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Guangzhou Air Quality Management and Planning System
(NORAD Project CHN 013)

Final Report

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Contents

Summary

The project "Guangzhou Air Quality Management and Planning System" (NORAD project CHN 013) started in November 1996. The 3-year project was completed by the end of 1999, according to the project plan. The present Final Report sums up the activities during the 3-year project period, and a discussion of the fulfilment of the four main project objectives is given. The Final Report draws extensively on the bi-annual workshop reports and annual reports which have been prepared throughout the project. The report is finalised by a brief discussion on completion and continuation of activities related to the project. Of particular importance is finding the means for the Guangzhou team to further the active use in P.R. China of the concept of analytical, quantitative air quality management that has been transferred through this project, through co-operation with authorities and research institutions in other areas and cities in China.

Guangzhou Air Quality Management and Planning System
(NORAD Project CHN 013)
Final Report

1 Introduction

The project "Air Quality and Planning System for Guangzhou" was established during the Autumn 1996 under the general agreement between the Norwegian Agency of Foreign Aid and Development (NORAD) and the State Science and Technology Commission (SSTC, now Ministry of Science and Technology, MOST) of P.R.China on co-operation on environmental issues. The specific guiding documents for the project are:
- Agreement between NORAD and SSTC on the Guangzhou project (NORAD project number CHN 013), signed on 8 November, 1996.
- Contract between NORCE (about NORCE, see below) and Guangzhou Municipal Science and Technology Commission (GMSTC), signed on 5 December, 1996.
- Contract between GMSTC and GRIEP, signed on 5 December, 1996.
- The Project Plan document, Final version of February 1997.

Four main objectives were formulated for the project, relating to
- establishment of an air quality management and planning system in Guangzhou, integrated within the air quality management institutions in Guangzhou;
- development of an action plan to improve air quality;
- improvement of the air quality monitoring system in Guangzhou
- transfer of tools and knowledge.

The larger goal that the project should support was formulated as *"contribution to the more active use of air quality management based upon cost analysis, in the P.R. China, especially in urban areas"*.

The project activities cover the period from November 1996 to December 1999. The project started with the Kick-off and workshop in Guangzhou on 23-29 November 1996. 2 workshops have been conducted per year (one in Norway and the remainders in Guangzhou), and the project ended with the last workshop in Guangzhou on 29 November - 3 December 1999, and the finalising activities during December and into January 2000.

The partners that carried out this co-operation project were:

On the Norwegian side: the following institutes which are partners in the NORCE consortium:
- Norwegian Institute for Air research (NILU)
- Centre for Economic Analysis (ECON)
- Centre for International Climate and Energy research (CICERO)
- Institute for Energy Technology (IFE)

On the Chinese side:
- Guangzhou Municipal Science and Technology Commission (GMSTC)
- Guangzhou Environmental Protection Bureau (GEPB)
- Guangzhou Research Institute for Environmental Protection (GRIEP)
- Guangzhou Monitoring Centre (GEMC).

Project secretariat and leading functions were established at NILU and GRIEP for the Norwegian and Chinese sides, respectively. A project management structure was established, which included Project leading groups on both sides. These groups met during the workshop to evaluate status and decide on the detailed work plans for the coming periods.

The present Final Report summarises the activities during the 3-year period, and the results are briefly evaluated against the main objectives of the project.

2 Main goal, objectives and summary of project plan

2.1 Main goal

The main overall goal of the project was formulated to give a direction of the large effort put into this 3-year project, towards future activities:

> *The overall goal of the project is to contribute to the active use of Air Quality Management, based upon cost analysis, in P.R. China, especially for urban areas.*

2.2 Main objectives

The following four main objectives were formulated at the start of the project, on the basis of which the detailed project plan was formulated:

- Develop and establish an air quality management and planning system for Guangzhou based upon the URBAIR concept (see section 2.3).
- Develop an air quality action plan as part of a city Environmental Master plan to reduce the air pollution in Guangzhou. This priority list of actions may be part of the Government Agenda 21 for the Environment.
- Update and improve the monitoring system by additional measurements (parameters and measurement points), in Guangzhou.
- Transfer tool and knowledge to the extent necessary to enable the Guangzhou counterparts to continue the Air Quality Management Strategy work in a qualified fashion.

The action plan was to be developed by the Chinese counterpart. The Norwegian counterpart was to perform transfer of and training in tools and knowledge, and assist in the action plan development.

The action plan was to form the basis for detailing a prioritized investment program to improve air quality.

The high priority put on this project and the quality of the local institutions which is high in China, assures the sustainability of the project.

Through inter-provincial co-operation in China between Guangzhou institutions and similar institutions in other provinces, it was planned that the expertise built up in Guangzhou could be transferred to other provinces and cities.

2.3 Summary of project plan

2.3.1 Basic project concept and scope of work

Active air quality management, in urban areas as more generally speaking, involves work and activities in many fields:

- Air quality and exposure assessment, including emissions, monitoring, dispersion modelling.
- Environment and health damage assessment, including dose-response relationships
- Abatement options assessment, including process technologies, cleaning, alternative processes, etc.
- Cost-benefit or cost-effectiveness analysis.
- Abatement measures prioritization/development of optimal control strategies.

The main elements of the approach can be grouped as follows:

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

Action plans and implementation: Categories of “actions” include the following:

- technical abatement measures;
- improvements of the factual data base (e.g. emission inventory, monitoring, etc.);
- institutional strengthening;
- implementing an investment plan;
- awareness raising and environmental education.

Monitoring: A third essential component of AQMS is continued monitoring, or surveillance. Monitoring is essential to assessing the effectiveness of air pollution control actions. The goal of an Air Quality Information System (AQIS) is, through thorough monitoring, to keep authorities, major polluters and the public informed about the short- and long-term changes in air quality, thereby helping to raise awareness; and to assess the results of abatement measures, thereby providing feedback to the abatement strategy.

Figure 1 describes how the necessary activities of an AQMS system should be linked together in an integrated system that enables abatement measures to be prioritised on the basis of cost-efficiency or cost-benefit analysis.

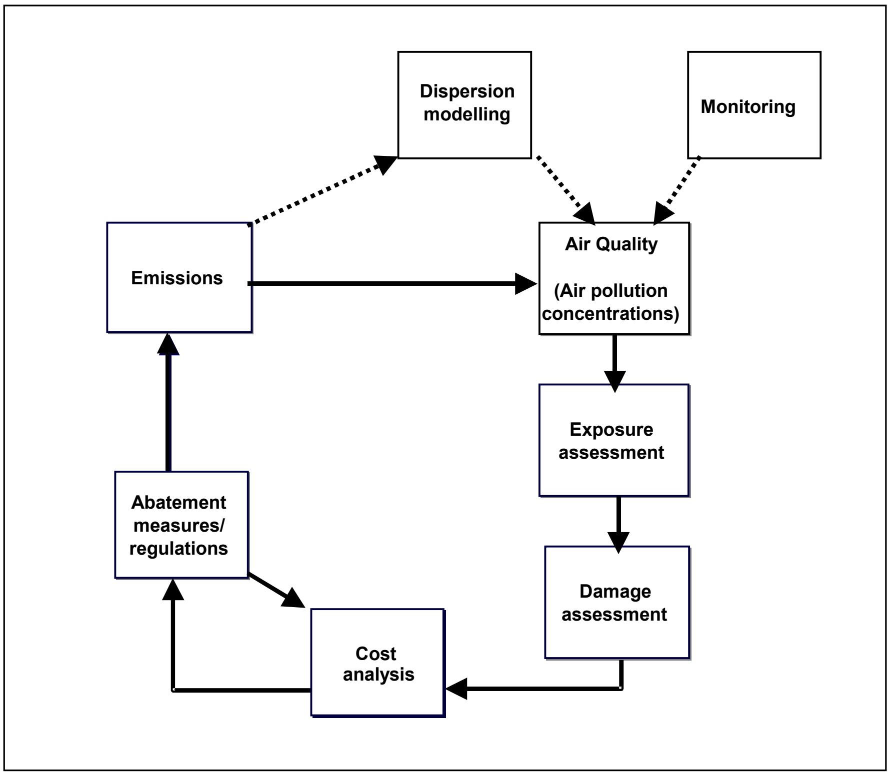


Figure 1: The system for developing an Air Quality Management Strategy (AQMS) based upon assessment of effects and costs

This concept was developed and applied to four South-Asian cities under the World Bank financed project "Urban Air Quality Management Strategy in Asia, URBAIR" carried out by the Norwegian Institute for Air Research and the Institute for Environmental Studies of the Free University Amsterdam. The URBAIR Guidebook (WB, 1997a) gives a detailed description of the methodologies that can be used to carry out the various activities. In the URBAIR project, which was carried out in 1993-1996, action plans for improved air quality were developed for four Asian cities: Jakarta, Kathmandu, Manila and Mumbai (WB, 1997 b, c, d, e).

Figure 2 gives a more complete indication of the topics and types of data and information involved in the AQMS process.

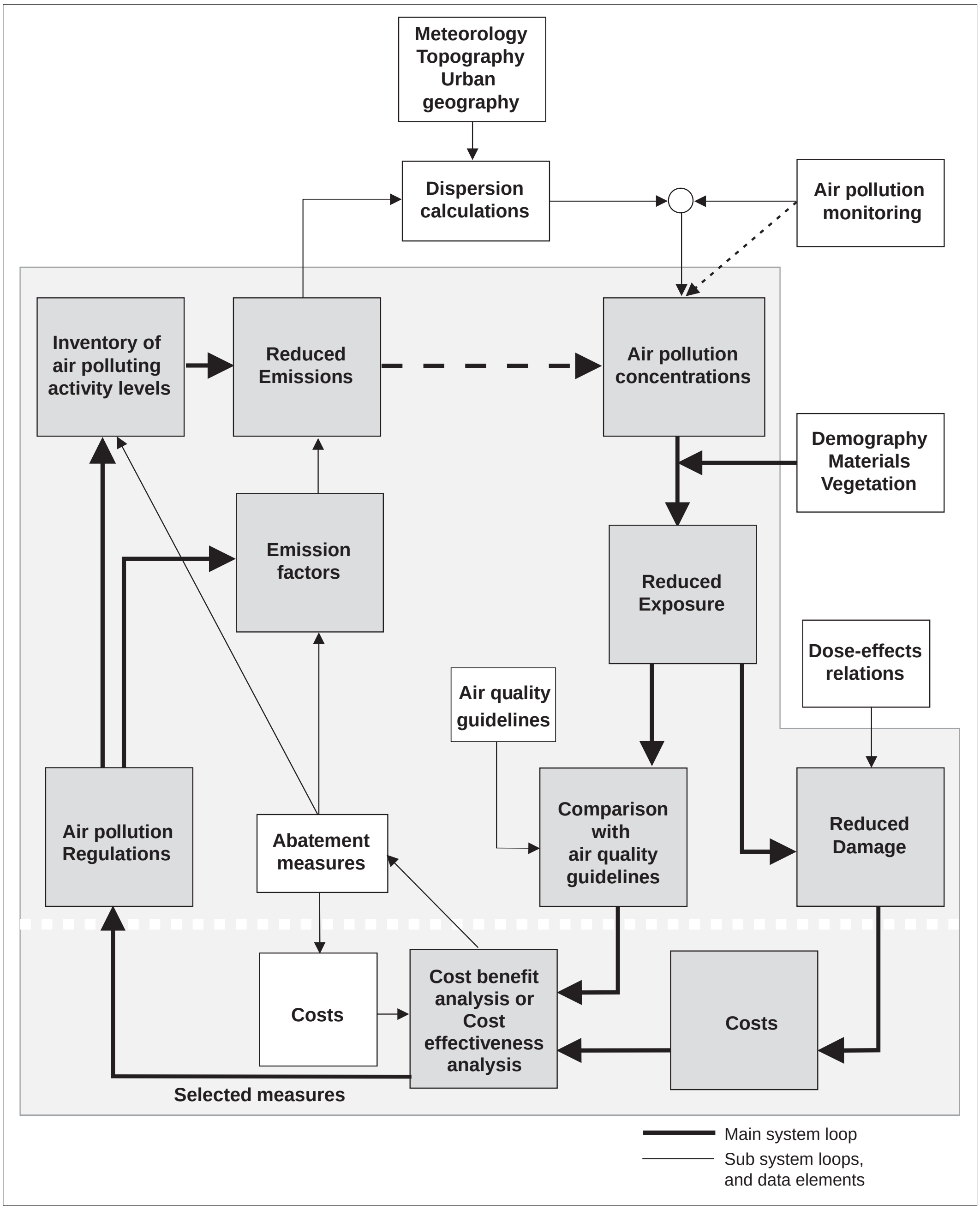


Figure 2: A more complete overview of the AQMS process

To meet the main project objectives, the Guangzhou AQMS project included the following activities:

- the development of emission inventories (for compounds such as SO_2, NO_x; particles and others), and a baseline future emission scenario;
- the use of dispersion models;
- the assessment of air quality;
- improvement of the monitoring system;

- the assessment of air quality impact and damage (mainly on health and materials, but also with a view to crop damage and emissions of climate gases);
- the assessment of control options;
- the study of motor vehicle pollution and photochemical smog;
- the study of energy production/consumption and coal smoke pollution;
- the establishment of an air pollution forecast system;
- a cost benefit analysis;
- the establishment and improvement of air pollution regulations and policy measures.

2.3.2 Project plan summary

With reference to the AQMS concept of Figure 1, the project was divided into the following 12 main task areas:

1. Emissions inventory;
2. Energy consumption and coal smoke pollution;
3. Dispersion modelling;
4. Air Quality monitoring;
5. Air pollution exposure assessment;
6. Damage assessment;
7. Control options;
8. Scenario development;
9. Cost-benefit/cost-effectiveness module;
10. Pollution control management and policy instruments;
11. Motor vehicle pollution and photochemical smog;
12. Pollution forecasting (short-term information and warning).

Project administration was defined as a separate task (13).

Tasks 2 and 11 are mainly descriptive tasks, where the two assumed major contributors to the air pollution in Guangzhou were to be described comprehensively regarding cause, history, technological status, quantitative contribution, and control options. This will draw information from tasks 1, 5, 6, and 7.

The analytical tasks (all except 2, 10 and 11) are connected in the loop shown in Figure 1: emissions → dispersion → air quality → exposure → damage → costs. Air Quality Management, involving short, medium and long-term strategies, involves going through the analytical loop iteratively, i.e. repetitively during the continuing work towards air quality improvement.

The main system tools were in the planning phase described as follows:

- Emission data base, dispersion models and exposure assessment models, connected together in an operative system on a PC platform (later referred to as the AirQUIS system);

- Damage assessment system, in the form of work sheets (e.g. EXCEL);

- Cost-benefit/cost-effectiveness model, in the form of work sheets (e.g. EXCEL).

It was not anticipated that it would be possible to integrate these tool elements fully with each other, as part of the project. The coupling between these main system tools was anticipated to be “manual”, in that the transfer of data files from one to the other is not automatic.

Annex 1 gives the details of the original plan for the 3-year projects, listing the main activities in each of the 3 1-year phases.

3 Project organization

3.1 Project organization structure

The organization structure was developed as part of the contract negotiations. Annex 2 describes the agreed structure in detail (it was included as Annex 5 to the contract between NORCE and GSTC).

The levels of the organization were:

- Steering Body: Director: Mr. Gan Haizhang, Director GEPB
13 members from city government department and GSTC.
- Advisory Group: 12 members from Chinese research institutions and city government.
- Project Leadership: Project Leader, Guangzhou: Mr. Wu Zhengqi, GRIEP
Deputy Leader, Guangzhou: Mr. Yu Kaiheng, GRIEP
Project Leader, NORCE: Mr. Steinar Larssen, NILU
Deputy Leader, NORCE: Mr. Haakon Vennemo, ECON
- Project Leading Group: Guangzhou: Representatives also from GEPB and GEMC.
NORCE: Representatives also from IFE and CICERO.
- Task teams: Working groups with members from Guangzhou and NORCE (see below).

Annex 2 gives the mandates and responsibilities of the various bodies and groups.

3.2 Task teams

The substance work of the project was carried out in task teams, with one team for each of the tasks listed on page 11. The participants of the task teams are given in Annex 3. Each task had two task leaders, one from the Chinese side, and one from the Norwegian side (see Table 1).

During the project there has been some changes of task leaders, both on the Chinese and the Norwegian sides.

There were two main reasons for organizing the work in task teams:

- The nature of this project was knowledge transfer. The topic of each task coincided to a large extent with the separate fields of knowledge and expertise needed in air quality management. Thus, knowledge transfer and training could take place within each task fairly independent of the other tasks. However, it was also important to take care of the needs for coordination between tasks.

- The tasks relate to each of the steps of the analytical sequence necessary to carry out to establish action plans. Thus, each task's responsibility in the analytical work could be rather easily specified.

Sub-division of the work into as much as 12 tasks requires well-functioning co-operation and information exchange between the tasks, as the work progress. Also, at any stage in the process, some tasks will have to wait for the results of other tasks before they can carry on. The experience from the project indicates that it might have been better to define fewer tasks with broader fields and responsibilities, thus task leaders with a wider scope, and larger teams.

The activities in the task teams centered around three hubs:

- The regular workshops, and preparations for these.
- The periods between workshops, when teams (the Chinese and Norwegian sides) worked separated, with contact mainly via e-mail, but which also included period of visits by the Norwegian task leader to Guangzhou.
- The training periods, when Chinese task leaders visited the appropriate institutions in Norway.

Table 1: Task team leaders

Task		Guangzhou side			NORCE side	
1.	Emissions	Huang Qingfeng	GEMC		Frederick Gram	NILU
2.	Coal pollution	Zhong Jieqing	GRIEP		Fridtjof Unander Andrew Yager	IFE 1997 IFE 1998-99
3.	Dispersion	Fang Zingqin Wang Daoming	GRIEP GRIEP	1996-98 1999	Atle Riise Leif Håvar Slørdahl Rune Ødegaard	NILU 1997 NILU 1998 NILU 1999
4.	Monitoring	Dong Tianming	GEMC		Steinar Larssen	NILU
5.	Exposure	Weng Shifa	GRIEP		Atle Riise Leif Håvar Slørdal Rune Ødegaard	NILU 1997 NILU 1998 NILU 1999
6.1	Health damage	Li Zhiqin	GRIEP		Kristin Aunan	CICERO
6.2	Materials damage	Tian Kai	GRIEP		Jan F. Henriksen	NILU
6.3	Vegetation damage	Su Xing	GEMC		Thorjørn Larssen	CICERO
7.	Control options	Cui Xia	GRIEP		Fridtjof Unander Andrew Yager	IFE 1997 IFE 1998-99
8.	Scenarios	Fan Changzhong	GRIEP		Haakon Vennemo	ECON
9.	Cost-benefit	Yu Jican	GRIEP		Haakon Vennemo	ECON
10.	Policy instruments	Liang Yujie Ge Yi	GRIEP GRIEP	1997 1998-99	Thorleif Haugland Knut Aarhus	ECON 1997 ECON 1998-99
11.	Motor vehicles pollution	Yu Kaiheng	GRIEP		Andrew Yager	IFE
12.	Pollution forecast	Chen Nengjian Liu Li	GEMC GEMC	1997 1998-99	Dag Tønnesen	NILU

3.3 The workshops

Workshops were organized twice a year, according to the original project plan. Table 2 shows the overall schedule and participants of the workshops from the country where the workshop was not held. Except for the first workshop of 1998, which was held in Norway, all workshops were held in Guangzhou (as planned). Separate reports cover the activities and results from each of the workshops (see chapter 5).

Table 2: Participants in the Workshops[1]

Name	Time and Place	Participants
Kick-off seminar and workshop	25-29 November 1996 GRIEP, Guangzhou	Steinar Larssen, NILU Frederick Gram, NILU Atle Riise, NILU Thor Christian Berg, NILU* Dag Tønnesen, NILU Jocelyne Clench-Aas, NILU Jan F. Henriksen, NILU Andrew Yager, IFE Fridtjof Unander, IFE Thorjørn Larssen, CICERO Haakon Vennemo, ECON Thorleif Haugland, ECON Knut Aarhus, ECON
Workshop 1/97	21-29 April 1997 GRIEP, Guangzhou	Steinar Larssen, NILU Andrew Yager, IFE Fridtjof Unander, IFE Thorleif Haugland, ECON Knut Aarhus, ECON
Workshop 2/97	19-27 November 1997 GRIEP, Guangzhou	Steinar Larssen, NILU Frederick Gram, NILU Atle Riise, NILU Andrew Yager, IFE Kristin Aunan, CICERO Haakon Vennemo, ECON
Workshop 1/98	11-15 May 1998 Ulvik/Oslo, Norway	Wu Zhengqi, GRIEP Sun Dayong, GEMC Cui Xia, GRIEP Fan Changzhong, GRIEP Fang Xingqin, GRIEP Jian Jianyang, GESI Yu Jican, GRIEP
Workshop 2/98	5-13 November 1998 Long Gui, Guangzhou	Steinar Larssen, NILU Frederick Gram, NILU* Leif Håvar Slørdahl, NILU Rune Ødegaard, NILU* Andrew Yager, IFE Thomas Krogh, IFE* Kristin Aunan, CICERO Thorleif Haugland, ECON* Knut Aarhus, ECON
Workshop 1/99	31 May - 4 June 1999 Long Gui, Guangzhou	Steinar Larssen, NILU Kathrine Sandvei, IFE Knut Aarhus, ECON
Workshop 2/99	26 November-3 December 1999 Long Gui, Guangzhou	Steinar Larssen, NILU Dag Tønnesen, NILU Kristin Aunan, CICERO Andrew Yager, IFE Haakon Vennemo, ECON Knut Aarhus, ECON

* These participants participated on their task budgets, and carried out task work and training in connection with the workshop.

[1] From the country where the workshop was NOT held. The participation from the host country always included most of the project participants.

The regular activities of the workshops were:

- Presentation and discussion of Status Report from each task.
- Discussion of overall project status
  - Comparison to plans
  - Critical delays
- Presentation of Detailed Work Plan for each task for the next 6 months.
- Discussion of overall work plan for the coming period
  - Modifications relative to original plan.
- Task work within each teams.

3.4 Project Leadership

The active leadership throughout the project was carried out by the project leaders (in NORCE and Guangzhou) in cooperation, with their deputies and the project leading groups in NORCE and Guangzhou.

Project leading group meetings were held during each workshop. Written agreements were produced and signed during these meetings concerning the activities in the coming 6-12 months, and their funding. The agreements, and minutes from the meetings, are included in the Workshop Reports and Annual reports.

Meetings within the project leading group in each country were held regularly. Minutes from those meetings are internal documents not published in reports.

4 Progress throughout the project

4.1 Kick-off seminar and workshop

Summary

The Kick-off seminar and 1. Workshop of the project was held in Guangzhou during 25-29 November. The week after (1-6 December) was used for continued task work in the 12 tasks of the project, with varying length of this activity for each of the tasks. The contents of the seminar and workshop was planned and carried out according to the overall Project plan.

Before the seminar the NORCE team was given a reconnaissance trip of Guangzhou, including to the Bai Yun mountain, which gave the team an impression of Guangzhou city and the air pollution situation.

The seminar on Monday 25 November had opening addresses by Mr. Dai Zhigao, Vice-mayor of Guangzhou, Mr. Wei Zhiqi, Chief, SSTC, Mr. Steinar Larssen, NILU/NORCE, Mr. Gan Haizhang, Director, GEPB and Mr. Zeng Shidu, Director, GSTC. These presentations documented the importance put on this project by SSTC (later MOST) and the authorities in Guangzhou, and that the project is well based in the municipal government. This was important in view of the main purpose of the project which, apart from knowledge and technology transfer, is to develop an action plan for cost-efficient air pollution abatement in Guangzhou, and to carry out the prioritized abatement measures to improve the pollution situation.

Further in the seminar, the overall project plan was presented, as well as an overview of the city's pollution situation.

The following workshops were held at the GRIEP institute during 26-29 November:

- Air quality assessment (subparts emissions, dispersion modelling, monitoring, exposure, pollution forecasting).
- Control options (including coal pollution and energy supply/consumption situation).
- Damage of the pollution (health damage, materials damage and vegetation damage as separate workshops).
- Cost/benefit analysis (incl. scenario development. Pollution management and policy options.
- Motor vehicles pollution.

The main task of the workshops was, on the basis of status presentations from the Guangzhou side and of methods and tools description from the NORCE side, to establish draft Detailed work plans for each of the 12 tasks, with emphasis on the 1997 activities.

The detailed work plan of each of the other tasks was presented at the concluding plenary session of the workshop, on the afternoon of Friday 29 November.

Conclusions

The overall objectives of the kick-off seminar and workshop were met:

- We arrived at a common understanding of the overall project plan.

- The relevant institutions and research groups in Guangzhou all participated in the seminar and workshop, and participated significantly to the results of the workshop. A clear division of tasks, and coordination and cooperation between these groups is important.

- The task teams were established, and through their meetings during and after the workshop discussed the plans and made progress towards a common understanding of the work contents in each task.

- The draft Detailed Work Plans were successfully established for each of the 12 tasks during or soon after the workshop. It is important that the work plans are followed up and carried out timely by both research teams (Guangzhou and NORCE).

- The work plans define the necessary resources that have to be made available for each of the tasks. It is the task of the project management in Guangzhou and in Norway respectively to make sure that these resources are made available to each task separately.

- The question of coordination between tasks was considered by all task teams, and coordination meetings between task teams were conducted.

- Through the participation in the seminar and the workshops, the project is embedded in the structure of the Municipal Government of Guangzhou. It is important for the success of the main objective of the project, which is to implement air pollution abatement in Guangzhou, on the basis of a prioritized action plan, that the project is firmly based in the Municipal Government, so that proposed abatement can be carried out.

Background documents, etc.

Background documents had been prepared mainly by the NORCE side before the seminar/workshop, including reports, notes, material from the open literature, relevant for the topic of each task. A selected set of this material was copied and collected, to be available to the participants. This material included copies of all transparencies from the presentations at the seminar and the workshop.

4.2 1997

Plans

The plans for 1997 were developed during the kick-off seminar and workshop. Detailed work plans were made for all tasks, with emphasis on the work during 1997.

Main activities

In this start-up period of the project, emphasis was put on the following activities:
- to acquire a good understanding of the project, the Air Quality Management (AQM) concept, the various parts of the AQM system, the relationships between the topics of the AQMS and the analytical work in each parts of the system, and thus the work to be carried out within each task and the relationships between the tasks;
- training and transfer of knowledge and tools;
- collection of the necessary data in each task, that are needed in the analytical work towards efficient management of air quality in Guangzhou and for the development of action plans.

Two workshops were held according to plans (in April and November, both in Guangzhou). 5 researchers had training in Norway during September – October. *5 additional task/training visits were made by NORCE researchers to Guangzhou, for training and task work. (See Table 5 Transfer of tools and methodologies).*

The project activities were interrupted for a 3-month period during the late Summer-early Fall in 1997 by the Chinese side, due to the general contract negotiations between NORAD and MOST (then SSTC).

Status by the end of the year

The status is summarised in the 1997 Annual report, copied in Annex 4 in this present report. The progress of the project suffered from the interruption of the work in the Fall, but efforts were made to correct the resulting delays.

Relative to the main objectives of the project, the status can be summarised as follows:
The first year's work has concentrated on the knowledge transfer and training, and moving towards making the foundation for the AQMS development. Also, improvement of the monitoring system is underway:

- *Knowledge and tools transfer, and training:*
  By the end of 1997, the participants had acquired a good understanding of the project, and the training periods and the task work had brought the participants up to a higher knowledge level in general.

- *The following tools were transferred during 1997:*
  - The NILU KILDER model system (Tasks 1 & 3).
  - The NILU Roadair model (Task 3).
  - Methods of monitoring network description and evaluations (Task 4).
  - Methodologies for cross-sectional epidemiological studies of health effects vs. air pollution exposure (Task 6.1).
  - Methods for materials lifetime and materials distributions calculations (Task 6.2).
  - Equipment for measurement of material degradation (for 10 field stations) (Task 6.2).
  - Initial MARKAL training (Task 7).
  - Data-base structure for baseline scenario development (Task 8).
  - Conceptual categories of policy instruments (Task 10).
  - Introduction to analysis of policy instruments' effectiveness and cost efficiency (Task 10.).

- *Improvement of monitoring system:*
  Purchase of monitors was prepared and in progress by the end of the year. The present monitoring system was being analysed. The evaluation and modification of the system had not yet started.

- *Development of action plan:*
  The collection of data in all tasks represent the start of the analytical work that is necessary for the action plan development. This had started in all tasks. The inventory of air pollution emissions (Task 1) was particularly important at this stage, since a complete emissions inventory had to be available before the analytical AQMS work could start. This is a large task, and a large team had been put on the work. Based upon the substantial work during 1997, it was anticipated that a first version of a complete emission inventory would be available by March 1998.

- From the other tasks, the following is mentioned:
    - The health damage assessment study (Task 6.1) is a very large effort, and during 1997, additional capacity and funds were secured from the Guangzhou side, so that the work could progress according to the original plans;
    - The materials damage study (Task 6.2) had a particularly good start, and the one-year field exposure program of various metal panel samples had started already in March 1997;
    - Regarding the management and policy instruments task (Task 10), the existing institutional framework, regulations and policies were being reported by the end of the year.
      There was progress in data collection also in all other tasks.

Delays

Except for the general delay due to the mentioned interruption of the project activities on the Chinese side, it should be mentioned that the delivery of the AirQUIS system was delayed, due to delays in the final development phase of the version to be delivered. The system was not delivered in 1997.

4.3 1998

Objectives and Plans

Specific objectives for 1998, and a summary of the work plans are given in Annex 4 (copied from the 1997 Annual report). For the 1998 plan, the original overall time schedule for the project, as worked out as part of the original project plan, had to be made more detailed. As guidance for the task teams, it was necessary that the plan show more specifically the relationships between the various tasks in the time sequence. Thus task time schedules were worked out, both regarding the information collection, and flow between the tasks, and regarding the development of abatement strategies and action plans. These time schedules are shown in Figure 1 and

Figure 2. They were used throughout the project.

The objectives for 1998 were:
- to continue transfer of tools and knowledge, and the training of participants;
- in particular to complete the data collection needed for the analytical work towards action plan development;
- to complete the first full sequence of analysis of costs and benefits of air pollution control in Guangzhou, based upon some selected short-term abatement activities. This would be a “trial run”, to gain experience for subsequent more complete analysis.
- To develop a first draft of an action plan by the end of 1998.

All details of the work plans for 1998 are given in the 1997 Annual report. The task work in 1998 would be geared towards fulfilling the above objectives. The task-time schedules in Figure 3 and Figure 4 provided guidance.

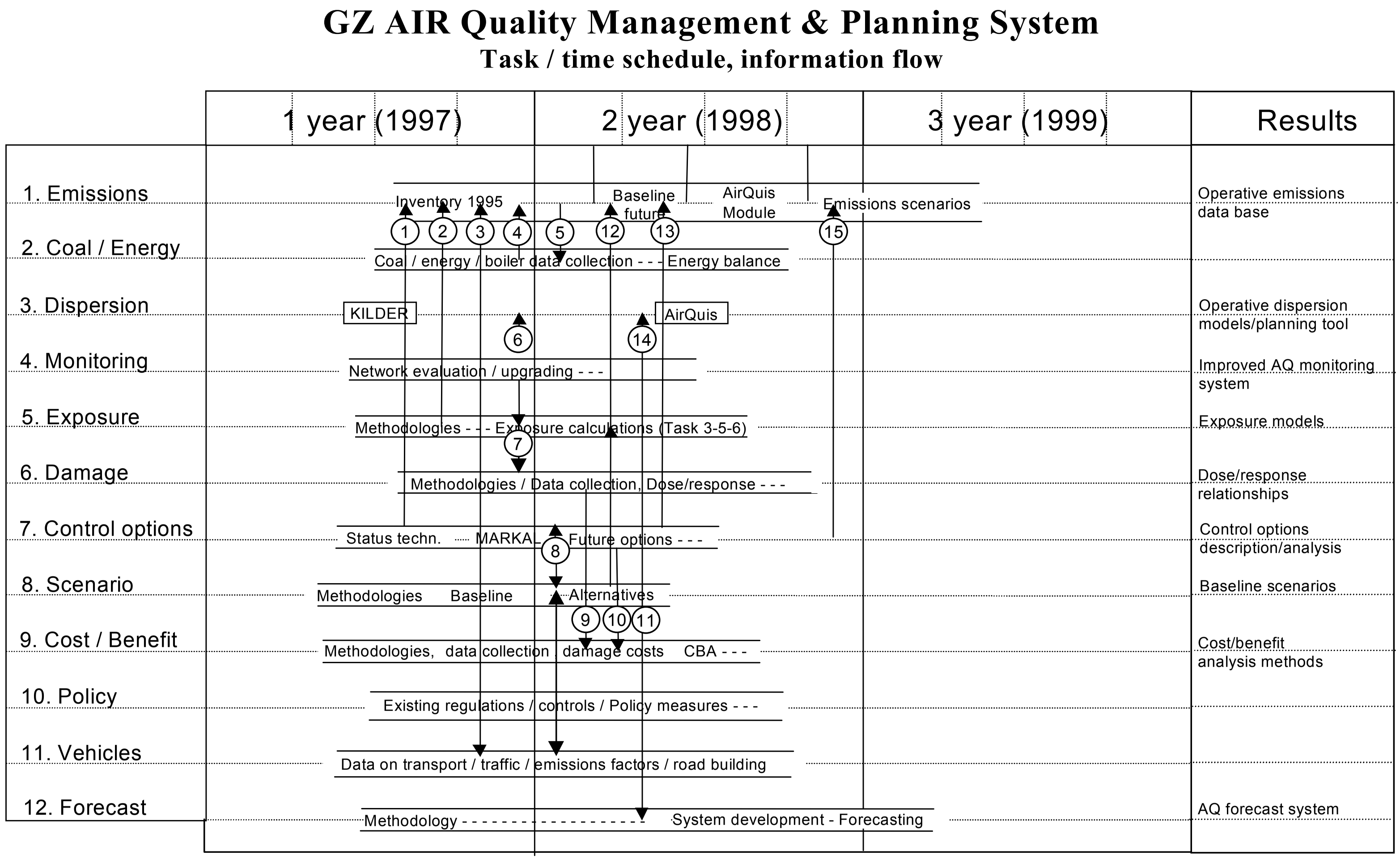


Figure 3: GZAIR Quality Management & Planning System. Time/task schedule information flow.

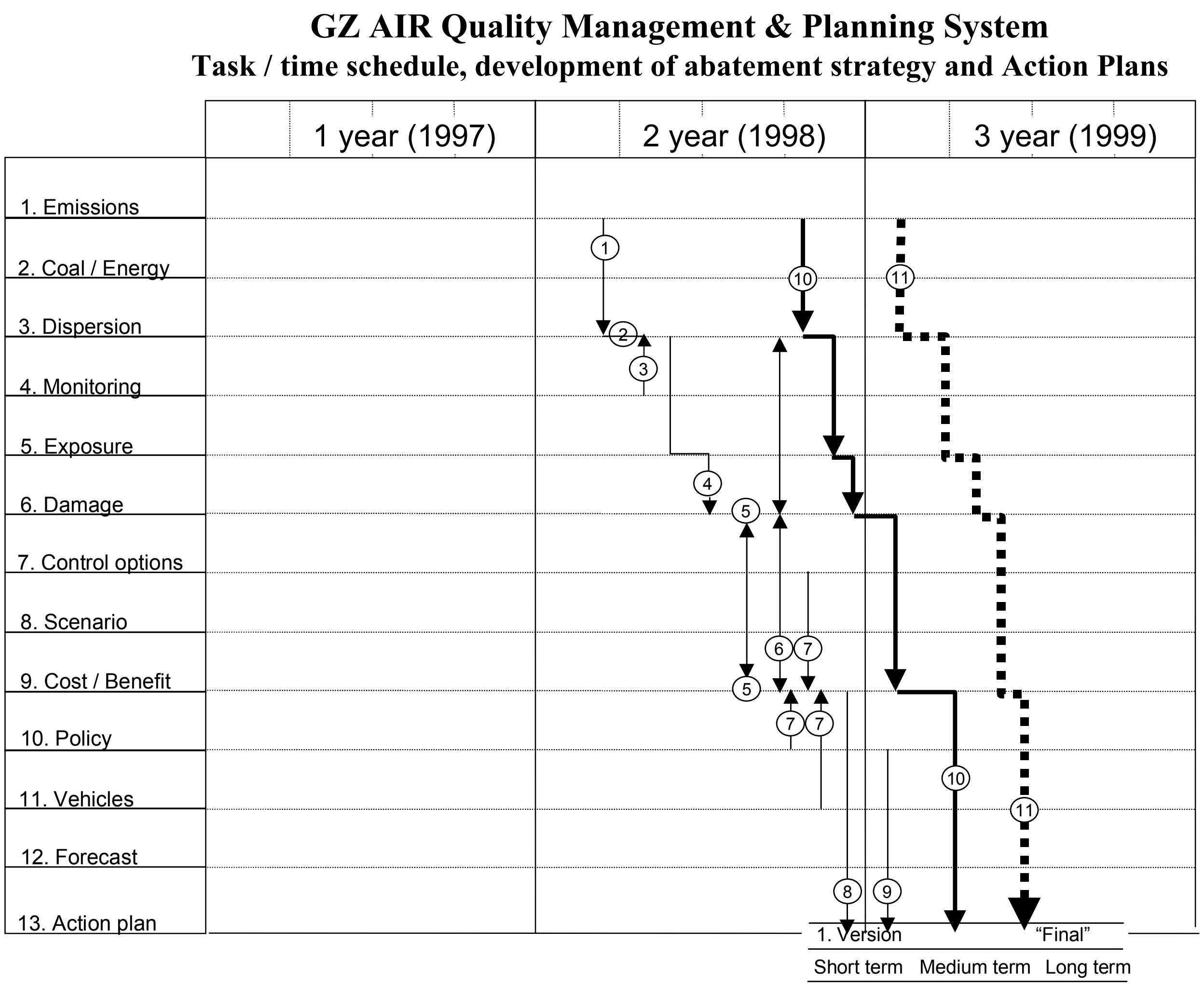


Figure 4: GZAIR Quality Management & Planning System. Time/task schedule development of abatement strategy and Action Plans.

Main activities

In 1998, emphasis was put on the following activities:

- Continued knowledge and tools transfer, and training:
  The AirQUIS system was installed at GRIEP in October-November, with training in the use of the system. Also, the MARKAL energy analysis model was installed, as well as a materials' damage cost model (CorrCOST).

- Work towards establishing AQMS analysis capability in Guangzhou, and a system/organisation in Guangzhou to continue the work. Achievements in 1998 connected with AQMS include:
  - the first version of a full emission inventory was completed;
  - meteorological data for 1995 had been acquired, necessary for the air pollution modelling;
  - KILDER calculations/preparations for AirQUIS calculations were carried out;
  - energy analysis had been carried out, and fuel use had been analysed;
  - scenarios for future development had been developed;
  - a first sequence of analysis of costs and effects of measures (AQMS analysis) had been carried out (see below).

- 1st sequence of analysis: carried out successfully and almost complete, according to the plan (see Workshop 2/98 report). The main purpose was:
  - training in carrying out the AQMS analysis;
  - simulate cost-benefit for some actual, selected measures.

  The details of the plan for this AQMS analysis exercise were laid during Workshop 1/98 (see that report). It was realised that the AirQUIS system would not be fully in operation in Guangzhou in time to use AirQUIS for the exercise. The following plans for the AQMS analysis work for the rest of the project were then formulated:

	Model System	Scenario	Abatement measures
1st sequence June-Nov. '98	Disp.: KILDER D/R: Existing?	1995 situation (or BASELINE)	First list
2nd sequence Jan.-June '99	Disp.: AirQUIS D/R: Local GZ	TREND	Additional feasible measures
Later sequences 1999 ⇛	"	"	Different packages of measures

Disp.: Dispersion model
D/R: Dose-response relationships

The 1st sequence of analysis was thus carried out using the KILDER model. This did not reduce much the training and in-sight-producing aspects of the exercise. The control measures used in this exercise were 5 measures selected by the Guangzhou side, which were measures partly introduced already, and partly contemplated for introduction by the city authorities:

- moving a large number of factories from central districts of Guangzhou;
- phasing-out of motorcycles;
- gasification of buses;
- gasification of 3rd industry;
- improving burner efficiency.

The calculations showed that in sum, the health benefits of introducing the control measures could be substantial. The cost side of the calculations were not well developed, so cost-benefit comparisons could not be done. Also, the use of KILDER instead of AirQUIS meant that the exposure reduction from reduced road-side concentrations through the measures on vehicles could not be calculated.

Still, this first fairly complete AQMS exercise provided insight, and impetus for the further improved analysis to be carried out in 1999. Due to time constraints and the physical separation between the NORCE and Guangzhou teams, much of the work on the 1st sequence was done by the NORCE side, but with some contributions from the Guangzhou task teams. Still, the demonstration provided for the Guangzhou teams training, insight and understanding of the process, so that subsequent analysis can be carried out by the Guangzhou team.

- A first version of an Action Plan for 2001 was developed.
  The original plan was to develop an action plan for 2005/2010, but during 1998 is was made clear that the Guangzhou side wanted/needed a plan to be developed for 2001, in connection with their effort to establish Guangzhou as an "environmental model city" by 2001.

  This first draft Action Plan 2001 was produced by the NORCE side, as an example for the Guangzhou side. It contained a preliminary analysis of about 40 control measures, in terms of:
  - What?: Description of the measure;
  - How?: Policy instrument/type of regulation;
  - Effects of the measure to reduce emissions, as well as its potential to reduce population exposure (in categories);
  - Costs of the measure;
  - Feasibility (for 2001 and 2010).

  Different measures for SO_2, NO_x and TSP were considered, categorised into:
  - fuel quality/fuel switch;
  - combustion related;
  - post-combustion cleaning;
  - technology improvements;
  - structural changes;
  - traffic management.

  This first draft Action Plan provided an excellent basis for the further action plan work during 1999.

- The monitoring system was being improved. A large number of monitors had been purchased, and the evaluation of the present system was underway.

Two workshops were held according to plans, in May (in Norway) and in November (in Guangzhou). 5 researchers had training in Norway following the May workshop.
7 visits by NORCE scientists to Guangzhou were carried out, for tasks 2 and 7 (combined), 3 and 4, some in connection with Workshop 2/98 (see Table 2 and Table 5).

Status by the end of the year

The status is summarised in the 1998 Annual report, as well as an evaluation of the degree of fulfilment of the project objectives, see Annex 5 here.

The emphasis of the work had been on completing the data collection necessary for the analytical work, to carry out an analysis sequence as complete as possible, and to get a good start on the action plan development.

In terms of the main objectives of the project, the status could be summed up as follows:

- *Knowledge and tools transfer, and training:*
  The tools transfer was complete, once the AirQUIS system was installed and established at GRIEP in October 1998. Knowledge transfer and training took place not least through the analytical sequence demonstration and the action plan work, preparing the Guangzhou team for taking more active part in this work in 1999.
- *Improvement of monitoring system:*
  This was well underway through putting the acquires monitors and equipment into operation, partly at existing and partly at a new station, and through the network evaluation work that has started.
- *Development of Action Plan:*
  As described above, by the end of 1998 (and a bit into 1999), the first draft plan for 2001 had been established, providing an excellent basis for the more developed plan to be produced during 1999, with more active contributions from the Guangzhou side.
- *Establishment of AQMS work integrated into the air quality management institutions in Guangzhou:*
  The basis for integrating the analytical concept of air quality management represented by this project is the build-up of a team in Guangzhou with full understanding of the concept and its parts, and with experience in carrying out all the various tasks necessary for the analysis, and also that a data base with all necessary data are in place. The main efforts through the first 2 years of the project have been to create this basis. The training, the demonstrations and the active task work has built up this basis, within a team or researchers from GRIEP and GEMC, and some from GEPB, which has been quite stable throughout the 2 years. The further development of action plans in 1999,

where the involvement of the Guangzhou team should be substantially stronger, should demonstrate the level expertise and experience acquired.

The integration of this process into the air quality management institutions in Guangzhou was one of the main objectives of the 1999 activities in the project.

Delays

An analysis was made of delays, especially those that could become critical in relation to finishing the project according to plan in time. Those are listed in Annex 5.

The delays relate mainly to the holes in data collection that still remained by the end of 1998, and also to the instalment at GRIEP of a new and improved AirQUIS version, which was carried out in October - November.

4.4 1999

Objectives and plans

A summary of the objectives and plans for the 1999 activities is given in Annex 6 (copied from the 1998 Annual Report). The objectives can be summarised as:

- First priority: develop the 2001 Action Plan;
- Further objectives: finalise all training and knowledge/tools transfer, data collection, task work; complete the monitoring system improvement; develop a 2010 Action; final reporting.

A time schedule was made, which included among others:

- to make the new AirQUIS version operative at GRIEP by end of February;
- complete the 2001 Action Plan development by May (by first workshop);
- complete the 2010 Action plan by November (by second workshop).

The Workshop report 2/98 contains the details of the task work to complete data collection, training etc.

Main activities

- New version of AirQUIS:
  Version 2.02 of the program system was installed in Guangzhou in October
- Completion of data collection:
  Throughout 1999, work in all tasks concentrated on completion of data collection. Details are given in Workshop Report 2/99. Also, the various technical reports from the tasks describe e.g. the details of the results of the data collection. A lot of diligent work was carried out by the Guangzhou team, with assistance from the NORCE team. The action plan development was dependent upon the availability of sufficiently complete data input.

- 2001 Action Plan development:
  After initial discussions on control options with the Guangzhou team, the NORCE team took charge of the development of this action plan. While waiting for AirQUIS calculations to be carried out, the results from the previous KILDER calculations of air pollution concentration fields in Guangzhou were used.

  An extra visit was made to Guangzhou on 22-27 March, to assist in and provide guidance of action plan work.

  By the first workshop in 1999 (early June) a fairly complete action plan could be presented, which included cost-efficiency calculations for many control options, for SO_2 and NO_x. During the rest of the year, the calculations were modified several times and refined. A final draft action plan could be presented by the last workshop of the project (in November) (see section 4.2 regarding the main results of the action plan work, e.g. cost-efficiency of various measures, and prioritisation of measures).

Important parts of the action plan development were, among others:

- 2001 development scenario: a baseline scenario for 2001 was completed, as a background for 2001 air pollution calculations. Change factors were developed regarding baseline emission development from 1995 (base year) and 2001 (Annex 7).

- A detailed plan for the AirQUIS calculations was worked out. The team for this task (Task 3, dispersion) followed this plan for the calculations. It turned out that it was not possible to complete the calculations within time for them to be used in the 2001 Action Plan, but they are available for use in the 2010 Action Plan (Annex 8)

- Completion of training program:
  Mrs. Li Zhiqin received training in Norway during August-October, on task 6.1: Health damage studies.

- 5 extra visits by NORCE scientists to Guangzhou were carried out, to provide guidance and training, especially regarding AirQUIS.

- Completion of task work, including reporting:
  All task work was completed by the time of the last workshop, and technical and reports were then largely finished (see reports list, chapter 5). An exception was Task 6.1: Health damage study. This substantial task, which includes the building up of a large data base with health effects information from Guangzhou (based upon a questionnaire study which included health questions to individuals, collection of health data from hospitals in Guangzhou, etc), and analysis of relationships between pollution exposure and health effects and symptoms, was not finished. During the second half of 1999, the AirQUIS system was used continuously to calculate exposure data for the individuals in the questionnaire study, and the analysis work on the

relationships started. It was not possible to finish this task within 1999, so the work has to continue after the project as a whole in terminated.

- 2010 Action Plan development:
  The start of this work became delayed due to the substantial activity that had to go into the 2001 plan development. The 2010 Action Plan work was started in the Guangzhou team during the Fall, and a first draft was presented at the last workshop (in November) (see section 6.4).

Status by the end of the year

See chapter 6, where the status of the project by the end of the 3-year period is evaluated in terms of fulfilment of its main objectives.

5 Reports produced within the project

Reports from the project are organized in 4 report series:

A	Administrative reports	• Annual reports (1997, 1998) • Workshop reports • Final project report (the present one)
B	Technical reports	• Includes the various technical reports from each task.
C	Scientific publications	
D	Mission reports	• Reports written to describe activities during special field or task work visits to Guangzhou.

Table 3 gives a list of the reports produced under this project. The reports are either in English or Chinese language, each with an English summary.

The task 6.1 reports will not be completed until the task itself is completed.

Table 3: List of reports and publications from the Guangzhou AQMS project

Report series:

Administrative reports (series A)

Technical reports (series B)

Scientific publications (series C)

Mission reports (series D).

Nomenclature:

C: Text in Chinese	TR: Technical report
E: Text in English	SR: Scientific report
	MR: Mission report

Task no.	Report	Authors	Report type				Project Report no.	Institute Report no.
			Adm	TR	SR	MR		
Adm	Air Quality Management and Planning System for Guangzhou Project proposal, final version.		E					STL/EMN/ O-96099
Adm	Report from Kick-off seminar and Workshop		E				A1	NILU OR 17/2001
Adm	Report from Workshop 1, 1997		E				A2	NILU OR 18/2001
Adm	Annual Report, 1997, incl. proceedings from Workshop 2, 1997		E				A3	NILU OR 19/2001
Adm	Report from Workshop 1, 1998.		E				A4	NILU OR37/98
Adm	Report from Workshop 2, 1998.		E				A5	NILU OR 8/99
Adm	Annual Report 1998		E				A6	NILU OR 9/99
Adm	Report from Workshop 1, 1999		E				A7	NILU OR 18/2000
Adm	Report from Workshop 2, 1999						A8	NILU OR 19/2000
Adm	Final Report		E				A9	NILU OR 17/2000
1	Travel report for visit to Guangzhou 10-20 March 1997	Frederick Gram (NILU)				E	D1	NILU RR 5/97

Task no.	Report	Authors	Report type				Project Report no.	Institute Report no.
			Adm	TR	SR	MR		
1	Travel report for visit to Guangzhou 17-27 July 1997	Frederick Gram (NILU)				E	D2	NILU RR 6/97
1	Air Pollution Emissions in Guangzhou 1995. Gridded emissions.	Huang Qingfeng (GEMC), Jian Jianyang (GESA), Yang Shurou, Pan Nanming, Sun Qun (GRIEP) and Frederick Gram (NILU)			E		B9	
1	Population distribution in Guangzhou 1995.	Yang Shurou (GRIEP) and Frederick Gram (NILU)		E			B10	
1	Traffic and traffic emissions in Guangzhou 1995.	Pan Nanming, Sun Qun, Wang Daoming (GRIEP), and Frederick Gram (NILU)		E			B11	
1	Emissions from point sources and fuel use in Guangzhou 1995.	Jian Jianyang (GESA), Kwang Junxia (GEMC), and Frederick Gram (NILU)		E			B12	
1	Technical Report for Emission Inventory in Guangzhou	Task 1 team		E			B13	-
2	Energy consumption and coal smoke pollution research in Guangzhou	Zhong Jieqing, Li Kangmin, Wang Daoming, Chen Hao (GRIEP), Fridtjov Unander, Andrew Yager and Kathrine Sandvei, IFE		C/E			B14	
3	KILDER Air Quality Calculations for Guangzhou 1995	Wang Daoming, Fang Xingqin (GRIEP) and Frederick Gram (NILU)		E			B15	

Task no.	Report	Authors	Report type				Project Report no.	Institute Report no.
			Adm	TR	SR	MR		
4	Background document for the topic: Monitoring, Kick-off seminar 25-29 November 1996	Steinar Larssen (NILU)		E			B1	NILU F 29/96
4	Air Quality in Guangzhou, 1990-1995.	Steinar Larssen (NILU) and Guangzhou task 4 team (GEMC)		E			B7	NILU OR 23/2001
4	Visit at Guangzhou Environment Monitoring Centre (GEMC) 25 July - 7 August 1998	Thor Chr. Berg		E			D3	NILU RR/2/2001
4	Evaluation of the AQ monitoring system of Guangzhou	Steinar Larssen		E			B31	
5	The study of population exposure to air pollution in Guangzhou city.	Task 5 team		E			B16	
6.1 & 9	Health damage assessment for Guangzhou– 1st sequence calculations.	Li Zhiqin, Yu Jican (GRIEP), Kristin Aunan (CICERO), Maj Dan Trong, Haakon Vennemo, Xu Zhao (ECON)		E			B17	
6.1	Health damage assessment for Guangzhou using exposure-response functions.	Li Zhiqin (GRIEP) and Kristin Aunan (CICERO)		E			B18	

Task no.	Report	Authors	Report type				Project Report no.	Institute Report no.
			Adm	TR	SR	MR		
6.1	Health effects of air pollution - methodology.	Li Zhiqin (GRIEP), Kristin Aunan (CICERO) and Jocelyne Clench-Aas (NILU)		E			B19	
6.1	Health effects from air pollution in GZ - respiratory symptoms and diseases. Results from an interview study.	Li Zhiqin, Chen Yang (GRIEP), Jocelyne Clench-Aas and Alena Bartonova (NILU)		E			B20	
6.1	Health effects from air pollution in GZ - mortality and hospital admissions.	Li Zhiqin, Xing Qi (GRIEP), Jocelyne Clench-Aas and Alena Bartonova (NILU)		E			B21	
6.2	Corrosion of steel and zinc in the Guangzhou area.	He Liangwan, Tian Kai (GRIEP) and Jan Fr. Henriksen (NILU)			E		B22	
6.2	Amount and distribution of materials in Guangzhou area based on random inspection and statistical treatment.	He Liangwan and Tian Kai (GRIEP)		E			B23	
6.2	Lifetime and maintenance cost of material in Guangzhou area.	He Liangwan, Tian Kai (GRIEP), Guri Krigsvoll and Jan Fr. Henriksen (NILU)		E			B24	
6.3	Assessment of crop damage due to air pollution in Guangzhou	Su Xing (GEMC) and Thorjørn Larssen (CICERO)		E			B25	
6.3	Vegetation damage in GZ.	Su Xing (GEMC) and Thorjørn Larssen (CICERO)		E			B26	

Task no.	Report	Authors	Report type				Project Report no.	Institute Report no.
			Adm	TR	SR	MR		
7	Technological Assessment of the Control Options	Kathrine Sandvei, Andrew Yager (IFE), Dr. Cui Xia, Fan Chang Zhong, Ye Lin (GRIEP), Prof. Huang		E			B27	
7	Suggested Air Pollution control scenarios for Guangzhou	Dr. Cui Xia, Ye Lin (GRIEP)		C			B28	
8	The General Development Scenarios During 1995-2000-2010 in Guangzhou	Haakon Vennemo, Maj Dang Trong (ECON) and Fan Changzhong (GRIEP)		E			B6	ECON memorandum No 29/99
9	See Task 6.1							
10	Air pollution control in China. An overview of the main principles and the political-administrative framework.	Knut Aarhus (ECON), Liang Yujie and Ge Yi (GRIEP)		E			B2	ECON memorandum No 25/99
10	Legal and administrative framework for pollution control in Guangzhou.	Knut Aarhus (ECON), Liang Yujie and Ge Yi (GRIEP)		E			B3	ECON memorandum No 26/99
10	Policy instruments for air pollution control - some successful international experiences	Knut Aarhus (ECON)		E			B5	ECON memorandum No 28/99
10	Air pollution regulations: emissions from transport, industry and power plants.	Knut Aarhus (ECON) and Ge Yi (GRIEP)		E			B4	ECON memorandum No 27/99

Task no.	Report	Authors	Report type				Project Report no.	Institute Report no.
			Adm	TR	SR	MR		
11	Current Motor Vehicle Situation and Future Motor Vehicle Emissions in Guangzhou	Zhu Chong Jian, Wang Boguang (GRIEP), Andrew Yager (IFE)		C/ E			B29	
12	Evaluation of Air Pollution forecasts in Guangzhou	Liu Li (GRIEP), Dag Tønnesen (NILU)		E			B30	

6 Main achievements of the project

6.1 Knowledge and tools transfer, and training

Transfer of knowledge took place throughout the whole project as part of the task work (this is covered in the half-yearly status reports for each task to be found in the Workshop Reports), and most importantly, during training stays of selected scientists from Guangzhou in Oslo.

The knowledge transfer and training activities have been summarized by the Guangzhou side. Their report is included as Annex 9 of this report.

A short summary of this is as follows:

- Totally 10 researchers had a total of 11 training periods in Oslo, each from 3 to 6 weeks (total 14.6 months) (see Table 1 in Annex 9). Reports from most of these training periods are included in the annual reports. Li Zhinqin's report from her stay in 1999 is included in Workshop report 2/99. The researchers were in Norway/Oslo in 3 groups:
  - September-October 1997: 5 researchers
  - May-June 1998: 5 researchers
  - August-October 1999: 1 researcher
- Training during workshops and field trips in Guangzhou: 38 researchers from the 12 task teams took part in the training. The accumulated number of days of training in groups of researchers was 45 days.
- Training during task specific field trips to Guangzhou by NORCE task leaders. Table 4 gives an overview of the field trips that have been carried out. Additional task trips carried out in connection with the workshops are shown in Table 2.

Tools and methodologies to be transferred were specified in Annex 2 of the contract between GSTC and NORCE. This is listed in Table 5, together with specification of what has actually been transferred as part of the project.

Table 4: Overview of task-specific field trips to Guangzhou by NORCE project leader and task leaders

(Additional task topics are specified in Tabel 2)

Person	Task	Period
1997:		
Mr. F. Gram	1	10-20 March
Mr. F. Gram	1	17-27 July
Mr. D. Tønnesen	3, 4, 12	15-20 June
Mr. H. Vennemo	7, 8	16-20 June
Mrs. J. Clench-Aas	6.1	21 June - 5 July
1998:		
Mr. T. Krogh	2, 7	1-8 April
Mr. T.C. Berg	4	25 July - 7 August
Mr. R. Ødegaard	3	24 October - 14 November
1999:		
Mr. S. Larssen	4, 13	22 - 27 March
Mr. A. Yager	2, 7, 13	22 - 27 March
Ms. K. Sandvei	2, 7, 13	22 - 27 March
Mr. K. Aarhus	10, 13	22 - 27 March
Mr. T. Haugland	10	In January
Mr. J.F. Henriksen	6.2	28 June - 6 July
Mr. R. Ødegaard	3	11 - 13 April
Mr. R. Ødegaard	3	20 - 26 June
Mr. R. Ødegaard	3	3 - 13 November

Table 5: Transfer of tools and methodologies

Task	According to Contract, Annex 2	Delivered
1 Emissions 3 Dispersion 5 Exposure	Tool: KILDER emissions model AirQUIS emission database. This is part of the NILU AirQUIS system Tools: The NILU KILDER dispersion model The NILU EPISODE dispersion model The NILU ROADAIR dispersion model The NILU AirQUIS GIS module. The AirQUIS Wind field model. Tool: The AirQUIS Exposure model	All the model modules listed under tasks 1.3 and 5 (except KILDER and ROADAIR) are part of the NILU AirQUIS system. The NILU AirQUIS system was installed in Guangzhou according to the following schedule: Oct. 1998: Version 2.0 Oct. 1999: Version 2.02 The KILDER model system and the ROADAIR model was installed separately (1997).
6.1 Health damage	Methodologies: Method for assessment of health risk level based on dose/response functions Method for cross-sectional epidemiological studies of health effects versus air pollution exposure.	1998 1997
6.2 Materials damage	Tools: 30 test panels of Zn, for 1-year exposure 30 test panels for C-steel, for 1-year exposure Methodologies Method for lifetime calculation for materials. Method for material distribution calculation Method for damage cost calculations	1997 1997 1997 1999
6.3 Vegetation damage	Methodologies: Method for damage assessment for vegetation and crops based on international established knowledge on dose-response relationships.	1997-98 (in the form of general methods, and knowledge transfer).

Task	According to Contract, Annex 2	Delivered
7 Control options	Tools: MARKAL-Energy system model User interface for MARKAL GAMS (General mathematics tool) for representation of optimization problems.	1998 1998 (Part of the MARKAL model system)
9 Cost-benefit	Methodologies: Principles and methods for valuation of external costs/environmental goods)	1998
10 Policy instruments	Methodologies: Conseptual categorization of policy instruments. Introduction to analysis of policy instruments' effectiveness and cost efficiency	1997 1997
12 Pollution forecasting	The NILU EPISODE model	1998

6.2 Improvement of the air quality monitoring system

The budget included the following sums, under Task 4 Monitoring, purchase of equipment to be used in connection with air quality monitoring and analysis of air quality samples:

NOK 1,430,000: Funds provided directly from NORAD to the Guangzhou side. These funds were used mainly by GEMC to purchase air pollution monitors (SO_2, NO_x, CO, O_3, PM_{10}), some calibration equipment, and one meteorological station.

NOK 1,500,000: Funds to be used by NORCE (NILU) for purchase of agreed equipment. After agreement on the types and the price of equipment to be purchased, it was decided it was most efficient to transfer the funds to the Guangzhou side, for them to make the purchases. This sum was used mainly by GRIEP to purchase some monitors, and laboratory equipment for VOC analysis, and one computer server. Most of these purchases were according to the original project plan.

According to the contract between NORCE and GSTC (reflecting Article VII, 2 of the agreement between NORAD and MOST on this project), the Guangzhou side is to make a report starting the procedures for continued use and maintenance of the equipment purchased for these funds.

Annex 10 contains the report from GEMC which details the equipment purchase and the associated activities to improve the air quality monitoring system of Guangzhou, as well as the details of the use and maintenance procedures of the equipment purchased by GEMC. Annex 9 contains likewise a table of the equipment purchased by GRIEP. A summary is as follows:

- GEMC purchased 17 units (see Table 1, Annex 10), total sum USD 195,665. The equipment was checked at reception, and is maintained as the rest of the monitoring equipment at GEMC. These monitors are in regular use within the air quality monitoring system in Guangzhou, from which e.g. weekly reports are made to SEPA. This equipment has resulted in the following improvements:

    - One new monitoring station has been established (a background station a bit outside Guangzhou), which gives an estimate of the regional air pollution level outside the city. This is important in connection with the analysis of the air quality improvement potential of reducing the emissions from sources in/near the city.

    - Two more parameters has been added: PM_{10} and O_3, in addition to SO_2, NO_x and NO_2, CO and TSP which have been regularly monitored for many years.

- Old monitors at existing stations have been replaced by new ones.

- The data transmission from stations to GEMC has been improved, from wireless system to lines.

- QA/QC procedures are being improved as a result of the training received from NORCE (NILU) as part of the project (see reports list, Task 4). The details of this QA/QC improvement process have not been completed yet.

- GRIEP has purchased 4 monitors (one each of SO_2 and NO_x, and 2 for O_3), as well as VOC-analytical laboratory equipment and an HP computer server.

- GEMC has plans to improve the monitoring system further:
  - Increase number of stations and parameters, e.g. near-road sites.
  - Improve the positioning of the stations, using results from calculations with the KILDER and AirQUIS models regarding air pollution dispersion and distribution in Guangzhou.
  - Improve QA/QC, including automatic calibration of monitors.
  - Connect other districts (Huadu, Panyu) into the monitoring system.
  - Connect on-line monitoring sites near industries to the system.

- The total sum of instrument purchase is:
  - GEMC: USD 195,665
  - GRIEP: RMB 1,333,340

  This corresponds well with the funds made available, totally NOK 2,930,000.

  Two reports produced under Task 4 has contributed to the improvement of the monitoring system (see reports list):
  - "Air Quality in Guangzhou 1990-1995". As part of the work behind this report, the existing system was thoroughly analysed (types and locations of stations).
  - "Evaluation of the Air Quality Monitoring System of Guangzhou". In this report, the existing system was evaluated by NORCE (NILU) in relation to the air pollution distribution in Guangzhou, as calculated by the KILDER model.

6.3 Action Plan 2001

One of the main objectives of the project was to develop an Air Quality Action Plan for Guangzhou. The work on this plan started at the time of the second workshop in 1998 (in November). The task work and the data collection had then progressed far enough that an analytical basis for the action plan development was available, although the basis was not entirely complete. Also, the exercise of the first analytical AQMS sequence had been carried out. It was also important to start the work on the plan, to be able to finish by the end of 1999.

As described in section 4.3, it was clear by the time of the first workshop in 1998 (in May) that the Guangzhou side needed an action plan to be worked out for

2001, due to the need to work towards an ”environmental model city” status for Guangzhou by that year. A first draft of the plan had been worked put by the NORCE side by early 1999, in the form of a table listing about 40 control options for SO_2, NOx and TSP, and first estimates of reduction effects, costs and feasibility. The first version of that table is given in the Workshop 1/99 report.

The final version of the 2001 Action Plan was available by early January 2000. The executive summary of the plan is included as Annex 11 to the present report.

The essence of the Action Plan is that it deals with air pollution exposure of the population (i.e. it deals with air pollution concentrations) rather than just emissions. In the action plan, the costs of each control option are calculated in terms of costs per percentage point of exposure reduction, and this is compared with the potential to reduce the pollution exposure that is associated with the option. Based upon this, the control options are ranked according to their cost-effectiveness. Least cost packages of control options to arrive at a given target for air quality can then be developed. This method is superior to the most used method of looking only at costs of emissions reduction and prioritising according to that, without taking into consideration the large effects that the emission conditions (location compared to the population centres, the stack height, etc.) have on the resulting pollution concentrations and exposure of the population.

The concept of the action plan is thus in accordance with the concept of air pollution control which was the starting point of the project (see section 2.3 and Figure 1), thus fulfilling the objective of the project. This action plan for Guangzhou represents the first complete effort to prioritise air pollution control options in a large urban area according to least cost control of population exposure rather than just least-cost control of emissions.

The concentration calculation for this action plan was carried out using the KILDER model, since the AirQUIS modelling system was still not fully functioning at GRIEP. The 2010 Action Plan is to be based on AirQUIS.

Figure 5 and Figure 6 below show the least-cost ranking of control options, and their associated reduction potential for concentrations, for SO_2 and NO_x respectively. The air quality target for annual average SO_2 concentrations can be met rather easily, while it is difficult to meet the target for maximum daily average concentrations with the control options which are available in the short term.

The NO_x target for annual average cannot be met with the available control options. It should be noted here that the air quality targets for NO_x in China are very strict compared to those in the European Union, USA and other countries. This has been pointed out to the Guangzhou project leadership.

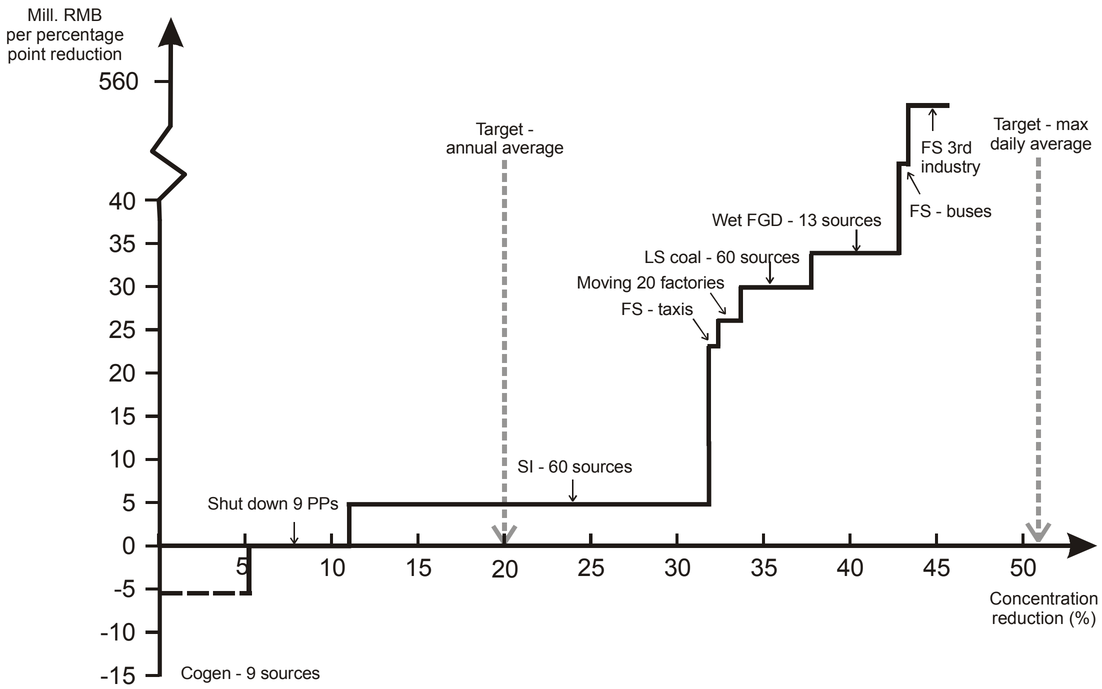


Figure 5: Cost curve, SO_2 control options

Cogen	-	Co-generation
PP	-	Power plants
SI	-	"Sorbent injection"
FS	-	"Fuel switch" (gasoline or diesel-to-LPG)
FGD	-	"Flue gas desulfurisation"

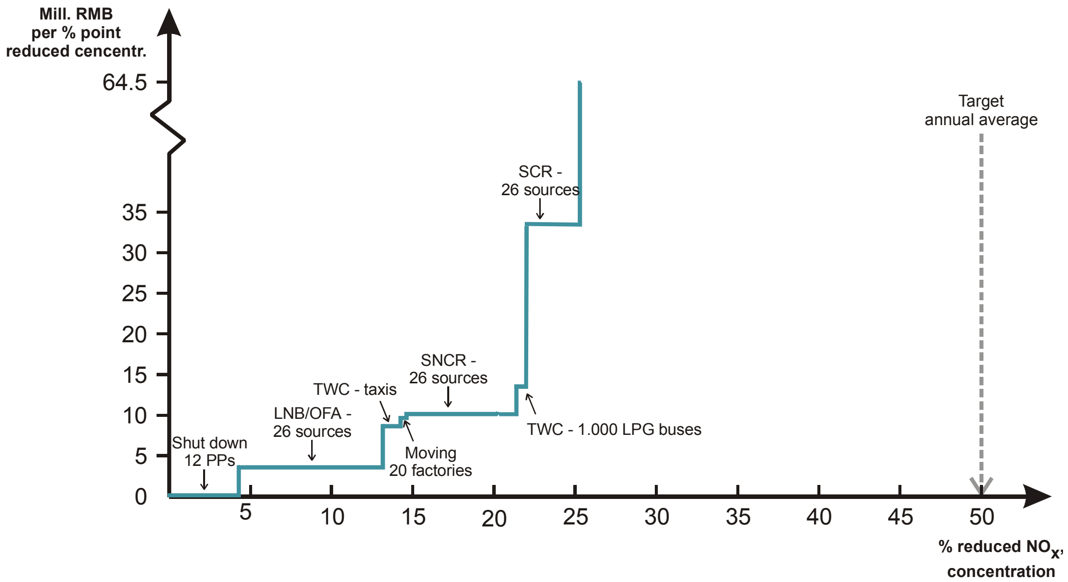


Figure 6: Cost curve, NOx control options

LNB/OFA	-	"Low-NO_x burner/Over-fire air"
TWC	-	"Three-way catalyst"
SCR	-	"Selective catalytic reduction"
SNCR	-	"Selective non-catalytic reduction"

The results of the calculations show that the 5 control options that were selected by the Guangzhou side in 1998 to be tested in the first sequence of analysis (moving factories, gasification of buses and 3rd industry, phasing-out of motorcycles, improving boiler efficiency) are not very cost-effective options at this stage, when substantial air quality improvements are necessary, and more cost-effective options are available.

The action plan report also contains a section with a first look at a Cost-Benefit analysis for SO_2, i.e. the estimate of damage costs, the reduced damage costs related to a control option, and comparison of the control costs and reduced damage costs. The reduced costs for health were based on an estimation of the reduced number of cases of different health effects that could be obtained from implementing the control options. An economic evaluation of the monetary value of the reduced health effects was then performed. Similar estimation was made of the costs of material damage. The preliminary analysis showed that for SO_2, the most effective control options have a higher benefit than costs. This analysis should be continued into the 2010 Action Plan.

6.4 Action Plan 2010

A draft of an Action Plan for 2010 has been made by the Guangzhou Task 13 team. It was presented and made available during the last workshop, in December 1999. This action plan builds upon the 2001 plan, and the draft contains the following main chapters:

1. Air Quality in Guangzhou, present situation.
2. Air Quality Targets for 2010.
3. Development scenarios 1996-2010.
4. Suggestions for constructing the Action Plan
    - Control of point sources, 4 different control programmes for different point source groups, control measures, etc.
    - Control of mobile sources, with various control options.
    - Control of households and 3'rd industries, mainly gasification.
    - Control of construction sources (dust control).
5. Cost benefit and cost-efficiency analysis.

This Action Plan is still under completion. The draft shows that the principles and steps used in the plan are in accordance with the concept of the project as a whole, and with the essence of the knowledge transfer that has taken place in the project.

The control options used for the various sections were taken from the work of Tasks 7 and 11, and calculations carried as far as to calculate the costs per reduced ton of emissions.

The projections included in the 2010 plan point to massive emission increases in Guangzhou, as a result of the projected development of the city. This includes increases both in fuel consumption, and of traffic.

By the end of 1999, cost-efficiency or cost-benefit calculations have still not been carried out, because the calculations of air, pollution concentration and exposure reductions had still not been completed.

The NORCE team gave significant comments to the draft 2010 plan in early January 2000.

7 Fulfilment of main project objectives

The Guangzhou air quality management project was a challenging one. The concept, scientific basis and the methodologies are firmly based in the state of air pollution science of the late 1990-ies, but the actual application of the method of air quality management through cost analysis of control measures versus value of benefits in terms of reduced damage, or cost effectiveness (improved air quality and reduced exposure of the population etc.), is still a young science also in Europe, USA and other areas. The URBAIR project showed the potential for improving air quality in large Asian cities without costs to the society in general, when putting a value on the damage caused by the pollution. It would be beneficial for P.R. China, with its very substantial local air pollution problems, to apply this methodology as soon as possible in its work towards improved air quality. The challenge was to introduce and apply the methodology via the Guangzhou project, which would place Guangzhou among the very few cities where the methodology is actively used so far. From here, the methodology could be further introduced and used by other cities and areas.

7.1 Transfer of knowledge and tools

The largest part of the activities on the project during the first two years (1997 and 1998) relates to this objective. The knowledge transfer took place between the Norwegian and Chinese sides of each of the task teams during and in connection with the workshops, during the other visits of experts to Guangzhou, and during the training stays in Norway.

Tools have been transferred as shown in Table 5.

Documentation:
Reports from the training stays, and the contents of the Technical Reports (see reports list in Table 3) document the results of the knowledge transfer. The 2010 Action Plan which is under development by the Guangzhou team, is another background for evaluation of the results of the knowledge transfer. The first draft shows the understanding of the concept and the use of the various tools and methods.

7.2 Establishment of the Air Quality Management System (AQMS) in Guangzhou

The activities towards fulfilling this objective have been along 3 main lines:

a) Collection of the information and data in all relevant parts of the AQMS work that are necessary to perform the quantitative AQM analysis.

Documentation:
The activities are described in the status reports and the detailed work plans documented in the workshop and annual reports, and in the Technical Reports (Table 3). Substantial data collection has been carried out. Examples are the emission inventory and population distribution, meteorological data, data on economic and social state and projections, laws and regulations on air pollution control, etc.

b) Training in the use of the tools and methodologies in the sequence of analysis that constitutes quantitative AQM.

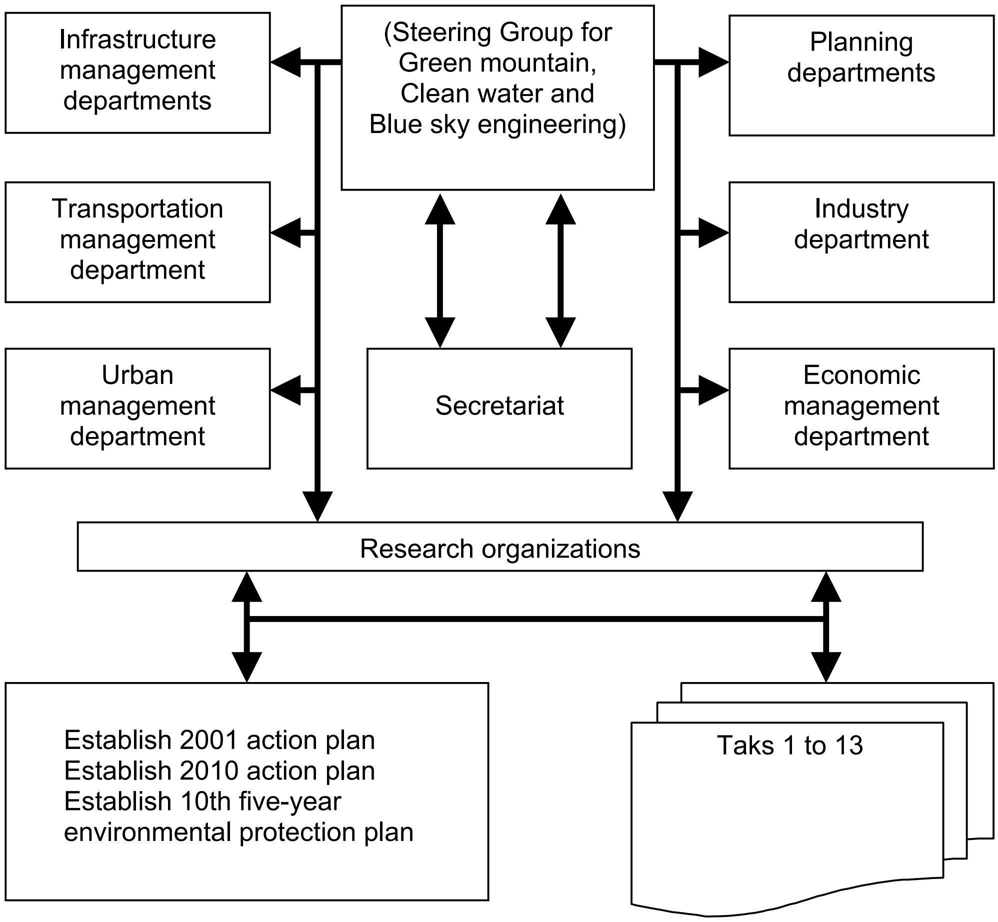
Documentation:
The results of the training in the use of tools and methodologies are documented in the Technical Reports. Examples are the emission inventory which has been developed by the Guangzhou side using the methods and tools provided, the fuel and energy analysis, the calculations of air quality using the dispersion model systems, the baseline scenario which has been developed, etc.

c) Integrating this URBAIR concept of AQM within the AQM institutions of the municipal government.

Documentation:
The background for integrating the quantitative AQM concept into the municipal institutions in Guangzhou is represented by the knowledge built up and the experience gained by the Guangzhou side of the task teams of the project, which are again based within the main institutions of the Guangzhou municipal government that work on air quality: GEPB, GRIEP, GEMC.

The structure for integrating this work within the municipal government is given in Box 1. The centre of the structure is the "Steering group of the Green mountain, Clean water and Blue sky Engineering" Commission in Guangzhou Municipal Government. There are direct connections between this steering group and the various relevant sector departments. The "research organisations" (GRIEP etc.) are embedded within this structure, and provides advice to the structure on the air quality management through the development of Action Plans, which are the result of the quantitative AQM analysis they carry out using the provided tools and methodologies.

Box 1 AQMS Organisation Establishment, Guangzhou (as presented by GRIEP Director, Mr. Wu Zhengqi)



The above diagram shows the following functions:
The Steering group put forward air quality improving requirements for the Secretariat, and then the Secretariat transfer the requirements for research organisations. Based on the requirements the research organisations do research works and find cost-effective air pollution control Policies & measures (P/M), and submit the P/M to the Steering group via the Secretariat. After the Steering group approves the P/M it ask the relevant sectors to implement the relevant policies and measures for controlling the air pollution.

In the establishment of AQMS in Guangzhou the various municipal departments have their roles:

- The municipal infrastructure department plays its role by managing the streets in urban area, constructions, transportations and so on. Specifically, it controls the pollution sources among 3rd industry, the local pollution caused by constructions, the littered-dust from the motor vehicles running on roads, and so on.
- The transportation management department plays its role by implementing the I/M programme, popularizing the use of the cleaner fuels for vehicles,

controlling the traffic volume, popularizing the use of cleaning equipment to reduce the emissions from motor vehicles, and so on.

- The urban management plays its role by popularizing and increasing the use rate of clean fuels in households.

- The planning department and economic management play their roles by planning & controlling the use of energy, improving the spatial distribution of industries, perfecting the industrial structure, and so on.

- The industry department plays its role by specifically controlling the emissions of air pollutants, popularizing the use of clean process technologies, specifically implementing the policies on perfecting the industrial structure, and so on.

7.3 Development of an Air Quality Action Plan

The original plan for the project was to develop one action plan, related to future years such as 2005/2010. As stated previously in section 4.3, this plan had to be changed in 1998, when the Guangzhou side requested that an action plan be made that would address the year 2001, and the necessary control measures to meet given targets for that year. This was connected to the plan of Guangzhou to become an Environmental Model City by that year. As a result, and to make sure that this plan could be developed and presented during 1999, the NORCE side took charge of the development of this plan, with input and contributions from the Guangzhou side.

The responsibility for the development of a more general action plan (for 2010) was then given to the Guangzhou side (in accordance with the original objectives), who benefited by the example of the 2001 Action Plan.

Documentation:

The report on the 2001 Action Plan has been completed. The 2010 Action Plan was presented as a draft to the project leading groups at the last workshop in December 1999, and the NORCE side has provided substantial comments. This action Plan will be finished by the Guangzhou side.

7.4 Improvement of the air pollution monitoring system of Guangzhou

The activities related to this objective were carried out within Task 4. Air pollution monitors and other equipment for about NOK 3 mill. have been provided by the project. All this equipment has been put into operation. The present monitoring system has been thoroughly described, evaluated and extended. A complete plan for a further improved monitoring system is being developed by the Guangzhou side.
The AirQUIS modelling system has been used to investigate an optimal spatial distribution of air quality monitoring stations in Guangzhou.

Documentation:

Technical Reports (Table 3) document the description and evaluation of the monitoring system. In Annex 10 to this report, this is summarised by the Guangzhou side. The annex also includes a documentation of the plans for the continued use and maintenance of the monitors and equipment after the close of this project.

8 Budget and cost tables, total project period

NORCE Side

Task/activity	1996 - 1997		1998		1999	
	Budget	Invoiced	Budget	Invoiced	Budget	Invoiced
1 Emissions	475000	424852	150000	282624	0	2040
2 Energy/coal	95000	105465	95000	67050	45000	52020
3 Dispersion	575000	131635	100000	718496	0	1020
4 Monitoring	582000	227477	170000	219832	0	5440
5 Exposure	90000	69795	100000	56225	0	12920
6 Damage	300000	503152	485000	287739	265000	213807
7 Control	500000	527105	520000	478081	310000	268937
8 Scenario	230000	253855	230000	182066	0	4080
9 Cost/benefit	75000	294698	500000	280312	560000	509990
10 Policy instruments	455000	454767	245000	238520	245000	210072
11 Motor vehicle/smog	65000	50520	65000	14650	45000	102000
12 Forecasting	50000	91505	75000	29990	100000	94040
13 Proyect administration	300000	337154	325000	260542	325000	273418
Workshops	1200000	1128317	450000	556343	500000	479118
Exchange program	140000	301047	70000	257973	65000	63611
TOTAL	5132000	4901344	3580000	3930443	2460000	2292514

Task/activity	Total	
	Budget	Invoiced
1 Emissions	625000	709516
2 Energy/coal	235000	224535
3 Dispersion	675000	851151
4 Monitoring	752000	452749
5 Exposure	190000	138940
6 Damage	1050000	1004698
7 Control	1330000	1274123
8 Scenario	460000	440001
9 Cost/benefit	1135000	1085000
10 Policy instruments	945000	903359
11 Motor vehicle/smog	175000	167170
12 Forecasting	225000	215535
13 Project administration	950000	871114
Workshops	2150000	2163778
Exchange program	275000	622631
TOTAL	11172000	11124300

The table shows budgets and invoiced expenditures ("costs") per task per year, and total. Invoiced expenditures exceed the budget on some tasks and are smaller than the budget on other tasks. This reflects the modifications on the weight of each task, as the project progressed.

The main discrepancy occurred for the Exchange Program, which was extended significantly relative to the original project plan. This lead to additional costs, about NOK 348,000,-, which had to be transferred from the other tasks.

The total invoiced amount is less than the total budget by NOK 47,700,-. This corresponds to the "loss" that was taken by the NORCE side in connection with the invoice for the 1996 costs which was then sent to MOST (SSTC). The loss is represented by the commission that was charged by MOST (SSTC) (approx. NOK 31,500,-) and a "currency loss" (approx. NOK 16,000,-).

In addition to the costs invoiced to NORAD, the NORCE institutes put their own resources into the project. Based upon accounted figures for this from the institutes (NILU, ECON ICE, CICERO), these additional resources amounted to about NOK 1,400,000,-, which is about 12-13% in addition to the total NORAD budget.

Guangzhou Side

unit:NOK

	1996-1997				1998				1999			
Task/Activity	GZ		GZ/NORAD		GZ		GZ/NORAD		GZ		GZ/NORAD	
	budget	Actual cost	budget	Actual cost	budget	Actual cost	budget	Actual cost	budget	Actual cost	budget	Actual cost
1 Emissions	324000	294738	60000	59568	31000	23783			0	36162		
2 Energy/coal	123000	102741			77000	56800			9000	130413		
3 Dispersion	450000	232189	50000	53117	107000	83007			99000	88670		
4 Monitoring	752000	751863	1430000	1435619	842000	823100			32000	49897		
5 Exposure	68000	77080	30000	29138	56000	54329			24000	41560		
6 Damage	246000	131227			178000	336789	30000	34338	99000	57984		
7 Control	191000	188263			93000	71239			70000	94873		
8 Scenario	101000	88962			46000	50235			38000	46803		
9 Cost/benefit	53000	46865			38000	40124			38000	42189		
10 Policy instruments	76000	76331			72000	71237			65000	65532		
11 Motor vehicle/smog	244000	198775			76000	60786			30000	89328		
12 Forecasting	151000	147640			30000	32014			84000	88489		
13 Project administration (workshop, exchange program)	1067000	999983	50000	51118	495000	475830	50000	48173	495000	583091	50000	51238
Total	3566000	3336657	1625000	1628560	2141000	2179273	80000	82511	1083000	1414991	50000	51238

	TOTAL			
Task/Activity	GZ		GZ/NORAD	
	budget	Actual cost	budget	Actual cost
1 Emissions	355000	354683	60000	59568
2 Energy/coal	290000	289954		
3 Dispersion	374000	403866	50000	53117
4 Monitoring	1626000	1624860	1430000	1435619
5 Exposure	148000	172969	30000	29138
6 Damage	523000	526000	30000	34338
7 Control	354000	354375		
8 Scenario	185000	186000		
9 Cost/benefit	129000	129178		
10 Policy instruments	213000	213100		
11 Motor vehicle/smog	350000	348889		
12 Forecasting	265000	268143		
13 Project administration (workshop, exchange program)	2058000	2058904	150000	150529
Total	6790000	6930921	1750000	1762309

9 Completion and continuation of project-related activities

9.1 Fulfilment of project objectives

The opinion of the Project Leading Group is that the main project objectives have been met, as described in Chapter 7. There are, however, parts associated with the project that have not been completed, as discussed briefly below.

Health effects study (parts of Task 6.1)

As described earlier in the report, the work planned under this task was very large, and it turned out not to be possible to finish the work by the time of the ending of the project period. The NORCE side has provided training and knowledge transfer about how to conduct health studies of relationships between air pollution and health effects. The Guangzhou side has collected a data base of health data from questionnaires and hospital data that are of a very substantial size. All the data have been entered properly in the data base, and data analysis is underway. The data base is unique, and the study should be completed, so that the information regarding relationships between health and air pollution in Guangzhou can be extracted.

Action Plan 2010

The objective of the study related to action plans was fulfilled by the completion of the 2001 Action Plan. The 2010 action plan is under development, as described in the report. Calculations of air pollution concentrations and exposure and its change due to the projected developments and selected control options, in underway using the AirQUIS system. These calculations will be speeded up using the new version of the system which has become available (March 2000). It is important that the Guangzhou side continue and complete this 2010 Action Plan. The experience gained and the results from the just completed UNDP project on reduction of NOx emissions from motor vehicles in Guangzhou will then also be used. Further guidance from the NORCE side would be of benefit to the Guangzhou side.

9.2 Continuing AQMS work in Guangzhou and other areas in P.R. China

The AQMS concept that has been established in Guangzhou through this project (the URBAIR concept) has been integrated within the air quality management authorities in Guangzhou. It is the intention of the Guangzhou side to continue to use this AQMS concept actively in their continuing work to improve their air quality.

The overall goal of this project is to contribute to the active use in P.R. China of analytical AQM, to find the most cost-effective means to reduce the damage caused by air pollution. It is hoped that the knowledge that has been transferred to Guangzhou research institutes and municipal authorities, and the experience they have gained through this project, can be transferred to other areas in China through cooperative projects between authorities of Guangzhou and of other cities and areas. The involvement of the NORCE group in the first of such cooperative projects, as advisers, would be beneficial.

10 References

(This reference list pertains only to references external to the project, and then only to reports desaibily the URBAIR concept and results from the URBAIR project (see section 2.3.1). References are not made specifically in the text to other reports from this Guangzhou project. For project internal reports, see reports list in Table 3).

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Annex 1

Project Plan details, as given in the original Project Plan Document (February, 1997)

Details of original Project Plan

The three yearly phases of the project are described below. The details of this description may change during the course of the project, based upon the contents of the agreed Annual Detailed Work Plans which will be developed for each year.

Phase 1 (Duration 1 year)

The following tasks will be undertaken during the first phase of the project:

1. Project preparation by NORCE and Guangzhou counterparts, to prepare for the kick-off seminar, and the necessary input to the seminar, in terms of presentations, study material and tools;
2. Project kick-off seminar to initiate the project in Guangzhou;
3. The development of a detailed working plan, distribution of tasks, appointment of the participants and directors of each sub-task. Budget. The final plan to be approved by the NORAD and Chinese counterparts;
4. Emission data collection (first phase emission inventory);
5. Collection of other relevant available information and data;
6. Software establishment; Databases, models, GIS (air quality assessment) on suitable hardware;
7. Institutional assessment, man power, infra structures, equipment etc;
8. Upgrading of the monitoring and information system and quality evaluation;
9. Start of the epidemiological study;
10. Start of the corrosion study;
11. Initial work on alternative control options (inventory of technological status and development trends);
12. Initiate damage assessment;
13. Start of baseline scenario definition;
14. Initiate appraisal of policy instruments and institutions.

In addition to the initial seminar two workshops will be arranged during the first phase.

The kick off seminar will be held in Guangzhou at the very start up of the project. Prior to the seminar the Norwegian side will prepare the necessary software and deliver this on a computer server. Tasks to be covered by the seminar will be:

- detailed working plan, distribution of tasks;
- discussion of data, data quality, shortcomings, gaps etc.;
- discussion of additional necessary equipment;
- transfer and training in the use of data bases and models;
- preparation of status report.

During parts of the seminar the participants will be divided into different working groups (workshops) with experts on emissions, measurements, models etc. The seminar and workshops will last for about one week.

Within 2 months after the kick-off seminar, a finalized project protocol will be presented to NORAD, detailing all tasks, indicators, responsibilities and products.

Two additional workshops will be arranged in Guangzhou during Phase 1:

a) The first one will be arranged midway in Phase 1 during the data collection and after some experience in modelling work has been gained. The workshop will include:

- presentation and discussions of the first phase database;
- presentation and discussion of first phase model results;
- preparation of status report for each sub-task;
- preparation for the tasks of Phase 2.

b) The second workshop will be arranged at the end of Phase 1 and include the same items as the first workshop, including the updated and completed data bases.

Between the seminar and the workshop the monitoring and information programme will be upgraded, and on-the-job training will be undertaken. Selected Guangzhou expert will receive training at NORCE institutes. Data collection will be continuously undertaken. Models will be tested and the first estimates of air quality will be presented.

Phase 2 (Duration 1 year)

Phase 2 will represent a continuation of the work started and reported from the Phase1. The following tasks will be covered by Phase 2:

1. Continued data collection;
2. Complete the Air Quality Assessment and Baseline emission scenario;
3. Continue the epidemiological and corrosion studies and damage assessment;
4. Continue the control option analysis;
5. Complete the policy instruments and institutional analysis, included proposed modifications and improvements;
6. Initiate the Air Pollution forecast system;
7. Initiate cost-benefit analysis;

Two workshops will be arranged also during the Phase 2:

a) Midway through the second phase work the workshop will be arranged in Guangzhou to include:

- presentation and discussions of the assessments;
- presentation and discussions of the control options;
- preparation of status report of each sub-task.

b) At the end of the second phase a workshop will be arranged in Norway. This workshop will include a consideration of the work undertaken so far, and will consider a possible extension of the project if necessary. The following items will also be included:

- presentation and discussion of second phase results;
- preparation of status report;
- preparation of tasks in Phase 3.

Selected Guangzhou experts will receive training in Norway.

Phase 3 (Duration 1 year)

During the third phase parts of the tasks started in Phase 2 will be continued. A list of priority measures will be established based upon the results from the impact assessment analyses and the cost evaluations for alternative scenarios. The new tasks covered by the third phase will thus be:

1. Complete the damage assessment;
2. Complete the control options analysis;
3. Complete the cost benefit/cost effectiveness analyses;
4. Complete policy instruments/institutions evaluation;
5. Priority evaluation and action plan;
6. Upgrading of the monitoring and information system to meet international standards and requirements;
7. Complete the Air Pollution Forecast System;
8. Complete the final report.

The third and final phase will include one work shop and a final seminar.

a) Workshop midway in phase 3
   - discuss the cost benefit input data and evaluate priorities;
   - discuss the up-grading of the monitoring and information system;
   - present and discuss the Air Pollution Forecast System;
   - discuss the results relative to the Guangzhou Master plan and Agenda 21.

b) Final seminar
   - presentation of the results of the project;
   - presentation of information system and results;
   - presentation of the Air Pollution Forecast System and results;
   - preparation of final report to be presented to NORAD and to Chinese Authorities.

Selected Guangzhou experts will receive training in Norway.

Time schedule

The following time schedule is presented for each of the tasks described in the Project Plan Chapter 5.

Activities			**Year 1**				**Year 2**				**Year 3**			
	Quartile	Task	1	2	3	4	1	2	3	4	1	2	3	4
1.	**Planning, preparations**		x											
2.	**Phase 1**													
2.1	Seminar		x											
2.2.	Emission data	1		x	x	x	x	x						
2.3.	Monitoring program updating	4	x	x	x									
2.4.	Other data collection	6,7,9	x	x	x	x				x	x			
2.5.	Data quality, evaluation/upgrading as necessary	4	x	x	x	x	x	x						
2.6.	Software establishment	1,3	x	x										
2.7.	Institutional analysis	10		x	x									
2.8.	Control options initial	7		x	x	x	x							
3.	**Phase 2**													
3.1	A.Q. assessment	5				x	x	x	x	x				
3.2.	Damage assessment	6				x	x	x	x	x	x	x		
3.3.	Control option final	7							x	x	x	x	x	
3.4.	Inst. evaluation	10						x	x					
3.5.	Motor vehicle pollution reduct.	11						x	x	x				
3.6.	Energy consumption and coal smoke pollution	2						x	x	x				
3.7.	Baseline scenario development	7			x	x	x	x						
3.8.	Air pollution forecast system	12						x	x	x	x	x	x	x
4.	**Phase 3**													
4.1.	Cost/benefit analysis	9								x	x	x	x	
4.2.	Priority action plan										x	x	x	x
4.3.	Final seminar													x
5.	**Training**													
5.1	On the job training			x	x	x	x	x	x	x	x	x	x	
5.2.	Visit to Norway			x						x				
5.3.	Exchange progr.				x	x			x	x				
5.4.	Workshops				x		x		x		x		x	
6.	**Status Reports to NORAD**				o									
	Status reports				o		o		o		o		o	
	Final report													o

Annex 2

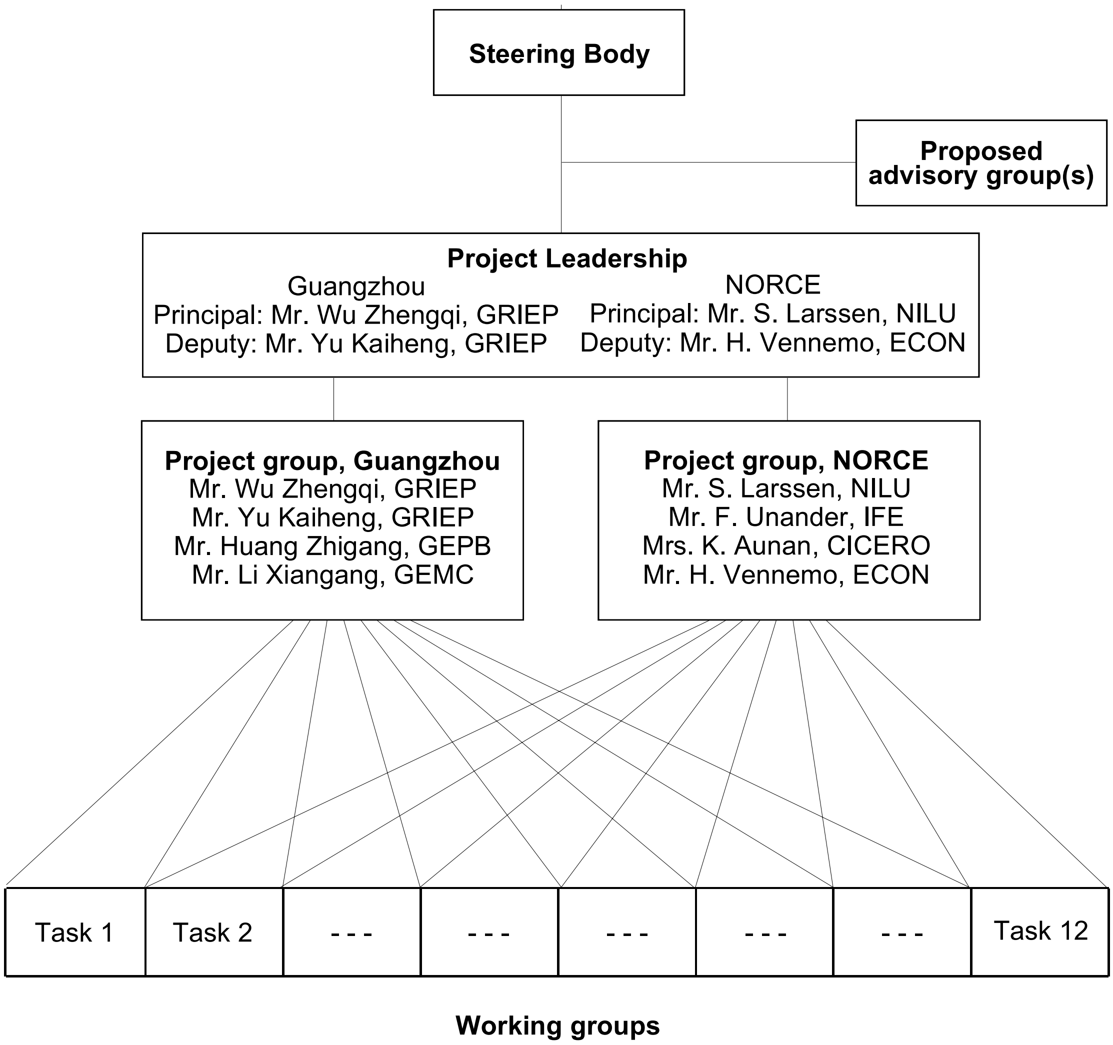
Project Organization Structure

Annex 5 to the Contract on NORAD Project CHN013

Annex 5 to the Contract on NORAD Project CHN013

Guangzhou Air Quality Management and Planning System

Project Organization Structure



A. Steering body

Director: Mr. **Gan Haizhang**, Director of GEPB

Vice-director: Mr. **Zhou Yizheng**, Vice-director of GSTC
Mr. **Lie Zengbiao**, Vice-director of GEPB

Members: Mr. **Zhan Qimin**, Vice-director of Guangzhou Foreign Affairs Office
Mr. **Chen Zhenhao**, Director of GFIILG
Mr. **Liu Zhenyong**, Director of Int.Sci. & Tech. Coopera. Dep. of GSTC
Mr. **Zhang Nanfeng**, Vice-director of Inter.Sci & Tech. Coopera. Dep. of GSTC
Mr. **Wu Zhihan**, Director of Planning Dep. of GSTC
Mr. **Luo Yukuan**, Vice-director of Sci. & Tech. Develop. Dep. of GSTC
Mr. **Huang Zhigang**, Director of Sci. & Tech. Dep. of GEPB
Ms. **Hu Shanyu**, Vice-director of Sci & Tech. Dep. of GEPB
Mr. **Wu Zhengqi**, Director of GRIEP
Mr. **Zhuang Jiawang**, Director of GEMC
Mr. **Huang Xinmin**, Director of GESI

Mandates and responsibilities:

a) Examining and approving the action plan, annual working plan and project budget.

b) Examining and approving members of the technical group and the task group; Inviting members of the consultative group.

c) Designating the person to buy the equipment under the Contract and the one responsible for maintenance and repair of the equipment.

d) Approving and choosing the task group members proposed by the technical group to go to Norway for training.

e) The Director should check the working status of task groups at least every season regularly; giving advice on the important affairs rising during the implementation of the project; Discussing the possible modification of the work plan and the budget.

f) Keeping in touch with SSTC, sending delegates to attend the consultations in March or April each year.

g) Keeping in touch with the project consultative group, striving for support from each relevant side and for the stringent technical guarantee.

h) Coordinating with all sides to make the project go smoothly under the Contract.

i) Raising funds positively from different sources for the project, and distributing resources of the project according to the requirement.

B. Advisory Group

Members: Mr. **Liu Jingxiang**, Vice-mayor of Guangzhou
Mr. **Dai Zhiguo**, Vice-mayor of Guangzhou
Mr. **Wang Yinkun**, Director of GDEPB
Mr. **Zhao Zhengqiang**, General-secretary of GMGO
Mr. **Zeng Shidu**, Director of GSTC
Mr. **Guo Xiling**, Director of Guangzhou Planning Commission
Mr. **Wen Jianhui**, Director of Guangzhou Financial Bureau
Mr. **Li Wenzhou**, Director of Guangzhou Foreign Affairs Office
Ms. **Tang Xiaoyan**, Member of CAE, Prof. of Peking University
Mr. **Liu Hongliang**, Member of CAE, Prof. of CRAES
Mr. **Fu Jiamo**, Member of CAS, Prof. of Guangzhou Institute of Geochemistry, CAS
Mr. **Yao Si**, Prof. of the Center of Urban Planning and Environmental Administration, Hong Kong University.

Mandates and responsibilities

a) Directing the project from large angle and coordinating with the relative departments.

b) Giving directions in solving the important technical problems in the project, providing technical information and direction according to the research objectives and contents of the project to avoid detours, get more benefit with less cost and make the achievements more advanced and practical.

C. Technical leading group

This group consists of the Guangzhou and NORCE Technical leading groups (TLG).

Leaders: Mr. **Wu Zhengqi**, GRIEP
Mr. **Steinar Larssen**, NILU/NORCE

Members: The members of the GZ and NORCE TLGs.

Task 13 is the overall task group.

Guangzhou		NORCE	
Responsible	Other participants	Responsible	Other participants
Mr. Wu Zhengqi, GRIEP	Yu Kaiheng, Li Xiangang, Huang Zhigang, Hu Shanyu Project office: Sun Dayong, Zhu Changjian, Liu Qiaomei, Fang Zingqin, Su Xing	Mr. Steinar Larssen, NILU	H. Vennemo, F. Unander, K. Aunan

Mandates and responsible

a) Establishing the annual Detailed Work Plans, and presenting them to the Project leading group.

b) Arranging a meeting after each workshop, to take care of all necessary business regarding project administration and work plans. The agenda for these project meetings is subject to the actual development of the project and to the state of affairs at the time of each workshop. Items for the agenda can be proposed by each of the GZ and NORCE teams before or at the start of the meetings. Writing minutes.

D. Technical Group (GZ)

Director: Mr. **Wu Zhengqi**, Director of GRIEP

Members: Mr. **Huang Zhigang**, Director of Sci. & Tech. Dep. of GEPB
Mr. **Yu Kaiheng**, Chief Engineer of GRIEP
Mr. **Li Xiangang**, Vice-director of GEMC

Mandates and responsibilities:

a) Synthesizing and deciding the project action plan and the working plan, work load and budget of 12 task groups and submitting the written information to the leading group.

b) Giving centralized technical control, coordination and direction to the work of 12 task groups, guarding against deviations from the project goal and passive effects on the technical quality, in order to guarantee the project progress and its technical quality.

c) Collecting and checking the reports from 12 task groups in each stage (especially in Dec. each year), submitting the general reports to SSTC and NORAD after approved by the leading group.

d) Keeping close touch with NORCE, exchanging information for relevant task groups in time and giving directions to their work.

e) Keeping close touch with the technical consultants, organizing the experts to attend the meetings to solve the technical problems in time, avoid technical deviations from the project, and appraise the achievements.

f) Examining and approving the list of equipment to be purchased under the project.

g) Writing the minutes of the relevant meetings of the project.

h) Establishing an office responsible for handling the routine duties, including information collection and arrangement, fax, translating, printing and copying of the relevant documents of the project, and related meeting affairs.

E. Technical Group, NORCE

Leader:	Mr. **S. Larssen**, NILU	**Stand in**:	Mr. H. Vennemo
Dty. leader:	Mr. **H. Vennemo**, ECON	**Stand in**:	Mr. T. Haugland
Members:	Mr. **F. Unander**, IFE	**Stand in**:	Mr. A. Yager
	Mrs. **K. Aunan**, CICERO	**Stand in**:	Mr. T. Larssen

Responsibilities

a) Deciding on the distribution of the NORCE annual budgets between the 12 tasks (the NORCE side of the budgets).

b) Coordination of the NORCE project work, in accordance with the agreed Detailed Work Plans.

c) Keeping close contact with the Guangzhou Technical Group throughout the project.

F. Working groups

There are 14 Task groups. Each task has a leader from Guangzhou and a leader from NORCE, who cooperate on the planning and execution of the task.

The table below shows leaders and members of the task groups.

Working group	Responsible in Guangzhou Person	Institutions	Other participants	Responsible in Norway Person	Institutions
Task 1	Ms. Huang Qingfeng Ms. Kuang Junxia Mr. Jian Jianyang Mr. Pan Nanming	GEMC GEMC GESI GRIEP	He Yan, Wang Jingwen, Yang Surou, Chen Yanning, Liang Xilin, etc.	Mr. Frederick Gram	NILU
Task 2	Ms. Zhong Jieqing Mr. Li Kangmin	GRIEP GGNTDC	Lin Nisheng, Lin Xuedong, Qin Jia, etc.	Mr. Fridtjof Unander	IFE
Task 3	Ms. Fang Xingqin	GRIEP	Cui Xia, Fuchun, etc.	Mr. Atle Riise	NILU
Task 4	Mr. Dong Tianming Mr. Song Weiping	GEMC GEMC	Sun Dayong, Wu Qingzhu, Huang Zuzhao, Wu Cunlong, Tian Kai, Wang Boguang, etc.	Mr. Steinar Larssen	NILU
Task 5	Mr. Weng Shifa	GRIEP	He Liangwan, Li Zhiqin, etc.	Mr. Atle Riise	NILU
Task 6 6.1	Health damage: Ms. Li Zhiqin	GRIEP	He Liangwan, Chenyang Xun Qi, Hu Diqin	Ms. Kristin Aunan Ms. Jocelyne Clench-Aas	CICERO NILU
6.2	Material damage: Mr. Tian Kai	GRIEP		Mr. Jan F. Henriksen	NILU
6.3	Vegetation damage: Ms. Su Xing	GEMC		Mr. Torjørn Larssen	CICERO
Task 7	Mr. Cui Xia	GRIEP	Li Zhanlong, Fan Changzhong	Mr. Fridtjof Unander	IFE
Task 8	Mr. Fan Changzhong	GRIEP	Cui Xia, Li Zhanlong, Wang Daoming, etc.	Mr. Haakon Vennemo	ECON
Task 9	Mr. Yu Jichan	GRIEP	Luo Jiahai, etc.	Mr. Haakon Vennemo	ECON
Task 10	Mr. Liang Yujie	GRIEP	Ge Yi, Liao Yungdong, Mo Xiuzehn, etc.	Mr. Thorleif Haugland	ECON
Task 11	Mr. Yu Kaiheng Ms. Mo Xiuzhen Mr. Zhu Changjian	GRIEP GEMC GRIEP	Shuang Jurong Zhang Xiaogang, Wang Boguang, Sun Qun, etc.	Mr. Andrew Yager Mr. Dag Tønnesen Mr. Steinar Larssen	IFE NILU NILU
Task 12	Mr. Chen Nengjian Ms. Liu Li	GEMC GEMC	Fu Cun, Hu Guipin, Chen Chan, Weng Shifa, Cui Xia, Fang Xingqin, etc.	Mr. Dag Tønnesen	NILU

Responsibilities

a) Making annual Detailed Work Plans (DWPs) to be discussed at the October workshop each year.

b) Carrying out the work on the task according to the DWP.

c) Reporting status of the work at each workshop, and writing annual reports.

Notices:

GEPB	-	Guangzhou Environmental Protection Bureau
GSTC	-	Guangzhou Municipal Science and Technology Commission
SSTC	-	State Science and Technology Commission
GRIEP	-	Guangzhou Research Institute of Environmental Protection
GEMC	-	Guangzhou Environmental Monitoring Center
GESI	-	Guangzhou Environmental Supervision Institute
GMGO	-	Guangzhou Municipal Government Office
GFIILP	-	Guangzhou Foreign Intelligence Import Leading Group
GPEPB	-	Guangzhou Province Environmental Protection Bureau
CAE	-	Chinese Academy of Engineering
CRAES	-	Chinese Research Academy of Environmental Sciences
CAS	-	Chinese Academy of Science
GGNTDC	-	Guangzhou General New Technology Company
NILU	-	Norwegian Institute for Air Research
ECON	-	Center for Economic Analysis
IFE	-	Institute for Energy Technology
CICERO	-	Center for International Climate and Energy Research

Annex 3

Task team leaders and participants

Task team leaders and participants

Task	*Guangzhou side*			*NORCE side*		
	Name	***Institution***	***Period****	***Name***	***Institution***	***Period****
1. Emissions	**Huang Qingfeng**	GEMC		**Frederick Gram**	NILU	
	Chen Yanning	GEMC				
	Kuang Junxia	GEMC				
	Sun Qun	GEMC				
	Jian Jianyang	GESI				
	Pan Nanming	GRIEP				
	Wang Daoming	GRIEP				
	Yang Shourou	GRIEP				
	Others	GEMC/GRIEP				
2. Coal pollution	**Zhong Jieqing**	GRIEP		**Fridtjof Unander**	IFE	1996-1997
	Li Kangmin	GGNTDC		**Andrew Yager**	IFE	1997-1999
	Chen Hao	GRIEP		Thomas Krogh	IFE	1998
	Wang Daoming	GRIEP				
3. Dispersion	**Fang Xingqin**	GRIEP	1996-1998	**Atle Riise**	NILU	1997
	Wang Daoming	GRIEP	1999	**Leiv Håvard Slørdal**	NILU	1998
	Cui Xia	GRIEP		**Rune Ødegaard**	NILU	1999
				Frederick Gram	NILU	
4. Monitoring	**Dong Tianming**	GEMC		Steinar Larssen	NILU	
	Song Weiping	GEMC		Thor Christian Berg	NILU	
	Sun Dayong	GEMC				
	Others	GEMC				
5. Exposure	**Weng Shifa**	GRIEP		**Atle Riise**	NILU	1996-1997
	He Liangwan	GRIEP		**Leiv Håvard Slørdal**	NILU	**1998**
	Li Zhiqin	GRIEP		**Rune Ødegaard**	NILU	**1999**
	Zhang Jinhong			Frederick Gram	NILU	

* The full 3-year period, unless otherwise noted.

Task	*Guangzhou side*			*NORCE side*		
	Name	***Institution***	***Period****	***Name***	***Institution***	***Period****
6.1 Health damage	**Li Zhiqin**	**GRIEP**		**Kristin Aunan**	**CICERO**	
	Chen Yang	GEMC		Alena Bartonova	NILU	
	Xing Qi	GRIEP		Jocelyne Clench-Aas	NILU	
	Huang Xiaoshan					
	Chen Weina					
6.2 Materials damage	**Tian Kai**	**GRIEP**		**Jan F. Henriksen**	**NILU**	
	He Liangwan	GRIEP		Guri Krigsvoll	NILU	
6.3 Vegetation damage	**Su Xing**	**GEMC**		**Thorjørn Larssen**	**CICERO**	
	Yang Danjing					
7. Control options	**Cui Xia**	**GRIEP**		**Andrew Yager**	**IFE**	1998-1999
	Fan Changzhong	GRIEP		**Fridtjof Unander**	**IFE**	1996-1997
	Li Zhanlong	GRIEP		Kathrine Sandvei	IFE	1998
	Ye Lin	GRIEP		Thomas Krogh	IFE	1998
8. Scenarios	**Fan Changzhong**	**GRIEP**		**Haakon Vennemo**	**ECON**	
	Cui Xia	GRIEP				
	Li Zhanlong	GRIEP		Xu Zhao	ECON	1998
	Wang Daoming	GRIEP				
	Huang Yingyu					
9. Cost-benefit	**Yu Jican**	**GRIEP**		**Haakon Vennemo**	**ECON**	
	Luo Jiahai	GRIEP		Maj Dan Trong	ECON	1999
				Xu Zhao	ECON	1998
10. Policy instruments	**Liang Yujie**	**GRIEP**	**1996-1997**	**Knut Aarhus**	**ECON**	**1998-1999**
	Ge Yi	GRIEP	**1998-1999**	**Thorleif Haugland**	**ECON**	**1997**
	Liao Yungdong	GRIEP		Maj Dan Trong	ECON	1999
	Mo Xiuzehn	GRIEP		Xu Zhao	ECON	1998

* The full 3-year period, unless otherwise noted.

Task	*Guangzhou side*			*NORCE side*		
	Name	***Institution***	***Period****	***Name***	***Institution***	***Period****
11. Motor vehicle pollution	**Yu Kaiheng**	**GRIEP**		**Andrew Yager**	**IFE**	
	Mo Xiuzehn	GRIEP		Dag Tønnesen	NILU	
	Wang Boguang	GRIEP		Steinar Larssen	NILU	
	Zhu Chongjian	GRIEP				
12.	**Chen Nengjian**	**GEMC**	**1997**	**Dag Tønnesen**	**NILU**	
	Liu Li	GEMC	**1998-1999**			

* The full 3-year period, unless otherwise noted.

Annex 4

Summary of project status per December 1997
Objectives and plans for 1998

Summary of project status per December 1997
Objectives and plans for 1998

1. Summary of project status per December 1997

The work on the project has progressed according to the Detailed Work Plans (DWP) produced during and after the kick-off seminar held in Guangzhou in November 1996.

Two workshops have been conducted in 1997:

- Workshop 1/1997: 21-29 April;
- Workshop 2/1997: 19-27 November.

The DWPs were modified to some extent in the 1st workshop.

The first period of the project, the period between the kick-off seminar and the 1st workshop in 1997 (December 1997-April 1998) should be considered a project start-up period. During this period, the participants needed to acquire a deeper understanding of the project as a whole, the expected results, and the place of each task in relation to other tasks, and its place within the whole project.

Status reports have been produced for all tasks at both workshops in 1997. The project status at the 1st workshop has been prepared in a separate report. A status summary from the 1st workshop is given in Annex 1 to this report. The status reports from the 2nd workshop are included in this report, Chapter 2.2. The actual progress of the work has, for some tasks, deviated somewhat from the DWP. There are various reasons for such deviations. Some of the tasks were still in the planning phase at the time of the 1st workshop, since clarification of the actual subtasks in the task was needed. Other tasks, which were well, and easier, defined, were already involved in actual work according to the DWP. Some delays in development and establishment of tools in Guangzhou are also a reason for deviations from the work plans.

After the 1st workshop in 1997, there has been active work in all the 14 tasks of the project. Table 1 shows an overview of those 14 tasks, in addition to the Administration task of the project, and workshops and the exchange program.

The first year of the project has been dedicated to the following main activities:
- Collection of data to provide the necessary basis for the Air Quality Management Strategy and Action Plan development;
- Training;
- Transfer of knowledge and tools.

By the end of 1997, it is apparent that the workshops and other activities on the project has resulted in progress towards all the participants' good understanding of the AQMS development process, the sequence of the steps necessary to carry out in order to develop an air pollution abatement strategy, and the place of each task in this process.

Training has taken place during and after workshops and other visits to Guangzhou (NORCE participants have made total 5 trips to Guangzhou in 1997, in addition to the workshop trips). Also, the 1997 training program included training stays for 5 Guangzhou participants in Norway (for a total of 5.5 months).

Data collection has progressed in all tasks, as described in the status reports.

Transfer of tools is progressing according to the work plans, but with delays for the AirQUIS system. The AirQUIS system transfer to Guangzhou is delayed, due to delay in the development of the version 2 of the system. This tool will be established in Guangzhou in June 1998, according to the current plan.

The status reports of November 1997 are included as chapter 2.2. Some key status items are listed below:

Task 1, Emissions:

Based upon extensive work in 1997, a first version of a complete emission inventory shall be available in March 1998, to be used as input to the KILDER pollution model.
Training in Norway for 1 month during 1997.

Task 2, Energy and coal:

The task team is now in the process of collecting the data needed to make an energy balance, to estimate future coal needs, and study boiler technologies. These data are important for emission inventories and for future scenario development.

Task 3, Dispersion modelling:

The first air quality modelling results will be available by June 1998, based upon the KILDER model and the emission inventory from Task 1.
Training in Norway for 1 month in 1997.

Task 4, Monitoring:

Purchase of monitors was prepared in 1997, and in now in progress. Evaluation and modification of the monitoring network is delayed, but will take place in 1998 when the requested AQ data are available from Guangzhou.
Training in Norway for 1 month during 1997.

Task 5, Exposure calculations:

This task is preparing for calculations, but awaits results from Task 3. Task 5 represents a link between the AQ modelling results and the assessment of damage (Task 6).

Task 6.1, Health damage assessment:

Substantial planning work was done in 1997, with e.g. development of questionnaires. The health studies and data collection needs more substantial funds and manpower, and the priority of this task needed to be strengthened. It

seems like this has now been done by the Guangzhou side, and the extra funds and manpower will be provided. Due to this, the questionnaire study will take place in early 1998.
Training in Norway is planned in 1998.

Task 6.2, Material damage assessment:

This task got a very good start during and after the kick-off seminar. A one-year field exposure program started already early 1997. This has been maintained during the year, and methodologies for damage assessment has been transferred.

Task 6.3, Vegetation damage:

Data collection is in progress. A problem here is the lack of dose-response functions for the damage items.
Training in Norway for 2 weeks in 1997.

Task 7, Control options:

After a period of better definition of the task work, the data collection is now in progress, re. energy use and balance (close connection with Task 2), and data on existing technologies. Transfer and training in the MARKAL model took place in Guangzhou in November 1997.
Training in Norway is planned in 1998.

Task 8, Baseline scenario development:

Transfer of knowledge and tools has taken place, and data for scenario development are being collected. The baseline scenario should be finished by June 1998.
Training in Norway planned in 1998.

Task 9, Cost-benefit analysis:

Knowledge transfer is taking place. Extensive work has been carried out at ECON on cost/benefit items related to control of vehicle emissions. The work will be intensified in 1998, to prepare for the use of the C/B analysis method during the autumn 1998.
Training in planned in Norway in 1998.

Task 10: Air pollution management and policy instruments:

Institutional framework for pollution control, and environmental regulations and policies in China and Guangzhou has been studied and reported. This task will be ready to make its input to the development of the first action plan in late 1998.
Training for 1 month in Norway during 1997.

Task 11, Vehicle pollution:

This task should extract data on the contribution from vehicles to the air pollution situation in GZ derived in other tasks, and also provide data on emissions from vehicles, and traffic and road data to the other tasks. Such work is now in progress.

Task 12, Air pollution forecasting:

Preparations for establishing a forecasting system in GZ is in progress. There is some delay relative to the work plan.
Training was provided during 1 month in Norway in 1997.

In summary, the work during 1997 progressed mainly according to plans, and has provided a good starting point for the continued work in 1998. There are some delays that need to be corrected early in 1998.

A number of people from the task teams participated in a NEPA/ODA course on Environmental Economics in Guangzhou during the 1st half of November, 1997.

2. Use of funds during 1997

NORCE side

Budget for "1st year" (1996+1997):NOK 5,197,000
Total spent, 1996+1997NOK 4,901,344
Funds transferred to 1998 budgetNOK_ 295.656

Details regarding budget and costs for 1996+1997 are shown in tables in chapter 7.1.

There is excess expenditure on some tasks, mainly Task 6 (Damage assessment) and Task 9 (Cost/benefit analysis), due to more work needed than expected when planning the project, and because work has been moved forward from 1998 to 1997. On other tasks, all funds have not been spent, due to delays for the various reasons summarised above.

The excess expenditures will be corrected during 1998 and 1999. The remaining funds on other tasks will be spent during 1998 when the delayed tasks are carried out.

Guangzhou side

Funds supported by Guangzhou government were planned as 4.671 million RMB (3.566 million NOK). According to the real status of the project, the expenses in 1997 were 3961050 RMB (3024000 NOK). The rest funds are transferred to be used in 1998.

3. Summary of project objectives for 1998

The project objectives for 1998 are described in chapter 4.1.

A summary of this is as follows:

- For the task work: To continue
    - towards improved knowledge in each task topic;

  - training in the use of the tools;
  - completion of the data collection.

  The effort to complete the data collection is particularly important. Important is also to assure the quality of the data collected.
- For the AQMS analysis: To complete the first full sequence of analysis of costs and benefits of air pollution control in Guangzhou, based on some selected short-term abatement alternatives. This will a "trial run", gaining experience for the subsequent more complete analysis, with development of an action plan for short- and medium-term abatement and control alternatives.
- For the action plan development: A first draft of an action plan for short-term control options shall be developed by the end of 1998.

A detailed task/time schedule for the work in 1998 and later has been developed, and presented in Chapter 3. The schedule shows the flow of information between the various tasks, and the sequence of calculations and analysis that leads to the development of strategies for air pollution control, and action plans.

4. Summary of the work plan for 1998

The DWPs for 1998 are included in this report (chapter 4.3). A summary of the plans is given in chapter 4.2. An overall summary of the plans for 1998 is as follows:

The task/time sequence figures (

- Figure 2 and Figure 3 in chapter 3) shows the main activities of each task in 1998. The task work in 1998 is geared towards fulfilling the project objectives described above. Some fine-tuning of the DWPs is still necessary to make sure that there in compatibility between the objectives and the task plans, and that the sequence of analysis can be followed.

  It is an important task for the Project and Technical Leading Groups to follow up the task work to make sure that the objectives of 1998 will be fulfilled.

- The planned exchange program for 1998 includes training periods in Norway for 5 people from Guangzhou on the following tasks: Task 1, 6.1, 7, 8, 9.

- Two workshops are planned for 1998:
  - In Norway, probably in May;
  - In Guangzhou in October/November.

- Task visits to Guangzhou are planned for all tasks.

- Procedures for accepting and publishing reports from the project will be made.

Annex 5

Summary of project status per December 1998

Summary of project status per December 1998

1. Status of 1998 Project Work. Summary

Based upon the Status reports presented at Workshop 2/98 in November 1998, the following is the overall project status:

Knowledge transfer, and training

- Much has been done as part of the task work, and the exchange program.
- Mrs. Li Zhiqin will go for training in Norway in 1999, and that will complete the exchange program.

The Exchange program in 1998 is described in section 2.4 in this report.

To enable a good completion of the knowledge transfer and training, the Task Status reports for 1998 contain an overview of what has been accomplished, and what should still be done (see Workshop Report 2/98).

Transfer of tools

The following tools have been transferred by now:

- Air pollution models (KILDER, ROADAIR, and EPISODE for forecasting);
- AirQUIS system (pre-release of version 2.0. Final version in February 1999);
- Materials' damage cost model (CorrCOST);
- MARKAL.

The Status reports contain an overview, and a completion plan (see Workshop Report 2/98).

Air Quality Management System

- Task work has been carried out according to the original Project Plan, towards establishing AQMS analysis capability in GZ, and a system/organisation in GZ to continue the work. This also includes the collection of necessary data, and establishment of groups that are familiar with the work, which can be continued after the project in finished;
- Emission inventory for GZ (1st version) has been made;
- 1995 air quality data and meteorological data (also 1990-1995 air quality data) have been collected;
- KILDER calculations/preparations for AirQUIS calculations have been performed;
- Damage assessment methods have been transferred (health and materials);
- Energy analysis carried out / fuel use analysed;
- Scenarios for future development has been made;
- Cost data on control options and health endpoints must be developed further, and very soon;

- Integration of tasks into a system of analysis, and team organisation: This must be developed further during 1999;
- 1st sequence of analysis: Carried out successfully and almost completely, according to plan (see Workshop Report 2/98). The main purpose was:
    - training in carrying out the AQMS analysis;
    - simulate cost-benefit of some actual measures.

  The 1st AQMS sequence was prepared with substantial guidance and leadership from NORCE. It is important that the GZ side go through the analysis on their own, and continue this work in 1999 as part of the Action Plan 2001 development.
- Organisation of AQMS work at GRIEP/in GZ must be well developed before the end of the project.

Action Plan development

- A 1st version has been proposed;

This work shall be continued with high priority, according to the plans for this (see e.g. the task/time sequence Figure 1 and

- Figure 2). This is one of the main topics of the work in 1999.

Monitoring System Improvement

- A large number of new instruments have been purchased, partly for funds available in this project, and put into operation.
- Evaluation of the present system is being carried out, and modification of the monitoring system will be implemented.
- Quality control and assessment work and guidance from NILU started in 1998.

Critical delays

Some delays may soon become critical, seen in relation to a successful completion of the project, if certain tasks are not carried out soon:

Task	
1	Emissions data to be input into AirQUIS. Must be completed before Spring festival (by the middle of February, 1999). Task 1 work.
3	AirQUIS: A fully operational version must be made available before the end of Spring festival (by end of February 1999 at the latest). NILU must deliver.
4	PM_{10} and O_3 data must be made available. Task 4 work.
5	Future population data (distribution in GZ) must be worked out. Task 1 work.
6.2	Building materials inventory must be finished early in 1999.
7	Data on costs of control measures must be developed and available early in 1999.
7, 1	Data on process emissions must be made available early in 1999.
9	Costs of health effects (for specific health “endpoints") must be developed for GZ and made available early in 1999.
11, 1	Data on Chinese emission factors for motor vehicles must be made available early in 1999.

2. Workshop Activities, 1998

Two workshops were carried out in 1998, according to plans. It is referred to the separate workshop reports for details.

Workshop 1/98, in Ulvik and Oslo, 11-15 May

- Participants from Guangzhou included the GZ project leader Mr. Wu Zhengqi, and 6 scientists/task leaders. 5 of the scientists stayed in Norway for 4-7 weeks after the workshop, for training. Also, a delegation of 7 representatives from GSTC and GEPB, including the Director of GSTC Dr. Zeng Shidu, participated in the workshop, and had a program visiting various institutions in Oslo.

- The activities of the workshop concentrated on:
  - discussing the work in each task, and modifying further plans where necessary;
  - preparing for carrying out the 1st Air Quality Management Analysis Sequence before the next workshop.

- Recommendations from the workshop included:
  - the need to start to develop candidate abatement measures for pollution control, to be analysed in the 1st AQMS sequence;
  - the need to co-ordinate this project and the UNDP project on NO_x emission control as well as possible;
  - recommendations re. the preparation and conduct of the next workshop.

Workshop 2/98, in Guangzhou and LongGui, 5-13 November

- Participants from Norway included the NORCE project leader, Mr. S. Larssen, and 8 scientists/task leaders.

- Before the workshop started, a team from NILU and NORGIT had installed the AirQUIS system, prerelease of the version 2, on computers at GRIEP, and training on use of the system had started.

- The activities of the workshop concentrated on
  - final preparation and the presentation of the results from the 1st AQMS analysis sequence;
  - discussion of status of task work;
  - development and discussion of Action Plans;
  - preparation and discussion of Detailed Work Plans for 1999.

- The main objectives of the work during 1999, as resulting from the proceedings of the workshop, are to:
  - establish an Action Plan for 2001, and prioritize abatement measures based upon cost-effectiveness analysis;

- finalize all knowledge/tools transfer, incl. documentation in technical reports;
- finalize all data collection (the first "batch");
- develop Action Plan 2010;
- improve monitoring systems;
- finalize and report all task work.

3. Exchange Program, 1998

The Exchange Program for 1998 included the following training stays in Norway:

Name	Task	Host	Period
Jian Jianyang	1	NILU	13 May - 7 June
Fang Xingqin	3	NILU	13 May - 7 June
Cui Xia	2/7	IFE	13 May - 26 June
Fan Changzhong	8	ECON	13 May - 26 June
Yu Jican	9	ECON	13 May - 26 June

The reports from the participants are included as Annex 2.

The main topics of each participants' training were:

Jian Jianyang: Training in emissions inventory work and calculations with the KILDER program:

- Study with Mr. Gram of the emissions and other data brought from GZ;
- how to use the data as input to the KILDER program;
- how to run KILDER programs, and analyze the results;
- discussion of emission factors re fuel use, especially to make use of Chinese factors, as summarized very well in a note by Mr. Jian;
- discussions on how to obtain harbour (ship) and airport (plane) emissions;
- the need to cover also industrial process emissions was discussed.

Fang Xingqin: The planned main topic was training on the AirQUIS system. Because of the delay in the development of the system, a full system could not be provided for the training, although some training (e.g. GIS) was done. Other topics that was covered during her stay at NILU:

- Mathews wind field model (a module in AirQUIS),
- Meteorological data and statistics for input to KILDER model;
- Development of wind field library, for dispersion calculations in GZ.

Cui Xia: Training/instruction on AirQUIS at NILU.
Training at IFE:

- The participants did some research to estimate emission factors based on the “point.xls” file. The suggestions were discussed with Task 1.
- To get a better knowledge of the energy system, the participants made some energy flow maps based on information from the Energy Balance. These maps are important to understand how the MARKAL system works.
- The instruction and training of MARKAL was continued. Since the information from GZ was not completed, the participants spent time using the model with some fictitious numbers (demo version).
- In co-operation with Task 9 some case studies were started. The participants selected 4 main industry sectors and started to collect more specific information of these sectors.
- A meeting at ABB Miljø in Oslo, to get information on the work by ABB in Schenzhen, China.

Fan Changzhong: Training at ECON on:

- Development of baseline scenario
- Sector distribution and activity indicators.
- Development of target scenario.

Yu Jican: Training at ECON on the principles of cost-benefit assessments, valuation of morbidity and mortality, designing a spread-sheet model of cost-benefit assessment of air pollution in Guangzhou, training on the spread-sheet model.

Annex 6

Objectives and plans for 1999

Objectives and plans for 1999

Objectives and Work Plan for 1999. Summary

1999 is the last year of the 3-year project. During the 2 first years there was a concentration on the following:

- transfer of methodologies, tools and instrumentation, and training through the exchange program and through the task work, where the GZ and NORCE teams work together.
- collection of the data needed for an objective air quality management process, and action plan development based upon cost-benefit analysis.

Most of this work has been finished, although some parts of it need to be completed.

In 1999 the work must concentrate on the development of the Action Plans.
The main objectives for the work in 1999 are shown below:

1999 WORK PLAN MAIN OBJECTIVES
First priority: • Develop action plan related to 2001. Further objectives: • Finalise all knowledge / tools transfer incl. documentation (in technical reports) • Finalise data collection, the first "batch" • Develop Action Plan related to 2010 • Improve the monitoring system • Finalise the all task work • Final reporting

Based upon this, the work plan for 1999 can be divided in several parts:

1. Make AirQUIS operative at GRIEP	:	by end of February, at the latest)
2. Completion of data collection	:	January - March
3. Action Plan 2001 development	:	January - May
4. Completion of training program	:	January - October
5. Completion of task work, incl. reporting	:	by October
6. Action Plan 2010 development	:	March - November

7. Final reporting to NORAD / MOST : by March 2000.

The two workshops in 1999 will be held in May and November, both in Guangzhou. This is described in the Agreement between the GZ and NORCE sides, about the 1999 work program (see Annex 5).

Detailed Work Plans (DWP) for each task are given in the Workshop 2/98 report.

Details regarding each of the above points are:

1. Make AirQUIS operative at GRIEP

A prerelease version of AirQUIS 2.0 was installed at GRIEP in November 1998, and selected persons given training. The prerelease version is suitable for the input of the necessary data (emissions, meteorology etc.) for the later model calculations. A final version of AirQUIS 2.0 will be installed before the end of February 1999.

2. Completion of data collection

In several of the tasks completion of data collection is necessary. This is detailed in each of the DWPs (see Workshop 2/98 report).

3. Action Plan 2001 development

The development process of the 2001 Action Plan as agreed at Workshop 2/98 in November 1998, is as follows:

1. The 1st selection proposed at the workshop 12 November 1998 to be evaluated By 15 December and amended, and sent to Guangzhou task 13.
2. GZ side to comment and completed, and send to NORCE side for final comments.By 10 January.
3. More commenting rounds may be necessary, but the final list of selected measures must be ready by end of January, at the latest.
4. GZ side will continue the work on the Action Plan document, By 31 January with a view to the contents list of the document proposed by NORCE side (updated draft, during the meeting at GRIEP on 11 November, background part).

   An updated version of the outline, and the background part of the document should be ready for commenting by NORCE side before the end of January. NORCE will be ready to assist in the writing of the updated draft, when requested by GZ side.

   The following chapters of the document will be written after January.

4. Completion of the training and exchange program:

This concerns several of the tasks. Details are given in the DWPs (see Workshop 2/1998 report).

The exchange program will be completed in 1999. Ms. Li Chiqin will stay in Norway for 4 weeks, related to task 6.1 training: health effects of air pollution.

5. *Completion of task work, incl. reporting:*

Details are given in DWPs. Several reports are planned in each of the tasks. The present list of task reports is given in chapter 0 below.

6. *Action Plan 2010 development:*

This work should start during Spring 1999, by developing further the List of selected measures used as basis for the Action Plan 2001. The further detailed plan for the work on the 2010 Action Plan must be made by the Workshop in May 1999.

7. *Final reporting to NORAD / MOST:*

The final reports to NORAD / MOST shall be delivered before March 2000.
The contents of the final reporting, and the time schedule for this, will be discussed during the workshop in May 1999.

Annex 7

Baseline scenario 1995-2001

- **Specifications of changes in the emission inventory of 1995 (NORCE note of 26 March 1999)**
- **The data Task 8 provides for Task 1 to construct the 2001 and 2010 emission inventories (GRIEP note of September 1999)**

Guangzhou AQMS project
STL/26.03.99

NOTE

Baseline scenario 1995 - 2001

Specification of changes in the emission inventory of 1995

1. Introduction

The base year for the Guangzhou AQMS project is 1995, and an emission inventory has been prepared by Task 1 for 1995. This emission inventory has been used in the 1st AQMS analysis sequence, to calculate air pollution concentrations and exposure in Guangzhou for 1995, using the KILDER model. The emission inventory has been loaded into the AirQUIS 2.0 system at GRIEP.

AirQUIS is going to be used by Task 3 to calculate concentrations and exposure for 2001, as part of the Action Plan 2001 development, and later for the 2010 concentrations. Then the emission inventory has to be modified to 2001, according to the base-line scenario (or the most likely scenario) developed by Task 8.

This note describes how we propose that the emissions are updated to 2001, in the AirQUIS data base. The proposal is based upon the Task 8 report by Mr. Fan Changzhong:

2. Specification of changes

2.1 Population amount and distribution

Mr. Fan's report gives the following population figures (excluding the floating population, which is estimated to be about 5% of the stationary population:

- 1995: 6.47 mill
- 2000: 7.05 mill:increase: 9% over 5 years.

From 1995 to 2001 we thus estimate that the total Guangzhou population increases by 11%.

Data in Mr. Fan's report suggests (in Table 1-8) that the population increases most in the "old downtown center" (4 districts, 54 km^2). There, the population density is estimated to increase about 18,000 to about 37,000 per km^2 from 1995 to 2000. This difference in population changes in different areas, if they are considered correct, should be taken into account when updating the population data in the data base. Use

Table 1-8 in Mr. Fan's report to find the factors for change to apply in the different areas. For instance, in the old downtown area (4 districts), the factor from 1995 to 2001 will be 2.05.

2.2 Point sources

2.2.1 Large point sources:

These are power plants and large industries, defined as sources with large fuel consumption. New point sources that are or will be established, must be included in the data base. Also, the data for all large point sources must be checked, so that changes or modifications in existing industries are included in the 2001 data base. Changes may occur in consumption, fuel type, technology changes that changes the emission factor, etc.

Power plants:

Mr. Fan's report lists a number of new power plants, and new units in existing power plants, that have been and will be put into operation between 1995 and 2001. These have to be included in the point source file.

We propose that Mr. Fan takes responsibility for obtaining the necessary data on these new plants and modifications in existing plants, the same type of data as for the Power plants already in the data base:
- location (x and y coordinates, at least approximately);
- fuel data (what type of fuel, S contents, consumption, etc.);
- emission factors;
- alternatively emission amount directly, if data exist (SO_2, NOx, particles);
- emission cleaning equipment and efficiency;
- time variation of emissions.

These data must be given to Mr. Jian, and discussed with him (quality assurance). It may also be wise to include Mr. Jian directly in the data collection on these new plants.

Large industries

If new large industries have been or will be established in 1995-2001, and also if changes are made in existing plants for 1995-2001, this must be included.

The procedure is the same as above for the power plants.
We propose that Mr. Fan takes responsibility for organizing the data collection, together with Task 1.

2.2.2 *Small point sources*

Small point sources are added together in the existing emission inventory, and treated as an area source, for which there is an emission field for 1995, in the emission inventory.

This emission field must be adjusted from 1995 to 2001, based upon the prognosis for changes in total fuel consumption from 1995 to 2001: Coal, oil.

Coal: The estimated increase in coal consumption, excluding the consumption for electricity consumption, from 1995 to 2000 is about 8% per year, i.e. totally about 57% from 1995 to 2001 (Table 2-29 in Mr. Fan's report). <u>So, multiply the coal consumption in the small point source field by 1.57. Unless more detailed data are available, use the same factor for all the grid squares.</u>

Oil: The fuel oil consumption for industry in Guangzhou is estimated to increase by 12% over the period 1995-2000 (Table 2.39 in Mr. Fan's report). <u>So, multiply the oil consumption in the small source field by 1.12, uniformly over all the grid squares.</u>

Emission factors?

2.3 Traffic

2.3.1 *Amount of total traffic*

<u>Alternative 1:</u>
From Table 2-8 in Mr. Fan's report can be estimated that the transport demand for road traffic, in the morning rush hour, will increase on the average about 5% per year from 1992 to 2010. The vehicle population is expected to grow about 10% per year in 1995-2000 (Table 2-9).

We propose to use an annual increase in road traffic of 5% per year , i.e. 34% from 1995-2001. <u>Unless more detailed data are available, we propose to multiply the traffic amount on all streets in the traffic data-base with 1.34.</u>

<u>Alternative 2:</u>
From the Inner ring road study, we know that there exists traffic data for 2000 for most of the road network in Guangzhou, probably calculated using a traffic distribution model. These data probably exist in electronic form. It would be of great advantage to our project, if these data were made available to the project. Then they could be used more or less directly for the 2001 traffic amount.

2.3.2 *Traffic speed*

This is estimated to increase somewhat during rush hours, probably based upon the belief that the construction of new road sections will reduce the traffic congestion, even if the vehicle population increases. Also, the opening of the No. 1 Metro line will help to reduce the congestion on roads in some areas. During the rest of the day (outside the rush hours), the traffic speed would probably not change much from today's conditions.

We propose that the speed data in the data base are not changed from what they are now. The NOx emissions are not very sensitive to traffic speed.

2.3.3 Vehicle composition

The composition of vehicles in the traffic, on the average, is projected to change from 1995 to 2010 (Table 2-10 in Mr. Fan's report). From this Table, the following distributions can be calculated:

		1995	2010	2001 (interpolated)
Cars	%	6.3	10.5	8.0
Taxis	%	16.0	7.4	10.8
Buses	%	60.7	62.5	62.9
MCs	%	17.0	19.6	18.3

Thus, the projection means that the vehicle composition in the traffic changes, with less light duty gasoline vehicles (cars plus taxis) in 2001 than in 1995, and increased contribution from buses! The MC part is projected to be unchanged. This projection might have been made before the recent regulation to not issue more new MC licences.

It should be noted that the vehicle type distribution in the table above disagrees substantially with the distribution which comes from the data collected in Tasks 1 and 11. The distribution above may be on persons carried by the various transport means, rather than vehicle distribution as such.

Note:

This note has not touched on the quotation of modifications of emission factors. This is not so important for the development towards 2001, but will be more important for the baseline scenario towards 2010.

The data task 8 provides for task 1 to construct the 2001 and 2010 emission inventories

(Note by Mr. Fan Changzhong, September 1999)

1. The specific change of population

1.1 The population in 1995

The population in each district and suburb county of Guangzhou citywide is able to be looked up from the Guangzhou Statistic 1996 Year Book. The detailed results are listed in Table 1.

Table 1: The registered permanent residences in each district and suburb county of Guangzhou citywide

Regions	Area of lands km^2	The population in the end of each year (persons)	Population density persons/km^2	Families in the end of each year families
Whole city	**7434.4**	**6467115**	**870**	**1871173**
Urban area	**1443.6**	**3853751**	**2670**	**1172515**
Dongshan district	17.2	576573	33522	171036
Liwang district	11.8	531326	45028	170116
Yuexiu district	8.9	458281	51492	145313
Haizhu district	90.4	738910	8174	225591
Tianhe district	108.3	426058	3934	118480
Fangcun district	42.6	159546	3745	50772
Bai yun district	1042.7	783014	751	235575
Huangpu district	121.7	180043	1479	55632
Suburb county-level city	**5990.8**	**2613364**	**436**	**698658**
Panyu city	1313.8	851573	648	245367
Hua Du city	961.1	557959	581	151439
Zhengcheng city	1741.4	732965	421	183215
Chonghua city	1974.5	470867	238	118637

1.2 The specific change of population of Guangzhou during 1995-2000-2001-2010

1.2.1 The specific change of population of total registered permanent residence

The reference, Toward a Modern International Metropolis-ninth-five year Plan and the 2010 Prospective Targets of Guangzhou, released a medium total population change scenario for Guangzhou city during 1995-2000-2010. The detailed results are shown in Table 2.

Table 2: The change of total registered permanent residences in Guagnzhou during 1995-2000-2010 (unit 10,000 persons)

	1995	2000	2005	2010
Whole city	646.7115	705.23	745.75	785.26
Urban area (8 districts)	385.3751	408.39	420.24	441.96
Suburb (4 counties)	261.3364	299.84	325.51	343.30
remarks:The population in 1995 is actual statistic number				

1.2.2 The change of floating population

According to the statistic data in 1995 there are 1.65 million floating persons in whole Guangzhou city. According to the planning, the Urban Master Plan (Draft) during 2000-2010 the each year's floating population of Guangzhou will be controlled under 1.50 million persons.

1.2.3 The planning for the population density in old urban area of Guangzhou city

The old urban area of Guangzhou includes Yuexu district, Dongshang district, Liwan district and the old streets of Haizhu except for the Xingjiao town and Chigang street. It covers 57 square kilometers. In the future with the development of subway system, road network and new district and by adopting some control, regulation and guidance policies, the persons will be evacuated out of the old urban area and the population density will reduce from 37344 persons/km^2 in 1989 to 34500 persons/km^2 in 2000, 32000 persons/km^2 in 2005, 30000 persons/km^2 in 2010 25000 persons/km^2 in the long term.

Table 3: The population density development planning in old urban area of Guangzhou

Districts	Area km^2	1989	1995	2000	2005	2010	After 2010
Total	57	37344		34510	32000	30000	25000
Yue Xiu	8.95	54398	51492	49000	45000	40000	25000
Liwang	11.8	49660	45028	41000	36000	31000	25000
Dongshang	17.2	31378	33522	32000	30000	28000	25000
Haizhu	19.7	27954		28000	26000	25000	25000

Reference: Toward a Modern International Metropolis-ninth-five year Plan and the 2010 Prospective Targets of Guangzhou

1.2.4 The great new residential area developed in near and medium term

According to the Urban Master Plan (1991-2010□(Draft in the near and medium term several great residential area will be developed in Guangzhou. The detailed results are shown in the Table 4.

Table 4:The great new residential area developed in the near and medium term

Name of residential area	Location	Area (km^2)	Planning population persons	Construc-tion time
Zhujian New Urban Center	The east, west , north and south of this area are Huanan road, Guangzhou Dadao, Huanpu Dadao and Zhujian respectively	6.6	17	in 15 year
Shabei Hensha development area	In the northwest of urban area and its east, north , west and south near to the Baisha river, Lishui town, Zhou Cun and Baisha Cun respectively	7.63	14.5	before 2010
Da Tan Sha Bei residential area	In the west of urban area and it is surrounded by river. The Zhujian bridge divide the Da TanShan into two parts and the planning residential area is located in the north part.	2.42	10-12	before 2010
Noxi Da Qiao Bei development area	In the south of Haizhu district. The north of the out-channel of Pearl River. Its length along the Pearl River is 7.87 kilometer.	10.8	14	before 2010
Xingzhou development area	In the northeast of Haizhu district. In north it close to Pear River, in the south it close to Hupu stream, in the west it close to the Chigang new district.	13.05(in which, land: 9.85, water surface: 3.2)	14.5	before 2010
Huadiwang residential area	In the Dongjiao town, in southwest of Fangcun.	102.6 hectare	8	before 2010
ChiGang new area	In the east tt close to Xingzhou development area, its south is the backland of Haizhu district and in the west it stride across the Guangzhou Da Dao.	129.8 hectare		before 2010

2. Transportation development

2.1 Out-walk mode forecast

According to the research results given by the Guangzhou Transportation Development Planning and the Guangzhou Urban Master Planning (Draft) (1992-2010) under the assumption that the economic development follows the medium scenario the forecasted optimum out-walk mode scenario in 2010 is shown in the Table 5.

Table 5:The out-walk mode of people in 12 hours in 2010 (unit: 1000 person-times)

Year		Car	Motor Cycle	Bus	Taxi	Bicycle	Subway	On foot	Total
1992	Actual out-walk amount	117	532	1806	503	2804	0	2540	8320
	Percentage(%)	1.4	6.4	21.7	6.1	33.8	0	30.6	100
1995	out-walk percentage(%)	2.6	7	24.8	6.6	29.5	0	23.2	100
2010	Actual out-walk amount	930	996	3513	518	1761	1606	2813	12138
	Percentage(%)	7.7	8.2	28.9	4.3	13.2	14.5	23.2	100

2.2 The ownership of motor vehicle increase in the future years

(Task 11 is predicting the ownership of each type of motor vehicle in the future years)

2.3 Traffic speed

According to the research results of Guangzhou Urban Master Planning (Draft) (1992-2010), during the morning rush hour in 2010 the general average speed of motor vehicle is able to reach 32.6 km/h and the overall situation is satisfactory. Though the ownership of motor vehicle will increase greatly in the urban central area, in which the traffic speed is still able to maintain at the level of 1995, i.e. 5.9 km/h between north and south and 16.6 km/h between east and west. The detailed forecast results are shown in the Table 6.

Table 6: The speed of motor vehicle running in each area (unit km/h)

Time	Regions	Running direction	1995	2010
Morning rush hour	Central area	N-S	16.1	15.9
		E-W	16.6	16.6
	South	N-S	20.1	27.2
		E-W	19.7	28.9
	East	N-S	23.6	36.8
		E-W	26.9	29.0
	North	N-S	23.2	21.5
		E-W	22.1	29.8
	Overall average speed			32.6

According to some reliable materials the motor vehicle running speed in the urban central area will increase from 16.8 km/h to 22 km/h after the project, the transportation ameliorating in the Guangzhou central area, is completed.

2.4 The road network planning

2.4.1 The highway development planning

The Guangzhou Urban Master Planning (Draft) (1992-2010) released the scenario of highway network development. The detailed results are shown in the Table 7.

Table 7: The development scenario of highway

Road name	Planning width (m)	Length (km)	Planning traffic speed (km/h)
Around-city highway	60-80	60	80-120
Guanghua highway	60	22	
Guangshao highway	100	25	
Guanghui highway	60	6.5	
Guangsheng highway	60	20	
Guangzhu highway (east line)	60	2.8	
Guangzhu highway（west line）	60	1	
Guangfo highway	60	1.5	
Bei er huang highway	100		
Guangzhao highway	100	3.8	

2.4.2 Speed way development planning

The Guangzhou Urban Master Planning (Draft) (1992-2010) released the scenario of express way network development. The detailed results are shown in the Table 8.

Table 8: The development scenario of express way network

Road name	Planing width(m)	Length(km)	Planning speed(km/h)
Guangqing road(107 national east line)	60	18	60-80
Guanghua road(106 national road)	60	22.4	
Guangchong road	60	38	
Guangshan road	60	42.5	
Guangyuan road	60	25.6	
Zhongshan Da Dao (Guangsheng road)	60	14	
Huanan road	80-100	35	
Guangpan road	80	6	
Guangzhong road	60	2	
Guangfo road	60	2	

3. Point source

3.1 Small point source

When we construct the 2001 and 2010 emission inventories the small point sources could be treated as area sources and their emission could be estimated based on the their energy consumption change in the future years.

3.1.1 The energy consumption prediction of whole society in Guangzhou

Toward a Modern International Metropolis-ninth-five year Plan and the 2010 Prospective Targets of Guangzhou issued the energy consumption prediction results for the whole society of Guangzhou. The detailed results are shown in Table 9.

Table 9: The energy consumption of whole society in Guangzhou during 1995-2010 (unit: 10,000 ton standard coal)

	1994 (Actual figure)	1995	1996	1997	1998	2000	2005	2010
The energy consumption of whole society	1419	1539	1670	1812	1966	2315	3401	4882

3.1.2 The coal demand in Guangzhou during 1995-2000-2010

The coal demand in whole society of Guangzhou during 1995-2000

Toward a Modern International Metropolis-ninth-five year Plan and the 2010 Prospective Targets of Guangzhou predicted the coal demand of whole society of Guangzhou during 1995-2010. The detailed results are shown in the Table 10.

Table 10: The coal demand prediction results during 1995-2000

	1996	1997	1998	1999	2000
Whole society total demand for the coal (10,000 ton)	1100	1195	1265	1305	1500
Annual increase rate			8%		
In which, electricity production demand	720	800	850	850	1000
Annual increase rate			8.5%		

The coal demand in whole society of Guangzhou during 2001-2010

Toward a Modern International Metropolis-ninth-five year Plan and the 2010 Prospective Targets of Guangzhou predicted the coal consumption of whole society of Guangzhou during 2001-2010. The detailed results are shown in the Table 11.

Table 11: The coal demand in whole society of Guangzhou during 2001-2010

	2001	2002	2003	2004	2005	2010
Total demand for coal in whole society(10,000 ton)	1750	1900	2150	2250	2350	3000
Annual growth rate			6.1%			
In which, electricity production demand(10,000 ton)	1200	1400	1600	1650	1700	2050
Annual growth rate			6.1%			

3.1.3 The oil demand prediction results

The oil demand prediction results during 1995-2000

Toward a Modern International Metropolis-ninth-five year Plan and the 2010 Prospective Targets of Guangzhou predicted the oil demand during 1995-2000. The detailed results are shown in the Table 12.

Table 12: The oil demand prediction results during 1995-2000 (unit: 10,000 ton)

Oil \ Year	1996	1997	1998	1999	2000	Remarks
Crude Oil	463	477	491	506	527	
Oil used in Industries	108	110	114	115	121	Fuel oil
Oil used for electricity production	185	196	207	220	233	
Diesel	90	95	100	105	110	
Gasoline	39	41	43	45	47	

The oil demand prediction results during 2001-2010.

Toward a Modern International Metropolis-ninth-five year Plan and the 2010 Prospective Targets of Guangzhou predicted the oil demand during 2001-2010. The detailed results are shown in the Table 13.

Table 13: The oil demand prediction results during 2001-2010 in Guanghzou (unit:10,000 ton)

Oil \ Year	2001	2002	2003	2004	2005	2010	Remarks
Crude oil	537	547	558	570	581	640	
Oil used in industries	123	125	128	131	134	150	Fuel oil
Oil used for electricity production	239	247	24	262	270	315	
diesel	116	122	128	135	142	180	
Gasoline	49	50	52	54	56	67	

3.1.4 The city gas development planning

Toward a Modern International Metropolis-ninth-five year Plan and the 2010 Prospective Targets of Guangzhou predicted the gas popularization rate of city gas would reach 80%-90% in 2000 and 95% in whole city in 2010.

3.1.5 Energy utilization efficiency

During 1995-2000 the annual energy saving amount reach million ton standard coal and in 5 years the total energy saving will amount to 500 million ton standard coal. The overall energy consumption per 10,000 RMB industrial production value will reduce from 0.79 ton standard coal in 1995 to 0.7 ton in 2000 and the overall energy consumption per 10,000 RMB GDP reach 2 standard coal in 2000. During 2001-2010 plans to save about 1.20 million standard coal in each year and in 10 years the total energy saving amounts to12 million ton standard coal. In 2010□the overall energy consumption per 10,000 RMB industrial production value will be controlled below 0.65 ton standard coal and the overall energy consumption per 10,000 RMB GDP will be controlled below 1.8 ton standard coal.

3.2 Large point sources

Toward a Modern International Metropolis-ninth-five year Plan and the 2010 Prospective Targets of Guangzhou issued some large projects which will be built before 2001. The emissions of each large point source could be gathered from their EIA report.

Table 14: The information on the emission of large point sources built before 2001

Large point sources	Location	Fuel	Annual Fuel consumption (10,000ton)	Air pollution alleviating technologies	Dust removing rate %	SO_2 emission (ton per year)	NOx emission (ton per year)	TSP emission (ton per year)	Pro-duc-tion value	Production amount	Time variation of emission	Stack height (m)	Stack diameter (m)	Flue gas amount (10,000 cubic meter per year)	Temperature of flue gas (℃)
Guangzhou paper making Plant	Guangzhi Road No. 40	pulverized coal	22.19	ESP	99.2	1689□95	1116□90	436□65		220ton/hour	Continuous running	150	2	266616	
Nanzhu dieseal power plant	Pazhou Village	Heavy oil	4.42	NO		825□65	551□15			4×12510 Kilowatt	Continuous running	24.5	1.4		300
Pearl Power plant 2nd phase	Panyu Tantou	High-quality coal	161	ESP	99	14677□2		1570□8		600MW	Continuous running	210	7	1467280	388K
Pearl Power plant 3rd phase	Panyu Tantou	High-quality coal	161	ESP	99	14677□2		1570□8		600MW	Continuous running	210	7	1467280	388K
Ethylene Project	Datianshan	Ethylene + torch				655□00	951□28	155		88.4ton/hour	Continuous running				
Yancheng vehicle	Xingtang	Coal	1.5	Venchury water-film precipitator	98	571□2	163	23□85			Continuous running	60	2	14900	60
Renming papermaking	Wanqinsha	Coal	11.7096	ESP	99	1236				6000 kilowatt	Continuous running	100	3□5	15□6128	120
Guangzhou iron and steel Plant	Fancun district	Coal				2573.66	1039.00	2355.72							
Pearl steel-making Plant	Dongji and Xiji small region	Coal		Baghouse	95	606.41	163.074	521.718				25-40	0.3-4. 5		50-250
Guangzhou Chemical plant	Yuancun industrial area			Emission reduction		-388.6	-76.77	-1297.39							

Large point sources	Location	Fuel	Annual Fuel consumption (10,000ton)	Air pollution alleviating technologies	Dust removing rate %	SO_2 emission (ton per year)	NOx emission (ton per year)	TSP emission (ton per year)	Pro-duc-tion value	Production amount	Time variation of emission	Stack height (m)	Stack diameter (m)	Flue gas amount (10,000 cubic meter per year)	Temperature of flue gas (℃)
Wuyan-Honda motor cycle	Xingang Xi No. 82		1576.8	NO		63.07□boiler□ 21.54□electricity generator□					Continuous running	55			
Da TanSha rubbish-fired power plant	Da Tansha	Rubbish	1000 ton/year	Baghouse precipitator	--	331.42	331.42	840.958				90		350400	
Guangzhou petrochemical co-generation plant	Da Tianshan	Coal	1×220ton/hour	ESP	99	5320	1792	448			Continuous running	150	4.5	163100	108.6
ABS resin	Da Tianshan	Fuel oil	1800 cubic meter	Organic waste gas fired in low-pressure torch						60,000 ton/year	Continuous running	30□			
Honda Vehicle	Huanpu Hengsha	Coal	2600 ton/year			24.7	28.6	---		30,000 vehicle /year	---	20	0.6	700	

Annex 8

AirQUIS calculations for Action Plan 2001

Guangzhou AQMS project (NORAD CHN 013)
STL/O97009/ 21 Sept.,1999

AirQUIS calculations for Action Plan 2001

Specifications

CORRECTED VERSION, 21 SEPTEMBER, 1999

1. Preparations

1.1 Baseline scenario 2001

The definition of the baseline scenario 2001 has been described in various notes during the last half year. The most up-to-date of those are:
- the note from NORCE (S. Larssen) from 21 May, 1999;
- the note by Mr. Fan which was e-mailed to us on 12 June, 1999.

Those notes provide the necessary background for introducing the necessary factors and changes in AirQUIS (in the emission and population modules) to make an AirQUIS project that represents the year 2001 well.

Task 8 must now, based on this, decide on the baseline scenario for 2001, and introduce, together with the Task 3 team, the necessary changes in AirQUIS.

The concrete proposals for the actual changes to be made should be presented to NORCE.

1.2 Receptor points

The concentrations will be calculated at the following points:

a) the centre points of the 1×1 km (or 2×2 km?) grids in the whole model area.

b) building points near the road network. The selection of the building points can be made as follows: for each road link, calculate the coordinates of the following points:
   - one point on each side of each road link, in the middle of the link, at a distance 15 meters from the edges of the road. (This is to calculated the same way as was done for the receptor points along the road links of the Task 6.1 calculations. Just remember that the points should be 15 from the EDGE of the road, and NOT from the centre line, so the width of the road must be included in the formula). These points must then be defined as BUILDING points.

     Alternatively, if these building points cannot be calculated, use the building points already calculated by Task 5 along the 3 selected roads.

Re. the number of people represented by the building points, see section 3 below.

1.3 Calculation period

The calculations should be done using the previously selected period of 4 months in 1995. The meteorological file covering these 4 months has already been prepared (Task 3 team?).

2. Selection of control measures

For each compound (SO_2, NO_x and PM), calculations should be done successively for a limited number of control measure scenarios. The control measures have been selected based upon the results of the previous KILDER calculations, and the estimates of costs of the control measures, as described in the draft Action Plan 2001 report, and presented at the workshop 1/99.

SO_2

1. 13 PP (Shut down of 13 Power Plants)

   This is simulated by setting their emission factor to 0 (zero) in the emission module.

2. 13 PP + LSC (LSC: Low-sulphur coal in 60 large point sources, the POI 50 file).

   This is simulated by, in addition, reducing the SO_2 emission factor with 33% in the emission module for all sources among the 60 main sources (see Annex A below) except those with fuel codes for heavy fuel oil and diesel and other which is not coal (e.g. sugar residue).

3. 13 PP + LSC + SI (SI: Sorbent injection in the 60 large point sources)

   This is simulated by reducing the emission factors from the previous step (low sulfur coal) with 50%.

4. 13 PP + LSC + WS (WS: Wet scrubbers in the 17 large point sources).

   This is simulated by reducing the emission factors from step 2 (with LSC) with 95%. Alternatively, initial emission factors should be reduced by 96.5%.

NOx

1. 13 PP + LNB/OFA (Low-NOx burner w/over-fire air, on 26 large point sources, listed in Annex B below).

   This is simulated by reducing the emissions from these sources by 45%.

2. LPG/BUS (Fuel switch to LPG on 1000 buses (diesel)

   This is simulated by reducing the emission factor for diesel buses by 50% multiplied by a factor which is equal to 1000 buses divided by the total number of buses.

3. 13 PP + LNB/OFA + LPG/BUS + SCR (Selected catalytic Reduction on 26 large point sources).

This is simulated by reducing the emission factors from step 1 by 80% (emission factors with LNB/OFA should be reduced by 80%. (Alternatively: initial emission factors should be reduced by 89%).

3. Exposure calculations

3.1 Number of people allocated to each receptor point

Population in grids
The population in Guangzhou has in AirQUIS been distributed in 1x1 km2 grids.

Population along roads
In addition, the selected building points near the road network (see section 1.2) shall represent the part of the population which lives and stays near the road network. The number of people to be allocated to the building points may be estimated as described below:

a) If building points are calculated along ALL road links (see section 1.2), then allocate the following number of people to each point: 2 persons x length of the road link (in meters).
b) If only the building points which have been selected by Task 5 already along the 3 selected roads are used, then do the following:
   - multiply the persons allocated to each building point by a factor.
   - Calculate the multiplication factor as follows:
     - The ratio between the total length of the main road network and the length of the 3 selected roads, multiplied by the ratio between the traffic volume averaged over the main road network and the traffic volume averaged over the 3 selected roads. This is done in order to use the substantial work done by Task 5 to make an estimate of the total number of people exposed along the road network.

3.2 Calculation of the population exposure

(To be completed later)

Annex A: List of approx. 60 large point sources for SO2 (POI 50)

No	Name	Contribution $(\mu g/m^3)$[2]	% of load	SO_2 emission (kg/h)	% of emission	X	Y	Emission t/year
8	Zini Sugar Refinery	154,23	1,48	130,00	1,03	26,16	2,77	1 139
9	Zini Sugar Refinery	97,18	0,94	128,58	1,02	26,05	2,76	1 126
10	Zini Sugar Refinery	97,81	0,94	129,41	1,03	26,05	2,76	1 134
19	Hengyun Dian Factory	267,87	2,58	210,32	1,67	45,26	21,20	1 842
20	Hengyun Dian Factory	200,68	1,93	182,67	1,45	45,26	21,20	1 600
22	Hengyun Group Factory	140,90	1,36	72,48	0,57	45,38	20,80	635
23	Hengyun Group Factory	120,98	1,16	61,41	0,49	45,38	20,80	538
27	Gz Yongda Group	101,01	0,97	30,63	0,24	34,00	17,30	268
29	Gz Yongda Group	356,90	3,44	112,15	0,89	34,00	17,40	982
30	Gz Yongda Group	273,25	2,63	234,39	1,86	34,00	17,40	2 053
31	Gz Yongda Group	81,67	0,79	56,33	0,45	34,00	17,40	493
35	Gz Danfei Factory	223,20	2,15	167,98	1,33	32,82	30,10	1 472
36	Gz Danfei Factory	387,28	3,73	135,03	1,07	32,82	30,10	1 183
39	Hp Power Plant	62,75	0,60	295,35	2,34	45,15	22,81	2 587
40	Hp Power Plant	52,22	0,50	245,77	1,95	45,15	22,81	2 153
41	Hp Power Plant	60,90	0,59	286,64	2,27	45,15	22,81	2 511
42	Hp Power Plant	64,63	0,62	304,18	2,41	45,15	22,81	2 665
43	Hp Power Plant	68,41	0,66	798,27	6,33	45,39	22,79	6 993
44	Hp Power Plant	52,35	0,50	610,86	4,84	45,39	22,79	5 351
56	Zj Rubber Tire Factory	62,54	0,60	41,10	0,33	3,76	55,41	360
60	Gz Weidagao Factory	204,71	1,97	99,80	0,79	21,75	22,78	874
74	Gz Shihuazong Factory	226,93	2,18	946,52	7,50	44,97	27,27	8 292
75	Gz Shihuazong Factory	126,97	1,22	90,06	0,71	44,69	28,11	789
78	Gz Shihuazong Factory	91,81	0,88	67,86	0,54	45,58	27,80	594
105	Gz Aosan Weijing Factory	168,16	1,62	115,63	0,92	21,17	22,30	1 013
112	Py Meishan Sugar Refinery	112,94	1,09	70,79	0,56	44,26	-5,03	620
113	Py Meishan Sugar Refinery	33,36	0,32	72,93	0,58	44,24	-5,02	639
115	Py Meishan Sugar Refinery	124,28	1,20	326,92	2,59	44,24	-5,03	2 864
116	Gz Zhujing Dian Factory	205,44	1,98	1021,85	8,10	51,70	-7,10	8 951
117	Gz Zhujing Dian Factory	204,65	1,97	987,11	7,83	51,70	-7,10	8 647
126	Gz Power Plant	317,99	3,06	1173,69	9,30	17,30	29,87	10 282
150	Gz Paper Making Factory	172,35	1,66	70,74	0,56	20,83	22,37	620
151	Gz Paper Making Factory	201,67	1,94	106,07	0,84	20,83	22,37	929
153	Gz Paper Making Factory	154,37	1,49	68,78	0,55	20,84	22,38	603
154	Gz Paper Making Factory	195,23	1,88	141,67	1,12	20,71	22,38	1 241
155	Gz Paper Making Factory	180,48	1,74	131,95	1,05	20,71	22,38	1 156

[2] The sum of calculated concentrations in all km^2 grid squares of the field area.

No	Name	Contribution $(\mu g/m^3)^2$	% of load	SO_2 emission (kg/h)	% of emission	X	Y	Emission t/year
158	Gz Zj Cement Factory	6,74	0,06	24,16	0,19	9,00	51,30	212
168	Gz Zj Paper Making Factory	537,97	5,18	99,76	0,79	31,70	26,50	874
180	Gz Zj Beer Factory	80,06	0,77	35,58	0,28	28,50	25,83	312
198	Gz Huaxian Factory	339,12	3,26	85,49	0,68	32,82	27,18	749
204	Gz Steel & Iron Company	105,43	1,02	120,79	0,96	18,70	22,20	1 058
207	Gz Steel & Iron Company	141,27	1,36	53,23	0,42	18,98	21,32	466
208	Gz Steel & Iron Company	164,13	1,58	102,88	0,82	18,98	21,28	901
279	Gz Haotian Huaxue Group	392,14	3,78	82,73	0,66	36,33	25,26	725
342	Py Yuguotou Sugar Refinery	11,40		17,40		29,94	-19,16	152
486	Gz Huaqiao Sugar Refinery	124,37	1,20	66,48	0,53	15,90	32,10	582
487	Gz Huaqiao Sugar Refinery	123,79	1,19	64,78	0,51	15,90	32,12	567
774	Gz Youzhiqi Factory	343,43	3,31	126,79	1,01	37,90	28,12	1 111
1122	Py Lianhuashan Zhi Factory	336,70	3,24	95,99	0,76	45,89	10,99	841
1135	Py Lianhuashan Dianli	1630,24	15,70	356,72	2,83	45,80	11,00	3 125
1161	Xinhua Cement Factory	9,67		10,24		16,12	55,87	90
1192	Nh Dianhuaqiye Group Facto	150,28	1,45	486,99	3,86	11,85	31,78	4 266
1193	NH DIANLISHIYE Group Facto	26,63	0,26	605,86	4,80	-16,13	-0,55	5 307
1194	NH DIANLISHIYE Group Facto	16,17	0,16	118,36	0,94	-16,10	-0,56	1 037
1195	NH DALI Power Plant	65,01	0,63	81,37	0,65	7,55	19,12	713
1200	SD GD Guoyingsugar Refiner	29,14	0,28	58,72	0,47	19,97	-4,11	514
1202	SD GD Guoyingsugar Refiner	20,56	0,20	60,60	0,48	20,07	-4,14	531
1204	SD Power Plant	53,30	0,51	72,40	0,57	20,55	-4,44	634
1205	SD Power Plant	52,37	0,50	89,14	0,71	20,57	-4,41	781

Annex B: 26 large NO_X sources

Stack Name	X	Y	Emission (kg/h)	Contribution (ug/m^3)
Zini Tangc	26,16	2,77	55,62	271,49
Hengyun Di	45,26	21,20	52,09	262,57
Gz Yongda	34,00	17,40	47,98	268,98
Gz Yongda	34,00	17,40	100,27	471,59
Gz Danfeic	32,82	30,10	71,86	396,67
Gz Danfeic	32,82	30,10	53,17	644,49
Gz Weidaga	21,75	22,78	42,70	367,88
Gz Shihuaz	44,97	27,27	234,43	222,05
Py Meishan	44,24	-5,03	128,73	201,61
Gz Zhujing	51,70	-7,10	253,09	208,65
Gz Zhujing	51,70	-7,10	244,49	207,51
Gz Fadianc	17,30	29,87	290,70	322,04
Gz Zaozhic	20,83	22,37	22,43	207,35
Gz Zaozhic	20,83	22,37	34,49	249,51
Gz Zaozhic	20,71	22,38	55,78	304,29
Gz Zaozhic	20,71	22,38	56,45	305,61
Gz Zj Zaoz	31,70	26,50	12,25	264,57
Gz Huaqiao	15,90	32,10	29,16	203,66
Gz Huaqiao	15,90	32,12	28,41	205,83
Py Lianhua	45,89	10,99	30,44	435,25
Gz Huaxian	32,82	27,18	30,70	484,00
Gz Haotian	36,33	25,26	26,20	494,80
Gz Youzhiq	37,90	28,12	54,24	569,58
Py Lianhua	45,80	11,00	96,31	1651,24
Hp Fadianc	45,39	22,79	232,83	81,50
Hp Fadianc	45,39	22,79	178,17	62,40
Sum			2462,99	9365,14

Annex 9

Reports on knowledge transfer, instrument transfer and training programmes provided by NORCE side (from 1997 to 1999)

Sino-Norwegian Cooperation Project

Guangzhou Air Quality Management and Planning System

Reports on knowledge transfer, instrument transfer and training programes provided by NORCE side (from 1997 to 1999). Nov. 23rd 1999.

(by Guangzhou side)

Briefing

According to the proposal of Norway-China cooperation project “Guangzhou Air Quality Management and Plan System” and the agreement achieved by two sides, in order to carry on the study smoothly, NORCE side took in charge of knowledge transfer and instrument transfer. Also NORCE side trained CHINA side staffs on schedule. Through statistics, there were three groups about eleven persons went to NORWAY for training from 1997 to 1999. Accumulative total time was 14.6 months (Table 1); The NORCE specialists (or assigned other specialists) trained 38 researchers of twelve task teams in Guangzhou. The accumulative total time was 45 days (Table 2). As to instrument, GEMC purchased 17 sets of (8 kinds) air quality monitors by use of NORCE side funds. The total value was 195665 US dollars (Table 3). Now all of them are working smoothly. GRIEP has 8 sets (7 Kinds) instruments subsidized by NORCE side. The total value is 1.33 million RMB □0.1606 million US$□ (see Table 4), the total cost of all the instrument including GRIEP and GEMC is 0.3617 million US$. About software, NORCE side supplied AIRQUIS system of ENSIS (2.0) and related form panels, KILDER model, ROADAIR model and EPOSODE model also MARKAL model for energy forecast. AIRQUIS (2.0) system was installed at GIEP, the cost for buying the Models is 0.5 million NOK. The operators were trained on the spot; As to knowledge transfer, 12 task teams were trained and taught the related knowledge respectively (Table 5), the training cost is 0.69 million NOK. The total costs is 4.27 million NOK (0.555 million US$) during the three year of cooperation.

The three-year friendly cooperation of NORCE side and CHINA side (especially the transfer of instrument and knowledge) provided good conditions and research means for the smooth development and accomplishment of this project. At the same time, this cooperation lays a sound foundation for the future research and development of our side. The strict working attitude and the patience of NORCE specialists impressed researchers on china side deeply.

Table 1: Staffs Training

Staff	Time	Location	Train subject	Knowledge acquired
Su X.	1997.8. 17-9.4	1. NILU 2. Oslo University	1. the means of forming emission list; 2. Vegetation damage assessment	1.the concrete method to collect aerial traffic data etc. 2.UTM coordinate system 3.preliminary knew the way of vegetation damage assessment
Fang XQ	1997.9. 4-10.3	NILU	Study KILDER, ROADAIR ,EPISODE etc. air pollution dispersion model	1.studied UTM coordinate system; 2.studied the structure of AIRQUIS database; 3. Understood the application procedure of ROADAIR,EPISODE;4.the collection and disposal of meteorological data
Song WP	1997.9. 4-10.3	NILU	1.the NARI automatic system of quality management and control; 2.the operation, conservation and maintenance of PM_{10},NO_X,SO_2,O_3 monitors	Understood the means of quality management and control of the NARI automatic system
Ge Y.	1997.9. 5-10.3	ECON	The successful experience on environmental supervisory management and the enforcement of policy and act	The function of environmental economic policy in NORWAY
Liu L.	1997.9. 4-10.3-4	NILU	EPISODE model and the application	Systematically knew the content of AIRQUIS, preliminary grasped the application of EPISODE
Fang XQ	1998.5. 9-6.8	NILU	Study the calculation of emission and modeling of AIRQUIS system	1.grasped the application method of AIRQUIS system 2.knew how to handle meteorological data by using KILDER model
Jian JY	1998.5. 9-6.8	NILU	Train on AIRQUIS system related to Task 1	1.grasped the operation method of AIRQUIS system 2.knew the input and output and the formation of report forms
Cui X.	1998.5. 9-6.8	1.NILU;2.IFE	1.the structure of ENSIS system;2.MARKAL model for energy analysis	1.grasped the relationship and characteristics of ENSIS and AIRQUI, and knew the function of GIS and database input and output;2.grasped the application of MARKAL model
Fan CZ	1998.5. 14-6.15	ECON	The formulation and establishment of baseline emission plan, objective emission plan and tendency emission plan	Clearly knew the working way, collected technical documents, preliminary grasped the method to establish the baseline emission plan

Staff	Time	Location	Train subject	Knowledge acquired
Yu JC	1998.5. 18-6.26	ECON	The fundamental principle of cost-benefit analysis, the method to assess the economic losses on public health, construction materials, crops and amenity by air pollution	Basically grasped the fundamental principle and means of cost-benefit analysis, definitely knew the relation to other task teams
Li ZQ	1999.8. 16-10.15	NILU, International weather &Environmental research center	The health damage caused by air pollution ,the application of SPPSS statistic software, the application of the dose-respect formula	Grasped how to carry on the data analysis of dose-respect formula by using SPSS statistic software

Table 2: The condition of training China side staffs in Guangzhou 1997 - 1999

No.	Content	Task team	Time (day)	Harvest
1	environmental economics training	Task 7,9,10	Accumulative total 3 days	Grasped the economic principle and calculation procedure of damage analysis
2	KILDER model training	Task 1,3,5,7	2	Grasped the structure, principle and calculation procedure
3	MARKAL model showing	Task 2,7,,8,9	2	Grasped the structure, principle, the construction of database and calculation procedure
4	AIRQUIS system training	Task 1, 3, 5, 6.1, 6.2, 6.3, 7, 8, 11	Total 25 days (including debug)	Grasped the data input and output, the data correction and transfer, and the operation procedure of form panels
5	Air quality monitoring system QA/QC training	Task4	5	The principle and methods of QA/QC
6	EPISODE model training	Task 12	2	Grasped the forecast method of EPISODE model
7	CorrCost model training	Task 6.2	1	Grasped the input method of model data (EXCEL pattern)
8	The eleventh train of china environmental management applied economics " Industry, energy and air"	Task 2, 6.1, 6.3, 7, 8, 9, 10	5	Knew general principal of environmental economics and applied examples

Annotate: 1.lectuers: NORCE specialists 2.may be uncertain on the statistic of training time

Table 3: Instruments received by GEMC

No.	Item	Type	Producing area	Number	Unit price (US dollar)	Total price (US dollar)	Remarks
1	SO_2	MODEL 43C	USA	3	12990	38970	Including filter membrane nip, instrument rack
2	NO_x	MODEL 42C	USA	4	13380	53520	Including instrument rack
3	CO	MODEL 48C	USA	2	12975	25950	Including filter membrane nip, instrument rack
4	O_3	MODEL 49C	USA	3	9865	29595	Including filter membrane nip, instrument rack
5	PM_{10}	MODEL 650	USA	1	18490	18490	
6	Zero source	MODEL 111	USA	1	5580	5580	Including CO filter, instrument rack
7	Proofed apparatus	MODEL 146	USA	1	15560	15560	Including filter PTO, JPT, instrument rack
8	Meteorological apparatus		USA	1	8000	8000	Including WS□WD□RH□T□P
9	Total			17		195665	

Table 4: Instruments received by GRIEP

No.	Item	type	Producing area	Number	Unit price (ten thousand RMB)	Total price (ten thousand RMB)
1	SO_2 automatic analyzer	MODEL 43C	USA	1	13.72	13.72
2	NO_x automatic analyzer	MODEL 42C	USA	1	13.02	13.02
3	O_3 automatic analyzer	MODEL 49C	USA	2	7.452	14.904
4	VOC low temperature concentration and sampling absorption system	MODEL 650	USA	1 set	72.04	72.04
5	Steel air sampling pot	MODEL 111	USA	1 set		
6	Clean and dilute system	MODEL 146	USA	1set		
7	HP computer station	HP	USA	1	19.65	19.65
8	HP computer server	HP		1		
9	Total			9		133.334

Table 5: The transferred methods and instruments to twelve task teams

Task team	Methods and instruments transferred
1	The establishment of emission list; input, output and transfer of AIRQUIS database
2	The application technique of MARKAL 1.0, the means of energy forecast
3	AIRQUIS system of ENSIS(2.0) and related form panels, KILDER model, ROADAIR model, EPISODE model and MATHEW wind field model
4	The reclamation suggestion of automatic monitoring spots, the statistic analysis of data, automatic air monitors (8 kinds, 17 sets)
5	Supplied the concept of population exposure, the calculation procedure on population exposure of AIRQUIS and KILDER
6.1	Supplied epodemiologic data, the method to calculate public health damage by using KILDER, and instructed to analyze dose-response formula by using SPSS
6.2	Supplied the calculation procedure on material damage, metal hanging pieces, material dose-response formula, and the cost model of material damage.
6.3	The dose-response formula of O_3 damage on crops in Europe and USA, the effect threshold concentration of SO_2,O_3,NOx and NH_3 on crops and forests
7	MARKAL 1.0 model and the application technique, the technique of building energy input database, the optimum control technique on air pollution
8	The building methods of baseline emission plan, objective emission plan and tendency emission plan, the application technique of MARKAL 1.0.
9	The fundamental principle of cost-effect analysis, the method of assessing the economic losses on public health, construction materials, crops and amenity by air pollution, related foreign data
10	The successful experience on studying the enforcement and effect of NORCE environmental protection technical economic policy
11	The control technique of tail-gas pollution and the successful experience
12	EPISODE model for forecast and the application method

Annex 10

The Report on Improvement of Guangzhou Air Quality Monitoring System - Task 13

The Report On the Improvement of Guangzhou Air Quality Monitoring System "

(by Mr. Sun Dayong)

According to the CHN013's agreement based on SSTC and NORAD ,one of the aim of Guangzhou air quality management and planning system (GAQMS) is: renewing and improving Guangzhou Air Quality Monitoring system(AQM) by increasing monitoring means (like parameter and monitoring site, etc).

1. Summary

Aim - improving monitoring system.

The aim is decomposed:

- To increase monitoring parameter.
- To increase monitoring site.
- Correlative training.

Planning:

- 1430000 NOK provided directly by NORAD is used to purchase air quality monitoring equipment.
- One of background monitoring site and one of meteorological observation site are increased in Guangzhou.
- QA/QC training is provided. Guangzhou Environmental Monitoring Center (GEMC) sends 1 person to go to Norway to accept QA/QC training. The expert of NILU will come to Guangzhou to train member of AQM. Plan 2 times.

2. Equipment transfer

The equipment funded from NORAD is used AQM.

These monitoring instruments were purchased in the beginning of 1998 by the China science instrument imports and Exports Company. On April 22 of 1998 these monitoring instrument arrived GEMC, amounts 8 kinds of 21 unit, total value is 230790USD. Four of them (1 SO_2, 1 NO - NO_2 - NOX, 2 O_3)' belong to GRIEP, value is 41559USD. GRIEP's instrument is not included in the below introduction. These instruments of GRIEP are managed according to themselves management procedure.

Checking and accepting:
These transfer instruments are checked and accepted according to GEMC equipment management procedure. The results are shown in Table 1 and Table 2.

Table 1:

Instrument	Model	Producing area	Quantity	Unit price USD	Total price USD	Remark
SO_2	43C	U.S.A	3	12990	38970	Including filter kit, rack.
NO_x	42C	U.S.A	4	13380	53520	Including rack.
CO	48C	U.S.A	2	12975	25950	Including filter kit, rack.
O_3	49C	U.S.A	3	9865	29595	Including filter kit, rack.
PM_{10}	650	U.S.A	1	18490	18490	
Zero air supply	111	U.S.A	1	5580	5580	Including CO cutter, rack
Dynamic calibrator	146	U.S.A	1	15560	15560	Including PTO, GPT, rack
Meteorological instrument		U.S.A	1	8000	8000	Including WS, WD, T, RH, P sensor
Total			17		195665	

Table2:

Instrument	Serial number	State	Accessories	Package	Electrifying	Evaluation	Problem	Principal
CO	48C-60241-326	OK	OK	OK	OK	OK		Huang zuzhao, Zhao haibo, Luo jianbo.
CO	48C-60240-326	OK	OK	OK	OK	OK		
NO_x	42C-59978-325	OK	OK	OK	OK	OK		
NO_x	42C-60356-327	OK	OK	OK	OK	OK		
NO_x	42C-62359-327	OK	OK	OK	OK	OK		
NO_x	42C-60185-326	NO	OK	OK	NO	NO	O_3 tube broken	
SO_2	43C-60371-327	OK	OK	OK	OK	OK		
SO_2	43C-59891-315	OK	OK	OK	OK	OK		
SO_2	43C-57423-313	OK	OK	OK	OK	OK		
O_3	49C-60619-327	OK	OK	OK	OK	OK		
O_3	49C-60320-326	OK	OK	OK	OK	OK		
O_3	49C-60716-328	OK	OK	OK	OK	OK		
Zero air supply	111-58931-321	OK	OK	OK	OK	OK		
Dynamic calibrator	146-60312-326	OK	OK	OK	OK	OK		
PM_{10}	650-60595-327	OK	NO	OK	OK	OK	No Calibration filter	
Meteorological unit	W1837	OK	NO	OK	OK	NO	No bracket	

The notes: The discount is 9.85%. The FOB price is 176392USD. The CIF price is 189232USD. All instruments are included.

Processing of problems:

- The parts of damage have been Changed, and lacking parts have been replenished.
- The bracket used in meteorological unit is a alone equipment. GEMC need to order by oneself. So GEMC still needs to order a bracket.

Debugging:
After checking and accepting, all of transfer instruments are debugged according to demand of China Metrology Accreditation (CMA) and GEMC equipment management procedure. All of index are accordant with environment monitoring technical specification. Debugging results of transfer instrument is shown in Table 3.

Table 3:

Instrument	Model	Environmental condition		Calibrator number	Zero air supply	Standard substance ppm..	Drift at 24 hour mg/m3		Response time	Repeatability %	Linearity
		T□	RH %				Zero	Span			
CO	48C-60241-326	28	67	60312	52321	5000	0.0002	0.0008	OK	0.2	OK
CO	48C-60240-326	28	60	60114	52321	5000	0.0003	0.0008	OK	0.2	OK
NOX	42C-59978-325	27	65	60114	52321	49.5	0.0002	0.0006	OK	0.3	OK
NOX	42C-60356-327	28	67	60114	52321	49.5	0.0003	0.0005	OK	0.1	OK
NOX	42C-62359-327	26	60	60114	52321	49.5	0.0002	0.0008	OK	0.1	OK
NOX	42C-60185-326	25	57	60114	52321	49.5	0.0002	0.0008	OK	0.2	OK
SO2	43C-60371-327	25	55	60114	52321	50.2	0.0002	0.0003	OK	0.3	OK
SO2	43C-59891-315	26	68	60114	52321	50.2	0.0002	0.0005	OK	0.1	OK
SO2	43C-57423-313	28	67	60114	52321	50.2	0.0004	0.0006	OK	0.2	OK
O3	49C-60619-327	28	67	17150	52321		0.0002	0.0002	OK	0.1	OK
O3	49C-60320-326	25	60	17150	52321		0.0002	0.0002	OK	0.1	OK
O3	49C-60716-328	25	52	17150	52321		0.0002	0.0002	OK	0.1	OK
PM10	650-60595-327	28	67	4408	52321			0.0008		0.3	

After the debugging report is completed, all monitoring instruments are managed according to the demand of CMA and GEMC equipment management procedure. Some reports are completed that are examination report, debugging report, calibrating procedure, using log and maintain documents.

Application:
All kinds of transfer instrument are almost used in the air quality weekly report that is gone on in Guangzhou. Transfer instruments of Guangzhou project have been used in Longgui site since Oct. 1998.

Maintenance and repair:

Maintenance and repair programs of transfer instrument are same to GEMC programs completely, and include regularly checking, regularly changing, regularly cleaning, the trouble diagnoses, the trouble repairing, etc. Transfer instruments repair record is shown at Table 4.

Table 4:

Instrument Serial number	Repair date	Description	Repair	Price	Technical support
48C-60241-326	1998.7.2	Correlation modulus is lower	Replace correlation wheel	Agent provides free part.	3 times
48C-60240-326	1998.7.7	No description	Replace processing board	Agent provides free part.	1 time
42C-59978-325	1998.8.12	No high power	Replace high power	Agent provides free part.	1 time
42C-60356-327	1998.7.5	O3 flow alarm	Tighten inlet	No	No
42C-62359-327		No	No	No	No
42C-60185-326	1998.6.14	O3 tube is broken	Replace O3 tube	Agent provides free part.	1 time
43C-60371-327	1998.7.1	No response	Replace UV lamp	Agent provides free part.	1 time
43C-59891-315	1998.7.5	UV lamp isn't flash	Replace UV lamp	Agent provides free part.	1 time
43C-59891-315	1998.7.8	UV lamp isn't flash	Replace lamp power board	Agent provides free part.	1 time
43C-57423-313		No	No	No	No
49C-60619-327	1998.6.15	Frequency alarm	Adjust UV lamp	No	No
49C-60320-326		No	No	No	No
49C-60716-328		No	No	No	No
650-60595-327		No	No	No	No

Service:
It is satisfied that GEMC shows to the service of Thermal Electron company (TE). GEMC is the long-term user of TE company, about 17 years, and has established good work relation between each other. GEMC has fairly rich use and repair experience to the monitoring instrument produced by TE. TE Guangzhou agency has provided good technique support to GEMC. All problems of transfer instrument are solved.

Evaluation:
Guangzhou project profit by transfer equipment at the below:

- To gain more integrated monitoring data.
- To gain more air pollution parameter monitoring data, for example O3 and PM10.
- To gain more place monitoring data, Longgui site newly established. GEMC profit by transferred equipment at the below:
- To partly raise continuously monitoring ability of NOX , SO2 and PM10 at GAQMS .
- To make directly benefit of air quality weekly report and air quality daily report of Guangzhou .
- To partly raise monitoring ability of PM10 and meteorological at AQM .
- To completely raise monitoring ability of O3 at AQM .
- To gain Longgui site monitoring data .

3. QA/QC training and action

The evaluation methods of monitoring network and monitoring site have been provided. Guangzhou team had completed description and evaluation to existing monitoring network and monitoring site under guidance of NILU expert.
The NILU expert had inspected all of sub-station of GAQMS and possible background sub-station position, and improvement suggestion had been provided about selecting and monitoring of background site and meteorology site. Longgui site became suburban background site of Guangzhou project.
Members of Guangzhou team were training at QA / QC by Mr. Berg, NILU's expert. Mr. Berg and member of AQM discussed about data transmitting and data processing together. Guangzhou team and NILU team discussed how to adjust the monitoring site position according to the result of KILDER model together. Some suggestions were provided to GEMC.
The documents of QA / QC had been provided by NILU.
Mr. Song Weiping from GEMC went to Norway to take in QA / QC training.

Evaluation:
The Guangzhou project profits at the below:

- To raise working ability of Guangzhou team.
- To be better to know air quality monitoring network in Guangzhou.
- GEMC profits at the below:
- To raise Guangzhou team QA/QC working ability.
- To gain the improvement suggestion .
- To make for working continuously in the future.

4. Equipments from other channels

GEMC is the underling unit of Guangzhou Environmental Protection Bureau (GZEPB). To accept GZEPB consign, GEMC report Guangzhou air quality monitoring data to government and public. Besides, GEMC provided Guangzhou air quality data to Global Environment Monitoring System.
GZEPB had provided some monitoring instruments to GEMC between 1997 to 1999:
1 air quality monitoring car (including: SO2, NO - NO2 - NOX, CO, O3, PM10, WS, WD, T, H, P, Calibrator, Zero air Supply, Datalog).
8 PM10 monitoring instruments (Model 650).
3 NO - NO2 - NOX Monitoring instruments (Model 42C).

5. The GAQMS improving evaluation

Table 5:

Item	Before improvement	After improvement	Comparison	Evaluation
Monitoring site	6	7	+1	To establish a new monitoring site
Parameter	4	6	+2	To gain O3 and PM10 monitoring data
Monitoring instruments			+17	To increase 17 monitoring instruments
Improvement of PM10 and TSP	Done by hand	Automatic	Automatization	To increase monitoring automatization and gain more data
Description of monitoring site	Simple description	Criterion table	Standardizatoin	To increase information and standardization
Data transmitting	Wireless	Line		Replacement plan have been made sure..
QA/QC	AQM procedure	AQM procedure	Planning	Modification plan have been made sure..
Data report	Regulated procedure	Regulated procedure	No changement	No plan.
Equipment management	GEMC procedure	GEMC procedure	No changement	No plan.

6. The long-term maintenance procedure of transfer equipment

Transfer equipment has been managed according to GEMC equipment management procedure. They are completely same with existing equipment from other fund channels. Pre-maintenance is very important in GEMC equipment management procedure. The procedure included:
The daily maintenance included that regularly change filter, dryer and other materials, keep the equipment clean.
The regularly maintenance included that regularly change expandable parts, check instrument state, regularly clean equipment tube and the sampler.

7. GAQMS improving potential and plan

- To improve monitoring site position , maybe increase monitoring site quantity.
- To establish 1~2 monitoring site near road according to requirement of World Bank traffic project.
- To improve calibrating procedure, achieve auto-calibration.

- To improve monitoring data transmitting system.
- To connect other district monitoring site and collect the data, like Huadu, Panyu, etc.
- To connect factory on-line monitoring site and collect the data.

8. Conclusions

In summary, we have completed:

- All of air quality monitoring instrument is transferred.
- One monitoring site, Longgui, has been established.
- Monitoring parameter quantity in AQM is increased , for example O3 and PM10.
- QA/QC training is finished.

We think:
<u>The aim of "the improvement monitoring system "have been realized.</u>

Annex 11

Action Plan 2001, Executive Summary

Action Plan 2001, Executive Summary

1. Introduction

The city government of Guangzhou has decided that Guangzhou should qualify as an Environmental Model City by 2001. National environmental authorities have defined the model city criteria to include *air quality indicators* for three different compounds, namely SO_2, NO_x and total suspended particles (TSP), as well as other environmental indicators. *The key concern of this action plan is to identify a package of control options that may meet these targets in a least cost manner.*
In this effort we have drawn upon the integrated *system for air quality planning and management in Guangzhou that has been established through a joint Sino-Norwegian project:* Air Quality Management and Planning System for Guangzhou *(see preface). This system includes the establishment of a grid and an emissions inventory for the different emission sources that can also be applied in projections of future emissions. Further, it includes a dispersion model with which we may calculate the ground level concentrations at any different location in the city/study area which in turn can be compared with measured levels in order to check the quality of the model. Then different control options that will reduce the emissions are identified as well as their effect on concentrations. Finally, we estimate the costs of applying the different control options and select the package of control options that will achieve the stated air quality objectives at lowest possible costs.*

2. SO_2 targets easier to obtain than NO_x targets

The measured levels in 1995 exceed the targets for all three pollutants. The values are shown in Table 1. The ranges are due to different values at different monitoring stations. As can be seen, the SO_2 targets will be the easiest to achieve, while the targets for NO_x will be very difficult, if possible at all to achieve. TSP lies in between.

Table 1: Necessary improvements in air quality from 1995 levels to reach 2001 targets (reduced concentrations)

	SO_2	NO_x	TSP
Annual average	0 – 20%	23 - 62%	8 - 50%
Max 24-hour average	11 – 52%	70 - 87%	48 - 78%

Each source category's contribution to concentration levels for each of the three air pollutants have been calculated and given in table below. This indicates what kind of sources that must be focussed on in a plan to reach the targets.

Table 2: Calculated 1995 contributions to concentrations, in 2×2 km grid cells

CONCENTRATIONS, % of sum	SO_2	NO_x	Particles
Large point sources	68.3	30.4	67.9
Small point sources	25.9	10.2	18.3
Domestic & commercial	1.6	6.1	7.9
Main roads & local roads	4.1	53.3	5.9
Sum	100	100	100

The main conclusions are first that approximately 60 large point sources represent nearly 70% of all contributions to concentrations of SO_2. Traffic is not important for SO_2. Second, traffic is the main source for NO_x concentrations, representing 53% of contributions. Third, for particles only combustion sources have been included in the calculations while resuspended dust from streets and dust from sources such as construction have been excluded. Almost 70% of contributions to concentrations stem from large point sources.

It is important to bear in mind that a very limited number of point sources are responsible for large contributions to concentration levels of SO_2 and combustion particles. This fact facilitates goal achievement because it is normally much easier to handle a few number of sources than a large number of sources, both in terms of formulating policies and regulations and in terms of enforcement.

3. Control options and least cost packages

For each substance we have sought to identify the potential of each option for reducing concentration in central Guangzhou and the costs of reducing e.g. the SO_2 concentration level by one percentage point relative to the 1995 level. The end result of this exercise is a cost curve consisting of the costs and additional concentration reduction potential of each option. This exercise takes into account that several control options address the same sources and same emissions.

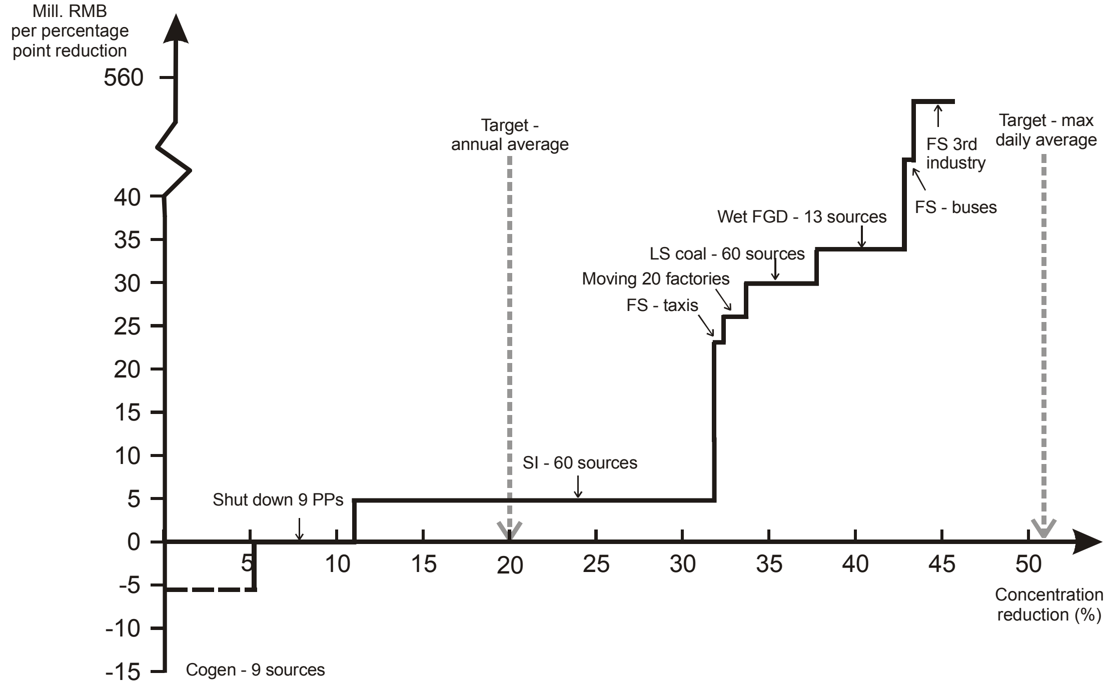
3.1 SO_2

For SO_2 the following options were considered:

- Sorbent injection in all large point sources (60 sources)
- Shut down a number of small, polluting power plants and increase production in bigger, less polluting plants with idle capacity
- Shift to low sulfur coal in all large point sources (60 sources)
- Wet flue gas desulfurization (FGD) in the 17 largest point sources
- Fuel switch for 15,000 taxis - from gasoline to LPG
- Fuel switch for 1000 buses - from diesel to LPG
- Co-generation of steam and power in 9 industrial facilities
- Switching fuel from coal and diesel to piped gas in restaurants and hotels (3^{rd} industry)
- Moving 20 factories out of urban area

The cost curve for these control options is shown in Figure 1. *Each option's additional potential for reducing concentration of* SO_2 *in central Guangzhou relative to the 1995 level is measured along the horizontal axis while the cost, expressed in million RMB per percentage point reduction, is shown along the vertical axis.*

Figure 1:Cost curve, SO_2 *control options*



The least cost package for achieving the target for annual average consists of cogeneration in 9 industrial facilities, shut down of a group of small power plants and sorbent injection in all 55-60 large point sources. The net annual costs will be less than RMB 70 million.

The technologies of cogeneration and sorbent injection are mature and well-known, and they are both used in Guangzhou already. These facts increase the feasibility of the options. The option of shutting down small power plants might face some institutional and political hurdles in the short term, but should be feasible in a somewhat longer term.

As for the maximum daily hour target, it is clear that it will be more difficult and costly to achieve, but not impossible. It will probably require a different composition of the package of control options where some of the most effective and more costly control options such as the wet or dry FGD needs to be applied on a larger number of large point sources.

3.2 NOx

For NO_x we considered the following control options:

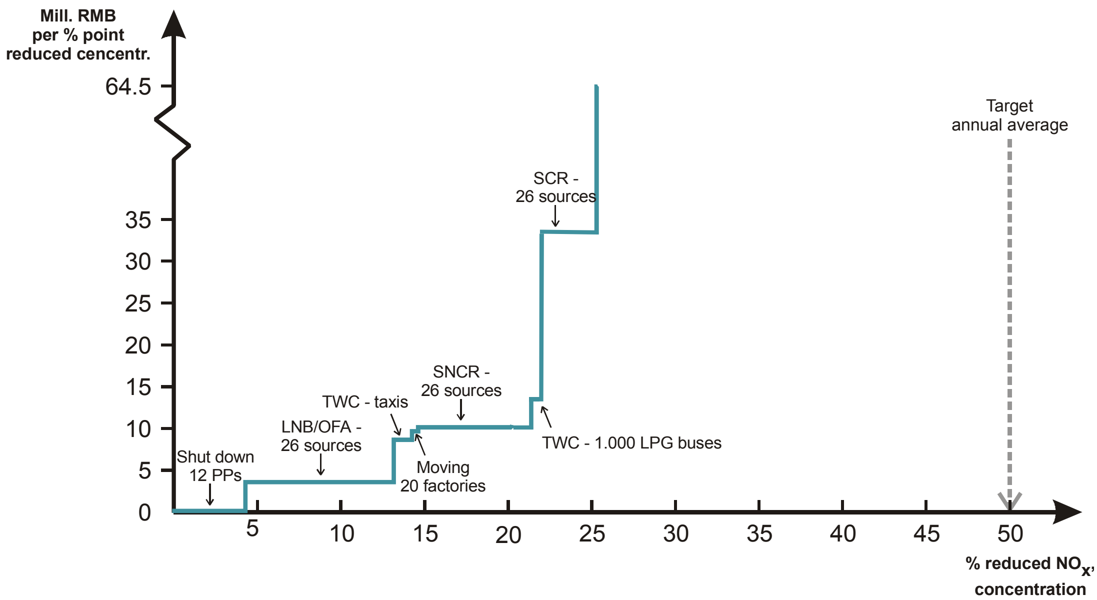
- Low NO_x burners in the 26 largest point sources
- Selective non-catalytic reduction (SNCR) in 26 largest point sources
- Selective catalytic reduction (SCR) in the 26 largest point sources

- Retrofit of three way catalytic converters on taxis
- Retrofit of three way catalytic converters on LPG buses

In addition, two options considered under SO_2 will also reduce NO_x emissions: moving 20 factories and close down of small and highly polluting power plants. *The cost curve for NO_x is shown in*

Figure 2.

Figure 2: Cost curve, NO_x control options



For NO_x we can conclude that the control options covered in this report will not be sufficient to meet the stated targets. There are two important reasons for this:

- background levels represent high shares of concentration levels
- traffic also account for high shares of concentrations and the control options for traffic are not very effective.

From this, different responses should be considered in terms of the targeted NO_x concentrations. *First*, Guangzhou should consider how it might help reduce out-of-area emissions that contribute to high background levels. *Second*, Guangzhou should consider more aggressive or potent options towards emissions from traffic. *Third*, Guangzhou might relax the NO_x target and instead focus on NO_2 as this compound is clearly the more significant one in terms of health effects. The NO_x target in China equals WHO's guideline for NO_2. This implies that the Chinese NO_x target is approximately twice as ambitious as the WHO guideline.

Finally, it would probably pay off to apply the most effective NO_x control options on a larger number of sources than we have done.

If the annual target is relaxed by 50%, this would imply a required reduction of concentrations of 25 percentage points from 1995 levels in central Guangzhou (annual average). The total annual costs of achieving such a target would be in the order of RMB 250-300 mill. Achieving the *current* targets for NO_x could easily prove to be a rather costly affair with questionable health improvements.

3.3 TSP

For TSP the following control options were considered:

- Low ash coal
- High efficiency electrostatic precipitators (ESP)
- Baghouse filters
- Street cleaning

In addition, some options considered under SO_2 and NOx will also produce reductions of particles: close down of small power plants, moving 20 factories out of urban area, fuel switch for taxis and buses and cogeneration in 9 industrial facilitites. Since the Guangzhou AQMS project primarily has focused on *combustion particles* whereas the air quality target is defined for *TSP*, we have not been able to construct a cost curve for TSP as we did for SO_2 and NO_x.
Nevertheless, we conclude that three options – cogeneration, shut down of small power plants and high efficient ESP on 11 sources – will reduce total emissions of combustion particles by 40,000-50,000 tons, or 35-40% from 1995 level. The total costs will be small, and all three options should be feasible. Cogeneration and high efficiency ESP are mature technologies which are also in use in Guangzhou.

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ABSTRACT
The project "Guangzhou Air Quality Management and Planning System" (NORAD project CHN 013) started in November 1996. The 3-year project was completed by the end of 1999, according to the project plan. The present Final Report sums up the activities during the 3-year project period, and a discussion of the fulfilment of the four main project objectives is given. The Final Report draws extensively on the bi-annual workshop reports and annual reports which have been prepared throughout the project. The report is finalised by a brief discussion on completion and continuation of activities related to the project. Of particular importance is finding the means for the Guangzhou team to further the active use in P.R. China of the concept of analytical, quantitative air quality management that has been transferred through this project, through co-operation with authorities and research institutions in other areas and cities in China.

NORWEGIAN TITLE

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ABSTRACT (in Norwegian)

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