Integrated Environmental Strategies – Philippines Project Report/Metropolitan Manila: A Focus on the Transport Sector

Ronald Subida, MD, M.A. Velas, and Dan MacNamara, SJ, PhD

December 2004

INTEGRATED ENVIRONMENTAL STRATEGIES – PHILIPPINES PROJECT REPORT \METROPOLITAN MANILA

Focus on the Transport Sector

Ronald Subida, M.D., M.A. Velas, Daniel McNamara, Ph.D.
Manila Observatory, POB 122, UP Campus, Quezon City

This project quantified and assessed the public health benefits of different mitigation measures with special focus on transport issues, common to both controlling ambient air pollution and greenhouse gases emissions. This project made use of health and economic impact as parameters in evaluating the benefits of the mitigation measures.

Co-benefits of policies were estimated with regards to greenhouse gases (GHG) and local air pollution reduction. These policies are assessed as to their capability to reduce emissions of GHG and local air pollutants from both stationary and mobile sources. Scenarios are developed from these policies. Ambient concentrations of the air pollutants are eventually modelled. Changes in ambient concentrations of the air pollutants are calculated by comparing the different policy scenarios with the business-as-usual scenario. Health benefits are then estimated based on the differences in ambient concentrations and concentration response functions that associate changes in ambient pollutant levels with specific health impact endpoints. Economic values of the avoided health impacts (or benefits) are likewise computed.

EXECUTIVE SUMMARY

1. Introduction

Background: Metropolitan Manila, Philippines

Metropolitan Manila or Metro Manila (MM) is located on the southwestern coast of the island of Luzon around the mouth of Pasig River which drains into the Manila bay. The metropolis is composed of 17 cities and municipalities. Approximately 15% of the land area is occupied by industrial establishments. These factories are located in areas with good transportation links. The number of businesses and industries had increased considerably in the past decade. In 1997, there were about 26,500 industries in the whole Metro Manila, composed mostly of light and medium scale types such as manufacturing, food and pharmaceutical industries as well as a few refineries. These were concentrated in the north of the metropolis.

In terms of the transport sector, there has been more than a four fold increase in the number of road vehicles in the past two decades in the Philippines, from less than a million in the late 1980’s to almost 4.2 million in 2003. In Metropolitan Manila alone, the number of vehicles increased from about 600,000 in the early 1990’s to approximately 1.4 million in 2003. This is about 33% of the total for the whole country. The increase is more pronounced among the diesel fuelled vehicles. The number of diesel fuelled vehicles in the whole country increased from about 331,000 in 1987 to 1.3 million in 2002, a more than three fold increase. Meanwhile, the number of gas fuelled vehicles increased from approximately 800,000 to 2.3 million in the same time period, a little more than a two fold increase. Fuel consumption naturally also increased considerably.

In a recent review of the state of environmental health in the Philippines that reviewed available studies and data, four main problems were identified. Two of these main problems were related to ambient air pollution namely, dust-related diseases such as bronchitis, and lead poisoning particularly in Metropolitan

Manila. Indoor air pollution was likewise considered. However, a recent study on indoor exposure to particulate matter, 10μm (PM_{10}) and nitrogen oxides (NOx) in Metropolitan Manila showed that there is no significant difference in the pollutant levels between inside and outside the homes. Therefore this particular aspect was deemed to be a consequential issue of the overall air quality problem.

Realizing that more than 90% of the air pollution comes from mobile sources based on the 2003 emission inventory, the project decided to concentrate primarily on the transportation sector particularly in Metropolitan Manila. Metropolitan Manila, as described before, has more than one-third of all the vehicles in the country. It also has the highest density of population in the country and probably the highest levels of air pollution as well.

2. Objective of the Project

This project quantified and assessed the public health benefits of different mitigation measures with special focus on transport issues, common to both controlling ambient air pollution and greenhouse gases emissions and made use of health and economic impact as parameters in evaluating the benefits of the mitigation measures.

3. Conceptual Framework

To estimate the co-benefits of policies with regards both greenhouse gases (GHG) and local air pollution reduction, the following framework was pursued in this project. The analysis included policies which could include mitigation measures for both GHG and local air pollution. These policies are assessed as to their capability to reduce emissions of GHG and local air pollutants from both stationary and mobile sources. Scenarios are developed from these policies. From these assessments or scenarios, GHG emissions reduction are estimated, at the same time, the reduction of local air pollutants is also estimated. Together with the development of scenarios from the policies, a business-as-usual scenario is also set. Ambient concentrations of the air pollutants are eventually modelled. Changes in ambient concentrations of the air pollutants are calculated by comparing the different policy scenarios with the business-as-usual scenario. Health benefits are then estimated based on the differences in ambient concentrations and concentration response functions that associate changes in ambient pollutant levels with specific health impact endpoints. Economic values of the avoided health impacts (or benefits) are likewise computed.

4. Scoping Decisions and Policies Considered

Based on a scoping meeting held in early on in the project, several mitigation measures were considered for the scenario development. For this project's purpose, these mitigation measures are called policy scenarios. Eight individual policies and three combinations of policies are assessed. Although other mitigation measures were suggested during the scoping meeting, these were not considered in this assessment due to either political reasons or data availability. The base year used is 2002 and projections to years 2005, 2010 and 2015 are made.

The following are the policies considered and for which scenarios were developed.

- (i) Transportation Demand Management through license plate scheme (TDM)
- (ii) Construction of Rail-based Mass Transit System
- (iii) Construction of Bikeways
- (iv) Implementation of the Motor Vehicle Inspection System (MVIS)
- (v) Introduction of the Compressed Natural Gas buses (CNG)
- (vi) Introduction of *Cocodiesel* for diesel-fuelled vehicles particularly jeepneys (CME)
- (vii) Two stroke tricycles switching to four-stroke engines.
- (viii) Improvement of vehicles by the Use of Diesel Traps
- (ix) Combo 1 – combination of policies: all policies except railways and switching of two stroke to four stroke tricycles

(x) Combo 2 – all policies except railways
(xi) Combo 3 – all policies including railways

5. Methodology

5.1. Scenario Development:

The policy measures analyzed were screened based on the following criteria: (a) feasibility of implementation; b) socio-economic and political acceptability, and c) availability of information. The scenarios with the corresponding policy measure and assumptions were summarized in Table 1,

Table 1. Summary of Scenarios and Corresponding Assumptions

Scenario	Policy and Assumptions
Baseline or Business-As-Usual (BAU)	BAU 2005: 2005 transportation demand+2005 transport network+I/M Standards BAU 2010: 2010 transportation demand+2005 transport network+I/M Standards BAU 2015: 2015 transportation demand+2005 transport network+primary and secondary road network in 2015+I/M Standards
Implementation of the Motor Vehicle Inspection System (MVIS)	Reduction of PM emission factors and the corresponding percentages of vehicle types with reduced emission factors MVIS2005: + STDS2 – I/M • Implementation of the STDS2 scenario without the I/M scenario • reduction in PM emission factor by 60% • percent of vehicles: cars=25%, jeepneys=100%, buses=30%, trucks=30% MVIS2010: + STDS2 • Implementation of the STDS2 scenario on top of the I/M Scenario • Reduction of PM emission factor by 60% after the 30% reduction of emission factor under the I/M scenario • percent of vehicles: cars=25%, jeepneys=100%, buses=30%, trucks=30% MVIS2015: + STDS3 • Implementation of the STDS3 scenario on top of the I/M Scenario • Reduction of PM emission factor by 60% after the 30% reduction of emission factor under the I/M scenario • percent of vehicles: cars=50%, jeepneys=100%, buses=100%CNG, trucks=40%
Transportation Demand Management (TDM)	Vehicle-kilometers of private transport modes such as gas car, gas jeepney/utility vehicle and diesel car/utility vehicle were reduced by 11.08% in all 98 traffic analysis zones
Replacement of 2-Stroke with 4-Stroke Motorcycles for Tricycles (4STC)	The PM emission factor of tricycles was reduced to 1/5 of the emission factor of tricycles in the baseline scenario applied to 100% of the tricycles in all zones
Construction of Bikeways	The rates of shift (1.5% in 2005 and 3.5% in 2015) from tricycle to cycling modes were applied as reduction rates of the tricycle

(BWMK and BWMM)	vehicle-kilometers of traffic analysis zones • Marikina (BWMK): applied to zones 74 and 76 only • Metro Manila (BWMM): applied to all 98 zones
Expansion of the Metropolitan Railway Network by 2015 (Rail 2015)	Expansion of the metropolitan railway network by 2015 by approximately 164.1 kilometers of new MRT/LRT lines and 19.7 kilometers of busways according to the MMUTIS Master Plan resulting to reduced road-based traffic demand
Diesel Particulate Trap (DPT) for Buses and Jeepneys (DPTBJ and DPTB)	Installation of the diesel particulate trap is expected to reduce the PM emission factor of buses and jeepneys by 30% DPTB: reduction of PM emission factor of buses only
Compressed Natural Gas (CNG) for Buses (CNGB)	Reduction of emission factor of buses by 86% if diesel is replaced by CNG • 2005 (Low: 0.88%/High: 1.76% applied to zones passed by C-5. EDSA and SLEX) • 2010 (Low: 11.47%/High: 22.93% applied to zones passed by C-5. EDSA, SLEX and NLEX)
Coco-methyl ester (CME) for Jeepneys (CMEJ)	Reduction of emission factor of jeepneys by 86% if diesel is blended with CME • 2005 (Low: 0.64%/High: 1.27% applied to all zones) • 2010 (Low: 2.0%/High: 4.0% applied to all zones)
Combo 1	Combination of all scenarios except railways and switching of two stroke to four stroke tricycles (2005)
Combo 2	Combination of all scenarios except railways (2010)
Combo 3	Combination of all scenarios (2015)

The methodology used for the analysis of the impact of transport- and fuel-related measures on emissions is similar to the environmental analysis model developed by the Metro Manila Urban Transportation Integration Study or MMUTIS (JICA, 1999). In this study, the total emissions for various policies were calculated as:

Emissions = f (travel distance, travel speed, emission factors)

Travel distance in terms of vehicle-kilometers and travel speed in terms of kilometers per day by planning zone were estimated using the 4-step travel demand forecasting model using the JICA STRADA, a travel demand analysis software. The MMUTIS Study defined 171 planning zones where 94 zones are in Metro Manila and the rest are in the nearby provinces. For the purposes of the IES study, these zones were combined to form 98 traffic analysis zones wherein 94 traffic analysis zones were constructed for Metro Manila and four (4) other zones corresponding to the four (4) adjacent provinces.

Vehicle-specific and speed range-specific emission factors for PM are used to estimate the total emission for each policy. The emission factors were derived from earlier studies such as the ADB VECP (1992), MMUTIS (1999) and JSPS Manila Project (2002). The share of travel distance of jeepneys and buses, and the share of gasoline and diesel-fed vehicles by mode were also estimated.

5.2. Air Pollutant Concentrations

5.2.1. The ISCLT3 Model

The ground-level concentration of particulates in Manila was predicted using the Industrial Source Complex Long Term Model (ISCLT3), which was selected due to its capability to predict the long-term concentration of pollutants from many sources and of many types using minimal meteorological data. ISCLT3 was run to predict concentrations in a 100-m receptor grid covering the entire Metro Manila. The study models PM_{10} only, and assumes that finer particles such as $PM_{2.5}$ are part of the PM_{10} load. The model does not include secondary particulate formation. No background levels were added to the model results owing to the lack of data, although the contribution of stationary sources was included.

5.2.2. Emissions Inventory

PM emissions associated with the traffic generated by the model are summarized in **Table X-1**. Diesel vehicles appear to account for bulk of the emissions; private vehicles, due to their numbers, contribute more than public vehicles. Emissions from public gasoline-driven vehicles are exclusively from two-stroke tricycles, which are often poorly maintained and overburdened.

Table X-1. Summary of PM emissions (in tons per year) from mobile sources (2002 baseline case)

Fuel	Private	Public	Total
Gas	939	4,254	5,193
Diesel	7,392	3,823	11,215
Total	8,331	8,077	**16,408**

The traffic flow generated by the NCTS traffic model was converted into emissions using appropriate emission factors. These traffic emissions, which were assumed to be uniformly distributed in each traffic zone, were then assigned to approximately 60,000 area sources each 100 m by 100 m in size covering Metro Manila. A color-coded map of PM emissions for the baseline, best-case and worst-case scenarios are shown in **Figure X-1.**

From the leftmost map in **Figure X-1**, vehicular emissions in Metro Manila can be seen to be highest at the center of the city where business, commercial and educational facilities are clustered. The series of zones with significant emissions that trace rough lines leading to this center indicate the major traffic routes. Traffic after population growth in 2015 does not appear to alter these routes, as shown in the business-as-usual (BAU) map at the center of the same figure, but the increase in emissions from all the zones is evident. The potential for reduction in 2015 under the most optimistic scenario is presented in the rightmost map, where emissions may be seen to fall to less than half of the 2002 levels.

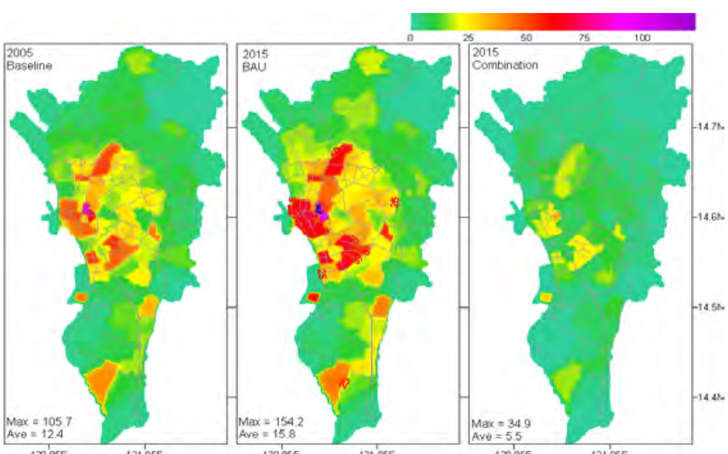

Figure x-1: Calculated particulate concentrations in μg/Ncm for the 2005 baseline (left), 2015 business-as-usual (middle), and 2015 combination of policies.

5.2.3. Modelling Results

Modeling results are shown as isopleth maps of ambient PM concentrations in **Figure X-1** for the 2002 baseline, 2015 business-as-usual (worst-case scenario), and 2015 under a combination of air quality management policies (best-case scenario). Poor air quality may already be seen from the 2002 baseline where highest annual concentrations from mobile sources alone reach 105 micrograms per Normal cubic meter (μg/Ncm), well above the Philippine standard of 60 μg/Ncm (indicated as red in **Figure X-1**). These levels are confirmed by the observations of the Manila Observatory at the Epifanio de los Santos Avenue, Metro Manila's main artery, where 24-hour concentrations are consistently higher than this value. Conditions get worse in 2015 under the business-as-usual case (center map in **Figure X-1**), where population growth heightens the exceedances.

The potential for improving air quality resulting from the implementation of several policies is shown in the rightmost map of **Figure X-1**, which shows the best-case scenario. Annual PM concentrations fall to less than half of their 2002 levels, and all exceedances disappear. Clearly, the adoption of even just a few strategically selected policies can result in dramatic improvement in Metro Manila's air quality.

5.3. Health Effects Estimation

The main methodology used was the health risk assessment approach using epidemiological studies, based on the Krzyanowski proposed method of assessing the extent of exposure and effects of air pollution in a given population. The basic principle of risk estimation could be illustrated by the following equation:

> **Attributable Number of Cases** = Exposure-response coefficient X excess exposure level X exposed population X baseline mortality/morbidity rates

The number of attributable cases for each policy scenario was calculated including that of the 'Business-as-usual' scenario (BAU) for the projected years. The attributable numbers of cases for the policy scenarios are then subtracted from the BAU scenarios for the respective projected years. These latter figures comprise the averted number of cases for each policy scenario. The exposed populations which cover the whole population of Metro manila for the 2005, 2010 and 2015 are projected based on the population growth rates predicted for those years. The predicted population growth rates consider both the birth and migration rates. With regards the baseline morbidity and mortality rates, these rates are assumed to be constant and similar to the rates in 2002 for 2005, 2010 and 2015 in this estimation. All data input and calculations of the estimates were made using the Analytica software. In this study, PM_{10} was used as an indicator of urban air quality and a proxy indicator for concurrent exposure to different pollutants.

The exposure response function or exposure correlation coefficient which is a measure of the relationship between variables, indicates the expected change in a given health outcome per unit of change of pollutant (PM_{10}, in this case). The exposure response coefficient values used here were derived from time series studies rather than the cohort studies.

The following health outcome variables were considered for this assessment: mortality, asthma, acute and chronic bronchitis and cardiovascular and respiratory hospital admissions.

5. 4. Economic Valuation

In order to conduct the economic valuation, the unit cost values to translate health impacts into economic values were needed. Several methods were used to estimate unit cost values: benefits transfer, direct cost of illness (medical costs), indirect cost of illness (lost work days).

Benefits transfer method was used in calculations of cost of most of the health outcomes. Values used were largely based on the adjusted values found in a study by Orbeta and Rufo (2003). The values were readjusted to set them in 1995 prices computed using Philippines Consumer Price Index and using the

2002 U.S. Dollar – Philippine Peso exchange rate. To estimate the unit costs of health impacts of different transport scenarios for years after 2002 (e.g., 2005, 2010, 2015), present values of the unit costs were calculated using a discount rate of 12%.

Direct cost of illness or medical costs were also used to estimate 'avoided medical cost'. Data from the Philippine Health Insurance system were used for this purpose. For indirect cost of illness, the lost income due to work loss days was utilized. Estimates of the number of work days lost for a specific illness was made by expert judgment of physicians. The income lost per day was assumed to be the minimum daily wage rate in year 2002 mandated by Philippine law (PhP 181.53 in 1995 prices).

6. Results

6.1. Scenario Development

Figure ES-1 shows the results of the estimation of travel demand for 2005. The total travel demand for the BAU scenario in 2005 was estimated at 74.5 million vehicle kilometers.

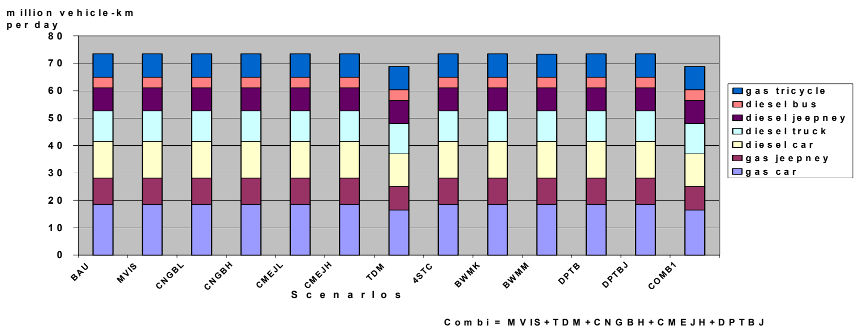

Figure ES-1. Projected Travel Demand: 2005

Figure ES-2 shows the results of the estimation of PM emissions in 2005. For the BAU scenario in 2005, the total PM emission in Metro Manila was estimated at 48.4 tons per day or about 17,670 tons per year.

The results of the simulation indicate that the greatest reduction in PM emissions relative to BAU scenario may be achieved with the combination of scenarios, which includes the MVIS, TDM, CNGBH or CNG for buses– high case, CMEJH – high case, DPTBJ or diesel particulate trap for buses and jeepneys, and the BWMM scenario. However, the 4STC scenario alone indicates an SPM reduction of almost the same magnitude as the combination scenario, that is, about 11.6 tons per day or 31%.

Figure ES-3 shows the results of the estimation of PM emissions in 2010. The total emission for the BAU scenario in 2010 increased by 9.8 tons per day or 20% compared to the BAU scenario in 2005. The increase in emission between the scenarios in 2005 and in 2010 is largely driven by the changes in assumptions that affect emission levels, for example, emission standards and increase in vehicles using alternative fuels.

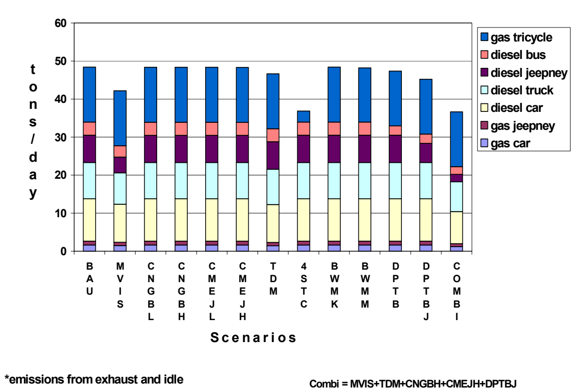

Figure ES-2. Projected PM Emissions: 2005

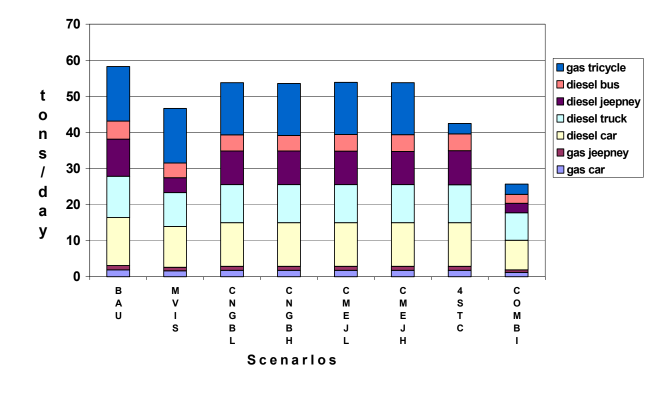

Figure ES-3. Projected PM Emissions: 2010*

6.2. Air Dispersion Modelling Results

Calculated ambient PM concentrations for the business-as-usual scenario were averaged for the entire municipality and are presented in **Figure X-1.** Air pollutant levels are expected to rise due to project growth if no measures are taken to actively reduce emissions from the transport sector. The city of Manila appears to receive the brunt of both the concentrations of PM as well as the growth of its levels, particularly between 2005 and 2010. The municipalities of Valenzuela and Navotas, which host the most number of stationary sources, appear to have lower spatially averaged particulate levels and minimal escalation, although concentrations at specific areas can be very high.

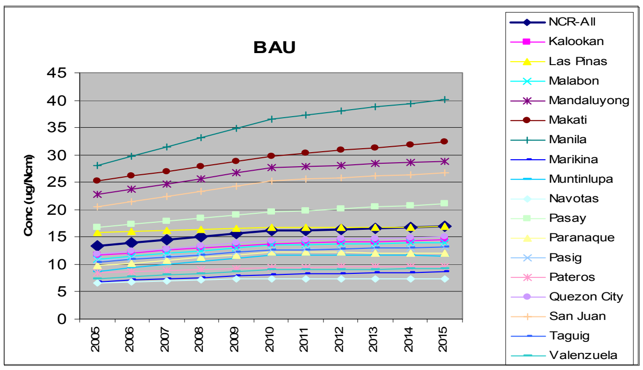

Figure X-1. Mean annual PM concentrations (μg/Ncm) per city/municipality and Metro Manila arising from the business-as-usual (BAU) scenario.

Figure X-2 shows the mean concentrations in Metro Manila arising from all the scenarios considered. The Motor Vehicle Inspection System (MVIS) appears to be the most effective. Remarkably, after 2010 the MVIS can actually cause air pollution levels to start decreasing as a result of the phaseout of the most pollutive vehicles and their replacement by new and cleaner units. Also effective is the shift to four-stroke tricycle engines, which can reduce mean PM concentrations nearly as much as the MVIS.

The impact of fuel shift from diesel to compressed natural gas (CNG) for public buses and the use of coco-methyl esters (CME) in jeepneys each give rise to a reduction in ambient levels by about 10 percent compared to BAU. These results show that a shift to cleaner fuel will not reverse the rising trend in PM levels unless a higher percentage of vehicles currently on the road is targeted for conversion.

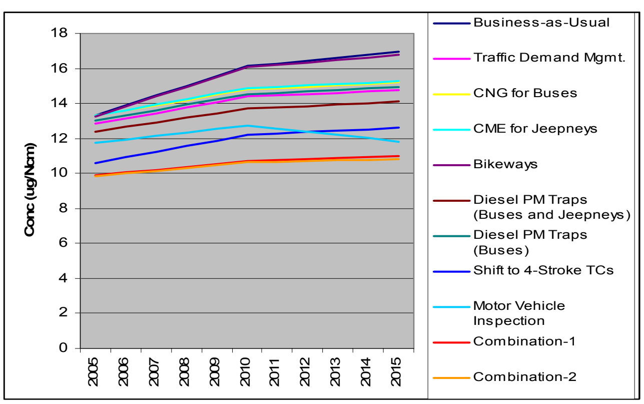

Figure X-2. Mean annual PM concentrations (μg/Ncm) in Metro Manila arising from the business-as-usual and other scenarios.

The impact of traffic demand management, or the banning of certain vehicles daily based on their plate numbers, results in improvement only as much as those from the shift in fuel. Improvement is also marginal with the installation of particulate traps for diesel buses. However, if jeepneys are also fitted with these devices, the reduction will be markedly larger.

Virtually no change in PM levels is expected from the construction of bikeways. However, the new railway envisioned to be completed in 2015 will cause a significant decrease (**Figure X-3)**, even if not all municipalities in Metro Manila will benefit.

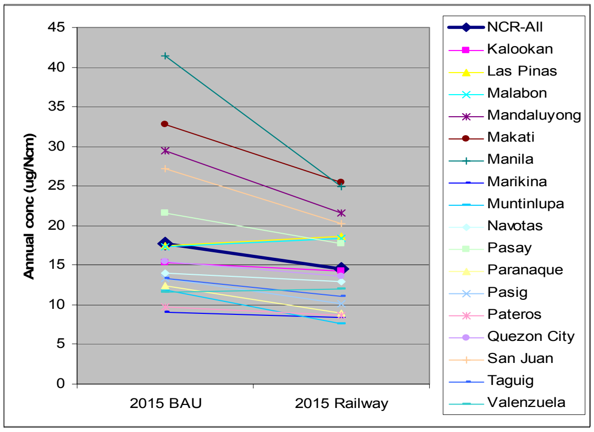

Figure X-3. Mean annual PM concentrations (µg/Ncm) per city/municipality and for Metro Manila arising from the business-as-usual (BAU) scenario and the projected operation of the proposed railway in 2015.

Applying the combination of measures described earlier to address Metro Manila's air quality is forecast to cause a dramatic improvement in PM levels. In 2005, a 25 percent reduction is immediately expected. But more important, the increase in pollution levels is minimized all the way to 2015 where by this average levels in Metro Manila fall to about 40 percent of baseline levels. This scenario, which is based on realistic estimates in the application of proposed air quality measures, reiterates an earlier prediction that PM levels in the capital can be controlled through concerted effort.

6.3. Health Impact of Each Scenario

Table 3 shows part of the overall results of the estimation exercise. It summarizes the cumulative health impact of the most significant single policy scenarios and the combination 1 scenario if implemented in 2005 until 2015. Combination 1 does not include the replacement of 2-stroke tricycles to 4 –stroke and the railways policies. In this analysis, the implementation of combination 2 which includes all policies except the railways starts in 2010 until 2015 and combination 3 with all the policies is implemented only in 2015.

Apart from the combination scenarios, the policies which could avert the most number of cases in all the years presented, are the conversion of tricycles from two stroke to four-stroke and the Maintenance of Vehicles and Inspection System. The Maintenance of Vehicles and Inspection System policy assumes that through an emission testing system, the quality of vehicles would be maintained and emissions will be decreased. This system depends entirely on the sustainability and consistency of implementation. Other policies also yielded results showing cases of health outcomes that could be averted, however, they were not as large as the two policies featured here.

Table 3:Cumulative Number of Cases Averted by the policy scenarios from year of implementation to 2015. (Note: Combo 1: from 2005-2015, Combo 2: from 2010-2015 and Combo 3: Only 2015.)

Policy Scenario	Natural Mortality	Respiratory Hospital Admissions	Cardiovascular Hospital Admissions	Asthma Attacks <15	Asthma Attacks >15	Bronchitis Episodes <15	Chronic Bronchitis
MVIS	1899 (1424-2376)	603 (47-1154)	111 (60-161)	102354 (63328-142988)	13639 (6710-20437)	3495 (1658-5323)	27997 (2683-53099)
TC4-stroke*	2082 (1562-	660 (52-1266)	121 (65-175)	112156 (69394-	14946 (7352-	3829 (1817-	30677 (2939-

	2603)			156683)	22393)	5834)	58182)
Combo 1	2827 (2120-3535)	898 (70-1719)	163 (89-239)	152325 (94247-212800)	20299 (9986-30413)	5200 (2465-7924)	41667 (3993-79021)
Combo 2	2643 (1982-3303)	840 (64-1605)	153 (23-224)	142376 (88092-198900)	18972 (9335-28428)	4861 (2307-7408)	4861 (2307-7408)
Combo 3	590 (443-738)	188 (15-359)	34 (18-50)	31801 (19676-44425)	4238 (2085-6349)	1086 (515-1654)	8698 (834-1649)

*replacement of 2 stroke with 4-stroke tricycles

The combinations of policies scenarios are still ideal and yield the most health gains. Moreover, this approach of estimating the health gains of individual policies also illustrates the importance of each policy. This would help decision and policy makers to appraise the merits of each policy especially in the event that due to budget constraints, only one or a few of the measures could be implemented.

6.4. Economic Costs of the Health Damages Averted by Each Policy Scenario

From the health damages section, economic costs of each policy scenario are calculated. The percent contribution of the costs of each averted health effect to the total cost of individual policy scenario shows that the total costs of the different measures or policy scenarios are dominated by the costs of the averted deaths and the morbidity due to chronic bronchitis. The premature mortality account for about 50% of the total cost of the policy scenarios while chronic bronchitis account for about 46% of the total. This occurrence is expected since cost per case of these two health effects is also quite high. In addition, this is consistent with another IES project result, e.g. Santiago, Chile.

In Table 4, the cost of cumulative health impact is shown. The policy scenarios with the largest costs averted are the combination scenarios, the MVIS and the replacement of 2-stroke to 4 stroke tricycles. In addition, it should be noted that, in spite of the low targets for the CNG and CME scenarios, the cumulative costs averted are still quite staggering at more than 3 billion pesos each. Despite the large figures seen here, these estimates remain as conservative, since they do not cover all the health damages that caused by particulate air pollution.

Table 4: Cumulative Total Health Costs Averted of each Policy Scenario, in millions, 2003

Policy Scenario	Cumulative Total Cost Averted, in millions
MVIS	12,126
CNG Buses	3,705
CME Jeepneys	3,523
Railway	538
Diesel Traps	7,812
Bikeways in Metro Manila	304
Tricycle Replacement to 4-stroke	14,141
TDM	5,468
Combo 1	19,083
Combo 2	13,359
Combo 3	2,813

6.5. Co-Benefits Results of Each Policy Scenario in terms of Emissions Reduction.

An evaluation of the policy scenarios in the reduction of emissions of particulates and the GHG gas, CO_2, is presented here. Table 30 shows that the replacement of 2-stroke to 4 stroke tricycles and the diesel particulate traps do not have an impact in the reduction of CO_2 emissions but had significant reduction in particulate emissions. In all the other policy scenarios, the reduction in particulates emissions approximates the reduction in CO2. Minimal impact is also seen with the CNG for buses and CME for jeepneys scenarios. Of the six single policies, the MVIS and the railways have the most impact in mitigating both the particulates and the CO2. As in the health damages and economic impact, the best results for mitigating both particulates and CO2 are seen with the combination of policies. This comparison would be of additional assistance to policy makers in determining which policy or combination of individual policies would have the most impact for both local air pollution and GHG emissions.

Table 30 – Percent reduction from BAU for each year

Policy Scenarios	SPM	CO2	SPM	CO2	SPM	CO2
MVIS	12.5	14.7	21.0	21.3	29.0	30.0
CNG for buses	0.6	0.04	8.6	0.6	9.8	3.6
CME for jeepneys	0.1	0.1	8.6	0.4	9.8	3.0
TDM	4.1	4.8	10.0	4.6	13.0	4.7
Replacement of 2-stroke tricycles	24.0	0.0	27.5	0.0	28.0	0.0
Bikeways	0.5	0.1	0.5	0.1	1.6	0.1
Diesel Particulate Trap for buses	2.0	0.0	7.7	0.0	11.4	0.0
Diesel Particulate Trap for jeeps/buses	7.0	0.0	32.7	0.0	34.0	0.0
Railway	--	--	--	--	18.2	13.0
Combination 1	27.0	31.6	--	--	--	--
Combination 2	--	--	57.1	32.0	--	--
Combination 3	--	--	--	--	69.0	53.0

7. Conclusions and Recommendations

7.1. General Conclusions and Recommendations

The savings from the health impact projected in 2005, 2010 and 2015 in implementing the single or combination of policies could mean very substantial savings on the health budget. In 2005, the savings from implementing the policy with the least health impact to the combination of policies would range from 0.13% to about 16% of the health expenditures for that year. In 2010, savings go up to almost 3% for the least, to more than 19% of the health budget, for the combination. In 2015, it's from 0.21% to 13% of the health budget. The savings in the national health budget that could be incurred is only based on savings from Metro Manila. If these policies could be implemented in the secondary cities, the savings on the national health budget could even be more. The following are the specific conclusions of the study:

1. Based on the assumptions made in the scenario development, three single policies have the advantage of having more health and economic benefits. These are the implementation of the maintenance of vehicle and inspection system, switching from four-stroke to two stroke tricycles, and use of the metro railways. These three policies must be seriously considered by decision makers particularly the Department of Transportation and Communication and the Metro Manila Development Authority.

2. The use of CNG in buses and CME among jeepneys did not show very important benefits because the assumptions on the targets, which were based on the government plans, were too low for any significant impact. The Department of Energy must exert extra effort to increase its target with regards the CNG and CME buses and jeepneys to have a more meaningful impact on air pollution.

3. CO2 emissions can also be considerably reduced with the policies proposed specially the MVIS and the TDM. However, at most benefits in terms of reduction of both PM and CO2 can be seen with the MVIS and the railways policy scenarios.

4. The other single policy scenarios also contributed to the reduction of air pollution and resulted to some health and economic benefits. These single policy scenarios are the collective responsibility of the DOTC, DOE, MMDA and the DENR

5. As expected, the combinations of policies resulted to the most health and economic benefits as well as reduction of CO_2. Hence, if at all possible, these combinations of policies must be implemented.

7.2. Other Recommendations

1. The cost effectiveness of the policy scenarios must be calculated to be able to have a more comprehensive evaluation of these policy scenarios
2. Stringent implementation of the Metropolitan Manila Air Quality Plan
3. Extension of this type of analysis to other sectors and sources of pollution, e.g. stationary sources or industrial air pollution
4. Implementation of similar type of assessment for other cities in the country, e.g. Cebu, Cagayan de Oro, Baguio and Davao.
5. Collection of more reliable data, e.g. meteorological data, and general Improvement of the models used.

References:

Anderson HR, et al. “Air Pollution and Daily Admissions for Chronic Obstructive Pulmonary Disease in 6 European Cities: Results from the APHEA Project.” *European Respiratory Journal* 10: 1064-1071,1997.

Asian Development Bank (2003) RETA 5937: Action Plans for Reducing Vehicle Emissions. http://www.adb.org/Vehicle-Emissions/reta5937.asp

Asian Development Bank (1992) Final Report for Vehicle Emission Control Planning in Metro Manila, July, ADB T.A. No. 1414-PHI

Chestnut LG, BD Ostro, N.Vichit-Vadakan. “Transferability of Air Pollution Control: Health Benefits Estimates from the United States to Developing Countries: Evidence from the Bangkok Study”. *American Journal of Agricultural Economics* 79(5).1630-1635,1997.

Cifuentes, LA et al. “Assessing the Health Benefits of Urban Air Pollution Reductions Associated with Climate Change Mitigation (2000-2020): Santiago, Sao Paolo, Mexico City, and New York City” . *Environmental Health Perspective* 109: supplement 3, 2001.

Clean Development Mechanism Executive Board

Department of Energy (2001), Feasibility Study on CNG Development for Public Utility Vehicles in Metro Manila

Department of Energy (2002), Philippine Energy Plan 2003 – 2012

Dockery DW. et al. “An Association between Air Pollution and Mortality in 6 U.S. Cities” *New England Journal of Medicine* 329(24).1753-1759,1993.

Dockery DW, J .Schwartz, and JD Spengler. “Air Pollution and Daily Mortality: Associations with Particulates and Acid Aerosols”. *Environmental Research*, 59 ,362-373,1993.

Eco-Tek Holdings, Limited (2002) Products and Services: Air Pollution, Eco-Trap (Diesel Particulate Trap).

Environmental Management Bureau (1993) Air Pollution Emission Inventory for Metro Manila 1990, March

Galassi I. et al. “Exposure to PM 10 in the Eight Major Italian Cities and Quantification of the Health Effects” . *ISEE 2000*, New York, USA, August 19-22,2000.

Integrated Environmental Strategies. Co- Controls Benefits Analysis Project for Argentina, USEPA, 2000.

Japan International Cooperation Agency (1999) Metro Manila Urban Transportation Integration Study: Final Report, May

Japan International Cooperation Agency (1999) Metro Manila Urban Transportation Integration Study Technical Report No. 10: Traffic Environmental Study, Air and Noise Pollution in Metro Manila. March 1999.

Japan International Cooperation Agency (1999) MMUTIS: Metro Manila Urban Transportation Integration Study Appendices. March 1999.

Japan Society for the Promotion of Science (2002) Metro Manila: In Search of A Sustainable Future – Impact Analysis of Metropolitan Policies for Development and Environmental Conservation, edited by Tatsuo Ohmachi and Emerlinda R. Roman, JSPS Manila Project and the University of the Philippines Press, Philippines

Kjellstrom T. “Preliminary Assessment of Human Health Indicators of Air Quality”. Technical Paper no.55, *Ministry of Environment*, Auckland, New Zealand, June 1999.

Kunzli N. et al. “Public Health Impact of Outdoor and Traffic-related Air Pollution: A European Assessment”. *Lancet* 356:795-801,2000.

Kyoto Protocol of the UNFCCC

Land Transportation Office, Philippines (2002) Number of Motor Vehicles Registered, By Region, By Type of Motor Vehicle and Type of Fuel Used (unpublished).

Mariño, A. (2001) ASEAN-NZ Natural Gas Utilization for Transport Program Philippines Experience, the 6th ASEAN Science and Technology Week, Brunei Darussalam, 17-20 September

McMichael AJ (1997) “Transport and Health: Assessing the Risks”. In: Fletcher T and McMichael AJ eds . *Health at the Crossroads. Transport Policy and Urban Health*. New York, John Wiley & Sons. pp. 9-26.

National Air Quality Action Plan (http://www.hangin.org/legal/aqap/index_AQAP.htm)

National Statistics Office, Demographic Data, Manila, Philippines, 2000.

Ostro B.et al. “Air Pollution and Mortality: Results from a Study of Santiago,Chile*”, Journal of Exposure Analysis and Environmental Epidemiology*, 6(1),97-114, 1996.

Partnership for Clean Air (PCA) Web Site http://www.hangin.org/
Philippine Council for Industry and Energy Research and Development and the U.P. National Center for Transportation Studies (2003) Standards Development for Local Motorcycle/Tricycle Sector

Pope C. et al. “Daily Mortality and PM10 Pollution in Utah Valley”, *Archives of Environmental Health*, 47 (3),211-217,1992.

Schwartz,J. and D.Dockery, “Increased Mortality in Philadelphia Associated with Daily Air Pollution Concentrations”, *American Review of Respiratory Disease*, 145,600-604,1992.

Schwartz,J. “Air Pollution and Daily Mortality in Birmingham, Alabama,” *American Journal of Epidemiology*, 137 (10), 1136-1147, 1993.

Schwartz J. “Air Pollution and Hospital Admissions for Cardiovascular Disease in Tucson”, *Epidemiology* 8:371-377 ,1997.

Schwartz J (1994) “Air pollution and Daily Mortality: a Review and Meta-analysis*”. Environmental Research*, 64, 36-52, 1994.

Schwela, D. “Exposure to Environmental Chemicals Relevant for Respiratory Hypersensitivity: Global Aspects”. *Toxicology Letters* 86: 131-142, 1996.

Shah, J. and Harshadeep, N. (2001) Urban Pollution from Two Stroke Engine Vehicles in Asia: Technical and Policy Options, Regional Workshop on Reduction of Emissions from 2- 3 Wheelers, September 5- 7, 2001, Hanoi, Vietnam. Manila [online]. Available from: http://www.adb.org/Documents/Events/2001/RETA5937/Hanoi/documents/20_Shah.pdf [Accessed 1st December 2003].

Shah, J. J., and Nagpal, T., 1994: *Urban Air Quality Management Strategy in Asia (Urbair)*. World Bank Technical Paper No. 380. Washington D.C.

Synerject LLC/Orbital Fluid Technologies and the Colorado State University (2002) Transfer of Clean 2-Stroke Engine Technology to Asian Markets, April, Concept Paper submitted to the USAID Asia Environmental Partnership

The World Bank (1997) Urban Air Quality Management Strategy in Asia: Metro Manila Report (World Bank Technical Report No. 380), edited by Jitendrah J .Shah and Tanvi Nagpal, December, International Bank for Reconstruction and Development/The World Bank, Washington, D.C., United States

Toman, Michael and Cazorla, Marina, *The Clean Development Mechanism: A Primer*, Resources for the Future, 29 September 1998, (http://www.weathervane.rff.org/features/feature048.html)

United Nations Framework Convention on Climate Change (UNFCCC)

U.P. National Center for Transportation Studies Foundation, Inc. (2000) Marikina City Bikeways Feasibility Study-Final Report

U.S. Environmental Protection Agency, 2001. Guideline on Air Quality Models: Appendix W, Part 51, 40 CFR Ch. 1.

U.S. Environmental Protection Agency, 1995*. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume 2.* EPA Publication No. EPA–454/B–95–003b. Environmental Protection Agency, Research Triangle Park, NC. (NTIS Nos. PB PB 95–222758).

U.S. Environmental Protection Agency Technology Transfer Network. Clearinghouse for Inventories & Emission Factors. *Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources*. http://www.epa.gov/ttn/chief/ap42/index.html (visited July 2003).

Whittemore AS and EL Korn. “Asthma and Air Pollution in the Los Angeles Area*”, American Journal of Public Health* 70: 687-696, 1980.

World Health Organization. “Air Quality Guidelines for Europe”*. WHO Regional Publications, European series No. 23* Copenhagen, World Health Organization.

World Health Organization. “Guidelines for Concentration and Exposure Response Measurement of Fine and Ultra Fine Particulate Matter for Use in Epidemiological Studies” *WHO Regional Publications*, European Commission, World Health Organization, 2002.

World Health Organization. “Health Impact Assessment of Air Pollution in the Eight Major Italian Cities ” *WHO Regional Publications*, Europe, 1989.

World Health Organization and United Nations Environment Program, “Urban Air Pollution in Megacities of the World” Cambridge, MA, Blackwell Publishers, 1992.

Xu, X. et al.,”Air Pollution and Daily Mortality in Residential Areas of Beijing, China*”, Archives of Environmental Health*, 49 (4), 216-222, 1994.