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# Integrated approaches using local air quality assessment in GHG abatement strategies

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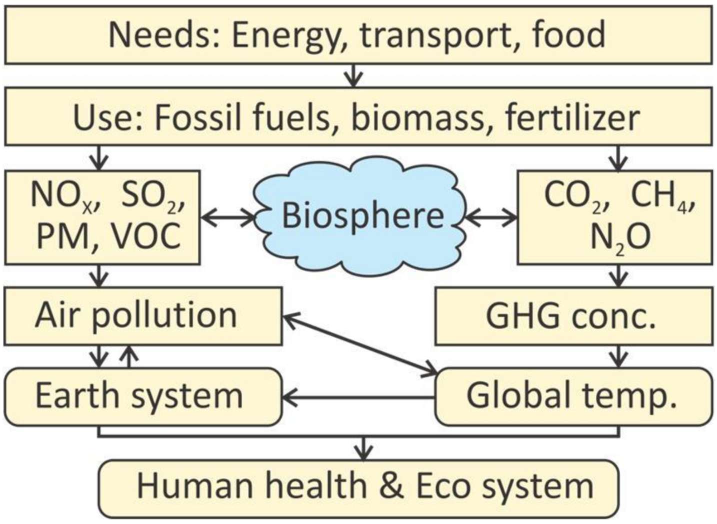


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# Integrated approaches using local air quality assessment in GHG abatement strategies

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*The development of an integrated Implementation plan for improving local air quality and, at the same time, reduce green house gas (GHG) emissions requires development of a unique plan with participation from all levels of society and stakeholders. These implementation plans contain an extensive list of elements, such as pollutants to be addressed, emission inventories, monitoring network, air quality analysis, model results, exposure risk assessment, attainment strategy demonstrations, regulations, and enforcement mechanisms.*

*NILU has developed and applied tools for air quality management planning on a local and regional scale, focusing mainly on possible health impacts. The system combines monitoring, data presentation, modelling and scenario assessment in one package. It also includes a module for emission inventorying, which enable to connect fuel consumption, energy use and industrial processes with emission rates of both air pollutants and green house gases.*

*Systems have been applied in several cities and the planning tool enable the user not only to present and evaluate the present situation, but also to undertake abatement planning including both local impacts and climate change issues.*

*Examples is presented for co-control and co-benefit approaches in cities in Norway and Asia. An analysis of alternative scenarios for the reduction of air pollution in Oslo Norway included an evaluation of GHG emissions. The results of these impact scenarios for several cities are presented.*

## 1 Introduction

The issue of co-benefits is on global scale often raised from the point of view of arguing for greater total benefits from climate change policies (Burtraw et al 2003). The matter has been treated by the European Environmental Agency (EEA, 2006) and by the Intergovernmental Panel on Climate Change (IPCC, 2007). Nemet and co-authors (2010) comprehensively review studies that look at co-benefits of climate change mitigation, pointing out that there are important benefits, but also important barriers for the inclusion of air quality in climate policies.

Empirical studies are looking into the links between climate change and urban air quality for specific locations and areas. On the side of effects, a recent review by Ebi and McGregor (Ebi and McGregor, 2008) summarizes research on health impacts related to ozone, particulate matter and health impacts, while Dietz and Atkinson (2010) are looking into acceptance of practical policy implementations, considering issues such as how difference in temporal and regional scale of climate change and air quality affect individual preferences.

United Kingdom (UK) Department of Environment, Food and Rural Affairs (DEFRA, 2010) provides a comprehensive and practical overview of UK climate and air quality commitments, benefits of combining both policies (targeting mainly the transport and energy sectors, but also agriculture sectors), and gives examples of local policies formulated with both political agendas in mind.

GHG abatement measures, such as changes in technologies to produce and consume energy, can also improve air quality by reducing emissions of pollutants including nitrogen oxides, sulphur dioxide, particulate matter and mercury. This can lead to substantial public health benefits. Even though the air quality co-benefits of climate change actions are well established, climate change policies do not typically account for them. Instead, the focus is on minimising the cost of climate change actions. Co-control studies were part of the scenarios investigated for air pollution mitigation in Norway (Sivertsen, 2008). NILU also was planning projects related to co-control and co-benefit issues in China (Sivertsen and Bartonova, 2010).

Incremental health benefits are larger when the starting levels of air pollution are high. Therefore as pollution emission reductions become more stringent, air quality co-benefits become less significant. The greatest air quality co-benefits were found in developing countries with high levels of air pollution. Even small reductions there are likely to have large health benefits. This implies that the most important time to include air quality co-benefits in long-term climate change strategies is at the beginning, particularly for developing countries without major air quality initiatives.

## 2 Top-down to bottom-up emission inventories

The most important input to any co-control study is an appropriate emission inventory. The approach that NILU is now applying is a combination of a simplified top-down emission inventory and a more detailed bottom-up inventory. The latter one is GIS based and represents the input for modelling exposure and local health impacts.

Emissions inventories often become a continuous work as the emission data need frequently to be updated. Many cities in Asia have started to prepare the basic input for air quality management planning and have needed to start collecting source information and prepare the emission data for modelling purposes.

As a starting point simpler top-down emission information has been used to identify sources and source areas. A first estimate using a top-down approach has been undertaken for $CO_2$ emissions based on the GAINS model (Greenhouse Gas -Air Pollution Interactions and Synergies). This model was developed by International Institute for Applied Systems Analysis (IIASA). It considers greenhouse gas emission rates and the associated value per ton of $CO_2$ equivalence. Historic emissions of air pollutants and GHGs are estimated for each country or mega city based on information collected by available international emission inventories and on national information supplied by individual countries.

The top-down emission inventory may be given by sector and represents a first look at the total emissions in the given area. In order to estimate local impacts, concentration distributions and population exposures a more detailed GIS based emission inventory is needed. NILU has based this on the NILU developed AirQUIS system, where source data and consumption/production data are collected in Excel based templates. (AirQUIS 2007).

Information concerning detailed bottom-up emission inventories have been available from various land use maps of the area, population distribution maps, statistic year books or energy consumption statistics. Sources have been divided into point-, line- and area sources, designed for modelling purposes. These approaches have been applied by NILU in several cities in Asia such as e.g. Hochiminh, Vietnam; Ulaanbaatar, Mongolia, Shanxi, China and Abu Dhabi UAE. NILU is presently working on similar studies in Dhaka, Bangladesh as shown below.

# 3 The NILU planning tool

The AirQUIS planning tool has been developed by NILU to handle a number of air pollution tasks and challenges. It is based on a GIS platform and includes monitoring data, emission inventory tools and models. The main objective has been to enable direct data and information transfer to perform user friendly emission data collections and to enable impact assessment using dispersion and exposure models.

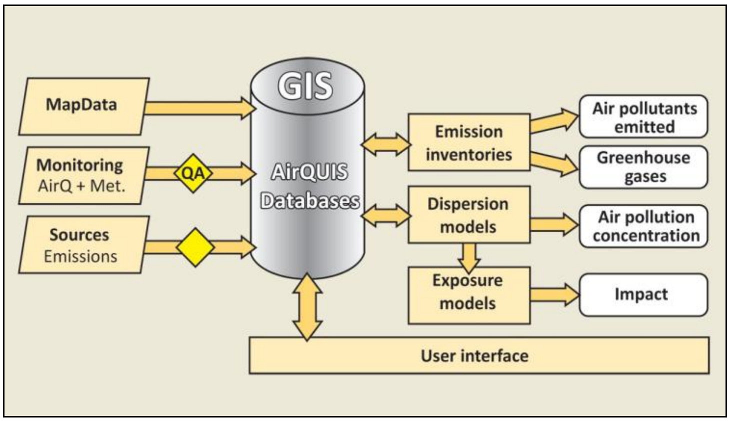


*Figure 1: The NILU developed air quality planning tool; AirQUIS used in co-control studies.*

The system combines all these issues in one package. The module for emission inventorying enables to connect fuel consumption, energy use and industrial processes with emission rates. The system can estimate classical air pollutants as well as greenhouse gas emissions.

The planning tool makes it possible for the user not only to present and evaluate the present situation, but also to undertake environmental planning for a sustainable future both when local impacts and health effects are concerned and when GHG emissions are to be evaluated. The GIS platform, on which the system is operated, provides easy access to the data and gives a perfect and easily understandable data presentation tool.

# 4 Co-control approach in Oslo, Norway

## 4.1 Scenarios Oslo

Studies have been performed in Oslo in order to evaluate the exposure to people for alternative scenarios identified in order to reduce the air pollution impacts. The most important source to air pollutants in Oslo is road traffic. This is also an important source for greenhouse gas emissions. The transport sector represented the largest increase in greenhouse gas emissions, both nationally and internationally. More cars on the road leading more congestion and poor accessibility, and hence more emissions per car per km run. Emissions are greater for heavier than lighter vehicles, especially when driving slowly.

In 2008 the air pollution authorities were commissioned by the Ministry of Environment to create an action plan for local air quality. The plan was to propose measures that were necessary to achieve the national goals. A first draft was prepared in 2008 (Tønnesen and Sundvor 2008).

The basis for this work was that the concentrations at several monitoring stations exceeded the limits for $PM_{10}$. Exhaust emissions from cars, re-suspended dust from the streets as well as wood burning were the main sources of $PM_{10}$, while the road traffic was the main source for $NO_2$.

Based on a complete emission inventory for Oslo, models were applied to estimate emissions of pollutants as well as emissions of $CO_2$. The model shows that private households (including heating with wood and fossil fuels) accounts for around 50% of emissions of particulate matter $PM_{10}$. Road traffic is responsible for 20% of the total $PM_{10}$ emissions and about 55% of the NOx emissions in Oslo.

The bottom-up emission inventory developed for air pollutants and aimed at evaluating the impact of pollution reductions on the local scale, was further applied to estimate the $CO_2$ emissions in Oslo. $CO_2$ from traffic is shown along the road system in Figure 2.

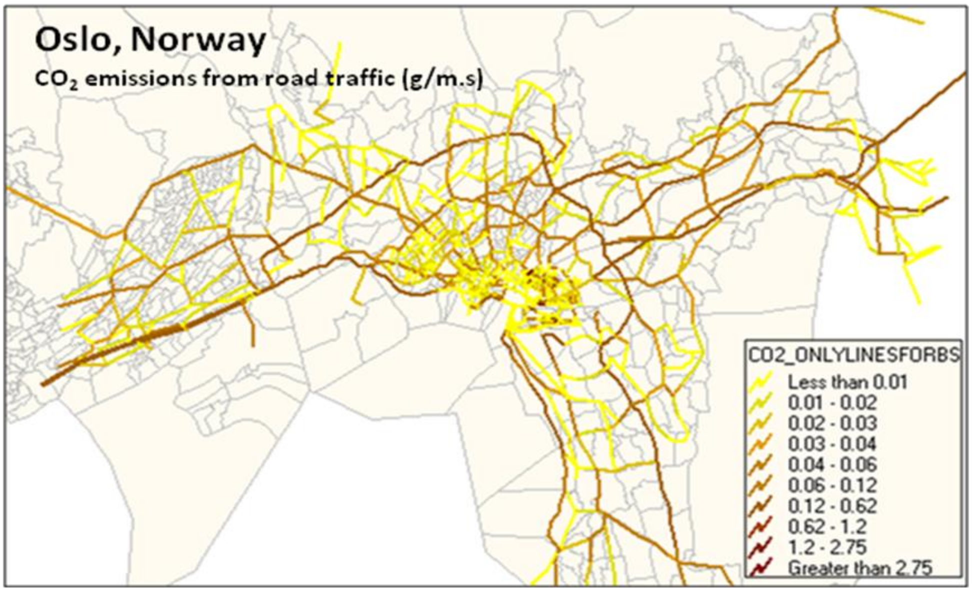


*Figure 2: CO2 emissions along the road system in Oslo given as g/m.s.*

These estimates have been used to integrate the emissions of $CO_2$ from Oslo. The results indicated that an area of maximum $CO_2$ emission over Oslo could create a “local” $CO_2$ concentration which is up to 15 % of the background $CO_2$ concentrations.

Several actions were included in the evaluation of an optimal abatement strategy for Oslo (Dalen and Amundsen, 2010). The possible actions and measures may be divided into 5 classes. For all these action estimates were performed in order to evaluate the local impact. Considerations were also discussed concerning the potential $CO_2$ emission reductions based on the baseline emission estimate for $CO_2$ emissions in Oslo. A summary of the final evaluation is presented in Table 2 below.

*Table 2: The results of various actions planned in order to reduce the impact of the emissions NO2, PM10 and CO2 in Oslo.*

| | Actions | $NO_2$ | $PM_{10}$ | $CO_2$ | Comments |
|---|---|---|---|---|---|
| **Traffic actions** | Prices, parking, public transport, mobility | ++ | ++ | ++ | Reduce car-km driven in Oslo |
| | Mobility planning | + | + | + | Long term policies |
| **Vehicles** | Non studded tires | 0 | ++ | 0 | Dust reductions, no CO2 effects |
| | Low emission zones | ++ | ++ | ++ | Immediate effects |
| | Eco driving | + | + | + | Long term effects |
| | Ban idling | + | + | + | Effect on CO emissions. |
| | Electric cars public transp | + | + | + | Long term |
| **Roads** | Speed limit reductions | 0 | ++ | 0 | Immediate effects. |
| | Road cleaning | 0 | ++ | 0 | Immediate effects. |
| | Reduce tunnel emissions | + | ++ | 0 | Clean road tunnel emisisons |
| **Wood burning** | Cleaner stoves | 0 | ++ | + | Long term effects. |
| **Harbour emissions** | Reduce ship emissions, change fuels | ++ | + | ++ | Immediate effects, also SO2 reduced. |

There are considerable co-benefits in implementing traffic actions in Oslo, which will reduce the number of kilometres driven. Also the introduction of low emission zones and measures for reducing ship emissions in the harbour of Oslo will give effects both on the local scale and on climate change issues.

## 5 Action plan based on cost-benefit for Shanxi, China

A cost benefit analyses was performed for a number of mitigation actions in three cities in the Shanxi province China. The usual bottom-up emission inventories were prepared and concentration distributions for $SO_2$ and PM were produced for a base-case year 2000 and a number of control scenarios planned for the year 2015 (Zhang et.al 2009).

Comparisons of cost-benefits were performed for various identified control actions in order to reduce the exposure and health impacts in three cities in the province. The project was implemented through the cooperation between Chinese and Norwegian experts in order to develop a "Master Plan against Air Pollution in Shanxi Province" (Shanxi, 2005).

The modelling exercise conducted through the Sino-Norwegian project provides a unique opportunity to understand impacts of city level pollution abatement tools in one of China's most energy intensive cities. The cost-benefit analysis is quite unique given that the health economics approaches are relevant in order to evaluating the cost/benefit of interventions. Despite the sparse, inconsistent, and sometimes questionable nature of the Chinese health data, the study has been successful in finding alternative data sources and comparing data with other international databases (Larssen ed., 2001).

The studies in Shanxi have shown that there are actions where the cost of implementing these actions are less than the cost-estimated benefits gain in improved health effects in the population.
A brief summary of the final results from one city, Taiyuan, is shown for $SO_2$ in Figure 2.

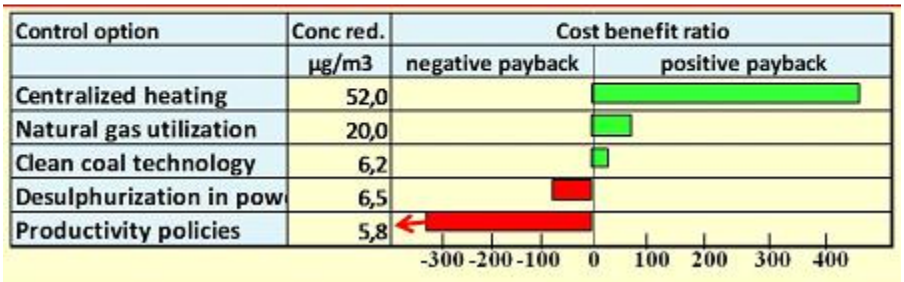


*Figure 2: Cost benefit ratios shown for five control options implemented in order to reduce the $SO_2$ concentrations in Taiyuan, Shanxi China.*

As demonstrated in Figure 2 the cost-benefit of various control options demonstrated that some of the actions actually gave a positive payback. This meant that the cost of implementing the actions were less that the monetary benefit caused by the reduced health impact.

For Taiyuan the most cost effective action in order to reduce the exposure and impact of $SO_2$ emissions (Figure 2) were the introduction of centralized heating. The cost of this action was much less than the value of the health benefits in this city.

The scenario-based and pollution sources-oriented health benefit evaluation based on bottom-up emission approaches in the city of Taiyuan in the Shanxi province have proven very useful. Even though selection of optimal control scenarios for Taiyuan requires further cost-benefit analysis, this study does provide decision makers with evidence about not only the significance of control that prevent environmental pollution, but also provides an indications of what measures are most effective.

This study did not include the co-control options and an evaluation of greenhouse gas emissions. Following this study a plan was developed for a co-control project for China in co-operation with several institutions in Norway and in China. This project has still not been financed.

# 6 Integrated assessment for Dhaka Bangladesh

A new project, the Bangladesh Air Pollution Management Project (BAPMAN) was initiated in August 2010. The project will be undertaken in co-operation between NILU and Department of Environment in Dhaka. The main objective is to build up the cross-institutional capability for development of an effective and sustainable air quality management programme in Bangladesh. The purpose is further to develop the technical, institutional and environmental research expertise necessary for effective and sustainable air pollution management in Bangladesh (Sivertsen et.al, 2010). The project includes emission inventories both based on top-down approaches as well as bottom-up approaches.

## 6.1 Top-down estimates

'Top-down' estimate of total emissions using gross statistical data and available emission factors to identify most of the local air emissions. Data collection and gap identification will be facilitated by contact with local and national traffic and statistical authorities. Emission source classification (necessary for policy) will be according to that specified by other Bangladesh authorities, if available.

A first estimate using a top-down approach has been undertaken for GHG emissions in Dhaka based on the GAINS Asia model and data from year 2010. In addition to PM, $SO_2$, $NO_X$ and other components, it considers GHG emission rates and the associated value per ton of $CO_2$ equivalence.. The GAINS model assesses emissions on a medium-term time horizon, emission projections are specified in five year intervals from 1990-2030.

Summary results for year 2010 in Dhaka are presented in Figure 3, where the GAINS model indicates that most of the GHGs (in $CO_2$ equivalents per year) are originating from industrial sources and from agriculture and power plants. As seen from these first top-down emission estimates the traffic in Dhaka only represents about 5% of the total GHG emissions. It is believed that this might be strongly under-estimated (Randall and Sivertsen, 2010).

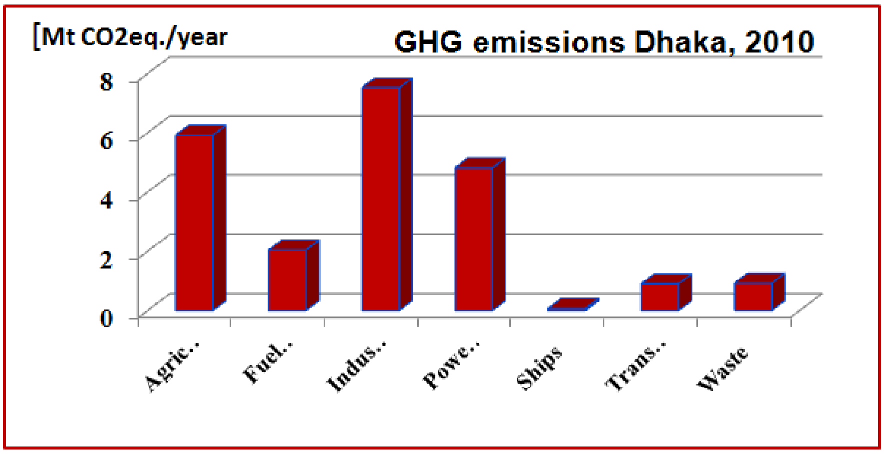


*Figure 3: Estimated GHG emission rates ($CO_2$ equiv. per year) for Dhaka Bangladesh, 2010, based on the top-down GAINS model.*

The GAINS model is best utilized to identify the general controls and related costs of these measures to reduce GHGs and local air pollutants concurrently, this first screening step is being conducted for Dhaka (Randall and Sivertsen, 2010), and NILU is presently collecting input data in order to perform a more detailed bottom-up emission inventory for Dhaka through the BAPMAN project.

### 6.2 Detailed 'bottom-up' emissions inventory.

Detailed type/location emission survey is necessary for dispersion modelling and planning of air pollution improvements. The GIS based inventory software integrated in AirQUIS (AirQUIS, 2007) contains the necessary forms and functionalities for producing a complete emissions inventory.

The basic collection of input data requires completion of templates for point sources (individual outlets), line sources (vehicle emissions from road links), and area sources (smaller or diffuse sources, e.g. home cooking, open burning, small industry). Templates have been supplied to local experts. Further information for their completion will be part of the training and the most important industrial source information will be collected using questionnaires.

Combining the top-down emission inventory with the more detailed GIS based bottom-up inventory will then enable analyses of local, regional as well as global impacts of mitigation scenarios.

# 7 A co-control issue for China

## 7.1 Integrates assessment for China

A new project is being proposed for China in collaboration between Norwegian institutions and Chinese experts, developing a programme for co-control. The project places a strong emphasis on assisting Chinese institutions in building technical capacity and expertise, specifically on the co-control of air quality, energy and climate change. In this way it will be easier for China to reduce local air pollution and contribute to greenhouse gas reductions. This is fully in line with Norwegian priorities for development cooperation, which has climate change and environmental protection as its cornerstones.

The project will be handled as an integrated approach assessing the needs for energy leading to the use of fossil fuels and biomass, which again will lead to air pollution and greenhouse gas emissions. Interactions between mitigation measures implemented on a local scale with action undertaken in order to reduce climate change issues will be an integrated part of the analyses.

It is foreseen that the possible actions will include structural changes which in many cases may prove to be better than the classical end-of-pipe solutions. We will evaluate the impact on all scales of e.g:

- Moving from fossil fuels to renewable
- Energy efficiency improvements
- Energy savings
- Improvement of housing: construction and heating/cooling
- From individual to public transport
- From road (and air) to rail

The interactive impact of emissions of pollutants and greenhouse gases into the atmosphere, acting on the biosphere, changing the global temperature again acting on the earth system and influencing at the end on the human health and on the ecosystem is visualised in Figure 4.

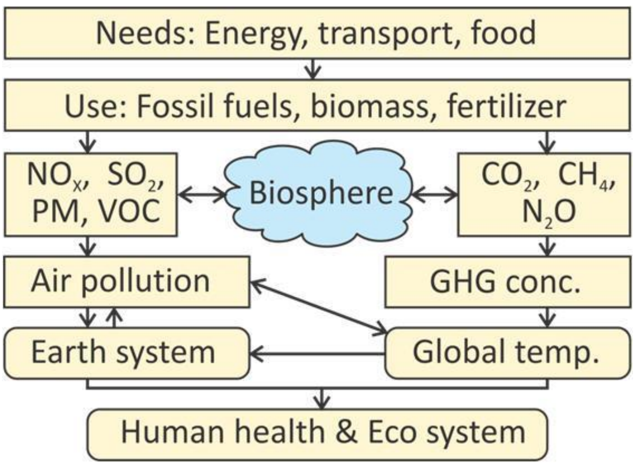


*Figure 4: From needs to impact*

### 7.2 Challenges in co-control approaches for China

The control of air pollution and emissions of greenhouse gases (GHG) according to co-control principles should be guided by national policy guidelines and regulations. However, local conditions and the local situation regarding the main economic sectors and their environmental impact will influence the process of control implementation according to co-control principles. Depending on which sectors dominate emissions and exposures in the particular area and what are the costs and benefits, the resulting ranking and recommendations will differ. Moreover, demonstration at the concrete level will educate and provide stimuli for scaling up

There are two institutional obstacles to implementing co-control policies: horizontal coordination and vertical coordination. Currently in China the Ministry of Environmental Protection of China (MEP) is responsible for environmental targets and environmental policy, for instance air quality targets and policies to reach those. The National Development and Reform Commission (NDRC) is responsible for energy and climate change targets and for energy policy, and has the main responsibility for carbon policy. Other ministries have overlapping responsibilities, for instance the Ministry of Science and Technology, Ministry of Construction and Ministry of Agriculture etc. The result is a fragmented pattern of responsibility, which is repeated at the provincial and local levels. Co-control policy is likely to suffer from the fragmentation since co-control requires coordination and a certain degree of centralisation to be implemented efficiently.

Another problem is that the provincial level might have independent views and agendas that sometimes are less environmentally inclined than the national level. Central government policy may or may not be implemented well, depending on the central-local relationship. There is also an institutional problem of energy and environmental monitoring. There are more than a thousand environmental monitoring stations, but the system is very fragmented. All of the local stations belong to their local governments and there is a lack of coordination with other networks.

## 8 Challenges and needs for further developments

Clearly, an integrated approach to development of measures leading to fulfilment of climate change and air pollution policies will provide benefits on local and global scale, and in short as well as long term horizon. A number of emission reduction options for GHG have co-benefits for air pollution, and a number of air pollution combating measures also provide significant climate change related benefits. It is important to identify those measures and their combinations that lead to a win-win situation, but due to the complexity of the issues involved, this task is not a simple one. Efficient tools that would help in this endeavour already exist.

Further development is needed in order to continue the work related to integrated assessment, co-benefit studies and co-ordination of climate change and local air pollution issues. Some of these issues are:

- Exposure-response on human health
- Local and regional influence of aerosols on climate forcing and weather patterns
- Development and application of combined integrated assessment at various scales

This integrated approach will require competence on:

- Emission inventories, air quality and atmospheric science
- Climate and pollution policies
- Integrated assessment modelling, including cost effectiveness / optimisation of abatement measures

Institutional building will be important, but also the policy consistency between economic, energy and environmental targets needs to develop in order to improve environmental management and allow for more success in achieving air emissions/air quality, $CO_2$ and energy efficiency objectives. It is important to tailor co-control policies to the actual situation. Hence one needs to formulate and analyse co-control policies based on a review of current policies and institutional characteristics as well as international best practice.

The issues presented in this paper are important issues in order to improve the tools for integrated assessments, and this work will continue in Norway and elsewhere.

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# Integrated approaches

## Local air quality assessment and GHG abatement strategies

*Bjarne Sivertsen*
*Norwegian Institute for Air Research*

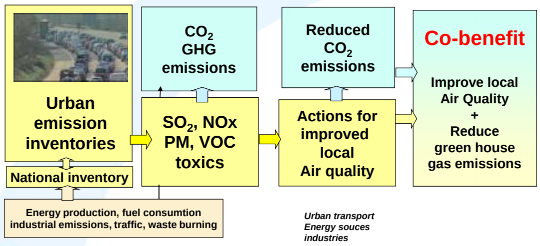
BAQ 2010, Singapore November 2010



# Co-benefit/co-control

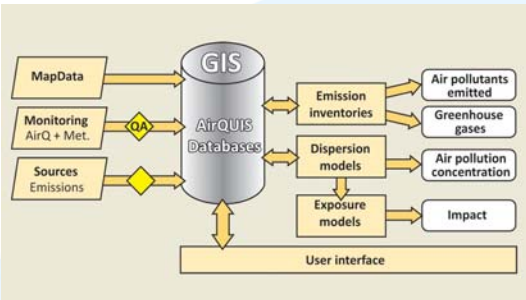
Integrated assessment

## Urban Air Quality Planning + Green house gas reductions





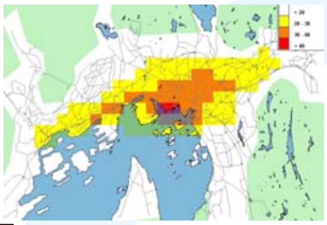

# The NILU planning tool




***Enable integrated planning !***



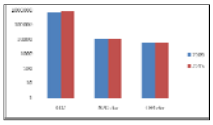
# Scenarios Oslo, Norway



Area exceeding limit values for $NO_2$, basic year 2015

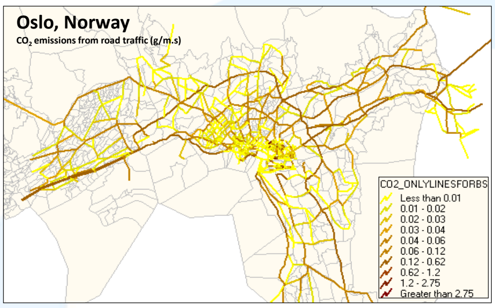
**Evaluated the exposure to people for alternative scenarios identified in order to reduce the air pollution impacts. GHG emissions Included !**

Estimated $CO_2$ equivalents tons per year; 2009 & 2015





# $CO_2$ emissions from traffic




Annual emissions Oslo: 1,5 mill tons CO2 (= 175 tons/hr)

*Estimated for model area 750 000 tons*



# $CO_2$ contribution from traffic emissions


**Background $CO_2$ = 380 ppm**

## Effects of actions in Oslo, Norway

| | Actions | $NO_2$ | $PM_{10}$ | $CO_2$ | Comments |
|---|---|---|---|---|---|
| Traffic actions | Prices, parking, public transport, mobility | ++ | ++ | ++ | Reduce car-km driven in Oslo |
| | Mobility planning | + | + | + | Long term policies |
| Vehicles | Non studded tires | 0 | ++ | 0 | Dust reductions, no CO2 effects |
| | Low emission zones | ++ | ++ | ++ | Immediate effects |
| | Eco driving | + | + | + | Long term effects |
| | Ban idling | + | + | + | Effect on CO emissions. |
| | Electric cars  public transp | + | + | + | Long term |
| Roads | Speed limit reductions | 0 | ++ | 0 | Immediate effects. |
| | Road cleaning | 0 | ++ | 0 | Immediate effects. |
| | Reduce tunnel emissions | + | ++ | 0 | Clean road tunnel emisisons |
| Wood burning | Cleaner stoves | 0 | ++ | + | Long term effects. |
| Harbour emissions | Reduce ship emissions, change fuels | ++ | + | ++ | Immediate effects, also SO2 reduced. |

*Positive effect = reduced impact*

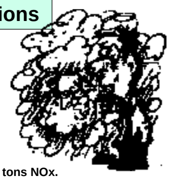
NILU

For the benefit of climate change:

## From fossil fuels to Bio fuel

Reduce: $CO_2$ : and GHG
$SO_2$ : Sulphur emissions

Increased: PM
PAH
NOx
VOCs



Bio fuel based power plant Finland emits annually 440 tons NOx.
Gas power plant at Kårstø Norway emits annually 150 tons NOx.
Same size (400 MW), and both are equipped with cleaning device

Norway: Bio fuels instead of fuel oil reduces electricity consumption only 3-4 %

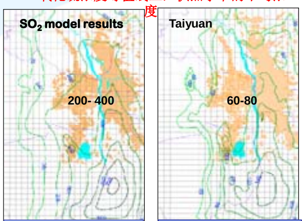
NILU

## 山西省， 以及项目重点执行城市
## Shanxi Province, action plan

3个项目执行重点城市:
太原， 大同， 阳泉

The project included 3 pilot cities:
**Taiyuan, Datong** and **Yangquan.**

$SO_2$ concentrations, heating season
二氧化硫浓度等值线土，供热季节的平均浓度




基准年２０００
Base-case 2000

实行全部的减排措施后
目标年２０１５年
2015 w/ full set of control scenarios

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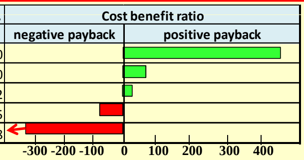
BAQ Singapore 2010

## 费用效益分析
## Cost benefit analysis

不同针对$SO_2$和TSP的控制方案费用效益分析列表比较（太原）
A comparison of cost-benefit of various control options for $SO_2$ in Taiyuan

| Control option | Conc red. µg/m3 |
|---|---|
| Centralized heating | 52,0 |
| Natural gas utilization | 20,0 |
| Clean coal technology | 6,2 |
| Desulphurization in pow | 6,5 |
| Productivity policies | 5,8 |




Similar analyses for TSP indicate same top two control options

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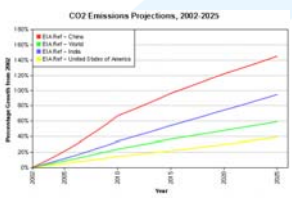
BAQ Singapore 2010

## Co-control and integrated air quality management (AQM) in China




二氧化碳排放量预测，2002- 2025

A joint China-Norwegian project proposal, applying for funding from the Royal Norwegian Government

NILU CICERO econ

MEP, PRCEE,
Tsinghua/Renmin/Beijing
Normal Universities

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## Dhaka, Bangladesh
## AQM planning and GHG

BAPMAN

Task1: Emission inventorying (top-down & bottom-up!)
Task2: Monitoring and laboratory procedures, and data acquisition capability
Task3: Air quality management capability, including modelling of air pollutant dispersion and population exposure
Task4: Health impact and scenario research, and strengthening capacity

Technical training
On the job experience
Workshops and seminars

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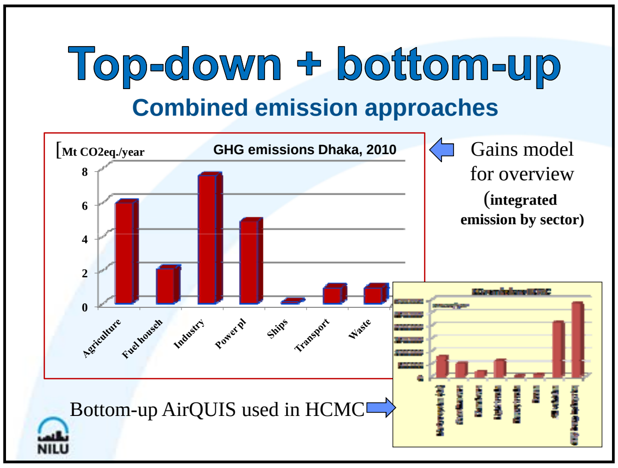
Top-down + bottom-up
Combined emission approaches
[Mt CO2eq./year
GHG emissions Dhaka, 2010
8
6
4
2
0
Agriculture
Fuel househ
Industry
Power pl
Ships
Transport
Waste
Gains model
for overview
(integrated
emission by sector)
Bottom-up AirQUIS used in HCMC
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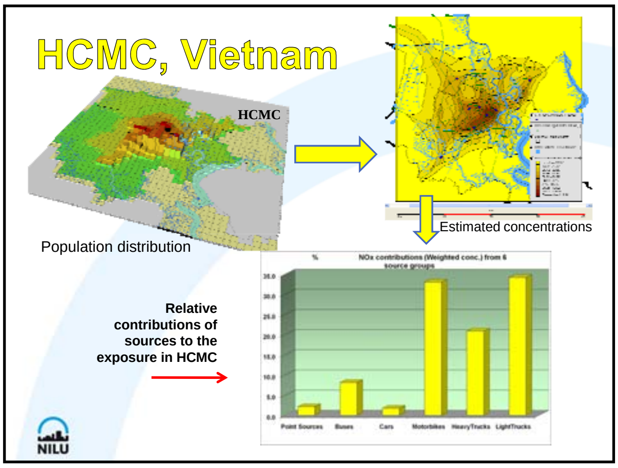
HCMC, Vietnam
HCMC
Population distribution
Estimated concentrations
Relative
contributions of
sources to the
exposure in HCMC
Point Sources
Buses
Cars
Motorbikes
HeavyTrucks
LightTrucks
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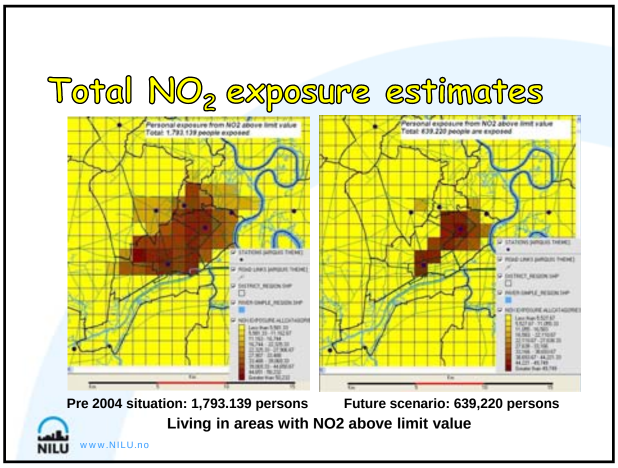
Total NO2 exposure estimates
Pre 2004 situation: 1,793.139 persons
Future scenario: 639,220 persons
Living in areas with NO2 above limit value
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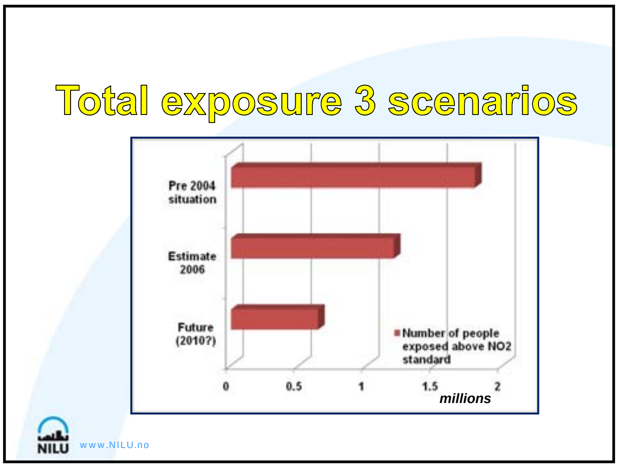
Total exposure 3 scenarios
Pre 2004
situation
Estimate
2006
Future
(2010?)
Number of people
exposed above NO2
standard
0
0.5
1
1.5
2
millions
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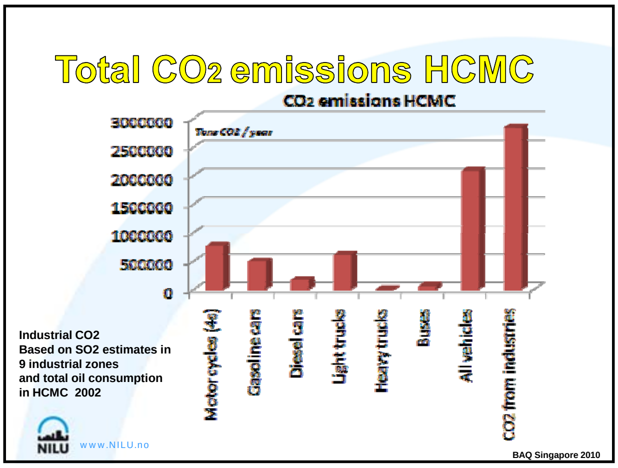
Total CO2 emissions HCMC
CO2 emissions HCMC
Tons CO2 / year
3000000
2500000
2000000
1500000
1000000
500000
0
Motorcycles (4s)
Gasoline cars
Diesel cars
Light trucks
Heavy trucks
Buses
All vehicles
CO2 from industries
Industrial CO2
Based on SO2 estimates in
9 industrial zones
and total oil consumption
in HCMC 2002
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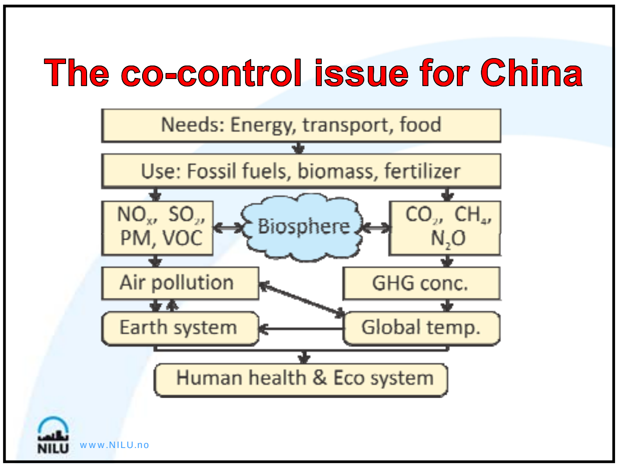
BAQ Singapore 2010


The co-control issue for China
Needs: Energy, transport, food
Use: Fossil fuels, biomass, fertilizer
NOx, SO2, PM, VOC
Biosphere
CO2, CH4, N2O
Air pollution
GHG conc.
Earth system
Global temp.
Human health & Eco system
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# Co-control actions and requirements China

**Possible actions**
**Structural changes** better than end-of-pipe

- From fossil fuels to renewable
- Energy efficiency improvements
- Energy savings
- Improvement of housing: construction and heating/cooling
- From individual to public transport
- From road (and air) to rail

*Integrated approaches*

*Impacts and costs*

**Requirements**
Needs for detailed data, on:
- Emissions
- Control options and their costs
- AP source-receptor and exposure-effects relationships

Costly and time consuming tasks
Requires skilled expertise

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Integrated Assessments and Co-controls are needed to support Sustainable Urban Developments.


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REFERENCE: E-109006
DATE: OCTOBER 2010

NILU is an independent, nonprofit institution established in 1969. Through its research NILU increases the understanding of climate change, of the composition of the atmosphere, of air quality and of hazardous substances. Based on its research, NILU markets integrated services and products within analyzing, monitoring and consulting. NILU is concerned with increasing public awareness about climate change and environmental pollution.

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Norsk institutt for luftforskning
Norwegian Institute for Air Research