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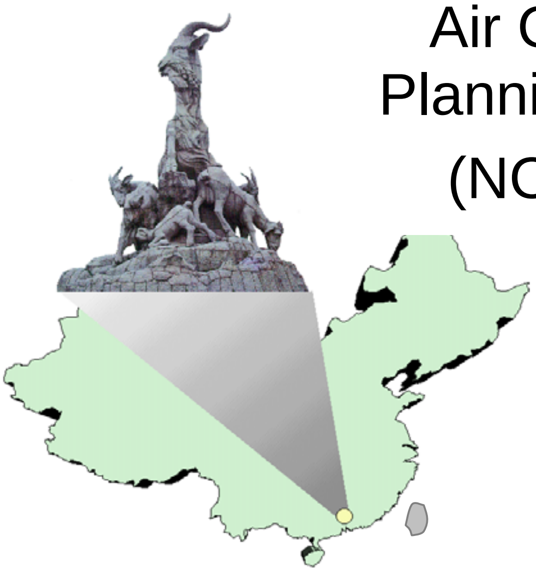
Report from Workshop 1, 1999

LongGui, Guangzhou, May 31 - June 4, 1999



Air Quality Management and Planning System for Guangzhou

(NORAD Project CHN 013)

Participating Institutions:

P.R. China: GMSTC, GEPB, GRIEP, GEMC
Norway: NILU, IFE, CICERO, ECON

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Report from Workshop 1, 1999

LongGui, Guangzhou, May 31 - June 4, 1999

Steinar Larssen

Contents

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1 Introduction

The first workshop in 1999 was held at the Ecological Education Centre at LongGui near Guangzhou on 31 May – 4 June. The main objective of this workshop was to present and discuss the Action Plan 2001, which had been developed during the first half of the year.

2 Program and participation

The program is given in Annex 1. Its main contents was:

- Monday 31 May:	Preparations, program finalisation Discussions within the Guangzhou team on the draft Action Plan, which was had been prepared by the NORCE side.
- Tuesday 1 June:	Plenary: Presentation and discussion of the 2001 Action Plan
– Wednesday 2 June:	Further discussions within the Guangzhou team on the Action Plan. Response from the Guangzhou team, and discussions, in plenary.
- Thursday 3 June:	Presentation of status of the work in each task, and detailed work plan for the final 6 months of the project.
- Friday 4 June:	Plans for the work on the 2010 Action Plan. Plans for finalisation of the project.

Participants at the workshop were:

- Guangzhou side:	Project leader Mr. Wu Zhengqi and all project participants.
- NORCE side:	Project leader Mr. Steinar Larssen, NILU Mr. Knut Aarhus, ECON Mrs. Kathrine Sandvei, IFE.

3 2001 Action Plan

3.1 1. June: 2001 Action Plan presentation

Mr. Larssen described the draft baseline scenario which had been constructed, in order that the 2001 Action Plan be based upon a good estimate of the projected air quality in 2001. This draft baseline scenario is shown in Annex 2.

The air quality targets used in the 2001 Action Plan are simply the Chinese AQ guidelines, for Class 2 areas.

Mr Aarhus then presented the draft 2001 Action Plan which had been e-mailed to GRIEP before the workshop, and distributed also at the workshop (the previous day). This draft had been discussed by the Guangzhou team the previous afternoon.

For SO_2, NO_x and TSP (i.e. combustion particles), the cost-effectiveness (C/E, costs per reduced ton of emissions) was presented for a number of selected control options:

For SO_2:
- Close-down of 13 small power plants;
- Low-sulphur coal;
- Wet flue-gas desulphurisation;
- Sorbent injection;
- others

For NO_x:
- Power-plant close-down;
- Low-NOx burners;
- Selective noncatalytic reduction;
- Fuel switch (to LPG), and 3-way catalysts, buses;
- 3-way catalysts, taxies.

For combustion particles:
- Power-plant shut-down;
- Electrostatic precipitators on 10 selected sources;
- Low-ash coal;
- Control of street and construction site dust.

The overhead transparencies from Mr. Aarhus' presentation are shown in Annex 3. Selected slides are shown on the following pages.

The preliminary C/E calculations have been made based upon the pollutant concentrations for the base year (1995) made with the KILDER model in 1998.

Preliminary calculations of cost efficiency in terms of costs per reduced percent of **pollution concentration** were also calculated, and preliminary figures were shown of:

- ranking of control measures according to this cost C/E ratio (Figure 1).
- accumulated costs of control measures for successive implementation of control measures (Figure 2).

These preliminary calculations indicate that shut down of 13 small power plants and the introduction of low-sulphur coal (butiminous) to Guangzhou will be sufficient to meet the target for annual SO_2 concentrations.

The continuing work on the action plan will improve these calculations.

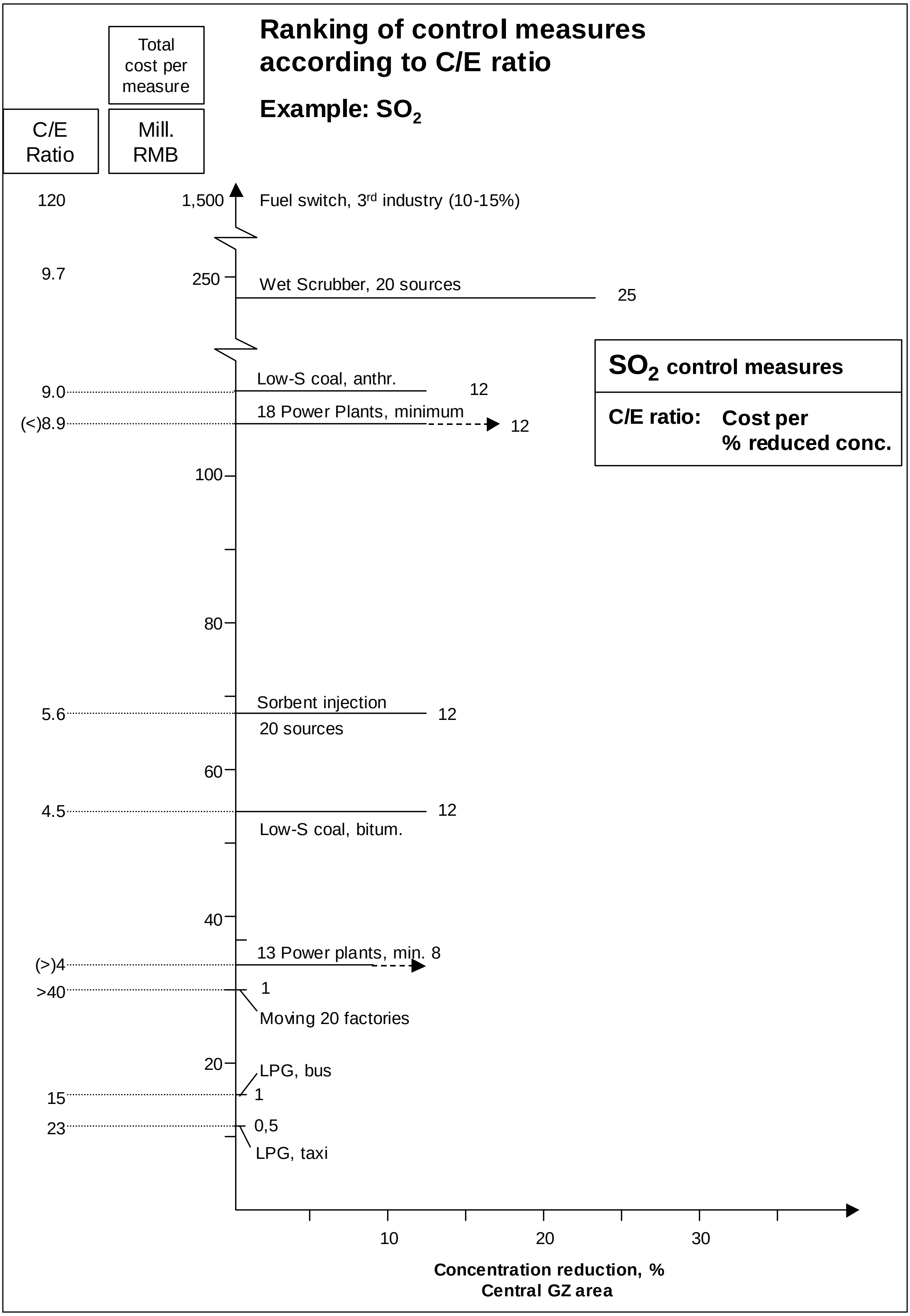


Figure 1: Ranking of control measures according to C/E ratio (in terms of cost per ***concentration reduction****).*

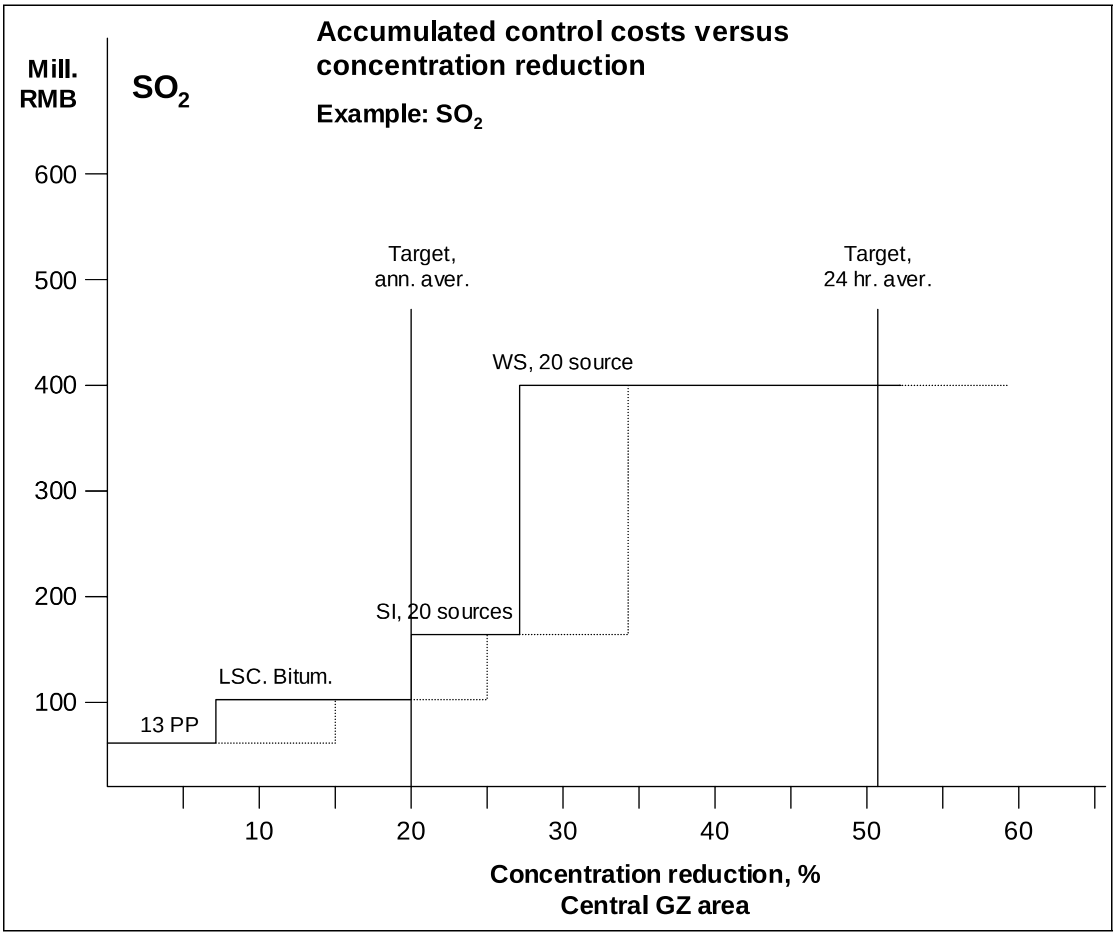


Figure 2: Accumulated control costs versus concentration reduction

Selected slides from mr. Aarhus 2001 Action Plan presentation

Action plan 2001- control options

In search of the most cost effective control options
to reach air quality targets in Guangzhou

Capital costs

- How should we convert investment costs to annual capital costs?
- Assumptions are very important for estimations of abatement costs
- Many estimates of abatement costs do not specify assumptions used
- Difficult to compare numbers

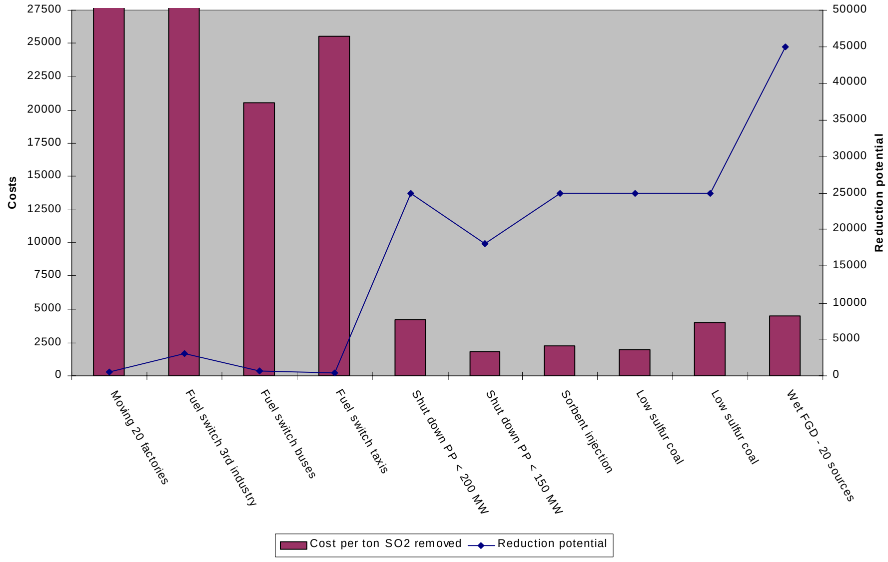
SO_2 control options

- We will present the following options:
  - Shut down small power plants
  - Low sulfur coal - all large point sources (POI 50)
  - Wet FGD on 20 largest point sources
  - Sorbent injection all large point sources (POI 50)
  - Other SO2 options

Comparison of options

Option	Cost per ton removed	Reduction potential
Sorbent injection in power plants and large industrial boilers	2500	POI 50 emissions down 50%
Shut down 18 power plants, 200 MW or less	4,250 or less	25,000 tons (+ 7,400 tons NOx + 27,000 tons particles)
Shut down 13 power plants, 150 MW or less	1,790 or less	17,800 tons SO_2 (+ 7,500 tons NOx + 26,100 tons particles)
All large point sources use low sulfur coal (shift from 0.75% S to 0.5% S)	2000	20-30,000 tons (max 33% of "bituminous part" of POI50 emissions)
All large point sources shift from bituminous (0.75% S) to anthracite (0.5% S)	4000	20-30,000 tons
Wet FGD on 20 largest point sources	4000-5000	40,000 - 50,000 tons
Dry FGD	Same as wet FGD	
Boiler replacement	27,500	
Fuel switch – taxis	25,555	450 tons (15,000 taxis) (+ 360 tons TSP)
Fuel switch – buses	20,600	700 tons (5000 buses) (+ 3,000 tons NOx and 540 tons TSP)
Fuel switch third industry	600,000	2,000-3,000 tons (2% of total emissions)
Moving 20 factories	72,400	500 tons (+ 130 tons NOx and 1,,150 tons particles

SO2 options



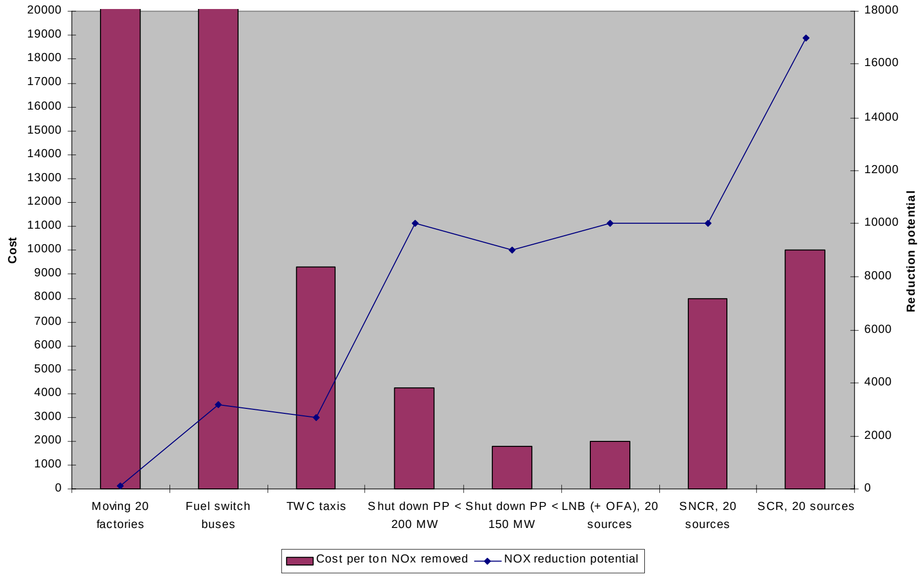
NOx options

- NOx options:
  - Low NOx burners and Over Fire Air on 20 large NOx sources
  - SNCR on 20 large NOx sources
  - SCR on 20 large NOx sources
  - Retrofit three way catalytic converters (TWC) on taxis
  - Other NOx options to be presented more briefly

Comparison of NOx options

Option	Cost per ton removed	Reduction potential
Moving 20 factories	72,400	136 tons
Fuel switch buses	20,600	3,200 tons
Shut down 18 power plants, 200 MW or less	4,250	7,400 - 13,000 tons
Shut down 13 power plants, 150 MW or less	1,790	7,000-11,000 tons
LNB (+ OFA) on 20 large sources	2,000	10,000 tons
SNCR on 20 large sources	8,000	10,000 tons
SCR on 20 large sources	10,000	17,000 tons
TWC – taxis	9,300	2,700 tons

NOx options

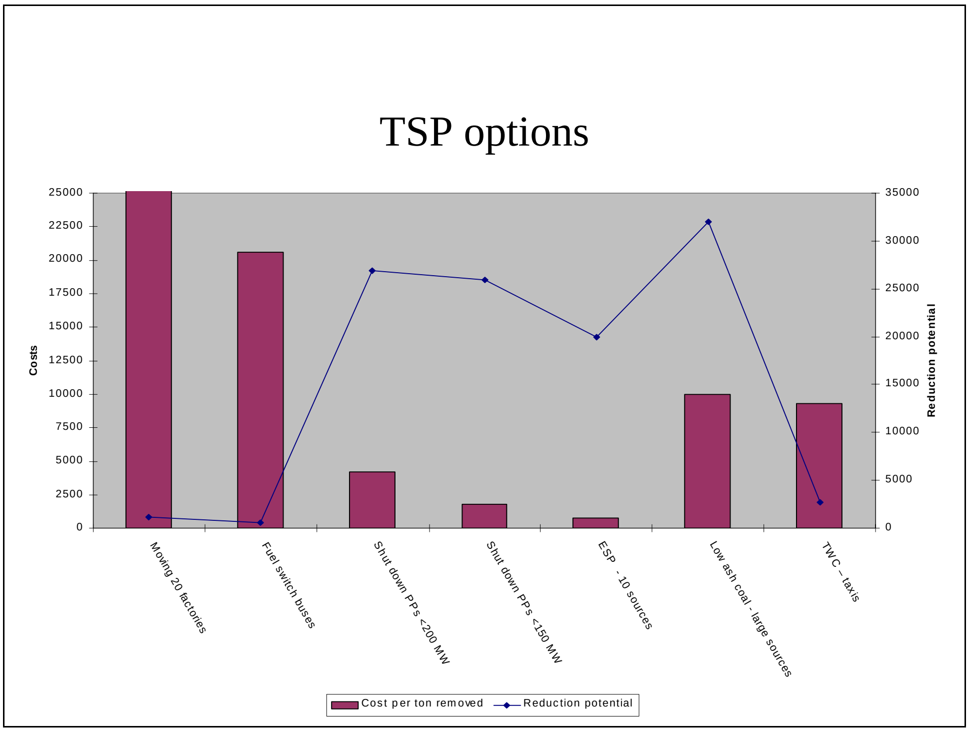


TSP options

- TSP options to be presented:
  - Retrofit high efficiency ESP on 10 sources
  - Low ash coal - all large point sources (POI 50)
  - Other options analysed under SO2 or NOx

Comparison of TSP options

Option	**Cost per ton removed**	**Reduction potential**
Moving 20 factories	72,400	Small (1,150 tons)
Fuel switch buses	20,600	Very small (540 tons)
Shut down 18 power plants, 200 MW or less	4,250	27,000 tons or more
Shut down 13 power plants, 150 MW or less	1,800	26,000 tons or more
ESP - 10 sources	500-1000	20,000 tons (10 sources)
Low ash coal - all large point sources	10,000-20,000 (90-95% cleaning)	32,000 tons
TWC – taxis	9,300	2,700 tons
Street cleaning	?	Limited?



TSP options
Costs
Reduction potential
25000
22500
20000
17500
15000
12500
10000
7500
5000
2500
0
35000
30000
25000
20000
15000
10000
5000
0
Moving 20 factories
Fuel switch buses
Shut down PPs <200 MW
Shut down PPs <150 MW
ESP - 10 sources
Low ash coal - large sources
TWC - taxis
Cost per ton removed
Reduction potential

3.2 2. June: 2001 Action Plan discussion

Before noon, the Guangzhou project leadership and project team had internal discussions on the 2001 Action Plan with the representatives from the municipal government institutions present.
The Norwegian side continued improving the action plan, and prepared for the afternoon discussion.

The afternoon plenary session was a discussion between the Norwegian and Chinese partners on the 2001 Action Plan. As a further input to that discussion, the Norwegian side had prepared figures showing the calculated cost-effectiveness (C/E) of the various control options, in terms of costs per reduced unit of exposure of the population in the city (i.e. the costs per reduced percentage point of air pollutant concentration in the central urban area of Guangzhou).

There was a rather vigorous discussion on the action plan and its implications.
From the discussion:

Mr. Wu (Director, GRIEP) and Mrs. Zheng (Vice Director, GEPB) made introductory comments. In general, they considered it a very good plan, and that the research behind it was “very significant”.
The Chief Engineer of GEPB commented, in relation to the option to shut down a number of small power plants, that the local policy had to be consistent with the national policy, and that the policy issues raised by some of the selected control options were very important to consider, when moving over to an implementation phase.

Comments and questions of a more technical nature:

- How to take all pollutants into account, when prioritising control measures? Would it be better to carry out the analysis by considering the improvements for all pollutants for each measure, instead of looking at one pollutant separately at a time? (Mr. Jian Jianyang).

In the analysis, one has to consider each pollutant for each measure at a time, but then, when prioritising and selecting control options, obviously one has to integrate or synthesise the analysis so that benefits for all pollutants are counted for each measure.

- Possible to make control plan for each district separately? (Mr. Pan).

In principle yes, but only as part of the whole city, where the calculations include all emissions the entire model area, since emissions in each district of the city influence the air quality in all other districts.

- How to include energy saving and clean production into the action plan? (Mrs. Zhong)

This is being considered in tasks 2, and will be a part of the plan.

- How can the contributions to the exposure represented by the roadside concentrations be included in the analysis? (Mr. Yu Kaiheng, GRIEP)

This will be included, when using the AirQUIS system to calculate the exposure.
Then, the NOx control options relating to vehicle emissions will be more significant and have a higher C/E ratio that they have when the KILDER system is used.

These was a discussion related to the fuel switch for buses, and more general on control options for vehicles. The planned fuel switch for buses from diesel to LPG has turned out be more problematic than anticipated, and the planned switch of 3,000 diesel buses to LPG has been delayed. This is in accordance with experience from elsewhere that fuel switch from diesel to LPG requires extensive engine modifications, which are expensive and requires a minimum level of engine performance. The present decision is to transfer 500 gasoline buses to LPG.
Regarding LPG fuelling stations, there are presently 7 stations in Guangzhou (per June, 1999).
Instead of fuel switching, a better alternative might be to concentrate on strict, state-of-the-art emission control regulations for new vehicles. This would not reduce air pollution much by 2001, but would be a significant measure for 2010.

There was a discussion about interest rates. For municipal infrastructure projects, 8% is being used in Guangzhou. May be one could make different scenarios for different interest rates.

Mr. Wu concluded this discussion, by stating that the task teams should check and if possible improve the quality of the data and information that they base their work on. Then, the Guangzhou teams would work on action plan development, based upon the C/E method. It would be important to use the AirQUIS in this further work.

3.3 Completion of the 2001 Action Plan

The action plan should be completed during the next 6 months towards the last workshop. Attempts will be made to use AirQUIS to calculate the pollution concentrations resulting from various control measures, but it is realised that there will be competition for computer time between the task 6.1 calculations of population exposure to study health effects, and the action plan calculations. The 2001 Action Plan work will be carried forward by the NORCE team, with comments and input from the Guangzhou team. As far as action plan work is concerned, the Guangzhou team will concentrate on the development of the 2010 Action Plan.

4 Task status reports

The status of the work on each task was reported in plenary on 3 June.
The contents of the status reports are given below.

Status Report for 1999

Task 1 Emission Inventory

Main achievement by now:

According to the DWP of 1999, emission inventory for Guangzhou must be finished by May. Three main jobs that must be done are

Job 1: to specify the feedback data to the format of AirQUIS input and finish the inputting.

In January, we finished all the input files for AirQUIS except files for domestic sources, which were made by March due to the late input specification (we saw the samples in March).

In February and March, we made the attempt to input data but not successfully.

During March 8~9, a computer expert from Norway stayed in Guangzhou to update the AirQUIS system. Under his guidance we tried the input again, but got the same result.

In April, with the help of Mr. Ordegaard, the input was finished at last. But we havn't got his final sample files.

Job 2: to establish the future emission inventory (for year 2001 and 2010).

In mid May we got materials about the future scenarios from subject office. But more help is needed. We suggest a meeting to decide how to make future emission inventory from that of basic year.

Job 3: to finish emission inventory for 1995 and technical report. According to the DWP, a draft of study report is now at hand.

As for basic information on this investigation, please see below

Table 1, Basic Information within the Investigation Area.

<table>
<tr><td colspan="2" rowspan="2">area / item</td><td rowspan="2">Total in the grid net</td><td colspan="2">Inside Guangzhou</td><td colspan="2">Outside Guangzhou</td></tr>
<tr><td>values</td><td>percentage %</td><td>values</td><td>percentage %</td></tr>
<tr><td colspan="2">area km2</td><td>2912</td><td>1996.4</td><td>68.6</td><td>915.6</td><td>31.4</td></tr>
<tr><td colspan="2">population 10,000</td><td>562.4</td><td>437.2</td><td>77.7</td><td>174.8</td><td>22.2</td></tr>
<tr><td colspan="2">Investigated industries</td><td>606</td><td>593</td><td>98.0</td><td>12</td><td>2.0</td></tr>
<tr><td colspan="2">Investigated sources</td><td>970</td><td>930</td><td>95.9</td><td>40</td><td>4.1</td></tr>
<tr><td rowspan="2">Engergy consum pt-ion 10000 ton</td><td>Coal</td><td>898.3</td><td>815.9</td><td>90.8</td><td>82.4</td><td>9.2</td></tr>
<tr><td>Oil</td><td>153.5</td><td>126.1</td><td>82.1</td><td>27.4</td><td>17.9</td></tr>
</table>

According to statistics for 1995, consumption of industry-used coal in Guangzhou was 8.97 million tons; for industry-used oil, 1.474 million tons. Inside Guangzhou area, 91% of industry-used coal and 85.8% of industry-used oil were involved during this investigation.

From the investigation result we can see that the consumption of coal and oil consumed by the investigated industries are 91% and 85.8% of the total industry coal use and total industry oil use respectively. That means, the main part of industry fuel use in Guangzhou was included, and the main characteristics of air pollutant emissions may be illustrated.

As for emissions for different air sources and their shares, please see below

Item / source	Energy consumption 10000t/y coal equivalent		emissions t/y							
			SO_2		NO_X		CO		Part.	
	A	B(%)	A	B(%)	A	B(%)	A	B(%)	A	B(%)
Total in the grid-net	1550.8	100	140271	100	66832	100	157899	100	114107	100
Industry	1324.5	85.4	134037	95.6	54127	81.0	48567	30.8	110258	96.6
Traffic	79.1	5.1	1822	1.3	11715	17.5	104412	66.1	3171	2.8
Domestic	126.7	8.2	2720	1.9	624	0.9	4692	3.0	284	0.2
3rd industry	20.5	1.3	1690	1.2	366	0.6	228	0.1	394	0.4

Main achievements:

1. Study Report on Emission Factors for Fuel Combustion (modified manuscript after expert examination);
2. Studying Report on Emission Inventory (draft);
3. Evacuation information for 20 industries.

Task 2 Energy consumption and coal smoke pollution

- Progress (Nov. 1998-May 1999)

After the second workshop in 1998, Task 2 used more than half of a year to finish the following work according to the DWP of 1999.

1. Stage report "Energy consumption and coal smoke pollution research of GZ".
2. The related information data have been collected and written into the report according to Action Plan of 2001.

Since there were a lot of necessary information and data should be collected for the Action Plan, we tried to visit more than 10 related departments, then we collected and sorted out the information.

1. The Forecast Report of Economy Development and Energy Demand of Guangzhou(Draft) has been finished.

1. Collecting and sorting a lot of history information of economy development and energy consumption;
2. Choosing the Basic Year: 1995;
3. Visiting the in charge industrial department of using energy, analyzing the problems, present situation, the shortcoming compared with the advanced countries, and exchange the necessary data for forecast with the industrial departments so as to get the agreement.
4. Comparing using energy with the advanced countries and areas and we confirmed the energy demand tendency in the future resulted from technology progress by the method of tendency forecast and the idea from experts.
5. According to the National Economy and Social Development Plan of 2010, we forecast the energy demand for socia-economic development and the produced volume of SO2 in the next 15 years.

Achievement Report

Serial number of subsidiary task	The persons in charge	assistants	Beginning	ending	Achievement report
1	Jieqing Zhong Kangmin Li	Daoming Wang Hao Chen	11/1998	2/1999	Research report of Guangzhou's energy consumption and coal smoke pollution (stage report)
2	Jieqing Zhong Kangmin Li	Daoming Wang Hao Chen	3/1999	4/1999	The report of information and date Collection for 2001 Action plan
3	Jieqing Zhong Kangmin Li	Daoming Wang Hao Chen	5/1999	6/1999	The research report of economic Development and Energy demand of GZ in 1995-2010(Draft report)

Task 3 Dispersion modelling

1. Works done after the second workshop in 1998.

1.1 Setting up the new project for AirQuis2.0

1.2 Import of meteorology data to the system.

1.3 Import of position data for 6 reception points.

1.4 Calculation work done on AirQuis2.0 system:

- Emission of SO2, NOx, and PM10 for total resources (1995.1.1-1999.1.10).
- Hourly and daily mean concentration of SO2, NOx, and PM10 for total resources (1995.1.1-1999.1.10).
- Emission of SO2 for main point resources (1995.1.1-1995.1.10).
- Hourly and daily mean concentration of SO2 for main point resources (1995.1.1-1995.1.10).
- Emission of NOX for traffic resources (1995.01.01.).
- Hourly and daily mean concentration of NOX for traffic resources (1995.01.01.-1995.01.10.).

1.5 Calculation on Kilder model (grip size:1kmx1km).

- Emission and yearly mean concentration of SO2,NOx,TSP.
- Background concentration of SO2,NOx,TSP.

2. Problems

A. For AirQuis system

- The calculation result can not be exported as a ".txt" file or an excel file in the AirQuis system, so it is difficult for us to analyze the result and make a erport. We hope this problem can be overcome very soon.
- The running speed of AirQuis model is fairly slow. As the work of calculation is too much, we think the system need some adjustment and improvement to promote the running speed.

B. For Kilder model

The concentration result of SO2 is quite close to the monitoring value ,but NOX TSP and CO modeling value are much less than the monitoring value.

Import and transfer of pollution resources data .

Because the work of calculation is very heavy and the running time is very large, we hope the pollution resources data of 1996,1997,1998 and 2001,2010 must be imported to the system.

Task 4 Monitoring system

1 Advancement

1.1 Improvement plan for the network

The report of Improvement plan for the network is being written in Chinese.

1.2 Online monitoring

Going on and online data was given correlative tasks.

1.3 Other work

To consummate the report of air quality tendency, and to write the report of O_3 P_{10} etc. Equipment's purchasing and installment and running-in.

2 Results

2.1 The report of Improvement plan for the network in Chinese(the front section).

2.2 The final report of air quality (waiting for GZEPA examine 1999'data) in Chinese.

2.3 The report of O_3 P_{10} etc. Equipment's purchasing and installment and running in Chinese.

Task 5 Population exposure modelling

1. Main achievement

1.1 Having been given training in the using of KILDER and AIRQUIS model by Norce-side, we mainly know how to use the two models to calculate the population exposure.

1.2 Dongfengzhong Road and Beijing Road (Typical major roads of Guangzhou City) have been investigated. The data including the buildings and the people in these buildings along the two roads have been put into the AIRQUIS system. If the calculation of the concentration distribution is finished by Task 3, the population exposure calculation along the two roads and the analysis will be done as soon as possible.

1.3 We have calculated the population exposure (based on the population data of Guangzhou in 1995) using KILDER model in the grid squares.

1.4 Preliminary estimates the population exposure using the calculation result of KILDER model, and one preliminary report has been delivered.

1.5 One part of the address data from interview study by Task 6.1 has been coded on the grid-system. The other will be finished in the future.

2. Problems

2.1 Because of the obvious difference between the calculation results of Task 3 with the actual monitored results, a proper scheme need to be drew up by Task Group and Task 3 to solve this problem.

2.2 Since the difficulties in using model to calculate, the concentration distributions of pollutants have not been finished with AIRQUIS model, the process of Task 5 has been delayed.

2.3 We hope that the persons of Task 5 in Norce-side can take part in the analysis of population exposure.

Task 6-1 Health Damage Assessment

May 1999

1¡ Work performed during the first half of 1999

According to the detailed work plan for 1999 (DWP for 1999), the work performed during the first half of 1999 covers the aspects as follows:

1) Disposing data collected from interview study and write a draft report on the interview study;
2) Checking address information collected from interview study and providing to Task 5 for coding and discussing the coding method with Task 5
3) Writing a draft report on the health statistic data collected from Guangzhou Public Health Bureau
4) Primarily disposing collected health statistic data;
5) Reviewing the international and domestic literatures on the effects of air pollution on human health and a draft report is to be finished together with the Norwegian experts during the workshop;
6) A draft report on the health improvements and the economic benefit based on the first sequence calculations discussed in the last workshop is written in cooperation with Task 9 experts.
7) Status Report for the first half of this year and Work Plan for the second half of the year.

2 Primary output details are given in the disk file

Reports:

1 Draft report on the interview study in winter of 1998;

2 Draft report on health statistic data collection;

3 Draft report on review international literature on the effects of air pollution on human health;

4 Draft report titled with ”Health damage assessment - 1st sequence calculations Health improvements and the economic benefit” based on the dose-response function of PM_{10} and SO_2 found from literature.

Data files

1 Data from interview study

- Data file for adult questionnaire numerals code SPSS file
- Date file for children questionnaire (numerals code SPSS file
- Address and medical use from adult questionnaire word EXCEL file
- Address and medical use from children questionnaire word EXCEL file

In addition, the manual files are given for the above files.

2. Health statistics

Annual statistics data of 1995,1996,1997 of mortality and morbidity is collected. And the daily data from 4 hospitals are collected including date in, date out, (or death date),age, gender, cause(ICD code), address.

The above data is saved in EXCEL file.

3 Problems and proposed resolution

1 Capacity

Since GZ team carry out the health study for the first time and experience on research of effects of air pollution on health is inefficient. NORCE experts have provided some useful guide in the period of data collection and data coding . GZ team hope could obtain more guide on data analysis from NORCE experts in the coming months.

2 Coordination with other groups

The analysis of dose-response function of Task 6-1 relates to the concentration data from Task 3 and exposure assessment from Task 5 closely. But according to the Detailed Work Plan these works are delayed.

The calculation data what Task 6-1 need has been informed to Task 3, and Task 6-1 hope Task 3 speed up the work.

On the other hand, the methods of address coding have been being discussed from the last workshop in Nov. 1998 and the final method and the distribution of work has been decided. Task 6-1 hopes that Task 5 can finish the address coding and begin the pollution exposure assessment as soon as possible.

3 Training delay

The training plan is delayed from 1998 to now due to the delay of AirQuis model. According to the work plan the major work of data analyses are to be done in the training period in Norway. So if the training is delayed too late, the data analyses and the study of Task 6-1, and the work of other relevant task as well, will probably be affected.

4 Work plan for the second half of 1999

Details are seen in the Detailed Work Plan for 1999. There is no important modification except for speeding up the study progress.

Task 6.2 Material damage assessment

1. The completed work after the second work shop in 1998

- The statistics of building materials, including:

(1) Determination of the area of exposed materials for typical building;
(2) Determination of the number of buildings in grids;
(3) Calculation of material amount in grids;
(4) Calculation of the total amount of materials;

- Calculation of pollution damage and economic cost of building materials in 1995

(1) Determination of dose-response and life time equation for major building materials in Guangzhou;
(2) Determination of repair price and cost of exposed materials;
(3) Determination of pollutants concentration in grids;
(4) Calculation of economic cost due to pollution damage of materials.

- Investigation and data collection for dust concentration of construction sites and dust pollution of traffic road

2. The completed work report

- Material field test report (Chinese and English edition);
- Report of calculating exposed building material amount (Chinese and English edition);
- Report of calculating economic cost of pollution damage for building materials.

3. Problems

- The dose-response and life time equation of materials such as ceramics, mosaic, rubber and stainless steel have not been determined. Two parties should research and discuss the problems to settle a resolution.
- As for as the calculation of economic cost of pollution damage for monuments, it is an important issue to estimate the pollution cost because of the special worth of the monuments. We have contacted the administration departments of the monuments in order to investigate the repair and maintenance price. The pollution cost of monuments will be estimated particularly.

Task 6-3 Vegetation Damage Assessment

- According to the detailed plan after last workshop, we have finished the work as below.

1. Two technical reports have been finished.

(1) Subtask 2: “The selection of plant species of air pollution resistant in Guangzhou area” (Chinese and English version)
(2) Subtask 6: “Acid rain pollution in Guangzhou area and its effect on the vegetation Eco-environment”

2. Vegetation assessment of urban area

Data analysis and statistic; Collecting data of Guangzhou air pollutant concentration distribution; Beginning writing report.

3. Crop damage assessment

Handle the data collected; O3 concentration distribution data collection,; Beginning writing report.

4. Forest damage assessment on Baiyun mountain

Data synthetic analysis; Beginning writing report.

5. Vegetation damaged by acid rain

After supplement data and information, we finished the technical report based on the status report.

6. New data collection

According to the requirement from the whole task, connecting with the Action Plan, we tried to find the relative data regarding to the distribution of Guangzhou flowers and fruit trees.

Task 7 Control options

Investigation and the date analyzing

Task 7 called on some important pollution source in Guangzhou and took a colloquia with the specialists, sorted out and analyzed the date which come from task 1.

1. Give the status and structure of fuel consume in Guangzhou.

The survey of SO2, NOx and smoke dust emission and technology of treatment at present were given.

Found out the important pollution source database from quantity of pollutant discharged.

2. Understood and evaluated the investment goal of the government about air pollution prevention and control options, including electric power plant desulfurization and city gas reform and so on.

Appraise present control options situation

Task 7 appraised the technology of air pollution control options in present, especially analyzed the problem in the dust removal and desulfurezed process from economy and technology side.

Measure and suggestion

On the basis of real condition and target of government, Task 7 give some suggestion of air pollution control option.

1. Readjust allocation of industry and structure of industrial.
2. Some suggestions about save energy and using pollution-free energy and encourage cleaning production.
3. Some suggestions about the control measure to different boiler type.
4. Some control plan about SO2, NOx and smoking dust in different industry.
5. Plant trees everywhere.

Etc.

Task 8 Baseline scenario development

1 Objectives

Tentatively Construct the 1995-2001-2010 socio-economic baseline development scenario for Guangzhou.

2 Main Activities

- Perfected the reports completed before
- Collected the data concerning the large point sources which has been or will be built during year 1995-2001.
- Corrected the data concerning the population variation during year 1995-2010.
- Helped task 1 construct the 2001 emission inventory
- Provided the population development data to task 5.

3 Progress and the problems

Generally speaking, the progress of task 8 is very good and have no any critical delays.

Task 9. Cost-benefit/cost-effectiveness

1.Work finished before May 31,1999

According to the detailed work plan from 1998.11—1999.5,task 9 has done following work

(1) Collect some data of moving factory.
(2) Collect some data of fuel switching of third industry
(3) Collect the data of GDP/per person and other data
(4) Do some study of willingness to pay
(5) Do a case study of valuation on health damage in Xinhau twon
(6) Do a case study of valuation on rice and vegetable damage with acid dose-response function Xinhau twon. t
(7) Collected some vegetation dose-response function. (SO_2 – forest, $O_{3,}$ --rice)
(8) Do a case study of environmental value of Beiyun mountain forest in GZ.

Task 11 Motor vehicles and photochemical pollution

Since the second workshop of last year, Task 11 has completed some field monitor work and investigated some motor vehicle basic data and written some phase reports according to the workplan of Task 11. Up to now, Task 11has finished writing six phase reports as follow:

NO. 1 Summary of Guangzhou City Motor Vehicles

Include,

- Has analyzed the growth and change of various motor vehicles by the yearly inclement rate of Guangzhou motor vehicles.
- Has collected and analyzed the number of the imported motor vehicles, national motor vehicles, taxi, bus and middle bus.

- Has introduced Guangzhou's I/M regulations, such as yearly inspection and road surveillance.
- Has introduced Guangzhou’s traffic road and city area motor vehicles running situation.

No. 2 Urban motor vehicle development forecast
Include:

- Collect Guangzhou’s annual GDP and population development and analyze the relationship of per capital GDP and motor vehicles development.

- Forecast the development of Guangzhou GDP and Pop in future referring to *Guangzhou city general plan (draft)* and *Guangzhou ninth five years plan and 2010 object.*
- Refer to future GDP and population development and use cumulated function forecast the change of the urban motor vehicles ownership in future, and describe the various motor vehicles developing scene by different economic development speed and policy factors.
- Due to only using single factor such as per capital GDP in forecasting model without thinking about the effect of future road establish and traffic development on motor vehicles increment, the forecasted result maybe exists a little bias.

3. Guangzhou urban annual auto-monitor result
Includes:
Has collected the data from Guangzhou auto-monitor stations since the stations were setup and analyzed the data.

- Has analyzed all ambient air quality function areas and summarize the change of Guangzhou ambient air quality.
- Has calculated the change of each pollutant and drawn their change trend referring to Lu Hu monitor station.

4. Discussion of Guangzhou Motor Vehicle Emission Factors
Includes:

- Introduced several current methods of deciding motor vehicle emission factors.
- Used Mobile5 Model to calculate Guangzhou emission factors in 1995, 2000 and 2010, and compared and analyzed the three results.
- Introduced motor vehicle emission factors coming from UNDP including Guangzhou driving cycle test.

5. Forecast results for Guangzhou motor vehicle catalogs
Includes:
Main used the motor vehicle speed increment data coming from Guangzhou Traffic Plan to forecast the every catalogs number of Guangzhou motor vehicle, and verified the forecast result.

6. Motor Vehicle Emission Controlling Strategies and Polices
Includes:

- According to the contribution of various motor vehicle emissions to total motor vehicle emissions, task 11 decided the key motor vehicles to be controlled.

- It should be the executable strategy for new vehicle to use stricter emission standard step by step, and Guangzhou should fasten the step of making new local motor vehicle emission standard.
- Referring to the future new national motor vehicle emission standard system and new local motor vehicle emission standards in Beijing and Shanghai, and integrating with actual situation in Guangzhou, task 11 gave some suggestion on making new local motor vehicle emission standard system for Guangzhou.
- In-using otor vehicle emission controlling strategy includes I/M regulars, in-using motor vehicle rebuilding regulars, fuel improving, fasten elimination and double fuels motor vehicle, and task 11 reported the cost and reduction effect on single motor vehicle when executing some above strategies.
- Other strategies introduction, such as encourage upgrading the in-using motor vehicle, special bus lane and build optimized traffic mode, etc.

Task 12 Air pollution forecasting

Works have been done from 11/1998 to 5/1999

1. receive the Episode model (V2.3) from NILU, there include a episode.exe and input/output files(*.dat),no meteo-preprocessor, and result is on the large grids(26*28)
2. Studied how to run the model, documents supplied by nilu
3. Finished a report of episode model(standalone), give a description of the model, and the factors iin the input files, and how to run the model in windows system. It’s convenient to other users.
4. Get some calculated result. Give an evaluation that the result are acceptable, there have possible to adjust it.
   Period:1/1/1995~1/7/1995
   Ratio of the calculated result and the reality data:
   Range:1.047~2.67
   Range of correlation:0.348~0.828
5. The additional work is to prepare the program to change the meteor-dat from meteor-station to the format demanded by the Episode model, this work is not finished.
   This work should be involved the technology transfer.
6. Use the episode model(standalone) to test the factors in the model.(for save the time)
7. Choose the numerical calculate period is 8/1995 and 11/1995.
8. The number of the task accept training of running the model.

Delay:

1. the numerical calculation, because the execution time of the EPISODE model in ENSIS is very long, we need much more time than anticipated time.

Period	component	user	time of execution
1/1/1995—7/1/1995	SO2		8hour.2min.32sec
1/1/1995 6.00—7.00	SO2	1	13min.19sec
1/1/1995 6.00—7.00	NOx	2	35min.46sec

2. The export the results from ENSIS system, there have some problems to do it.

Demand:

1.Norway side:the preprocessor as soon as

3. task4:meteor-data from the auto-station
4. task1:traffic emission data

5 Detailed work plans for the next 6 months

The Detailed Work Plans (DWP) for each task for the last 6-month period of the study were presented in plenary on 3 June. The work plans were to address the completion of the task work, pertaining to the collection of data, and the contributions to action plan development and to the AQMS work.

The DWPs are given below.

Work Plan for the Rest of 1999

Task 1 Emission Inventory

Work object:

According to the demand of subject office, data collection must be ended, and final studying report delivered within this year.

Work progress:

By June: finishing the outline of the studying report.
By August: finishing the draft of studying report.
By September: finishing a series of technical reports.
By October: finishing the modification of the draft report.
By November: finishing the printing of all reports.
By end of this year: finishing the appraisement.

Task 2 Energy Consumption and Smoke Pollution

A. Objective

According to the work plan made before and the general requirement from the project, information data collection shall be finished in the fist half of 1999, and be handed in the related research results. We will try to finish the final report .by the and of this year and pass the appraisal.

B. Detailed Work Plan

1. **Submit the outline of research report (June)**
2. Modify the draft report (July-Aug)
3. Submit the draft report (July-Aug)
4. Continue modify and to improve the research report (Oct.)
5. Pass the appraisal (Dec.)

Task 3 Dispersion modelling

Work plan for the second half of 1999.

Time	Work	Responsible side	Note
99.06.	Calculation on emission and concentration of 1995.	GZ	Emission factors must be adjusted in time by task 1.
99.07. - 99.08.	Calculation on emission and concentration of 2001. Calculation on concentration of 96,97,98.	GZ/Norce GZ	Resources data must be available in the system. For task 6-1.
99.09.	Calculation on concentration of 2010.	GZ	Resources data required.
99.10.	Preparing for report.	GZ/Norce	

Task 4 Monitoring

1 The report of Improvement plan for the network (in Chinese) is being finished and translated in English as soon as possible.
2 Online monitoring is going on, and online data is being given correlative tasks.
3 All reports is finished in October,1999.

Task 5 Population exposure modelling

1 Objective

The objective of this task in late 1999 is to calculate the population exposure in Guangzhou area (baseline scenario, trend scenario and target scenario) with KILDER and AIRQUIS model, and then assess the population exposure in Guangzhou area (baseline scenario, trend scenario and target scenario). Also calculate the interviewed people exposure for Task 6.1. In the Last we will finish report about the population exposure assessment.

2 Sub-tasks description

Detailed Work Plan TASK 5

Input/Output	From	To	When	Resp.	Questions and comments
a) Annual mean concentration for 1995 from KILDER.	3		June., 99	GZ	Components: NO_x, SO_2 and PM_{10}
b) Annual mean concentration for 1995, combined with population, giving the number of people in conc. Intervals (in grid), using KILDER		6.1	June. 99	GZ	
c) The road links of all the roads considered in the interview study of Task 6.1 has to be defined within the AirQUIS system	1		Aug., 99	GZ	Should be less than 10 roads.
d) Coding Interview study Receptor points and population distribution of the interviewed persons.		6.1	From June to Aug., 99	GZ	Produce three Excel input files. (One for AirQUIS and one for Task 6.1).
e) Obtain hourly /daily conc. data for 1995 (AirQUIS-2.0).	3		From July to Aug., 99	GZ	Hourly NO_x , SO_2, and daily PM_{10}
f) Exposure calculations for 1995 (AirQUIS-2.0).		6.1	From July to Aug., 99	GZ NILU	
g) Conc. data for 2001 and various measures for 2001 (AirQUIS-2.0).	3,7		June, 99	GZ	Hourly NO_x , SO_2, and daily PM_{10}
h) Exposure calculation for 2001 and for various measures for 2001 (AirQUIS-2.0).		6.1	Aug.,99	GZ NILU	
i) Conc. data for 2010 and for various measures for 2010 (AirQUIS-2.0).	3,7		June, 99	GZ	Hourly NO_x , SO_2, and daily PM_{10}
j) Exposure calculation for 2010 and for various measures for 2010 (AirQUIS-2.0).		6.1	Aug., 99	GZ NILU	
k)Report			Oct.,99	GZ NILU	

3 Organization, Time Schedule and Results

Sub Task	Sub Task Name	Personnel GRIEP	Personnel NILU	Products	Time needed
1	KILDER exposure calculation	Mr. Weng, Zhang, Wang, Mrs.Li	Mr. Slordal	Results and Result report	Two weeks
3	AIRQUIS exposure calculations	Mr. Weng, Zhang, Wang, Mrs.Li	Mr. Slordal	Results and Result report	52 weeks
4	Work for Task 6.1	Mr. Weng, Zhang, Wang, Mrs.Li	Mr. Slordal	Exel files of coded positions of the interviewed people, and grid distributions of these people.	42 weeks
5	Report	Mr. Weng, Zhang, Wang, Mrs.Li	Mr. Slordal	Report	24 weeks

4 Co-ordination with Other Tasks

Task 5 needs concentration data from task 3. This includes the first estimate from the KILDER model, and the result of Action Measures from Task 7. To serve the needs of Task 6.1 better, Task 5 not only needs the population data from Task 1 and the pollutants distribution data from Task 3, but also needs the address data of interviewed people from Task 6.1.

Task 6-1 Health Damage Assessment
May 1999

1.Objective

The objective of this task is to assess damage to health in Guangzhou due to air pollution using dose-response functions in such a way that the benefit of reduced damage due to emission reductions can be calculated in cooperation with Task 9.

The objectives of the work to be done in 1999 are:

- To analyze the results from the interview study aiming at screening the prevalence of respiratory health symptoms in adults and children in Guangzhou. The study gives a lot of information about the respiratory health of Guangzhou citizens and will be the basis for estimation of dose-response functions for these symptoms.
- To analyze the collected data on crude mortality rates and number of hospital admissions related to a number of end-points that are regarded as relevant in

the context of air pollution epidemiology. Dose-response functions may be found also from these investigations.

- To review Chinese literature on air pollution epidemiology. Dose-response functions available in this literature and from other internationally published studies will be used in the estimation of possible reductions in health effects that may be obtained from the 2010 Action plan.

2.Description of each subtask

Overall tasks of Task 6-1 are distributed into 4 major subtasks in 1999:

Subtask 1) Interview study (epidemiological study)

The collected data will serve as basis for answering the following questions:

- What is the prevalence of the various respiratory symptoms and chronic diseases that were recorded in the interview study?
- What dose-response functions may be derived from the data? (Task 5 will provide the data that are needed to estimate exposure level for the people that were interviewed)

The analysis of dose-response relationship will be done during the training period of Li Zhiqin in Norway.

A report will be made from this part of the study. Preliminary title: ***"Health effects from air pollution in GZ – respiratory symptoms and diseases. Results from an interview study"***

Content (preliminary):

- Methods used in planning and performing the interview study
- Results: 1) Frequency of symptoms and diseases in GZ. 2) Established dose-response functions

Subtask 2) Health statistics for Guangzhou

The collected data will serve as basis for answering the following questions:

- What is the present rate of annual deaths in the various population groups?
- What is the present frequency of hospital admissions for the various ICD9 disease groups and population groups?
- What dose-response functions may be derived from the data? (Task 3 will provide concentration data on a district level for 1996 and 1997 for this purpose)

In addition to the collected data, the GZ team will try get information about epidemics during the study period.

The analysis of dose-response relationship will be done during the training period of Li Zhiqin in Norway. Some preparatory statistical analysis and data descriptions will be made before the training period.

A report will be made from this part of the study. Preliminary title: ***"Health effects from air pollution in GZ – mortality and hospital admissions"***
Content (preliminary):

- Methods used for collecting and analyzing health statistics
- Results: 1) Mortality rates and HA rates in GZ. 2)Established dose-response functions

Subtask 3) Reviewing dose-response functions from Chinese and international studies
This task concerns the follow-up on the work on external dose-response functions that was started in 1998. More effort will be made to investigate what is available of Chinese studies in this field. The results from this part of the study will be reported together with the report from the 2. sequence calculations (see below).

Subtask 4) 2. sequence calculations

This subtask includes calculations of reduced health damage due to implementation of abatement measures by use of dose-response functions from GZ (from and from international studies for the 2010 Action plan

A report on the results from this will be made.

5) Status reports
Two status reports will be written and submitted during the period of two workshops in 1999.

3.Overview of subtask, organization, time schedule and products
The schedule is based on the plan made in the last November workshop, no other modification except the time limit.

Subtask	Responsible	Output	Time limit
1. Interview study	Li Zhiqin		
- Report on the procedure for planning and performing the interview study	Li Zhiqin	Technical report (or chapter in final report from the interview study)	June
- Data description: Sorting data, making crosstables etc.	Li Zhiqin	Data files to be used in Norway for the dose-response analysis (training period)	July
- Training in Norway: Dose-response analysis	Li Zhiqin (guidance by Jocelyne Clench-Aas and Alena Bartonova)	Dose-response functions and prevalence rates for the various symptoms	? Depends on the Airquis output
- Report on the result from the interview study	LZ, JCA	Report	As above
2. Health statistics from GZ	Chenyang (GEMC)		
- Report on the procedure for collecting health statistics	Li Zhiqin and Chenyang	Technical report (or chapter in final report from the ecological study)	June
- Basic statistical analysis	Chenyang	Data files to use in Norway for the dose-response analysis (training for Li Zhiqin)	July
- Training in Norway (Li Zhiqin): Dose-response analysis	Li Zhiqin (guidance by Jocelyne Clench-Aas and Alena Bartonova)	Dose-response functions, and statistical data on mortality rates and hospital admission rates	?
- Report on the results of the study	Li Zhiqin and Chenyang	Report	August
3. External dose-response functions	Kristin Aunan and Li Zhiqin		
- Write a report reviewing the relevant dose-response literature from China and internationally - Report the 1. Sequence calculations	Kristin Aunan and Li Zhiqin	Technical report	July July
4. 2nd sequence			
- Apply the dose-response functions from GZ (and external functions if required) in the calculation of benefits from the given action plan	Kristin Aunan and Li Zhiqin	Estimated reduced health effects of abatement measures Technical report	??

4.Coordination with other tasks

The detail may be seen from the following table:

Input needed	Time limit	Task 6 sub-task	Output
	June		*To Task 9:* Data from the interview study that regard medicine use, income and salary, and willingness to pay will be provided to *Task 9**
From Task 5: (1) The addresses for all participants of the interview study of Task 6-1 should be coded in the grid system and be punched into an Excel file. In addition the positions for the peoples selected in traffic area should be written into an Excel file.	End of June	1	*To Task 3:* Excel file containing addresses code will be the basis for Task 3 to calculate the pollution level
(2)Based on the concentration data from Task 3, Task 5 should provide Task 6 the exposure of the interviewed persons in the period Sept. 1997 to March 31st 1998. Excel file shall contain the following: For each person (ID): Daily mean and maximum of PM_{10} at home and at workplace; hourly mean at home and at workplace; hourly mean of NO_2 (?) and SO_2 at home and at workplace	July	1	*To Task 6-1*
From Task 3: Concentration level of the interviewed persons in the period Sept. 1997 to March 31st 1998. Mean daily concentration, maximum daily conc. 98 percentile of PM_{10} at home and at workplace; maximum hourly and 98 percentile of PM_{10} at home and at workplace; Mean hourly , 98 percentile of NO_2 and SO_2 at home and at workplace	June June	1	*To Task 6-1 subtask 4*
From Task 3: Daily average concentration for the 8 districts in 1995, 1996 and 1997: PM_{10} , NO_2 and SO_2:	June	2.	*To Task 6-1 subtask 4*
From Task 5: Population exposure in GZ (total) in baseline year and scenario years. PM_{10}, SO_2, and NO_2 2010 Action plan	?	4.	*To task 9:* List of health end-points so that Task 9 can prepare estimates of the economic unit value. Estimated reduced health effects of abatement, 2001/2010

* ***NB:*** These issues were included in the study on request from Task 9. Task 9 is responsible for coding and analyzing the data from this part of the interview study.

5. Training

Since the training are delayed due to the Airquis Model and the progress of Task 6-1 is affected. We hope to finalize the time when we could obtain the data from Task 3 and Task 5 so that the timing of training can be decided finally. We propose the training to be held in August/September.

6. Plan for work completion of Task 6-1

The detailed work plan is given as above. Due to the delay of Task 3, the exposure assessment of Task 5 was delayed too. According to the opinion of Task 3, the calculation of Task 3 is to be finished by the end of July. Therefore, Task 6-1 suggests that the training for data analysis is arranged in August/September and begins the final analysis and report writing from September. The draft final reports are to be written out by November during the second workshop. The final reports shall be finished before next March.

Task 6.2 Materials damage assessment

Work plan for the second half year of 1999

Time	Work	Work amount	Personnel
1999.6	Further verification of dose-response and life time equation; statistics of building material amount and calculation of pollution cost in grid within the large range	130 hour·person	He liangwan, Tian Kai
1999.7 - 1999.8	Calculation of pollution cost for monuments	140 hour·person	He liangwan, Tian Kai
1999.9 - 1999.10	Scenario analysis for material damage in 2001, 2010; cost-benefit analysis of material damage in 1995, 2001, 2010	280 hour·person	He liangwan, Tian Kai
1999.11 - 2000.1	Summary report preparation	260 hour·person	He liangwan, Tian Kai
2000.2	To submit the summary report		

Task 6.3 Vegetation damage assessment

- **Objective**

All task technical reports shall be finished after the synthetic analysis of the collected data and information. The reports shall be written in Chinese and English. And transfer to the related tasks.

- **Description of work plan:**

1. Investigation and research in Guangzhou

In order to know glowing situation and distribution of flowers and fruit trees in Guangzhou, we are going to visit the relative units such as the Flower Research Institute of Guangzhou, the Garden Research Institute of Guangzhou and the Civil Engineering Bureuo of Guangzhou and so on. And we hope to know the relationship between these and the air pollutants.

2. Investigation and research outside of Guangdong

According to the requirements from the whole task, we shall go to visit the relative units such as Nanjing Research Institute of Environment Science. We hope to get useful information regarding to the relationship between flowers, fruit trees and the air pollutants.

3.Crop damage assessment

The report shall be finished after supplement the Ozone data in Guangzhou and the crop lose shall be estimated.

4. Forest damage assessment on Baiyun mountain

Continue to improve the report and translate.

- **Subtask, schedule and responsibility**

subtask	Subtask 1	Subtask 3	Subtask 4
responsibility	Su Xing	Su Xing	Hu Di-Qin
schedule	Oct., 1999	Aug., 1999	July, 1999

Task 7 Control options

1 Objective:
Task 7 will want Identification of options for abatement of air pollution in Guangzhou, and evaluation of these according to their cost and abatement potential. The results of the control option assessment will form input to the cost-benefit analysis and to the cost-effectiveness analysis of possible actions to be included in an overall air pollution abatement strategy.

2.Action
1) Evaluation of existing control options
The cost and abatement data for the various control options provide the input to the cost-benefit analysis, with the benefits measured in terms of damage cost. From the collected data on cost and abatement potential, a ranking of relevant technical options according to their cost-effectiveness in reducing emissions can be established. This ranking will be used as a basis for identifying the least costly way of satisfying a specific environmental goal, or a combination of several goals.

2) Contribution to baseline emission scenario development from the emission of the technologies the projections
Data on emissions factors for technologies to be included in the baseline emission scenario Input to Task 1. From the emission of the technologies the projections of baseline emissions will be calculated

3) Identification of cost efficient control options for emission abatement
Use energy system model or other methods to find cost and emission reductions of different control options as input to cost-benefit analysis and dispersion modeling. The emission levels (abatement effect) are input to the loop; dispersion-exposure-damage assessment, and subsequently input to cost-benefit calculations. The costs of the option are direct input to cost-benefit calculations.
Measures for abating stationary emissions can be divided into the following main categories:

- -Removal of pollutants from flue gases (end-of-pipe techniques);
- -Improving fuel quality, including fuel switch;
- -Adjustment of combustion conditions;
- -Reduced fuel use through energy conservation measures.

4) Take sets of meetings for control options. Cost-efficient is for Specified emission targets, input to cost-effectiveness analysis.
5) Write a report for air pollution control options in Guangzhou

3 Time schedule, budget and relation to other tasks

Sub-tasks	RESEARCH CONTENT	Time	Work(week. Person)	Relationship
1	Evaluation of existing control options	1999.2~1999.6	15	T1, T11
2	Contribution to baseline emission scenario development from the emission of the technologies the projections	1999.3~1999.7	20	T1,T11 ,T8
3	Identification of cost efficient control options for emission abatement	1999.3~1999.9	35	
4	Take sets of meetings for control options. Cost-efficient is for Specified emission targets, input to cost-effectiveness analysis.	1999.6~1999.10	45	T9,T1
6	Write a report for air pollution control options in Guangzhou	1999.6~1999.12	10	
Total			125	

Task 8 Baseline scenario development

1 Objectives

Finally construct the 1995-2001-2010 socio-economic development scenario for Guangzhou.

2 Main works

- Perfect the research reports further
- Gather the data concerning the socio-economic development scenario of Guangzhou during 1995-2010.
- Help the relevant task group, e.g. task 1, task 5 and etc. to fulfil their work.
- Strengthen efforts to pass the approval of the final research results of task 8.
- Conclude all of the work of task 8.

3 Work plan

Subtask	Participants	Jun.-July	Aug.-Sept.	Oct.-Nov.	Dec.
1	Dr. Haakon, Miss Maj Mr. Fan, Dr. Cui and Mrs Huang	✓	✓		
2	Dr. Haakon, Miss Maj Mr. Fan, Dr. Cui and Mrs Huang	✓	✓		
3	Dr. Haakon, Miss Maj Mr. Fan, Dr. Cui and Mrs Huang	✓	✓	✓	
4	Dr. Haakon, Miss Maj Mr. Fan, Dr. Cui and Mrs Huang				✓
5	Dr. Haakon, Miss Maj Mr. Fan, Dr. Cui and Mrs Huang				✓

4 Resources

	Subtask 1	Subtask 2	Subtask 3	Subtask 4	Subtask 5	Total
Time Hours	80	80	60	40	40	300

Task 9 Cost-benefit analysis

According to the detailed work plan for task9 in 1998 and base on the work progressing. The work that task9should be done in 1998.6—1998.12 task 9 is as following:

1. Write a report on vegetation damage valuation base on the work of task 6.3 vegetation damage. Finished: August15
2. Health:Collect data on GDP/person, cost of staying overnight in hospital.cost of visiting physician,cost of additional medicine,and other relevant items. Finished: October15.
3. Write a report on health damage valuation base on the work of task 61 health damage. Finished: October15.
4. Write a report on material damage valuation base on the work of task 6.2 material damage. Finished: October30.
5. Finish cost benefit analysis report on moving factory. October15.
6. Finish cost benefit analysis report on fuel switch of third industory October15.
7. Finish cost benefit analysis report on SO2 control. October15.
8. Finish cost benefit analysis report on Nox control. October15.

Organisation, time schedule,output(Chinese side)

Subtask	Participants	Relevant task	output	Jun-Jul	Aug-Sep	Oct-Nov	Dec
1	Yu jican		report				
2	Yu jican		Data				
3	Yu jican		Report				
4	Yu jican	6.2	Report				
5	Yu jican	6.1	Report				
6	Yu jican		Report				
7	Yu jican	6.2	Report				
8	Yu jican	6.1	Report				

TASK 10 : Policy instruments

Introduction

The work of task 10 in 1999 will consist of three main parts:

- revise and finalise work planned to be finished by December 1998
- analysis of policy proposals to support selected control options for 2001 Action Plan
- analysis of policy proposals as input to the 2010 action plan

Subtask 1

Two reports which exist in draft form (and originally scheduled to be finalised by the end of 1998) will be finalised. These reports will, together with previous reports from task 10, serve as background and basis for the analysis of policy proposals which will be input to the work on the action plans.

The two reports deal with i) enforcement of existing policies and regulations, and ii) selected successful international experiences of air pollution control.

Enforcement report: During 1998 efforts were undertaken to evaluate strengths and weaknesses of existing regulations and enforcement of these regulations. A draft report exists in Chinese version and a first English translation is being prepared in December 1998. The report will be discussed and revised by GRIEP in the second half of December 1998 and then sent to NORCE (ECON) for comments. The final version will be prepared by January 20, 1999.

Successful international experiences report: During 1998 relevant information were gathered and analysed and a first draft report was prepared for the workshop in November 1998. This report will be finalised by NORCE (ECON) by the end of January 1999.

Subtask 2
Task 10 will start its work on analysis of policy instruments to support the realisation of the control options or measures that will be selected for the 2001 action plan.

- Policy instruments that will be considered and analysed will be among the main categories: command and control, economic instruments, voluntary agreements and information. The main focus of the discussion and selection of policy instruments should be on problems and challenges for the actual realisation of each control options and how such problems could be reduced or challenges overcome by choice and design of alternative policy instruments. Special emphasis should be given to effectiveness of policies, their characteristics in terms of cost effectiveness, political and administrative feasibility.

- This work was initiated before and during the November workshop (1998) focusing on the first five control measures already decided upon by the Guangzhou authorities. A first brief document will be prepared by NORCE (ECON) containing suggestions for how to structure the analysis and selection of proposed policy instruments to support the first five options. This will be sent from NORCE side before January 1st 1999.

- GRIEP will then prepare a document containing a first discussion of possible policy proposals that will facilitate the implementation of the first five control options and including a proposed package of policies/policy instruments. To the extent possible it should also try to assess This should be done by March 15th.

- As soon as the list of selected measures for the 2001 action plan is finally decided in January 1999, the work of task 10 can proceed (in parallel) to the same kind of analysis for the remaining selected measures. This work should be finalised by mid-April so as to facilitate the incorporation in the draft action plan for 2001.

Subtask 3
This subtask will analyse and suggest more long term policy proposals for three main sectors (power plants, industry and transport) based upon our previous evaluation of both the existing policies, regulations and the implementation and enforcement of these policies and regulations in Guangzhou. This part will also include proposals based upon of successful national and international experiences which have been studied in 1998, for example traffic pollution management in Singapore, pollution charges in Sweden or direct emissions regulations in several countries such as Germany, Norway, tradable emission quotas in the USA, etc. These systems should be evaluated for a Chinese context.

The work on sub-task 3 will be concentrated after the May 1999 workshop. The output will be in the form of sector-wise documents (power plants, industry and transport) which will serve as input for the 2010 action plan.

Table 1 Timetable for task 10

Sub tasks	Dec 1998	1st q.1999	2nd q. 1999	3rd q. 1999	4th q. 1999
Subtask 1 - Enforcement report	xxxxxxxxxxx				
Subtask 1 - International instruments report	xxxxxxxxxxx				
Subtask 2	xxxxxxxxxxxxxxxxxxxxxxxx				
Subtask 3	xxxxxxxxxxxxxxxxxxxxxxxxxxxx				

Task 11 Motor vehicles pollution and photochemical smog

Objective

According to the plan of China-Norway Cooperation Project, Task 11 should complete all its work in the end of 1999. Basing on the analysis of present situation, every sub-task has nearly finished its work need in the progress, but some sub-tasks are still to be completed in late time. It appeared to be very busy in the second half year of 1999. Task 11 will continue to complete following four uncompleted sub-tasks and at the same time write the reports. We will complete all the sub-tasks and reports but the final report of Task 11 may be submitted in the January of next year.

Workplan In the Second Half Year

1. To evaluate the current situation and forecast the future effect of motor vehicle emissions on Guangzhou urban air quality.
2. To forecast Guangzhou motor vehicle emission factors using the achievement from UNDP.

Reports to be Submitted In The Second Half Year of 1999

1.Current Motor Vehicle Situation and future Motor Vehicle Emission In Guangzhou
2. Guangzhou City Streets Forecast on Motor Vehicle Emissions and Pollution
3. Task 11 Report Framework
We will do some modification for the completed six sub-reports of Task 11 and add up to a Task 11 Report Framework.
4. To complete and submit the Task 11 Final Report before the January of next year.

Schedule of the Workplan

1. 1999/6/1~6/30
   To continue to sample VOC and PM and do the sample analysis
   To submit the completed reports

2. 1999/7/1~7/31
   To continue to sample VOC and PM and do the sample analysis
   To submit the completed reports

3. 1999/8/1~9/30
   To forecast the Guangzhou road motor vehicle emissions and pollution.
   To write above report

4. 1999/10/1~10/31
   To write the analysis report of VOC and PM emitted from Guangzhou Motor Vehicles
5. 1999/11/1~11/30

To collect other task groups research results related to Task 11 and continue to complete and submit report

6. 1999/12/1~12/31

To sum up all the sub-reports of task 11 to compile a total Task 11 Report

8. 2000/1/1~1/30

To complete all the work of Task 11 and submit the research achievement

Supplementary

1£ According to the initial Task 11 Workplan in the kickoff of Sino-Norway Project, it would need to collect the relative research achievement of other task groups. So Task 11 needs do itself work and at the same time to get our task groups' relative research achievement and conclude them into task 11 report. That is why Task 11 should have to be a little later than other tasks.

2£ From the submitted reports and materials by Task 11, Norway side experts have thought Task 11 had basically completed its work items. But China side experts think it is essential to do further and deep research about motor vehicle pollution and know that motor vehicle pollution do great effluent on ambient air quality and is rather important to improve Guangzhou air quality. Hence, all the second half year workplan in 1999 have been required by China side and will main depend on China experts to complete the work.. But we will consult Norway side experts on our final research achievement.

Sino-Norway Cooperation Project Task 11
May.28, 1999

Task 12 Air pollution forecasting

Subtask	contents	dateline
Subtask1	we have chose the calculate period in 1999, we will calculate the concentration distribution on large grids in ENSIS system, and analyse the relation between calculated result and reality data.	6/10/99-7/10/99
Subtask2	Use the Episode(standalone)model to test the factors in the model, to definite the value of these factors in the model,	7/10/99-8/30/99
Subtask3	Use the statistic result(have done in last two years) to modify the calculated value.	7/10/99-8/30/99
Subtask4	purchase the meteor-data from meteor-department, use the modified model to make air pollution forecasting everyday, make the final decision of this factors.	9/1/99-10/10/99
Subtask5	choose the forecasting method	9/1/99-10/10/99
Subtask6	make the reports and the final reports.	10/10/99-10/30/99

6 2010 Action Plan

6.1 Summary from meeting discussions

The 2010 Action Plan was discussed in two meetings on 4 June.

Preparatory meeting in selected group:

Participants:
- Guangzhou side: Mr.Wu, Luo, Yu, Sun, Zhu, Mrs. Ge, Cui, Yu Jican, Fan
- NORCE side: Mr. Larssen, Aarhus, Ms. Sandvei.

These topics were discussed in preparation for the later plenary discussion:
1. The nature of the 2010 Action Plan:
   - general or specific?
   - oriented towards targets, or based upon optimisation/cost-benefit?
2. The importance of the baseline scenario
3. The need for damage functions (relationships between exposure and effects)
4. The participation in the central group on the Guangzhou side, which shall direct and integrate the work.

In the following plenary discussion, also representatives from the Guangzhou planning commission, the GEPB (Director Mr. Gan), the GSTC (Vice Director Mr. Liu) participated. A summary of the discussion in the preparatory meeting was presented, in which the essential parts of the work in each task was specified, which is needed as contribution to the 2010 Action Plan development.

The 2010 Action Plan development work is specified in the following two notes:
- one note covering the discussion on 4 June, and including the task-specific work necessary to be carried out;
- one note specifying the procedure for the development of the plan.

6.1.1 The nature of the Action Plan 2010

Target or cost/benefit - optimization?

Air quality targets for 2010 has been set for GZ, so the action plan needs to address those targets.

On the other hand, it is important to base the work on the comparison of costs and benefits, to show to the authorities that until a certain level of air quality has been reached, air pollution control is economically beneficial for the society as a whole. Also it is important to show how to determine the point where a marginal increase in control costs is equal with the marginal reduction in damage costs. The air quality targets may be reached before this marginal balance is reached, implicating that benefits are larger than costs, or it may be reached after the point of marginal balance, indicating that there is a net control cost in reaching the target.

So, the 2010 Action Plan should both relate to targets, and it should be based on cost-benefit calculations.

6.1.2 2010 Baseline Scenario

This constitutes a very important basis for the action plan.

It must reflect:

- national, regional and local plans and targets for energy, technology, population and other societal developments
- an educated evaluation of to what extent the plans and changes will actually be implemented as a result of policies and regulations which are in place, or are expected to be in place in the near future ("in-the-pipeline").

This is the basis for constructing the projections reflecting the "most likely development". Projections should be constructed for high, medium and low degree of implementation of plans and policies.

It is important to distinguish between:

- the actual and/or probable changes/measures that will take place as a result of existing plans and policies, on the one hand;
- and on the other hand, the further measures needed to reach the target or desired air quality.

The GZ side will consult with the local/regional authorities, such as the Planning Commission and other departments.

It is important that the baseline scenario work is carried out soon. There must be cooperation between Tasks 8, Task 7 (control options), Task 11 (Traffic) and Task 10 (Policy instruments). Task 1 must also be involved, since Task 1 will have to introduce modifications in the emission inventory, reflecting the 2010 baseline scenario.

6.1.3 Damage Functions

Damage functions, or dose-response relationships, must be in place to do cost-benefit analysis.

The special studies carried out in Task 6.1 (Health) and Task 6.2 (Materials) gives basis for local GZ damage functions. The materials study is almost finished. It is very important now to finish the work on the health studies, so that local damage functions for health effects can be developed and used in the cost-benefit analysis.

6.1.4 Central Action Plan Group on the GZ side

It is important to integrate the following tasks into the work of a Central Action Plan Group on the Guangzhou side: Tasks 7, 8, 9, 10 and 11.

According to Mr. Wu's opinion, tasks 7 and 8 should consult with the Planning Commission in their continued work related to the Action Plans, especially for 2010.

6.1.5 Some details of work in each task

Task 1 (Emissions):

- Should take responsibility for modifying and developing new emission factors, for improved technologies and new sources.
  Tasks 7 and 11 must provide input.

Task 2 (Coal):

- Should develop forecasts for coal use towards 2010, (including improved and new processes using coal). This should give input to Task 8, scenario development.

Task 3 (Dispersion)

- Should calculate air quality and exposure (with Task 5) for 2010, for scenario/action plan packages developed by the Central Group.

Task 4 (Monitoring)

- Should continue to monitor and improve data quality, and establish the trends in air quality.
- Should continually improve and modify the monitoring system, as the city develops.

Task 5 (Exposure)

- Should continue to work on establishing a building register for GZ, with coordinates and number of people, to be input in AirQUIS, to improve exposure assessments.

Task 6.1 (Health Effects)

- Should continue the analysis of health studies data to develop local dose-response relationships, and calculate estimated health damage costs, and reduced damage costs associated with the various control scenarios from Task 13.

Task 6.2 (Materials Effects)

- Should run the material damage calculations for 2010 scenarios, with the reults from the building inventory, and by using the air pollution concentration fields calculated by Task 3.
- Improvements in the building data base can be done particularly for the extrapolated data for the amount of buildings from the Guangzhou centre to the larger Guangzhou area.

Task 6.3 (Vegetation Effects)

- Should continue to work on development of dose-response relationships, and calculate estimated vegetation damage costs, and reduced damage costs as a result of the various control scenarios from Task 13.

Task 7 (Control Options)

- Should identify the most probable development towards improved and new technologies for various stationary source categories (input to Task 8, baseline scenario), and establish emission factors for them (input to Task 1). Also, further possibilities for improved technology that will reduce emissions should be identified (input to Task 8, further scenarios).

Task 8 (Scenarios)
- Should continue to develop baseline and further scenario for 2010 (and further). Input from tasks 7, 11 and 10.

Task 9 (Cost-benefit)
- Should continue to collect data on costs of control options (from Tasks 7 and 11), and economic benefits from reduced damage (based upon input from Task 6).

Task 10 (Policy Instruments)
- Should focus on implementation of the selected packages of abatement, from task 13.

Task 11 (Motor vehicle)
- Should focus on forecasting the baseline development of vehicles technology/and emission factors, (input to Task 1), and development of road infrastructure and traffic (input to Task 8).

Task 12 (AQ Forecasting)
- This is a task which is somewhat separate from the rest of the Air Quality Management System and Action Plan Development. This task should focus on developing a functioning forecasting system.

Task 13 (Control Group)
This group should:

- oversee, guide and coordinate the work in the other tasks,
- be responsible for proposing the packages of control options that should be basis for the air quality and exposure calculations carried out by Task 3.
- Select the package(s) of control options to be implemented.

6.2 Note on Procedure for developing Action Plan 2010

BASIS
One of the 4 main objectives of this project is to develop action plans for improving urban air quality, on the basis of a methodology of analysis which results in cost-effective abatement. The transfer of knowledge, training in methodologies, and transfer of tools have been geared towards assisting the Guangzhou side in this work. Also the collection of data which has been carried out in most tasks have had the goal to make the development of cost-efficient action plans possible.

ACTION PLAN 2001
The 2001 action plan has been developed with the goal to improve the air quality to meet given targets with the least costs. The development has been in 2 stages:
-Stage 1: Preliminary plan, based upon the calculations with the KILDER system, to select the control measures with the largest potential to reduce concentrations

with the least cost per concentration reduction, and to make a first analysis of the packages of control measures needed to reach the targets, and the total costs involved. This stage is being completed.
- Stage 2: Complete analysis, following the same basic procedure as in stage 1, but using the AirQUIS system to calculate more precisely the cost efficiencies, and the control packages needed. This stage 2 is in the process of being carried out.

ACTION PLAN 2010
We refer to the note dated 8 October, on the Action Plan 2010 development.
The difference between this plan and the 2001 plan is mainly that the benefit side is included: Based upon dose-response relationships, the value of the reduced damage associated with the abatement measures is calculated, and compared with the costs of the measures. Apart from that, the procedure is basically the same.

The note of 8 October points out the importance of the Baseline scenario for 2010, and that it should reflect the "most likely development". The note also mentions some details of the work in each task that is necessary to carry out as contributions to the 2010 action plan development.

Below, the complete step-wise procedure is given, when the calculations are carried out with the AirQUIS system. A simplified procedure is also described, to be used if it is not possible to carry out the full procedure in time for results to be given at the last workshop.

These procedures follow the basic analysis concept (the URBAIR concept) which has, throughout the project, been the guiding concept of the project, and are basically the same as formulated during the Workshop1/98 in Norway, and described in the report from that workshop.

Complete procedure

1. Develop the Baseline scenario 2010, based upon development and change factors which can be forecasted from the present-day situation. (Task 8) (This baseline has been developed).
2. Include also, in the baseline scenario, the abatement measures that will be introduced as a result of the 2001 Action Plan. (Task 8). This may be called the "Actual" Baseline scenario. Modify the emission inventory according to the actual baseline. (Task 1).
3. Calculate the concentration fields in the model area, in grid and road receptor points, using the selected 4-month meteorological period. Compare concentrations with targets. (Task 3).
4. Calculate the concentration and exposure contributions from different selected source categories and groups, by excluding the emissions from these groups, one -by-one, from the emission inventory. (Task 3 and 5). On the basis of this, set up, on paper, simplified relationships between source group emissions and concentration and exposure contributions. This is to be used to estimate reduction potentials, see point 7 below. (Task 3 and 13). Select the source categories and groups on the basis of experience on which

groups of sources are probable candidates for abatement (e.g. small power plants, industrial sectors with similar technology, taxies, etc.). (Task 3 and 13).
5. Calculate the damage costs associated with the "Actual baseline scenario", and the contributions to damage from each source group/category, using dose-response relationships, and the results from point 4 above. (Task 6 and 9).
6. Investigate possible further control and abatement options (Task 2, 7and 11).
7. Estimate concentration, exposure and damage cost reduction potential per option, using the simplified relationships. (Task 3 and 13). Prioritise the further control/abatement options according to their estimated cost-efficiency and cost-benefit ratio. (Task 13).
8. Based on point 8, select packages of control/abatement options that seems necessary to reach targets, and calculate resulting concentrations, exposure and damage costs for these packages, and compare with the damage costs of the "actual baseline scenario". Compare the reduced damage costs with the costs of the control packages.
9. If necessary, continue to introduce abatement and control options, until the point is reached, where the control costs become higher than the reduced damage costs.

7 Plan for AirQUIS calculations

At the time of this Workshop 1/99, the AirQUIS version 2 had been installed at GRIEP, and training had been provided so that the AirQUIS (Task 3) team was capable of running the system and performing calculations. At the workshop, the AirQUIS team showed some results calculation results obtained for the period 1-10 January 1995. Calculated 24-hour averages were shown for the positions of the 6 automatic monitoring stations in the city, and comparisons with measured values.

The AirQUIS system is to be used both for calculating population exposure as part of the Task 6.1 study (on health damage and development of dose-response functions), and also for making the necessary calculations for the 2010 Action Plan. The calculation speed of the available AirQUIS version is still fairly slow, so a program for the calculations had to be developed which prioritised the calculations to be made.

The following note to that effect was made during the workshop.

Guangzhou AQMS project (NORAD project CHN 013)
NILU/STL/O 97009
2 July, 1999

Plan for AirQUIS calculations at GRIEP

Starting early July, 1999

There are two types of calculations that shall be done:

1. Calculations to provide air quality data for the health studies (Task 6.1)
2. Calculations related to the Action Plans, for selected packages of control measures.

The calculations for the health studies must now be prioritised, since Ms. Li Zhiqin is coming to Norway for training in August-September. The Action Plan-related calculations must be done afterwards.

After Mr. Rune's last stay in Guangzhou, most of the remaining problems with AirQUIS are presumably solved, so that the system is ready for calculations. Mr. Rune will assist in the setting up the system for the calculations specified below, to make sure that things are done correctly.

Calculation program

1. Calculations for the health studies (Task 6.1)

1.1 Calculations for the interview study (Dr. Jocelyne's part)

Time period:
Sept. '97 and Jan. '98. These months have been chosen so that the period represents a typical part of the meteorological year in Guangzhou.

Compounds:
SO2, particles and NOx or NO2.

Meteorological data:
The file with meteorological data should be prepared as a continuous file. That means that the hourly data for January should be linked to the hourly data for September, in such a way that the system thinks the January data are data for October. It is necessary to link the data this way, otherwise the system will stop after calculating for September.

Emissions data:
We use the 1995 emission inventory without any modifications.

Calculation points:
- the 2x2 km grid points
- the 500x500 meter grid points of the control area: Defined as receptor points. Use the coordinates of the centre (midpiont) of these 500x500 m grids).
- The 500x500 meter grid points of the two industrial areas (Defined as above).
- The selected points near the selected streets where the people in the “traffic” area of this study are living. See the note of Mr. Slordahl, made after the workshop in November last year.

Calculation schedule:
The calculations must be done for the whole 2-months period without stop.

1.2. Calculations for the health statistics study (Dr. Kristin’s part)

Time period:
The whole of the years ’97 and ’98. The calculations must be done for successive, shorter parts of the period, e.g. for each quarter of a year (see below).

Compounds:
SO_2, particles, and NO_x or NO_2.

Meteorological data:
Must be divided up into successive, 3-months periods

Emission data:
We use 1995 emissions as they are.

Calculation points:
The 2x2 km grid points only

Calculation schedule:
Do the calculations separately for consecutive 3-month periods.

2. Calculations for the Action Plan, for selected packages of control measures

The plan for these calculations will be made later.

7.1 3. Calculation time schedule

There are 2 servers available. We propose to do the calculations the following way:

Server A:
First: Calc. For the interview study (see section 1.1 above).

SO2 first, then particles, then NOx or NO2.
Hopefully, this will take nor more than about 11 days totally, if no time is lost between each compound..
Then: Continue with calc. For the health statistics study (see section 1.2 above), for NOx or NO2.
This will take about 7.5 days for each 3-month period, and about 30 days for the first year (1997). After 1997 is finished, continue with 1998.

Server B:
Calc. For the health statistics study. Start with SO2, then continue with particles. This will take about 2 days for each quarter, and about 8 days for the whole of 1997. After 1997 is finished, continue with 1998.

8 Minutes from task meetings

The following note summarises some of the important points discussed in task meetings during the workshop.

Guangzhou AQMS project (NORAD CHN 013)
STL/O97009/4.June,1999

NOTES FROM MEETINGS AND OTHER ACTIVITIES DURING WORKSHOP 1/99, 31 May - 4 June, 1999

These notes are intended to provide necessary and useful information to task team members not present.

Task 1 / Task 3 Emissions-Dispersion

<u>Meeting to present results from NILUs AirQUIS calculations (1 June 1700-1800)</u>
The calculations were briefly shown during the plenary meeting the same afternoon, concerning the 2001 action plan.
Task 1 and 3 were called, to see and discuss the results more in detail. Tables and color-coded grid maps were shown. The generally good comparison with measurements (i.e. monthly averages) was pointed out. (The NORCE team has no 24-hour or 1-hour measurement data to compare with).
It turned out that the GZ task 3 team had also finished AirQUIS calculations, for 1-10 January 1995, and compared them (daily averages, SO2, NOx, PM) with measured concentrations.
They provided tables with calculated and measured values, as well as maps with isolines (on map with geodata). Comparison was good for some days, and poorer on other days.
Liuli (task 12) had also done her own AirQUIS calculations, for the first week of January. Her results were different somewhat from those of task3 team.

Discussions:

- Calculation speed:

- Task 3 team had used 10 days of calc. time total to calculate 1 month, for 3 compounds. During that time, there were sometimes more than 1 user on the server.
- Liuli had observed calc. time several times. It varied: 1 week for SO2 took 8 hours, with one user; another time, 1 hour of SO2 took 13 minutes, also 1 user; another time, 1 hour NOx took about 36 minutes, with 2 users.

- Overall impression:

Task 3 team was generally satisfied with the modeling results, but the slow speed is a real problem.

- Main problems

- Slow speed;
- Still do not know how to change input data;
- Do not know how to export data;
- Some problem with "time step" function: max. 10 days?

Task 5 Exposure

Meeting 3 June 1900 - 1930

w/ Mr. Wang, Mr. Zhang, Ms. Li.

The Task 5 team in GZ has calculated population exposure with KILDER. Results were generally good, compared with measurements, but it seems clear that KILDER underestimates the contribution from traffic.

They used the following background values, in order to get agreement with measurements: SO2: 10 ug/m3; NOx: 15 ug/m3; TSP: very large value (70?).

We discussed the methodology to calculate population exposure with AirQUIS, including roadside exposure, using "road receptors". When they will calculate exposure, it will be based upon AirQUIS calculations at the following points: grid-points; road receptor points; building points along Dongfengzhong and Beijing roads. (**The GZ Task 3 team must be aware of this**).

It was also made clear that they shall not calculate exposure for 2001.

The priority work for GZ task 5 team now is to finish the coding for Task 6.1, before they continue other work, such as translating their KILDER calculation report, etc.

Task 6.1 Health damage

Meeting 2 June, evening

w/ Ms. Li, Mr. Wang and task 5 team, Mr. He Liangwan and others from task 3 team.

We went through Mrs. Li's status, as well as the methodologies for coding the addresses in the various study areas. This was clarified completely, according to the previous plans and notes.

Then the possibility for task 5 to finish the coding was discussed. It was agreed that this is the most important work now, and if task 5 could concentrate on it, it will not take so much time. This was taken up with Mr. Wu, and he has told task 5 to prioritise this work, and to finish it as soon as possible.

Task 8 Scenario development

<u>Meeting with Mr. Fan, 4 June, afternoon (Mr. Larssen)</u>
1. Mr. Fan wanted to discuss my note on Baseline Scenario 2001, sent to the GZ side previously as a background for introducing change factors in the emissions module in AirQUIS, for 2001 calculations. I explained how I had used Mr. Fan's reports to extract the change factors I had proposed in my note.
One example: From tables in Mr. Fan's report showing projected increases in rush-hour traffic and number of vehicles, I had proposed to use a 5% increase in traffic per year, resulting in 34% increase from 1995 to 2001. The data in Mr. Fan's report supported this. But Mr. Fan, and others of the GZ team, means that many streets in GZ have already filled their capacity today, so there is no room for increase. So how to distribute the projected increase over the road network? This example shows that the official projections for development in GZ may not all be realistic, or said differently, they require substantial infrastructure developments.
Conclusion: My note must be considered as a proposal for the change factors from 1995 to 2001. (Similar change factors also have to be developed for 2010). The GZ side must decide which change factors are most realistic, and thus should be used.

2. The GZ side discusses which task should be responsible for developing the change factors to be used in the emission inventory, to calculate (estimate) baseline for 2001 and 2010. Tasks 8,1, 7 and 11 are involved in this. During the plenary meeting on Friday 4 June, about the 2010 Action Plan, the NORCE side proposed that Task 1 should take the leading role in this work, coordinating the work in a group consisting of Tasks 1,8,7,11. **The GZ side must decide how this work should be carried out, now and in the future, and which task/which person should take the leading role.**

3. During the Action Plan 2010 discussions in plenary, the importance of constructing a realistic baseline scenario was emphasised. **Mr. Fan would like Mr. Vennemo and Aarhus to help suggesting how this should be done**: How to take account of policies and regulations already in effect or "in the pipeline", how to take account of national and local plans (will they be implemented?), how to construct various development alternatives, and the most probable one?

Task 12 Pollution forecasting

<u>Meeting with Mrs. Liuli, on 2 June, morning (Mr. Larssen)</u>
1. Ms. Liuli has tested the Episode model, using the AirQUIS system, since there is no meteorological preprocessor included with the exe-version of EPISODE she has at GEMC. She is generally satisfied with the performance, how it compares with measurements.
2. To set up the model for forecasting, she needs on-line meteo-data, from the meteo-office.

Annex 1
Workshop Program

Guangzhou AQMS Project (NORAD CHN 013)
Guangzhou, 31 May, 1999
STL/O-97009

WORKSHOP 1/99

Guangzhou (LongGui), 31 May – 4 June, 1999

PROGRAM

Monday 31 May: Preparatory work

- Before noon:	General preparations	
- After noon:	Program discussions: Guangzhou team	Meeting Mr. Wu and Mr. Larssen Introductory discussions, in groups, On the Action Plan 2001 document (the English version of the document was copied and distributed).
	NORCE team:	Preparations for the presentations on Tuesday

Tuesday 1 June: Action Plan 2001 presentation

-All day, in plenary: Presentation of the Action Plan document

Introduction:	Mr. Larssen
Baseline scenario	Mr. Larssen
Air Quality Targets	Mr. Larssen
Selected control measures, Costs and benefits	Mr. Aarhus.
Comments and discussion	

Wednesday 2 June: Action Plan 2001 discussion

- Before noon:	Guangzhou team:	Further discussion of the draft Action Plan
	NORCE team:	Time available for task work, etc.
- After noon:	Plenary:	Response from the Guangzhou side on the draft Action Plan.

Thursday 3 June: Task status and plans for finalisation

- Before noon: Work in task teams
- After noon: Plenary: Presentation of task status/plans. 15 min. per task.

Friday 4 June: Plan for 2010 Action Plan work, and Project finalisation

Detailed program for this day to be made later

Note:

Free time within this program and schedule should be used for task work.

Annex 2
Draft Baseline Scenario 1995 - 2001

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 emissions inventory has been prepared by Task 1 for 1995. This emissions 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 emissions 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 emissions 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

Table … in 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 km2). There, the population density is estimated to increase about 18,000 to about 37,000 per km2 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. <u>Use Table 1-8 in Mr. Fan's report to find the factors for change to apply</u>

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 fuel consumption larger than……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, NO_x, 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 take 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). 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.

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). So, multiply the oil consumption in the small source field by 1.12, uniformly over all the grid squares.

2.3 Traffic

2.3.1. Amount of total traffic

Alternative 1:
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. Unless more detailed data are available, we propose to multiply the traffic amount on all streets in the traffic data-base with 1.34.

Alternative 2:
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 nor 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.

Annex 3
Overhead transparency copies from Mr. Aarhus' presentation of the Draft 2001 Action Plan

Action plan 2001- control options

In search of the most cost effective control options
to reach air quality targets in Guangzhou

Capital costs

- How should we convert investment costs to annual capital costs?
- Assumptions are very important for estimations of abatement costs
- Many estimates of abatement costs do not specify assumptions used
- Difficult to compare numbers

Capital costs (cont.)

- We assume: 12% interest (norm in China, very high in international terms)
- 12% represents the benefit of the investment if we had spent it differently (profit, interest rate saving in the bank, etc.)
- Then we consider the lifetime of equipment - this determines the mortage
- 20 years: 1st year depreciation = 5%

Capital costs (cont.)

- Interest rate + depreciation: 12% + 7.3% = 19.3%
- Example:
  - abatement equipment requires an investment of RMB 100 mill.
- Annual capital cost = 100 mill. x 19.3% = 19.3 mill.
- Annual capital costs + annual operating costs / reduced emissions = cost effectiveness ratio

SO_2 control options

- We will present the following options:
  - Shut down small power plants
  - Low sulfur coal - all large point sources (POI 50)
  - Wet FGD on 20 largest point sources
  - Sorbent injection all large point sources (POI 50)
  - Other SO2 options

Shut down small power plants

- One option: shut down all power plants less than 200 MW (18 plants)
- Alternative option: shut down plants less than 150 MW
- Why? Because they are dirtier than the rest
  - Because the cleaner plants (in Gz and outside) are only partly run; no short term investments needed
- Reduction potential (18 plants):
  - SO2: 48,000 tons
  - NOx: roughly 15,000 tons(?)
  - Particles: 52,000 tons

Small power plants (cont.)

- Reduction potential will depend on which plants will substitute small plants
  - 100% imported: reduced emissions = reduction potential
  - 100% by other plants in Gz:
    - SO_2: emissions of small plants - corresponding partial increase of big Gz emissions: 25,000 tons
    - NO_x: 7,500 tons
    - TSP: 27,000 tons
- Costs: Costs considered = costs of shutting down power plants before the end of their useful life
- Costs = scrapping capital goods that have not been fully depreciated
- We ignore differences in operating costs (kWh/unit coal, labour costs, etc.)

Small power plants (cont.)

- We assume that average power plant has served 15 of 20 years (3/4)
- Costs of power plant capacity: RMB 360 mill. per 100 MW
- 18 plants = 1400 MW $\Rightarrow$ 14 x 360 mill. x 1/4 = RMB 1260 mill.
- Reduction potential: emissions reductions x 5 years = 296,000 tons SO_2, NO_x and TSP
- Cost effectiveness: 1,296 mill. / 296,000 tons = RMB 4,250 per ton
- If 100% of electriccity lost from small plants is imported: cost per ton = 0

Shut down power plants smaller than 150 MW

- This means that 13 instead of 18 plants are closed down
- Eliminates a smaller share of total installed capacity (510 instead of 1400 MW)
- 13 plants represents:
  - 30,000 tons SO2
  - 11,000 tons of NOx
  - 39,000 tons of particcles
- If Huangpu replaces production of 13 plants
  - SO reduction (annual): 18,000 tons
  - NOx reduction: 7500 tons
  - TSP: 26,000 tons

Power plants smaller than 150 MW (cont.)

- Total emission reduction 5 years: 257,000 tons (SO2, NOx and TSP together)
- Cost effectiveness ratio: RMB 460 mill./ 257,000 tons = RMB 1800 per ton
- In other words: by being a bit more selective: abatement costs are reduced by 60% per ton
- Conclusion: this option has high reduction potential and low costs
- Costs of transmission lines + distribution system?
- Any restrictions on imports from the regional network?
- What is the capacity utilization of big plants in Gz (or the ability to replace smalll plants)?

Low sulfur coal - all large point sources

- Assumption: Average sulfur content in coal used by large point sources = 0.75%
- By reducing this to O.5% ⇒ POI 50 emissiosn will be reduced by 33%
- Equivalent to 20% reduced concentrations
- Coal related SO_2 emissiosn from POI 50 sources: 85-90,000 tons ⇒ emission reduction potential: 25-30,000 tons
- Costs
  - 1 ton anthracite (0.75% sulfur): RMB 315 ton
  - 1 ton anthracite (0.5% sulfur): RMB 325 ton

Low sulfur coal (cont.)

- SO_2 emission from 1 ton of 0.75% S coal = 15 kg
- SO_2 emission from 1 ton of 0.5% S coal = 10 kg
- Difference = 5 kg ⇒ 200 tons coal = 1 ton of SO_2
- Cost effectiveness ratio = 200 tons coal x price difference = RMB 2000 per ton SO_2

Wet flue gas desulfurization

- A limitednumber of point sources are responsible for large emissions and high contributions to concentrations
- 17 sources contribute approxximately to 50% of *concentrations*
- Wet FGD has an SO2 removal efficiency of 90%
- Retrofitting wet FGD on 17 sources would remove approximately 45,000 tons of SO2

Wet FGD (cont.)

- Costs:
  - Abatement cost estimates vary from RMB 865 to 5000+ per ton removed
  - Costs vary according to:
    - new plant or retrofit
    - plant characteristics
    - assumptions made
  - Luohong power plant (Sichuan): RMB 865 per ton
  - WB: RMB 4000-5000 per ton
  - Illustrate with two examples in GZ: GZ power plant and GZ SINOPEC Petrochemical Factory (errror in document)

Wet FGD (cont.)

- Using international cost data:
  - Investment costs: RMB 1040 per kW
  - Operating and maintenance costs (O&M), fixed: RMB 96 per kW
  - O&M costs, variable: RMB 0.012 per kWh
- GZ Power Plant:
- Investment costs: 200,000 kW x RMB 1040 = 208 mill.
  - Assuming 20 years depreciation and 12% interest rate:
    - annual capital costs = 208 mill. x 19.3% = 40.1 mill.
- O&M costs, fixed: 200,000 kW x RMB 96 = 19.2 mill
- O&M costs variable: 200,000 kW x 6000 hours x RMB 0.012 = 14.4 mill
- Total annnual costs: RMB 73.7 mill
- Sulfur removed: 95% of 10,281 tons= 9767 tons

Wet FGD (cont.)

- Cost effectiveness ratio: RMB 73.7 mill. / 9767 tons = RMB 7,550 per ton removed.
- GZ SINOPEC Petrochemical Factory:
  - Investment costs: 55,000 kW x RMB 1040 = 57.2 mill.
  - Annnual capital costs: 19.3% of 57.2 mill = 11 mill.
  - O%M fixed costs: 55,000 kW x RMB 96 = 5.28 mill.
  - O&M variable: 55,000 x 6000 hours x RMB 0.012 = 3.96 mill.
  - Total annual costs: 20.3 mill
  - Emission reduction: 95% of 8,291 tons = 7877 tons
  - Cost effectiveness ratio: 20.3 mill. / 7877 tons = RMB 2,575 per ton
- Rough estimates for other sources indicate costs closer to 5000 than 1000-1500.

Sorbent injection (SI)

- Reduction potential: Concentrations ccould be reduced by 25% if SI is applied to all large point sources of SO2
- Emissions from each individual source: 50% lower
- Costs: Cost effectiveness ratiosof SI reported in different sources vary from RMB 790 to 6000 per ton removed
- CE ratios will of course depend on SO2 emission intensity (SO2/MW)
- Two examples x three cost assumptions:
- Guangzhou power plant
    - Chinese cost data: Investment costs = RMB 212 per kW
    - Investment costs: 200,000 kW x 212 = 42 mill.
    - Annual capital costs: 19.3% of 42 mill = 8.2 mill.
    - O&M costs = 200,000 kW x RMB 91per kW = 18.24 mill.
    - Total annual abatement costs: 26.4 mill.

Sorbent injection (cont.)

    - Emisssion reduction (50% cleaning) = 50% of 10,280 tons = 5140 tons
    - Emissions reduction (70% cleaning) = 7200 tons
    - CE (50% cleaning) = 5100 per ton
    - CE (70% cleaning) = 3650 per ton
  - International data I:
    - Investment costs = RMB 800 per kW
    - O&M costs = RMB 48 per kW
    - Total annual abatemment costs: RMB 40.5 mill.
    - CE (50% cleaning): RMB 7870 per ton removed
    - CE (70%) removed): RMB 5,600 per ton removed.

Sorbent injection (cont.)

- International data II (ABB)
  - Investment costs: RMB 120 per kW
  - + ESP costs: 120 per kW
  - O&M costs: RMB 88 per kW (both sorbent injection and ESP)
  - CE (50% cleaning): RMB 5225 per ton SO2 removed
  - CE (70% cleaning: RMB 3730 per ton SO2 removed
  - In addition TSP will be reduced, making the option more cost effective.

Sorbent injection (cont.)

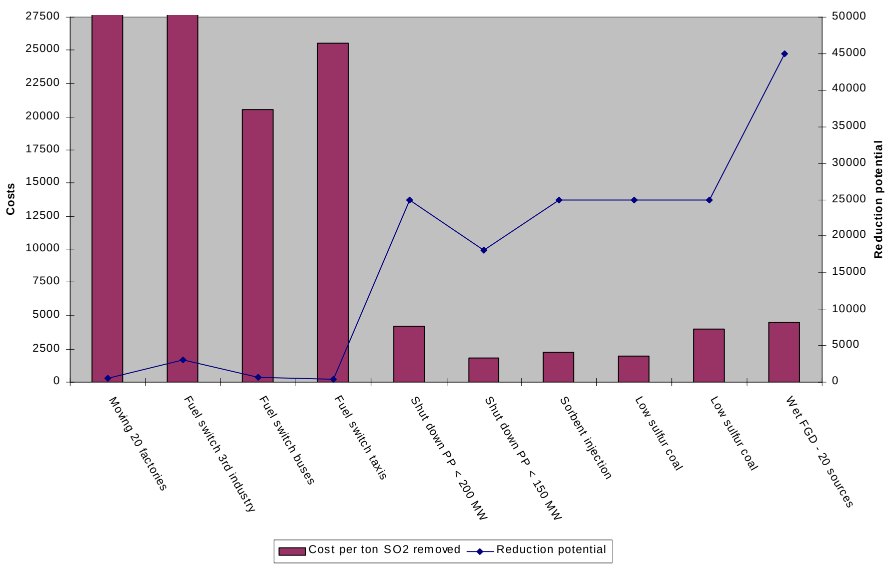
- Guangzhou Fertilizer Factory
  - Chinese data: 24,000 kW x RMB 212= 5 mill
  - Annual capital costs: 19.3% of 5 mill = 980,000
  - O&M: 24,000 kw x RMB 91 per kW = 2.2 mill
  - Total annual abatement costs: 3.2 mill.
  - SO2 reduction: 1320 tons (50% cleaning); 1860 tons (70% cleaning)
  - CE: RMB 2400 per ton (50% cleaning); RMB 1700 (70% cleaning)

  - International data I: CE = RMB 3680 (50% cleaning); RMB 2600 (70%)
  - International data II: CE = RMB 2450 (50% cleaning); RMB 1730 (70%)
- Conclusion: RMB 2000-2500 is the best estimate for SI

Comparison of options

Option	Cost per ton removed	Reduction potential
Sorbent injection in power plants and large industrial boilers	2500	POI50 emissions down 50%
Shut down 18 power plants, 200 MW or less	4,250 or less	25,000 tons (+ 7,400 tons NOx + 27,000 tons particles)
Shut down 13 power plants, 150 MW or less	1,790 or less	17,800 tons SO_2 (+ 7,500 tons NOx + 26,100 tons particles)
All large point sources use low sulfur coal (shift from 0.75% S to 0.5% S)	2000	20-30,000 tons (max 33% of "bituminous part" of POI50 emissions)
All large point sources shift from bituminous (0.75% S) to anthracite (0.5% S)	4000	20-30,000 tons
Wet FGD on 20 largest point sources	4000-5000	40,000 - 50,000 tons
Dry FGD	Same as wet FGD	
Boiler replacement	27,500	
Fuel switch – taxis	25,555	450 tons (15,000 taxis) (+ 360 tons TSP)
Fuel switch – buses	20,600	700 tons (5000 buses) (+ 3,000 tons NOx and 540 tons TSP)
Fuel switch third industry	600,000	2,000-3,000 tons (2% of total emissions)
Moving 20 factories	72,400	500 tons (+ 130 tons NOx and 1,,150 tons particles

SO2 options



NOx options

- NOx options:
  - Low NOx burners and Over Fire Air on 20 large NOx sources
  - SNCR on 20 large NOx sources
  - SCR on 20 large NOx sources
  - Retrofit three way catalytic converters (TWC) on taxis
  - Other NOx options to be presented more briefly

LNB and OFA

- NOx emissions may be reduced by 30-60% by applying LNB in combination with OFA
- 20 sources with highest contributions to conncentrations emit 21,000 tons NOx
- By applying LNB and OFA on these 20 sources, emissions could be reduced by 10,000 tons (6,300 - 14,700), or twice as much depending on emission factors
- If LNB and OFA applied on <u>all</u> large point sources: emissions could be cut by 10,000-24,000 tons
- Costs:
- Large variation in costs reported

LNB and OFA (cont.)

- Coststhat should be considered: Retrofit investment cost for LNB minus costs for conventional burner + lost investment of existing burner if it replaced before end of useful life
- Example: Guangzhou Power Plant (200 MW)
- Investment costs: 200,000 kW x RMB 120 per kW = RMB 24 mill.
- Minus cost of conventional burner: 200,000 kW x RMB 7-8 per kW = RMB 1.5 mill.
- Additional investment costs = 22.5 mill.
- Annual capital costs (3 years depreciation, 12% interest) = 22.5 mill x 74% = 16.7 mill
- Emissions reuction: 50% of 2546 tons = RMB 13,150 per ton NOx removed

LNB and OFA (cont.)

- This estimate is very high compared to costs reported in international literature (800-3000 per ton)
- Are NOx emissions underestimated?
- Example 2: GZ SINOPEC Petrochemical factory
- Investment costs: 55,000 kW x RMB 120 = RMB 6.6 mill.
- Minus costs of conventional burner: 55,000 x RMB 7,.5 = 400,000
- Additional capital costs: 6.2 mill
- Annual capital costs: 6.2 mill. x 74% = 4.61 mill.
- Emissions reduction: 50% of 2050 tons = 1025 tons

LNB and OFA (cont.)

- CE: RMB 4,500 per ton
- This fits better with other estimates, we choose RMB 4,500 per ton NOx removed as our estimate
- If NOx emisssion factors are twice as high: Cost effectiveness ratio will be cut by 50% (2250 per ton)
- Since abatement costs is 100% investment related (not operating costs), the estimate for LNB/OFA is very dependent on e.g. interest rate. If rate lowered from 12% to 8% or 5%, CE ratio will decrease significantly

SCR/SNCR

- NOx removal by SCR: 70-90 %
- SNCR: 30-70%
- Applying SNCR to 20 largest sources: NOx reduction = 10,000 tons
- Applying SCR to 20 largest sources: NOx reduction = 17,000 tons
- Costs - SCR
  - Investment costs assumed to be RMB 180 per kW
  - Operating costs: RMB 0.012 per kWh
    - this assumes a urea price which is 84% higher than GZ price
  - Example 1: GZ Power Plant
  - Investment costs: 200,000 kW x 180 RMB = 36 mill.
  - Annual capital costs (20 years depreciation, 12% interest): 36 mill. x 19.3% = 7 mill.

SNCR (cont.)

- O&M: 200,000 kW x 6000 hours x RMB 0.012 per kWh= 14.4 mill.
- Total annnual aabatement costs: RMB 21.35 mill.
- NOx reduction per year: 60%of 2540 tons = 1525 tons NOx
- CE: 21.35 mill / 1525 tons = RMB 14,000 per ton
- If emission factor is doubled: CE is 7000 per ton

- Example 2: SINOPEC Petrochemical Factory
- Investment costs: 55,000 kW x RMB 180 per kW = RMB 9.9 mill.
- Annual capital costs: 9.9 mill x 19.3% = 1.9 mill.
- O&M costs: 55,000 kW x 6000 hours x RMB 0.012 = 3.96 mill.
- Total annual abatemment costs: 5.86 mill
- Emissions reduction: 60% of 2050 tons = 1230 tons
- CE: RMB 4770 per ton

SNCR/SCR (cont.)

- If 50% cleaning and doubled emission factors: emissions reduction = 2050 tons
- CE = RMB 2,850 per ton
- International estimates are in the middle of the two GZ examples covered: we use RMB 8000 as best estimate.

- Costs SCR:
- Investment costs - retrofit: RMB 700-1200 per kW
- O&M: RMB 0.024 per kWh
- Example: GZ SINOPEC Petrochemical
- CE: RMB 10,000 per ton NOx removed
- This fits well with estimate from Shanghai study (9600): we use RMB 10,000 as best estimate

Retrofit TWC on taxis

- Emission reduction: from 1 g/km to 0.3 g/km
- Assumed lifetime of TWC = 300,000 km
- Assumed driving distance per taxi: 100,000 km per year
- Reduction over three years: 3 years x 100,000 km x 0.7 g = 210 kg
- Cost - retrofit: RMB 5000
- Cost effectiveness: RMB 5000 / 210 kg = RMB 24,000 per ton
- Emissions reduction per year: 15,000 taxis x 100,000 km x 0.7 g/km = 1050 tons NOx

Retrofit TWC on taxis (cont.)

- Emission factor of 1 g NOx per km seems very low.
- If emissions are 2.1 g/km: emissions reduction = 1.8 g/km
- 3 years x 100,000 km x 1.8 g/km = 540 kg
- Cost effectiveness ratio: RMB 5000 / 540 kg = RMB 9300 per ton

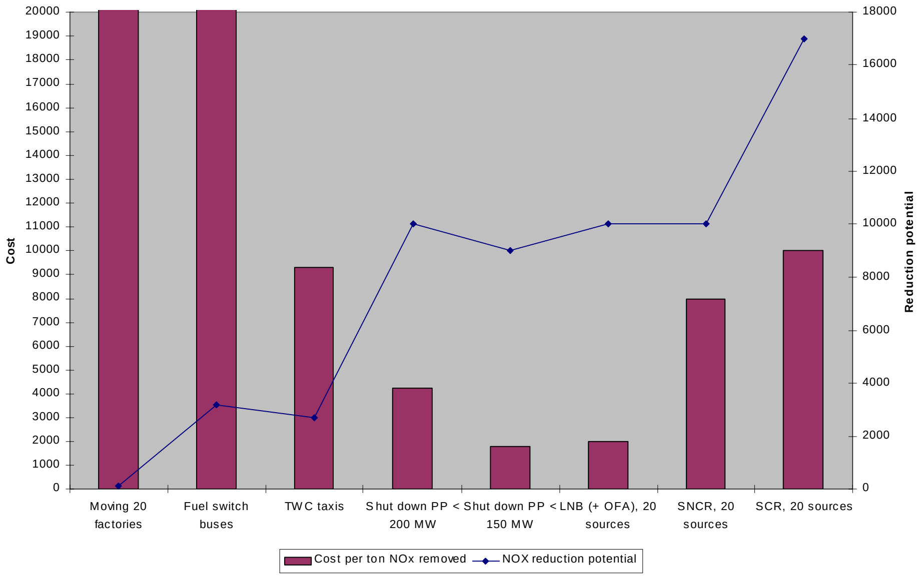
Other options

- Shut down of 13 power plants is the cheapest option and has a large reduction potential
- Moving 20 factories is an expensive option with almost no reduction potential for NOx
- Fuel swiitch buses is relatively expensive, even if spreading costs on all pollutants. Moderate reduction potential compared to other options.

Comparison of NOx options

Option	Cost per ton removed	Reduction potential
Moving 20 factories	72,400	136 tons
Fuel switch buses	20,600	3,200 tons
Shut down 18 power plants, 200 MW or less	4,250	7,400 - 13,000 tons
Shut down 13 power plants, 150 MW or less	1,790	7,000-11,000 tons
LNB (+ OFA) on 20 large sources	2,000	10,000 tons
SNCR on 20 large sources	8,000	10,000 tons
SCR on 20 large sources	10,000	17,000 tons
TWC – taxis	9,300	2,700 tons

NOx options



TSP options

- TSP options to be presented:
  - Retrofit high efficiency ESP on 10 sources
  - Low ash coal - all large point sources (POI 50)
  - Other options analysed under SO2 or NOx

Retrofit ESP on 10 sources

- Emission inventory shows that 12 sources contribute to 32 % of the total particle emission and large contributions to concentrations.
- 10 of these have cleaning efficiencies of particles of 88%. The remaining 2 have cleaning efficiencies of 96-97%.
- Example on calculation of cost effectiveness: Yongda power plant
- Annual emissions: 8 900 tonnes
  1995 dust removal efficiency: 88.4%
  New efficiency after retrofit of ESP: 99.5%
  Reduced emissions: 8500 tonnes

Retrofit ESP (cont.)

- Costs:
  - Investment cost (retrofit) 61,000 kW x 240 RMB pr. kW = RMB14.6 mill.
  - Annual capital cost: RMB 2.81 mill. (20 years, 12 % interest rate)
  - Annual operating costs (electricity): 61,000 kW x RMB 40 per kW = 2.44 mill
  - Total annual abatement costs: RMB 5.25 mill
  - Cost effectiveness: 5.25 mill/ 8500 tons = RMB 610 per ton.

  - The same calculation method applied on Zini Tangchiang: (45 MW, cleaning efficiency 88%, 1995 emissions = 5060 tons (2 of 6 stacks) results in abatement cost per ton = RMB 800 per ton

Retrofit ESP (cont.)

- Reduction potential:
  - Retrofit ESP on 10 sources with low cleaning efficiency
  - A reduction of total emissions of 20% should be realistic.
  - The cost will be in the range of 610 – 800 RMB per ton particles removed.

Low ash coal

- Coal is dominant in energy supply of GZ
- Low ash coal for large coal consumers of coal has great potential for reducing emissions of particles
- We will cconsider a shift from bituminous coal (32% ash) to anthracite coal (22% ash) for all large point sources

- Large point sources used 7.7 mill tons coal (1995)
- Of which roughly 5.6 mill . tons bituminous coal
- Average ash content of bituminous = 32%
- Assume 95% cleaning/dust removal
- Emissions = 5,600,000 tons x 32% ash content x 90% (of coal ash to flue gas) x 5% (not removed) = 80,000 tons

Low ash coal (cont.)

- If this coal quantity is replaced by coal with 22% ash content (but the same energy content), emissions will be:
- 5,600,000 x 22% x 90% (of coal ash to flue gas) x 5% (not removed): 55,550 tons
- Reduction potential: 80,000 tons - 55,550 tons = 25,000 tons

- Costs:
  – Average price anthracite = RMB 315 per ton
  – Average ash ccontent anthracite: 22%
  – Average price for 32% ash bituminous coal: RMB 220 per ton
  – Price difference: RMB 95 per ton

Low ash coal (cont.)

– Burning 1 ton bituminous coal (32% ash): 320 kg x 90% (of coal ash to flue gas) x 5% (not removed): 14.4 kg fly ash emission
– Burning 1 ton anthracite (22% ash): 220 kg x 90% (of coal ash to flue gas) x 5% (not removed): 9.9 kg fly ash emission
– Difference = 4.5 kg
– 220 tons of coal: 1 ton less fly ash emission if burning 22% ash anthracite compared to burning 32% ash bituminous coal.
– Cost effectiveness ratio: 220 tons x price difference: RMB 21,000

Low ash coal (cont.)

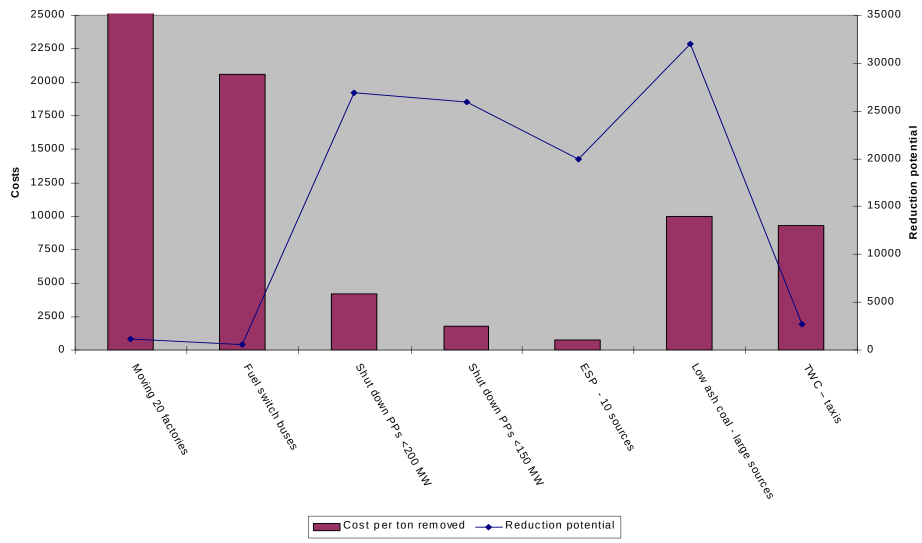
– However, anthracite has a higher energy content than bituminous (5-10% higher), so this would reduce the ratio somewhat.
– If average dust removal efficiency is higher than 95%, ratio will be higher; if dust removal efficiency are lower than 95%, ratio will be lower.
– Dust removal efficiency = 90% $\Rightarrow$ cost effectiveness is RMB 10,000 per ton

Other TSP options

Comparison of TSP options

Option	Cost per ton removed	Reduction potential
Moving 20 factories	72,400	Small (1,150 tons)
Fuel switch buses	20,600	Very small (540 tons)
Shut down 18 power plants, 200 MW or less	4,250	27,000 tons or more
Shut down 13 power plants, 150 MW or less	1,800	26,000 tons or more
ESP - 10 sources	500-1000	20,000 tons (10 sources)
Low ash coal - all large point sources	10,000-20,000 (90-95% cleaning)	32,000 tons
TWC – taxis	9,300	2,700 tons
Street cleaning	?	Limited?

TSP options



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ABSTRACT

The Sino-Norwegian cooperation project “Guangzhou Air Quality Management and Planning System” holds two workshop per year. The 1st workshop in 1999 was held in Guangzhou during May 31- June 4, 1999. It was arranged according to the agreement about this made between the partners, at the 2nd workshop in 1998 in Guangzhou.

The workshop was attended by the full Guangzhou team, and from NORCE by 5 NORCE Task Leaders and by the project leader Mr. Steinar Larssen.

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