Management System (AQMS)
- ✓ Common Standard Operational Procedure for the instrument park
- ✓ Air Quality Management Competence and system at DONREH complying with international standards

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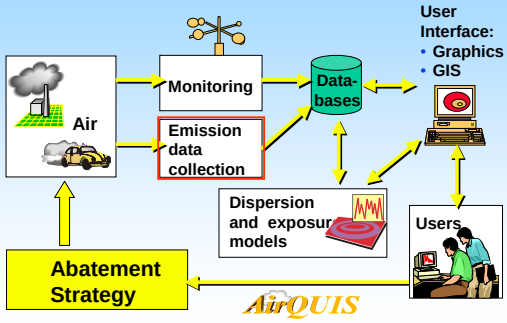
# Air Quality Management

## Emission inventories input data needed

Norwegian Institute for Air Research (NILU)



## Air pollution management system






## The Emission Inventory

**is a compilation of all sources of air pollution within an area**



## Emission inventories

- **Complete:**
  - All sources included
- **Consistent:**
  - Same definitions applied by all countries. Appropriate and up-to-date emissions factors
- **Transparent:**
  - Contains all information necessary to check how emission estimates are obtained.



## Detailed description of an inventory:

- Geographic area (**geographic domain for the inventory**)
- Pollutants (**purpose the inventory**)
- Source Categories (**Anthropogenic/Natural sources**)
- Modelling (**Geographically/time resolution, Pollutant species**)
- Spatial resolutions
- Temporal resolution (**variability of emissions over time**)
- Speciation (**Disaggregates into indiv. chemical comp.or groups**)
- Base year (**reference year**)

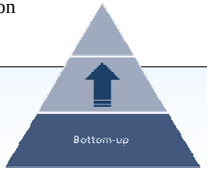


## Two different approaches: a) *top-down* inventory

- Activity statistics (consumption,production,vehicle type etc)
- Population statistics, land-use and emission factors
- Detailed information about location not required

## Two different approaches: b) *bottom-up* inventory

- Detailed knowledge of source types and locations
- Specific emissions for individual sources
- Consumption and or production data using emission factors






## Emissions Inventory Planning

- Define the inventory uses and users
- The structure of the inventory
- The data quality objectives (DQOs)
- The source types, categories, and pollutants to be included included
- Necessary level of spatial and temporal resolution

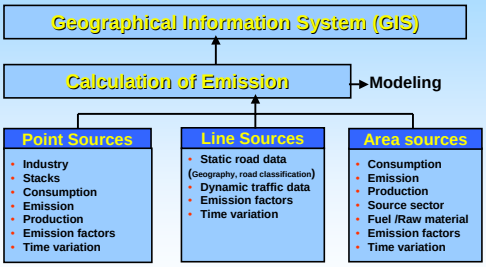


## Emission Model

- **Area sources:**
  - Uses annual consumption of fossil fuels, emission factors, time variations and temperature variations to calculate hourly emissions from area sources
- **Line sources:**
  - Uses road and traffic data and classifications, emission factors, traffic dependencies and time variations to calculate hourly emissions from line sources
- **Point sources:**
  - Uses physical stack data, process consumption or direct emission data, emission factors and time variations to calculate hourly emissions from point sources

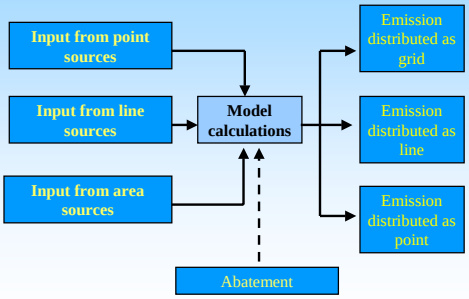


## Emission Data Base






## Emission Model






## Point Sources

**Emission estimates provided on an individual plant or emission outlet in conjunction with data on location, capacity or throughput, operating conditions etc.**

## Point Sources - Input Data

- Industries
- Stacks
- Cleaning devices
- Processes
- Processes emission/consumption data
- Fuels
- Time variations
- Source sectors
- Emission factors



## Classification:
## Fuels and source sectors:

| Fuel | |
|---|---|
| Fuel ID | Name |
| 8 | Gasoline |
| 19 | Diesel |
| 1 | Coal |
| 2 | Coke |

| Source Sectors | |
|---|---|
| Source Sector ID | Source Sector Name |
| 1000 | Stationary combustion |
| 1100 | Industry and energy sectors |
| 1200 | Primary industries |
| 1300 | Private services |
| 1400 | Public administration |



## Emission Inventory-
## Ex.:Contact person register

| Owner ID | Owner Name | Postal Address | Visiting Address | Zip Code | City | Country | Contact person last name | Contact person first name | Title | E-mail | Telephone | Fax |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NILU | Pb100 | Instituttveien 18 | 2027 | Kjeller | Norway | Hansen | Jan | Scientist | JIA@nilu.no | 4763898000 | 4763898050 |



## Emission Inventory-
## Ex.:Industrial plant register

| Industrial Plant Register | | | | |
|---|---|---|---|---|
| Industrial Plant ID | Name of Industrial Plant | Source sectors Name | Region Name | Owner Name |
| 301005 | Industry nr 301005 | COMBUSTION INDUSTRIES | Bangladesh | Government |
| 301006 | Industry nr 301006 | District heating plants | Dhaka | Government |
| 301012 | Industry nr 301012 | Coal mining, oil / gas extraction, pipeline compressors | Chittagong | Government |



## Emission Inventory-
## Ex.: Stack data

| Stack data | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stack ID | Stack name | X Co-ordinate | Y Co-ordinate | Stack height (m) | Stack Diameter (m) | Gas Temperature (C) | Gas Velocity (m/s) | Gas Flow Rate (m^3/s) | Building Height | Building Width | Industrial Plant Name |
| 30100501 | Pipe 301005-1 | 600669 | 6645282 | 10 | 0.5 | 130 | 16.27 | 3.19 | 5 | 10 | Industry nr 301005 |
| 30100601 | Pipe 301006-1 | 598856 | 6646044 | 20 | 0.5 | 178 | 10 | 2.00 | 5 | 10 | Industry nr 301006 |
| 30101201 | Pipe 301012-1 | 604096 | 6646518 | 46 | 0.9 | 250 | 20 | 6.67 | 18 | 28 | Industry nr 301012 |
| 30101301 | Pipe 301013-1 | 600071 | 6644966 | 14 | 0.4 | 190 | 12.6 | 10.00 | 6 | 10 | Industry nr 301005 |
| 30101502 | Pipe 301015-2 | 598835 | 6644487 | 40 | 3 | 225 | 5 | 35.34 | 18 | 40 | Industry nr 301006 |
| 30101901 | Pipe 301019-1 | 604474 | 6649890 | 30 | 0.8 | 110 | 20 | 10.00 | 12 | 18 | Industry nr 301012 |



## Emission Inventory-
## Ex.: Consumption data

| Process Fuel and Raw material Consumption Data | | | | | | |
|---|---|---|---|---|---|---|
| Process ID | Process Name | Fuel name | Consumption Amount | Unit name | Time variation Name | Validity Period |
| 30100501 | Prosess 301005-1 | Hard coal | 190.987 | ton/year | | 1998 |
| 30100601 | Prosess 301006-1 | Brown coal | 175.075 | ton/year | | 1998 |
| 30101202 | Prosess 301012-2 | Natural gas | 889.427 | ton/year | | 1998 |
| 30101201 | Prosess 301012-1 | Heavy fuel oil | 2.74308 | ton/year | | 1998 |
| 30101302 | Prosess 301013-2 | Other liquid fuels | 366.362 | ton/year | | 1998 |

## Emission Inventory- Ex.: Emission factor data

| Process Fuel and production Emission factor Data | | | | | | |
|---|---|---|---|---|---|---|
| Process ID | Process Name | Fuel/product Name | Component Name | Factor | Unit Name | Year |
| 30108101 | Prosess 301081-1 | Heavy fuel oil | PM10 | 10 | kg/tonn | 1998 |
| 30108101 | Prosess 301081-1 | Heavy fuel oil | PM2.5 | 5 | kg/tonn | 1998 |
| 30108101 | Prosess 301081-1 | Heavy fuel oil | NOx | 0.001 | kg/tonn | 1998 |
| 30108101 | Prosess 301081-1 | Heavy fuel oil | NO2 | 0.01 | kg/tonn | 1998 |



## Emission estimate

$$E = P \bullet f$$

E = emission rate (g/h)
P = production, fuel use etc... (ton/h)
f = emission factor (g/ton)

point
area
line

source emission rates



## Emission Inventory- Ex.: Emission data

| Process Emission Data | | | | | | |
|---|---|---|---|---|---|---|
| Process ID | Process Name | Component Name | Amount | Emission Unit Name | Time Variation Name | Validity Period |
| 30108101 | Prosess 301081-1 | PM2.5 | 0.218125 | ton/year | TV-1082 | 1998 |
| 30108101 | Prosess 301081-1 | PM10 | 0.349 | ton/year | TV-1083 | 1998 |
| 30108101 | Prosess 301081-1 | NO2 | 40.6 | ton/year | TV-1084 | 1998 |
| 30108101 | Prosess 301081-1 | NOx | 406 | ton/year | TV-1085 | 1998 |
| 30108201 | Prosess 301082-1 | PM2.5 | 4.96875 | ton/year | TV-1086 | 1998 |
| 30108201 | Prosess 301082-1 | PM10 | 7.95 | ton/year | TV-1087 | 1998 |
| 30108201 | Prosess 301082-1 | NO2 | 12.4 | ton/year | TV-1088 | 1998 |
| 30108201 | Prosess 301082-1 | NOx | 124 | ton/year | TV-1089 | 1998 |



## Line sources

**Vehicle emissions from road transport are provided for sections along the line of the road**



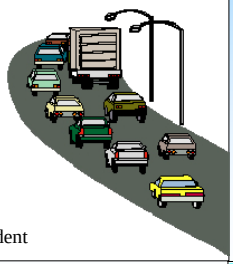
## Emission Inventory-Traffic data

- Static data (road network)
- Dynamic data (Annual Daily Traffic)
- Road link vehicle distribution (e.g. buses,passenger cars)
- Traffic emission factors



## Traffic data

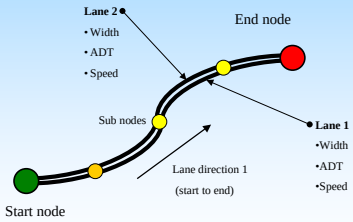
- Traffic modelling (G-MAT)
  - Road network
  - ADT
  - Vehicle fleet distribution
- Traffic counting
  - ADT
  - Vehicle fleet distribution
- Vehicle emission factors
  - fuel and technology dependent



## Concept of line sources

**ROAD LINK DATA:**

- ID
- NAME
- GRADIENT (%)
- LENGTH
- DIRECTION
- LANE WIDTH
- ROAD CLASS
- ADT
- SPEED

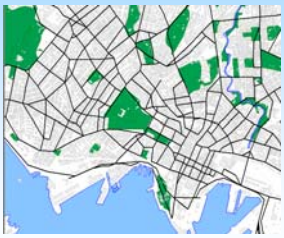





## Emission Inventory -Traffic data

**ROAD LINK DATA:**

- Annual Daily Traffic
- Vehicle distribution
- Emission factors





## Emission Inventory- Ex.: Static traffic data

| Road Link Definition | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Road Link ID | Road Link Name | Road Class ID | Descritption | Start Node ID | End Node ID | Length in meter | Direction (1 = Start to End Node, 2 = End to Start Node , 3 = both ways) | Road width 1(m) (Start to End) | Road width 2 (m)(End to Start) | Road Gradient (%) |
| 1 | Dhaka Aricha Hara | 1 | Main road to t | 1 | 2 | 5000 | 3 | 15 | 15 | 0 |
| 2 | New Airport Road | 2 | Main road to t | 3 | 4 | 10000 | 2 | 15 | 15 | 0 |



## Emission Inventory- Ex.: Dynamic traffic data

| Dynamic Traffic Data | | | | | |
|---|---|---|---|---|---|
| Road Link ID | Road Link Name | Direction (1 = Start to End Node, 2 = End to Start Node | Annual Daily Traffic | Free Flow Speed (km/h) | Validity period (year(s)) |
| 2 | Main road to the | 1 | 45000 | 60 | 2006 |
| 2 | Main road to the | 2 | 45000 | 60 | 2006 |



## Emission Inventory- Ex.: Vehicle distribution

| Road Link Vehicle Distribution | | | | | | |
|---|---|---|---|---|---|---|
| Road Link ID | Road Link Name | Link Direction | Vehicle Class ID | Vehicle Class Name | Vehicle Class Fraction % | Vehicle Class Time Variation Name |
| 2 | Main road to the Airport area | 1 | 1 | Motor Car | 60 | TV traffic |
| 2 | Main road to the Airport area | 1 | 2 | Bus | 28 | TV traffic |
| 2 | Main road to the Airport area | 1 | 3 | Auto rickshaws/autotempo | 10 | TV traffic |
| 2 | Main road to the Airport area | 1 | 4 | Motorcycles | 2 | TV traffic |




## Hanoi traffic emissions

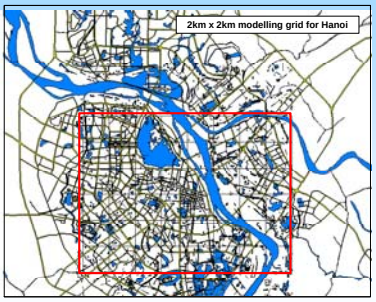
- 10 vehicle classes
- Emission factors
- Traffic density estimates

| Vehicle type | Fuel | NOx | PM | Ref |
|---|---|---|---|---|
| MC-2 stroke | Gasoline | 0.02 | 0.30 | Shu |
| MC-4 stroke | Gasoline | 0.20 | 0.10 | Khaliquzzaman |
| | | | | |
| Light car | Gasoline | 1.5 | 0.10 | Anglo |
| Heavy car | Gasoline | 6.1 | 0.15 | Lentz |
| Bus | Gasoline | 3.2 | 0.40 | Anglo |
| Truck | Gasoline | 7.5 | 0.24 | Anglo |
| | | | | |
| Light car | Diesel | 8.5 | 0.6 | Suksod |
| Heavy car | Diesel | 11.0 | 0.8 | USEPA, Anglo |
| Bus | Diesel | 7.6 | 1.5 | Suksod |
| Truck | Diesel | 17.0 | 1.6 | Khaliquzzaman |

Emission factors

g/km

## Grid area for Hanoi

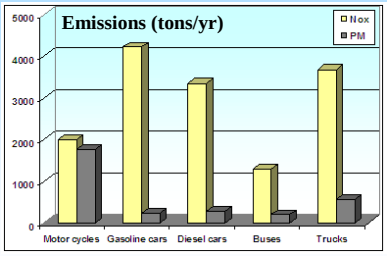



2km x 2km grid inner city (Area: 16x12km$^2$)



## Annual emissions of NOx and PM

**Estimated inside the modelling area of Hanoi**




**Total:**
**NOx: 18200**
**PM: 2300**
**tons/yr**

**PM emissions under estimated (need discuss Emission factors?)**



## Traffic emission estimates

Emissions from **motor cycles:**

Motor cycles: **Q(x,y,i) = (365 x EF(i) x (0.5x8xP(x,y) + (ADT(x,y) x f(i)-4))/1000000**

Emission rate (tons/ year) estimated for each **vehicle class** in each square is:

Diff vehicles: **Q(x,y,i) = 365 * ADT(x,y)*{(EF(lc)*(N(lc)/N + EF(hc)*N(hc)/N)/1000000**

Q(x,y,i) = emission rate from vehicle class i in square (x,y) (tons/yr)
EF = emission factor (g/km)
N(i) = number of vehicles in class i
L(i) = length driven per day of class i vehicle (km)
P(x,y) = number of people i square (x,y)
P(tot) = total population inside Hanoi grid
ADT(x,y) = annual daily traffic work in each 2kmx2km square (x,y)
N = number of vehicle type
lc = indicates light cars
hc = indicates heavy cars
f(i) = share of vehicle class i in Hanoi

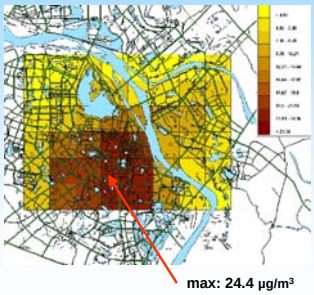


## Data base Hanoi (2006): Vehicles and emissions

| | Fuel | g/km | | | | Emission (ton/yr) | |
|---|---|---|---|---|---|---|---|
| Vehicle type | | NOx | PM | N vehicles | km/day | NOx | PM |
| MC-2 stroke | Gasoline | 0.02 | 0.3 | 14000 | 20 | 2.0 | 30.7 |
| MC-4 stroke | Gasoline | 0.2 | 0.1 | 1400000 | 20 | 2044.0 | 1022.0 |
| | | | | | | 0.0 | 0.0 |
| Light car | Gasoline | 1.5 | 0.1 | 100000 | 40 | 2190.0 | 146.0 |
| Heavy car | Gasoline | 6.1 | 0.15 | 20000 | 70 | 3117.1 | 76.7 |
| Bus | Gasoline | 3.2 | 0.4 | 7000 | 130 | 1062.9 | 132.9 |
| Truck | Gasoline | 7.5 | 0.24 | 100 | 60 | 16.4 | 0.5 |
| | | | | | | 0.0 | 0.0 |
| Light car | Diesel | 8.5 | 0.6 | 8000 | 40 | 992.8 | 70.1 |
| Heavy car | Diesel | 11 | 0.8 | 12000 | 60 | 2890.8 | 210.2 |
| Bus | Diesel | 7.6 | 1.5 | 800 | 120 | 266.3 | 52.6 |
| Truck | Diesel | 17 | 1.6 | 23720 | 40 | 5887.3 | 554.1 |
| Total | | | | 1585620 | | 18469.7 | 2295.7 |



## Gridded estimates of NOx in Hanoi




**Annual average NOx concentrations in 2km x 2km squares from Trucks in Hanoi**

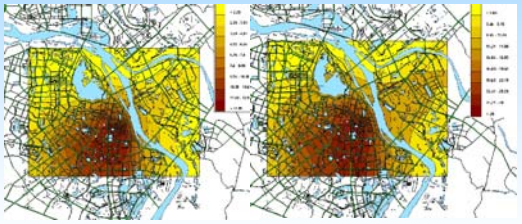
***µg/m³***



## Hanoi

### Annual NOx concentrations (µg/m³)

**4-stroke Motor cycles** **Petrol driven cars**



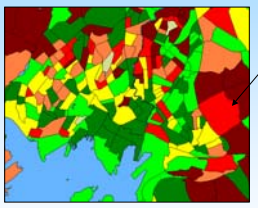
**Max 16 µg/m³** **Max: 28 µg/m³**

## Area Sources

Smaller or more diffuse sources of pollution (home heating, public services etc.) are provided on an area basis either for administrative areas, such as counties, municipality etc, or for regular grids.



## Concept of Area Sources



- **Area sources**
  - •Regions ID
  - •Emission/Consumption Value
  - •Emission factors



## Area Sources

- Stationary combustion
  - Consumption dataset for combinations of source sectors and fuel
  - Emission factors for different components for the same combinations
- Process emissions and evaporation:
  - Emission dataset for combinations of source sectors and components



## Area Sources -Input

- Regions (polygons) and grids
- Fuels/components
- Source sectors
- Time Variations
- Consumption or emission data
- Emission factors



## Emission Inventory- Ex.: Area sources

Region Data Defintion Emission

| Data set ID | Data set name | Source sector Name | Component Name | Dataset unit ID | Region | Ground level source(ground level=0, not ground level=1) |
|---|---|---|---|---|---|---|
| 1 | Emission from PM2.5 from woddburning | COMBUSTION IN MANUFACTURING IN | PM25 | ton/year | 4 | 0 |
| 2 | Emission from PM2.5 from industry | Other furnaces | PM25 | ton/year | 4 | 0 |
| 8 | Emission from PM10 from industry | WASTE TREATMENT AND DISPOSAL | PM10 | ton/year | 4 | 0 |



## Emission Inventory- Ex.: Area sources values

Region/grid Values

| Dataset ID | Region ID | Datasett Name | Value | Time variation Name | Validity periode |
|---|---|---|---|---|---|
| 100 | Bel Air | Consumtion of biomass for open air burning | 50000 | TV biomass | 2006 |
| 100 | Rufish | Consumtion of biomass for open air burning | 10000 | TV biomass | 2006 |

The World Bank

# Air Quality Management

## Introduction to Models Applications in Asia


Bjarne Sivertsen, Norwegian Institute for Air Research (NILU)



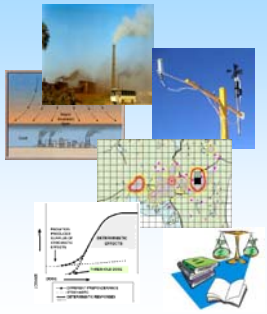
## A complete Air Quality Management System

- Monitoring (Air Qual.)
- Meteorological data !
- Data retrieval
- QA/QC
- Databases (GIS based)
- Dispersion Models
- Assessment tools
- Planning tools
- Forecasts (met+AQ)



## 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

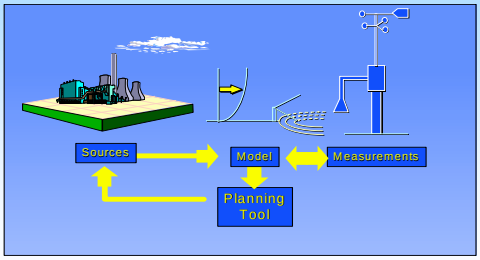
Optimised plan

modelling



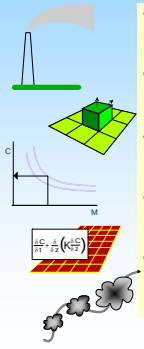
## Dispersion models

linking: sources – meteorology – air quality





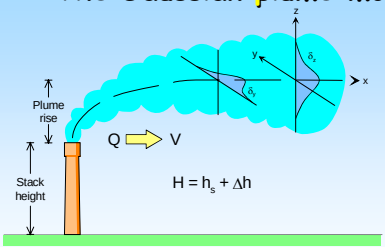

## Several types of models



- **Gaussian models**
  - most used models for estimates of dispersion from stacks.
  - available for area sources and urban areas.
- **Box models**
  - based upon budgets analysis
  - used in simple urban air pollution modelling.
- **Statistical models**
  - based upon established relationships.
  - can not be used for planning purposes.
- **Numerical models**
  - based upon numerical solutions of the continuity equations.
  - Several models have been developed and applied.
- **Trajectory / puff models**
  - based upon knowledge of the wind field and the variations of winds
  - suited for dispersion from single sources at larger distances or in cases with space and time variations in meteorology

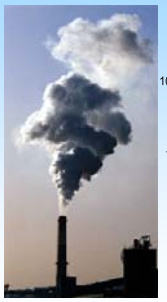


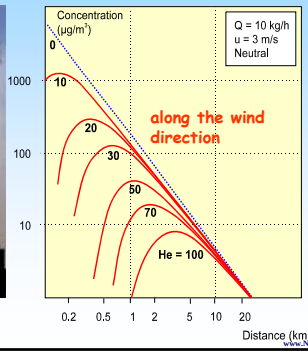
## The Gaussian plume model



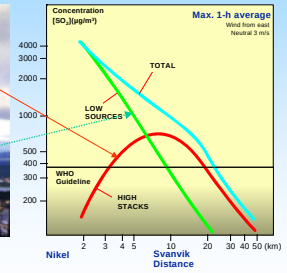

$$\text{Concentration} = \frac{\text{Release rate}}{\text{Wind speed} \bullet \text{dispersion}}$$

## Concentration at ground level

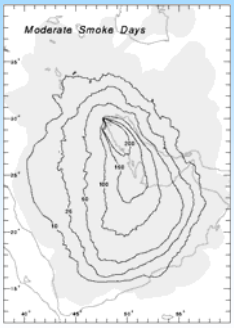





## Short term $SO_2$ impact


**For urban areas:**

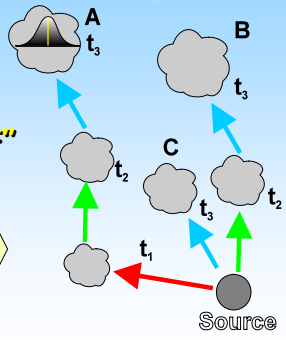



## Multiple source Gaussian models

**concentration distributions from a multiple of sources in a defined urban area**

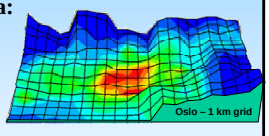
## Puff Trajectory Model "INPUF"

Puffs are transported by ever changing wind




## Numerical models

- **Hourly gridded input data:**
- **Emissions**
- **Meteorology**:
  - Wind field (u, v, w)
  - Temperature at ground level
  - Vertical temperature gradient (stability)
  - Mixing height
  - Turbulence ($\sigma_v$ and $\sigma_w$)




## Model input

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

## Emission Data Base

Geographical Information System (GIS)

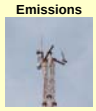
Calculation of Emission Fields → Modelling

| Industry | Traffic | Population | Consumption |
|---|---|---|---|
| • stacks<br>• process<br>• consumption<br>• component<br>• time variation | • road information<br>• road type/class<br>• vehicle class<br>• emission factors<br>• time variation | • distribution in sub areas<br>• area use | • fuel type<br>• emisson factors<br>• temp. variation<br>• time variation |



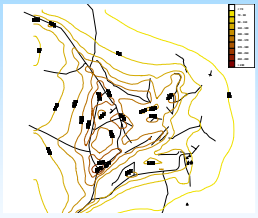
## Model test and verification


Emissions


Meteorology


Air Quality

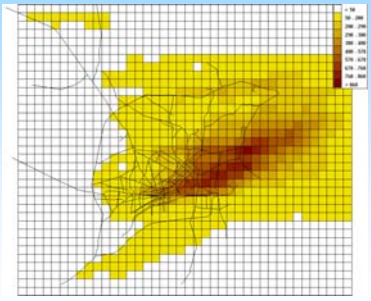
model test verification



Operational dispersion model



## The first test estimates, HCMC



Grid HCMC:
40 km x 35 km

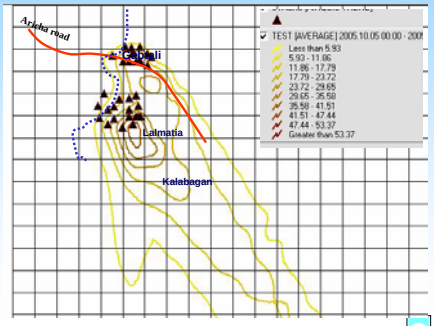
All vehicles, max hour 13-14 January 2005



## Dhaka Bangladesh Estimated 24-h concentration

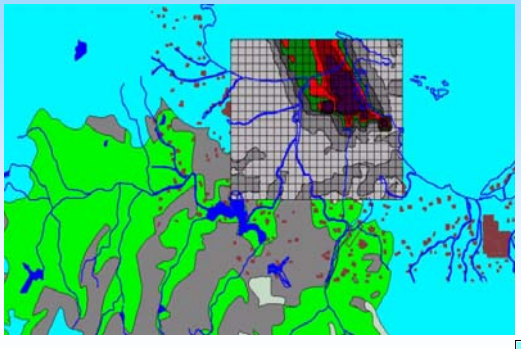
$SO_2$

33 stacks at brick factories north-east Dhaka





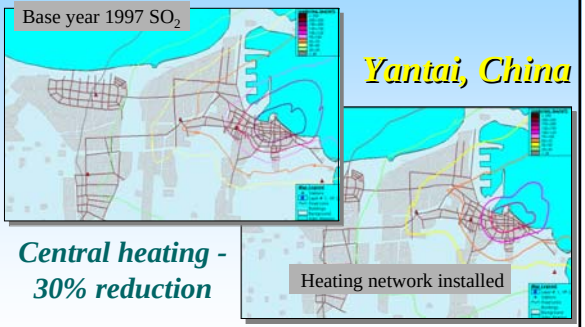

## Yantai, China





## AirQUIS Assessment

Base year 1997 $SO_2$



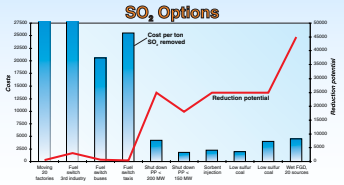

*Central heating - 30% reduction*

Heating network installed

## Guangzhou

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

Cost effective $SO_2$ options

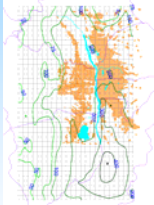




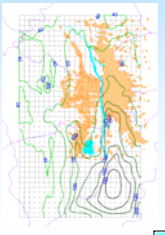

## Master Plan Air Pollution in Shanxi Province

中挪合作"山西省大气污染防治总体规划"

- Cost-benefit analysis
- Using AirQUIS in 3 cities
- Best cost-benefit control options:
  - District heating
  - Cleaning coal
  - Natural gas
  - Desulfuration
  - Shutdown and eliminate out-of-date processing technologies



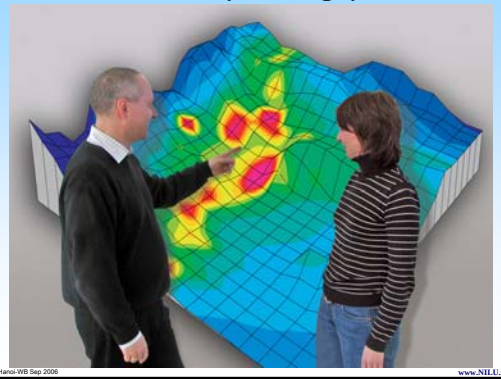
Predicted 2010 Taiyuan SO2 levels
预测的太原市2010年SO2污染水平



Taiyuan SO2 levels in 2010 (district heating applied)
采用集中供热措施后的太原2010年SO2污染水平

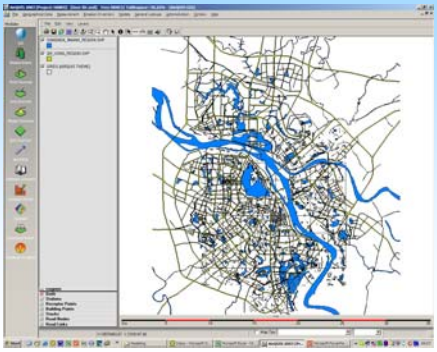


## Models used in planning processes





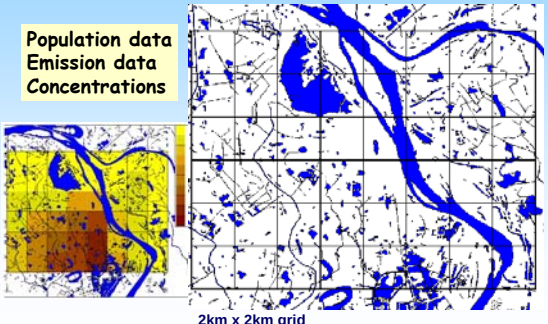
## Hanoi – GIS system for modelling





## Hanoi gridded information

Population data
Emission data
Concentrations

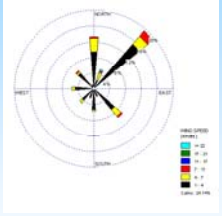


2km x 2km grid

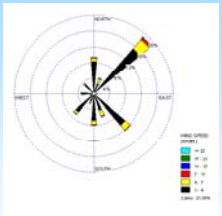


## Wind data for Hanoi

Wind roses Hanoi



September 2005

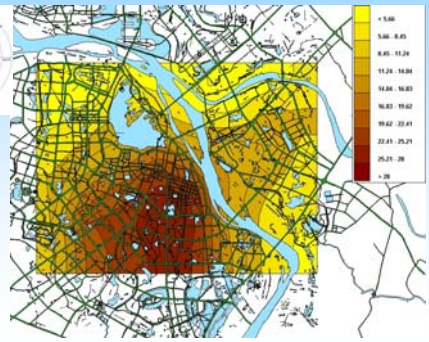


Annual wind

*from WMO database*

## Estimated NOx from petrol cars

wind direction frequency (windrose)

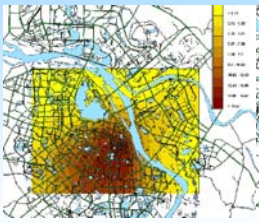


µg/m³



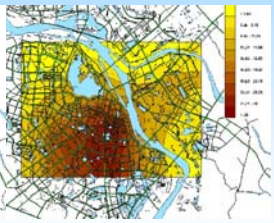
## Hanoi: Annual NOx conc (µg/m³)

4-stroke Motor cycles



Max 16 µg/m³

Petrol driven cars



Max: 28 µg/m³

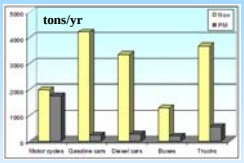


## Hanoi: model verification

| NOx concentrations (µg/m³) | | | |
|---|---|---|---|
| Site | Model estimate | Measured | |
| | Annual aver. | Average (yr) | Max (24-h.) |
| DONREH 1 | 22-30 | | |
| DONREH 2 | 60-70 | | |
| CEETIA | 70-90 | 33 | 90 |
| HydroMet | 60-80 | | |
| CTET | 25-30 | | |
| | | | |



## What are the sources for PM ??

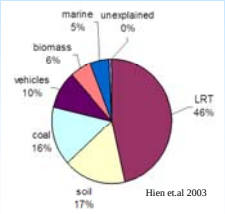



PM from combustion engines small ?

Measured $PM_{10}$ : 74 – 112 µg/m³

What are the sources?

Receptor models indicate:
- Only 10 % from vehicles
- 46 % from outside Hanoi
- 17 % soil
- 6 % biomass




Hien et.al 2003

*Has to be reflected in the emission data !*



## Further work is needed

- ✓ Improve input data
- ✓ Emissions from point sources
- ✓ Small industries and area sources?
- ✓ Better meteorology, Stability data?
- ✓ Emission factors for MC, cars, industries etc
- ✓ Complete emission inventory

AQM



## Thank you !

Modelling environmental friendly vehicles !

no engine
no pollution !

## Area source emission estimates

- Emission factors and activity data
  - E.g. fuel used, production rate
  - Population/ households/land use
- Surveys (measurement/ sampling)



## The success in urban scale modelling is in the description of the emission sources!

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2331 | 40 | 48 | 120 | 40 | 32 | 20 | 20 | 160 | |
| 2329 | 48 | 40 | 20 | 140 | 20 | 40 | 160 | 60 | |
| 2327 | 60 | 120 | 160 | 240 | 220 | 200 | 64 | 40 | |
| 2325 | 80 | 220 | 200 | 240 | 280 | 20 | 16 | 24 | |
| 2323 | 56 | 200 | 180 | 200 | 240 | 120 | 8 | | |
| 2321 | 40 | 100 | 200 | 180 | 200 | 120 | 60 | | |
| x | 580 | 582 | 584 | 586 | 588 | 590 | 592 | | |

Annual average daily traffic work (vehicle-km/day) in Hanoi



## Further work on emissions in Hanoi !

### Uncertainties for air quality dispersion modelling

- Total mass – lack of sources/ emission
- Geographical distribution (area distributed data)
- Temporal distribution
- Characteristics of pollutant (e.g $PM_{10}/PM_{2.5}$ )
- Physical parameters e.g stack height

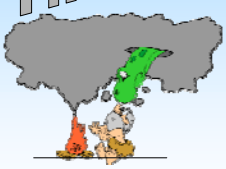


## Maintenance of emission inventory

- Need continuously updating and maintenance
- Continuously collect new data to present current state
- Improve the existing inventory



## Thank you !



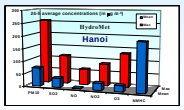
www.nilu.no

Norwegian Institute for Air Research

The World Bank

# Air Quality Management

## Understanding air pollution
## AQ Management and planning




*Bjarne Sivertsen, Norwegian Institute for Air Research* (NILU)

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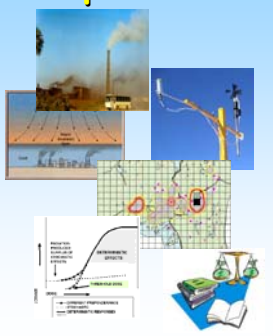
AQMS - a complete integrated analyses

# Impact Pathway Approach



- Identify sources Emission inventory
- Meteorological data Dispersion and turbulence
- Dispersion modelling SOx, NOx, PM
- Concentrations, Exposure
- Exposure/response functions
- Effect / cost data

Now !

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# The air quality in Hanoi

**Based on the selected air quality indicators:**

PROJECT CLEAN AIR

- $SO_2$ (Sulphur dioxide)
- $NO_2$ (Nitrogen dioxide)
- $PM_{10}$ (Particles with aerodynamic diameter < 10 micrometer)
- $O_3$ (Ozone)
- CO (Carbon monoxide)

www.NILU.no

# AQ Guidelines and standards

| Pollutant | Averaging Time | WHO (µg/m³) | TCVN-2005 (µg/m³) |
|---|---|---|---|
| $SO_2$ | Annual Avg. | 50 | 50 |
| | 24 Hours | 125 | 125 |
| | 1 Hour | 500 (10min) | - |
| CO | 8 Hours | 10 000 | 10 000 |
| | 1 Hour | 30 000 | 30 000 |
| $NO_2$ | Annual Avg. | 40 | 40 |
| | 24 Hours | - | - |
| | 1 Hour | 200 | 200 |
| $O_3$ | 8 Hours | 120 | 80 *(24 h)* |
| | 1 Hour | - | 120 |
| PM10 | Annual Avg. | 20 | 50 |
| | 24 Hours | 50 | 150 |
| Pb | Annual | 0.5 | |

LV

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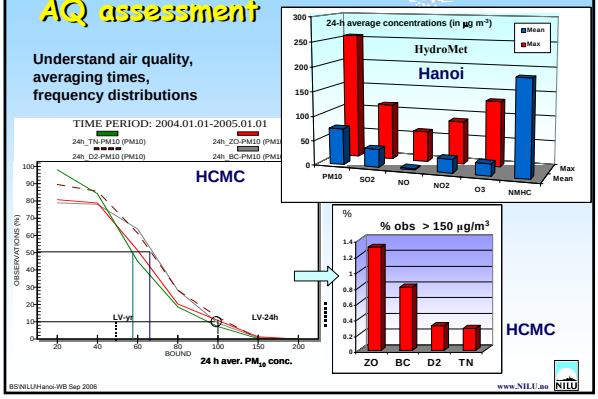
# AQ assessment

**Understand air quality, averaging times, frequency distributions**

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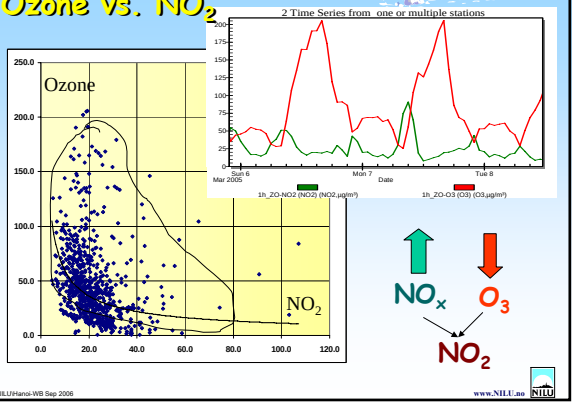
# Ozone vs. $NO_2$

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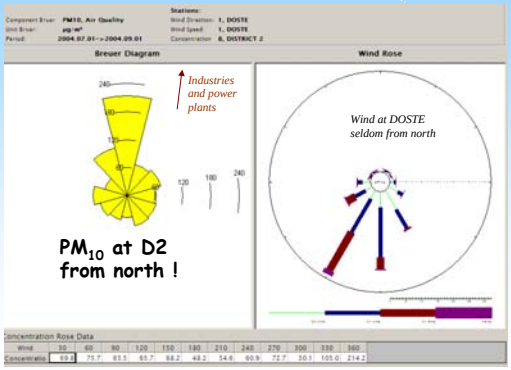
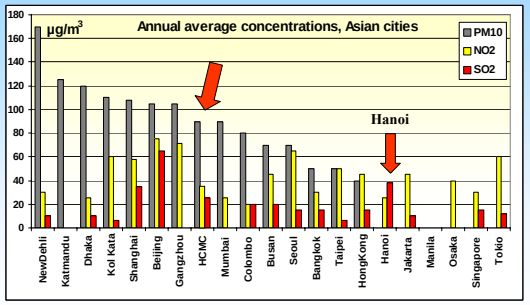
## Night time surface inversion

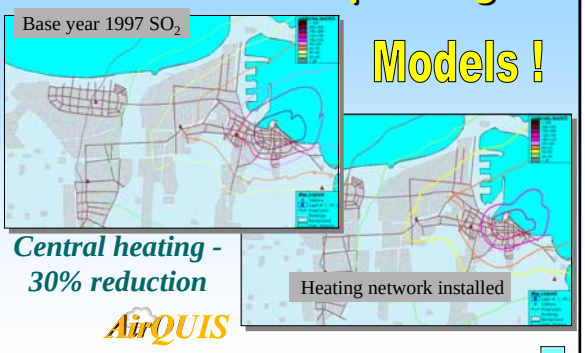

## Where does dust come from at D2 ?



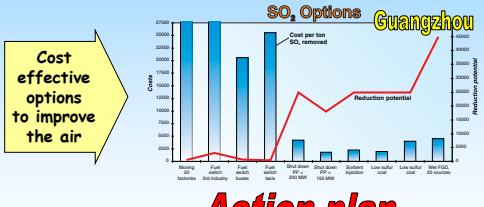

## HCMC compared to Asian cities



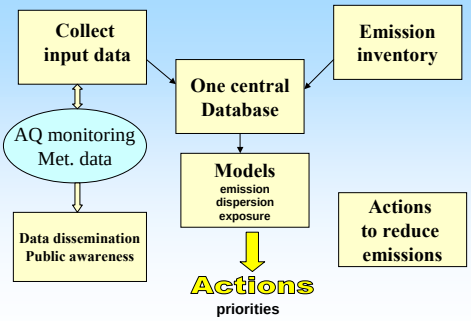

## Assessment and planning




## Optimal abatement and Air Quality planning for Hanoi




## A long way to go ?



## Immediate actions

- Improve the air quality monitoring programme
- Support siting of new stations
- Perform QA/QC upgrading & some training
- Specify instruments for monitoring stations
- Improve emission inventory
- Collect input data for modelling
- Introduction to modelling, training
- Estimate importance of sources



## Possible data sources

**CIDA, VICEP**

Some analyses of emission sources in Hanoi (report at DONREH)

**SIDA, AIRPET**

AIRPET programme has collected data on air quality (Dr Hoang Xuan Co)

**JICA**

A Master Plan is being implemented (Report of HAIDEP available?)

**Hanoi Transport Management and operation centre**

Traffic data (Dr Luu Xuan Hung)

**Swisscontact/Pechan and associates Inc.**

E.H. Pechan & Associates, Inc. presented project to assist the SVCAP. Status from Swisscontact.

**CEETIA**

Traffic data (number of vehicle, type...) have been collected in some streets, crossroads by CEETIA (Pro. Pham Ngoc Dang)

*need for co-ordination !*

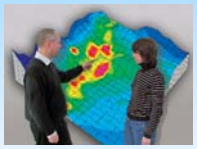


## Other sources in Hanoi ?

- Hanoi Industrial and Processing zone
- No power plants, cement factories, chemical industries, and smelters within Hanoi area.
- Stacks at pressure-furnace using Diesel Oil or Fuel Oil?
- DONREH has survey of about 200 industrial factories (Insufficient?)
- New questionnaires for industries needed?
- Small-scale industries limited database (get report 01C-09/08-2001-2).
- Open air waste burning not allowed in Hanoi.



## Training and institutional building



- ✓ Understanding air pollution
- ✓ Meteorology & dispersion
- ✓ QA/QC- operations
- ✓ Emission inventorying
- ✓ Modelling
- ✓ AQM and planning

Training needs assessment

- *Institutional building*
- *Seminars*
- *Workshops*
- *On-the-job traiining*
- *Visit NILU – AQM training programme*



## Future

Planning - training - working

skilled staff – organisation – co-ooperation




Thank you !
May I help ??



Norwegian Institute for Air Research

The World Bank

# Air Quality Management

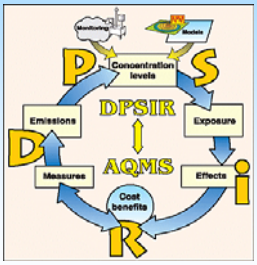
## AQM Hanoi future application
## Organising AQM in Hanoi

*The Nguyen Thanh*
*and Bjarne Sivertsen*

Norwegian Institute for
Air Research (NILU)



## Hanoi needs:
## Integrated air quality planning




**AQM**

**DPSIR**

**will have to be reflected in the institutional set-up**



## Applications of the AQM tools:

- **Environment impact assessment**
- **Air Quality management**
- **A.Q. forecasting and early warning**
- **Optimal abatement strategies**
- **A.Q. information systems**

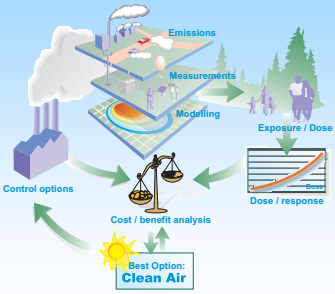
**to be achieved by several institutions Co-operation required !**



## A systematic integrated planning tool

**Action plans to improve air quality**

**Require input from many stakeholders !**




**most cost-effective options**



## On-line information on Web




## Tasks and obligations

- **Assess the present air pollution situation,**
- **Compare to standards and guidelines / trend analyses.**
- **Develop control options / potential control strategies**
- **Analyse the effect of control options and their cost-effectiveness or cost-benefit ratios.**
- **Select control strategies for short/medium/long term, and enforce them.**
- **Disseminate AQ information and prepare Internet applications**
- **Information to the public and policy makers including on-line presentations.**

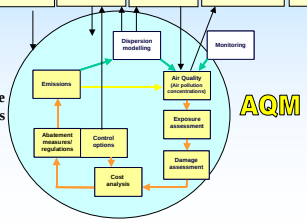
## AQM, an integrated process

Ministry

Overall strategy/ policy formulation

Basis for AQM policies

Tasks: AQM admin | Directives regulations | Control strategy | AQ monitoring | Information dissemination | Enforcement




The elements

AQM



## AQM organisation in HCMC

People Committee

DONRE
Dep of Natural Resources and Environment

HEPA
HCMC Environmental Protection Agency

EQMA
Division of Environm. Quality, Monit and Assessm

Env. Inspection Division

- Head of Division; Mr Dam
- Operation and instruments; Mr Tuan and Mr Dung
- Data and reporting; Mr. Huy and Mr Duc
- Emission inventory and modelling; Ms Hang and Mr Dam



## Hanoi DONREH as co-ordinator

AQM component: Upgrade Hanoi's capacity in air pollution control and air quality improvement

DONREH will also develop a Master Plan for Air Quality Management in Hanoi.

Strengthen project management capacity at DONREH

Need of a strong Steering committee of stakeholders



## Partners of the "Policy Reform" component

| Topic | Partners (I: Implementation, R: Resource) | Role of implementation partner |
|---|---|---|
| National Program on Vehicle Emission Reductions (NPVER) | I: MOT/VR<br>R: Nat. & int. consultants | Responsible organization for definition and implementation of NPVER. Lobbyist for and facilitator of inter-departmental working groups and multi-stakeholder consultations. |
| Clean Air legislation on national level | I: MONRE/DOE<br>R: Nat. & int. consultants | Responsible organization for drafting/proposing clean air legislation.<br>Facilitator of inter-departmental and multi-stakeholder discussions. |
| Air Quality Management (AQM) plan for Hanoi | I: HPC/Hanoi DONREH<br>R: Nat. & int. consultants, various research institutes, HCMC DONREH | Responsible organization for drafting/proposing AQM plan for Hanoi.<br>Facilitator of inter-departmental AQM working group and multi-stakeholder discussions. |

*From: Swiss-Vietnamese Clean Air Program*



## Relevant organisations

| Organization | Function | Tasks | Mandated by |
|---|---|---|---|
| Vietnam Environmental Protection Agency (VEPA) | Inspection and supervison | Inspection and supervison of legislation and regulations | MoNRE |
| Centre for Environmental Monitoring, Data and Information (CEMDI) | Information and data management | Environmental monitoring, data management, data producer | MoNRE/VEPA |
| Hanoi Department of Natural Resources, Environment and Housing (Hanoi DONREH) | Environmental management at city level | Data management, data producer | Hanoi People Committee |
| Centre for Environmental Engineering of Towns and Industrial Areas (CEETIA) | Research unit of Hanoi University of Civil Engineering | Data producer | MoNRE/VEPA |
| Institute for Environmental Science and Technology (INEST) | Research unit of Hanoi University of Technology | Data producer | MoNRE/VEPA |
| Centre for Environmental Technology Treatment (CTET) | Research | Data producer | MoNRE/VEPA |
| National Centre for Hydro-Meteorology | Survey and forecast of meteo-hydrology, environmental monitoring | Weather forecast, data producer | MoNRE |

From SVCAP Phase I



## People Committee Decisions

**DONREH** key stakeholder
(Decision No.101/2003/QDU, August 2003).

Establishment of **CENMA**
(Decision 158/2005/QD-UB) .

**Steering Committee**
(2370/QD-UBND, May 22, 2006).

*We will have to identify other agencies that should cooperate with DONREH*

## Organisation of AQM in Hanoi

People Committee Hanoi

MONRE VEPA

DONREH
AQM, reporting data dissemination

Steering Committee Environment

Transport
Health
Vietnam Register
HydroMet
Universities
District PC

CENMA
Emission inventories Dispersion modelling

Data from stations QA/QC

Ministry of Natural Resources and Environment (MONRE).
Department of Natural Resources, Environment and Housing (DONREH)



## Organisation of AQM in Hanoi

City level | National level

Control
Strategy
Monitoring
Enforcement
Information

People Committee Hanoi

DONREH

CENMA

Environment Managem Div.

Monitoring | Emissions | Modelling | Reporting

Data dissemination

Directives and Regulations

MONRE VEPA



## Personnel required

- ✓ Project manager
- ✓ QA/QC officer
- ✓ Computer expert on the local data retrieval computer
- ✓ Electronic engineer
- ✓ Chemist/physicist
- ✓ Technicians to support in field operations and calibrations



## AQM Steering commitee

### Main duties

- ✓ Review the work accomplished
- ✓ Assess the project's effectiveness and efficiency
- ✓ Approve Project Document
- ✓ Evaluate expected outputs relative to budget
- ✓ Approve the annual plans
- ✓ Give guidance for project implementation
- ✓ Ensure the policy dialogue with other Ministries and Agencies

### High-level representatives from Vietnamese stakeholders :

- Hanoi People's Committee
- Ministry of Planning and Investment
- Ministry of Transport
- Ministry of Industry
- Ministry of Construction
- Ministry of Finance
- Ministry of Environment



## Project co-ordination needed

- **Worldbank/GEF** (Hanoi Urban Transport Development Project),
- **European initiatives** in Hanoi (focus public transport),
- **JICA projects**
- **Vietnam Cleaner Production Centre** (focus industry),
- **CAI-Asia / US-AEP** (focus regional exchange and standards tightening)
- **Swiss projects** in the environmental field (institutional building)
- **NORAD** (support AQM system ?)




A strong organistaion with good co-operation

clean the air and make people happy !

Thank you !