



Research Reports

Pollution Tax For Controlling Emissions From The Manufacturing And Power Generation Sectors: Metro Manila

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"The choking smoke that shrouds Manila, the capital of the Philippines has increased its 11 million residents' chances of developing lung cancer by up to 15%."

- Kate Noble, Health Report, *Time*, February 9, 1998

1. INTRODUCTION

Dasgupta and Maler (1991) ruefully observed: "The fact that for such a long while environmental and development economics have had little to say to each other is a reflection of these academic disciplines; it does not at all reflect the world as we should know it." Fortunately for us, environmental concerns are now in the forefront of discussions on economic growth. While the manifestations of environmental abuse would differ depending on the conditions of each country, they are generally of two kinds: (i) those that arise primarily because of poverty and population growth; and, (ii) those that arise from increased industrialization and urbanization leading to the pollution of water, air and soil. The latter is the subject of the current endeavor.

In the course of producing (and consuming) commodities, negative or beneficial side effects arise that are borne by the economic agents not directly involved in the production or consumption of the commodities. Broadly defined, an externality is a relevant cost or benefit that individual economic agents fail to consider when making rational decisions. Externalities drive a wedge between private and social costs or benefits and therefore, prevent the attainment of economic efficiency and Pareto efficiency. However, the collective effect of ignoring externalities is socially undesirable. Without any corrective action taken to internalize externalities, resources will not be allocated efficiently, even if the economy is otherwise competitive. Externalities may be internalized by government intervention through different avenues: i) Pigovian taxes or subsidies; ii) through voluntary agreements between individuals involved (e.g., tradable emission permits); and, iii) control of quantities of polluting inputs or outputs that would otherwise prevail in an unregulated market.

Historically, environmental policies rely heavily on regulations. The approach has not solved the environmental problems (and some even contend that they have exacerbated the situation). Out of the economists' tool-kit comes the standard prescription of using market-based policies to arrive at the least cost solutions to environmental problems.

Section one of this paper looks at the damage wrought by industrialization in Metro Manila's air quality and how

economic instruments can be utilized to curb the problem. In particular, it aims to come up with estimates of emission loads, abatement costs and appropriate emissions tax for selected industries within the manufacturing and power generation sectors.

Section two provides some background information on the study area, the pollution situation and the prevailing rules governing environmental protection. Section three explains why economic instruments such as a pollution tax may be a more effective means of regulating emissions from the industries. The conceptual framework is set forth in the fourth section while the estimates are contained in section five.

2. THE SCENE

2.1 Profile of Metro Manila

Metropolitan Manila, otherwise known as the National Capital Region (NCR) currently consists of nine cities and eight municipalities (See Figure 1). The cities are Manila, Kalookan, Quezon, Pasay, Mandaluyong, Makati, Pasig, Muntinlupa and Parañaque. The latter five are newly created cities. It is home to over eight million people and plays host to about 69% of the country's 19,000 industrial firms -- all this in its 636 square kilometers of land (NSO, 1994).

The spatial concentration of industrial activity and population in highly urbanized areas generate pollution. These industrial activities increase the adverse effects of pollution in the socio-economic development of these areas. Metro Manila, as the country's center of business and economic activities, is overcrowded with people and factories grossly exceeding nature's assimilative capabilities and affecting the health and welfare of millions of people (Cruz and Repetto, 1992). Needless to say, the economic cost of air and water pollution, and solid waste accumulation is rising.

Environmental assessments show an increasing trend in air pollution since the mid-70s. Commuters are regularly exposed to high concentrations of 1,000 mg/cubic meter of respirable suspended particulates (DENR, 1989). Eleven monitoring stations around Metro Manila have registered a growing level of total suspended particulate matter (PM) in the air throughout the years.

It is also expected that as economic activity increases in the Asia-Pacific region, notably highlighted by a huge influx of migration both within and outside the country, there will be an added pressure on resources. Pollution standards and regulations will be harder to meet, monitor and enforce. Increased energy use is expected as the Philippines tries to catch-up with its contemporaries in the region. Equally disturbing is the fact that as environmental laws overseas become more stringent, there is a tendency for "dirty" industries from developed economies to migrate to Third World countries in the form of foreign investments.



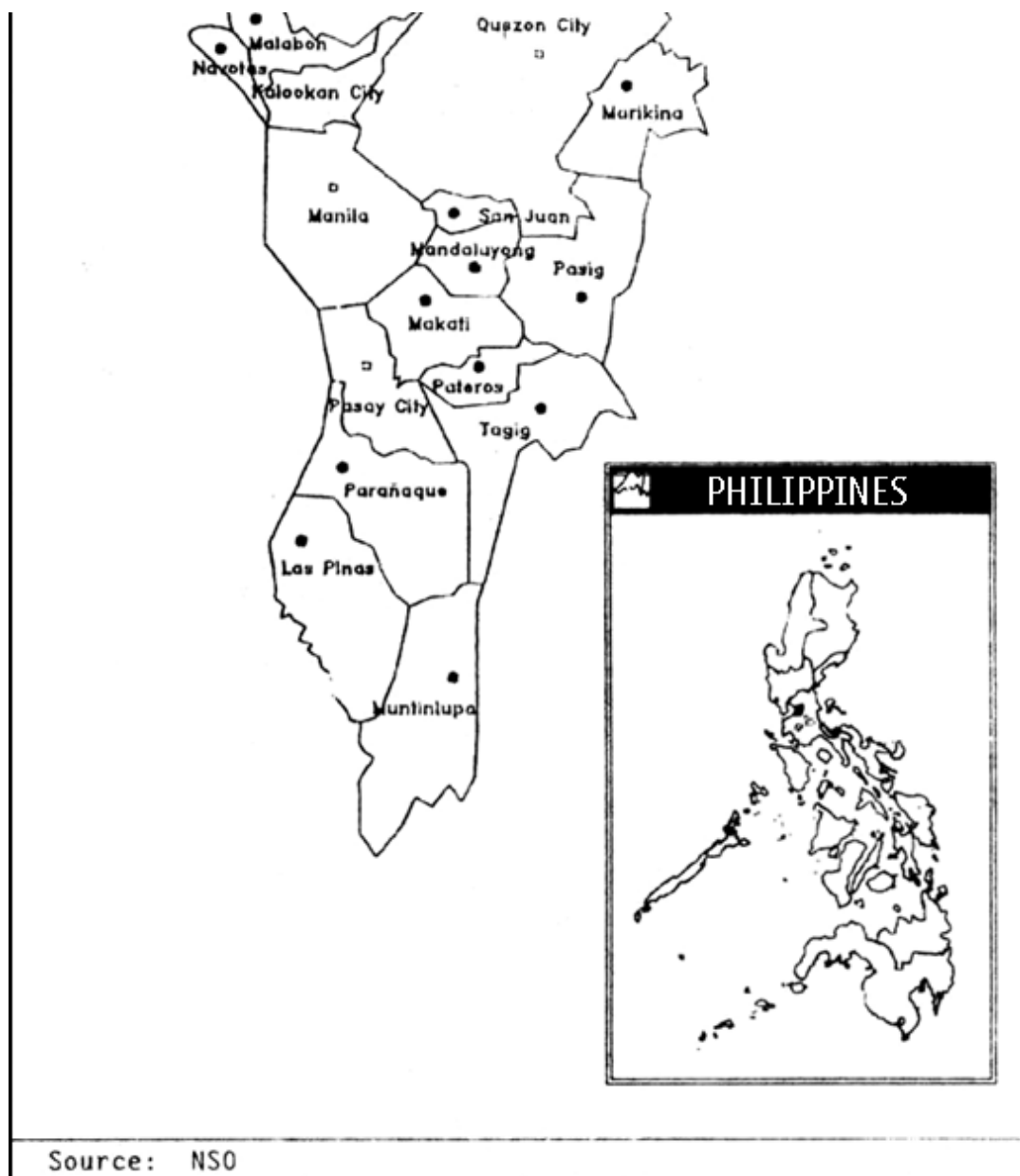


Figure 1. Map of Metro Manila

2.2 State of Environmental Regulation

While the country's policymakers have long since recognized the need for strengthened environmental and resource conservation efforts, they tended to focus on the latter. It is only during the 1990s that several environmental problems in the Philippines have taken center stage. Among these, the reduction of emissions was diagnosed to be in the highest priority.

Prior to the Clean Air Act of 1999, the National Pollution Control Decree of 1976 (PD 894) as amended by Executive Order 192 of 1987, was the main legislation dealing with air and water pollution. It sets the tone on the administrative and regulatory mechanism for pollution control. It was operationalized through the imposition of regulatory requirements prior to, during and after the actual operation of an industrial firm.

Air quality standards have also been set for the major pollutants. As per DENR Administrative Order No. 14 dated March 1993, the Philippines has revised its own ambient air quality standard for pollutants (Table 1). Emission standards

for stationary sources, which vary across sectors, dates when the establishments were put up and types of pollutant, are also shown in Tables 2 and 3. Three standards also set the maximum allowable sulfur content in fossil fuels effective January 1996. Prior to that, the sulfur content of fuels used were much higher (Table 4).

Before a firm can build a plant and operate, it has to obtain the following from the DENR: (1) an Environmental Compliance Certificate (ECC); (2) Authority to Construct (AC); and (3) a Permit to Operate. Aside from the necessary environmental permits prior to operation, firms are likewise subjected to periodic inspections. This shows that we do not lack the basic rules governing pollution control. What is sorely lacking is a workable incentive scheme owing to asymmetric information. The problem can easily be set in terms of prisoners' dilemma wherein the government (principal) could opt to inspect or not while the firms (agents) could comply with the standards or not. Ideally, we should have a situation where even without constant monitoring, the firms should actually comply with the standards. However, that set – is far from reality.

To sum, the Pollution Control Law and the DENR Administrative Orders provide the air and water quality regulations, standards for critical pollutants, and guidelines pertaining to prohibitive acts and penalties for violation. There are neither prescribed performance nor technology standards. The firms, therefore, are free to choose the technology and pollution control measures for as long as they meet the emission standards. However, these laws do not provide a specific environmental tax system or a policy mix to effectively curtail air quality degradation. Worst, the Philippines seemingly lacks strong political mandate in meeting the air quality standards as evidenced by the delays in legislating the Clean Air Act.

Table 1. Philippine ambient air quality standards (in $\mu\text{g}/\text{m}^3$, unless otherwise stated)

Pollutant	1 hour	24 hour	1 year
PM	300	230	90
PM ₁₀	200	150	60
SO ₂	340	180	80
CO	35 μg	10 μg (8 hr)	6 μg
NO ₂	400*	150	100**
Lead		1.5 (3 months)	1.0

Source: DENR

Note: *WHO standards; **U.S. standards

Table 2. Maximum emission limits for particulates in stationary sources (in $\mu\text{g}/\text{m}^3$)

	New Source 1993-onwards	Existing Source After 1978	Existing Source Before 1978
Fuel burning steam generators			

a. Urban or industrial areas	150	300	500
b. Other areas	200	300	500
Incinerators	200	300	500
Cement plants (Kilns, etc)	150	300	---
Smelting furnaces	150	300	500
Other stationary sources	200	300	500

Source: EMB-DENR

Notes:

1. For existing sources, the applicable date classification in columns 3 and 4 refers to the initial plant construction or modification, whichever is appropriate
2. For fuel-burning steam generators or sources, the concentration of particulate matter at the point of emission shall be corrected on the basis of 12% CO₂ by volume
3. For the purposes of this table, the following definitions apply:
 - a. "Other Stationary Sources" means a trade, process, industrial plant or fuel burning equipment other than thermal power plants, industrial boilers, cement plants, incinerators and smelting furnaces
 - b. "Urban Area" means a poblacion or central district area of cities or municipalities having at least 50,000 population, or twin political subdivisions with contiguous boundary which essentially form one community whose population is more than 50,000 inhabitants. Inside these centers of population are some scattered industrial establishments

Table 3. Maximum permissible emissions for sulfur oxides in stationary sources

	Existing Sources	New Sources
Manufacture of sulfuric acid and sulf(on)ation process	2.0 gm/ m ³ as SO ₃	1.5 gm/ m ³ as SO ₃
Fuel burning steam generators	1.5 gm/ m ³ as SO ₂	1.0 gm/ m ³ as SO ₂
a. January 1, 1994	---	0.7 gm/ m ³ as SO ₂
b. January 1, 1998	---	
Other Stationary Sources	1.0 gm/ m ³ as SO ₃	0.2 gm/ m ³ as SO ₃

Source: EMB-DENR

Table 4. Sulfur contents in fossil fuel, existing sources

Fuel	Max S (% by weight)	
	July 1993	January 1996
Fuel oil (all grades)	3.5	3.0
Industrial diesel	0.7	0.5
Coal	2.5	1.0

In 1997, the Industrial Ecowatch Project, a public disclosure program was introduced in the NCR. This falls in the third type of pollution control instrument that O'Connor (1996) refers to as suasive instruments (SI). The Ecowatch is patterned after the Proper/Prokasih project in Indonesia, which relies on a rating and disclosure scheme to control water pollution. It initially covered some 1,000 companies involved in beverages, food manufacturing, textile, chemical manufacturing, pulp and paper, pharmaceuticals and other consumer products. U.S. consultants, together with DENR personnel who conducted inspections, later reduced the list to 88 industrial firms whose initial rating was disclosed to them individually and confidentially. These companies were then given six months to improve their ratings. During the disclosure ceremonies last November 1998, it was reported that 26 companies have already received a "blue" rating, which means that they have sufficiently complied with the applicable environmental regulations; 9 were rated "red" and 10 were rated "black".

Companies complying with the requirements and standards of the DENR are expected to receive a "green" rating if they remain in compliance for two consecutive years. They will be eligible for "gold", the highest rating, if they remain "green" for another two years. A rate of "red" is given when a firm's control measures are not enough to meet the standards and the lowest rating, "black" is reserved for those who make no effort to comply. The initial success of the project convinced the department to adopt it as a new compliance monitoring system. At the moment, it only covers BOD effluent although it may later include air emissions.

The use of market-based instruments (MBIs) for environmental protection is at its infancy. The Department of Finance has reported that in 1997, the major sources of tax revenues are the corporate income (17.33%), import duties (11.86%), excise taxes (13.34%), individual income (11.54%) and the value-added tax or VAT (10%). While these traditional taxes are sometimes viewed as disincentives to economic activities, environmental taxes provide incentives to productive activities and to minimal distortions in the market. These environmental taxes include rent charges, energy tax, and charges on emissions and effluents. Tax revenues from fuels & oils, mining and forest charges account for only 6.19%, 0.016% and 0.024%, respectively.

As a risk-liability component of the Environmental Impact Assessment System, the Environmental Guarantee Fund is a "fund that proponents, required or opting to submit an EIS, shall commit to establish, when an Environmental Compliance Certificate (ECC) is issued for projects and undertakings determined by the DENR to pose significant risk to answer for damage to life, health, property and the environment caused by such risk, or requiring rehabilitation or restoration measures." The EGF is an established financial arrangement between the DENR and the firm. It is intended to assure that the firm is fulfilling its commitments to environmental

protection and rehabilitation. Ideally, the bond should equate the potential value of environmental damage from the firm's operations and the cost of eventual clean-up of the damage.

Only recently, an environmental user's fee to protect the Laguna Lake was established. It is composed of a fixed fee and a variable fee. The fixed fee is expected to cover the administrative cost of implementing the system while the variable fee depends on the volume and concentration of the wastewater discharge. All parties that discharge wastewater into the

lake are affected. However, since the system for collecting from households is still being developed, the first phase applies only to industrial establishments.

2.3 Power Generation and the Industrial Sectors

It is widely documented that the Philippines, like most developing countries, has opted to push for its industrial sector (particularly, manufacturing) as its primary agent of growth. The following macroeconomic incentives previously only promoted and encouraged producers to use technology intensive intermediate inputs: (1) The fiscal and trade policies that favored importation of intermediate input notably energy intensive technology. These forms of investment highly favor capital; (2) Import-substitution program that raised the prices of finished goods but kept intermediate inputs inexpensive; and (3) Foreign-trade related incentive structure. As production level expands and the use of intermediate inputs become limitless, the industrial waste stream grew rapidly due to greater discharge of residuals, more energy use, and more post-consumer waste (Cruz and Repetto 1992).

Industry, as the relatively advanced sector of the economy is often targeted as the main culprit in the deterioration of air and water quality. Taking into account the recent trade, investment and industrial policy reforms, it appears that the sector is set for more rapid growth. An emerging problem, however, is that despite efforts to deconcentrate industry from Metro Manila, most manufacturing firms remain there. This concentration of activity rather than the rapid growth of the manufacturing sector has led to increasing concern about the impacts of industrial pollutants (World Bank, 1993). Also, we must realize that efforts towards improving industrial efficiency will only reduce pollution from industrial sources.

The power generation sector produces an environmentally benign final product: electricity. On the other hand, it emits pollutants (notably SO_x) in the process of generating electricity. Munasinghe (1995) mentioned that the energy sector contributes 49% of greenhouse gases and electricity generation alone produces over 25% of energy related carbon dioxide emissions. Power generation in the Philippines is basically government-run and has suffered from inefficiencies. Financial difficulties experienced by the National Power Corporation caused delays in their new investments and rehabilitation projects. This resulted in the infamous power outages during the early 1990s. Most of its oil-fired plants, which include those in Metro Manila, are over 30 years old and will have to be retired. The Sucat power plant will be closed for rehabilitation. But while the existing facilities are still operational, we have to contend with their higher pollution intensities per unit of power generated.

Tables 5 and 6 show the estimates of the distribution of emissions from different sources in Metro Manila in 1990. Admittedly, the share of stationary sources pale in comparison to those coming from households and vehicles. Pollution problems accorded high policy priority are said to be those where abatement would result in significant benefits and can be achieved at relatively low cost. Such is the case for particulates, especially those coming from stationary sources. However, since pollution abatement does not cater exclusively to a single pollutant, it is natural to include other pollutants like sulfur and nitrogen oxides in the study. The available, albeit limited, data and the pivotal role of the industries in economic endeavors make these sectors the consequent subject of research.

Table 5. Summary of emissions from all sources in Metro Manila, 1990

Source Category	Pollutants (tons per year)					
	TOG	CO	NO _x	SO _x	PM	PM ₁₀
Mobile	100,954	572,626	66,216	10,350	13,220	11,450
Stationary	1,816	4,046	13,418	78,094	9,323	7,494
Area	5,162	525	276	12	102,386	51,042

TOTAL	107,932	577,197	79,910	88,456	124,929	69,986
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Source: Ayala, 1993

Table 6. Contributions to air pollution in Metro Manila, 1990 (tons/year)

Pollutant	Transport	Industry	Energy Generation	Total
SO _x	15,900* (15.9%)	8,818 (7.8%)	79,805 (76.9%)	103,923 (100%)
PM	12,100 (63.1%)	1,449 (7.6%)	5,636 (29.4%)	19,185 (100%)
Pb	72 (100%)			72 (100%)
NO _x	73,000 (86.7%)	1,867 (2.2%)	9,299 (11.0%)	84,166 (100%)
CO	537,000 (99.4%)	2,502 (0.5%)	845 (0.2%)	540,347 (100%)
HC	89,100 (99.7%)	195 (0.2%)	42 (<0.1%)	89,337 (100%)

Source: World Bank (1993), based on 1992 LLDA survey

Note: SO_x for transport is based on extrapolation of 1987 EMB estimate of 11,900 (tons/year) increase in diesel used.

3.0 CONCEPTUAL FRAMEWORK

Environmental regulation and assessment in countries like the Philippines is a tedious but necessary process. There are many limitations to evaluating environmental conditions and implementing policies that improve them. Weak institutional capacity, high monitoring and administrative costs for individual programs and limited (or even non-existent) engineering

information hinder the activity.

Direct regulation methods that the Philippines has adopted as its major policy instrument include concentration-based regulation that set the upper limit of effluent/emission regulations. Direct regulation can control the discharge of a target pollutant within a relatively short period of time, but it can provide industry no incentives to make greater efforts for pollution control beyond the level required by law. Likewise, they are often hampered by difficulties in enforcement and high administrative costs. These measures fall under the category of command-and-control instruments (CACs). In contrast, MBIs, otherwise known as economic instruments (EIs) work through market forces to combine economic and environmental decision making. Market signals, like prices, are utilized to influence the behavior of players to coincide with environmental goals set by society.

An important branch of the MBI family is environmental tax. If the regulating body imposes taxes on environmentally detrimental activities equal to the damages they cause, polluters will be forced to account for these damages in their production and consumption decisions. In effect, when the externalities are internalized, the appropriate levels of pollution control and emissions will result. OECD (1996) lists the various environmental tax instruments as follows:

- *Emission taxes* – These involve payments that are directly related to the measurement (or estimation) of the pollution caused. They are directed to those actually emitting a certain substance into the environment and are usually suitable for stationary sources because of their high monitoring and administrative costs.
- *Product charges or taxes* – A product tax is levied on the units of harmful substances contained in products. The taxation is linked to the product itself or part of its contents that are detrimental to the environment. Product charges may be applied to raw materials, intermediate, or final (consumer) products. They can be a substitute for emission taxes when direct measurement of emissions is not possible.
- *User charges* – These are payments related to services delivered. The revenue raised is used to provide a service, such as the collection and public treatment of effluents.
- *Tax relief* – These consist of provisions in income tax systems designed to encourage some kind of behavior either by consumers or producers. The most common form of tax relief is accelerated depreciation, but many countries also provide investment tax credits for certain types of investment such as pollution control equipment.

A number of studies showed the advantages of using MBIs to complement existing command-and-control policies. The newfound popularity of economic incentives is bolstered by the view that they potentially offer some added efficiency and cost savings in achieving the country's environmental objectives. Figure 2 illustrates the use of a least cost marginal cost curve represented by the envelope from the marginal cost schedules for different available technologies. The least cost placement of technologies is achieved by exhausting all lower cost efforts, across all technologies, before moving on to the higher cost ones.

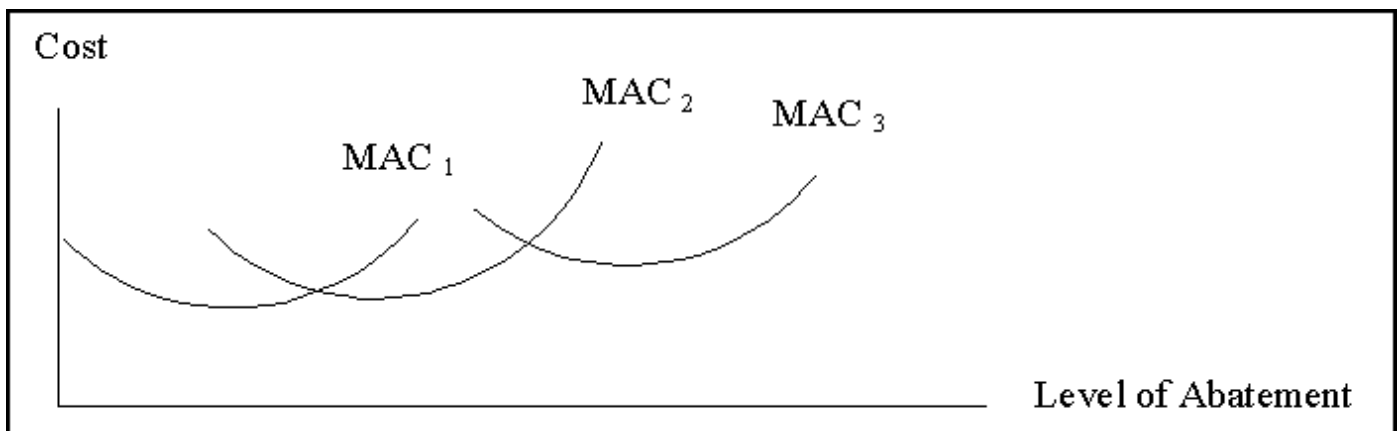


Figure 2. Least cost envelope of abatement strategies

Total emission control costs can be reduced relative to the CAC outcome by encouraging the lower cost source to control more and allowing the higher cost source to control less. This is shown in Figure 3.

The diagram indicates that the total cost of abatement is minimized by the distribution of effort between the two firms where $MAC_A = MAC_B$. A corrective tax will enable the higher cost source to increase its emissions by paying taxes instead of paying for the more expensive control costs. At the same time, the lower cost source has the incentive to further reduce its emissions to avoid paying taxes.

Perhaps an equally important consideration for the interest on environmental taxes among policy makers is that these can provide much needed government revenues. Repetto, *et.al.* (1992) pointed out that switching some of the revenue burden from taxes on income, employment and profits to environmental charges on resource waste, collection and pollution would yield double economic benefits. Gains come in the form of improved environmental quality, higher rates of savings and investments, and faster productivity growth.

Among the MBIs is the emissions charge for management of air quality. However, environmental charges, as part of the tax system, have political repercussions. For example, hard-core environmentalists may think that paying taxes gives the firms "the right to pollute", while industrialists see the added cost as a burden. There are also financial managers who see environmental taxes as another means of collecting much needed revenue. It should be emphasized then that the main purpose of this MBI is to correct externalities brought about by unabated pollution, and that the revenue-generating aspect is just an added bonus.

The primary objective of this study is to come up with an emissions charge that will induce industries, particularly manufacturing firms, to reduce their emissions to the standard levels. This implies that the emissions charge be equated with the marginal abatement cost.

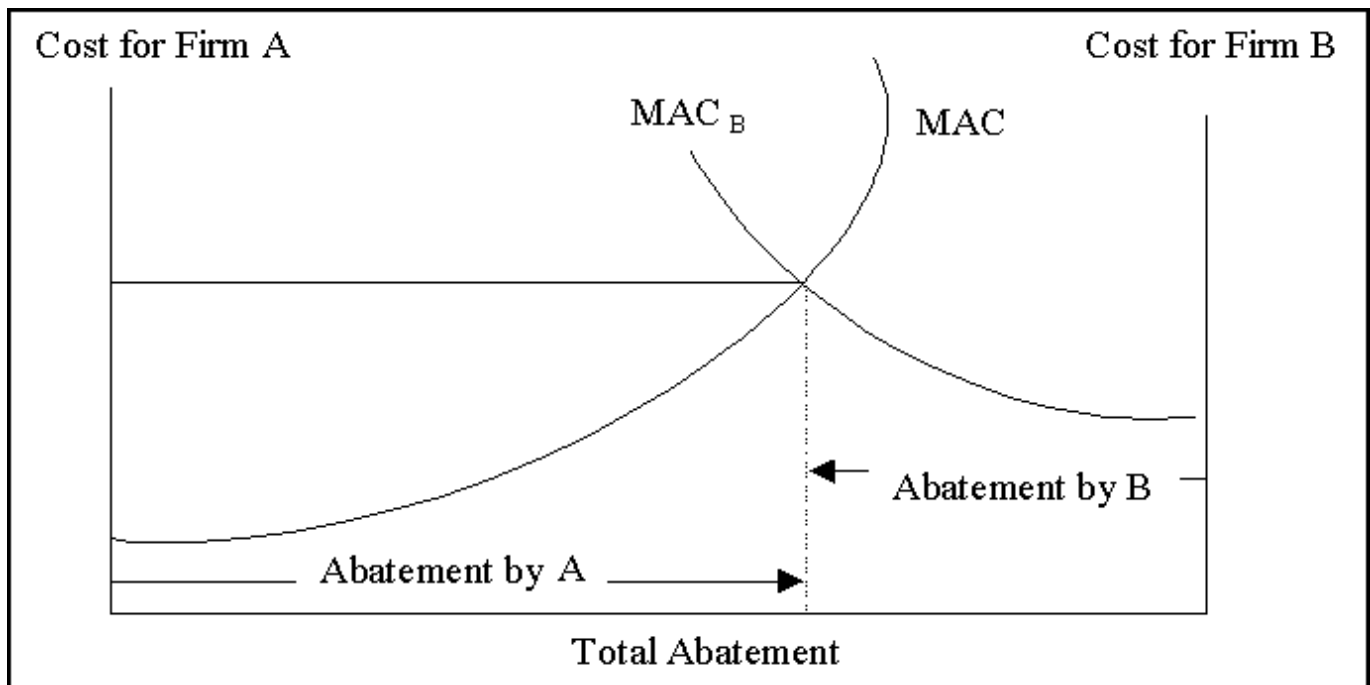


Figure 3. Distribution of abatement effort

The study intends to set an appropriate tax level based on the magnitude of actual pollution concentration vis-à-vis prevailing environmental standards. It aims to estimate the abatement cost incurred by the selected industrial and electricity sectors in an attempt to minimize emissions of air pollutants, notably of particulate matter, in compliance to the

set guidelines. From the estimated cost functions, we will attempt to calculate a uniform emissions charge. To ensure the continuity and effectiveness of tax instruments as incentives, annual adjustments on pollution charge per unit of emission to take into account inflationary effects will be considered¹.

The probable effect of the tax would be to induce (a) energy conservation; (b) substitution of other energy sources with less emissions; (c) substitution of other technology for more efficient and less pollutive production processes; and d) construction of pollution control facilities.

The paper will adopt OECD's Polluter Pays Principle (PPP) which requires a polluting firm to pay the full costs of measures to reduce pollution at levels prescribed by the authorities to protect the environment from the pollution resulting from its activities². The optimal emissions charge is achieved at the point where the marginal control/abatement cost (MAC) corresponds with the "allowable" levels of emission. Emissions exceeding the standard shall be taxed accordingly (See Figure 4).

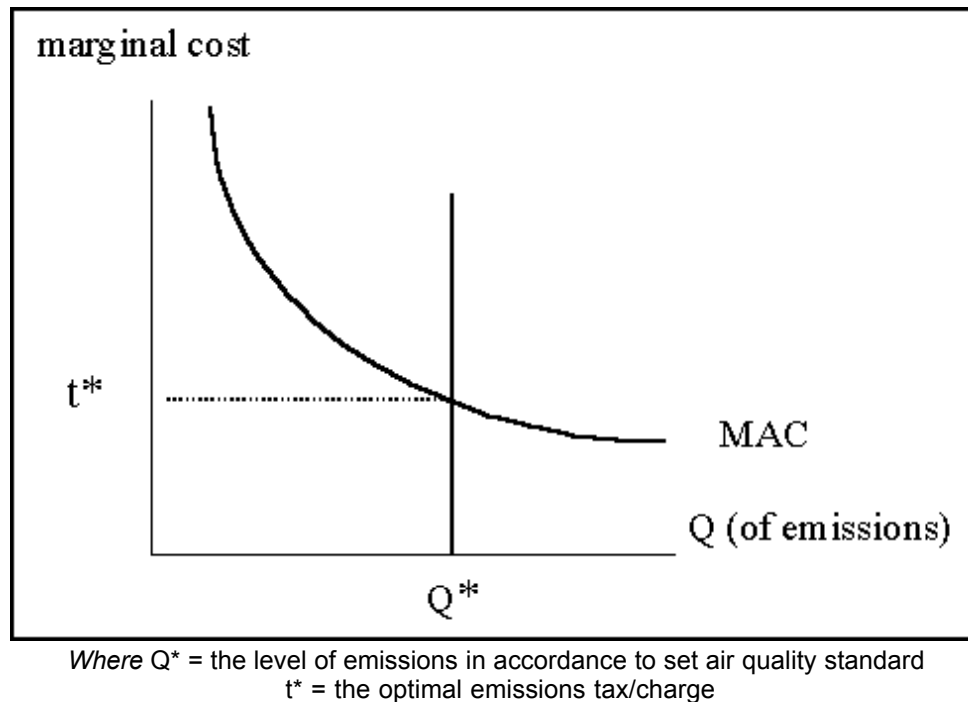


Figure 4. Defining an emissions reduction scheme

Baumol and Oates (1971) succinctly noted that whereas the above described resource-use prices will not likely lead to a Pareto-efficient allocation of resources, it is an easier and practical approach. Moreover, it provides a least cost method of achieving the reduction targets.

Note that the efficient solution does not call for the total elimination of pollution. While each firm faces a different abatement cost function depending on its production capacity and available abatement technology (among others), it results in $n > 1$ optimal charges when matched with the standard. Hence, the need for a least cost marginal cost curve derived from marginal cost schedules associated with different abatement technologies. This would serve as a basis in the estimation of a uniform emissions charge across polluters.

Figure 5 shows the framework for arriving at a potential economic instrument, which is the tax that meets a specified set of criteria. As an initial step, the study looked into the existing government policies/laws and how policy and market failures lead to environmental problems. Ideally, environmental impacts are assessed through corresponding economic valuation of damages but this was not carried out in the present study. By setting environmental targets and identifying the priority sectors, a set of criteria was formulated. In this study, a pollution tax was used as the economic instrument to

control emissions.

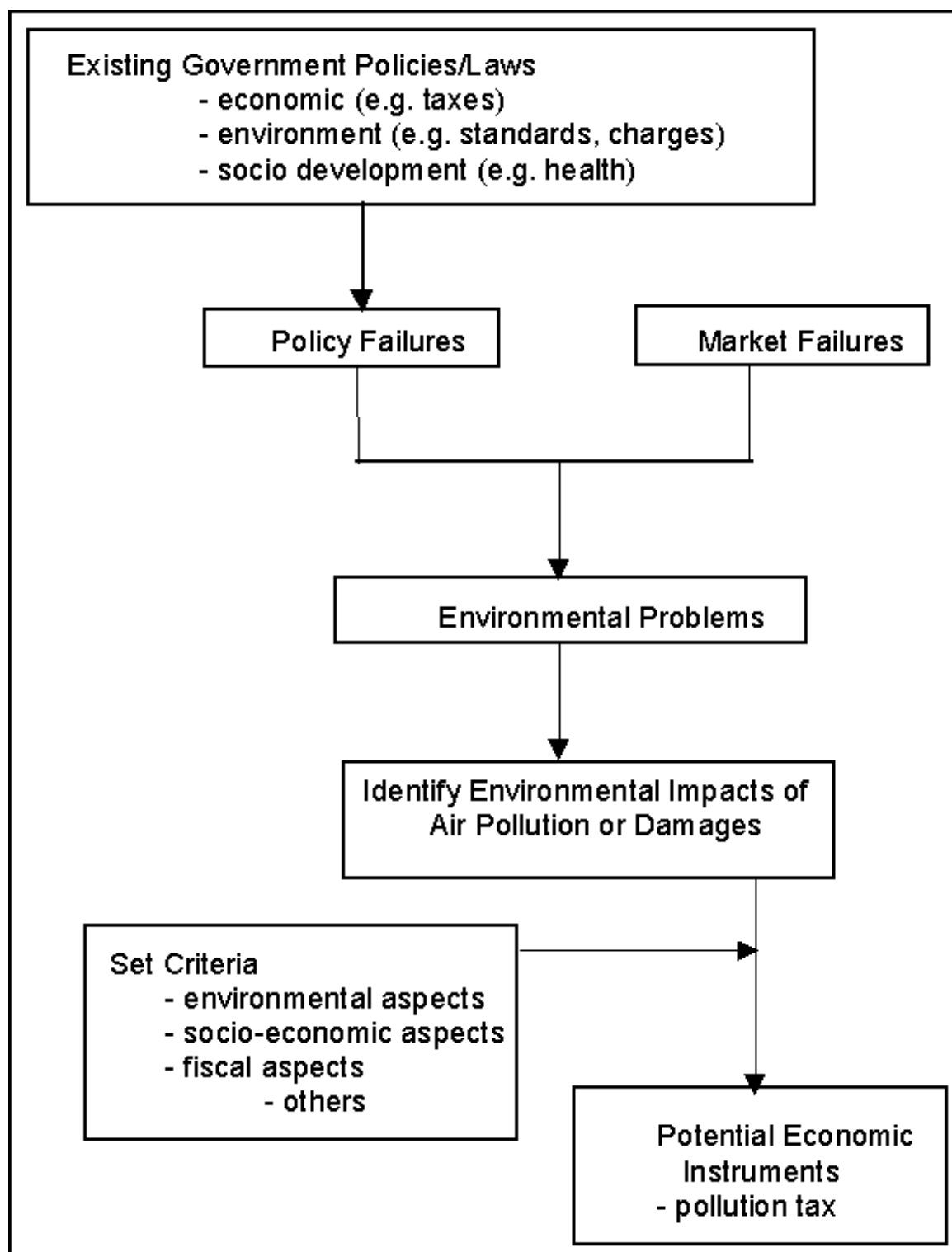


Figure 5. Analytical framework

4.0 ESTIMATING EMISSIONS

A detailed emissions inventory for Metro Manila is presented in Table 7². In the Ayala Inventory, the more significant 149 emitters in the DENR/NCR database were used in the model calculations.

The Ayala/EMB emissions inventory is hampered by its selective coverage. As Urbair (1994) observed, there is lack of industrial plant and emissions data in the said surveys from the areas covered by the Laguna Lake Development Area (LLDA). The areas excluded are Manila, Quezon City, Caloocan, Marikina, Pasig, Taguig and Muntinlupa which form the bulk of Metro Manila. As industrial establishments (particularly food manufacturers) abound in these places, the said inventory is already underestimating the emission loads. In view of the problems associated with the said database, other estimates were made.

4.1 Pollution from Power Generation

The estimates covering the period 1990-1995 were made based on the procedure outlined in the Handbook of Emission Factors (1988). Specific data which affect the plants combustion process obtained in a survey (i.e., type of fuel used, sulfur content of fuel, actual fuel consumption, operating hours) were used to adjust typical emission factors for local conditions.

In Metro Manila, the power stations are bunker-fuel oil (BOF) fired. The biggest facility is the Sucat (Gardner) Power Station on the edge of Laguna de Bay in Muntinlupa -- a four-boiler, two-stack base-load station with a total power generating capacity of 850 MW. We also have the Manila (Tegen) Power Station on Isla de Provisor in the Pasig River -- a boiler, two-stack base-load station with a capacity of 2 x 100 MW. Supplementing these two plants, especially during the energy crisis in the early 1990s, are several power barges: Sucat Barge and Navotas Barges 203 & 204. The Rockwell Station which used to supply additional electricity had been on lease since 1993 and is not included in the study. Table 8 presents a summary of the estimates on these power stations. Details are contained in the Appendices.

Table 7. Emissions from the industrial sector, Metro Manila, 1990

Table 8. Estimated emissions from BOF-fired power plants, Metro Manila, 1990-1995 (in metric tons)

Year	Gross Energy Generation (in MWH)	NO _x	PM	SO ₂	CO	CO ₂
1990	4,150.10	7,488.92	643.53	66,512.03	635.06	380,914.51
1991	6,217.07	12,810.43	964.04	99,638.70	951.36	570,631.04
1992	6,161.37	12,653.15	955.40	98,745.87	942.83	565,517.79
1993	4,657.04	8,625.46	722.16	74,639.44	712.66	427,460.22
1994	4,881.26	9,172.74	756.91	78,230.31	746.95	448,025.14
1995	4,299.63	7,778.16	666.72	68,908.80	657.95	394,640.80
Average 1990-95	5,061.08	9,754.81	784.79	81,112.52	774.47	464,531.58

Source of basic data: National Power Corporation; Handbook of Emission Factors (1988)

4.2 Emissions from Selected Manufacturing Industries

Two sets of estimates were made for the manufacturing sector. One utilized the fuel consumption of manufacturing establishments. The emission factors applied are similar to those employed by Orbeta (1994).⁴ Process equipment, refrigeration, lighting and air conditioning units primarily use electricity. Fuels are used by boilers, cookers and mobile equipment. The boilers burn bunker oil fuel, some LPG, diesel oil, bagasse and coal. Diesel is used for start-up purposes and for vehicles. The typical energy mediums would be boilers, electric generator sets, kilns and furnaces and are major sources of flue gas emissions.

The Ayala Inventory together with the other pollution estimates served as a guide in identifying the more pollutive industries in Metro Manila. These would be a) food manufacturing; b) textile mills c) paper and allied products; d) chemicals; and e) iron and steel.

Emissions from fuel combustion are based on sales figures from the Department of Energy. The five sectors listed above account for over 61% of Metro Manila's BOF demand. That alone is an indicator of these sectors' relative importance in managing the emissions problem.

As a rule, it is necessary to include emissions from production processes, especially in computing for PM emissions. Orbeta and Indab (1996) showed that 91.3% of PM emissions come from processing but for the other pollutants the opposite holds. This observation becomes relevant in view of the lack of data necessary to compute for process emissions. It requires data on the production of the sub-sectors expressed in terms of actual quantities of goods produced (e.g., in kilograms or in gallons). Unfortunately, what is often reported is the monetary values of products produced by the industries. Sometimes if they are at all reported they are in aggregate or national levels. Given the above observation, we know the extent of underestimation of the previous estimate and adjust these accordingly.

DENR records reveal that as of April 1998, 502 of the 737 major establishments in the metropolis did not have the necessary pollution control facilities. Conversation with some environment inspectors in the EMB revealed that even among companies with existing anti-pollution devices, not all are operational because companies believe that these are too expensive to operate. Such observations are taken into consideration in the calculations. Tables 9 and 10 show the estimates.

4.3 An Application of the Industrial Pollution Projection System

An alternative procedure is based on the World Bank's Industrial Pollution Projection System (IPPS). The IPPS was developed based on the notion that the scale of industrial activity, its sectoral composition and the process technologies used in production affect industrial pollution. The IPPS operates through sector estimates of pollution intensity (pollution per unit of activity). Estimates came from combining production with emissions data from 200,000 factories in the U.S.

Table 9. Estimated uncontrolled emissions: processing and fuel combustion bunker fuel oil, Metro Manila, 1997 (in metric tons)

Table 10. Estimated controlled emissions: processing and fuel combustion Bunker Fuel Oil, Metro Manila, 1997 (in metric tons)

Most developing countries have no, or at best, limited industrial pollution data but have industry information on employment, output and value added. This information can be applied to sectoral pollution intensity estimates derived from US database, though they are an imperfect substitute for measurements from country specific data. The IPPS has been used in other countries to map pollution control strategies.

O'Connor (1994) mentioned three reasons why other countries might show different intensities from that of the US. One, they may use more or less polluting technologies than the US in any given industrial sector. Two, even with the same technologies, different ages of capital stock may be associated with different pollution intensities. That is, the older

the capital stock, the more polluting it is going to be. Third, within a given 3 or 4 digit industrial sector classification, the product composition of output may vary considerably across countries and hence, there would be differences in processes and pollution streams.

Eskeland and Devarajan (1996) recognize that simplified models of emission generation which uses marginal emission factors fixed by output or fuel use abstract much of the variations among plants. Consequently, these models may be inadequate for analyzing policies aimed at modifying the determinants of the emission factors at the firm level. However, they say that these have credibility in the analysis of policies that would mainly change incentives at broader levels.

The people behind the IPPS have consistently noted that despite mitigating factors which cause fluctuations in pollution intensities within identical sectors between the US and developing countries, the relative ranking of intensities across sectors usually remain constant, especially with employment-based intensities.

To quote Laplante and Smits (1998), "The purpose of such an estimation is not to supplement proper monitoring activities of pollution sources. Its purpose is, in the absence of such activities, to provide the regulator with information that can be used to prioritize its monitoring effort and allocate its monitoring resources more efficiently."

For comparative purposes, an estimate for emissions using the IPPS pollution intensities are applying 1994 sectoral employment data presented in Table 11. These are basically uncontrolled emission. As expected the results do not coincide with the calculations using the fuel consumption data. The IPPS results should only be taken as a guide for identifying problem sectors. These estimates are more beneficial in ranking pollution sectors (and regions) rather than in using them as absolute estimates of pollution loads.

5.0 ON ABATEMENT COSTS

Environmental regulations and standards would be more efficient if the regulator has information on relative abatement costs. Otherwise, the regulator might end up barking at the wrong tree.

Sell (1992) notes that in cases where industrial emissions are concentrated on a few points, abatement may be done through three basic systems:

1. Through dry systems that use gravity, centrifugal force or fabric filters to trap pollutants. These are relatively low cost but are only effective in the removal of heavy particulates.
2. Through wet scrubbers which uses streams of water or other liquids in order to improve collection efficiency. It is capable of cooling and washing waste streams and in removing gas. Operating costs of high efficiency systems tend to be high.
3. Through electrostatic precipitators wherein pollutants are trapped by channeling the waste stream between two electrodes – a high voltage discharge electrode and a grounded collecting electrode. This is effective in collecting very fine particles.

Table 11. Estimated emission loads, manufacturing sector (employment-based) Metro Manila, 1994 (in metric tons)

Understandably, in the process of controlling pollution, industries are faced with a menu of choices. For example, when different industries decide on generating their own power, they would have common control problems (in this case, sulfur oxide removal). At the same time they would be having unique problems due to differences in sectoral production processes. In effect, sectoral abatement costs would reflect a mix of common and sector specific costs. Costs of controlling discharges would vary not only across subsectors but even within the same industry across firms of different scales and with capital equipment of different vintages (World Bank 1993).

For industries in Metro Manila, the presence of standards and a penalty scheme does not seem to deter their dumping/polluting activities. Most of the existing factories have devices only for controlling dust and particulates. Statistics show that majority of the industries have already been served notices of violations and fined by the Pollution Adjudication Board of the DENR. Commercial operators prefer to pay the P50,000 fine⁵ thinking that complying with environmental standards is too costly. One wonders how they ever got their permits to operate. Unlike in water pollutants where the evidence remains, the problem with emissions is that they tend to disperse as they exit the stacks.

Despite the supposedly strict rules set forth by the DENR/EMB, its enforcement record leaves much to be desired. In cases brought to the PAB, a cease-and-desist order and a fine is imposed. However, as cited in ADB (1997), it seems that fines are rarely collected as evidenced by the paltry amount of P329,000 (US\$12,700) collected by the DENR from 1989 to 1993.

The power plants surveyed rely only on tall smokestacks, multicyclones and dust collectors as anti-pollution devices (Table 12). The tall smokestacks commonly used by industries and utilities in Metro Manila do not remove pollutants but simply boost them higher into the atmosphere, thereby reducing their concentration at the site. These pollutants may then be transported over large distances and produce adverse effects in areas far from the site of the original emission. Considering that sulfur dioxide emission is the major problem of power generation, these anti-pollution devices will not suffice. The cyclones and dust collectors are part of the plant design for the turbines to work effectively. Thus, they are basically for maintenance purposes and the fact that they control PM is just a plus factor. This means that the cost of environmental protection (via the installed PCDs) is part and parcel of the fixed assets and current operating expenditures of the power facilities.

The NPC has admitted that at present, we do not have any treatment facility for NO_x and SO_x in the Philippines. Only the Calaca 2 and Pagbilao plants located outside NCR are equipped with low NO_x burners and there are no Flue Gas Desulfurizers yet in any of the plants. With the impending more restrictive SO_x emission limits in 1998 from 1,500 mg/m^3 to 700 mg/m^3 , the power generation sector will be in trouble. What is even more disturbing is the NPC's decision to veer away from the use of diesel and fuel oil in power generation and instead boost its use of coal in a bid to reduce the country's dependence on imported crude oil. Local coal, being of lower quality (in terms of sulfur content and heating value), is going to exacerbate our SO_x problems.

Table 12. Pollution control equipment by generating plant, Luzon Grid

Plant	Plant Size (MW)	Fuel Type	Stack Height (m)	Air Pollution Control			Water Pollution Control		
				TS	DC	ESP	Sep	SNB	Inj
Malaya	650	Oil	90	X	X		X	X	
Sucat	850	Oil	122 + 87	X	X		X	X	
Manila	200	Oil	76	X	X		X		
Bataan	225	Oil	84	X					
Tiwi	330	Oil	22						X
Macban	330	Geo	22						

Batangas	300	Coal	120	X	X	X	X	X	X
Navotas	160	Gas	11						

Source: National Power Corporation

Notes: TS = Tall Smokestack; DC = Dust Collection with Ash Disposal;
 ESP = Electrostatic Precipitator; Sep = Oil/Water Separator;
 SNB = Settling/Neutralizing Basin; Inj = Brine Reinjection

The Urbair report estimated that power-generating plants require an initial outlay of US\$10 million for an electrostatic precipitator (95-99% effective) with an annual cost of US\$3-5 million. WB (1993) valued 90% percent SO₂ reduction via flue gas desulfurization at approximately \$1,500 per ton (including capital amortization and operation). To put this in perspective, the over 81,000 tons/year of SO₂ emitted by the Metro Manila power plants estimated in 1990-1995 would require US\$121 million annually. Given the prohibitive costs of the said devices, an alternative feasible measure is to switch to low sulfur fuel since SO₂ emission is proportional to the sulfur content of the fuel. In addition, the use of low sulfur fuel leads to a decrease in PM particles. As mentioned earlier, power plants are currently using BOF with 3.12% sulfur. Reducing the sulfur content to 2% will reduce the emissions from power plants by 40%.⁶ The actual cost involved will depend on the sulfur premium, which is the increase in the world market price of fuel oil with decreasing sulfur content. Urbair places the sulfur premium to be around US\$5-10 per ton per percentage sulfur.⁷

The basic components of an air pollution control system are: hood, ductwork, the air pollution control device or collector and fan. Many iron and steel companies have inadequate design of hoods rendering their pollution control systems and costly to operate. Hoods are suction points wherein contaminants enter the system. Many ductworks are worn-out and have leakages. Also, the fan components are underrated resulting in less efficient systems. Most industries that require pollution control equipment rely on cyclones, bag houses or electrostatic precipitators. There are no wet systems like spray towers or venturi scrubber.

For the food manufacturing and textile industries, the use of cyclones and mechanical collector would be most appropriate in dealing with their airborne problems. In contrast, for paper and chemical manufacturing, wet scrubber and baghouses should be included in their acquisitions list. Table 13 provides a list of abatement technologies available.

In the food processing industry, dust is generated during conveying, screening, mixing and grinding of dry raw materials. Dust collectors such as cyclones and filter bags are used to avoid dusty conditions in the processing areas and to recover valuable raw materials. One company even mentioned that odorous exhaust gases from cookers and dryers of the plant are controlled using packed tower wet scrubbers. Chlorine or potassium permanganate is often added to scrubbing water.

The paper and pulp sector generally acquire used equipment from foreign pulp and paper companies. As such paper mills operate outdated and old machines usually lacking in spare parts and adequate instrumentation or control. Automated controls are no longer operational and have to be operated manually. As a result the mills produce excessive wastewater and to lesser extent, atmospheric discharges.

What seems to be a recurring scenario is that most companies do not know exactly how efficiently they are burning fuel. Hence, combustion might be occurring with too much excess air or with deficient air. Either way, energy is wasted. Ensuring combustion efficiency with efficient burners is viewed as the best and most inexpensive means of reducing the emissions of unburned carbon and hydrocarbons (Raytheon Engineers and Constructors, Inc., 1994). Moreover, pollution control devices are inadequately maintained or inappropriately designed. Punctured bags in baghouses contribute to emissions in some facilities. Ironically, this could easily be rectified.

The report of Hartman, Wheeler and Singh (1994) on pollution abatement costs of US manufacturing industries can

serve as a guide. The data is based on a 20,000 plant random survey and the fact that the US manufacturing sector is "characterized by enormous variation in equipment vintages, processes, operational efficiency and degrees of operation control" which would enable countries without adequate data to use it as a ballpark estimate. The authors believe that these estimates will "provide conservative upper-bound estimates of pollution control costs in developing countries. Its major handicap, however, would be in grouping together the most expensive with the cheapest control possible in a single category, which generated high variances in the results. Table 14 is culled from the study while Figure 6 illustrates how the different industries compare in terms of the abatement costs for PM and SO₂.

Table 13. Cost of controlling emissions from stationary sources (in P1992/mt)

Table 14. Average abatement cost by sector, 1979-1985 (in P1993/mt)

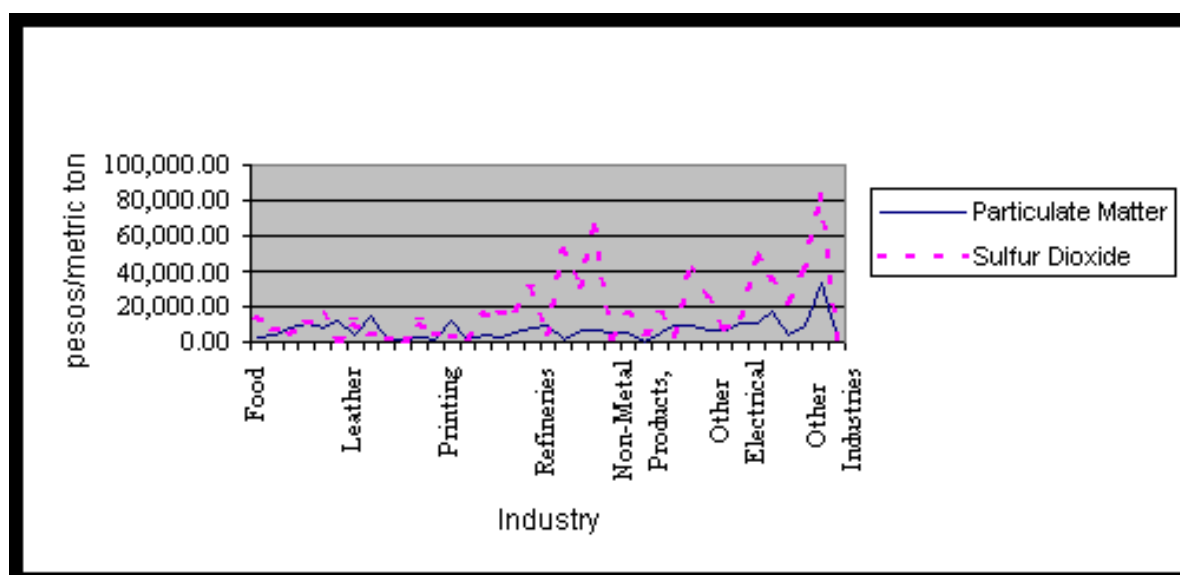


Figure 6. Average abatement cost for PM and SO₂ (P1993/ton)

Aside from the typical end-of-pipe treatment, Urbair (1997) considers switching to cleaner fuels for fuel combustion other than for power production (lowering sulfur content in heavy fuel oil to 2%) and computes the cost to be around US\$10-20 per ton of fuel. Reducing sulfur content of fuel used will reduce emissions by as much as 40% (Table 15).

Table 15. Cost-effectiveness of clean fuel

	Characteristic	Effectiveness	Cost
Power generation	• use of 2% sulfur fuel oil	• 40% reduction in emissions	• additional US\$5-10 per ton
	• use of lighter fuel oils	• 70%-80% reduction	• unknown
Fuel combustion other than for power production	• use of 2% sulfur fuel oil	• 40% reduction in emissions	• additional US\$10-20 per ton
	• switching to	• 99% reduction	• unknown

	natural gas	
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Source of basic data: Urbair (1997), MEIP

Lately, there is a growing interest in reducing or eliminating industrial waste at the source due to the economic benefits associated with it. This involves substitution of environmentally acceptable materials in the process, changes in process operations, recycling and reuse of waste materials. While effectiveness of such programs is not easily established at this point, one cannot say that they are insignificant. In fact, in one of companies, upgrading and re-fitting equipment was being planned but the financial slump forced them to shelve their plans.

6.0 MBIs: THROUGH THE LOOKING GLASS

The choice of a market based instrument for environmental protection is not only dictated by perceived allocative efficiency but by its acceptability to members of the system affected. A study conducted under the Industrial Environmental Management Project of the DENR and USAID examined the issue of MBI's acceptability in the country. Industry groups were asked to rank from 0 to 3 (from the least to the most suitable) seven MBIs and evaluate them in terms of the following:

- market penetration (would the MBI affect environmental decision-making within the industry or sector?)
- equity and fairness
- economic efficiency (do costs justify the benefits?)
- political feasibility
- administrative feasibility (could the instrument be implemented under existing administrative set-up or would additional resources be necessary?)
- effectiveness in achieving objectives (can the MBI bring about compliance and bring about voluntary pollution prevention?)

The result is presented in Table 16.

Table 16. Suitability ratings of selected MBIs in the Philippines

Interesting enough the above results coincide with findings of a survey and roundtable discussions done by the ASEAN Environmental Improvement Project together with the Management Association of the Philippines and the Asian Institute of Management on selected CEO's reaction to MBIs. The survey showed the following:

- Most CEOs, though unfamiliar with MBIs, were in favor of the use of market forces for environmental management.
- Philippine CEOs favored markets for waste and financial incentives – MBIs that directly contribute to company revenue. User fees which tend to cut into the firm's income were the least favored of the economic instruments.
- CEOs generally favor schemes they are more familiar with and expressed interest and openness to learn more about how to implement MBIs.
- Some CEOs think MBIs involve complicated procedures and can work well only with responsible companies and governments.
- Many CEOs recommended implementing a more comprehensive environmental protection program directed at internalizing corporate values on the environment, competing globally to meet world class environmental standards and strong and fair enforcement of environmental laws.

The findings are predictable considering the interests of the producers /manufacturers on the impact of MBIs on their bottom lines. Despite their appeal, most MBIs are hard to administer and can be politically unacceptable. It is then essential that the fiscal instruments designed for pollution control be appropriate to the existing situation. It is interesting to note that there seems to be a preference for input taxes over emission charges. This is understandable in the case

where there are a lot of players in the market such that monitoring would be extensive and costly. However, it was shown that a large part of the responsibility on the fouled up air quality in Metro Manila lies on only a handful of industries. Hence, an emissions charge seems appropriate.

7.0 EMISSIONS CHARGE ESTIMATES

Estimates of various pollutants emitted can be arrived at in several ways as discussed previously. In computing an emissions charge, relevant data is the ambient air quality. With the inadequacy of ambient quality monitoring, the next best thing is to adopt the results of a dispersion modeling. Urbair (1997) used a dispersion model to establish the relationship between emissions and air quality in Metro Manila. It covered power plants, industrial zones and other major exposure areas. Based on its results, PM concentration in the area exceeded the national air quality guidelines by as much as five times. While this is alarming, most of it comes from vehicular sources and is not within the scope of the current study. Ambient concentrations in the NCR area have exceeded the standards for SO_x by 54.8 %. Assuming a linear relationship between level of emissions and ambient quality, then we say that there is a need to reduce emissions also by 54.8%. In terms of the quantities this would be 36,647 metric tons of the 66,873 metric tons of sulfur dioxide generated by the entire manufacturing sector.

Given the above conditions, which industry is likely to purchase PCDs to avoid paying SO_2 emissions charge? The data on average abatement tells us that it would be the furniture manufacturers having the lowest abatement cost. While data is not the marginal cost we are interested in, at the least-cost combination, the marginal cost would be equal to the average cost. Using these we can achieve a desired level of abatement at the lowest possible cost which is the biggest advantage of MBIs. The cost structure can also serve as a guide for setting the emissions charges. By setting a charge higher than the minimum-cost solution, there would be some voluntary abatement by the firms. The US data, which obviously reflects foreign technology, would have to be adjusted upwards to reflect cost of transportation (PCDs are exempted from import duties and local taxes if the firm importing belongs to an industry covered by the Investment Priorities Plan).

It would be erroneous to assume that industries are able to achieve a hundred percent removal of pollutants. While removal efficiency of pollution control devices can go as high as 99.99% for newly installed ones, most old firms rely on vintage technology; poor maintenance will reduce that capacity. Authorities place the expected removal at around 50-80% across industries to account for the different technologies in place.⁸ Tables 17a and 17b show the sectoral emissions for particulate matter assuming 80% and 50% removal efficiency, respectively as computed via the IPPS and the cost data by ascending average abatement. Similar tables are constructed for sulfur dioxide (Tables 18a and 18b).

To illustrate, if we assume an 80% removal efficiency of the PCDs and desire to achieve a 60% reduction in PM, then we should charge around P4,500/ton of PM emitted. Similarly, if the target is to meet the national ambient standard for sulfur dioxide (58.4% reduction, as per Urbair finding) at 80% removal efficiency of PCDs, a charge of approximately P14,200 per ton of SO_2 emissions has to be levied. In other words, the marginal social cost at 58.4% abatement of SO_2 is P14,200/ton. The higher the desired level of abatement, the higher will be the cost of abatement. In instances where the abatement technology in place is inefficient and poorly maintained, the cost will tend to be even higher. To understand the dynamics further, several graphs are constructed for illustrative purposes. Figures 7a and 7b are applicable for particulate matter while Figures 8a and 8b should be used in conjunction with Tables 18a and 18b for sulfur dioxide.

From the above exercise it can be observed that the cost of sulfur dioxide clean up is prohibitive. As mentioned before, there are hardly any facilities capable of dealing with SO_2 emissions. Not even the three power plants have the necessary equipment. A more realistic way of controlling SO_2 is via the sulfur content of the fuel used. The predominant fuel used is bunker oil fuel with 3% sulfur content as prescribed by law. Reducing it further to 2% will mean an additional

US\$10-20 per ton of fuel but this will reduce SO₂ emissions by 40% and an added bonus of decreasing PM as well. This roughly translates to P272-543 (in 1993 pesos for comparative purposes). Obviously, this is a more feasible and cost effective alternative. Reducing O₂ emissions by a measly half a percentage point via end of pipe treatment will cost a firm nearly as much.

- [Table 17a.](#) Cost-effective regulatory strategy for particulate matter
- [Table 17b.](#) Cost-effective regulatory strategy for particulate matter
- [Table 18a.](#) Cost-effective regulatory strategy for sulfur dioxide
- [Table 18b.](#) Cost-effective regulatory strategy for sulfur dioxide

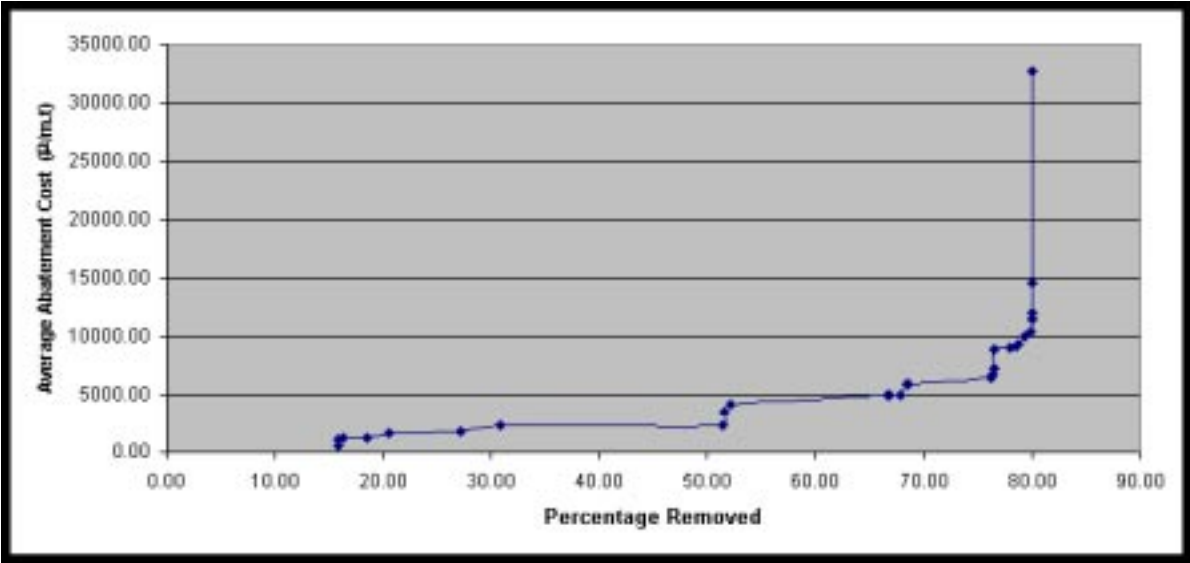


Figure 7a. Abatement cost for PM (80% removal efficiency)

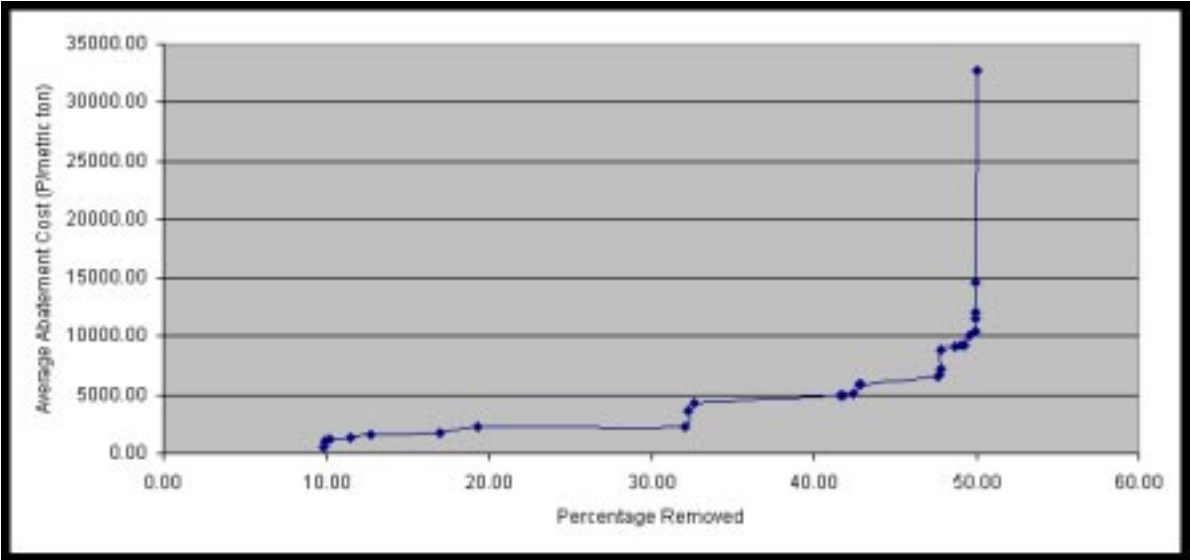


Figure 7b. Abatement cost for PM (50% removal efficiency)

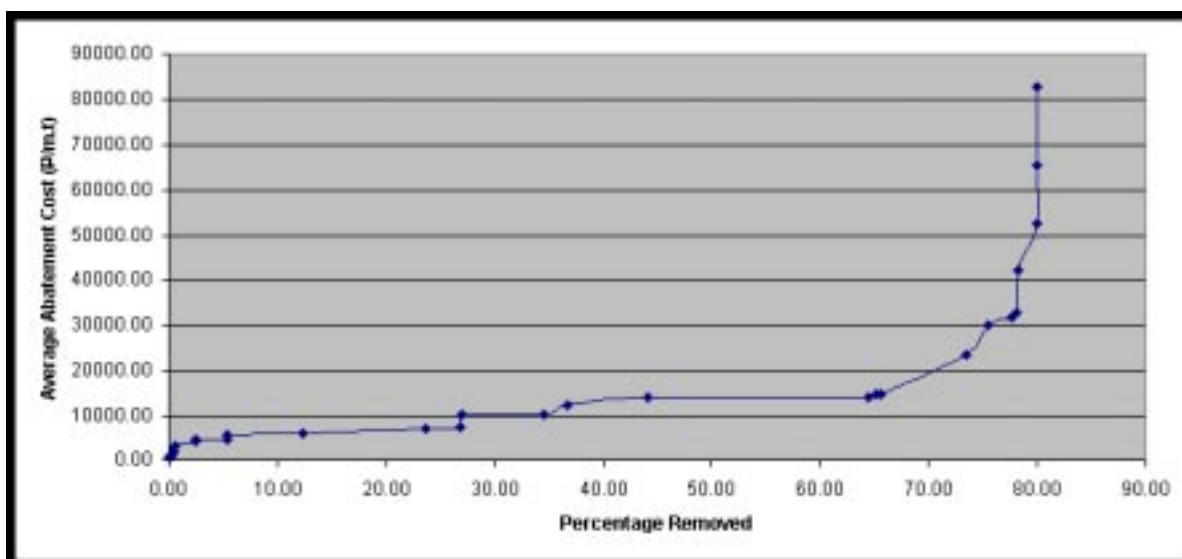


Figure 8a. Abatement cost for sulfur dioxide (80% removal efficiency)

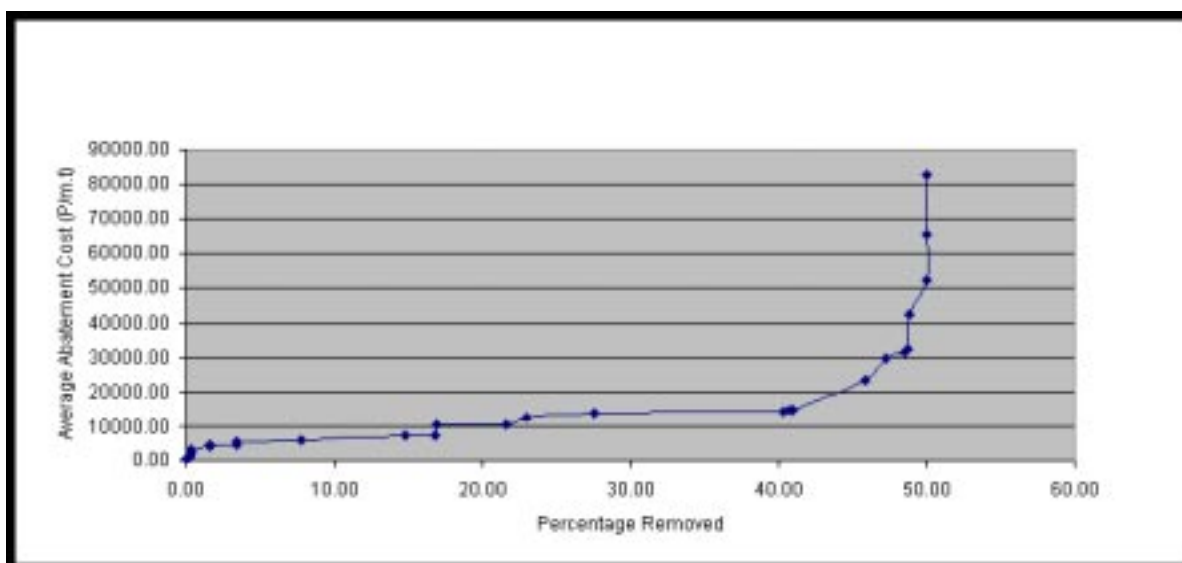


Figure 8b. Abatement cost for sulfur dioxide (50% removal efficiency)

The above analysis dealt with the manufacturing sector. As often mentioned, the power generation sector is a major contributor to the pollution problem in Metro Manila. The use of filters will reduce PM by more than 95% and will cost less than US centavos 0.1 per kWh of power generated or P1750.86/ton of PM.⁹ This is lower than the average abatement cost faced by the manufacturing sector since the multicyclones and the filters are part of the turbine designs which have to be maintained otherwise they will not function. So some of the control costs must have been incorporated in the operating expenses of the facility itself. Due to tall smokestacks that disperse emissions, power plants are not significant sources of ground level particle concentrations. But SO₂ control is more expensive. Flue gas desulfurization will cost P40,725/ton of SO₂ cleaned. Again the cheaper alternative is to switch to low sulfur fuels as shown in a previous table. Because power plants are charged a lower price when they purchase fuel, the switch will only cost an additional P136-272/ton of fuel used.

As power stations make more contributions to ambient air quality deterioration, they should be charged a different fee from that of the manufacturing sector. The PM and SO charges would depend on the cost of clean up aforementioned.

A two-tiered charge structure can be designed for Metro Manila. There can be separate charges for particulate matter and sulfur dioxide: at the same time there will be different charges for the power plants and the manufacturing sector. For the power generation sector, ₱1750.86/ton of PM emitted can be used as a baseline value. The amount to be charged initially for PM may be small but knowing that the emissions can be about four times the normal emissions if the multicyclones and filter bags are out of order, the cost to the power plant (and the potential revenue) then becomes substantial and provides the incentive to properly maintain their existing control facilities. Before setting a charge for SO₂ emissions we need to consider the options at hand (Table 19).

Table 19. Alternatives for controlling SO₂

A ₱40,725/ton of SO₂ emitted can be charged to power plants to force them to prioritize the acquisition of sulfur dioxide control equipment. Since the government owned NPC runs the power plants, it would appear that the monitoring and implementation of the law governing pollutive activities is compromised. The lack of ample electricity supplied means we can not afford to shut them down for a long time for rehabilitation; neither does the NPC have the funds to do so. Perhaps the moves to privatize NPC would be able to address the problem. To meet the standards, the power plants can use the 2% sulfur fuel. In Table 19, to achieve a 40% reduction would mean an additional ₱136-272/ton of fuel used, which translates to about ₱2347.36 to ₱4694.72 per ton of SO₂. There is a wide disparity in the options provided such that a more realistic level rests somewhere in between but if the intention is to influence the behavior of the players immediately then the upper bound seems appropriate at this point.

For the manufacturing sector, a simple simulation using the data provided earlier on the average abatement cost and emissions by each sector is presented. Let us assume that pollution control devices currently installed would only have a 50% removal capacity (Tables 20 and 21).

Table 20. PM charges assuming 50% reduction

Potential Charge (pesos per ton)	% Emission Abated	Remaining Emission (in tons)	Potential Revenue (in million pesos)
542.40	9.88%	9,856.27	5.35 M
176.80	17.00%	9,077.57	16.00 M
2332.32	32.12%	7,423.92	17.31 M

Note: The total emission amounts to 10,936.83 metric tons

Table 21. SO₂ charges assuming 50% reduction

Potential Charge (pesos per ton)	% Emission Abated	Remaining Emission (in tons)	Potential Revenue (in million pesos)
5,776.56	7.72	3,0857.05	178.25 M
7,037.64	14.77	2,8499.63	200.57 M

14,129.52	27.55	2,4226.19	342.30 M
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Note: The total emission amounts to 33,438.5 metric tons

It is evident that increasing the amounts of emissions abated will increase the cost of the exercise. If the PCDs are only capable of removing 50% of the emissions, to reduce PM emissions by 10% means that the firm can either pay the tax of P542 per ton emitted or undertake the clean-up on its own.

While the Philippines has minimal administrative experience and financial capacity, as seen from the experience on mining and forest charges, environmental taxes appear to be feasible. We can not say that this is the optimal solution considering the amount of literature spawned against emission charges. According to Tietenberg and Wheeler (1998) while the introduction of MBIs have added flexibility and improved cost effectiveness it has not solved all of the problems of pollution regulation. The lack of manpower and adequate budget made designing, implementing, monitoring and enforcing MBIs doubly hard. Still, compared with subsidies and emission standards, emission taxes have an added appeal of raising revenue while curbing pollution loads. With the exception of lump sum taxes, the conventional tax measures possess a distortionary cost in the form of induced changes in the taxpayers behavior. Environmental taxes possess an "efficiency value" if the said tax revenues would replace those obtained through distortionary means.¹⁰ There has been substantial interest in the potential of environmental taxes to reduce the costs involved in raising fiscal revenues. Unlike the typical taxes, environmental taxes correct economic distortions (i.e., the failure to price pollution in accordance to its social cost). Hence, we have the "double dividend" argument -- aside from the environmental benefits, the revenue gains will allow reduction on other taxes that may have distortionary effects on the labor supply, investment or consumption.

Economic instruments like the pollution tax intends to provide an incentive function in order to make the players choose the most appropriate measures based on their own assessed cost and benefit. This is going to be difficult to achieve in the short run as the introduction of the new tax measures will have economic and political repercussions. To facilitate the transition, the revenue obtained from the proposed emission charge can be used for the following purposes: a) improve monitoring and enforcement; b) clean up the environment; c) invest in research and development; and d) subsidize the acquisition of pollution control devices. The choice of subsidy as the top MBI for the business sector may help in forging cooperation and bankroll the initial stages of the cost of abatement. Note that this does not mean that we should provide artificial support to obsolete plants. Lovei (1995) discusses the role of effluent charges in providing pollution abatement funds in Central and Eastern Europe. This can also be done in the Philippines.

The experience of OECD countries attests to the fact that MBIs need to be used with regulations to be effective. Institutions like the community may be tapped to strengthen the incentive mechanism particularly in Asian settings where the concept of "hiya" (shame) is strong. Dasgupta, Laplante and Mamingi (1997) looked at the stock market reactions to environmental news in Argentina, Chile, Mexico and the Philippines and noted the following: 1) stock values rise when good environmental performance is publicly recognized by the government; and 2) stock values fall in response to publicized citizens' complaints about the polluters. Still, the use of the capital market as a reinforcing mechanism tends to be constrained to the extent of its development and if pollution-ridden industries are listed in the market. Also, since majority of the consumers belong to the lower income brackets, their primary consideration remains to be the level of prices.

One needs to clarify the role of the MBI in the scheme of things -- as a revenue raising device and/or an incentive mechanism. As the rate of charges rise, the government's revenue increases but this is checked by a decline in the pollution discharges by firms. The more inelastic the abatement cost function, the bigger the potential revenue; but as the tax burden grows the greater the incentive for the firm to abate. One must also consider the cost recovery principle in the design of the tax. Manasan (1994) noted that the contribution of user charges in total national government revenues declined from 15.3% in 1976 to 5.8% in 1992. This has been attributed to the government's failure to adjust user charges to reflect changes in the cost of producing goods and services. For the proposed emissions charge, it should be adjusted for inflation.

To sum up the proposed emissions tax has the following structure:

- For the manufacturing sector, charge P4,500/ton of PM emitted in excess of the allowable amount; P14,200/ ton of sulfur dioxide emitted.
- For the power generating plants, P1,750.86/ton of PM and P40,725/ton of SO₂.
- Allow for adjustments in inflation to maintain the deterrent impact of the charges.
- The tax and its related components should be evaluated regularly to check for efficacy and relevance. The uniform charge initially set may evolve into a system where beyond a certain range of emissions being taxed, a higher rate can be imposed to excessive emissions. In this way, the industries will be forced to limit emission to the bare minimum.

8.0 ENVIRONMENTAL TAXES: ISSUES AND CONCERNS

Drawing down from the extensive experience of the OECD countries which pioneered the use of MBIs are some lessons that are relevant to developing countries (See OECD, 1996 and 1997; O'Connor, 1996). Product charges are the most common followed by emission charges. Examples of charges and taxes currently in effect are:

- Water pollution charges in France, Germany and the Netherlands
- Nitrogen oxides charge in Sweden
- Sulfur tax in Sweden
- Carbon taxes in Finland, Sweden, Denmark, the Netherlands

In designing a pollution tax, certain conditions have to be met. An "ideal" tax should be able to answer all of the following in the affirmative:

- **Effectiveness:** Is the tax or instrument able to succeed in reducing the pollution?
- **Efficiency:** Is the instrument able to cost-savings or minimize abatement costs across polluters?
- **Administration:** Is the cost involved in administering the instrument reasonable?
- **Dynamic Effects and Innovation:** Is the instrument able to bring about innovation in pollution technology?
- **Behavioral Effects:** Is there a change in attitude, awareness and capacity building due to the instrument?
- **Revenue Generation:** Is the instrument able to reduce other forms of taxes or will there be increased spending for environmental protection?

It seems that the Philippines is headed towards emission charges to further environmental cause (ADB, 1997 and Clean Air Act). The efficiency case for environmental taxes as redefined in the standards and charges approach do contribute in achieving predetermined policy goals but as the cliché goes, it's no panacea.

A pollution tax is not confined to emission charges. It could take the form of an input or a fuel tax to account for the differential effects of different types of fuel (e.g., Sweden's diesel tax). In the Philippines, industries generally use BOF for firing their equipment. The maximum allowable sulfur content of residual fuel is 3%. While this is already lower than what was used earlier during the decade, it still is potentially hazardous to health. As such we can also adopt a fuel tax. An input tax has the advantage of being easier to put into action as there is automatic collection of revenues from the sales of the fuel.

Despite the absence of any formal position on the part of the Department of Energy, it seems logical that a fuel tax would be unpopular considering that prices of fuel in the country is already among the highest in the region, second only to Japan. The deregulation of the oil industry did not bring about the expected price drops. Moreover, such a tax, imposed early in the production chain faces the danger of including in its tax base those activities that do not damage the environment. As pointed out in OECD (1996) in such instances, a rebate system has to work in tandem with the tax

(and that will increase administrative cost) so as not to penalize those who practice environmentally friendly processes.

All emission related problems should be included in the tax base. The base would differ if the pollution arises from production or consumption. In the manufacturing sector, they are part of the base albeit, can be at either poles. Also, the number of polluters and whether the source of pollution is scattered or point-source will determine the optimal point of tax imposition.

The tax should reflect market prices. Policy makers should have information regarding the cost functions of polluters in different areas. We have to reiterate that for firms facing huge abatement costs, it might be advantageous just to pay the tax instead of coming down on emissions. How large is the tax going to be in order to achieve the necessary reduction? The tax should be adjustable given certain changes in conditions. Otherwise, inflation may erode its incentive effect. The P50, 000 per day fine in the Philippines has to be revised. There are a lot of materials dealing with the EMB and DENR's limited capacity to regulate and administer the country's environmental laws. The fine would appear to be minimal especially with the lax monitoring: you only pay if you get caught.

The choice between an emission and a product tax will also depend on the cost and ease of monitoring. It is easier to implement an emissions charge if there are few, large, stationary sources. For diffuse and numerous sources, product taxes would be more appropriate. Pollution taxes should be imposed as close as possible to the point of emission to minimize collection points. The major concern at the moment would be how ready is the DENR/EMB to implement an emissions charge. Considering that there are only a handful of sectors responsible for over 70% of pollution in Metro Manila, yet DENR/EMB are hampered by limited resources and institutional limitations.

While conducting the study, it became apparent that anchoring a tax solely on particulates is not advisable. As mentioned earlier, most of the PCDs used are geared towards PM control. There are other pollutants being spewed out in larger quantities and therefore, require greater control. On the contrary SO_x and NO_x emissions tend to be concentrated on a handful of polluting units, hence, they may be appropriate tax avenues. If a tax on all the pollutants be devised, how should the weights be assigned? Do we need to have graduated or differential taxes wherein larger quantities emitted would be slapped higher fees? In designing appropriate environmental taxes, the end goal should be the change in behavior of players. Environmental taxes should not be viewed as substitutes for the other taxes because like any ordinary tax they have short and long term behavioral effects. Revenue from environmental taxes should serve the environment and should be earmarked accordingly. Previous experience in the country, as in the case of forest charges, showed how the revenues got lost in the government coffers. As incidence of pollution drops we can expect revenue from environmental taxes to drop and policy makers should view that as a move towards the right direction.

In view of the above, if the emissions charge is put in place there is a need to:

- a. Improve collection and information dissemination (information on prices, technologies, environmental conditions and objectives);
- b. Strengthen the institutional and technical capacity of the line agencies tasked with administering environmental regulations;
- c. Review existing fine and penalty schemes to account for present conditions;
- d. Simplify policies and synchronize policies to avoid working at cross purposes; and
- e. Conduct a review of economic policies that have a substantial impact on the environment.

¹ The Clean Air Act calls for at least 10% adjustment every three years for the fines to maintain their deterrent function. [Back](#)

² The PPP can be interpreted in two ways: (a) as requiring the polluters to pay only the cost of pollution control & prevention; or (b) interpretation (a) plus compensating the people for damages they suffer from pollution. This study uses the narrow PPP interpretation. [Back](#)

³ Ayala (1993) used the following assumptions for the emissions inventory: 1) application of the US-EPA emission factors. Adjustments were made to account for the presence/absence of control devices, efficiency of control, fuel composition; 2) rated capacity of the facility is equated into its equivalent fuel consumption and process rates for fuel burning sources and process operations; 3) effective operating period of the facility is set at 12 hr/day with 200 days/year; 4) composite efficiency of the control device for PM is 50% while

the composite efficiency of the control device for the reduction of gaseous pollutants like SO_x is negligible; 5) power interruption period is equivalent to 10% of the effective operating period; and 6) short ton (2,000 lb/ton) is used as conversion factor. [Back](#)

⁴ These are also taken from the 1990 Metro Manila emissions inventory which are basically from the US-EPA and WHO Rapid Assessment Methodologies. [Back](#)

⁵ The recent Clean Air Act upped the fine to a maximum of P100,000 per day but some environmental planners think this is still low. [Back](#)

⁶ The use of lighter types of fuel oils (grades 5 and 4) will lead to even greater reduction in SO₂ emissions but they are more expensive. [Back](#)

⁷ They estimated that in 1995 the fuel consumption in power plants was about 1.4 million tons and that purchase of oil with a sulfur content of 2% instead of 3% would cost an additional US\$10 million. [Back](#)

⁸ Estimate was obtained in consultation with EMB and DENR personnel and concurred upon by a pollution device service provider. [Back](#)

⁹ Based on World Bank (1993) estimates for a coal-fired facility. This should be considered an upper estimate since the cost of pollution control for a coal-fired facility is higher. [Back](#)

¹⁰ Terkla (1984) defines efficiency value as the reduction in excess burden resulting from the substitution of these revenues for current and future resource distorting tax revenues. [Back](#)

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Appendices

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Appendices

Appendix Table 1. Power generating plants in Metro Manila, gross generation, 1990-1995, (in megawatthours)

Power Plant	1990	1991	1992	1993	1994	1995
Sucat (barge)	0.00	0.00	0.00	139,700.00	28,130.00	15,140.00
Sucat 1,2,3 & 4	2,772,220.00	4,580,890.00	4,519,570.00	2,889,910.00	3,209,490.00	3,216,760.00
Manila 1	663,670.00	728,830.00	661,410.00	639,780.00	565,010.00	502,680.00
Manila 2	714,210.00	631,990.00	683,080.00	723,450.00	661,720.00	418,880.00
Navotas (barge 203 & 204)	0.00	275,360.00	297,310.00	264,200.00	416,910.00	146,170.00
Total	4,150,100.00	6,217,070.00	6,161,370.00	4,657,040.00	4,881,260.00	4,299,630.00

Source of Basic Data: National Power Corporation, Sucat Power Plant

Appendix Table 2. Power generating plants in Metro Manila, estimated fuel consumption, 1990-1995, (in metric tons)

Power Plant	1990	1991	1992	1993	1994	1995
Sucat (barge)	0.00	0.00	0.00	34,759.89	6,999.25	3,767.11
Sucat 1,2,3 & 4	689,778.55	1,139,808.41	1,124,550.88	719,061.96	798,579.25	800,388.16
Manila 1	165,133.12	181,346.11	164,570.79	159,188.85	140,584.72	125,075.89
Manila 2	177,708.39	157,250.56	169,962.68	180,007.46	164,647.92	104,224.93
Navotas (barge 203 & 204)	0.00	68,514.56	73,976.11	65,737.75	103,734.76	36,369.74
Total	1,032,620.05	1,546,919.63	1,533,060.46	1,158,755.91	1,214,545.91	1,069,825.83

Notes:

1. Based on the fuel requirement per megawatthour of the Sucat Power Plant
2. Fuel requirement per MWH generated = 0.248818 ton of BOF

Appendix Table 3. Power generating plants in Metro Manila, estimated nominal fuel requirement, 1990-1995, (in metric tons)

Power Plant	Capacity (MW)	1990	1991	1992	1993	1994	1995
Sucat (barge)	30	0.00	0.00	0.00	57,327.69	57,327.69	57,327.69
Sucat 1,2,3 & 4	850	1,624,284.65	1,624,284.65	1,624,284.65	1,624,284.65	1,624,284.65	1,624,284.65
Manila 1	100	191,092.31	191,092.31	191,092.31	191,092.31	191,092.31	191,092.31
Manila 2	100	191,092.31	191,092.31	191,092.31	191,092.31	191,092.31	191,092.31
Navotas (barges 203 & 204)	60	114,655.39	114,655.39	114,655.39	114,655.39	114,655.39	114,655.39
Total	1,140	2,121,124.66	2,121,124.66	2,121,124.66	2,178,452.35	2,178,452.35	2,178,452.35

Source of basic data: National Power Corporation; Libongco, Ramos and Santos (1997)

Notes:

1. Estimates are based on the plant capacity and the capacity factor of 80%.
2. Power plants undergo rehabilitation and maintenance checks for an average of 45 days per year.

Appendix Table 4. Estimated NOx emissions from BOF-fired power plants in Metro Manila, 1990-1995, (in metric tons)

Year	Gross Energy Generation (in MWH)	Total Fuel Consumption (in m. tons)	Estimated Nominal Fuel Requirement (in m. tons)	Total Operating Hours	Actual Rate of Fuel Consumption (in kg/hr)	Nominal Fuel Consumption Rate (in kg/hr)	Load Factor (L)
1990	4,150.10	1,032,620.00	2,121,124.66	7,680	134,455.73	276,188.11	0.486826644
1991	6,217.07	1,546,920.00	2,121,124.66	7,680	201,421.88	276,188.11	0.729292356
1992	6,161.37	1,533,060.00	2,121,124.66	7,680	199,617.19	276,188.11	0.722758086
1993	4,657.04	1,158,760.00	2,178,452.35	7,680	150,880.21	283,652.65	0.531918910
1994	4,881.26	1,214,550.00	2,178,452.35	7,680	158,144.53	283,652.65	0.557528835
1995	4,299.63	1,069,830.00	2,178,452.35	7,680	139,300.78	283,652.65	0.491096351
Average 1990-1995	5,061.08	1,259,290.00	2,149,788.51		163,970.05	279,920.38	0.590000000

Source of basic data: National Power Corporation; Handbook of Emission Factors (Part 3), the Netherlands

Notes:

1. Power plants, on the average, only operate for 320 days per year; 45 days are allocated for check-up and maintenance purposes.
2. The rate of fuel consumption = Total fuel consumption/Total operating hours.
3. Load factor (L) = Actual rate of fuel consumption/Nominal consumption rate.
4. Load (N) = HC (net heat of combustion) * Actual rate of fuel consumption. For residual oil, HC = 41 MJ/kg.
5. The emission factor for residual oil-fired power plants is 230 g/GJ. This subject to load correction.
6. For liquid fuels, the load correction factor (fL) = 1 - 0.45 (1-L)
7. Adjusted emission factor = Emission factor * Load correction factor
8. Average emission rate = (Adjusted emission factor * Load)/1000
9. Total emissions = (Average emission rate * Operating hours)/1000

Appendix Table 5. Estimated PM emissions from BOF-fired power plants in Metro Manila, 1990-1995, (in metric tons)

Year	Load (in GJ/hr)	Total Operating Hours	Emission Factor (in g/GJ)	PM Correction Factor	Adjusted Emission Factor (in g/GJ)	Emission Rate (in kg/hr)	Total Emissions (in metric tons)
1990	5,512.68	7,680	20	0.76	15.2	83.792736	643.5282125
1991	8,258.30	7,680	20	0.76	15.2	125.526160	964.0409088
1992	8,184.30	7,680	20	0.76	15.2	124.401360	955.4024448
1993	6,186.30	7,680	20	0.76	15.2	94.031760	722.1639168
1994	6,483.92	7,680	20	0.76	15.2	98.555584	756.9068851
1995	5,711.33	7,680	20	0.76	15.2	86.812216	666.7178189
Average 1990-1995	6,722.81					102.190000	784.7900000

Notes:

1. The PM emission factor and correction factor for residual fuel are from the Handbook of Emission Factors (Part 3).
2. The adjusted emission factor = EF * Correction factor
3. Emission rate = Load * Adjusted EF
4. Annual emission = (Emission rate * Total operating hours)/1000

Appendix Table 6. Estimated SO₂ emissions from BOF-fired power plants in Metro Manila, 1990-1995, (in metric tons)

Year	Gross Energy Generation (in MWH)	Load (in GJ/hr)	Emission Factor (in g/GJ)	Emission Rate (in kg/hr)	Total Emissions (in m. tons)
1990	4,150.10	5,512.68	1,571	8,660.42	66,512.03
1991	6,217.07	8,258.30	1,571	12,973.79	99,638.70
1992	6,161.37	8,184.30	1,571	12,857.54	98,745.87
1993	4,657.04	6,186.30	1,571	9,718.68	74,639.44
1994	4,881.26	6,483.92	1,571	10,186.24	78,230.31
1995	4,299.63	5,711.33	1,571	8,972.50	68,908.80
Average 1990-1995	5,061.08	6,722.81		10,561.53	81,112.52

Notes:

1. EF for SO₂ = [(2,000x)*(1-y)]/HC
 x = sulfur content (%) of BOF = 35g/kg of BOF
 y = mass fraction of sulfur retained in ash = 0.08
 Hc = net heat of combustion = 41 MJ/kg of BOF
2. Load = Actual fuel consumption * Hc
3. Emission rate = EF * Load

Appendix Table 7. Estimated CO and CO₂ emissions from BOF-fired power plants in Metro Manila, 1990-1995, (in metric tons)

Year	Load (in GJ/hr)	CO Emission Factor (in g/GJ)	CO Emission Rate (in kg/hr)	Total CO Emissions (in metric tons)	CO2 Emission Factor (in g/GJ)	CO2 Emission Rate (in kg/hr)	Total CO ₂ Emissions (in metric tons)
1990	5,512.68	15	82.6902	635.060736	78,100	49,598.24	380,914.51
1991	8,258.30	15	123.8745	951.356160	78,100	74,300.92	570,631.04
1992	8,184.30	15	122.7645	942.831360	78,100	73,635.13	565,517.79
1993	6,186.30	15	92.7945	712.661760	78,100	55,658.88	427,460.22
1994	6,483.92	15	97.2588	746.947584	78,100	58,336.61	448,025.14
1995	5,711.33	15	85.6699	657.945216	78,100	51,385.52	394,640.80
Average 1990-1995	6,722.81		100.8400	774.470000		60,485.88	464,531.58

Source: OECD (1994)

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Table 7. Emissions from the industrial sector, Metro Manila, 1990

Industry	TOG	CO	NOx	Sox	PM	PM10
food & kindred products	334.09	61.93	397.12	1,121.14	340.81	211.30
tobacco	1.61	4.47	36.17	93.64	8.79	6.15
textile mills products	32.81	297.21	1,205.14	6,729.46	172.28	120.60
lumber & wood products	45.38	129.65	484.55	90.38	831.65	332.66
paper & allied products	618.41	1,766.48	1,262.16	158.76	1,596.40	1,117.48
printing & publishing	0.20	0.02	0.07	0.01	0.01	-
chemical & allied products	90.41	14.96	145.09	4,113.13	37.07	21.60
petroleum & coal products	3.91	8.86	14.66	62.23	832.30	499.38
rubber & misc. plastic products	32.64	9.19	97.72	278.70	21.53	15.11
stone, clay & glass products	220.54	20.48	475.32	360.30	102.93	92.64
primary metal industries	264.17	553.78	39.78	133.28	65.94	46.15
fabricated metal products	14.96	470.55	10.92	34.42	447.09	312.96
machinery except electrical	1.68	-	-	-	-	-
electrical & electronic equipment	27.16	20.44	91.38	185.88	7.71	6.71
transportation equipment	24.31	0.08	0.36	0.02	0.04	0.03
misc. mfg. industries	0.01	0.11	1.17	3.37	0.26	0.18
electric, gas & sanitary services	102.58	683.84	9,117.82	68,331.23	4,849.54	4,704.05
gen. merchandise stores	0.05	0.15	0.70	0.05	0.05	0.04
hotels & other lodging places	0.38	2.55	22.62	54.43	4.37	3.80
personal services	0.06	1.00	9.76	31.52	2.04	1.78
health services	0.38	0.63	5.98	13.68	1.95	1.70
Total	1,815.73	4,046.36	13,418.48	78,093.63	9,322.81	7,494.32

Source: Ayala, 1993

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Table 9. Estimated uncontrolled emissions: processing and fuel combustion bunker fuel oil, Metro Manila, 1997 (in metric tons)

ISIC3	Industry	Fuel Cons (1000 lit.)	PM	PM10	SOx	NOx	VOC	CO
311-312	Food products	78,370	681.40	610.89	5,184.06	528.62	2.89	49.84
321	Textiles	56,348	489.93	439.23	3,727.34	380.08	2.08	35.84
341	Paper and products	24,173	210.18	188.43	1,599.01	163.05	0.89	15.37
351	Industrial chemicals	11,675	101.51	91.01	772.28	78.75	0.43	7.43
352	Other chemicals	10,332	89.83	80.54	683.45	69.69	0.38	6.57
371	Iron and steel	45,784	398.08	356.88	3,028.54	308.82	1.69	29.12
	TOTAL	226,682	1,970.92	1,766.97	14,994.67	1,529.02	8.36	144.17

Source of basic data: Department of Energy, ENRAP (1997)

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Table 10. Estimated controlled emissions: processing and fuel combustion Bunker Fuel Oil, Metro Manila, 1997 (in metric tons)

ISIC3	Industry	Fuel Cons (1,000 lit.)	PM	PM10	SOx	NOx	VOC	CO
311-312	Food products	78,370	233.02	221.90	3,243.11	341.38	1.76	31.03
321	Textiles	56,348	167.54	159.54	2,331.79	245.45	1.26	22.31
341	Paper and products	24,173	71.87	68.44	1,000.33	105.30	0.54	9.57
351	Industrial chemicals	11,675	34.71	33.06	483.13	50.86	0.26	4.62
352	Other chemicals	10,332	30.72	29.25	427.56	45.01	0.23	4.09
371	Iron and steel	45,784	136.13	129.63	1,894.63	199.44	1.03	18.13
	TOTAL	226,682	673.99	641.83	9,380.55	987.43	5.09	89.77

Note:

1. Controlled emissions are estimated based on the assumption that only 32% of the major establishments in Metro Manila have the required PCDs.
2. The existing PCDs are only 50% efficient.

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Table 11. Estimated emission loads, manufacturing sector (employment-based) Metro Manila, 1994 (in metric tons)

ISIC	ISIC3DES	NO ₂	PM ₁₀	SO ₂	CO	PT	VOC
311-312	Food products	6,129.35	2,863.18	6,114.89	1,667.29	5,604.75	1,592.75
313	Beverages	1,734.52	38.34	2,724.22	143.06	177.16	2,944.55
314	Tobacco	1,438.21	18.66	2,376.54	187.34	44.39	472.70
321	Textiles	2,425.11	49.12	1,846.22	340.39	387.20	1,110.16
322	Wearing apparel, except footwear	28.00	0.70	74.38	7.85	3.48	18.57
323	Leather products	23.62	2.45	93.79	6.89	52.26	154.18
324	footwear, except rubber or plastic	0.47	0.00	4.03	0.00	0.24	34.53
331	Wood products, except furniture	394.69	39.05	204.15	987.03	574.65	475.46
332	Furniture, except metal	37.67	35.16	53.32	39.98	120.02	1,209.76
341	Paper and products	5,188.02	529.07	9,422.71	10,682.34	1,837.21	1,717.06
342	Printing and publishing	26.52	0.27	20.40	102.11	10.96	680.41
351	Industrial chemicals	6,971.26	173.92	6,313.69	3,373.45	1,010.05	5,296.53
352	Other chemicals	2,538.79	1,324.00	6,544.30	46,274.29	2,097.46	4,956.68
353	Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00
354	Miscellaneous petroleum and coal products	905.56	44.68	1,455.48	685.57	558.28	227.35
355	Rubber products	613.00	25.64	1,770.15	75.39	196.41	1,905.43
356	Plastic products	11.79	11.31	54.17	3.87	16.53	653.74
361	Pottery, China earthenware	22.95	0.00	45.77	15.92	54.00	178.31
362	Glass and products	1,264.10	26.79	635.29	340.50	253.61	162.16
369	Other non-metallic products	3,296.20	4,705.87	5,831.81	612.72	4,324.23	170.55
371	Iron and steel	7,406.89	4,712.85	17,051.72	26,572.73	3,950.82	2,282.58
372	Non-ferrous metals	54.85	15.47	1,684.09	783.40	141.44	61.27
381	Fabricated metal products	449.94	5.83	133.18	896.42	72.54	1,090.08
382	Machinery, except electrical	132.72	0.97	295.45	319.51	43.71	335.93
383	Machinery electric	873.85	10.85	1,777.48	977.12	191.39	1,189.35
384	Transport equipment	163.32	24.81	314.30	221.03	129.81	1,173.71
385	Professional & scientific equipment	0.66	0.00	0.39	0.07	0.12	0.93
390	Other manufactured products	25.88	7.51	36.44	8.46	20.92	243.33
	Total	42,157.94	14,666.48	66,878.37	95,324.72	21,873.67	30,338.07

Source of basic data: NSO; Hettige, Martin, Singh and Wheeler (1995)

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Table 13. Cost of controlling emissions from stationary sources (in P1992/mt)

Pollutant	Abatement Technology	Removal Efficiency (%)	Actual Abatement Cost
PM	Electrostatic Precipitator (ESP)	97 - 99.0	370 - 1,590
	High efficiency ESP	99 - 99.9	490 - 2,200
	Baghouse filter	99 - 99.9	370 - 1,590
	Mechanical collector	50 - 90.0	250 - 1,710
SO ₂	<i>Pre-combustion Control</i>		
	coal-cleaning - conventional	5 - 40	
	- advanced	> 90	
	<i>Combustion Control</i>		
	Sorbent injection	30 - 60	
	Sorbent injection hybrid system	60 - 95	9,760 - 85,400
	<i>Post-combustion Control</i>		
	Semi-dry Flue Gas	65 - 95	14,640 - 97,600
	Desulfurization (FGD)		
	wet FGD	70 - 95	19,250 - 122,000
	wet scrubber	90	4,131
NO _x	<i>Combustion Control</i>		
	low-NO _x burners (LNB)	50 - 60	18,300 - 170,800
	off-stoichiometric combustion (OSB)	< 30	
	flue gas recirculation	45 (for oil)	
		50 -70 (gas)	
	<i>Post-combustion Control</i>		
	Selective catalytic reduction (SCR)		3,308,635 - 29,777,705
	Selective non-catalytic reduction		
Combined SO ₂ and NO _x	Limestone injection	50-60 (NO _x)	
	Multi-stage burners (LIMB)	50 (SO ₂)	
	Regenerable FGD/SCR	>90 (SO ₂)	
	Systems: activated carbon	60-80 (NO _x)	

Source: ADB (1997)

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Table 14. Average abatement cost by sector, 1979-1985 (in P1993/mt)

ISIC	Industry	Particulates	Sulfur Oxides	NO2, CO2	Hydrocarbons	Lead	Hazardous Emissions	Others
3110	Food	2,332.32	14,129.52	6,210.48	4,393.44	1,264,117.44	1,491.60	1,491.60
3130	Beverages	4,230.72	7,349.52	323,216.16	323,216.16	2,061.12	2,061.12	2,061.12
3140	Tobacco	7,268.16	4,529.04	4,529.04	326,253.60	3,471.36	3,471.36	4,529.04
3210	Textiles	10,739.52	10,739.52	37,398.48	37,398.48	32,299.92	32,299.92	32,299.92
3211	Spinning	7,376.64	14,509.20	38,808.72	5,098.56	21,180.72	5,098.56	5,098.56
3220	Apparel	12,068.40	1,654.32	1,654.32	1,654.32	1,654.32	1,654.32	1,654.32
3230	Leather	3,579.84	10,224.24	228,621.60	17,166.96	3,579.84	8,786.88	11,580.24
3240	Footwear	14,644.80	5,613.84	26,930.16	42,252.96	600,463.92	32,462.64	24,435.12
3310	Wood	1,274.64	1,030.56	1,030.56	1,030.56	1,030.56		

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Table 16. Suitability ratings of selected MBIs in the Philippines

Industry	Pollution/ Effluent Charge	Financial Incentive/ Subsidy	User Fee on Key Inputs	Risk and Liability System	Creating Markets for Waste	Refund- Deposit System	Industry Rating for all MBIs
Pig farm	1.2	2.0	1.7	0.7	2.2	1.0	1.47
Electroplating	1.7	2.7	1.5	0.8	2.7	0.5	1.65
Coconut oil	1.8	2.7	2.3	1.0	2.5	--	1.72
Fish canning	2.3	2.2	2.3	2.7	2.8	--	2.05
Semi-conductors	1.7	1.8	2.3	2.0	2.8	1.0	1.90
Sugar milling	2.5	2.8	2.8	1.8	2.2	--	2.02
Tannery	1.3	2.7	1.2	1.0	2.8	--	1.50
Textiles	2.0	1.7	2.0	1.2	1.0	0.8	1.45
Pulp and paper	1.8	1.8	1.8	1.5	1.8	1.0	1.62
Cement	1.7	2.0	1.8	2.5	1.2	--	1.53
MBI rating for all ten industries	1.8	2.2	2.0	1.5	2.2	0.4	

Source: IEMP

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Table 17a. Cost-effective regulatory strategy for particulate matter

ISIC	Industry	Particulates (in metric tons)	% share to total emission	Cum. Emission (in %)	Uniform 80% Reduction	Remaining Emission	% share in the reduction	Cum. Reduction (in %)	Abatement Cost (P/ton)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
3690	Non-metal products, n.e.c.	4,324.23	19.77	19.77	3,459.39	864.85	15.82	15.82	542.40
3900	Other industries	20.92	0.10	19.86	16.74	4.18	0.08	15.89	1,030.56
3320	Furniture	120.02	0.55	20.41	96.02	24.00	0.44	16.33	1,166.16
3310	Wood	574.65	2.63	23.04	459.72	114.93	2.10	18.43	1,274.64
3540	Petroleum, coal	558.28	2.55	25.59	446.63	111.66	2.04	20.47	1,600.08
3410	Pulp and paper products	1,837.21	8.40	33.99	1,469.77	367.44	6.72	27.19	1,762.80
3510	Industrial chemicals (incl. agri chem)	1,010.05	4.62	38.61	808.04	202.01	3.69	30.89	2,305.20
3110	Food	5,604.75	25.62	64.23	4,483.80	1,120.95	20.50	51.39	2,332.32
3230	Leather	52.26	0.24	64.47	41.80	10.45	0.19	51.58	3,579.84
3130	Beverages	177.16	0.81	65.28	141.73	35.43	0.65	52.23	4,230.72
3710	Iron, steel	3,950.82	18.06	83.34	3,160.66	790.16	14.45	66.68	4,935.84
3610	Pottery	54.00	0.25	83.59	43.20	10.80	0.20	66.87	5,017.20
3620	Glass	253.61	1.16	84.75	202.89	50.72	0.93	67.80	5,044.32
3550	Rubber	196.41	0.90	85.65	157.13	39.28	0.72	68.52	5,939.28
3560	Plastics	16.53	0.08	85.72	13.22	3.31	0.06	68.58	5,939.28
3520	Chemical products (including drugs)	2,097.46	9.59	95.31	1,677.97	419.49	7.67	76.25	6,522.36
3820	Machinery except electrical	43.71	0.20	95.51	34.97	8.74	0.16	76.41	6,766.44
3140	Tobacco	44.39	0.20	95.72	35.51	8.88	0.16	76.57	7,268.16
3530	Refineries	0.00	0.00	95.72	0.00	0.00	0.00	76.57	8,895.36
3210	Textiles (including spinning)	387.20	1.77	97.49	309.76	77.44	1.42	77.99	9,058.08
3720	Non-ferrous metals	141.44	0.65	98.13	113.15	28.29	0.52	78.51	9,220.80
3810	Metal products	72.54	0.33	98.46	58.03	14.51	0.27	78.77	9,302.16
3840	Transport equipment	129.81	0.59	99.06	103.84	25.96	0.47	79.25	10,034.40
3830	Electrical machinery	191.39	0.87	99.93	153.11	38.28	0.70	79.95	10,400.52
3420	Printing	10.96	0.05	99.98	8.77	2.19	0.04	79.99	11,498.88
3220	Apparel	3.48	0.02	100.00	2.78	0.70	0.01	80.00	12,068.40
3240	Footwear	0.24	0.00	100.00	0.19	0.05	0.00	80.00	14,644.80
3850	Professional goods	0.12	0.00	100.00	0.10	0.02	0.00	80.00	32,760.96
		Total 2,1873.67	100.00		Total 17,498.93	Total 4,374.73	80.00		Average 6,969.36

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Table 17b. Cost-effective regulatory strategy for particulate matter

ISIC	Industry	Particulates (in metric tons)	% share to total emission	Cum. Emission (in %)	Uniform 50% Reduction	Remaining Emission	% share in the reduction	Cum. Reduction (in %)	Abatement Cost (P/ton)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
3690	Non-metal products, n.e.c.	4,324.23	19.77	19.77	2,162.12	2,162.12	9.88	9.88	542.40
3900	Other industries	20.92	0.10	19.86	10.46	10.46	0.05	9.93	1,030.56
3320	Furniture	120.02	0.55	20.41	60.01	60.01	0.27	10.21	1,166.16
3310	Wood	574.65	2.63	23.04	287.33	287.33	1.31	11.52	1,274.64
3540	Petroleum, coal	558.28	2.55	25.59	279.14	279.14	1.28	12.80	1,600.08
3410	Pulp and paper products	1,837.21	8.40	33.99	918.61	918.61	4.20	17.00	1,762.80
3510	Industrial chemicals (incl. agri chem)	1,010.05	4.62	38.61	505.03	505.03	2.31	19.30	2,305.20
3110	Food	5,604.75	25.62	64.23	2,802.38	2,802.38	12.81	32.12	2,332.32
3230	Leather	52.26	0.24	64.47	26.13	26.13	0.12	32.24	3,579.84
3130	Beverages	177.16	0.81	65.28	88.58	88.58	0.40	32.64	4,230.72
3710	Iron, steel	3,950.82	18.06	83.34	1,975.41	1,975.41	9.03	41.67	4,935.84
3610	Pottery	54.00	0.25	83.59	27.00	27.00	0.12	41.80	5,017.20
3620	Glass	253.61	1.16	84.75	126.81	126.81	0.58	42.38	5,044.32
3550	Rubber	196.41	0.90	85.65	98.21	98.21	0.45	42.82	5,939.28
3560	Plastics	16.53	0.08	85.72	8.26	8.26	0.04	42.86	5,939.28
3520	Chemical products (including drugs)	2,097.46	9.59	95.31	1,048.73	1,048.73	4.79	47.66	6,522.36
3820	Machinery except electrical	43.71	0.20	95.51	21.86	21.86	0.10	47.76	6,766.44
3140	Tobacco	44.39	0.20	95.72	22.19	22.19	0.10	47.86	7,268.16
3530	Refineries	0.00	0.00	95.72	0.00	0.00	0.00	47.86	8,895.36
3210	Textiles (including spinning)	387.20	1.77	97.49	193.60	193.60	0.89	48.74	9,058.08
3720	Non-ferrous metals	141.44	0.65	98.13	70.72	70.72	0.32	49.07	9,220.80
3810	Metal products	72.54	0.33	98.46	36.27	36.27	0.17	49.23	9,302.16
3840	Transport equipment	129.81	0.59	99.06	64.90	64.90	0.30	49.53	10,034.40
3830	Electrical machinery	191.39	0.87	99.93	95.69	95.69	0.44	49.97	10,400.52
3420	Printing	10.96	0.05	99.98	5.48	5.48	0.03	49.99	11,498.88
3220	Apparel	3.48	0.02	100.00	1.74	1.74	0.01	50.00	12,068.40
3240	Footwear	0.24	0.00	100.00	0.12	0.12	0.00	50.00	14,644.80
3850	Professional goods	0.12	0.00	100.00	0.06	0.06	0.00	50.00	32,760.96

	Total		Total	Total		Average
	2,1873.67	100.00	10,936.83	10,936.83	50.00	6,969.36

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Table 18a. Cost-effective regulatory strategy for sulfur dioxide

ISIC	Industry	Sulfur Dioxide (in metric tons)	% share to total emission	Cum. Emission (in %)	Uniform 80% Reduction	Remaining Emission	% share in the reduction	Cum. Reduction (in %)	Abatement Cost (P/ton)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
3320	Furniture	53.30	0.08	0.08	42.64	10.66	0.06	0.06	678.00
3900	Other industries	36.40	0.05	0.13	29.12	7.28	0.04	0.11	705.12
3310	Wood	204.10	0.31	0.44	163.28	40.82	0.24	0.35	1,030.56
3220	Apparel	74.30	0.11	0.55	59.44	14.86	0.09	0.44	1,654.32
3610	Pottery	45.70	0.07	0.62	36.56	9.14	0.05	0.49	2,874.72
3420	Printing	20.40	0.03	0.65	16.32	4.08	0.02	0.52	3,173.04
3720	Non-ferrous metals	1,684.00	2.52	3.17	1,347.20	336.80	2.01	2.53	4,122.24
3530	Refineries	0.00	0.00	3.17	0.00	0.00	0.00	2.53	4,474.80
3140	Tobacco	2,376.50	3.55	6.72	1,901.20	475.30	2.84	5.38	4,529.04
3240	Footwear	4.00	0.01	6.73	3.20	0.80	0.00	5.38	5,613.84
3690	Non-metal products, n.e.c.	5,831.80	8.72	15.45	4,665.44	1,166.36	6.98	12.36	5,776.56
3410	Pulp and paper products	9,422.70	14.09	29.54	7,538.16	1,884.54	11.27	23.63	7,037.64
3130	Beverages	2,724.20	4.07	33.61	2,179.36	544.84	3.26	26.89	7,349.52
3230	Leather	93.70	0.14	33.75	74.96	18.74	0.11	27.00	10,224.24
3510	Industrial chemicals (incl. agri chem)	6,313.60	9.44	43.19	5,050.88	1,262.72	7.55	34.55	10,450.24
3210	Textiles (includes spinning)	1,846.20	2.76	45.95	1,476.96	369.24	2.21	36.76	12,624.36
3110	Food	6,114.80	9.14	55.09	4,891.84	1,222.96	7.31	44.08	14,129.52
3710	Iron, steel	17,051.70	25.50	80.59	13,641.36	3,410.34	20.40	64.47	14,319.36
3620	Glass	635.20	0.95	81.54	508.16	127.04	0.76	65.23	14,916.00
3820	Machinery, except electrical	295.40	0.44	81.98	236.32	59.08	0.35	65.59	14,916.00
3520	Chemical products	6,544.30	9.79	91.77	5,235.44	1,308.86	7.83	73.42	23,404.56
3550	Rubber	1,770.10	2.65	94.42	1,416.08	354.02	2.12	75.53	30,021.84
3830	Electrical machinery	1,777.40	2.66	97.07	1,421.92	355.48	2.13	77.66	31,689.72
3840	Transport equipment	314.30	0.47	97.54	251.44	62.86	0.38	78.03	32,733.84
3810	Metal products	133.10	0.20	97.74	106.48	26.62	0.16	78.19	42,388.56
3540	Petroleum, coal	1,455.40	2.18	99.92	1,164.32	291.08	1.74	79.93	52,667.04
3560	Plastics	54.10	0.08	100.00	43.28	10.82	0.06	80.00	65,494.80

3850	Professional goods	0.30	0.00	100.00	0.24	0.06	0.00	80.00	82,607.52
		Total			Total	Total			Average
		66,877.00	100.00		53,501.60	13,375.40	80.00		17,914.54

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Table 18b. Cost-effective regulatory strategy for sulfur dioxide

ISIC	Industry	Sulfur Dioxide (in metric tons)	% share to total emission	Cum. Emission (in %)	Uniform 50% Reduction	Remaining Emission	% share in the reduction	Cum. Reduction (in %)	Abatement Cost (P/ton)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
3320	Furniture	53.30	0.08	0.08	26.65	26.65	0.04	0.04	678.00
3900	Other Industries	36.40	0.05	0.13	18.20	18.20	0.03	0.07	705.12
3310	Wood	204.10	0.31	0.44	102.05	102.05	0.15	0.22	1,030.56
3220	Apparel	74.30	0.11	0.55	37.15	37.15	0.06	0.28	1,654.32
3610	Pottery	45.70	0.07	0.62	22.85	22.85	0.03	0.31	2,874.72
3420	Printing	20.40	0.03	0.65	10.20	10.20	0.02	0.32	3,173.04
3720	Non-Ferrous Metals	1,684.00	2.52	3.17	842.00	842.00	1.26	1.58	4,122.24
3530	Refineries	0.00	0.00	3.17	0.00	0.00	0.00	1.58	4,474.80
3140	Tobacco	2,376.50	3.55	6.72	1,188.25	1,188.25	1.78	3.36	4,529.04
3240	Footwear	4.00	0.01	6.73	2.00	2.00	0.00	3.36	5,613.84
3690	Non-Metal Products, n.e.c.	5,831.80	8.72	15.45	2,915.90	2,915.90	4.36	7.72	5,776.56
3410	Pulp and Paper Products	9,422.70	14.09	29.54	4,711.35	4,711.35	7.04	14.77	7,037.64
3130	Beverages	2,724.20	4.07	33.61	1,362.10	1,362.10	2.04	16.81	7,349.52
3230	Leather	93.70	0.14	33.75	46.85	46.85	0.07	16.88	10,224.24
3510	Industrial Chemicals (incl. agri. chem.)	6,313.60	9.44	43.19	3,156.80	3,156.80	4.72	21.60	10,450.24
3210	Textiles (includes spinning)	1,846.20	2.76	45.95	923.10	923.10	1.38	22.98	12,624.36
3110	Food	6,114.80	9.14	55.09	3,057.40	3,057.40	4.57	27.55	14,129.52
3710	Iron, Steel	17,051.70	25.50	80.59	8,525.85	8,525.85	12.75	40.30	14,319.36
3620	Glass	635.20	0.95	81.54	317.60	317.60	0.47	40.77	14,916.00
3820	Machinery, except Electrical	295.40	0.44	81.98	147.70	147.70	0.22	40.99	14,916.00
3520	Chemical Products	6,544.30	9.79	91.77	3,272.15	3,272.15	4.89	45.88	23,404.56
3550	Rubber	1,770.10	2.65	94.42	885.05	885.05	1.32	47.21	30,021.84
3830	Electrical Machinery	1,777.40	2.66	97.07	888.70	888.70	1.33	48.54	31,689.72
3840	Transport Equipment	314.30	0.47	97.54	157.15	157.15	0.23	48.77	32,733.84
3810	Metal Products	133.10	0.20	97.74	66.55	66.55	0.10	48.87	42,388.56
3540	Petroleum, Coal	1,455.40	2.18	99.92	727.70	727.70	1.09	49.96	52,667.04
3560	Plastics	54.10	0.08	100.00	27.05	27.05	0.04	50.00	65,494.80

3850	Professional Goods	0.30	0.00	100.00	0.15	0.15	0.00	50.00	82,607.52
		Total			Total	Total			Average
		66,877.00	100.00		33,438.50	33,438.50	50.00		17,914.54

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Table 19. Alternatives for controlling SO₂

Control Technology	Effectiveness	Cost	Average Emissions (in metric tons)	Potential Abatement (in metric tons)	Remaining Emissions (in metric tons)
Flue Gas Desulfurization	>90%	US \$1,500 per ton	81,112.52	73,001.27	8,112.52
Switching to 2% sulfur fuel	40%	US \$5-10 per ton of fuel used	81,112.52	32,445.01	48,667.51

Note: The power plants consume around 1.4 million tons of fuel per year

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