8.6 Conclusion

8.6.1 Shift to Natural Gas

The shift to natural gas is a countermeasure of the first priority for the mitigation of SO_2 concentration in the BMR. It can be introduced by an economic mechanism, and need not prepare new or more stringent regulations. It is consistent with the national policy to enhance natural gas in manufacturing sector.

Natural gas is almost a domestic energy for Thailand. And in many cases, the shift to natural gas brings energy saving effects. Moreover it is an environmentally friendly measure in many aspects, such as lower dust and SOx emissions and lower chances of black smoke.

However, the simulation analysis shows the necessity to investigate in detail. According to the inventory prepared by generalized economic growth frame and Airviro Grid module simulation, three grids show exceeding concentrations of Thai standard in the 2011 BAU case (Chapter 6). Three grids locate in Bangkok, Nonthaburi and Samut Sakhon. In the 2011 Control case, one grid in Samut Sakhon shows an exceeding concentration of Thai standard. It is not appropriate to identify the share of ground level concentration of respective emission source by the current simulation. However it is possible to consider sources around exceeding grids.

Concerning sources around exceeding grids of Bangkok and Nonthaburi, they may be attributed to the aggregation of small sized ones. Concerning Samut Sakhon, they may be regarded as the group of large sized sources. However, as mentioned already, it is necessary to investigate by appropriate simulation model and detailed inventory including future operation plan by respective factory.

8.6.2 Step by Step Implementation

Currently, Thai SO_2 standard is satisfied in the BMR. According to the simulation results, some limited grids will not satisfy the standard in the year 2011. For mitigation of this possible deterioration of the environment, the shift to natural gas is recommended. The shift to natural gas can be introduced by economic mechanism without new or more stringent regulations, i.e. the introduction will not burden private company with extra economic cost.

In order to mitigate possible deterioration beforehand, it is appropriate and realistic to enhance step by step introduction. Generally high concentration grids appear in high emission source areas by Airviro simulation. Therefore, the first priority is the introduction of shift in and around high concentration grids. After the introduction of shift in and around high concentration grids, other grids become targets of the introduction of shift to natural gas.

At the actual stage of implementation, it is important to take into consideration that the mitigation measure for some factories depend on specific condition, not on general condition. In such cases, various measures can be regarded as possible. In specific cases, the fuel shift from fuel oil, i.e. heavy oil, to lighter oil and utilization of lower sulfur coal and lignite might be possible measures. In order to satisfy environmental and economic requirement, the best way should be selected.

Concerning WHO guideline, shift to natural gas will be able to reduce the number of exceeding grids significantly. However still 35 grids show exceeding value by Airviro simulation in the 2011 Control case. The attainment of WHO guideline is a future long-term issue. According to NEQA, B.E. 2535, ambient air quality standard shall be modified and improved in the light of scientific and technological progresses and changes in economic and social conditions of the country. WHO guideline will be an important reference for modification.

For the sake of reference, the critical load approach is described. If the idea of the critical load was adopted and a 25% risk ratio value by BC/AL ratio was applied, ATMOS2 simulation results showed following (Supporting Report, Chapter 5 and 9). By 2011 Control case, almost all grids in the BMR exceeded critical load values, and maximum exceeding ratio was more than 3. If the target of countermeasure was supposed to keep critical load, it was necessary to introduce countermeasure with larger reduction amount. The situation was similar in Eastern and Central regions where deposition amount by ATMOS2 showed larger value than critical load values (Supporting Report, Chapter 5).

8.7 Action Plan

8.7.1 Financial Arrangements

The shift to natural gas is a countermeasure of the first priority for the mitigation of SO_2 concentration in the BMR. According to EPPO and PTT, the fuel shift to natural gas is one of important energy policies, and should be enhanced.

However, the shift to natural gas is an option for the individual private company. Even the pipeline is laid down, the connection of industries to the pipelines depends upon their willingness. In fact, even in the area where the pipeline is laid down, limited industries that could obtain benefit from the fuel conversion have connected to the network.

The price scheme that PTT provides gives incentives for the big industries that can produce a profit from the conversion due to the price difference, but this does not work well as an incentive for the small and medium-size industries. For such industries that especially encounter financial problems due to the economic crisis and that cannot afford the connection,

financial support is indispensable. It is necessary to publicize economic and environmental benefits to such industries, and enhance the introduction for the shift to natural gas.

In order to support the fuel shift to natural gas financially, soft loans by the Environmental Fund and the JBIC's two-step loan are applicable mechanisms. The introduction of overseas investment by the CDM would also be one economic mechanism for supporting the shift to natural gas.

8.7.2 Institutional Issues and Capacity Building

8.7.2.1 Institutional Issue for the Shift to Natural Gas

The shift to natural gas is consistent with national policy to encourage natural gas in the manufacturing sector, and it can be introduced by economic mechanisms, and need not prepare new or more stringent regulations. However, it is necessary to enhance the shift by environmental administration.

Natural gas is distributed solely by Petroleum Authority of Thailand (PTT). PTT has the intention to promote gas distribution in the BMR. Therefore PCD should discuss with PTT the plan of the shift, i.e. what area should be prioritized for the shift and how apply supporting mechanism by the Government. The base data for selection of area is the simulation result of the Study. After the arrangement of plan, PCD should raise public awareness for shift to natural gas.

In addition, it is necessary for the mitigation of acid deposition and SO_2 concentration to reinforce the institution and capacity of PCD. Following sections describe the issue for institution and capacity.

8.7.2.2 Designation of Analysis and Simulation Group

The major subject for the expansion of capacity is the designation of an analysis and simulation group in an adequate sized administration unit. The role of the group is not to collect monitoring data but to analyze causes and results of environmental issues. Besides, it is necessary to analyze the effect of policy options by simulation. Thus PCD with an analyzing and simulation group has the capability of taking initiative in environmental administration.

The function of analysis and simulation cannot be completed by government agencies alone. Involvement of private sector after adequate and clear job assignment is necessary.

8.7.2.3 Designation of Inventory Group

In order to analyze the causes of environmental issues, inventory data are indispensable.

Currently inventory databases of the environmental field in Thailand are not sufficient. The data sets of other agencies are not sufficient for the administration of PCD. Inventory databases are essential for analyses. Periodical and continuous compilation of inventory data should be assigned to the group of PCD. The function of preparation of inventory cannot be completed by government agencies only. Involvement of the private sector after adequate and clear job assignment is necessary.

8.7.2.4 Capacity Building

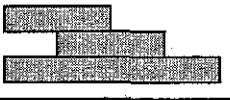
For effective environmental administration, it is necessary to build the managing capacity of staff. The point of capacity building is the systematization of environmental knowledge. Systematized knowledge leads to the implementation of advanced policy. Monitoring data, inventory information, simulation results, outcomes of research, and socio-economic conditions are materials for the systematization of environmental knowledge. When formulating policy, it is necessary to investigate varied fields such as health effects, socio-economic conditions and financial matters. The experience of policy formulation and the preparation of various reports are important methods for capacity building.

8.7.3 Action Plan

In order to enhance the shift to natural gas, because of natural gas is distributed solely by Petroleum Authority of Thailand (PTT), PCD should discuss with PTT the plan of the shift, i.e. what area should be prioritized and how apply supporting mechanism by the Government. After the arrangement of plan, PCD should raise public awareness for shift to natural gas.

Table 8.7.3.1 shows tentative schedule of the shift to natural gas and reinforcement of institution and capacity for acid deposition and SO_2 mitigation.

Table 8.7.3.1 Action Plan

	2003 2004 2005 2006 2007 2008 2009 2010 2011
Countermeasure: Shift to Natural Gas Western Part of Bangkok NG Ring (Main Pipeline by PTT) Installation Planning (PCD and PTT) Supprting Planning (PCD, PTT, and IFCT) Public Relation for Shift to NG Instalation of Necessary Facilities by Individual Industries (Application of Environmental Fund, JBIC's Two Step Loan)	
Reinforcement of Institution and Capacity of PCD Designation of Analyzing & Simulation Group Designation of Inventory Group Nurturing Private Sector	

9. Countermeasures for NO_2 in the BMR

9.1 Methodology

To begin with the countermeasures selection, the 1st draft countermeasures were formulated from the analysis of the 2011 (BAU Case) simulation results shown in Figure 9.1.1.1 and summarized in Table 9.1.1.1. The 1st draft countermeasures, shown in Table 9.1.1.2, were screened through two steps as shown in Figure 9.1.1.2. First, they were evaluated from a social, financial acceptability and technical possibility perspective, at the preliminary level, and then the selected countermeasures, 2nd draft countermeasures, were evaluated by the cost-effectiveness analysis.

■ : Grid over Thai NO_2 ambient air quality standard
▨ : Grid over WHO NO_2 ambient air quality guideline

Figure 9.1.1.1 NO_2 Airviro Simulation Result of 2011 (BAU Case)

Table 9.1.1.1 Simulation Result of the BAU Case

Case Description	NOx Emission Volume (kt@2011)	No. of Grid over the standard (BMR: 26,320 Grids)	
		Over WHO	Over Thai
BAU Case	277	2,127 (8%)	60 (0.2%)

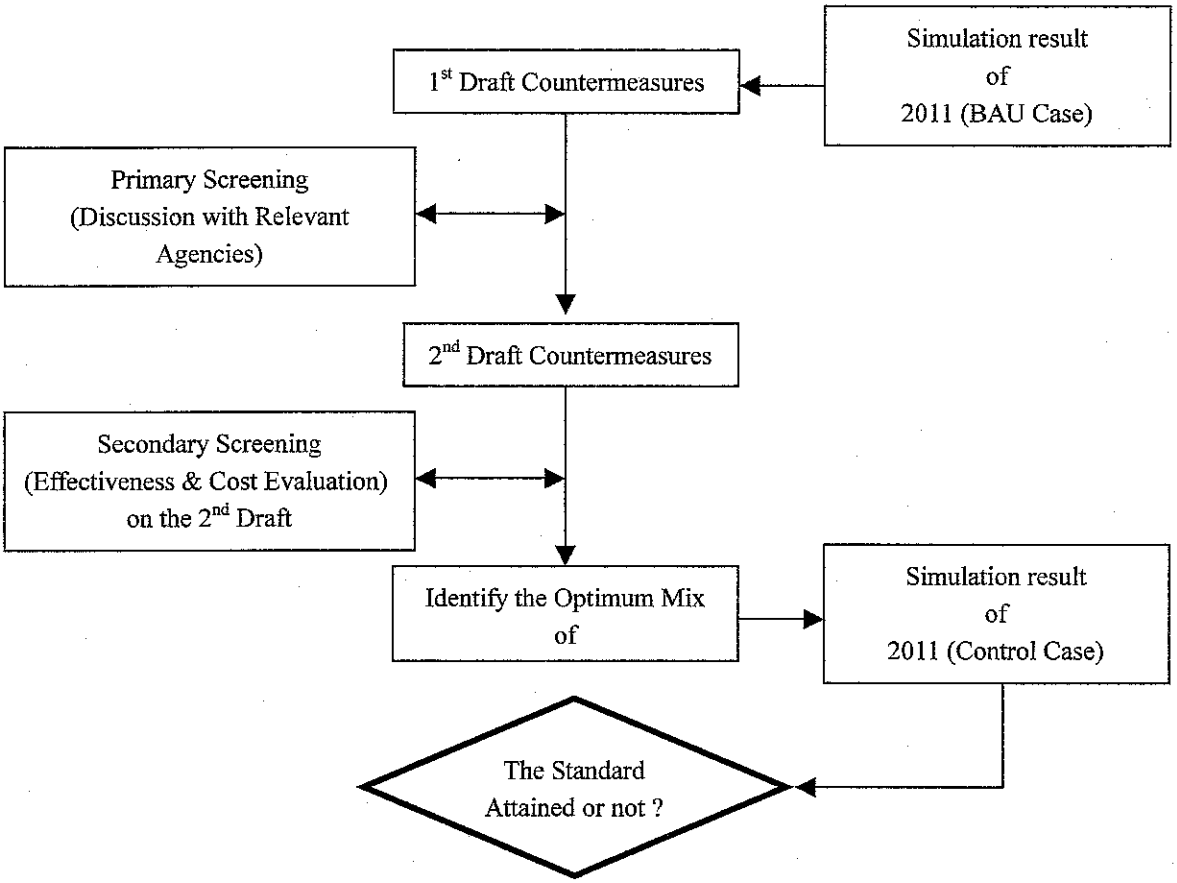


Figure 9.1.1.2 Basic Flowchart for Building the Scenario for the NO_2 Countermeasures

Table 9.1.1.2 Outline of the 1st Draft Countermeasures

	Countermeasure	Description
BAU Case	■ EURO3 Enforcement (**EURO 3**) - Light-duty Vehicles/Trucks (2004 -) - Heavy-duty Vehicles/Trucks (2006 -)	- EURO3 is a more stringent emission standard than EURO2. - Unlike EURO2, the EURO3 vehicles require lower sulphur content in gasoline and diesel oil to attain the emission standards.
Tentative Countermeasures for Control Case	■ EURO4 Enforcement (**EURO 4**) - Light-duty Vehicles/Trucks (2010 -) - Heavy-duty Vehicles/Trucks (2011 -)	- EURO4 is a more stringent emission standard than EURO3. - Like EURO3, the EURO4 vehicles require lower sulphur content in gasoline and diesel oil (lower than EURO3 level) to attain the emission standards.
	■ Low-Emission-Vehicle Promotion (**LEV**) - NGVs - Hybrid or others	- Target vehicle type is HDDV/Ts, namely Urban Buses (BMTA), Coaches (Long-haul Buses) and H-Truck (Heavy Truck) - LEV generally emits NOx much lower than conventional Diesel vehicle. - For LEV promotion, Aftermarket engine conversion of old (in-use) HDDV/Ts and New LEV purchase were considered.

	■ Overage Vehicle Retirement (**OVR**)
	- Accelerating retirement of overage vehicles
	- Introduction of inducements to New vehicles
		- Target vehicle type is HDDV/Ts, namely Urban Buses (BMTA), Coaches (Long-haul Buses) and H-Truck (Heavy Truck)
		- By this countermeasure, Over 10 years old HDDV/Ts could not be registered in the BMR, for the following reasons,
		  - The air pollution problem occurs primarily in the BMR and the major HDDV/T traffic in the BMR is considered as HDDV/T registered in the BMR.
		  - If it also covers up-country, it would cause fatal impact there.
		- Tampering (mainly engine replacement) would be prohibited as a rule since,
		  - The vehicle age control assumes that the engine age should be same as fleet age. If the engine can be replaced without certification, the vehicles emit higher than they are supposed by their age deterioration
		  - Tampering normally would be accompanied with the removal or disabling of emission control devices and cause high emission.
		However it is allowed only when the engine switched vehicles match exactly any certified configuration of the same or newer model year as the chassis. (Tampered vehicle should be treated as new vehicle when it is tampered)

	■ HDDV/T Substantial Compliance with emission standard (**Real-EURO**)	- PCD test data show that the actual NOx emissions of EURO 2 HDDV/T in Thailand are much higher than they are supposed to be if they are to meet the EURO 2 standards. This countermeasure would require HDDV/T to comply with EURO standard stricter through random sampling/testing by unannounced inspection, and to emit as same level as European HDDV/T.
Supplement[1]	■ *Traffic Control* *- No HDDT (24hrs) in Middle-ring Road Area (113 km²)*	- *This is the 4th stage of OCMLT traffic control plan for the mitigation of traffic congestion. It is not treated as countermeasure.* - *There is no traffic simulation of this control. The Study estimated presumable traffic volume on rough assumption, namely no HDDT in control area without any vehicle type shift (Case 1), with shift from 1 HDDT to 6 LDDTs (Case 2) with the same traffic situation as BAU case*

Note: Traffic control was not considered as a countermeasure since it was not environment-oriented. However, they were treated as supplement to estimate their preliminary impact.

As shown in Figure 9.1.1.3, HDDV/Ts (H-Trucks and Buses), would share approx. 80% of the total NOx emission from mobile sources in 2011 (BAU). The 1st draft of the countermeasures were considered as the effective reduction of NOx emission from HDDV/Ts.

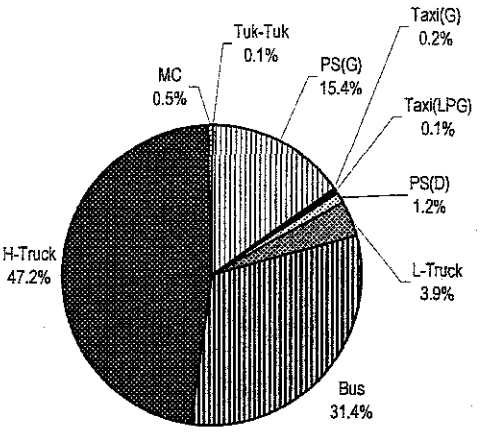


Figure 9.1.1.3 NOx Emission estimated by Vehicle Type in 2011 (BAU Case)

The 1st draft for the countermeasures, as follows, are summarized in Table 9.1.1.2.

- EURO 4 (More stringent vehicle emission standard than EURO 3, considered in the BAU Case)
- LEV (Low Emission Vehicle: Low emission Heavy Duty Vehicles/Trucks with alternative fuel to high speed diesel oil)
- OVR (Overage Vehicle Retirement: Retirement program of overage HDDV/Ts, which were considered as high emitters), and
- Real-EURO (Substantial compliance of HDDV/Ts with the latest emission standard)

9.2 Countermeasures Selection

The target vehicle types for the 1st draft of countermeasures were selected through primary screening and they were complied into the 2nd draft countermeasures. The 2nd draft countermeasures were evaluated by the cost-effectiveness analysis and institutional evaluation, secondary screening. Figure 9.2.1.1 shows the following results of the secondary screening,

- Real-EURO should be placed as the first priority because it was considered the most effective (relatively negligible cost for reduction) in spite of minor institutional reform.
- EURO 4 should be rejected from the definitive viewpoint of only NOx reduction, because it would need the largest financial support (55 million B/t) if it is to be avoided that end-users (new vehicle buyers) will carry the burden by the unit price increase, even though small effectiveness.
- OVR and LEV were considered competitive with each other to be placed as the second priority (OVR: 0.4-3.3 million B/t, LEV: up to 0.2 million B/t), therefore possible combinations of them were analyzed and the optimum mix was selected hereafter.

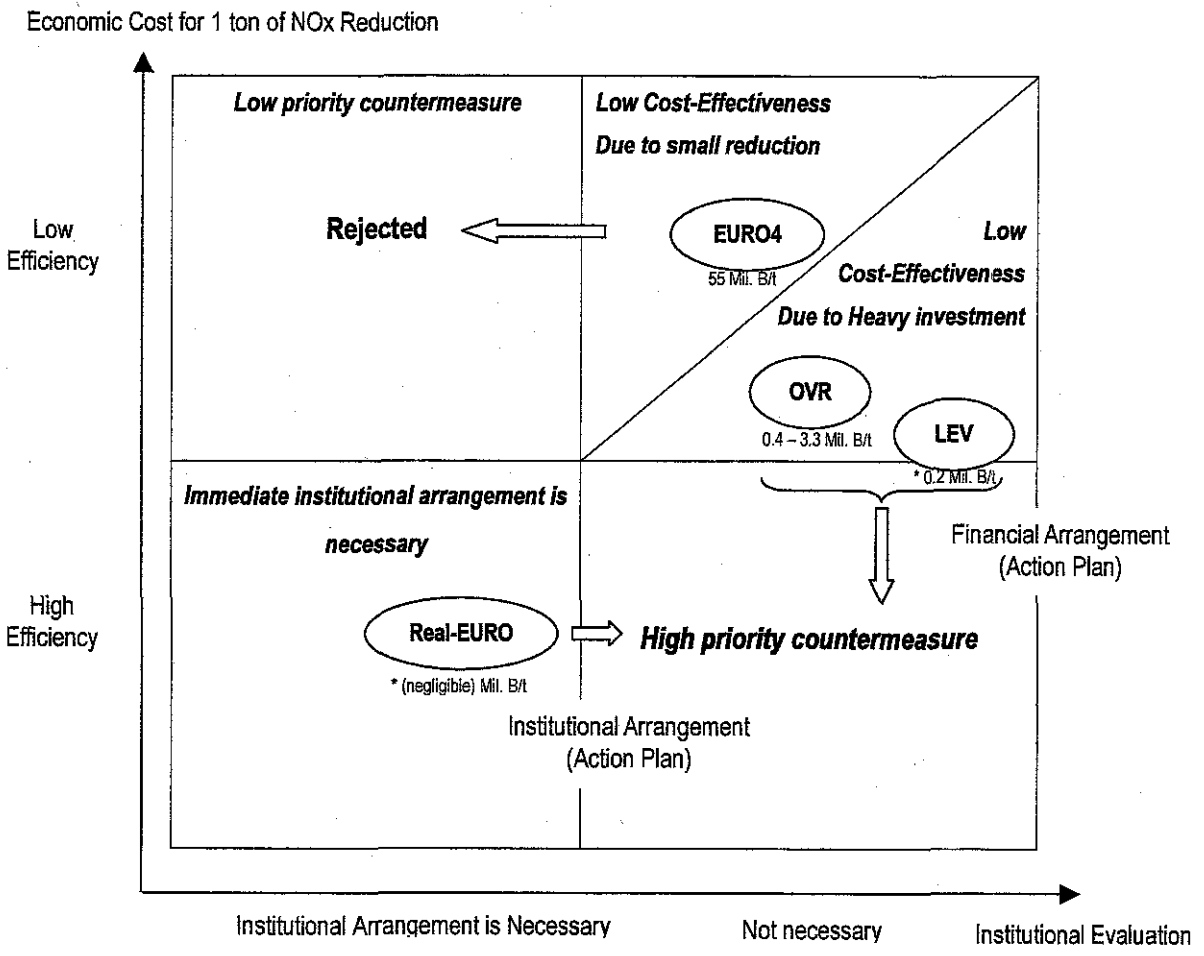


Figure 9.2.1.1 Schematic Diagram for Secondary Screening Result

The optimum mix of LEV/OVR with Real-EURO was selected as the most cost-effective with certain NOx reduction volume. The result is shown in Table 9.2.1.1 and the following three control cases were recommended.

Table 9.2.1.1 Evaluation of NOx Reduction/Cost on LEV/OVR Mix with Real-EURO

Case ID	Urban Bus		Coach/Truck		NOx Reduction Volume from BAU (ton)	Annualized Cost (Bil. Bahts)	Cost for 1 t NOx Reduction (Th. Bahts)	Case Description
	New	Old	New	Old				
BAU					---	---	---	BAU Case
VR1		VR1			4,577	1.9	415	UB Transition from Old to New Diesel
NG3		NG3			(8,220)	(1.8)	(219)	UB Transition from Old to New NG
VR2				VR2	(28,975)	(95.3)	(3,289)	Ch/Tr Transition from Old to New Diesel
VR1+VR2		VR1		VR2	32,551	97.2	2,986	UB, Ch/Tr Transition from Old to New Diesel
NG3+VR2		NG3		VR2	(37,014)	(97.1)	(2,623)	UB Transition from Old to New NG and Ch/Tr Transition from Old to New Diesel
NG2	NG2				14,338	0.3	21	New NG UB purchase only
NG2+VR1	NG2	VR1			18,915	2.2	116	New NG UB purchase and UB Transition to Old to New Diesel
NG2+NG3	**NG2**	**NG3**			**22,558**	**2.1**	**93**	**New NG UB purchase and UB Transition to Old Diesel to New NG**
NG2+VR2	NG2			VR2	(43,449)	(95.6)	(2,200)	New NG UB purchase and Ch/Tr Transition from Old to New Diesel
NG2+VR1+VR2	NG2	VR1		VR2	47,890	97.5	2,036	New NG UB purchase, UB Transition from Old to New Diesel and Ch/Tr Transition from Old to New
NG2+NG3+VR2	NG2	NG3		VR2	52,346	97.4	1,861	New NG UB purchase, UB Transition from Old to New NG and Ch/Tr Transition from Old to New

Note: The following combinations were considered difficlut for the following reasons,

NG3	UB Transition from Old to New NG could not happen without NG2 (New NG UB purchase as New UB)
VR2	Ch/Tr Transition from Old to New Diesel could not happen to prior to UB.
NG3+VR2	UB Transition from Old to New NG could not happen without NG2 (New NG UB purchase as New UB)
NG2+VR2	Ch/Tr Transition from Old to New Diesel could not happen to prior to UB.

First-Recommended Case

Real EURO(all) + NG2(UB) + NG3(UB)	**105,898**	**2.1**	**20**	**New NG UB purchase and UB Transition to Old Diesel to New NG, and the stricter compliance with EURO standard by Ch/Tr.**

Second-Recommended Case

Real EURO(all) + NG2(UB) + VR1(UB)	**104,599**	**2.2**	**21**	**New NG UB purchase and UB Transition to Old to New Diesel, and the stricter compliance with EURO standard by Ch/Tr.**

Third-Recommended Case

Real EURO (all)	**93,557**	**	**	**The stricter compliance with EURO standard by all HDDV**

First-Recommended Case;

- All HDDV/Ts except Urban Buses, namely Coaches and H-Trucks, should comply stricter with the latest emission standard when they come onto the market (Real-EURO),
- New NG Urban Buses should be purchased instead of conventional diesel ones (NG2),

- Over aged Urban Bus (over 10 years) should be replaced with New **NG** ones (NG3).
  Second-Recommended Case;
- All HDDV/Ts except Urban Buses, namely Coaches and H-Trucks, should comply stricter with the latest emission standard when they come onto the market (Real-EURO),
- New NG Urban Buses should be purchased instead of conventional diesel ones (NG2),
- Over aged Urban Bus (over 10 years) should be replaced with New **Diesel** ones (VR1).
  Third-Recommended Case;
- All HDDV/Ts except Urban Buses, namely Coaches and H-Trucks, should comply stricter with the latest emission standard when they come onto the market (Real-EURO),

Table 9.2.1.2 shows the summary of the simulation results of ambient NO_2 concentration in the Control Cases and Figure 9.2.1.2 shows the concentration maps for them. At 2011 in the First-recommended Case, the number of the grids over the Thai NO_2 standard would be reduced from 60 to 5 and over the WHO guideline from 2,127 to 1,075. In the Second-recommended Case, the number of the grids over the Thai NO_2 standard would be reduced from 60 to 5 and over the WHO guideline from 2,127 to 1,086. In the Third-recommended Case, the number of the grids over the Thai NO_2 standard would be reduced from 60 to 7 and over the WHO guideline from 2,127 to 1,237.

Table 9.2.1.2 Simulation Results of Recommended Control Cases

Control Case and Countermeasure Description	Reduction Volume (kt@2011)	Reduced No. of Over-standard Grid	Airviro Simulation (BMR: 26,320 Grids)		
			No. of Grid	Over WHO	Over Thai
First-Recommended Case - Substantial Compliance with HDDV/T emission standard - Purchase New NG Urban Buses (BMTA) - Replace Over 10 years old Urban Buses with New **NG** Buses (BMTA)	-106 kt (277 kt :BAU)	-1,052 (WHO) -55 (Thai)	BAU Case	2,127 (8%)	60 (0.2%)
			Control Case	1,075 (4%)	5 (0.0%)
Second- Recommended Case - Substantial Compliance with HDDV/T emission standard - Purchase New NG Urban Buses (BMTA) - Replace Over 10 years old Urban Buses with New **Diesel** Buses (BMTA)	-105 kt (277 kt :BAU)	-1,041 (WHO) -55 (Thai)	BAU Case	2,127 (8%)	60 (0.2%)
			Control Case	1,086 (4%)	5 (0.0%)
Third-Recommended Case - Substantial Compliance with HDDV/T emission standard	-94 kt (277 kt :BAU)	-890 (WHO) -53 (Thai)	BAU Case	2,127 (8%)	60 (0.2%)
			Control Case	1,237 (5%)	7 (0.0%)

2011 First-Recommended Case (Real-EURO + NG2 + NG3)

2011 Second-Recommended Case (Real-EURO + NG2 + VR1)

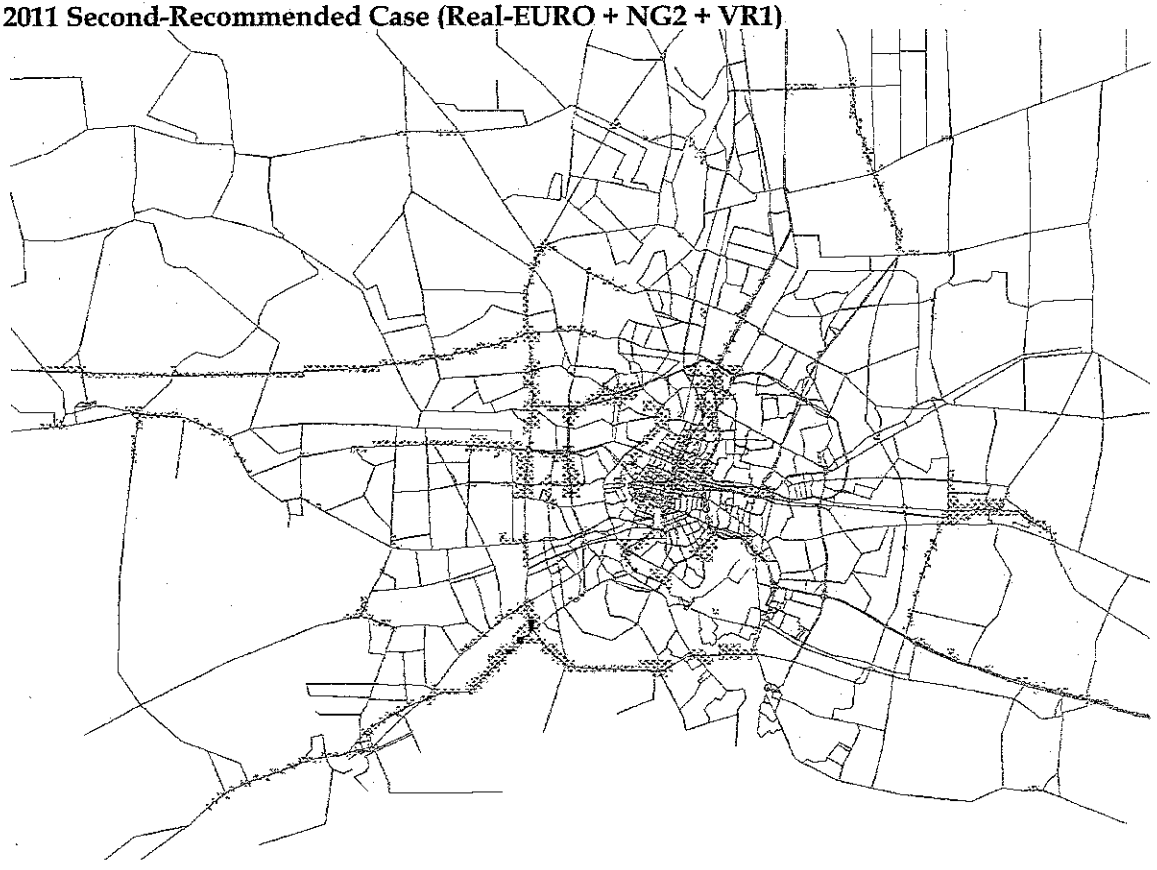


Figure 9.2.1.2(1) Airviro simulation result of ambient NO_2 concentration in the Control Cases

2011 Third-Recommended Case (Real-EURO)

Figure 9.2.1.2(2) Airviro simulation result of ambient NO_2 concentration in the Control Cases

9.3 Conclusion

The countermeasures are recommended as follows,

Substantial Compliance with the Latest emission standard (Real-EURO)

- All HDDV/Ts should comply more strictly with the latest emission standard when they come onto the market (Real-EURO)

Low Emission Vehicle Promotion (LEV)

- New NG Urban Buses should be purchased instead of conventional diesel ones (NG2),
- Over aged Urban Bus (over 10 years) should be replaced with New NG ones (NG3)

Overage Vehicle Retirement (OVR)

- Over aged Urban Bus (over 10 years) should be replaced with New Diesel ones (VR1)

Substantial Compliance with the Latest emission standard (Real-EURO) was considered essential for NOx emission reduction in the BMR, since it could reduce nearly a third of the total NOx emission from vehicle there even by itself. Therefore it is concluded that

Real-EURO should be assigned as the highest priority countermeasure among them. It was highly recommended that government of Thailand should consider Real-EURO as emergency countermeasures and should implement Real-EURO as soon as possible.

The other countermeasures, namely Low Emission Vehicle Promotion (LEV) and Overage Vehicle Retirement (OVR), should be launched with Real-EURO at the further steps for additional NOx reduction although their additional effects were estimated relatively small. Because the traditional countermeasures for NOx reduction, namely enforcement or compliance of stricter emission standard for new vehicles, would have their definite limits in the near future like that Japan is confronting. Therefore LEV and OVR should be provided for future full implementation immediately.

The simulation result showed that heavy traffic there would cause those areas to be unattainable and it was considered to be inevitable since trunk roads there were appointed and designed to accommodate heavy traffic.

Therefore, the study team recommended PCD to conduct a further study of future NO2 concentration for those areas. If a further study will ascertain that the NO2 concentration will exceed the standard and it will bring sever health damages, only a passive countermeasure, like land-use control, would be considered for those areas.

9.4 Action Plan

As shown in the Schematic Diagram for Secondary Screening Result, Real-EURO would require institutional arrangement and LEV/OVR would require financial arrangement. The action plans for the countermeasures were recommended below with their implementation schedules shown Table 9.4.1.1 to 9.4.2.2.

9.4.1 Institutional Arrangement

Substantial Compliance with the Emission Standard (Real-EURO: HDDV/T)

- In advance to the institutional arrangements for the relevant agencies, PCD should a Feasibility Study for Real-EURO to confirm the validity of the Real-EURO enforcement by close and diligent investigation concerning the emission factor of Thai HDDV/T. The major tasks were presumed as, Data collection of chassis and engine dynamometer test of in-use/new HDDV/Ts to estimate Thai conversion factor, and Recheck the attainment of HDDV/T engine emission standard although they were once type-approved.
- TISI should call a technical committee to discuss the amendment of TIS to enable TISI to implement the additional conformity inspection for the stricter compliance, namely

unannounced (surprise) inspection of Thai HDDV/T manufacturers' assembly lines with the authority to order the manufacturers to remove the engines for the retest.

- MOTC should amend Land Transport Act from the viewpoint of anti-tampering program for HDDV/T, which can detect any damage, disablement or removal of emission control components. Once detected, the owner would be required to restore the vehicle's emission control system and have the vehicle re-inspected.
- LTD should follow the amended Land Transport Act and inspect tampering like engine replacement in addition to the existing checkpoints after appropriate training program for technical service staff.
- RTP should conduct random roadside emission test to complement the periodic IM program, which was considered not to detect tampering efficiently since it is predictable and gives vehicle owners an opportunity to evade the program.

Table 9.4.1.1 Implementation Schedule for Real-EURO

Institutional Arrangement for Real-EURO

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
PCD (FS Study)									
PCD (Periodical Update Research)									
TISI (TIS Reform)									
TISI (Additional Inspection)									
MOTC (Land Transport Act Amendment)									
LTD (Prohibition against Engine Replacement by IM Program)									

9.4.2 Financial Arrangement

Low Emission Vehicle (LEV: NG Urban Bus)

- About 45 billion baths is necessary to replace 17,500 diesel buses (from year 2004 to 2011) operated by the BMTA and the private bus companies into NG buses,.
- Subsidies or investment from the ENCON fund, soft loans (e.g. JBIC) and overseas investment (e.g. CDM) are available as financial sources, however any single source does not enable to cover the necessary investment.
- In case that the BMTA replace their buses by self-finance and the private bus companies use the possible financial sources, 42.4 billion baths (95% of the total investment cost) are uncovered.
- In order to solve the problem, it is recommended that the related governments need to

discuss possible financial sources for such financially weak companies that cannot utilize the soft loans considering governmental subsidies or special loan with low interest and long repayment period.

Overage Vehicle Retirement (OVR: Urban Bus)

- A large amount of investment about 36.8 billion baths is necessary to replace 6,100 diesel buses (from year 2004 to 2011) operated by the private bus companies operating under the BMTA into new diesel buses.
- Soft loans (e.g. JBIC) are available as financial support, however most of the private bus companies are financially weak. Considering such financial conditions of the bus operators, it would be quite limited they could get special loan treatment. It is very important for them how to get reasonable financial supports to implement the countermeasure. Therefore, it is recommended that the related governments need to be discussed possible financial sources for such financially weak bus operators including governmental subsidies or special loan with low interest and long repayment period.

Table 9.4.2.1 Implementation Schedule for LEV

Financial Arrangement for LEV

year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Financial Improvement of BMTA & Private Bus Operators									
Study On Financial Improvement									
Governmental Support for Financial Improvement									
Purchase of NG buses by ENCON Fund									
Exploration of Possibility for Purchase of NG buses by CDM									
Preparation for CDM project by Thai Gov.									
Feasibility Study									
Purchase of NG buses by Soft Loan									
Approved by local banks (IFCT etc)									
Purchase of NG bus by individual private bus operator									
Purchase of NG buses by Governmental subsidies or loan									

means that NG buses will be purchased occasionally by using each financial source.

Table 9.4.2.2 Implementation Schedule for OVR

Financial Arrangement for OVR

year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Financial Improvement of BMTA & Private Bus Operators									
Study On Financial Improvement									
Governmental Support for Financial Improvement									
Purchase of New Diesel Buses by Soft Loan									
Approved by local banks (IFCT etc)									
Purchase of New Diesel Buses by individual private bus operator									
Purchase of New Diesel Buses by Governmental subsidies or loan									

means that New Diesel Buses will be purchased occasionally by using each financial source.

10. Acid Deposition Control Strategy

10.1 Introduction

Innumerable pollutants are discharged by a variety of human activities. Sulfur oxides and nitrogen oxides are typical pollutants, and cause acid deposition and ambient air pollution. Currently acid deposition and ambient air pollution are both subjects of public concern in Thailand. Major causing materials of acid deposition are sulfur oxides and nitrogen oxides, and they bring about SO_2 and NO_2 ambient air pollution also. Therefore, on the one hand, countermeasures for acid deposition and ambient air pollution cannot be separated. The points of countermeasures for both issues are the reduction of emission amount of sulfur oxides and nitrogen oxides. On the other hand, acid deposition has its own characteristics. It is a consequence of a series of physical and chemical processes. The spatial expanse of acid deposition is wide and complex, and reaches to East Asia. And it is not a short-term issue. Sometimes, the effects of acid deposition appear after many years.

Therefore, the control strategy tackling acid deposition should include various activities. The collaboration of respective activity will enable a mitigation of issues. Figure 10.1.1.1 shows relating activities. Control Strategy should cover these activities.

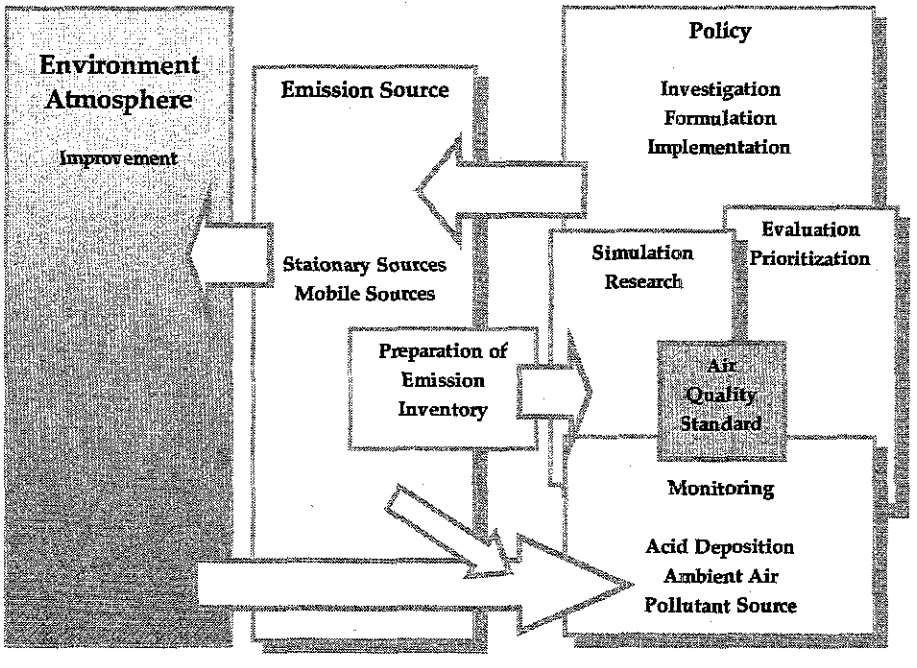


Figure 10.1.1.1 Acid Deposition Control

Control strategy has two faucets, i.e. countermeasure and management for acid deposition and air pollution. Regarding countermeasure, according to evaluation and prioritization in Chapter 7, the direct countermeasure for acid deposition includes ambient air pollution aims the reduction of nitrogen oxides and sulfur oxides in the BMR. In Chapters 8

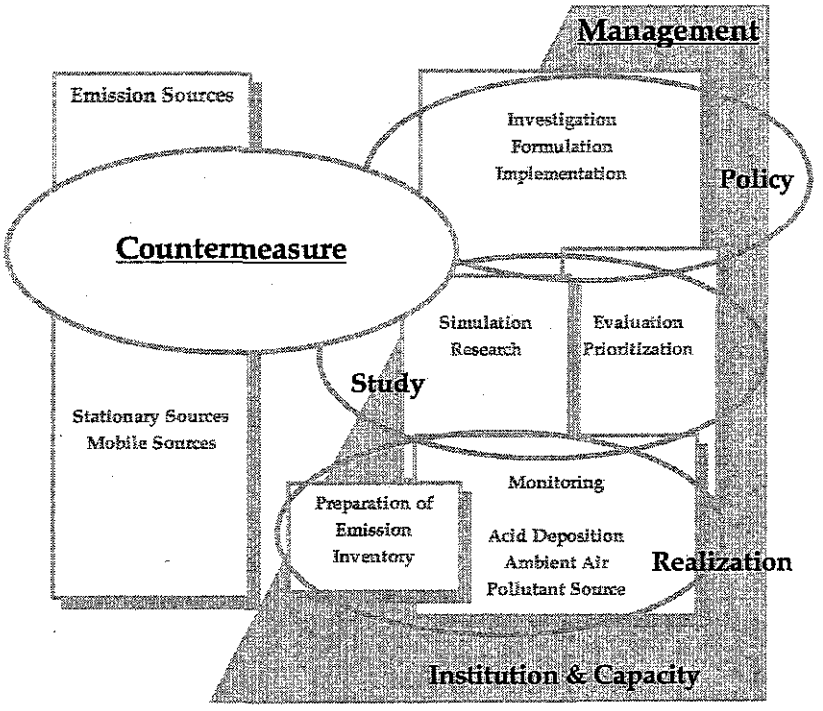


Figure 10.1.1..2 Countermeasure and Management

and 9, countermeasures are described. The management, acid deposition management including ambient air pollution management should cover the diversity of activities. That is the field of realization, study, and policy. The series of management is realization, study and policy. Through the series of management, the countermeasures are formulated. And the basis for management is definite setting of function and improved capacity. Those activities and basis for management are illustrated with countermeasure in Figure 10.1.1.2

10.2 Control Strategy

According to the concept of countermeasure and management (Figure 10.1.1.2), following integrated control strategy is proposed.

Concerning the countermeasure for mitigation of air pollution in the BMR, following two strategies are proposed.

Strategy A: Fuel shift to natural gas by stationary sources

Strategy B: Introduction of substantial compliance with the emission standard (Real-Euro), low emission vehicle promotion (LEV), and over age vehicle retirement (OVR).

The selection of these strategies is described in Chapters 8 and 9.

Concerning acid deposition and air pollution management,

Strategy C: Enhancement of Environmental Management

The Strategy C is the prioritized approach in the series of management and the reinforcement of institution and capacity to tackle problems of acid deposition and air pollution.

Figure 10.2.1.1 shows proposed strategy for acid deposition and air pollution.

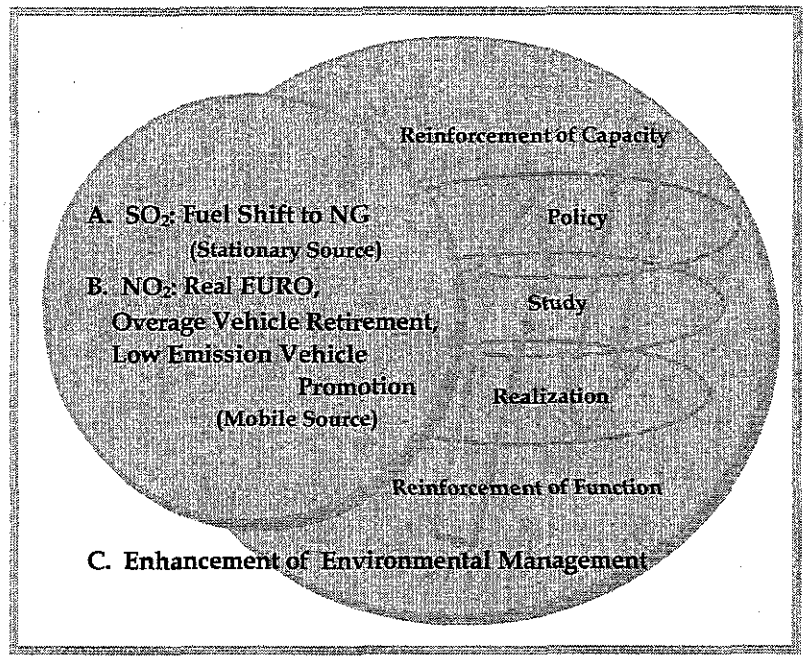


Figure 10.2.1.1 Strategy

Concerning the strategy for countermeasures derived by the critical load approach, because of current discussion on the critical load, they were regarded as the reference in the Study. For the sake of reference, it can be commented as follows. According to Chapter 8, the deposition value in the BMR by ATMOS2 simulation exceeds critical load value in the 2011 control case. Therefore, it will be necessary to introduce wider reduction measures for SOx. And the situation will be similar to some extent in Eastern and Central regions. It may be necessary to follow the critical load approach in the future.

10.3 Strategy A: Shift to Natural Gas for SO_2 Mitigation in the BMR

10.3.1 Outline for the Recommended Countermeasure

The shift to natural gas is a countermeasure of the first priority for mitigation of SO_2 concentration in the BMR. It can be introduced by economic mechanisms, and need not prepare new or more stringent regulations It is consistent with national policy to encourage natural gas in the manufacturing sector.

Natural gas is almost a domestic energy for Thailand. And in many cases, the shift to natural gas brings energy saving effects. Moreover it is an environmentally friendly measure in many aspects, such as lower dusts and SOx emissions and lower chances of black smoke.

Currently in the BMR, the trunk pipeline is laid in the eastern area. Another trunk line in the western area will be laid by the end of the year 2005. After the completion of the western part, the Bangkok Gas Ring will be finished and available. The Bangkok Gas Ring will enable many areas in the BMR to shift to natural gas, mainly in industrial estate.

The price of natural gas has enough competitiveness with other fuels. In the case of the shift to natural gas, it is necessary to lay branch pipes and gas pipes in factory premises, and

to install meters and gas burners. Even considering these costs, because of the energy saving merit, natural gas has competitiveness with other conventional fuels.

10.3.2 Step by Step Implementation

Currently, Thai SO_2 standard is satisfied in the BMR. According to the simulation result, some limited grids will not satisfy the standard in the year 2011. For mitigation of this possible deterioration of the environment in the future, the shift to natural gas is recommended. The shift to natural gas can be introduced by economic mechanisms without new or more stringent regulations, i.e. the introduction will not burden private company with extra economic costs.

In order to mitigate possible deterioration beforehand, it is appropriate and realistic to enhance a step by step introduction. The first priority is the introduction of shift in and around high concentration grids. After the introduction of shift in and around high concentration grids, other grids become targets of the introduction of shift to natural gas.

At actual stage of implementation, it is important to take into consideration that the mitigation measure for some factories depend on specific conditions, not general conditions. In such cases, various measures can be regarded as possible. In order to satisfy environmental and economic requirement, the best way should be selected.

Concerning the WHO guideline, the shift to natural gas will be able to reduce significantly the number of grids exceeding the standard. However still 35 grids show exceeding values by Airviro simulation in the 2011 Control case. The attainment of the WHO guideline is a future long-term issue. According to the NEQA, B.E. 2535, ambient air quality standard shall be modified and improved in the light of scientific and technological progresses and changes in economic and social conditions of the country. The WHO guideline values will be important reference values for modification of the standard. Therefore in the course of modification of Thai Ambient air quality standard, countermeasures for modified standard will be studied and introduced. This process will satisfy further the WHO guideline.

10.3.3 Financial Arrangement

The shift to natural gas is an option for individual private companies. Even the pipeline is laid down, the connection of industries to the pipelines depends upon their willingness. In fact, even the area where the pipeline is laid down, limited industries that could obtain benefit from the fuel conversion have connected to the network.

The price scheme that PTT provides gives incentives for the big industries as it can produce a profit from the conversion due to the price difference. However this does not work as an incentive for the small and medium-size industries. For such industries that especially encounter financial problems due to economic crisis and cannot afford the connection,

financial support is indispensable. It is necessary to publicize the environmental and economic benefits to such industries, and to enhance introduction for the shift to natural gas.

In order to support the fuel shift to natural gas financially, soft loans by Environmental Fund and others, JBIC's two-step loan are applicable mechanisms. And if overseas investment by CDM can be introduced, it will be one of the economic mechanisms for supporting the shift to natural gas.

10.3.4 Institutional Issues and Capacity Building

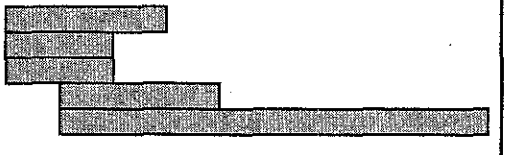
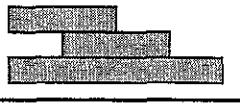
Natural gas is distributed solely by Petroleum Authority of Thailand (PTT). PTT has the intention to promote gas distribution in the BMR. Therefore PCD should discuss with PTT the plan of the shift, i.e. what area should be prioritized for the shift and how apply supporting mechanism by the Government. The base data for selection of area is the simulation result of the Study. After the arrangement of plan, PCD should raise public awareness for the shift.

For enhancement of shift to natural gas, major subjects for expansion of capacity of PCD are the designation of an analysis and simulation group and an inventory group. The role of analyzing and simulation group is not collecting monitoring data but analyzing causes and results of environmental issues. Besides, it is necessary to analyze the effect of policy options by simulation. The role of inventory group is to prepare emission database for analyzing and simulation periodically and continuously. The function of analyzing and simulation as well as preparation of inventory cannot be completed by government agencies only. The involvement of the private sector after adequate and clear job assignment is necessary.

10.3.5 Action Plan

Table 10.3.5.1 shows tentative action plan of the shift to natural gas and reinforcement of institution and capacity for PCD.

Table 10.3.5.1 Action Plan

	2003 2004 2005 2006 2007 2008 2009 2010 2011
Countermeasure: Shift to Natural Gas Western Part of Bangkok NG Ring (Main Pipeline by PTT) Installation Planning (PCD and PTT) Supprting Planning (PCD, PTT, and IFCT) Public Relation for Shift to NG Instalation of Necessary Facilities by Individual Industries (Application of Environmental Fund, JBIC's Two Step Loan)	
Reinforcement of Institution and Capacity of PCD Designation of Analyzing & Simulation Group Designation of Inventory Group Nurturing Private Sector	

10.4 Strategy B: Enhancement of Real-EURO and LEV/OVR

10.4.1 Outline for the Recommended Countermeasures

The countermeasures are recommended as follows,

(1) Substantial Compliance with the Latest emission standard (Real-EURO)
- All HDDV/Ts should comply more strictly with the latest emission standard when they come onto the market (Real-EURO)

(2) Low Emission Vehicle Promotion (LEV)
- New NG Urban Buses should be purchased instead of conventional diesel ones (NG2),
- Over aged Urban Bus (over 10 years) should be replaced with New NG ones (NG3)

(3) Overage Vehicle Retirement (OVR)
- Over aged Urban Bus (over 10 years) should be replaced with New Diesel ones (VR1)

Substantial Compliance with the Latest emission standard (Real-EURO) was considered essential for NOx emission reduction in the BMR, since it could reduce nearly a third of the total NOx emission from vehicle there even by itself. Therefore it was concluded that Real-EURO should be assigned as the highest priority countermeasure among them. It was highly recommended that government of Thailand should consider Real-EURO as emergency countermeasures and should implement Real-EURO as soon as possible.

The other countermeasures, namely Low Emission Vehicle Promotion (LEV) and Overage Vehicle Retirement (OVR), should be launched with Real-EURO at the further steps for additional NOx reduction although their additional effects were estimated relatively small. Because the traditional countermeasures for NOx reduction, namely enforcement or compliance of stricter emission standard for new vehicles, would have their definite limits in the near future like that Japan is confronting. Therefore LEV and OVR should be provided for future full implementation immediately.

10.4.1.1 Substantial Compliance with the Latest Emission Standard (Real-EURO)

As mentioned in Chapter 4 "4.2.2 Mobile Source Inventory of the Year 2000 in the BMR", the vehicle emission factors were determined by chassis dynamometer test data collected in Thailand and only the test data of HDDV/T complying with EURO 2 showed much higher emission level than they are supposed if they really comply. Furthermore, according to PCD, it was possible that HDDV/Ts might be modified when they were installed with type-approved engines since engine dynamometer test instead of chassis dynamometer

controlled them. Therefore the study team proposed further investigation and substantial (stricter) compliance with the standard.

10.4.1.2 Low Emission Vehicle Promotion (LEV)

Natural Gas Vehicle (NGV) was selected to be promoted as LEV, since BMTA has operated few NGVs and the NGV infrastructure would be developed through PTT's natural gas promotion strategy.

Urban Bus operated by BMTA was targeted, while Heavy Truck and the other Bus, namely Coach or Long-haul Bus, were not since they are likely to be operated beyond the area supplied with natural gas and proper garages.

BMTA were proposed to purchase NGV instead of the conventional diesel and replace their old buses (over 10 years) with NGV successively.

10.4.1.3 Overage Vehicle Retirement (OVR)

Although more stringent emission standard limits the emission from new vehicles, the effect would be limited usually and the ambient NO_2 level could not be improved drastically, since the worn-out vehicles from overwork and overage engines, especially overage HDDV/Ts emit considerable amount in total. There would be considerable number of worn-out HDDV/Ts still in-use at the target year in Thailand, therefore the retirement program of them was considered effective.

However only Urban Bus operated by BMTA was targeted since it was considered quite difficult in financial aspect to conduct this program on private commercial vehicle, namely Heavy Truck or Coach.

10.4.2 Effectiveness

The Real-EURO implementation would reduce around 34%of vehicle NOx emission of 2011 (BAU Case). The implementation of Real-EURO with LEV (NG2+NG3) and Real-EURO with OVR (VR1) would reduce around 38%.

Accordingly, the Real-EURO implementation would reduce the grids over Thai ambient NO_2 standard from 60 to 7 and over the WHO guideline from 2,127 to 1,237, the Real-EURO with LEV (NG2+NG3) would reduce over-Thai grids from 60 to 5 and over-WHO grids from 2,127 to 1,075, the Real-EURO with LEV (NG2) and OVR (VR1) would reduce over-Thai grids from 60 to 5 and over-WHO grids from 2,127 to 1,086.

10.4.3 Institutional Arrangement

Real-EURO would require some institutional arrangement for its implementation although it would have little financial problem. Therefore the study team proposed the absolutely necessary tasks to be assigned to the relevant agencies as below.

First, in advance to the institutional arrangements for the relevant agencies, PCD should have a feasibility study for Real-EURO to confirm the validity of the Real-EURO enforcement by close and diligent investigation concerning the emission factor of Thai HDDV/T. The major tasks were presumed as, Data collection of chassis and engine dynamometer test of in-use/new HDDV/Ts to estimate Thai conversion factor, and Recheck the attainment of HDDV/T engine emission standard although they were once type-approved.

Secondly, TISI should call a technical committee to discuss the amendment of TIS to enable TISI to implement the additional conformity inspection for the stricter compliance, namely Unannounced (surprise) inspection of Thai HDDV/T manufacturers' assembly lines with the authority to order the manufacturers to remove the engines for the retest.

Thirdly, MOTC should amend the Land Transport Act from the viewpoint of anti-tampering program for HDDV/T, which can detect any damage, disablement or removal of emission control components. Once detected, the owner would be required to restore the vehicle's emission control system and have the vehicle reinspected.

Fourthly, LTD should follow the amended the Land Transport Act and inspect tampering like engine replacement in addition to the existing checkpoints after appropriate training program for technical service staff.

Lastly, RTP should conduct random roadside emission test to complement the periodic IM program, which was considered not to detect tampering efficiently since it is predictable and gives vehicle owners an opportunity to evade the program.

On the other hand, neither LEV nor OVR would demand such institutional arrangements for its implementation as long as they target only BMTA's Urban Bus since BMTA has already operated NGV for LEV and OVR is just to accelerate the conventional vehicle retirement program of BMTA.

10.4.4 Capacity Building

LEV would need to train more technicians with enough skill of NGV maintenance and Real-EURO might need to augment the appointed staff for the inspection proposed. However they were considered to be achieved enough by the existing institutional system and additional arrangement would not be necessary to be proposed in the study.

OVR would not either as long as it target BMTA's Urban Bus since its inspection would not be necessary for BMTA, which can be controlled by the government policy.

10.4.5 Financial Arrangement

LEV would require a large amount of financial allocation to implement the fuel conversion policy by introduction of LEV although there are a few technical problems. Therefore, the Study proposed its financial arrangement with the Clean Development Mechanism and supplementary governmental subsidies or loan in addition to the existing subsidies presumed available.

OVR would require a large amount of investment about 49 billion bahts for its implementation and it would give considerable financial burden on the bus companies. Although soft loans of the JBIC and local banks are available, its application would be quite limited due to the severe financial conditions of the private bus companies. This Study proposed supplementary governmental subsidies or loans for the financially weak companies that cannot utilize the soft loans.

On the other hand, Real-EURO would not demand it since it could be achieved by the existing staff though it burden them with little tasks additionally.

10.5 Strategy C: Enhancement of Environmental Management

Because of environmental management covers various fields, many agencies are allocated respective responsibility and manage them in Thailand as in other countries. Among such agencies, PCD is expected to conserve and improve the environment, based on scientific knowledge.

In order to satisfy the mission highly on the outcome of the Study, PCD should reinforce its institutional facet and build its capacity of staff further.

Table 10.5.1.1 Strategy for Environmental Management

C	Enhancement of Environmental Management		
	C-1	Intensification of Focused Activity	
		Realization	
			Regular Monitoring
			Specific Monitoring for Investigation
			Establishment of Emission Inventory
		Study	
			Evaluation of Acid Deposition & Atmospheric Condition Data
			Application of International Simulation Model
			Research of Acid Deposition
			Prioritization of Acid Deposition Issues
		Policy	
			Investigation of Policy
			Formulation and Implementation of Policy
	C-2	Reinforcement of Institution & Capacity	
		Institution	
			Inventory Group
			Analyzing and Simulation Group
			Scientific Advisory Function
			Policy Investigation Function
		Capacity	
			Systematization of Environmental Knowledge
			Investigation of Policy

The concept of strategy is illustrated already in Figure 10.2.1.1, the management strategy should be integrated with countermeasure strategies. And as shown in Table 10.5.1.1, it is divided into two groups. They are the intensification of focused and prioritized approach and the reinforcement of institution and capacity. Concerning focused and prioritized approach, as shown in Figure 10.1.1.2, various activities of management are divided into three fields, i.e. realization, study and policy.

10.5.1 Intensification of Focused Activity

10.5.1.1 Realization

Regular monitoring and specific monitoring for the investigation and establishment of emission inventory are items for realization.

The origin of causing substances of acid deposition is scattered broadly across the country. In order to obtain information on the causing substances, it is necessary that the inventory covers the whole Thailand. For the implementation of scientific environmental administration, one of the elemental starting points is the quantitative emission inventory and

its periodic revision. Here the inventory is prepared by the Study. It is necessary to improve the preparing system for inventory through the revision of the inventory.

10.5.1.2 Study

The monitoring data and the quantitative inventory enable further study. In the first place, the evaluation of monitoring results reveals the objective for simulation, and the research and monitoring result provides basis for simulation. The analysis and simulation provides indispensable information for the investigation and study policy. The simulation of the Study provides indispensable information for the preparation of policy.

Because acid deposition is a global issue, it should be analyzed by an internationally approved model. International models are developed by international discussion. The outcome of the Study can be regarded as the basis of participation to the international modeling activity. It is necessary to contribute to the international developing activity. In order to have participation from Thailand, PCD should support researchers of the model.

10.5.1.3 Investigation, Formulation and Implementation of Policy

The acid deposition issue has a complex nature. It is an environmental issue and an otherwise energy issue, and is sometimes a transportation issue. The sulfur content of oil products relates to the national energy policy and the national environmental policy of stationary sources and mobile sources. Moreover it is a matter of commercial activity. Sometimes economic incentives by the Government are a key factor. These series of tasks are necessary to consolidate the investigation of policy. The Study investigated the wide range of issues and prepared a policy.

PCD, based on its scientific function, should investigate the policy independently or by cooperation with other agencies. The outcome of the Study is material for the next step, i.e. the formulation and implementation of policy.

It is necessary to assign a responsible agency and relevant agencies when considering the formulation and implementation of policy. Relevant agencies are expected to participate to the formulation and implementation of policy. According to the nature of the policy, PCD will be the responsible agency or cooperating agency.

10.5.2 Reinforcement of Institution and Capacity

10.5.2.1 Institution

1) Designation of Inventory Group

The preparation of inventory needs experience and a huge volume of study. It also

needs specialty. A specific implementing group for the inventory is a starting point for preparing the inventory. And the commissioning of adequate parts of the study to the private sector is important. After the designation of the inventory group, it is necessary to revise the inventory of the Study.

2) Designation of Analysis and Simulation Group

Analysis and simulation is important for scientific administration. Every administration group has an analyzing function. However, it is necessary to set up a group for analysis and simulation for PCD. Concerning acid deposition, the evaluation of the ambient air quality and critical load, and the simulation analysis are typical subjects for the group. Simulation by the international model is one function of this group. The role the of group is not to collect monitoring data but to rationalize the causes and results of the environmental issues on the basis of outcomes of the Study. Besides, it is necessary to analyze the effect of policy options by simulation. Thus PCD with an analysis and simulation group has the capability of taking the initiative in the environmental administration. The group undertakes the core functions of evaluation, simulation and the prioritization of environmental issues.

The function of analysis and simulation cannot be completed by government agencies alone. Involvement of the private sector after adequate and clear job assignment is necessary.

3) Reinforcement of Policy Investigation and Scientific Advice

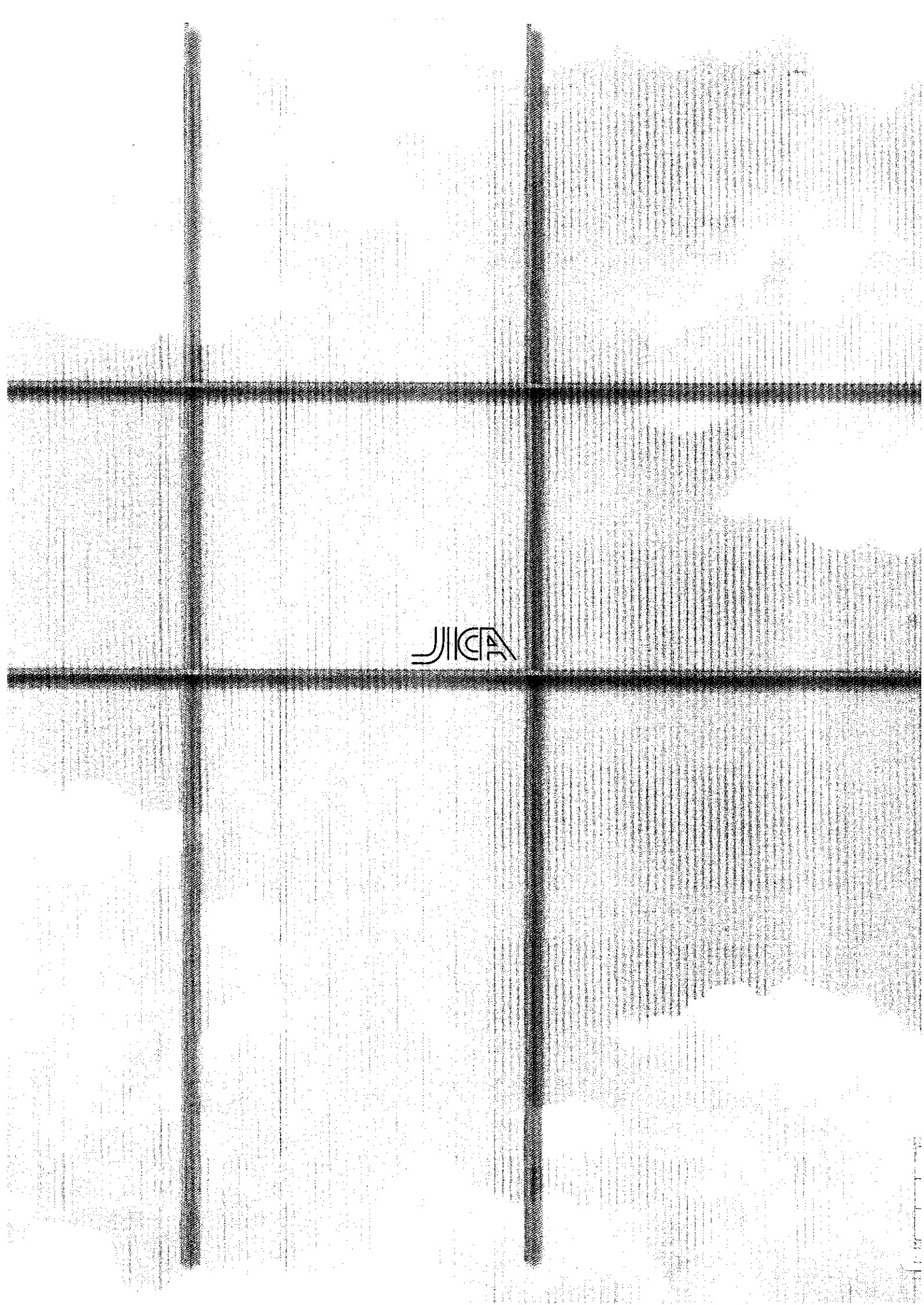
The capacity of scientific approach enables the formulation of adequate policy. The scientific approach is an assigned core function of PCD. In order to reinforce this function, it is necessary to assign an analysis/simulation group and an inventory group, as mentioned above. And it is necessary to systematize various environmental knowledge and integrate them into policy. The function of systematization can be undertaken by reinforcement of the planning group.

Moreover, a scientific advisory function for the policy setting committees, i.e. National Environment Board and others is a necessary function. However, due to limited resources, PCD cannot fulfil all of the necessary functions fully. This function should be performed by a well-formulated body. The body that mobilizes core scientists of the field can perform the scientific advisory function. PCD undertakes the secretary function of the body, which includes studying the topics beforehand.

10.5.2.2 Capacity

Capacity building for systematized knowledge is an important factor of capacity building. Environmental administration can not be undertaken without systematic knowledge.

In order to get systematized knowledge, it is necessary to experience the preparation of annual reports or similar reports that integrate various fields. And investigation of policy is another important chance for this capacity building. Policy is a result of synthesis. It cannot be established by consideration of just narrow fields. Studies of the social issues, the economic situation, and scientific facts should be integrated. Many administration fields, i.e. energy, transportation, commerce, revenue and environment should be investigated simultaneously. It is necessary to discuss with other groups of PCD and other agencies frequently. Concerning institutional side for capacity building, it is necessary to discuss with other groups or agencies regularly. It is also necessary to move to the other section of PCD by adequate term. Through these processes, a systematized knowledge will be developed.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