CREED FINAL REPORT

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by Ritu Kumar, Nick Robins,
AK Chaturvedi, R Srinivasan and J Gupta

- International Institute for Environment and Development, UK
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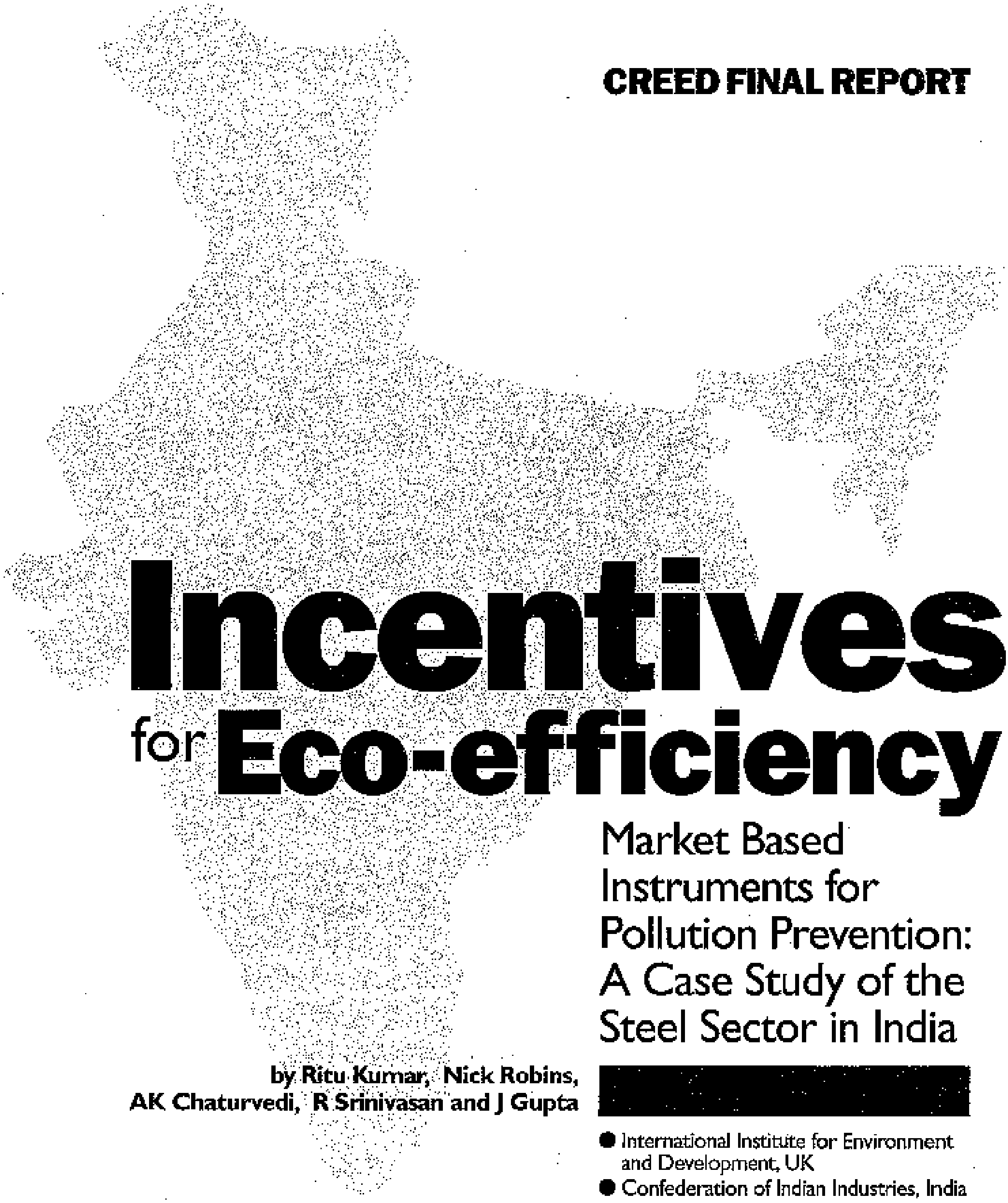

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This report is based on a case study of the Indian steel industry. Four policy scenarios are designed that combine command and control measures, ie discharge standards with market based instruments: pollution charges and intra-plant trades. The analysis is based on primary data on costs of abatement provided by two large-scale integrated iron and steel mills. The methodology follows the 'least cost approach'. It takes either the ambient standards or the existing effluent/emission standards as a bench mark and then designs the appropriate policy instrument to achieve the given abatement target implicit in the standard. The scenarios are evaluated according to five criteria: environmental efficiency, cost effectiveness, incentives for adoption of cleaner technologies, administrative feasibility and public transparency. The paper also discusses the broader policy and corporate implications of introducing economic incentives for pollution control in India. On the policy front, the importance of achieving coherence with existing policies, building trust among key stakeholders, and gradually phasing in market based instruments is emphasised. The corporate sector would need to have a clearer understanding of environmental costs and benefits of pollution control and prevention.

Contents & preface

Contents

Preface

Incentives for Eco-Efficiency presents the results of an international study examining the application of market-based instruments to promote pollution prevention in the steel sector in India. The study was initiated in 1995 by the International Institute for Environment and Development, London, UK and forms part of the CREED programme (Collaborative Research on the Economics of Environment and Development), a joint venture between IIED and the Institute for Environmental Studies, Amsterdam, Netherlands.

The study itself was undertaken as a collaborative research effort between IIED, the United Nations Industrial Development Organization (UNIDO), and the Confederation of Indian Industries (CII). Research inputs were provided by Ms. Ritu Kumar of UNIDO, Mr. Nick Robins of IIED, and the following members of the CII team: Mr. A. K. Chaturvedi, Mr. R. Srinivasan, and Mr. Joydeep Gupta. In addition, invaluable inputs were provided by personnel of the Tata Iron and Steel Company (TISCO), Mr. R. P. Sharma, and the Steel Authority of India Ltd (SAIL), Messrs. Rastogi and Ghosh.

The objectives of the study were twofold:

- first, to assess the potential of market-based instruments for pollution prevention in the steel sector and recommend a set of policy measures: to reduce discharge levels in most cost effective manner; to induce firms to adopt cleaner technologies; and to encourage firms to economise on energy and water resources; and
- second, to strengthen the capacities of CII, TISCO and SAIL to assess the potential of market-based instruments to complement existing environmental policies and regulations.

The preliminary findings of the study were presented at an international seminar in New Delhi in July 1996, and the results of that meeting, along with more detailed comments from a number of peer reviewers have been incorporated into the final report. Special thanks are due to Professor M. V. Nadkarni of the Institute for Social and Economic Change, Bangalore and to Dr. David O'Connor and Mr. J. P. Barde of the Organization for Economic Cooperation and Development, Paris, for their inputs.

Executive summary

Executive Summary

Background to the Study

Mounting pressures on industry to reduce pollution, remain globally competitive and meet requirements of international standards and norms require fundamental changes in government policy and corporate approaches to environmental management. It is becoming increasingly clear to governments and to private industry that regulations should be supplemented and combined with a system of economic incentives that internalise the externalities arising from pollution in a more cost effective manner. In 1992, the Ministry of Environment and Forests, Government of India, issued a policy statement emphasising the need to develop and apply financial incentives for pollution prevention.

In response to these emerging needs, the International Institute for Environment and Development (IIED), United Nations Industrial Development Organization (UNIDO) and the Confederation of Indian Industry (CII), launched a joint effort to design and implement market based instruments (MBIs) for pollution prevention. The main objective of this initiative was to provide policy makers and industrial managers with a set of options that would most cost effectively prevent and reduce levels of pollutant discharge and encourage resource conservation. The steel industry was selected as the pilot sector, with two large-scale integrated iron and steel plants — the Tata Iron and Steel Company (TISCO) Jamshedpur facility and the Steel Authority of India Limited (SAIL) Bhillai plant — selected as case studies. The aim was to generate lessons from the steel sector that could be more generally applied in Indian industry.

One of the more innovative aspects of the study was its collaborative nature, with the active involvement of the corporate sector throughout the economic research, both from CII and the case study companies. This helped to allay preconceptions about the possible negative impacts of MBIs, raised awareness of the benefits of economic incentives and pointed to the need to institute an environmental cost accounting system within the firm. The interim results were also tested at an international seminar in New Delhi, bringing together corporate decision-makers from a number of sectors, government officials, academics and NGOs.

Aims of the Study

The study had two broad aims:

- the first was to devise a set of market based instruments for pollution prevention in the steel industry in India. This involved designing charging systems that would lead to a reduction in pollution discharges from the steel industry in a cost effective manner and induce firms to adopt cleaner production and abatement technologies. It also involved devising a system of emission trading within TISCO based on the 'bubble concept'.
- a second objective of the study was to strengthen the capacities of CII, TISCO and SAIL to devise and assess the potential of market-based instruments to complement existing environmental policies and regulations. This was done by undertaking the research on a collaborative basis by IIED, CII, TISCO and SAIL. At an institutional level, the study provided CII with a methodological framework for designing economic incentives for pollution prevention. At an individual level, it enabled all participants to test and apply their understanding of economic theory and environmental management in the Indian context.

The Economic Approach to Pollution Prevention

Chapter 1 explores the need for market based instruments. Growing levels of pollution and environmental degradation suggest that traditional command and control measures for pollution control have not been sufficient to induce industry to adopt pollution prevention practices. A major reason for this is that polluters are not given an economic stake in reducing emissions and the flexibility to find least cost solutions. Economic conditions must make cleaner production options financially more attractive to persuade businesses to implement these options.

The institutional machinery in India, as in a number of developing countries, is geared towards command and control systems. The introduction of MBIs, with the advantage of built-in incentives for eco-efficiency, should be seen as complementary to the existing system for them to be administratively and politically feasible options. The study therefore concentrates on policy scenarios that combine the economic approach (pollution charges) with traditional command and control measures (regulatory discharge standards).

The Indian Steel Sector

Total steel production in India for 1995 is estimated at approximately 20 million tons per year, and is dominated by large integrated iron and steel mills engaged in the operation of coke oven batteries, blast furnaces, basic oxygen furnaces, continuous casting, and rolling mills. Each of these process stages generates pollution, and consumes significant amounts of scarce water and energy resources. The major water pollutants are suspended solids, phenol, cyanide, ammonia, oil and grease, while for air, the main problem is emissions of suspended particulate matter. In addition, solid wastes are generated at various stages of the production cycle, some of which are recycled and others disposed as landfill.

Currently, government regulations on emissions and effluent discharges apply for each unit within the steel plant rather than at the factory gate. Pollution control measures have limited discharges to prescribed levels in quite a few cases, but there has been no systematic effort at estimating the costs of control for individual companies and the cost effectiveness of standards.

Looking ahead, it is estimated that steel production is likely to increase to 36 million tons in 2010. This could lead to considerable increases in pollution loadings as well as in resource use if appropriate policies are not adopted early on. Such measures must include incentive schemes to encourage investment in clean and productive technologies.

Designing Scenarios for the Steel Sector

The study presents four policy scenarios: the first option combines concentration-based discharge standards with pollution charges, where the charge is levied on pollutants unabated upto the specified standard ('Standards Plus'); the second scenario is an extension of the first and allows for a rebate to be paid to those units that abate more than required by the standard ('Pollution Prevention Rebate'); the third policy option envisages a move to mass-based standards and charges that are economically and environmentally more efficient than concentration-based measures ('Eco-Efficiency Charge'); the fourth scenario introduces the option of a company to trade permits for pollution between different units, using mass-based standards set at the factory gate ('Intra-Plant Trades').

These scenarios were assessed using primary data on the costs of abatement provided by TISCO and SAIL. The data was first collected by means of a questionnaire. Personal interviews were then conducted to verify the data, fill in gaps and elaborate cost functions for five pollutants: total suspended solids, phenol, cyanide, ammoniacal nitrogen and suspended particulate matter. Separate marginal abatement cost functions were then elaborated for each discharging unit within the steel plant. These equations were used, together with data on emissions and abatement levels, to carry out a number of simulations and iterations in order to equate marginal costs across units and arrive at combinations of charges and standards that result in higher abatement levels at least cost to industry as a whole.

The methodology used the "least cost approach", and took the existing effluent/emission standards as a bench mark. The MBI scenarios were then designed to achieve the given abatement target implicit in the standard, and evaluated according to five criteria: environmental efficiency, cost effectiveness, incentives for adoption of cleaner technologies, administrative feasibility and public transparency.

Key Results

The cost minimisation model demonstrated that scenarios which combine command and control measures (discharge standards) with MBIs are more cost effective than existing standards; in other words they achieve more pollution abatement for less cost to the industry as a whole. Moreover, low pollution control cost units benefit from a mixed policy, while high cost polluters would lose unless they change to cleaner technologies.

The results also point to the fact that a switch to mass-based standards and charges ('Eco-Efficiency Charge' scenario) as well as intra-plant trades would result in the most substantial reduction in pollution discharges at a considerable saving to industry. These are the most most environmentally efficient as well as cost effective options. One explanation for the better performance of a system based on total pollution loads per tonne of steel, as opposed to a concentration based scenario, is that it encompasses volume of waste water discharged, and makes dilution an unattractive option for industry.

Whereas environmental efficiency and cost effectiveness are quantifiable, and most MBIs perform well according to these criteria, it is more difficult to assess the administrative feasibility and public transparency of policy instruments. Each of the four scenarios were thus evaluated according to the five criteria mentioned above, and it was found that the 'Eco-Efficiency Charge' and 'Intra-Plant Trade' scenarios performed better in terms of effectiveness, efficiency and incentives for cleaner production than the 'Standards Plus' and 'Pollution Prevention Rebate' options. However, the picture changed somewhat when qualitative judgments on political feasibility and transparency were considered. The combined quantitative and qualitative analysis points to two main conclusions:

- first, that an MBI strategy should start with a politically acceptable and publicly transparent 'Standards Plus' scheme based on existing concentration discharge standards and gradually evolve a more efficient and effective system based on pollution loads per tonne of finished product; and

● second, that the introduction of MBIs must be done on a case by case basis for each pollutant and policy mix since a blanket prescription is not possible.

Implications for Policy and Industry

Chapter 3 explores the broader policy and corporate implications of introducing economic incentives for pollution control in India. Designing and implementing any of the four scenarios would require a reform of the existing regulatory framework as well as a change in corporate management practices. On the policy front, the importance of achieving coherence with existing policies, building trust among key stakeholders, and gradually phasing in market based instruments is emphasised. On the corporate side, there is a need to have a clearer understanding of environmental costs and benefits of pollution control and prevention.

Policy makers should take particular note of the following issues in implementing MBIs:
a) Ensure compatibility of new MBIs with existing legislation to avoid double penalties.
b) Study the effectiveness of introducing MBIs in the presence of currently subsidised rates for water and energy resources.
c) Use revenues raised from pollution charges in a manner that would minimise competitiveness impacts on industry.
d) Encourage the participation of key stakeholders in the design and implementation of MBIs.
e) Introduce MBIs in a phased manner, ensuring that requirements of transparency and accountability are met at all times.

Corporate managers should review the following practices:
a) Develop accounting procedures as part of their environmental management systems so that they are able to allocate costs (such as pollution charges) and benefits (rebates) to the appropriate unit.
b) Modify environmental statements to include abatement costs and make it a legal document.
c) Adopt cleaner production technologies in response to the incentives provided by MBIs.

Next Steps

This study is seen as a valuable contribution to the process of developing a strategy for the introduction of market based instruments in India. However, to ensure continued success in the design and implementation of MBIs and to make economic incentives a normal part of the policy tool kit, considerable work still needs to be undertaken by policy makers, researchers and business managers. In Chapter 4 of the report, areas for further research are highlighted which would facilitate the transition to maturity for MBIs. These relate to:
a) Improving the methodology, for example by: introducing dynamic innovation variables; incorporating monitoring and enforcement costs in the abatement cost functions; using behavioural cost functions; incorporating resource pricing into the pollution abatement model; and, making a more rigorous evaluation of the administrative feasibility and transparency of policy instruments.
b) Extending the model to the steel sector as a whole.
c) Applying the model to a sector that has a mix of large and small enterprises such as leather tanning or textile dyeing and finishing.
d) Further investigation into the possibilities of intra-plant trading within steel plants.

Chapter 1

Market based instruments: the challenge

Chapter 1

1. Market Based Instruments: The Challenge

1.1 Market Based Instruments: The Economic Approach to Pollution Prevention

In recent years, India, along with many other developing countries, has adopted far-reaching economic reforms to boost its competitiveness in the global economy through trade liberalisation, market deregulation, industrial restructuring and the dismantling of price controls. Alongside this shift towards more market-friendly development strategies, there has been a recognition that these economic policy reforms should encompass tougher environmental protection measures if the benefits are to be sustainable. But strengthening environmental action does not simply mean tightening the policies of the past.

Indeed, there is a growing consensus amongst policy makers, practitioners and industrialists in developing countries that environmental policy must move from a reactive stance that almost inevitably means command and control regulation to a more proactive sustainable development approach, which looks to make markets work for the environment. As a result, developing countries are becoming increasingly interested in the application of economic incentives, at least as supplements or reinforcements of environmental standards (Panayotou, 1992).

Designing and implementing policies that can deliver economic development at a time of increasing scarcity of environmental resources has now become critical. There is an urgent need to find ways which achieve a more socially just and economically efficient allocation of these scarce resources. Classically, the state and the market are the two principal mechanisms for allocating resources among competing claims. In the state-led approach, the authorities use legal sanctions to limit environmental damage and control resource use through physical planning and rationing. The market based approach starts from the need to find prices that equate demand and supply; for environmental policy, this means internalising the costs of environmental damage into prices so that the polluters pay. For either system to achieve its objective, a number of prerequisites are needed. These include,

Table 1: Environmental Policy Alternatives

Command and Control	
Engineering Standards	Regulate technology (e.g. scrubbers on smokestacks to reduce gas emissions)
Performance standards	Require plants to operate in specified manner
Discharge standards	Set limits on emission levels
Ambient standards	Environmental quality standards (e.g. BOD of receiving water or sulphur dioxide concentrations in air)
Prohibitions/Sanctions	Preclude certain activities or the use of certain inputs (e.g. certain pesticides)
Economic Instruments	
(a) Price based MBIs	
Pollution charges	A tax applied per unit of pollutant (e.g. carbon tax)
Product charges	A tax applied to products used in or resulting from a polluting activity
User fees	Payment for public treatment facilities (e.g. for wastewater)
Input taxes	A tax on productive inputs that contribute to environmental pollution (e.g. tax on sulphur content of coal)
Deposit refund systems	A tax on unreturned environmentally harmful products (e.g. batteries, containers)
Tax differentials	Two surcharges levied onto other product charges i.e. positive charge on polluting product and negative charge on cleaner alternative (e.g. differential taxing of leaded and unleaded gasoline)
(b) Quantity based MBIs	
Marketable permits	Emission permits that can be used, sold or leased
Concessions	Permit system applied to forest or mine reserves: a fee for the amount of resource extracted
(c) Other economic incentives	
Non-compliance fees	A fee on discharge in excess of standards
Performance bonds	A payment made to regulatory authorities that is returned if environmental damage does not occur
Liability assignment	Polluters are liable for paying victims and restoring damage
Social tools	
Voluntary compliance	Proactive actions by industry in response to perceived threats of stricter environmental regulations (e.g. Responsible Care programme of the Chemicals Manufacturers, PROKASIH programme in Indonesia)
Information systems	Public disclosure of pollution, naming of polluting firms, ecolabelling etc. Awareness and education programmes, support for innovation
Education and R&D Demonstrations of cleaner production	Demonstrations of the economic and environmental benefits of cleaner production techniques (e.g. DESIRE study for pulp and paper, textiles and pesticide formulation, UNIDO)

for example, the existence of sufficient information on resource endowments, consumer preferences and technologies in the case of state planning, along with well defined and transferable property rights in the case of efficient market allocation of resources. Since neither of these sets of conditions is always met in full measure, there is a strong case for devising the right mix of polices including both regulatory and market based instruments to manage environmental resources and mitigate the negative environmental consequences of economic activity (Panayotou, 1992).

Modern approaches to environmental protection rely on three main types of interventions: command and control measures; economic instruments; and social tools (see Table 1). Traditional approaches to pollution prevention, especially in developing countries, have relied on the use of command and control measures to ensure compliance to set standards for pollutant discharge and ambient environmental quality. These have often been supported with the provision of government subsidies for private investment in clean technologies and for public provision of environmental infrastructure. In addition, social tools have been used to demonstrate the financial and environmental payback of adopting environmental management systems and environmentally friendly technologies. Existing evidence on the growing levels of environmental degradation suggests that this approach has, however, been insufficient to prompt industry to engage in pollution prevention. While command and control regulations can, in theory, guarantee that environmental action will be taken, weak implementation and enforcement has been a universal stumbling block. Furthermore, a system based solely on command and control measures does not provide incentives for companies to improve reduce pollution levels or improve the quality of pollutant releases beyond permitted levels. In other words, polluters are not given an economic stake in reducing emissions and the flexibility to find least cost solutions. Demonstrations of the advantages of clean technologies by themselves are also unlikely to persuade business unless economic conditions make these options financially superior compared with competing investment options.

The economic approach to environmental regulation focuses on the choice of instrument that provides continuous financial and other inducements for sources to reduce pollution loads. The Environment Directorate of the Organisation for Economic Cooperation and Development (OECD) defines these economic instruments more specifically as instruments that affect costs and benefits of alternative actions open to economic agents, with the effect of influencing behaviour in a way that is favourable to the environment (OECD, 1991 & 1994). They either involve a transfer of funds between polluters and the community (e.g. pollution charges and taxes levied with respect to emissions, ambient levels or products, user charges for services, subsidies, financial assistance), or the creation of markets for pollution emissions (e.g. marketable/tradable permits, deposit refund schemes). A more narrow interpretation of economic instruments is that of market based instruments. These include only those economic incentives that are implemented through mechanisms having direct effects on economic markets. For example, information on risk can be an economic incentive but not a market mechanism, whereas pollution charges and tradable permits or pollution reduction credits qualify as both by virtue of the fact that they change the price of pollution directly.

The theory of market based instruments (MBIs)

A basic objective of MBIs is to promote the efficient use and allocation of environmental resources so that the socially optimal level of economic activity coincides with the private optimum. In other words, the external costs of pollution, which result in the divergence between private and social objectives, should be internalised with the help of economic instruments. We are starting with the premise that internalisation of costs associated with pollution is essential. Full internalisation of pollution costs would occur when the marginal abatement costs are equal to the marginal damage costs. This will give an "efficient" level of pollution control. In practice however it is difficult to estimate the damage costs resulting from pollution emissions[1] and therefore difficult to arrive at an ideal "Pigouvian" tax that exactly reflects the marginal costs of pollution.

A second best approach then is to estimate "cost effective" pollution control allocations that equate the marginal costs of controlling pollution across firms. This may be done for example by levying a per unit tax on pollution discharged or by tradable pollution permits, which in turn provide the right incentive to individual firms for cost effective total investment in pollution control. Under conditions of perfect competition and profit maximisation this procedure is the least cost method for achievement of specified abatement targets. In the following paragraphs an attempt is made to illustrate the theoretical framework underlying the development of two types of MBIs: pollution charges and tradable permits. This is done for a simplified abstract case to demonstrate the economic rationale and cost effectiveness of using market based instruments. A more detailed discussion of the methodology is given in Annex 1.

The following paragraphs of this section describe the theoretical case of a comparison between a pure charge scenario and a pure command and control scenario (or standards only scenario) as in Figure 1, and a tradable permit scheme as in Figure 2. A real life application would of course consist of a mix of charges/permits and standards. The latter constitutes the main body of the present study and is the subject of discussion of Sections II and III.

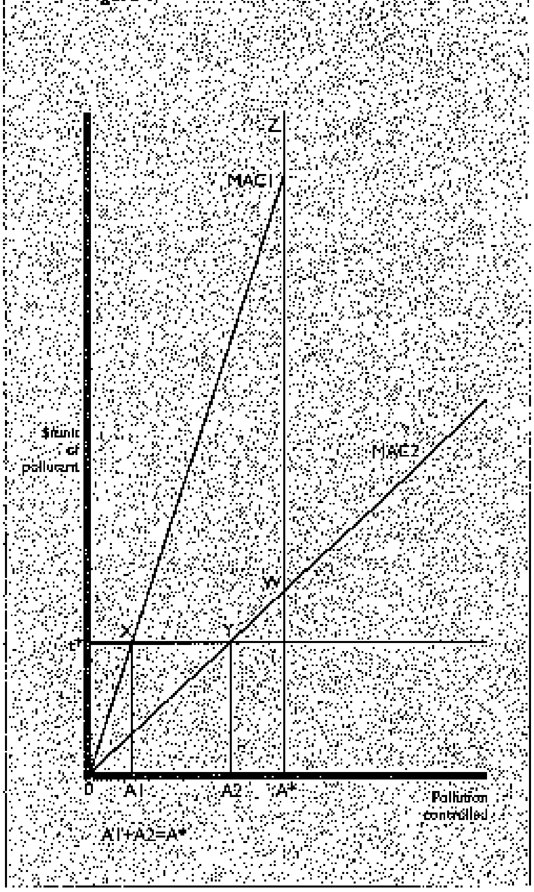
1. A number of valuation methods such as hedonic pricing, travel cost, contingent valuation, dose response functions etc, are used to estimate environmental resource prices. In practice however it can be extremely difficult and costly to undertake these valuation exercises.

Pollution charges

Figure 1 illustrates the cost effective policy approach for a uniformly mixed flow pollutant[2] for a two firm case. The analysis assumes that firms are cost minimising and operate in a perfectly competitive world.

Taking aggregate desired abatement level to be fixed at A*[3] we then ask the question: how to achieve this in the most cost effective manner? If we were to consider only two firms with marginal abatement costs MAC1 and MAC2, then the least cost method would require allocating the aggregate abatement level between the two factories in a manner that equates their marginal abatement costs (MAC1=MAC2). The pollution charge is then set at t*=MAC1=MAC2, which equates the MAC of all firms but allows them to abate at different levels. With the pollution charge, the total costs of abatement are the sum of OXA1 and OYA2. If the government were to set an ambient standard at A* for the industry as a whole in place of the pollution tax, the total costs of abatement would be higher at OZA* plus OWA*. Moreover the government would require detailed information on the costs faced by each source.

Figure 1



It should be noted that the above result is valid only under the assumption that cost curves are accurately estimated. If the true marginal abatement cost curve is above the estimated curve then, depending on the elasticity of the marginal benefits with respect to the pollutant, it may well be that a uniform standard would minimise the net loss in social surplus. In addition, the approach is useful only if the marginal abatement costs across different sources are very different.

Tradable Permits

Tradable permits offer another way to minimise the total costs of abatement and achieve cost effective pollution control. For purposes of illustration it is assumed once again that there is perfect competition and firms maximise profits. The government uniformly allocates a fixed amount of permits to each firm. Firms are free to trade permits amongst themselves. It is also assumed for the moment that there are no transaction costs and that there is no entry or exit from the permit market. In reality, of course, the assumption of zero transaction costs[4] is highly improbable. The implications of this for tradable permits have been studied in some detail by Robert Stavins (Stavins, 1993).

Assuming that the government allocates emission permits equivalent to 7.5 tonnes of pollutant each to the two firms facing marginal abatement cost functions as depicted in figure 2, the firms will start exchanging permits until they reach point E where any further gains from trade have been eliminated. At all points to the left of E firm 2 will be willing to buy permits at a price less than C and therefore controls less (since it is has higher costs of control), and firm 1 will sell permits at a price greater than A and therefore controls more. This exchange will continue until point E where the total level of pollution control is equal to the desired level.

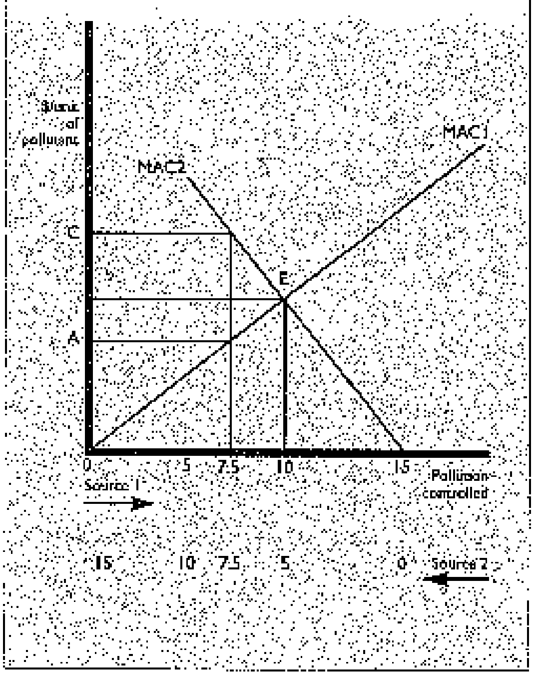
There are two main variants of the trading system, depending on the manner in which

2. A flow pollutant does not accumulate in the environment over time. A uniformly mixed pollutant is one for which the location of individual emissions has no effect on ambient pollution concentrations. The more complex case of non-uniformly mixed pollutants can be developed by examining charges and permit schemes based on ambient levels rather than emission levels and permits.

3. Note that the desired level of pollution control is taken as exogenously determined and remains a question mark. One way to ascertain the level A* is to use prevailing ambient standards or emission standards as benchmarks.

4. Transaction costs of exchanging permits can be classified into three broad categories: search and information costs; bargaining and decision costs; and monitoring and enforcement costs. Search and information costs arise because a potential buyer of an emission permit spends time, effort and possibly money (if a broker is hired) in locating a seller. Bargaining costs are incurred for fees for legal, brokerage and insurance services. Monitoring and enforcement costs are borne by the government to ensure that emission reductions are compatible with permits exchanged.

Figure 2



the "bubble" is defined. The first type is inter-plant trading (as described above) which allows routine shifts in emission limits among existing plants if total emissions under the bubble do not increase. In this case the bubble is usually a geographical boundary defined over a fairly vast area that covers a number of polluting industries. A second variant, in which the bubble is defined on the basis of a single large firm, is that of intra-plant trading. This allows large firms with more than one discharge outfall to make trades that offer them the option of reducing pollution loads beyond discharge limits at one or more outfall and crediting it to other outfalls at the same facility so that the predetermined level of pollution reduction or environmental standard is met. The trades may also be subject to additional restrictions such as the requirement that net discharge of traded pollutants must be less than the discharge allowed without trades by a certain reduction factor. The basic rationale and concept is however the same as in inter plant trading.

It should be noted that inter-industry trades of pollution permits as a means of cost effective pollution prevention may not be a viable alternative in many developing countries if transaction costs of exchanging permits are very high (Stavins, 1995). Since these costs are lower in the case of intra plant trades, it may be better to design trading schemes for single large firms with multiple discharge outfalls as a first step. Success in this initiative could pave the way for more ambitious ventures if prerequisites for successful application, including low transaction costs, are met. In the present study, an intra-plant trading scheme has been devised for Tata Steel Ltd. on an experimental basis. This will be discussed in detail in section 2.2.

Global Experience of Market Based Instruments

As the 1990s have progressed, there has been growing global interest in the pollution prevention potential of market based instruments. A new alliance of policy makers, enlightened industrialists and environmentalists has emerged, which sees MBIs both as a necessary complement to market-friendly economic policies, and as a powerful tool for reducing environmental damage and conserving natural resources. At the 1992 Earth Summit, the Agenda 21 action plan agreed among the world's governments gave special place to the role of MBIs, arguing that "market-oriented approaches can in many cases enhance capacity to deal with environment and development issues by providing cost-effective solutions, applying integrated pollution prevention control, promoting technological innovation, influencing environmental behaviour, as well as providing financial resources to meet sustainable development objectives" (UNCED, 1992). The business community also came out in favour, with Changing Course, the report of the Business Council for Sustainable Development, arguing that "the prices of goods and services must increasingly recognise and reflect the environmental costs of their production, use, recycling and disposal" (Schmidheiny, 1992)[5].

5. The implicit assumption here is that producers revise prices of final products based on internalisation of environmental costs. The latter may be on account of pollution taxes, realistic pricing of raw materials including water and energy, etc.

By 1992, a total of 169 market based instruments had been introduced in 23 OECD countries, ranging from product and emission charges to deposit-refund systems and tradable permit schemes (O'Connor, 1996). There is no comparable picture for the application of MBIs in developing countries, but their use is definitely growing. Significant examples include Malaysia's effluent charge system for palm oil mills and China's industrial pollution charges and experiments with SO_2 taxation and permits (see Annex 3). Singapore has also introduced an innovative tradable permit scheme for the import and use of ozone-depleting substances.

These *first generation* applications of economic instruments in OECD and other countries have been based on a pragmatic approach, often conceived within an overarching command and control framework and rarely based on the economic methodology described above (OECD, 1994). Thus, pollution charges have been used primarily to raise revenues for environmental action, with the aim of providing incentives for pollution prevention a secondary or subsequent goal. The evolution of the Dutch Surface Water Charge is a good example of this 'first generation' approach. Even tradable permit schemes in the USA have traditionally been based on negotiated agreements developed by the US Environmental Protection Agency, and not on economic models.

Recently, a *second generation* of MBIs has emerged, characterised by a comprehensive

Box 1 - Five principles for designing economic incentives

- **The ambient quality target** - Flexibility of response is important, but the aim should be the achievement of an environmental quality (ambient) standard. The target ambient quality standard should be specific, monitorable and verifiable.

- **The minimum cost principle** - The desired ambient quality standard must be attained though the most cost-effective means (the lowest possible cost to the economy). The costs should include monitoring and enforcement costs to the regulatory agency and output reduction and pollution control costs to the industry.

- **The polluter pays principle** - The chosen policy instrument must be self-financed, and equitable. While the payment is collected from the industrial producer, the ultimate burden (incidence of the pollution charge) is shared between the producer and the consumer in a proportion determined by the elasticity of demand for the product in question.

- **The competitiveness imperative** - The policy instrument chosen should minimize any reduction in the overall competitiveness of industry, although it would unavoidably change the industrial mix in the medium to long run, if it is effective.

- **Policy transition** - changing the industrial mix from high to low polluting industries is one of the desirable outcomes of an effective pollution control instrument. Structural change takes time. Allowance for adjustment during the transition period must be made. The stability and predictability of the policy is crucial if industrial investment is to be gradually shifted from high to low polluting industries.

Source: (OECD, 1992)

application of the economic approach both in the analysis of the environmental problem to be tackled and in the design of the instrument itself. The Swedish Nitrogen Oxide Charge is a case in point, where the Ministry of Environment linked the rate set for emissions of nitrogen oxides from power stations to estimates of abatement costs. Recent tradable permit schemes in the USA also take this comprehensive approach.

The formulation of 'second generation' economic incentives is a complex task which must be undertaken on a case by case basis. The capability of countries and sectors to design and enforce MBIs is likely to vary greatly. Even so, there are some general principles that should be adhered to while developing an environmental protection system based on economic incentives. These have been summarised by OECD as follows (Box 1).

1.2 India's Growing Interest in Market Based Instruments

Over the past 20 years, India has established a comprehensive set of environmental regulations. These do not, however, provide the structure of incentives that could stimulate industry to adopt such a cleaner and more efficient development path. Indeed, after two decades of water pollution control legislation, it is estimated that approximately 70% of India's surface water is polluted. Based on the traditional "command and control" model, India's regulations to contain industrial environmental impacts do not allow companies to make cost effective investment decisions or encourage them to go "beyond compliance".

Minimal national standards (MINAS) are set by the Central Pollution Control Board for each industrial sector, based on a review of production processes and environmental issues. Although the standards are set to ensure that pollution control measures are affordable for industry, no assessment of pollution abatement costs is carried out. According to current legislation, companies are not allowed to discharge effluents or emissions for each industrial unit in excess of the prescribed norms into water, air or land. This limits corporate flexibility to trade off environmental investments in one unit against another to achieve the overall desired levels of reduction needed to meet ambient quality goals. Furthermore, no 'carrots' are provided for polluting less than these norms and equally there are no 'sticks' to distinguish between degrees of non-compliance: an industrial unit discharging one unit above the limit is equally liable to legal sanction as one which is 100 units over the limit. Compliance with the standards is very often lacking or at best incomplete due to a number of reasons, the most important one being the lack of a proper enforcement mechanism and the high costs of meeting the standards. Costs of enforcement are high, and are rising as industrial expansion forges ahead.

Currently, the use of market based instruments in India is limited to the water cess aimed at raising revenue for the state pollution control boards and a range of fiscal subsidies for investment in pollution control systems (see Box 2). The rate of the cess is still too low to stimulate water conservation measures, and although it is possible in theory for firms to win a 25% rebate on their water cess if they meet pollution control and water consumption norms, only a few have exploited this option. Furthermore, since the primary aim of the cess is to raise revenues for the pollution control boards, there is little incentive for the authorities to provide companies with a rebate; in addition, where rebates are awarded the levels are too small to offer much incentive for conservation. Turning the cess into a forceful instrument for water conservation and pollution prevention is thus a timely challenge.

These measures have some potential for stimulating investments in environmental technologies. But these schemes are directed at supporting the installation of end of pipe control measures, thereby subsidising the costs of compliance. There is no motivation for companies to institutionalise resource efficiency or pollution prevention, and no specific

BOX 2 - Fiscal Measures for Pollution Control

→ Depreciation allowance at the rate of 100% for installing Pollution Control Equipment.

→ Custom duty at reduced rates of 35% plus 5% auxiliary charges levied on equipment and spares for pollution control.

→ Custom duty at the reduced rate of 25% and full exemption from additional duty for kits required for conversion of petrol driven vehicles to compressed natural gas driven vehicles.

→ Excise duty at the rate of 5% on manufactured goods that are used for pollution control.

→ Exemption under Section 35 of CCB of the Income Tax Act to assessee who incurs expenditure for carrying out programmes of conservation of natural resources.

→ Exemption of Excise Duty on the production of building materials using fly ash and phosphogypsum in 25% or more quantities as raw material.

→ Exemption of Excise Duty on bricks and tiles manufactured using red mud, 25% or more quantities as raw materials.

→ Exemption of Custom Duty on the import of equipment, machinery and capital goods required for the production of building materials, using fly ash/phosphogypsum such as bricks, light weight aggregates and light weight concrete elements.

support is available for cleaner technologies or techniques, barring some awareness raising measures. Furthermore, the value of some of these schemes is likely to decline as customs duties are lowered and trade rules are liberalised.

Recently, there has been a growing interest in government, academic, non-governmental and business circles in the use of MBIs, perhaps heralding an important shift in India's environmental policy in the near future.

Within government, an active exploration of MBIs is now underway. In 1992, the Ministry of Environment and Forests (MOEF) issued a Policy Statement for Abatement of Pollution, which stated that a new emphasis would be placed on "an increase in the development and application of financial incentives" (MOEF, 1992). This fitted within the Ministry's wider goal of shifting from a curative to a preventive approach to resolving industrial pollution problems, and in particular, encouraging industry to increase its uptake of clean technologies as part of a more eco-efficient development path. The focus of attention remained, however, on the provision of subsidies and tax breaks, whereby the government pays the polluter to clean-up, rather than on the use of environmental taxes and charges which make the polluter pay.

The statement opened the way for further investigation of MBIs, and in August 1995 the Ministry set up a special task force to "examine the feasibility of the different types of economic instruments for industrial pollution abatement in India" and to "develop a plan of action for selectively introducing the appropriate ones" (MOEF, 1995). Since then the task force has held a series of consultations across the country, and is scheduled to publish its final report by the end of 1996.

Policy and academic institutions have also carried out numerous studies of the possible benefits and costs of MBIs in India.[6] These studies show that economic methodologies for designing MBIs are available and being used by a small, but growing group of policy makers in India. Furthermore, the broad scenarios for the use of MBIs in India are becoming clear, notably the 'standards plus' and 'charge/reward' options. But significant questions remain unanswered on a number of points. Thus, no clear consensus has emerged on the balance that should be struck between the macro-economic use of MBIs as part of an 'ecological tax reform' and the more micro-economic use to tackle particular pollution problems. Also concerns about the winners and losers of a shift towards greater use of MBIs — whether in terms of the competitiveness of particular industrial sectors or the income opportunities of particular social groups — have yet to be subject to detailed scrutiny. Finally, the degree of innovation in pollution control authorities and corporate environmental management required by a greater use of MBIs has still to be resolved.

The *business sector* is also taking steps to improve its environmental performance and reduce the financial costs of pollution and waste. Companies are drawing up environmental policies and installing environmental management systems. Environmental audits are being carried out, and six companies in India have already received certificates for their environmental management systems according to international standards. Companies are also publishing details of their performance in annual environmental reports. Central to these approaches is the argument that good environmental practice is good business. Standard procedures for assessing pollution prevention opportunities have been developed in India, such as the National Productivity Council's From Waste to Profits manual, the result of the UNIDO sponsored Project DESIRE (Demonstration in Small Industries for Reducing Waste) (NPC, 1994).

But the spread of pollution prevention is constrained by the lack of market prices that "tell the environmental truth". Project DESIRE concluded that "waste and emission generation and excessive resource consumption are still too cheap to really bother the industrial entrepreneur" (van Berkel, 1995). In addition, even where resource scarcity is beginning to bite financially, companies still lack adequate internal environmental cost accounting procedures to enable them to accurately evaluate the profitability of pollution prevention measures. Typically, environmental management costs are pooled in overhead and/or maintenance accounts, obscuring the real costs of meeting regulatory norms and hampering a full assessment of the benefits of investments in clean technologies. Although one of the driving forces behind the introduction of environmental management systems is the desire to gain financial savings, neither the BS7750 or ISO14001 standards explicitly require companies to assess environmental costs and benefits.

Looking ahead from the mid-1990s, three strategic dilemmas confront India in its search for a more sustainable development path:

- how to raise the competitiveness of its industries as it adjusts to an increasingly open, globalised economy;
- how to extend the new opportunities for economic development throughout society to tackle continuing problems of poverty; and
- how to ensure that the substantial economic growth on which both of these goals rest can be sustained on a dwindling resource base.

In 1991, India embarked on an extensive programme of economic reforms, which have now begun to transform the country's model and pace of development. Tariff walls have been brought down and licensing controls on industrial development have been cut back. Annual growth in industrial production has increased from 0.6% in 1991-92 to 8.4% in 1994-95, and there is general confidence that India should be able to sustain high levels of growth over the next decade.

But such rapid industrial growth, combined with a consumption explosion among the affluent and continuing expansion of the population could place insupportable burdens on an already constrained environmental resource base. Looking first at the availability of key environmental inputs, water supply is under particular pressure. Industrial demand for water is expected to double from 15 billion kilolitres (bkl) to 30 bkl between 1990 and 2000, and

6. See, for example, CSE (1992); Bhatia, Rogers, Briscoe and Sinha (1994); Mehta, Mundle and Shankar (1993); Van Amelsooy (1994); CII (1995); Kumar and Sherif (1995).

quadruple again to 120 bkl by 2025. On the output side, air pollution generated by energy generation and the industrial sector per unit of production (notably suspended particulates) is already substantial and may rise considerably over the next two decades (WRI, 1995). Similarly, water effluent and solid waste generation levels are rising. Most water effluent remains untreated, while the disposal of hazardous wastes is largely uncontrolled.

Already, industries are facing a "resource crunch", where the physical scarcity of inputs, such as raw materials and water, is limiting production (Gadgil & Guha, 1995). Certainly, in some cases, 'necessity has been the mother of invention' and firms have been propelled into cleaner production, resource conservation and waste minimisation programmes to overcome these shortages, for example, Harihar Polyfibres in Karnataka and Madras Refineries in Tamilnadu. Equally, however, many companies do not have the financial or technical capacity to respond positively to such a "resource crunch", and may simply cease production.

According to the Tata Energy Research Institute, the consequences of India continuing along a development path of indiscriminate resource use and unchecked pollution would be severe economically, socially and environmentally. As part of its GREEN-India 2047 study, TERI argues that:

- expansion plans might have to be curtailed;
- industry could prove vulnerable to competition from 'greener' companies;
- raw materials will be in short supply;
- power cuts will be more frequent and last longer; and
- productivity per person is likely to be lower (TERI, 1995).

This prospect goes far beyond the isolated examples of "resource crunch" faced by today's industry. It suggests that India's industrial development trajectory as a whole will face a "sustainability crunch" unless determined preventative action is taken. Since the Earth Summit, the business sector has been working on a strategy for avoiding such a future, through the promotion of 'eco-efficiency', whereby resource use and pollution per unit of output is reduced continuously at a rate sufficient to enhance environmental resources for future generations. Internationally, the Factor 10 Club of academics, policy makers and business executives has concluded that "in industrialised countries, current resource productivity must be increased by a FACTOR of 10 during the next 30 to 50 years" as a prerequisite for meeting the goal of long-term global Sustainability" (Factor 10 Club, 1994).

To meet India's own national development objectives, a similar commitment to an eco-efficient future is required, and market based instruments offer a way of driving a wedge between economic growth and environmental degradation. By giving polluters an economic stake in reducing pollution and the flexibility to find least cost solutions, incentive based policies could achieve India's environmental goals at a lower overall cost to society. Such incentives would also encourage innovation in cleaner technological processes and result in a process of change that would, over time, lead to progressive prevention of pollution, as opposed to control of pollution through end of pipe treatment.

Designing market based instruments for the steel sector

Chapter 2

Chapter 2

2. Designing Market Based Instruments for the Steel Sector

To assess the feasibility of MBIs in the Indian context, this chapter focuses on the steel sector, drawing on detailed information from two integrated steel plants, the Steel Authority of India Limited's (SAIL) Bhillai plant in Madhya Pradesh and Tata Steel Limited's (TISCO) Jamshedpur plant in Bihar. Based on an assessment of the environmental issues facing the sector, the economic and environmental implications of four different MBI scenarios are modelled.

The steel sector was chosen for this modelling exercise for three main reasons:

- first, the steel sector is a major source of industrial pollution, and a significant consumer of water and energy;
- second, integrated steel plants are large and easily identifiable sources of pollution. Environmental performance data is readily available for the sector, and both SAIL and TISCO were willing to participate actively in the research;
- third, the integrated steel sector with its mix of public and private ownership provided an opportunity for comparative cost analysis.

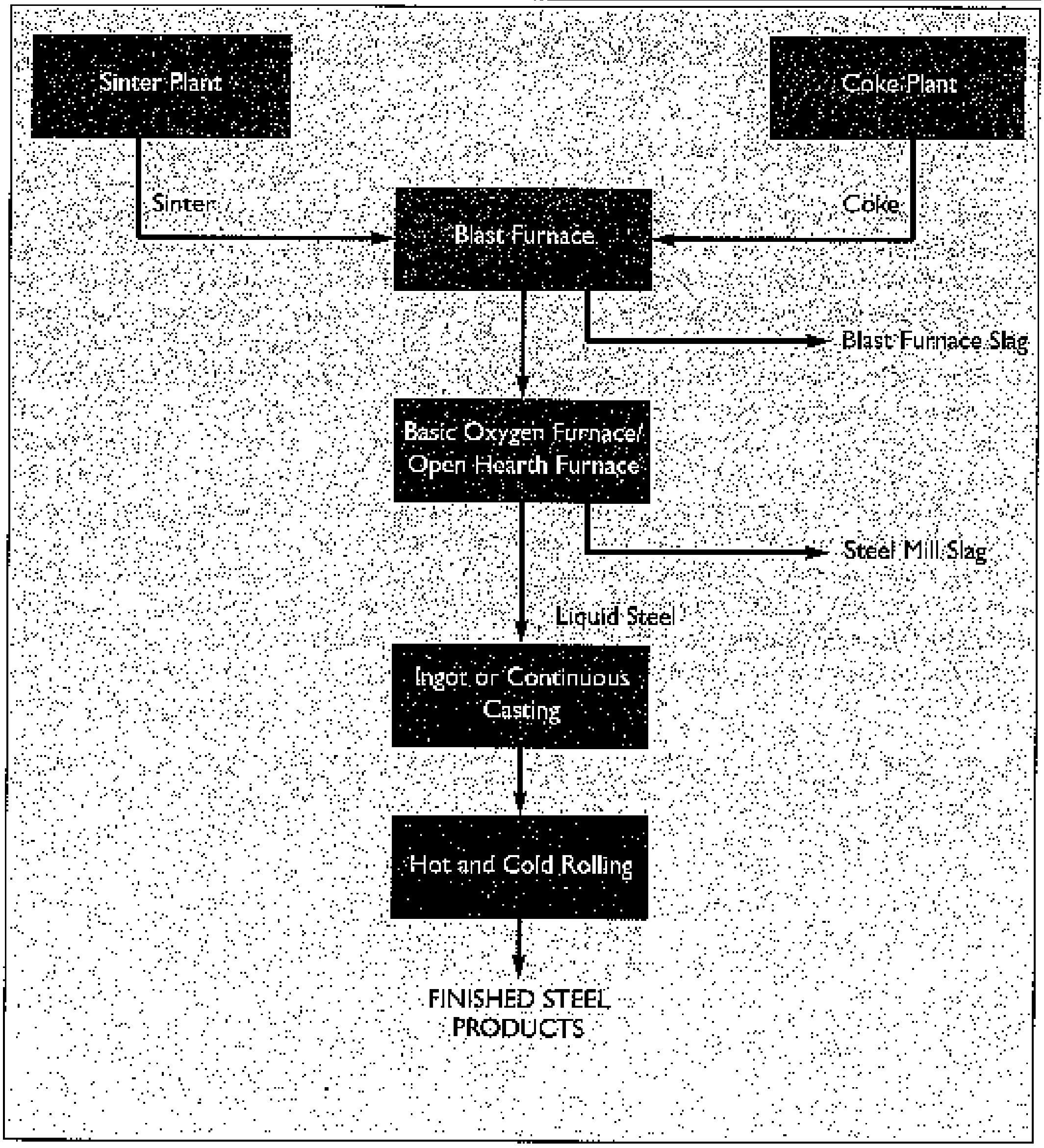
2.1 The Steel Sector in India: Environmental Performance and Prospects

Indian Steel Industry

The production of steel in India is dominated by a number of large integrated iron and steel plants mainly operated by the public sector under the control of the Steel Authority of India Ltd. (SAIL). Tata Steel Ltd. is the only major private company active in this very capital intensive and large scale (in terms of fixed investments and turnover) sector. The integrated plant process is perhaps a natural choice in the Indian context given the adequate availability of major raw materials and mineral resources. There are five main production stages in an integrated steel plant: coke oven batteries; blast furnaces; basic oxygen furnace; continuous casting; and rolling mills (see Figure 3).

Figure 3

A Typical Flowchart of Principal Operations in Iron & Steel Production



In 1995, integrated mills produced more than three times the amount of steel than other processes such as Direct Reduced Iron (DRI) and Electric Arc Furnace (EAF) in 1995 (see Table 2).

Table 2: Steel production in India - 1995

Process	Production (million t/yr)	Per capita steel consumption (kg/yr)
Integrated steel plants	15.1	
DRI-EAF/EAF route	4.6	
Total	19.7	22

DRI - Direct Reduced Iron; EAF - Electric Arc Furnace

Although the integrated plant route continues to be popular, proposals for producing steel by other methods are presently under consideration and could result in a substantial increase in production capacity by the year 2010 (see Table 3).

Table 3: New proposals for steel production in India to 2010

Process	Proposed capacity (million t/yr)	Number of proposals
BF-BOF	8.17	13
DRI-EAF	4.21	4
EAF	1.77	7
Corex/BOF	1.76	1
Total	15.91	25

Environmental problems

An integrated steel plant generates environmental pollution at each stage of the production process; it is also a significant consumer of scarce water and energy resources. Table 4 summarises some of the main pollutant releases from the steel industry in India.

Water is probably the most important issue for the steel industry. The manufacture of steel generates waste water containing suspended solids, oils, phenol and BOD, which is generally discharged into rivers and streams. Another water related issue is that of water conservation. The existing pricing structure for industrial water use does not reflect the true price of water as a scarce resource. At present, no incentive schemes exist which would make it profitable to recycle water as opposed to using fresh water in the production cycle.

Solid wastes are generated at various stages in the steel making process. Some of these can be effectively recycled, but those which cannot are being used as landfill. Tata Steel currently reuses 40% of the solid waste from its production processes in cement manufacturing. Landfills are a contentious issue and are increasingly becoming a matter of public discontent. Firms are not subject to a tax on landfill and dumping sites scattered in residential areas are not an uncommon sight.

Table 4: Pollution sources from steel making

	Process	Pollutants
AIR	Coke ovens	Particulates and gases (PAHs)
	Sintering plant	Mainly particulates
	Refractory materials plant	Mainly particulates
	Steel melting shop	Mainly particulates
WATER	Coke ovens	Phenol, cyanide, ammonia, oil and grease, suspended solids
	Blast furnace	Suspended solids, cyanide
	Sintering plant	Suspended solids
	Steel melting shop	Suspended solids
	Rolling mills	Oil and grease, acids
NOISE	Blast furnace	High levels of noise
	Oxygen plant	High levels of noise
	Rolling mills	High levels of noise
SOLID WASTES	Coke ovens	Tar sludge
	Blast furnace	Slag and GCP sludge
	Steel melting shop	Slag and GCP sludge
	Rolling mills	Mill scales

The obvious social conseqences of these environmental problems, in terms of living conditions and health effects, are immense and difficult to control given the magnitude and low income levels of the exposed population.

To deal with these environmental problems, steel companies have developed environmental policies and established environmental management departments to define strategies and investments. Both SAIL and TISCO produce annual environmental reports describing their environmental actions. Indian steel plants have mainly been using end of pipe control equipment for controlling air and water pollution. Equipment for air pollution abatement includes various types of water scrubbers, mechanical seperators (e.g. cyclones), bag filters and electronic precipitators (ESPs). With respect to water pollution, the main area of concern in the steel industry is the coke oven complex which has problems of phenol, cyanide, and ammonia in its effluent. Most Indian steel plants have opted for activated sludge effluent treatment plants (ETP) for coke ovens. Some plants are also considering 'land treatment' as polishing units. Apart from coke ovens, effluent treatment is mainly confined to removal of suspended solids, oil and grease, and neutralisation of acidic effluents from pickling lines.

Government emission and effluent standards apply for each unit within the steel plant, rather than at the factory gate (see tables 5 and 6 for existing air and water standards). Pollution control measures may have limited emission and effluent discharges to prescribed standards. But there was no systematic attempt at estimating the costs of control for individual companies or cost effectiveness of the standards. In particular, it was not asked whether it is cost effective and desirable (given that enforcement is lax) for firms to abate at the level set by the standard.

Table 5: Stack emission norms (discharge standards for air pollutants)

Process	Parameter	Norms
Coke oven	Particulates	50 mg/Nm³
	Carbon monoxide	3 Kg/t of coke produced
Blast furnace	Particulates	150 mg/Nm³
Steel melting shop	Particulates	400 mg/Nm³ (during oxygen lancing)
		150 mg/Nm³ (normal operation)
Rolling mills	Particulates	150 mg/Nm³
Sulphuric acid plant	Acid mist	50 mg/Nm³
	SO_2	4 Kg/t of 100% acid

Table 6: Effluent discharge norms (discharge standards for water pollutants)

Parameters	Norms
Wastewater generation	16 m^3/t of finished steel
Suspended solids	100 mg/l
Oil and grease	10 mg/l
Phenol	1 mg/l
Cyanide	0.2 mg/l
Ammoniacal nitrogen	50 mg/l
Biochemical oxygen demand (BOD)	30 mg/l
Chemical oxygen demand (COD)	250 mg/l

Moreover, the results of an area wide study of Jamshedpur showed that ambient air quality parameters with respect to levels of suspended particulate matter have been declining over the years but still remain above the standard norms set by the Bihar State Pollution Control Board (NEERI, 1995). Air quality is also adversely affected by vehicular and transport activities in the area and by the emissions of gaseous pollutants like sulphur and nitrogen oxides. The introduction of technological processes and the phasing out and retrofitting of pollution prone plants has been helpful in reducing pollution from identifiable polluting sources like steel making, coke oven plants, and sinter plants. However, the pollution from diffused/fugitive sources and gaseous pollutants is more difficult to control.

Future trends

Steel production is estimated to increase from 19.7 million tonnes in 1995 to 35.6 million tonnes in 2010. Since steel making is a multi-process industry with environmental implications at various stages, such an increase in production could lead to considerable increases in pollution from steel making as well as in resource use, if the "right" policies and measures are not adopted early on. Such measures would include a combination of regulations and incentive schemes including market based instruments to encourage investment in clean and preventive technologies.

2.2 Four Scenarios of Market Based Instruments

The method

The four scenarios described below are based on a methodology adapted from the basic conceptual framework for cost minimisation described in section 1.1 (Stavins, 1993) and in Annexe 1. Pollution abatement cost functions were estimated for six pollutants discharged from different facilities operating in the two large integrated iron and steel mills. The pollutants covered by the study include water and air borne pollutants and not solid wastes and noise pollution. Solid wastes are not included since both TISCO and SAIL discharge the waste on their own property at present. Moreover existing regulations do not cover solid wastes. Noise can have a fairly high incidence in steel making, however, it was not considered by the present study due to difficulties in modelling and data collection. Amongst air pollutants, only suspended particulate matter is included. Although steel plants do emit some sulphur dioxide, this is not included in the present analysis since it is not a significant pollutant from the steel industry.

The specific pollutants covered by the study are: total suspended solids (TSS), phenol, cyanide, ammoniacal nitrogen and suspended particulate matter (SPM). SAIL's Bhilai and TISCO's Jamshedpur steel plants provided unit specific data on various parameters including: on production levels for hot metal, crude steel, finished steel and saleable steel; input and material consumption including energy and water consumption; volume and quantity of air emissions, waste water, and effluents discharged; costs of abatement (wastewater treatment, solid waste disposal and air pollution control) and costs of meeting the required standards, broken down into capital and operating costs.

The data were collected by means of a questionnaire. Personal interviews with the environment division staff of the two plants were then conducted to verify the data, fill in data gaps and elaborate engineering cost functions for the five pollutants. A separate cost function for each discharging unit was estimated. Annexe 1 gives details of the various cost functions and describes the methodology, the model and its assumptions.

Engineering cost functions were derived from estimates of the financial costs of abatement based on historic capital and operating expenditures; this approach differs from economic or behavioural cost functions derived from an analysis of marginal costs equations. The decision to use engineering cost functions rather than economic or behavioural cost functions was guided by practical constraints of data and time availability. A similar analysis would be possible by deriving marginal cost equations from well behaved production functions maximised subject to input constraints of different units in the steel plants. The net benefits of the latter approach are theoretically greater because of the advantages of econometric cost functions. In practice however it is unclear how much they would change the results of the model.

Annexe 1 describes total and marginal abatement cost functions for each pollutant. In each case the cost of pollution abatement is assumed to be a function of capital and operating costs. Capital costs are treated as fixed since the model is based on existing clean up operations.[7] Annual operating costs of each pollutant are described as a function of various parameters, as summarised below:

Total suspended solids

Operating costs = f (price of chemicals; quantity of waste water discharged; TSS abated; quantity and price of sludge removal)

Phenol, Cyanide and Ammoniacal Nitrogen

These three pollutants contribute to BOD discharged in waste water from coke oven units of the steel making process. The costs of the three pollutants were separated and apportioned according to the relative costs of nutrients that go into the BOD treatment plants of TISCO and SAIL. The functional form of the abatement cost functions for the cyanide, phenol and ammoniacal nitrogen are similar.

Operating costs = f (price of chemicals, quantity of waste water discharged; quantity of pollutant abated)

Suspended particulate matter

Operating costs = f (cost of electricity, volume of flue gas, suspended particulate matter abated)

Marginal abatement cost functions were derived for each pollutant by differentiating total abatement costs. These equations were used, together with data on emissions and abatement levels to perform a number of simulations and iterations in order to equate marginal costs across units and arrive at combinations of charges and standards that result in higher abatement levels at least cost to the industry as a whole.

The following paragraphs describe the results of applying the model to four scenarios or policy options that are relevant for the introduction of MBIs for pollution prevention in the steel industry in India. All four scenarios allow for the development of "hybrid" instruments that combine command and control measures with economic incentives. These can also be combined with various awareness raising instruments (e.g. demonstration and dissemination of cleaner production technologies, education awareness programmes etc.) to

7. The authors acknowledge that introduction of a dynamic innovation factor representing the application of cleaner production technologies would improve the model and may change the final results. Incorporation of such an innovation factor is considered desirable. It would also strengthen the case for levying a charge on pollution levels that exceed regulatory standards. Innovation in pollution prevention and control technologies will shift the abatement cost curves downwards, thereby making it possible to abate more than statutorily required.

make them more attractive. The advantage of such an approach is that it gives policy makers the flexibility to "achieve a balance among at times competing objectives of efficiency, equity and effectiveness" (O' Connor and Turnham, 1992).

Before discussing the four hybrid scenarios in detail, it must be mentioned that the study also considered the hypothetical case of the pure charge policy, where the government does away with command and control measures altogether and instead institutes a system of pollution charges only. It was felt that the benefits of such a system in terms of cost effectiveness would be far outweighed by the constraints placed on existing administrative and institutional mechanisms. The institutional limitations of charges and the preconditions for their successful application would be difficult to meet in the present Indian set up. For this reason, the pure charge scenario was not considered a practical option.

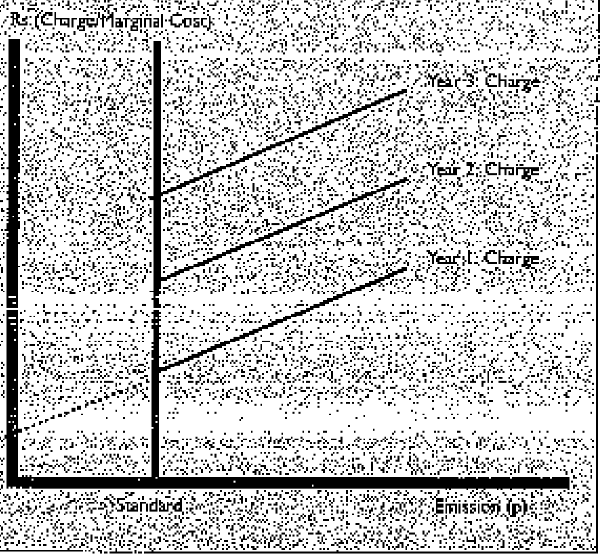
Scenario One: Standards Plus

A practical environmental management system is likely to revolve around effluent standards which reflect a social consensus (or technocrats' judgement) on an acceptable level of environmental quality. A system based on MBIs would also need to employ some benchmark to indicate a desired level of environmental quality, which it would try and achieve in the most cost effective way. This desired level of environmental quality is implicit either in ambient standards for air and water pollution or in discharge standards. Each standard corresponds to a total level of pollution abatement for the specific pollutant it pertains to. The "standards plus" scenario describes an option where a charge is levied on those firms whose pollution levels exceed discharge standards. Various combinations of standards plus charge levels are examined for their impact on total abatement, total abatement cost (defined as capital costs plus operating costs of abatement) and total revenue in order to select a suitable combination of standard plus charge level for each pollutant.

Figure 4 illustrates the Standards Plus scheme for a pollutant " P". The upward sloping lines indicate that pollution charges are directly proportional to levels of emission, being set at marginal abatement costs at each level. The diagram also shows the charge rate sliding upwards on an annual basis, reflecting the need to index the charge to inflation to ensure that the real value remains constant. Variations of such a Standards Plus system may be found in a number of OECD countries as well as a few developing countries, such as Malaysia, where it appears as a compliance fee system.

Results of applying the Standards Plus model to TSS, phenol, cyanide, ammoniacal nitrogen and suspended particulate matter in TISCO and SAIL are summarised below.

Figure 4 Standards Plus



Total suspended solids

Inherent in the existing policy of a standard of 100 mg/litre is a total abatement level of 1.16 million tonnes for six units (blast furnace, steel melting shop, and rolling mill at TISCO, and blast furnace, steel melting shop and refractory at SAIL). The total abatement cost for achieving a standard of 100 mg/litre for the six units combined is Rs. 567.87 million. There is a fair degree of variation in abatement costs between different facilities. As indicated in Table 1 of Annex 2, marginal costs (MC) vary from Rs. 497 to Rs 3,484 and total abatement costs (TAC) vary from Rs. 7.45 million to Rs. 150.8 million. This variation in costs is due to differences in the initial pollution load, in influent concentration, the volume of effluent discharged and the vintage of facilities.

A series of iterations were conducted and various alternative combinations of standards and charge levels were examined for their impact on total abatement (TA), total abatement cost (TAC) and total revenue (TR). Annexe 2 gives a range of options for combining various levels of charges with different standards and their implications for total abatement, total abatement costs and revenues collected.

The analysis indicates that if the *existing standard of 100 mg/litre is combined with a pollution charge of Rs. 1,100 per mg/litre of TSS on all firms discharging more than the standard*, it results in a higher level of total abatement (1.25 million tonnes) at a lower cost of Rs. 566.31 million. This is possible because facilities that have high control costs (such as TISCO blast furnace and Bhilai steel melting shop) abate less and those that have lower marginal abatement costs such as the TISCO steel melting shop increase total abatement from 0.12 million tonnes to 0.32 million tonnes. In addition, a total revenue of Rs. 10.1 million is collected which can be used to set up an environmental fund (see section 3.1 below). This policy is more attractive to industry as well as to government than the standards alone policy since it achieves a higher level of abatement at lower costs to the industry as a whole. [8]

Another option that could be considered for introduction in the *medium and longer term* is that of tightening the standard to 75 mg/litre and levying a charge on defaulting units. If a charge of Rs.1,100 is levied with a standard of 75 mg/litre, a total abatement of 1.27 million tonnes is achieved at a cost of Rs. 566.5 million to the industry as a whole, and a total revenue of Rs. 13 million is collected. The policy is cost effective in comparison with the existing standard alone policy, since total costs to the industry are still less than those of meeting the existing standards of 100 mg/litre. It is further recommended that the charge be gradually increased over time, not only to adjust for inflation but also to provide further incentives for pollution reduction through the adoption of cleaner production techniques.

Table 7 summarises the above results and compares the outcomes of the recommended policy combinations with the existing case of a pure CAC system.

Table 7: Model results: Total suspended solids

Scenario	Total abatement	Total abatement cost	Total revenue
Current standard (Concentration based): 100 mg per litre of wastewater	1.16 million tonnes	Rs 56.87 million	Nil
Standard plus: Current standard and a charge of Rs 1,100 per litre of wastewater	7.76% increase	0.27% decrease	Rs 10.1 million
Standard plus: a tightened standard of 75 mg per litre of wastewater and a charge of Rs 1,100 per mg per litre of wastewater	9.48% increase	0.24% decrease	Rs. 13 million

Cyanide

The study covers three coke oven plants operating in TISCO, Bhilai Steel Plant and Rourkela Steel Plant (the latter two belong to SAIL). These are the only units in the steel making process that discharge cyanide.

Inherent in the existing policy of a standard of 0.2 mg/litre is a total abatement level of 247.85 tonnes. The total abatement cost for achieving this standard for the three units together is Rs. 68.77 million. There is a large degree of variation in abatement costs between different facilities. As indicated in Table 5 in Annex 2, the marginal costs (MC) vary from Rs. 14364 to Rs 840154 and total abatement costs (TAC) vary from Rs. 7.17 million to Rs. 45.9 million. This variation in costs is due to differences in the initial pollution load, in influent concentration, the volume of effluent discharged and the vintage of facilities.

Again, a series of iterations were conducted and various alternative combinations of

8. Note that the industry as a whole is represented by six TSS producing units, three in TISCO and three in Bhilai Steel Plant.

standards and charge levels were examined for their impact on total abatement (TA), total abatement cost (TAC) and total revenue (TR). Annexe 2 gives a range of options for combining various levels of charges with different standards and their implications for total abatement, total abatement costs and revenues collected.

The analysis indicates that if the *existing standard of 0.2 mg/litre is combined with a pollution charge of a little over Rs. 18,000 per mg/litre of cyanide on all firms discharging more than the standard*, it results in a higher level of total abatement (279.66 tonnes) at a considerably lower cost of Rs. 56.70 million. As in the case of TSS, this is possible because facilities that have high control costs abate less and those that have lower marginal abatement costs increase total abatement. In addition, a total revenue of Rs. 3.19 million is collected which can be used to set up an environmental fund (see section 3.1 below). This policy is more attractive to industry as well as to government than the standards alone policy since it achieves a higher level of abatement at lower costs to the industry as a whole.[9]

In the longer run, it may be worthwhile examining the possibility of relaxing the standard and increasing the charge. This should however be done bearing in mind that the quality of receiving water bodies does not deteriorate. The option to consider in the longer run therefore is that of relaxing the existing standard from 0.2 mg/litre to 0.3 mg/litre and levying a charge of Rs. 19,000 per mg/litre on units that fail to achieve the standard. This combination of a standard cum charge gives a higher level of total abatement (322.69 tonnes) and a marginally higher TAC of Rs. 57.38 million than the previous combination. The total cost to industry is still lower than that with the existing standards alone policy. In fact it is possible to gradually increase the charge up to Rs. 27,000 per mg/litre without surpassing the TAC with the existing standards alone policy (Rs. 68.7 million). In effect what this means is that inefficient units with high abatement costs will bear the burden of the higher charge, and therefore should, over time, switch to cleaner production processes. However, as mentioned above, it must be ensured that as charges are increased water quality standards are not violated at any location by firms that choose to abate less.

As in the case of TSS it is recommended that the charge be gradually increased over time, not only to adjust for inflation but also to provide further incentives for pollution reduction through the adoption of cleaner production techniques.

Table 8 gives a summary of the above results and points to the fact that it may be worthwhile relaxing the standard and levying a higher charge in order to achieve an optimal combination of pollution reduction, cost savings and revenue collection.

Table 8: Model results: Cyanide

Scenario	Total abatement	Total abatement cost	Total revenue
Current standard (Concentration based): 0.2 mg per litre of wastewater	247.85 tonnes	Rs 68.77 million	NIL
Standard plus: Current standard and a charge of Rs 18,000 per mg per litre of wastewater	12.8% increase	17.6% decrease	Rs 3.19 million
Standard plus: A relaxed standard of 0.3 mg per litre of wastewater and a charge of Rs 19,000 per mg per litre of wastewater	30% increase	16.6% decrease	Rs 4.03 million

9. The reliability of numerical values calculated by the model are dependent on accuracy of data provided by the steel plants. Since Bhilai and Rourkela have only recently installed treatment plants for cyanide, phenol and ammoniacal nitrogen, the recommendations for these three pollutants should be treated as tentative pending reliable data received from the steel plants.

Phenol

The functional form of the engineering cost equations for phenol (and ammoniacal nitrogen) is very similar to that of cyanide since the treatment process is similar. The sample of units includes the same three coke oven plants as with cyanide.

Inherent in the existing policy of a standard of 1.00 mg/litre is a total abatement level of 2178.31 tonnes. The total abatement cost for achieving this standard for the three units together is Rs. 146.29 million. There is a large degree of variation in abatement costs between different facilities. As indicated in Table 9 in Annex 2, marginal costs (MC) vary from Rs. 14091 to Rs 17487 and total abatement costs (TAC) vary from Rs. 32 million to Rs. 114.2 million.

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relaxing the standard and levying a charge does not provide the d with cyanide. However, as in the case of TSS it is recommended ally increased over time, not only to adjust for inflation but also to ves for pollution reduction through the adoption of cleaner

9 the advantage of switching to a standard plus scenario for phenol ue collected since the percentage changes in total abatement and mal.

	Total abatement	Total abatement cost	Total revenue
based)	2178.31 tonnes	Rs 146.29 million	Nil
and a re of wastewater	1.1% increase	Negligible change	Rs 4.49 million

ide, three coke oven plants operating in TISCO, Bhilai Steel Plant t are included in the analysis since they are the only ones that rogen.

g policy of a standard of 50 mg/litre is a total abatement level of al abatement cost for achieving this standard for the three units million. Once again the variation in abatement costs between s from differences in the initial pollution load, in influent of effluent discharged and the vintage of facilities. Marginal costs 78 to Rs 22,371 and total abatement costs (TAC) vary from Rs.) million.

lternative combinations of standards and charge levels, including tement (TA), total abatement cost (TAC) and total revenue (TR) . A range of options for combining various levels of charges with heir implications for total abatement, total abatement costs and Annexe 2).

that if the *existing standard of 50 mg/litre is combined with a 000 per mg/litre of ammoniacal nitrogen on all firms discharging* results in a considerably higher level of total abatement (7178.82 lower cost of Rs. 84.76 million. Total revenue collected amounts fact the iteration results show that charges can be increased to per mg/litre without exceeding total pollution abatement costs standards alone policy. The corresponding revenue collection is . 75 million. It is however recommended that the escalation in radually over time. As with cyanide, this policy is more attractive government than the standards alone policy since it achieves a at lower costs to the industry as a whole.[10]

10. The reliability of numerical values calculated by the model are dependent on accuracy of data provided by the steel plants. Since Bhilai and Rourkela have only recently installed treatment plants for cyanide, phenol and ammoniacal nitrogen, the recommendations for these three pollutants should be treated as tentative pending reliable data received from the steel plants.

Tightening the standard to 25 mg/litre and levying a lower charge of Rs. 2,800 per mg/litre reduces the total cost to industry to Rs. 90.83 million and results in a much higher level of abatement of 10416.72 tonnes. This option appears more attractive at an aggregate level and would surely produce a greater incentive for adoption of cleaner technologies. However once again, it must be ensured that quality of receiving water bodies at plant locations does not deteriorate.

As with other pollutants it is recommended that the charge be gradually increased over time, not only to adjust for inflation but also to provide further incentives for pollution reduction through the adoption of cleaner production techniques.

Table 10 summarises the results and compares them with the existing standards alone policy.

Table 10 :Model results: Ammoniacal nitrogen

Scenario	Total abatement	Total abatement cost	Total revenue
Current standard (Concentration based): 50 mg per litre of wastewater	6429.84 tonnes	Rs 122.5 million	Nil
Standard plus: Current standard and a charge of Rs 3,000 per mg per litre of wastewater	11.6% increase	30% decrease	Rs 32.25 million
Standard plus: A tightened standard of 25 mg per litre of wastewater and a charge of Rs 2,800 per mg per litre of wastewater	62% increase	26% decrease	Rs 38.05 million

Suspended Particulate Matter

Suspended particulate matter in the steel making process is emitted from a number of sources. For purposes of this study we have included seven units – five from TISCO (blast furnace, steel melting shop, power plant, refractory and sinter plant) and two Bhilai units (steel melting shop and refractory). All these units are required to meet a standard of 150 mg/Nm^3 of flue gas or 0.15 mg/litre of flue gas. Coke ovens which also discharge particulates, are required to meet a higher standard of 450 mg/Nm^3 and have not been included in the analysis.

The existing policy of a standard 0.15 mg/litre has an inherent total abatement of 28560.09 tonnes and a total abatement cost of Rs. 655.82 million. Marginal abatement costs vary from as low as Rs. 22 per mg/litre to Rs. 6,462 per mg/litre.

A series of iterations was conducted and various alternative combinations of standards and charge levels were examined for their impact on total abatement (TA), total abatement cost (TAC) and total revenue (TR). Annexe 2 gives a range of options for combining various levels of charges with different standards and their implications for total abatement, total abatement costs and revenues collected.

The analysis indicates that if the *existing standard of 0.15 mg/litre is combined with a pollution charge of Rs. 200 per mg/litre of SPM on all firms discharging more than the standard,* it results in a much higher level of total abatement (113878 tonnes) at a cost of Rs. 656 million, which is approximately the same TAC as with the standards alone policy. The total revenue collected amounts to Rs. 0.33 million.

According to our analysis relaxing the standard below 0.15 mg/litre and combining it with a charge, resulted in total abatement levels below those of the existing standard alone policy. We therefore considered tightening the standard to 0.1 mg/litre and 0.05 mg/litre. With a standard of 0.10 mg/litre and a charge of Rs. 180 per mg/litre the total abatement is still higher than the standards alone policy at 90807.21 tonnes and the abatement cost is almost the same at Rs. 656 million. Similar results appear with a standard of .05 mg/litre and a charge of Rs. 180 mg/litre. In view of the fact that tightening standards and combining them with charges do not give additional dividends in terms of cost effectiveness, it may be better to retain the existing standard of 0.15 mg/litre and combine it with a gradually increasing charge starting from Rs. 200 per mg/litre.

Table 11 provides a comparative summary of the above results for SPM where the base case is the existing standards alone policy.

Table 11: Model results: Suspended particulate matter

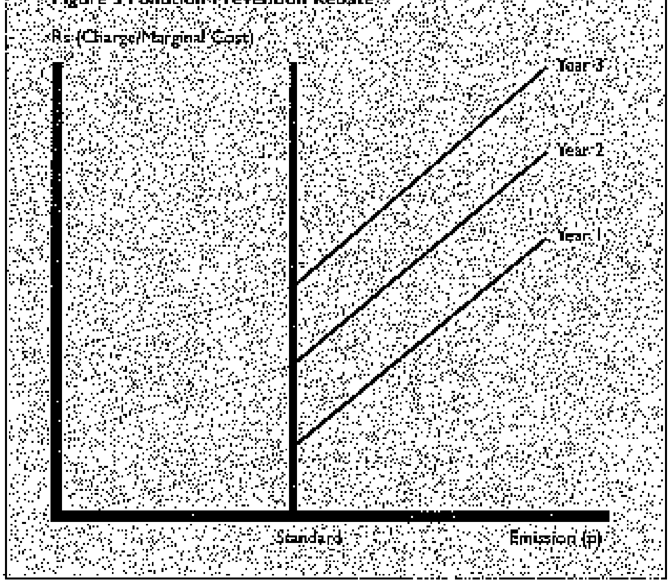
Scenario	Total abatement	Total abatement cost	Total revenue
Current standard (Concentration based): 150 mg per Nm^3 of flue gas	28560.09 tonnes	Rs 655.82 million	Nil
Standard plus: Current standard and a charge of Rs 200,000 per mg per Nm^3 of flue gas	100% increase	Negligible change	Rs 0.33 million
Standard plus: A tightened standard of 100 mg per Nm^3 of flue gas and a charge of Rs 180,000 per mg per Nm^3 of flue gas	21.8% increase	Negligible change	Rs 0.42 million

Scenario Two: Pollution Prevention Rebate

This option is an extension of the standard plus scenario whereby a rebate is provided to those firms or units that are able to reduce pollution emission levels below a specified amount (example, the level inherent in the discharge standard). Figure 5 below gives a general idea of how this system may work.

The idea of a rebate is to provide further incentives for adoption of pollution prevention methods and techniques. A rebate may be given to units who abate more than the standard recommended. In figure 5 this corresponds to the area to the left of the vertical line representing the standard. The amount of rebate will vary depending on how much revenue is collected from pollution charges, and on the criteria for disbursement of environmental funds (see section 3). The rebate could take the form of duty/tax exemptions not related to the pollution charge, reimbursement of expenditures up to a certain level etc. In general, it is recommended that the rate of rebate should be lower than the rate of charge.

Figure 5 Pollution Prevention Rebate



An example of a system of charges plus rebate is the Swedish scheme described in Annexe 3.

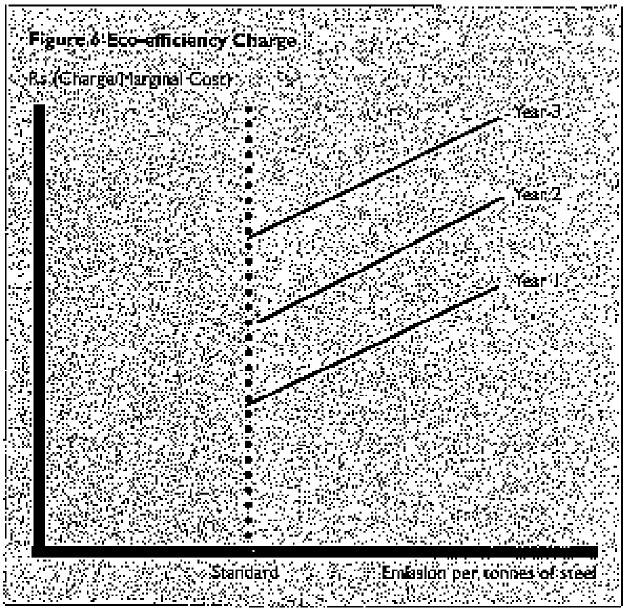
In the above two examples the charge is levied on the concentration of pollutant e.g. on total suspended solids per unit of waste water. If firms exceed the concentration based standard, they are charged a certain fee. This type of incentive scheme has the inherent disadvantage that firms could meet discharge standards and avoid fees by diluting their waste streams with fresh water. Moreover, it provides incentives for firms to meet discharge standards but not to go beyond the level of abatement specified in the standards, even if the marginal cost of abatement is small. This has been the experience in China where pollution control levies have not had the desired incentive effect. As reported by Florig et al, "fees are not indexed for inflation, and, for state owned enterprises, they can be included under costs and later compensated through price increases or tax deductions". To induce firms to go beyond compliance, a volume or mass based waste water discharge fee would be more effective (Florig et al, 1995). We now turn to what is termed an "eco-efficiency" charge that addresses some of the problems inherent in a concentration based charge.

Scenario Three: Eco-efficiency Charge

The "eco-efficiency charge" differs from the two scenarios described above in that the charge is levied on emissions per tonne of steel produced rather than on emission concentrations. The scheme would necessarily require that emission standards also be specified in terms of emissions per tonne of steel. This would require a substantive reform of the existing system of concentration based discharge standards. The possibility of this happening is not entirely remote, since the Indian Government has announced its intention to switch to mass or load based regulatory standards (Ministry of Environment and Forests).

Figure 6 illustrates how an eco-efficiency charge would work. Since the charge is linked to steel production it automatically adjusts to the rate of inflation. However, there is a danger that with continuous increases in the amount of steel production accompanied by less than proportionate changes in emissions the incentive to reduce pollution beyond compliance may erode. In order to safeguard against this possibility a gradual tightening of the charge linked to annual rates of increase in steel production is introduced. This is reflected in the upward escalation of the marginal cost curve as depicted in figure 6.

Figure 6: Eco-efficiency Charge



Model results for total suspended solids in TISCO (blast furnace, steel melting shop, rolling mill) and Bhilai steel plant (blast furnace, steel melting shop and refractory) indicate very substantial advantages in switching to an eco-efficiency charge of the kind described above. The current standard of 100mg/litre of TSS and a wastewater generation standard of 16 cu.meters per tonne of finished steel translates to 1.6 kg of TSS/tonne of finished steel. This corresponds to a total abatement of 26063.23 tonnes for all six units at a total abatement cost of Rs. 623.47 million if the industry were in full compliance. The degree of variation in costs between units is considerable. Marginal abatement costs vary from Rs. 2,8907 per kg/tonne of finished steel to Rs 2.14 million per kg/tonne of steel. It should be noted that in this case the variation in costs is due not only to differences in pollution loads (which is dependent on volume and effluent concentration of wastewater) and influent concentration, but also due to differences in the size of the units.

A series of iterations were conducted and various combinations of standards and charges were examined for their impact on total abatement, total abatement costs and total revenue. It was found that a charge of Rs. 82,000 per kg per tonne of steel combined with a mass-based standard of 1.6 kg/tonne of steel, gives a high level of total pollution abatement (174627.55 tonnes) at a lower cost to the industry of Rs. 619.82 million. Clearly this is a more cost effective policy than the standard alone policy. How does it compare with scenario one?

With scenario one (concentration-based standard plus charge) the percentage increase in total abatement is 7.76 and the percentage reduction in total abatement costs is 0.27. The corresponding figures for scenario three (eco-efficiency) are 570 per cent and 0.58 per cent respectively[11]. This demonstrates the tremendous advantages of switching to a mass-based eco-efficiency charge system. Table 12 summarises the above results.

11. It should be noted that the figures for total abatement and total abatement costs are not comparable under scenarios one and three. The calculation of total abatement (and costs) under scenario three is made on the basis of a direct translation of the concentration based standard of 100 mg/litre to a mass-based standard of 1.6kg of TSS per tonne of steel. This does not mean that the total abatement levels are comparable in absolute terms. What is comparable is the percentage change in abatement and abatement costs when pollution charges are added on in both schemes.

Table 12: Model results: Total suspended solids			
Scenario	Total abatement	Total abatement cost	Total revenue
Current standard(mass based): 1.6 kg of TSS per tonne of finished steel	26023.23 tonnes	Rs 623.47 million	Nil
Standard plus: Current standard and a charge of Rs 82,000 per kg of TSS per tonne of finished steel	570% increase	0.58% decrease	Rs 88.9 million

An additional advantage of the eco-efficiency charge is that it is more amenable to the introduction of intra-plant trades where the "bubble" covers the steel plant, and standards in terms of emissions per tonne of steel are set at the factory gate. This scheme is described in the following paragraphs.

Scenario Four: Intra Plant Trading

As mentioned in section 1.1, intra-plant trading schemes may be devised using second best cost minimisation models of the type used for modelling the first three scenarios. Ideally we should use such an economic analysis, based on marginal abatement costs to devise a permitting system. An alternative approach is to use the negotiated settlement route, as taken by the US Environmental Protection Agency for its steel water bubble policy (see Industrial Economics Inc.1994). In the following analysis we have combined the economic approach with the "negotiated settlement" route to devise a set of experimental intra-plant trades for TSS[12] in the TISCO plant. A similar exercise is possible for Bhilai.

On the basis of abatement per tonne of finished steel, which is 1.6 kg/tonne of finished steel by the current standard, it was found that in the blast furnace, steel melting shop and rolling mill of TISCO, the present abatement was 2022.7, 299.2 and 59.8 tonnes respectively. Current total TSS abatement by TISCO is 2381.7 tonnes. The rolling mill has the highest marginal abatement cost of the three units. Let us assume that TISCO management decides that the rolling mill should reduce its abatement by 30 tonnes, provided the other two units increase their total abatement by an additional 15%. The amount by which the other two units increase their total abatement is proportional to their respective marginal abatement costs. Therefore the blast furnace, with a lower marginal abatement cost, is responsible for 57% of the increase, and the steel melting shop is responsible for the rest. The results, which mean an increase in total pollution abatement before the pollutant leaves the factory gate, are given in Table 13 below.

Table 13: TISCO - Unit-wise and Total TSS Abatement with Negotiated Permit System				
Unit	Present TA	TA With Permits	TA Increase	TA Decrease
Blast Furnace	2022.7	2042.4	19.7	
SMS	299.2	314.0	14.8	
Rolling Mill	59.8	29.8		30
Total	2381.7	2386.5	34.5	30

Annexe 3 provides a description of how this methodology has been used in the US for the 'steel water bubble'.

Conclusions

The results described above point to the fact that a switch to mass-based standards and charges and intra-plant trades would result in a substantial reduction in pollution discharges at a considerable saving to industry as a whole. If the four scenarios are compared with the existing CAC system of discharge standards (which must be met by each unit within the plant) and ranked according to criteria of environmental efficiency and cost effectiveness, it emerges that eco-efficiency standards plus charges perform the best followed by concentration-based standards plus charges (with or without rebate). One explanation for the better performance of a system based on total pollution loads per tonne

12. Cyanide, phenol and ammoniacal nitrogen were not suitable pollutants since there is only one discharge outfall in the factory.

of steel, is that it encompasses volume of waste water discharged. A concentration-based scenario may be ineffective in bringing down pollution loads (unless accompanied by a wastewater charge) if firms resort to dilution of waste water. With a mass-based standard or charge, dilution would no longer be an attractive option for industry, and correspondingly pollution discharge levels will increase. Our results indicate, in addition, that this may well be at a lower cost to industry.

2.3 Evaluating the Scenarios

The previous section has described four hybrid scenarios, combining command and control measures with MBIs,[13] within the general decision framework of cost effectiveness. However, cost effectiveness need not be the only objective of policy makers. Issues pertaining to distributional justice, political acceptability, administrative feasibility, corporate response, monitoring, enforcement, legal and institutional requirements, are also important. Any evaluation of options open to policy makers should investigate the impact the chosen option will have on environmental effectiveness, economic efficiency and equity (O'Connor, 1996).

Environmental effectiveness essentially means the extent to which the policy instrument achieves the pollution reduction target. This target could be inherent in the existing standards or could be set by the pollution control authority depending on the nature of the pollution problem at hand.

Economic efficiency refers to the costs of achieving the pollution reduction target. This includes both pollution abatement costs as well as costs to the regulatory authorities of monitoring and enforcement.

Equity and distributional implications of a policy change will determine the extent of political acceptability of that policy choice. These issues are not only more difficult to analyse but are also probably the most crucial for political constituencies. By ignoring the redistributive effects of an environmental policy, we may either unintentionally harm certain groups in society or undermine the political acceptability of the programme (Baumal and Oates, 1988). With pollution charges based on the principle of polluter pays, the distributive implications of the tax would depend on the extent to which the incidence of tax is passed on to consumers in the form of higher prices. If the demand for finished steel is relatively inelastic (as it is likely to be) steel producers will be able to pass on a portion of the tax increase to their buyers.

Baumal and Oates (1988) and Freeman (1972) contend that environmental programmes are generally not very well suited to the achievement of distributional objectives, and that the primary purpose of environmental programmes is allocative. To address these distributive distortions, they suggest that environmental programmes and policies be accompanied by the use of adjustment assistance to spread the costs more evenly amongst society.

Clearly, any analysis of the distributive implications of a charge system for the steel industry would require a study of the finished steel market, a task that is beyond the scope of the present study but should be undertaken in the event that the Government of India introduces pollution charges. In this paper we have not analysed the distributive implications per se of the proposed policies, but have instead concentrated on two other aspects of political acceptability: one is potential opposition from steel producers on whom the tax is levied; and the other is that of public transparency of the policy instrument. The former problem i.e. that of political opposition from industry, is addressed by maintaining revenue neutrality of the tax in two ways: offering the possibility of a pollution prevention rebate; and, setting up a pollution prevention fund from the proceeds of the charge.

In this study we have chosen to evaluate the proposed policy scenarios according to a set of criteria that derive from the broader issues of efficiency, effectiveness and political acceptability discussed above. These are as follows (see Kumar and Sherif, 1994):

13. These are by no means the only options open to policy makers and various combinations of instruments are possible.

1. Does the policy achieve the stated goals in terms of pollution reduction?

Each of the four scenarios is designed to achieve a certain level of pollution reduction. The base case takes this as the level inherent in the specified discharge standard for each pollutant. All scenarios considered above surpass the total abatement levels inherent in the existing standard, and are therefore recommended in terms of environmental effectiveness.

2. Is the policy cost effective?

For each policy, the total pollution abatement cost of achieving the targeted level of pollution reduction is calculated and compared to the costs of the existing "standards alone" policy. Ideally, we should add a cost component corresponding to the monitoring and enforcement costs that would be borne by the regulatory authorities. However, due to the lack of accurate data , only a qualitative and rough idea of the latter is possible.

Policy combinations considered in the previous section have been selected only if they result in a lower or similar total abatement cost than the existing standard. This makes the proposed policies more cost effective than the existing standards alone policy.

3. Does the policy provide incentives for research and innovation for better pollution control and pollution prevention technologies?

This is an important criteria that has been included since a major theoretical advantage of MBIs is precisely that they provide incentives to go beyond compliance. An interesting study by Jung et al (1996) has evaluated the incentive effects of five environmental policy instruments and rank-ordered them, from most to least incentive, as follows: auctioned permits; emissions taxes and subsidies; issued marketable permits; and performance standards. This ranking is found to be invariant with respect to the size of firms, the size of the industry, or the industry's abatement cost structure (Jung, Krutilla and Boyd, 1996). Our findings are in line with this rank ordering, in that we find that intra-plant trades with mass-based standards and charges have the largest incentive effect, followed by the pollution prevention rebate and standards plus approach.

4. Is the policy administratively feasible to monitor and enforce?

The administrative feasibility of policy implementation depends to a large extent on the effectiveness of the administrative authority charged with monitoring and enforcing environmental protection measures. In the Indian context, the State Pollution Control Boards (PCBs) have been vested with the responsibility of monitoring and enforcing the existing system of discharge and ambient standards. The effectiveness of PCBs in undertaking this task varies a great deal between Boards in different states. The general feeling is that the pollution control boards are understaffed and lack adequate resources and facilities to effectively monitor and enforce the existing system.

Any of the four policy options described above would require effective monitoring and enforcement. The NIPFP study conducted by Shekhar et al has used a simple model developed by Malik (1992) to show that although enforcement costs can be higher for incentive based policies than for policies based on direct controls, no general result is available regarding which policy minimises the sum of abatement and enforcement costs. One recent paper by Gangopadhya, Goswami and Sanyal (1991) has examined the enforcement question on the assumption that enforcers are corrupt and want to maximise their own expected incomes. It has been shown that incentive compatible enforcement systems are feasible even if we assume that regulators are prone to corruption.

In any event, there is a case for investigating the possibility of: first, lessening the monitoring burden on the pollution control boards by encouraging self monitoring or third party monitoring; second, augmenting the resources of the PCBs and making them more effective. The mix of policy instruments in the four scenarios elaborated in this study addresses both these issues. A third aspect that becomes important in the case of pollution charges or eco-taxes is the administrative ability to collect tax revenues. As it stands, the Indian tax collection system appears to be reasonably effective at least in terms of the tax collection machinery, although problems of tax evasion do exist. A fourth issue that is of relevance to tradable permits is the existence of an institutional machinery for issuing permits and monitoring trades (O'Connor, 1996). This can be a serious constraint in the Indian case. Fortunately however the institutional demands of intra-plant trading (as opposed to inter-plant trades) are confined to the management of the steel plant. The plant authorities are responsible for allocating permits to their different facilities and for recording and checking trades against actual emissions. The effectiveness of this task is therefore an internal managerial problem and not an additional burden on the PCBs. As will be discussed in a later section, there could be considerable differences between public and private sector companies in the effective management of intra-plant trades, due largely to their different accounting systems.

5. Is the policy publicly transparent?

Public transparency of an environment policy instrument includes a number of aspects. The first and simplest is that of public visibility, which can be enhanced through advertising and announcing the pollution charges well in advance of their imposition. But transparency can also increase risks of failure (O'Connor, 1996). Since MBIs make the costs of control more apparent than discharge standards, the taxed party, in this case the steel industry, may object much more to pollution charges than to discharge standards, even if the loss in producers surplus is smaller. If standards are combined with pollution charges, the transparency problem of pollution charges is mitigated to some extent. The same argument is true for the eco- efficiency charge cum standard policy. Transparency is enhanced if the charge is combined with a standard.

Conclusions

Going beyond the issue of cost effectiveness and environmental efficiency to questions of political acceptability and transparency affects the performance of the four scenarios. Table 14 below gives an overall assessment of how the scenarios perform when ranked according to the evaluation criteria.

Table 14: Evaluating the scenarios

	Environmental efficiency	Cost effectiveness	Incentives	Feasibility	Transparency
Standard plus	**	**	*	***	***
Tax/Rebate	**	***	**	**	**
Eco-efficiency	***	***	**	*	**
Intra-plant trade	***	***	***	*	*

All policy combinations achieve more pollution abatement for less cost than the existing CAC system. However, the eco-efficiency and intra-plant trade scenarios perform better in terms of effectiveness, efficiency and incentives than the standards plus and tax/rebate scenarios. This picture changes somewhat when we consider political feasibility and transparency as evaluation criteria. It should be noted, that unlike the first two criteria, the latter two depend on qualitative assessments.

This combined quantitative and qualitative analysis points to two main conclusions:

- first, that an MBI strategy should start with a politically acceptable and publicly transparent standards plus scheme based on existing concentration discharge standards. It should gradually evolve a more efficient and effective system based on pollution loads per tonne of finished product; and
- second, MBIs should be introduced on a case by case basis for each pollutant and policy mix since a blanket prescription is not possible.

Chapter 3

Exploring the implications

Chapter 3

3. Exploring the Implications

Clearly, if MBIs were to be introduced in India, they could not be limited to the steel sector. Broader structural changes to existing legislation and administration would be required, adapted to the special circumstances of each sector's requirements. This section looks beyond the steel industry to make general conclusions about the role of MBIs within India's environmental policy. Irrespective of which scenario or combination of policy measures the Government selects, it is imperative that the broader implications of any policy reform be analysed prior to its implementation. In the following paragraphs we attempt to do this by looking at the implications of introducing MBIs within the existing policy environment including aspects such as: the presence of price distortions prevailing in the steel sector; use of revenues; coherence with existing environmental policies; and, monitoring capabilities. We also analyse the implications of policy reforms for the corporate sector and make suggestions on how the policy should be introduced and phased in order to minimise any adverse implications either at the macroeconomic or the micro levels.

3.1 Regulatory Reform

India's existing environmental policy system makes little use of MBIs. In the real world, policy makers have to build on inherited regulatory systems, adjusting these to the opportunities provided by MBIs. If MBIs are to be harmoniously married with the existing system, then the following six issues of regulatory reform will need to be tackled.

i. Legal sanctions, fines and MBIs: avoiding double jeopardy

Existing environmental regulations require companies to comply with prescribed norms for effluent/emission discharges. Contravention may result in imprisonment, a fine or both. This fine is currently levied at a flat rate, irrespective of the quantum of pollution discharged above the compliance. If a company is not to be faced with the prospect of paying twice for the same pollution, then the relationship between MBIs and legal sanctions would need to be re-examined. In the Netherlands, the Dutch have maintained the ultimate sanction of legal action and fining recalcitrant polluters in addition to the use of water effluent charges designed to stimulate pollution prevention (see Annexe 3).

Clauses in the existing regulation relating to threat of closure or imprisonment should also be re-examined. A priori considerations suggest that the provision of closure or imprisonment should be retained in some appropriate form to prevent the use of MBIs as a "license to pollute". If this is not the case then some companies may continue to discharge large amounts and pay the higher charges rather than cut down on pollution loads. Accordingly, the cutoff limit for empowering regulators to effect closure of the erring unit must be specified. This limit may be specified according to ambient air and water quality requirements by the concerned state pollution control boards. Advance specification and advertisement of these limits will also enhance public acceptability of the charge.

With the introduction of MBIs, the issue of defining damage liability becomes important. Experience in the USA has shown that defining liability laws is a complicated task that requires a fairly complex legal system. Since India does not yet have a system for addressing legal problems related to environmental damage, it may be not be cost effective to introduce the idea at this stage. However, the introduction and/or continuation of a ceiling as described above should accompany a policy of MBIs.

ii. Policy design and administrative co-ordination: the centre and the state

A critical legal implication of introducing MBIs is that of jurisdiction. Presently the Government of India promulgates three environmental laws: the Water (Prevention and Control) Act, 1974; the Air (Prevention and Control) Act, 1981; and, the Environment (Protection) Act, 1986. These laws vest authority in Central/State Pollution Control Boards and the Central Government to prescribe standards for water and air quality (ambient and site specific). As it stands, this provision does not include the power to prescribe effluent/emission charges or any other kind of MBI which has economic implications for industry. Therefore adjudicating an MBI policy would warrant necessary amendments in existing environmental regulations, including appropriate centre-state jurisdiction for different media such as air and water.

iii. Water cess and MBIs: achieving coherence

The Water (Prevention & Control) Cess Act, 1977 is India's main environmental use of economic instruments. Under this Act certain specified industries are required to pay cess on the quantity of water consumed. The primary objective of the water cess is to augment the resources of Pollution Control Boards and not to provide incentives for water conservation or water treatment. The cess as it presently exists is levied on water use and not on pollution.

If effluent charges are levied on the discharge of water pollutants in conjunction with the existing system of a water cess, the prospects for co-existence and coherence of the two systems must be analysed in terms of their respective benefits (revenue) and impacts. In particular it will be important to analyse the extent to which an effluent charge does or does not impact on water use. If, as has been mentioned earlier, the effluent charge is accompanied by a charge on the volume of waste water, it is likely that the objectives of the water cess, in terms of reduced water use, will be met by the waste water charge. In this case it would be appropriate to integrate the cess and the charge. If however the water cess is to co-exist with an effluent charge it will be important to avoid duplicating cumbersome procedures in the assessment of the cess and the charge.

Another related issue is that of water pricing. For any system of MBIs to work effectively, the pricing of resources must reflect their true scarcity. India has traditionally subsidised the use of water (and energy) in almost all sectors including industry. With growing economic liberalisation, MBIs should be phased in gradually and should be accompanied by a gradual phasing out of fiscal subsidies especially for water and energy resources. The work undertaken by Bhatia, Rogers et al is a significant contribution towards a rational pricing of industrial water resources in India (see Bhatia et al, 1994). The authors have undertaken an empirical analysis of the industrial sector in Jamshedpur by simulating the impact of increases in water price and effluent charges on water quality and water use for the TISCO steel plant. [14]

They find, not surprisingly, that "water prices, effluent charges, and fiscal incentives are effective management tools for improving water quality and managing the use of total water resources. However, the application of these tools needs to be carefully orchestrated. For example, when water prices are low, conservation and recycling are not attractive options regardless of the level of effluent charges". This conclusion is valid for the present study as well. If the Government introduces MBIs, especially in the form of pollution charges, it must rationalise the pricing structure for key resource inputs such as water and energy. An in-depth analysis on the levels of pollution charges combined with appropriate levels of resource pricing would be a useful complement to this study.

iv. Fiscal subsidies and MBIs: from government pays to polluter pays

Indian economic policy has traditionally relied on subsidising energy, water and other raw material inputs needed by industry, especially heavy or "core" industries such as steel, coal and power. Consequently pricing of water and energy has not reflected the true scarcity or price of the resource. Recent liberalisation measures have attempted to rectify some of these imbalances, especially in the area of trade barriers and investment incentives (foreign and domestic). However, price distortions in energy and water still remain. To what extent does the persistence of such policy failures impact on the efficacy of MBIs for pollution prevention? Conventional economic theory suggests that an industrial sector facing soft budget constraints responds sluggishly to pollution charges or to fines for non-compliance. This has been the experience of Poland and the former East Germany (see Panayotou, 1992).

Others have countered that economic instruments for pollution control can achieve real benefits even in the presence of distortions. China, for example, has instituted a system of pollution levies that has worked reasonably well even though price reforms have a long way to go (Florig et al, 1995). Permit markets, being quantity-based market instruments are likely to be more effective than other policy tools (including CAC and pollution charges) in the presence of market distortions and soft budget constraints (Zylicz, 1994). Another study has assessed the results of introducing economic instruments in Estonia whose economy is still partly characterised by centrally fixed prices and soft budget constraints in some sectors. It concludes that although market instruments cannot work perfectly in such a system, there is considerable scope for combining some elements of regulations, economic instruments and resource pricing by following a pragmatic approach to the implementation of MBIs (Kallaste, 1994).

14 Bhatia et al. treat TISCO as a cost minimising firm with a given production function, an assumption that is compatible with the model used in the present study.

v. The use of revenues: setting up a fund or reforming the tax system ?

Although the primary purpose of the MBIs illustrated in the four scenarios is to provide incentives for pollution prevention, some revenue will be raised for government authorities.

To minimise negative impacts on competitiveness, money raised from the MBIs should be revenue neutral for industry as a whole so as not to add to the overall fiscal burden. The question remains of how to use the revenues: whether to set up a ring-fenced fund for environmental purposes outside of the normal budgetary process, or to use the revenues to cut other distortionary taxes on labour or investment.

The first option is to set up a *pollution prevention fund*, focused on financing efforts in the industry sectors affected by the MBI to accelerate the spread of techniques and technologies to prevent pollution, thereby complementing the objectives of the MBI itself. A portion of the funds could also be earmarked for the state pollution control boards to cover the costs of collecting the MBIs and to the central authorities to finance studies into the design of MBIs. This has been done quite successfully in China where roughly 80% of revenues are lent or granted to enterprises for pollution control, and the remaining 20% goes to upgrade the capabilities of monitoring and enforcement agencies (O'Connor, 1996).

Setting up such a fund could increase political acceptability and transparency, and could help persuade industry that the charges that they are paying will not become absorbed in the government bureaucracy. This could be further enhanced by involving industry and environment NGOs on a steering panel for the fund. The pollution prevention fund might also be particularly appropriate where large revenues are not anticipated, and where the government does not wish to create dependency on a source of funds whose revenues may decline over time. The major drawback with this approach is that it reduces government flexibility in revenue disbursement. Box 4 suggests a possible scheme for administering a pollution prevention fund. Further work is needed to decide the balance between grants and loans; between sectoral and a common pool of funding; and between establishing state-level funds and a single national fund.

BOX 4 MANAGING THE POLLUTION PREVENTION FUND

ACTIVITY	RESPONSIBILITY
Submission of Modified Environmental Statement	Industry
Collection and Monitoring of tax	State Pollution Control Board (SPCB) will collect and transfer the revenue on a quarterly basis to the financial institution
Verification of Compliance	State Pollution Control Board on the basis of monitoring and analysis carried out by a recognised environmental laboratory
Establishment of the Fund (similar to the Environmental Relief Fund under the Public Liability Act)	Financial Institution (central level)
Apportionment of the Fund	Financial institution with possibly 30% of funds for the centre for supporting environmental policy initiatives and high priority programmes and services; and 70% for state level activities that accelerate environmental improvement in industrial enterprises. Unutilised funds from states' shares could be transferred to the central share after a two year period.
Disbursement of the Fund	Financial Institution on the basis of recommendations from a governing panel representing SPCBs, CPCB, industry associations and environmental organisations.

It is important that well designed procedures are elaborated to ensure that the fund targets priority environmental problems and that revenues are spent effectively. Three broad areas can be identified for effective use: strengthening enforcement capabilities of state pollution control boards; providing incentives to industry for adoption of cleaner production techniques; and raising awareness about the benefits of environmental protection. The latter may include a programme designed on the lines of the PROPER PROKASIH programme in Indonesia.

In this respect OECD's *Guidelines on Environmental Funds in the Transition to a Market Economy* (OECD, 1995) could also be useful for the Indian context. These guidelines stress two key environmental policy considerations to guide the design and operation of

BOX 5 The Lessons from Environmental Funds

The Environmental Action Programme for Central and Eastern Europe (EAP) recommends that Economies in Transition should set clear priorities for short-term environmental actions, based on an assessment of the most serious problems in terms of their impact on human health and the natural environment. Specific national priorities can be set through the development of a National Environmental Action Programme. The EAP argues that the most cost-effective and lasting solutions will require concurrent work in three areas: policy reform, institutional strengthening and investments. In this context, Environmental Funds can be most effective if they focus their spending in areas such as the following (Lovei, 1994b):

1. Supporting the improvement of environmental policy

Strengthening enforcement. In the long run, environmental improvements should increasingly be financed from private sources, in response to taxes and charges, regulations, and enforcement. To make this possible, proper enforcement of environmental policies and requirements will be essential, and will require the development of effective, independent environmental inspectorates.

Both these elements are essential for a wellfunctioning environmental policy. Where adequate resources are not available from the government budget, Environmental Funds could assist with financing.

2. Accelerating the process of environmental improvement in industrial enterprises

– Co-financing environmental audits. Modifications in existing production processes and management practices at industrial plants can provide initial reductions in pollution loads that are far more cost effective than pollution control investments. Environmental Funds can accelerate their adoption by promoting environmental audits.

– Supporting priority investments in the enterprise sector. While these depend on country conditions, the EAP identifies three key regionwide problems: reducing particulate emissions from ferrous and nonferrous metal plants; reducing toxic air pollution that affects large populations; and pretreating wastewaters from industrial plants that discharge high levels of heavy metals and toxic chemicals.

3. Financing the provision of high priority environmental programmes and services

– Conserving natural resources and biodiversity. In particular, there are priority areas where financing is needed to prevent irreversible damages and large future costs.

– Priority environmental programmes. Environmental Funds can help finance initiatives that tackle specific national priorities. For example, Funds can support actions to protect groundwater from non-point source pollution or can mobilise private investment to convert from coal to natural gas heating in highly polluted cities.

– Financing environmental infrastructure. In this area, Environmental Funds should focus on priority projects. Where possible, cost recovery through user charges and financing from other sources should be tapped.

environmental funds[15]. The first is that the fund should support the implementation of a coherent environmental policy; and the second is that it should not violate the polluter pays principle. Box 5 gives more details on OECD criteria for disbursement of environmental funds for transition economies.

The second option is to use the revenues from MBIs to cut other taxes and charges on business in a form of *ecological tax reform* (ETR). From the point of view of economic theory, this would be the most desirable outcome, as it would allow the economy to reap win-win gains in terms of internalising environmental costs and removing fiscal distortions. Strong arguments have been made, particularly in Europe, for a wide-ranging reform of the fiscal system to shift the burden of tax from 'goods' such as labour and investment and onto 'bads' such as pollution and resource depletion. However, the ETR approach risks obscuring the original incentive aims of the MBI and would only be advisable when the MBIs would bring large and predictable flows of funds. Furthermore, additional general equilibrium analysis of a proposed tax scheme would have to be carried out (O'Connor, 1996).

In view of these considerations, and the fact that revenue generated from MBIs is not likely to be that large relative to the Government budget, we propose the establishment of an earmarked pollution prevention fund.

vi. Administration: policy design and monitoring capacities

The introduction of MBIs will change the existing regulatory system and require new skills and resources in government. According to a Winrock International report for USAID, these include capacity of government to "(a) design and administer the instrument; (b) monitor experience with it; (c) enforce the conditions of instrument use; and (d) modify the instrument in response to changing conditions" (Winrock, 1992). In terms of administration, there is also often a 'virtue of simplicity', and Winrock adds that "there is a trade-off between designing a simple system that can be implemented with limited effort and a complex system that is capable of yielding 'optimal' results but is beyond the administering agency's capabilities".

To deal with this challenge, the Government should draw up and implement a *capacity development plan*, specifying the investments in personnel, procedures and technology that would be required to manage the MBI in practice; the plan should be self-financing from the revenues of the MBI itself. One particular need would be to increase the number of personnel skilled in environmental economics to design and upgrade any MBIs; in addition, more general awareness raising and training sessions could be required to inform existing pollution inspectors of the new regulatory issues raised by MBIs. Greater understanding of the dynamics of industrial innovation would also be required to allow the cost functions governing the MBIs to be revised in line with technological change. As part of this plan, the Government should assess alternative options for monitoring and enforcement, relying on third party verification or negotiated agreements with industry, thus shifting part of the burden onto industry itself.

In the case of intra-plant trades and pollution charge and permits set at the factory gate, the Government would need to set conditions of the establishment of more environmental laboratories to cater to the growing needs of industry, specially for the purpose of verification of compliance. A switch to a hybrid system of market-based instruments and command and control may in fact increase the number of disputes relating to monitoring results and the collection of revenues. One suggestion is to ask industry to submit periodic pollution generation returns on the basis of data generated through monitoring and analysis carried out by the environmental laboratories recognised by Central/State Governments under the Environment (Protection) Act, 1986.

Reporting requirements and procedures would also need to be adapted. In particular, the Government would need to establish clear definitions of pollution abatement costs and then require companies to report these on a regular basis so that the MBI could be adjusted to changing conditions.

15. It should be noted that the term Environmental Funds as used by OECD differs from the Pollution Prevention Fund proposed here, in that the former can be used to finance environmental protection initiatives not directly linked with industry, whereas the latter is restricted to the industrial sector.

3.2 Corporate Environmental Management

Promoting Environmental Accounting in Business

Environmental accounting has emerged as one of the new challenges for business in North America and Europe as companies strive to go beyond a purely physical approach to environmental management. Environmental accounting can be classified into four main categories:

- Identifying and calculating potential *environmental liabilities*;
- Identifying and allocating internal *environmental management costs*;
- Identifying and appraising the costs and benefits of *environmental investments*;
- Identifying and assessing the *environmental externalities* of processes and products

(BT, 1996).

In the USA, studies have shown that pollution prevention activities were most successful where some form of environmental accounting was being practised. However, according to the *Green Ledgers* report from the World Resources Institute (WRI), "conventional accounting practices developed to serve financial reporting requirements rarely illuminate environmental costs or stimulate better environmental performance" (WRI, 1995). Difficulties arise from the absence of standard accounting rules for defining and evaluating environmental costs and benefits. It is also important to distinguish between the environmental costs borne by firms and wider environmental costs externalised by firms onto society: the aim of regulation is to push these external costs into the corporate domain so that the polluter pays. Traditional environmental regulation does not generally make these environmental costs explicit for firms, but rather results in firms paying 'proxy' costs in the form of permit fees, investments in pollution control and environmental management expenditure.

Environmental costs can be incurred at every stage of industrial activity, sometimes amounting to as much as 20 per cent of total costs. For one US company, environmental costs exceeded the operating profit for a particular product (WRI, 1995). These costs can include raw material costs (such as the value of lost inputs and the cost implications of environmental product specifications), capital costs (such as depreciation on pollution control investments and maintenance), management costs (such as time spent on compliance monitoring, legal expenses, environmental training) and waste treatment. These costs can be difficult to control if they are accumulated as overheads rather than traced directly to their source. The nine companies that worked with WRI on its environmental cost accounting project found that a clearer understanding of full environmental costs yielded numerous benefits. These ranged from core business issues such as making decisions on their product mixes and choosing least cost manufacturing inputs, to assisting in the assessment of pollution prevention projects and the evaluation of waste management options. Companies can also use environmental accounting to compare environmental costs across facilities, thereby facilitating the transfer of best practice within their organisations. Ultimately, a sound knowledge of environmental costs could drive corporate decisions on the pricing of products and indeed, which products to make and market.

Intuitively, there is a strong complementarity between market based instruments and environmental accounting. Both focus on the costs of environmental action. MBIs give companies a further incentive to develop accounting procedures as part of their environmental management systems, which enable them to accurately allocate costs (such as pollution charges) and benefits (such as rebates) to the appropriate unit: environmental accounting is thus a natural corporate complement to MBIs, both aiming to make the polluter pay.

The introduction of MBIs would pose a new challenge for corporate environmental management. Companies would be required to move from an essentially legal response to environmental regulation (are we in compliance?) to a financial response (are we minimising our environmental costs?). For example, in the case of a pollution charge, companies would need to be able to assign the payments to the polluting units; distributing the costs of a charge as an overhead would defeat the economic purpose of MBIs. A company's capacity to respond effectively to the incentives provided by MBIs would depend heavily on both corporate culture and financial accounting systems. Companies that retain a planning culture could fare less well compared with those with a market culture, reflected in the allocation of environmental costs and benefits to the appropriate units throughout the organisation.

Both TISCO and SAIL already publish details of pollution control investments in their annual environmental reports; TISCO also includes the costs of the water cess, power consumption for pollution control and environmental management costs and adds details of fiscal subsidies it is claiming. If MBIs are introduced more widely, the financial implications of the environment will become increasingly pertinent for both internal management and external reporting.

The natural starting point for environmental accounting is to build on existing corporate efforts to design and operate environmental management systems. Currently, neither the BS7750 standard nor the draft ISO standard explicitly requires companies to assess environmental costs and benefits. These therefore need to be supplemented by simple and low-cost accounting procedures. Based on the recommendations of an international review of environmental accounting in industry, three steps could be considered by companies in India on a 'no regrets' basis to prepare for MBIs (BT, 1996):

- Include market based instruments within a regular corporate statement of environmental expenditures and revenues.
- Allocate MBIs to the appropriate units as part of a wider effort to take environmental costs out of overhead accounts and assign them to selected processes.
- Introduce different scenarios of future MBIs into capital budgeting processes.

Although most companies have yet to deal adequately with their internal environmental costs, it could still be useful for companies with long-term investment horizons to consider evaluating the external environmental costs (and benefits) that they are generating. Canada's Ontario Hydro, one of the pioneers of accounting for external costs, believes that 'in the long run it is better for industry to recognise these costs now, since as legislation and regulation develop today's externalities can quickly become tomorrow's internal costs' (BT, 1996). In Europe, the BSO/Origin software company has taken the lead by calculating the financial costs of the environmental externalities it generates, and then subtracting from this the amounts it pays in environmental charges on fuel, water and waste to arrive at a figure for its 'net value extracted'.

Chapter 4

Conclusions

Chapter 4

4. Conclusions

This concluding section highlights the study's basic findings and describes the insights gained in a number of critical areas: methodology; policy and corporate implications; capacity strengthening; areas for further research; and thoughts towards developing an MBI strategy.

4.1 Summary of Findings

The study proposes four policy scenarios that combine regulatory discharge standards with MBIs. The first scenario is a 'Standards Plus' option that combines concentration-based discharge standards with pollution charges, where the charge is levied on pollutants unabated up to the specified standard. The second scenario is an extension of the first and allows for a rebate to be paid to those units that abate more than required by the standard ('Pollution Prevention Rebate'). The third policy option is the 'Eco-Efficiency Charge' which envisages a move to mass-based standards and charges that are economically and environmentally more efficient than concentration-based measures. The fourth scenario of 'Intra-Plant Trades' introduces the option of a company to trade permits for pollution for different units using mass-based standards set at the factory gate.

These policy scenarios are evaluated according to five criteria of cost effectiveness, environmental efficiency, incentives for innovation, administrative feasibility, and public transparency. An additional scenario that considers only pollution charges as the policy instrument for pollution abatement was discussed briefly. Quantitative analysis of this scenario in terms of total abatement and abatement costs was also undertaken. However a pure charge policy was not considered a realistic option in the Indian context. The institutional machinery for pollution control in India is geared towards standards and the introduction of charges should be seen as a supplement or complement to the existing system. Moreover, doing away with standards altogether would not be a desirable outcome from the environmental and economic point of view either. The study therefore concentrates on policy options that build on existing institutional mechanisms and combine a system of charges with discharge standards. This combination of MBIs and CAC measures also ensures that policy instruments are designed to go beyond the sole objective of revenue collection to provision of incentives for pollution prevention as well.

As a result, the study found that a number of general conclusions could be made:

- The introduction of MBIs must be done on a case by case basis for each pollutant and policy mix since a blanket prescription is not possible.
- Scenarios that combine CAC measures with MBIs are more cost effective than existing standards i.e. they achieve more pollution abatement for less cost to the industry as a whole.
- A fairly precise quantification of environmental efficiency and cost effectiveness is possible and MBIs perform well according to these criteria.
- It is more difficult to assess administrative feasibility and public transparency of policy instruments. Even so, the most efficient and effective instruments rank lower when assessed against criteria of feasibility and transparency.
- Low pollution control cost companies benefit from a mixed policy and high cost polluters lose unless they change to cleaner technologies.
- A pragmatic MBI strategy should start with a politically acceptable and publicly transparent 'Standards Plus' scheme based on existing concentration discharge standards and gradually evolve a more efficient and effective system based on pollution loads per tonne of finished product.

4.2 Assessing the Methodology

The methodological approach used in the study is based on a cost minimisation model which is an acceptable second best approach for devising market based instruments. As mentioned at the outset, the ideal approach would be to evaluate marginal costs and benefits of pollution abatement and use the resulting optimal allocations as a basis for devising MBIs. This, however, is not practically feasible since an estimation of marginal damages would be difficult if not impossible given data limitations. Standard economic theory on cost minimisation has proven to be a good second best approach.

The more interesting debate with respect to methodology relates to the formulation of cost functions. The present study has made use of engineering cost functions for pollution abatement based on treatment technologies used in the steel industry. From a purely theoretical point of view, it would have been better to use economic cost functions whereby the functional form of the cost function is derived from maximising the production function subject to a number of constraints. In the Indian context, we found that the data on a number of parameters required for estimating economic cost functions were not available and would have had to be approximated on a rough basis. This implies that the resulting marginal cost equations would in all probability be inaccurate approximations of real marginal costs, giving misleading results. The probability of such errors with technologically specified engineering cost equations is lower and correspondingly the accuracy of marginal costs is higher.[16] Of course, if time and resources are available for more intensive data and information gathering, it would be ideal to derive behavioural cost equations, and this could be a fruitful area for future research.

The engineering cost functions used in the present study are based on a number of assumptions specified in Annexe 1. Although some of these assumptions are rigid, there are ways to relax them and to carry out a sensitivity analysis with respect to each. For example, the assumption of zero innovation and no technological progress can be fairly easily dealt with by introducing an innovation factor representing the application of cleaner production technologies. In the longer term, the widespread adoption of cleaner technologies can reduce the conflicts between environmental quality and financial returns for the enterprise. Incorporating such an innovation factor is therefore considered desirable and would also strengthen the case for levying a charge on pollution levels that exceed regulatory standards. Innovation in pollution prevention and control technologies will shift the abatement cost curves downwards over time, thereby making it possible to abate more than required by regulation alone. This expanded model can also be used to examine the relative technology diffusion effects of MBIs and existing CAC measures. In the long term, an

16. For example, one recent study has used economic cost functions for deriving policy instruments (James and Murthy, 1996). The values for R^2 corresponding to these functions were considerably low.

important determinant of the success and failure of environmental protection policy will be precisely the extent to which such policies result in the development and spread of new technologies. Jaffee and Stavins (1995) have developed a theoretical framework for an empirical comparison of the effects of alternative policy instruments on the diffusion of new technology, which can be a useful starting point for future work in this area.

The study has evaluated and ranked the four different policy scenarios according to five pre-determined criteria. Scenario rankings show that the performance of policy measures changes when qualitative assessments of administrative feasibility and public transparency are added to the more precise criteria of environmental efficiency, cost effectiveness and incentives for innovation. Assessments on the basis of the latter three give high grades to scenarios three and four ('Eco-Efficiency Charges' and 'Intra-Plant Trades') whereas evaluations on political acceptability are not as favourable. This is an important result and worthy of more rigorous treatment. It would be desirable to make a more quantitative analysis of the performance of economic incentives with respect to administrative feasibility and public transparency. One step towards achieving this would be to incorporate monitoring and enforcement costs explicitly in the cost equations and derive the corresponding marginal cost equations. Marginal costs equated across firms would then give a charge level that minimises abatement costs to the firm as well as monitoring costs for the Government. It may well be that proposed charges are higher than those indicated by the present study. However, the magnitude of the difference will depend on the type of policy scenario and the implied burden on monitoring and enforcement. With the 'Eco-Efficient Charge' and 'Intra-Plant Trade' scenarios, the inclusion of monitoring and enforcement costs may not make much difference to levels of charges. It would, however, reflect a more accurate analysis of the problem.

Experience with the collection of data on pollution emissions and control costs has shown that at the outset the project sought to collect too much information, some of which turned out to be superfluous. This may be because the research team designing the questionnaire erred on the side of caution. Future studies of this kind could well be conducted with a more streamlined questionnaire to economise on time and information requested from companies.

In summary, the methodology could be improved in the following areas:

- remodelling on the basis of behavioural economic cost functions for pollution abatement. It may be useful purely from a conceptual point of view to compare the policy outcomes using behavioural cost functions as opposed to engineering cost functions.
- introducing a dynamic innovation and technological progress variable in the model to examine the relative technology diffusion effects of MBIs versus CAC measures.
- evaluating MBIs on a quantitative basis with respect to administrative feasibility and public transparency criteria.
- incorporating monitoring and enforcement costs in the equations.
- improving the design of the survey questionnaire

4.3 Policy Design and Implementation

The study has looked beyond issues of methodology and modelling to questions of designing and implementing MBIs for pollution prevention. The study took a pragmatic stance, seeking to identify those scenarios which could enhance the performance of India's environmental policy at a time of rapid economic change. The study started from the general assessment that existing regulations have not adequately controlled or prevented pollution from large and small scale industry. Current regulations also emphasise end of pipe treatment rather than pollution prevention which is often not the most economically efficient option. Furthermore, the main economic instrument used in India's environmental policy - the water cess - is geared towards raising revenue rather than providing an incentive for pollution prevention. Government of India subsidies, such as the relaxation in custom and excise duties and depreciation for pollution control equipment, are also biased towards capital expenditure on end of pipe treatment: they do not focus on cleaner production processes or offer incentives for the actual operation of the equipment.

Introducing market based instruments with the purpose of providing incentives to polluters to find the least cost option to achieve environmental targets is therefore of immediate policy relevance in the Indian context. The present study should be viewed as a step forward in adding to the policy debate on market based instruments by providing a methodology for the industrial sector to devise practical and realistic measures.

As Chapter 3 revealed, the implications for policy of a shift towards greater use of MBIs in India's environmental policy are numerous. Designing and implementing any one of the four scenarios for MBIs would require a reform of the existing regulatory framework. Issues that would require particular care by policy makers relate to:

- the compatibility of new MBIs with existing laws, legal sanctions and fines to ensure that companies do not face double penalties.
- the coherence between the existing water cess (the only economic incentive being used at present) and proposed pollution charges. In particular it is important to analyse the extent to which an effluent charge impacts on water use.
- the effectiveness of MBIs in the presence of currently subsidised water rates for industrial uses. For any system of MBIs to work effectively, the pricing of resources must reflect the true scarcity and opportunity cost of the resource.[17]
- the use of revenues raised from pollution charges in a manner that would minimise competitiveness impacts on industry. Revenues could be earmarked for a 'Pollution Prevention Fund', which could then be used to: strengthen the monitoring and enforcement capabilities of pollution control boards; assist industry in the adoption of cleaner production techniques; and promote environmental awareness among the public and industry. The Indonesian PROPER programme could be a useful model for this.

4.4 The Corporate Sector

One of the more innovative aspects of the study was the decision to undertake applied economic research on the use of MBIs with the business sector. To date, business has usually not been involved in the analysis of how MBIs could help raise environmental performance, while promoting industrial competitiveness. In the OECD, this has meant that industries potentially affected by MBIs have taken a reactive and often negative stance. By involving industry representative from the outset certain preconceptions about the impact of MBIs could be allayed. In fact, the New Delhi workshop generated a highly positive response from assembled business executives on the impacts of MBIs on corporate prospects:

- MBIs would provide greater scope for companies to become competitive, opening up the potential for greater flexibility by firms to meet environmental goals.
- The use of MBIs could involve increased start-up costs for business in the start-up phase, but the cost of control per tonne of product would fall over time.
- The introduction of MBIs would provide an incentive for pollution prevention and would trigger innovation. To maximise this potential, full cost pricing of resources would be needed along with the removal of subsidies on resource inputs.
- There could be transitional problems faced by small and medium sized enterprises. Options suggested to overcome this structural reality included phasing in the charge to affect larger firms first; grading the charge rate based on size; and targeting finance from the Pollution Prevention Fund to smaller firms
- The emission trading option was seen as particularly cost effective and desirable, but would involve considerable changes to existing regulations targeted at each unit. It was suggested that the approach could be extended from large integrated complexes to industrial estates.

17. A new study to supplement the present one will be undertaken, beginning January 1997, to devise realistic water pricing schemes in conjunction with effluent charges.

- MBIs would help to raise the profile of environmental management within firms by putting a financial price on pollution. MBIs make it necessary for companies to develop accounting procedures as part of their environmental management systems, which would enable them to accurately allocate costs (such as pollution charges) and benefits (such as rebates) to the appropriate unit.
- Environmental reporting requirements could need to change. To work effectively, the current environmental statement required of companies would have to become a legal document and be modified to include abatement costs. Disclosure requirements for companies to publish their resource use and emissions would further stimulate action.

4.5 Strengthening Capacities

Alongside the goal of elaborating policy recommendations on MBIs, the second aim of the study was to strengthen the capacity of the Confederation of Indian Industry (CII), Tata Iron and Steel Company (TISCO) and the Steel Authority of India Ltd. (SAIL) to develop appropriate tools and methodologies for formulating and applying market based policy incentives for pollution control and resource conservation as a complement to regulatory mechanisms. In doing so, these organisations would be better equipped both to undertake research on the economic analysis of pollution prevention and resource use, and to participate in public policy discussions. Alongside this goal was the objective of building up real world experience within IIED and UNIDO of the application of the economic approach to MBIs to specific industrial sector in the developing world.

The *modus operandi* for this capacity strengthening dimension of the project was one of extensive research collaboration between international (IIED and UNIDO) researchers and Indian counterparts (CII, TISCO and SAIL). The project team consisted of seven core members, two of which belonged to the international institutes and five to local industry organisations, with a multi-disciplinary background (economists, engineers and environmental specialists).

This capacity strengthening process took place over a two year period and involved research collaboration at each stage of the project, including during extensive field trips and brainstorming sessions. The multi-disciplinary nature of the study resulted in an effective exchange of knowledge and understanding between economists, engineers and environmental specialists. This has led to changing perceptions on the part of all members. IIED/UNIDO also provided its partners in India with access to international research networks, latest literature on the subject and facilitated participation in international fora, such as the International Society for Ecological Economics (ISEE) Conference in Boston in August, 1996.

In the process, two types of capacity were strengthened during the study:
- At an *institutional* level, the CII now has a methodological framework for understanding economic incentives for pollution prevention, along with a software programme for devising MBIs. The software could be adapted for use by other industries and pollutants without much difficulty.
- At an *individual* level, the project enabled all participants to test their understanding of economic theory and environmental management and to engage in 'learning by doing' about the potential of MBIs in the Indian context.

4.6 Research Follow Up

The study revealed a number of promising areas for research follow-up.
- Extending the existing model to other steel plants operating in India. The abatement cost functions would need to be adapted and modified to account for differences between

integrated steel and other production processes. Such an extension would make the policy outcomes relevant for the steel industry as whole. The extension of the model to other plants in the steel sector is a relatively simple exercise and could be undertaken by policy makers if the decision to introduce MBIs on a wide scale is implemented.

- Applying the model to an industrial sub-sector with a mix of large and small scale enterprises. The environmental problems and treatment solutions of small and medium scale industry are significantly different from those of their larger counterparts to merit special attention. Policy and corporate implications for small industry would also have a different dimension from those discussed in the present report. Applying the model in this case may not be as straightforward, but the basic software and computer model could be suitably modified at a relatively low cost to accommodate other industrial sectors, e.g. the leather tanning industry or the textile dyeing and finishing industry.
- Investigating the possibilities of intra-plant trading for other steel plants and other pollutants. The present study elaborates a policy scenario for intra-plant trading for total suspended solids in TISCO steel plant alone. Such a scheme could only be implemented when there is a switch to mass-based standards monitored at the factory gate. If indeed the Government decides to implement mass-based standards in place of existing concentration-based policies, it would be worthwhile to look at the potential of intra-plant trading for other plants and pollutants. It may also be worth exploring the cost effectiveness of introducing inter-plant permit trading similar to the permit trading system for sulphur dioxide (SOx) in the USA. However, the analytical issues involved in inter-plant trading could become quite complex given the very real possibility of high transactions costs.
- Incorporating resource pricing into the pollution abatement model. For pollution charges to have their desired effect, the price of environmental resources must reflect the true scarcity of the resource. Currently industrial water use is heavily subsidised and the price of water does not reflect the opportunity cost of water or the clean up costs. For industry to conserve and recycle water, pollution charges must be accompanied by a rational pricing structure for water use and by a gradual phasing out of subsidies. This is also crucial for the effective implementation of water conservation and recycling measures by industry.

During 1997, UNIDO, IIED and CII will extend the study to incorporate the water pricing issue, dealing with the cost of water and the associated costs of recycling and reuse. The minimisation of resource cost and abatement costs will give an economic and environmental price of water that reflects the true opportunity cost of water. The considerable amount of data on water use which has already been collected as part of the present study will be used to derive demand functions for industrial water use and, subsequently, a carefully orchestrated system of water prices and effluent charges. The TISCO steel plant has expressed its willingness to update data and provide further information as required

4.7 Developing a Strategy

Introducing market based instruments in India to accelerate the spread of pollution prevention will require a subtle combination of pragmatism and vision. It is likely and desirable that instruments will be introduced on a step by step basis, tailored to the specific circumstances of particular problems of air or water pollution and waste generation. There can be no single plan for an across-the-board introduction of MBIs. But similarly, if India starts to move more in favour of a market-based approach to environmental protection, then a strategic view will be required on the different steps that could be required as part of the phasing-in of MBIs, and the basic principles that should guide action.

Four main phases can be identified - debate; design; implementation; and transition to maturity - and two key principles should guide action: transparency and capacity development.

India is currently in the middle of the *debate* phase. The report on the Government Task Force on Economic Instruments and this report should help to stimulate an informed public discussion on the potential and risks of MBIs. Because MBIs have to be introduced by legislation, they must win not just theoretical acceptance but also political support from the public, industry and the government machinery itself. The introduction of new types of policy tool, such as MBIs, will challenge existing regulatory traditions, and this requires an understanding of the regulatory expectations of different stakeholders. For some, market based instruments fit well with their incentive-based vision of the world, while others see it as almost immoral to allow polluters to pay rather than cut their emissions. In general terms, industry will need to be convinced that MBIs will really provide an incentive for improved performance and that the revenues will not disappear down a 'black hole'. Citizens and NGOs will need to be convinced that their rights to a clean environment will not be compromised by giving companies a 'license to pollute'. Regulators will need to be assured that their environmental policy objectives can really be obtained at least cost with MBIs.

Transparency and accountability are thus basic requirements for the legitimacy of a shift towards MBIs. All interested parties must have access to information on proposed policies, and be extensively consulted prior to any legislative decision: the public hearings being held by the Government's Task Force on MBIs throughout India are an excellent example of this open approach to policy making. Not only does this increase the legitimacy of government action in a formal sense, it also enables government to anticipate potential problems and obstructions at a later debate.

If consensus is eventually reached on the need for MBIs, then government will enter the *design* phase. It is here that specific items of legislation will have to be passed through Parliament to specify the new institutional arrangements that will govern the MBI such as: who and how the rate will be set; the coverage in terms of pollutants (eg all water effluents or just one); the sector-by-sector competitiveness effects of different MBIs; and the phase-in period and whether any companies will receive temporary exemptions. It is here that the regulatory authorities will need to invest in the new capacities needed to manage the MBI, and where business should start examining its response in terms of management systems and investment plans.

The *implementation* phase also requires a similar commitment to transparency and capacity development. Key stakeholders should be included as far as possible in the execution of MBIs (for example, as part of a management panel governing the proposed Pollution Prevention Fund). The performance of MBIs in achieving their goals should also be made public through accessible and regular reports to enable learning from experience and to promote an informed discussion on necessary adjustments to MBI rates and systems.

After a number of years, an MBI can make the *transition to maturity*, whereby it becomes a normal part of the policy tool kit. A review could be carried out on the continuing need for the MBI and whether its basis should be extended to other pollutants in the same environmental media or lessons learned for other environmental problems.

No country has or is likely to have MBIs designed for every environmental problem produced by industrial production. Governments world wide are still experimenting with both the methodology and practice of market based instruments. India's special advantage is that it can learn from the successes and failures of others, but also contribute to world wide progress through a careful and well thought out introduction of MBIs. It also has the advantage of not having made existing commitments to either charges or permits as the preferable route to giving incentives. Indeed, both approaches could be used for different pollutants as the circumstances determine. What India can now do is demonstrate that the economic approach to pollution prevention is as relevant to a fast growing emerging economy as to the industrialised world.

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Annexe 1

Methodology

Annexe 1

Methodology

The model used in this study is based on engineering cost functions. Total abatement cost for a pollutant is the sum of capital cost and operating costs involved in the clean-up operation. For purposes of this study, the data is provided in annualised figures, so no discount factor has been used within the model.

The model derives marginal costs of pollution abatement for different polluting units in TISCO and Bhilai Steel Plant (BSP). Since this model deals with existing clean-up operations, capital cost is a fixed sunk cost, and does not play any part in the marginal cost calculations.

The first step in developing the model was to identify the factors which lead to variability in operating costs. Then, the form of the variability was specified in each case. This specification was developed in consultation with engineers from CII, as well as the engineers in TISCO and BSP who actually operate these plants.

Thus, for example, in the matter of reducing pollution caused by total suspended solids (TSS) in water, it was found that the dependent factor in the cost function was the quantity of chemicals that would have to be used to precipitate the TSS, and this factor would depend upon the quantity of wastewater, plus a ratio of TSS abated : TSS influent, when both are measured in terms of concentration (mg per litre of wastewater). The engineers expected the quantity of chemicals required to vary in the following manner

$$Q_{chem} = \left\{ \left(\frac{Q}{1000} \right) \left(\frac{TSSa}{TSSo} \right) \right\}^{\alpha}$$

Where Q_{chem} = Quantity of chemicals used (kg/day)
Q = Quantity of wastewater (cu.m/day)
TSS_o = Influent concentration of TSS (mg/l)
TSS_a = TSS abated (concentration) (mg/l)
α = Different variable for every facility, calculated through the given data

The value of α was expected to be between 1 and ε (2.71). This could be checked, because α is the only unknown in this equation, and for all pollutants the values of α were as expected. The model results for all pollutants are shown at the end of this explanation.

This first step allowed the calculation of annual operating costs in a clean-up facility for a particular pollutant. In the second step, the operating costs were then plugged into the total abatement cost equation, and the annualised capital cost was added to it to find the total abatement cost in a year.

For example, in the case of TSS abatement, the annual abatement cost was found to be

TAC = CCA + O&M Costs

Where TAC = Total abatement costs in the year

CCA = The annualised capital cost of abatement

The O&M cost, in turn, was found to be dependent on two factors, the cost of chemicals, and the cost of sludge disposal. The equation was

$$O\&M \text{ costs} = 365\ (P_{chem}\, Q_{chem} + P_s S)$$

Where P_s = Price of sludge disposal

S = quantity of sludge disposed

This means the total abatement cost will be

$$TAC = CCA + 365\left[P_{chem}\left\{\left(\frac{Q}{1000}\right)\left(\frac{TSSa}{TSSo}\right)\right\}^{\alpha} + P_s S\right]$$

The total abatement cost was then differentiated with respect to actual abatement in order to find the marginal abatement cost for a particular pollutant in a particular facility. This third step later enabled the model to compare the marginal cost of different facilities in abating one particular pollutant.

The entire model was then fed into a tailor-made software programme. The programme, written in C, allowed iterations of different marginal costs, total abatement costs, levels of total abatement, the total revenue associated with each level, all at different standards and different charges. These iterations were then run again and again to come up with the recommended charges and standards in the report, and the implication of each charge, standard or a combination of the two.

Five pollutants were examined through this model:

1. Total suspended solids (TSS)
2. Cyanide
3. Phenol
4. Ammoniacal Nitrogen and
5. Suspended particulate matter (SPM)

The first four are water-borne pollutants, while the fifth is an air-borne pollutant.

Total Suspended Solids (TSS)

The major assumptions which went into the model specification for TSS were

1. Quantity of chemicals Q_{chem} is independent of influent particle size, but is a direct function of influent concentration TSS_o and influent water quantity Q_i
2. Quantity of sludge removed S_i is a function of quantity of chemicals Q_{chem} and influent concentration TSS_o. Precipitation of heavy metals is ignored except for pickling metal
3. Price of sludge removal P_s is an exogenous variable
4. TSS is a uniformly mixed flow pollutant
5. Variability in abatement costs between plants arises from (i) quantity of chemicals used; (ii) volume of sludge removed; and (iii) quantity of wastewater.
6. Labour costs are included in the respective components of the unit O&M costs
7. The efficiency factor of pollution abatement gives a better measure of cost variability than abatement by itself. This efficiency factor is obtained by dividing the level of pollution abated TSS_a by the influent pollution TSS_o, both in terms of concentration.

Given these assumptions, the set of equations for TSS removal cost is

$$Q_{chem} = \left\{\left(\frac{Q}{1000}\right)\left(\frac{TSSa}{TSSo}\right)\right\}^{\alpha}$$

$$TAC = CCA + 365\left[P_{chem}\left\{\left(\frac{Q}{1000}\right)\left(\frac{TSSa}{TSSo}\right)\right\}^{\alpha} + P_sS\right]$$

$$MC = 365\,P_{chem}\,\alpha\left(\frac{Q}{1000}\right)^{\alpha}\left(\frac{TSSa}{TSSo}\right)^{\alpha-1}$$

Where TAC = Total Abatement Cost (Rs)
CCA = Capital Cost of Abatement (Rs)
Q_{chem} = Quantity of chemicals used (kg/day)
Q = Quantity of wastewater (cu.m/day)
TSS_o = Influent concentration of TSS (mg/l)
TSS_a = TSS abated (concentration) (mg/l)
P[chem] = Cost of chemicals used (Rs/day)
P_s = Price of sludge removal (Rs/tonne)
S = Quantity of sludge removed (tonnes/day)
α = Different variable for every facility, calculated through the given data
MC = Marginal abatement cost (Rs/mg/l)
TA = Total abatement (tonnes)

Cyanide

The major assumptions which went into the model specification for Cyanide were

1. Cyanide is a uniformly mixed flow pollutant
2. Labour costs are included in the respective components of the unit O&M costs
3. Quantity of nutrients is a direct function of influent pollution

Given these assumptions, the set of equations for Cyanide removal cost is

$$Q_{chem} = \left\{\left(\frac{Q}{1000}\right)(CN_a)\right\}^{\alpha}$$

$$TAC = CCA + 365\left[P_{chem}\left\{\left(\frac{Q}{1000}\right)(CN_a)\right\}^{\alpha}\right]$$

$$MC = 365P_{chem}\alpha\left(\frac{Q}{1000}\right)^{\alpha}(CN_a)^{\alpha-1}$$

Where TAC = Total Abatement Cost (Rs)
CCA = Capital Cost of Abatement (Rs)
Q_{chem} = Quantity of chemicals used (kg/day)
Q = Quantity of wastewater (cu.m/day)
CN_o = Influent concentration of Cyanide (mg/l)
CN_a = Cyanide abated (concentration) (mg/l)
P_{chem} = Cost of chemicals used (Rs/day)
α = Different variable for every facility, calculated through the given data
MC = Marginal abatement cost (Rs/mg/l)
TA = Total abatement (tonnes)

Phenol

The major assumptions which went into the model specification for Phenol were

1. Phenol is a uniformly mixed flow pollutant
2. Labour costs are included in the respective components of the unit O&M costs
3. Quantity of nutrients is a direct function of influent pollution

Given these assumptions, the set of equations for Phenol removal cost is

$$Q_{chem} = \left\{\left(\frac{Q}{1000}\right)(PH_a)\right\}^{\alpha}$$

$$TAC = CCA + 365\left[P_{chem}\left\{\left(\frac{Q}{1000}\right)(PH_a)\right\}^{\alpha}\right]$$

$$MC = 365 P_{chem}\, \alpha \left(\frac{Q}{1000}\right)^{\alpha}(PH_a)^{\alpha-1}$$

Where TAC = Total Abatement Cost (Rs)

CCA = Capital Cost of Abatement (Rs)

Q_{chem} = Quantity of chemicals used (kg/day)

Q = Quantity of wastewater (cu.m/day)

PH_u = Influent concentration of Phenol (mg/l)

PH_a = Phenol abated (concentration) (mg/l)

P_{chem} = Cost of chemicals used (Rs/day)

α = Different variable for every facility, calculated through the given data

MC = Marginal abatement cost (Rs/mg/l)

TA = Total abatement (tonnes)

Ammoniacal Nitrogen

The major assumptions which went into the model specification for Ammoniacal Nitrogen were

1. Ammoniacal Nitrogen is a uniformly mixed flow pollutant
2. Labour costs are included in the respective components of the unit O&M costs
3. Quantity of nutrients is a direct function of influent pollution

Given these assumptions, the set of equations for Ammoniacal Nitrogen removal cost is

$$Q_{chem} = \left\{\left(\frac{Q}{1000}\right)(AN_a)\right\}^{\alpha}$$

$$TAC = CCA + 365\left[P_{chem}\left\{\left(\frac{Q}{1000}\right)(AN_a)\right\}^{\alpha}\right]$$

$$MC = 365 P_{chem}\, \alpha \left\{\left(\frac{Q}{1000}\right)^{\alpha}(AN_a)^{\alpha-1}\right.$$

Where TAC = Total Abatement Cost (Rs)
CCA = Capital Cost of Abatement (Rs)
Q_{chem} = Quantity of chemicals used (kg/day)
Q = Quantity of wastewater (cu.m/day)
AN_o = Influent concentration of Ammoniacal Nitrogen (mg/l)
AN_a = Ammoniacal Nitrogen abated (concentration) (mg/l)
P_{chem} = Cost of chemicals used (Rs/day)
α = Different variable for every facility, calculated through the given data
MC = Marginal abatement cost (Rs/mg/l)
TA = Total abatement (tonnes)

Suspended Particulate Matter (SPM)

While looking at this lone air pollutant in the study, the model has considered sinter plants, power plants and refractories. The various techniques for removing SPM that have been considered are

1. Bag Filter (BF)
2. Electrostatic precipitator (ESP)
3. Dust Suppression (DS)
4. DS + BF
5. DS + ESP
6. Venturi Scrubbers

The major assumptions which went into the model specification for SPM were

1. Where DS + BF or DS + ESP, then DS are included in total cost
2. SPM is a uniformly mixed flow pollutant
3. Labour costs are included in the respective components of the unit O&M costs
4. Equipment cleaning cost is relatively negligible
5. Capital cost includes cost of spare parts replacement

Given these assumptions, the set of equations for SPM removal cost is

$$Cash \left\{\left(\frac{V_f}{1000000}\right)(SPM_a)\right\}^{\alpha}$$

$$TAC=CCA+8760 \left\{\left(\frac{V_f}{1000000}\right)(SPM_a)Pe\right\}^{\alpha}$$

$$MC= 8760\alpha \left(\frac{V_f}{1000000}\right)^{\alpha}(SPM_a)^{\alpha-1}$$

Where TAC = Total Abatement Cost (Rs)
CCA = Capital Cost of Abatement (Rs)
C_{ash} = Cost of ash removal (Rs/hr)
Vf = Volume of flue gas (cu.m/day)
SPM_o = Influent concentration of SPM (mg/l)
SPM_a = SPM abated (concentration) (mg/l)
Pe = Cost of electricity (Rs/yr)
α = Different variable for every facility, calculated through the given data
MC = Marginal abatement cost (Rs/mg/l)
TA = Total abatement (tonnes)

Annexe 2

Model results

Annexe 2

Model results

Table A.1 : Implications of existing standard of TSS = 100 mg/l												
Unit	TC (Rs mil)	CC (Rs mil)	Qchem /Day (Kg)	Pchem /Kg (Rs)	Cchem /Day (Rs)	Q (cum/day)	TSSa (mg/l)	TSSn (mg/l)	Ps (Rs)	S/day (tonnes)	MC (Rs/mg/l)	TA/yr (tonnes)
TISCO-Blast Furnace	147.55	130	12	500	6000	240000	1200	1300	33	210	2940	105120
TISCO-SMS	114.07	100	6	500	3000	84000	4000	4100	33	210	497	122640
TISCO-Rolling Mill	125.35	115	6	500	3000	84000	800	900	33	50	2541	24528
BSP-Blast Furnace	74.5	45	3750	2	8250	395892	4500	4600	48	181	1013	650252.6
BSP-SMS	150.8	140	3762	16	9784	136598	3900	4000	112	107	1720	194447.3
BSP-Refractory	11.2	10	175	50	8750	84000	1900	2000	183	12	3484	58254
Total											12195	1155241.86

Table A.2: α of various units : TSS	
Unit	α Value
TISCO-Blast Furnace	1.61
TISCO-SMS	1.82
TISCO-Rolling Mill	1.86
BSP-Blast Furnace	1.50
BSP-SMS	2.25
BSP-Refractory	2.07

Table A.3 : Effluent Charge Policy (which complies with existing standard TSS = 100 mg/l) with a charge of Rs 1100/mg/l					
Unit	TSSa (mg/l)	TSSo (mg/l)	TA (tonnes)	TC (Rs mil)	TR (Rs mil)
TISCO-Blast Furnace	240.04	1300	21027.50	132.69	1.06
TISCO-SMS	10564.97	4100	323921.88	108.93	7.22
TISCO-Rolling Mill	300.95	900	9227.23	115.70	0.55
BSP-Blast Furnace	6576.43	4600	950298.56	53.00	2.28
BSP-SMS	551.70	4000	27506.64	144.64	3.68
BSP-Refractory	648.57	2000	19885.10	11.15	1.38

Table A.4 : Effluent Charge Policy (which complies with tightened standard TSS = 75 mg/l) with a charge of Rs 1100/mg/l					
Unit	TSSa (mg/l)	TSSo (mg/l)	TA (tonnes)	TC (Rs mil)	TR (Rs mil)
TISCO-Blast Furnace	251.00	1300	21987.97	132.70	1.07
TISCO-SMS	10764.44	4100	330037.62	109.06	7.41
TISCO-Rolling Mill	319.71	900	9802.21	115.79	0.56
BSP-Blast Furnace	6706.87	4600	969146.36	53.10	2.40
BSP-SMS	556.11	4000	27726.80	144.65	3.71
BSP-Refractory	662.94	2000	20325.72	11.15	1.39

Table A.5 : TSS - Marginal costs of abatement in compliance with varying levels of effluent standard			
Unit	Standard = 75 mg/l	Standard = 100 mg/l	Standard = 125 mg/l
TISCO-Blast Furnace	2977	2940	2902
TISCO-SMS	189	186	183
TISCO-Rolling Mill	3660	3596	3531
BSP-Blast Furnace	477	472	467
BSP-SMS	2981	2905	2830
BSP-Refractory	2176	2128	2081

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT, TOTAL ABATEMENT COST AND TOTAL REVENUE

Table A.6: TOTAL SUSPENDED SOLIDS (STANDARD : 75mg/l)				
Charge (Rs/mg/ lit)	T A(million tonne)	T A Cost (Rs million)	Total Revenue (Rs million)	TCS(TC+TR) (Rs million)
100	0.032	554.05	1.57	555.62
200	0.086	554.22	2.91	557.13
300	0.158	554.54	3.99	558.52
400	0.249	555.05	4.73	559.78
500	0.357	555.79	5.16	560.95
600	0.484	556.78	6.34	563.12
700	0.628	558.04	7.53	565.57
800	0.789	559.62	8.69	568.31
900	0.967	561.53	9.80	571.32
1000	1.165	563.80	12.84	576.63
1100	1.379	566.45	16.53	582.99
1200	1.610	569.53	20.83	590.36
1300	1.859	573.04	25.77	598.81
1400	2.125	577.02	31.40	608.41
1500	2.408	581.49	37.74	619.22
1600	2.708	586.48	44.83	631.31
1700	3.026	592.01	52.73	644.74
1800	3.361	598.11	61.46	659.57
1900	3.713	604.81	71.06	675.87
2000	4.083	612.13	81.57	693.70

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT , TOTAL ABATEMENT COST AND TOTAL REVENUE ...

Table A.7: TOTAL SUSPENDED SOLIDS(STANDARD : 100mg/l)

Charge (Rs./mg/l)	T.A (million tonne)	T.A Cost (Rs million)	Total Revenue (Rs million)	TCS(TC+TR) (Rs million)
100	0.037	554.05	1.55	555.60
200	0.085	554.21	2.89	557.10
300	0.156	554.53	3.95	558.48
400	0.245	555.04	4.70	559.73
500	0.352	555.76	5.09	560.85
600	0.476	556.73	6.27	562.99
700	0.617	557.97	7.44	565.40
800	0.775	559.51	8.58	568.09
900	0.951	561.38	9.68	571.05
1000	1.143	563.59	12.55	576.15
1100	1.352	566.19	16.17	582.36
1200	1.578	569.19	20.38	589.57
1300	1.821	572.62	25.21	597.83
1400	2.080	576.50	30.71	607.22
1500	2.357	580.87	36.91	617.78
1600	2.650	585.73	43.85	629.59
1700	2.959	591.13	51.57	642.70
1800	3.286	597.08	60.10	657.18
1900	3.629	603.61	69.48	673.09
2000	3.989	610.74	79.75	690.49

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT , TOTAL ABATEMENT COST AND TOTAL REVENUE ...

Table A.8: TOTAL SUSPENDED SOLIDS(STANDARD : 125mg/l)

Charge (Rs./mg/l)	T.A (million tonne)	T.A Cost (Rs million)	Total Revenue (Rs million)	TCS(TC+TR) (Rs million)
100	0.032	554.05	1.54	555.59
200	0.084	554.21	2.86	557.07
300	0.154	554.52	3.92	558.44
400	0.242	555.02	4.66	559.68
500	0.346	555.73	5.04	560.77
600	0.468	556.68	6.19	562.86
700	0.606	557.89	7.34	565.24
800	0.761	559.40	8.48	567.88
900	0.933	561.23	9.56	570.79
1000	1.121	563.40	12.27	575.67
1100	1.325	565.93	15.81	581.74
1200	1.546	568.87	19.93	588.79
1300	1.783	572.21	24.66	596.87
1400	2.036	576.00	30.04	606.04
1500	2.306	580.26	36.10	616.36
1600	2.592	585.01	42.89	627.89
1700	2.894	590.27	50.43	640.70
1800	3.212	596.07	58.77	654.83
1900	3.547	602.43	67.93	670.36
2000	3.897	609.37	77.96	687.34

Table A.9 : Implications of existing standard of Cyanide = 0.2 mg/l

Unit	TC (Rs mil)	CC (Rs mil)	Qchem /Day (Kg)	Pchem /Kg (Rs)	Cchem /Day (Rs)	Q (cum/day)	CNa (mg/l)	CNo (mg/l)	MC (Rs/mg/l)	TA (tonnes)
TISCO-Coke Oven	7.17	3	3300	8	24750	1800	27.8	28	840154	18.3
BSP-Coke Oven	45.90	28.6	66	200	13200	4800	46.8	47	180403	82.8
RSP-Coke Oven	26.44	22	90	40	3600	3240	124.8	125	14364	147.6
Total									1034921	247.85

Table A.10: α of various units : Cyanide

Unit	α Value
TISCO-Coke Oven	2.59
BSP - Coke Oven	1.75
RSP - Coke Oven	1.36

Table A.11: Effluent Charge Policy (which complies with existing standard Cyanide = 0.2 mg/l) with a charge of Rs 18000/mg/l

Unit	CNa (mg/l)	CNo (mg/l)	TA (tonnes)	TC (Rs mil)	TR (Rs mil)
TISCO-Coke Oven	2.46	28	1.62	3.02	0.46
BSP-Coke Oven	2.19	47	3.83	28.62	0.80
RSP-Coke Oven	231.87	125	274.21	25.06	1.93

Table A.12: Effluent Charge Policy (which complies with relaxed standard Cyanide = 0.3 mg/l) with a charge of Rs 19000/mg/l

Unit	CNa (mg/l)	CNo (mg/l)	TA (tonnes)	TC (Rs mil)	TR (Rs mil)
TISCO-Coke Oven	2.54	28	1.67	3.02	0.48
BSP-Coke Oven	2.34	47	4.10	28.63	0.84
RSP-Coke Oven	267.98	125	316.93	25.73	2.72

Table A.13: Cyanide - Marginal costs of abatement in compliance with varying levels of effluent standard

Unit	Standard = 0.1 mg/l	Standard = 0.2 mg/l	Standard = 0.3 mg/l
TISCO-Coke Oven	844950	840154	835367
BSP-Coke Oven	122247	121918	121588
RSP-Coke Oven	8323	8312	8301

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT, TOTAL ABATEMENT COST AND TOTAL REVENUE

Table A.14: CYANIDE (STANDARD = 0.1mg/l)

Charge (Rs/mg / lit)	T A (tonne)	T A Cost (Rs million)	Total Revenue (Rs million)	TCS(TC+TR) (Rs million)
10000	57.64	53.95	1.51	55.45
11000	74.34	54.10	1.50	55.60
12000	93.86	54.28	1.44	55.73
13000	116.40	54.52	1.31	55.84
14000	142.14	54.82	1.11	55.93
15000	171.26	55.17	1.30	56.48
16000	203.94	55.60	1.82	57.43
17000	240.35	56.11	2.45	58.56
18000	280.68	56.71	3.20	59.91
19000	325.08	57.40	4.08	61.48
20000	373.73	58.20	5.11	63.31
21000	426.79	59.12	6.29	65.42
22000	484.43	60.17	7.65	67.83
23000	546.81	61.35	9.20	70.56
24000	614.08	62.69	10.95	73.65
25000	686.41	64.19	12.92	77.12
26000	763.94	65.86	15.13	80.99
27000	846.85	67.71	17.59	85.31
28000	935.27	69.77	20.32	90.09
29000	1029.36	72.04	23.34	95.38

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT , TOTAL ABATEMENT COST AND TOTAL REVENUE

Table A.15: CYANIDE (STANDARD : 0.2mg/l)

Charge (Rs/mg / lit)	T A (tonne)	T A Cost (Rs million)	Total Revenue (Rs million)	TCS(TC+TR) (Rs million)
10000	57.48	53.95	1.51	55.46
11000	74.12	54.09	1.50	55.60
12000	93.58	54.29	1.44	55.73
13000	116.03	54.52	1.31	55.84
14000	141.67	54.82	1.11	55.93
15000	170.68	55.17	1.30	56.47
16000	203.23	55.60	1.82	57.41
17000	239.50	56.11	2.44	58.55
18000	279.66	56.70	3.19	59.89
19000	323.88	57.39	4.06	61.45
20000	372.33	58.19	5.09	63.27
21000	425.16	59.10	6.27	65.37
22000	482.55	60.15	7.62	67.77
23000	544.65	61.33	9.16	70.49
24000	611.62	62.66	10.91	73.56
25000	683.62	64.15	12.87	77.02
26000	760.80	65.81	15.07	80.88
27000	843.32	67.66	17.51	85.17
28000	931.33	69.70	20.23	89.93
29000	1024.97	71.96	23.23	95.19

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT, TOTAL ABATEMENT COST AND TOTAL REVENUE

Table A.16: CYANIDE (STANDARD = 0.3mg/l)

Charge (Rs/mg/l lit)	T A (tonne)	T A Cost (Rs million)	Total Revenue (Rs million)	TCS(TC+TR) (Rs million)
10000	57.32	53.95	1.50	55.45
11000	73.91	54.10	1.50	55.60
12000	93.29	54.29	1.44	55.73
13000	115.66	54.52	1.31	55.84
14000	141.21	54.81	1.11	55.93
15000	170.11	55.17	1.29	56.46
16000	202.53	55.59	1.80	57.40
17000	238.66	56.10	2.43	58.52
18000	278.65	56.69	3.17	59.86
19000	322.69	57.38	4.04	61.42
20000	370.93	58.17	5.06	63.23
21000	423.54	59.08	6.24	65.32
22000	480.67	60.12	7.58	67.70
23000	542.50	61.30	9.12	70.41
24000	609.17	62.62	10.86	73.47
25000	680.84	64.10	12.81	76.91
26000	757.67	65.76	15.00	80.75
27000	839.81	67.60	17.43	85.03
28000	927.40	69.63	20.14	89.77
29000	1020.61	71.88	23.12	95.00

Table A.17: Implications of existing standard of Phenol = 1.0 mg/l

Unit	TC (Rs mil)	CC (Rs mil)	Qchem /Day (Kg)	Pchem/kg (Rs)	Cchem /Day (Rs)	Q (cu.m/day)	PHa (mg/l)	PHo (mg/l)	MC (Rs/mg/l)	TA (tonnes)
TISCO-Coke Oven	32.0	14.75	6500	2	13000	1800	399	400	17128	262.1
BSP-Coke Oven	114.2	62.7	461	73	33561	4800	875	876	17487	1533.0
RSP-Coke Oven	62.2	48.2	344	29	9986	3240	324	325	14893	383.2
Total									49509	2178.3

Table A.18: Effluent Charge Policy (which complies with existing standard Phenol = 1.0 mg/l) with a charge of Rs 16500/mg/l

Unit	PHa (mg/l)	Pho (mg/l)	TA (tonnes)	TC (Rs mil)	TR (Rs mil)
TISCO-Coke Oven	366.53	400	240.81	18.95	0.54
BSP-Coke Oven	692.94	876	1214.02	71.85	3.00
RSP-Coke Oven	444.58	325	525.75	53.74	1.99

Table A.19: Phenol - Marginal costs of abatement (Rs/mg/l) in compliance with varying levels of effluent standard

Unit	Standard = 0.5 mg/l	Standard = 1.0 mg/l	Standard = 1.5 mg/l
TISCO-Coke Oven	17138	17128	17119
BSP-Coke Oven	14385	14380	14376
RSP-Coke Oven	15939	15932	15926

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT , TOTAL ABATEMENT COST AND TOTAL REVENUE

Table A.20: PHENOL (STANDARD : 0.5mg/l)

[illegible] (Rs/mg/lit)	[illegible] (tonne)	[illegible] (Rs million)	[illegible] (Rs million)	[illegible] (Rs million)
10000	353.19	127.93	12.93	140.87
11000	486.54	129.03	13.08	142.13
12000	654.23	130.51	12.72	143.23
13000	861.70	132.47	11.75	144.22
14000	1114.81	134.99	10.04	145.03
15000	1419.82	138.21	7.70	145.91
16000	1783.41	142.26	6.40	148.66
17000	2212.65	147.28	4.49	151.76
18000	2715.04	153.44	7.58	161.01
19000	3298.47	160.92	15.68	176.60
20000	3971.27	169.93	25.74	195.67
21000	4742.16	180.69	38.05	218.74
22000	5620.27	193.45	52.91	246.36
23000	6615.15	208.46	70.65	279.12
24000	7736.75	226.02	91.65	317.68
25000	8995.45	246.44	116.30	362.75
26000	10402.03	270.06	145.02	415.08
27000	11967.68	297.23	178.27	475.50
28000	13704.02	328.34	216.55	544.89
29000	15623.05	363.82	260.37	624.18

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT , TOTAL ABATEMENT COST AND TOTAL REVENUE

Table A.21: PHENOL (STANDARD : 1.0mg/l)

Charge (Rs/mg / lit)	T.A (tonne)	T.A Cost (Rs million)	Total Revenue (Rs million)	TCS(TC+TR) (Rs million)
10000	351.84	127.92	12.92	140.85
11000	484.63	129.02	13.08	142.10
12000	651.59	130.49	12.73	143.22
13000	858.14	132.44	11.77	144.21
14000	1110.10	134.95	10.08	145.02
15000	1413.71	138.15	7.70	145.85
16000	1775.60	142.18	6.40	148.58
17000	2202.81	147.17	4.49	151.66
18000	2702.80	153.30	7.43	160.73
19000	3283.42	160.74	15.49	176.23
20000	3952.93	169.71	25.49	195.20
21000	4720.01	180.41	37.73	218.14
22000	5593.74	193.10	52.50	245.60
23000	6583.62	208.04	70.14	278.18
24000	7699.54	225.50	91.03	316.53
25000	8951.81	245.81	115.53	361.35
26000	10351.14	269.30	144.09	413.39
27000	11908.68	296.32	177.16	473.47
28000	13635.95	327.26	215.21	542.47
29000	15544.89	362.53	258.78	621.32

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT, TOTAL ABATEMENT COST AND TOTAL REVENUE

Table A.22: PHENOL (STANDARD :1.5mg/l)

Charge (Rs/mg / lit)	T.A (tonne)	T.A.Cost (Rs million)	Total Revenue (Rs million)	TCS(TC+TR) (Rs million)
10000	350.54	127.92	12.93	140.84
11000	462.78	129.01	13.08	142.08
12000	649.04	130.47	12.74	143.21
13000	854.72	132.41	11.79	144.20
14000	1105.60	134.91	10.11	145.02
15000	1407.89	138.10	7.70	145.79
16000	1768.19	142.10	6.40	148.50
17000	2193.49	147.07	4.49	151.56
18000	2691.23	153.17	7.29	160.46
19000	3269.21	160.58	15.30	175.88
20000	3935.65	169.50	25.25	194.75
21000	4699.19	180.15	37.42	217.57
22000	5568.86	192.77	52.11	244.88
23000	6554.09	207.63	69.66	277.29
24000	7664.74	225.01	90.43	315.44
25000	8911.06	245.21	114.81	360.02
26000	10303.71	268.58	143.21	411.79
27000	11853.75	295.46	176.10	471.55
28000	13572.66	326.24	213.95	540.19
29000	15472.32	361.33	257.29	618.62

Table A.23: Implications of existing standard of Ammoniacal Nitrogen = 50 mg/l

Unit	TC (Rs mil)	CC (Rs mil)	Qchem /Day (Kg)	Pchem/kg (Rs)	Cchem /Day (Rs)	Q (cu.m/day)	ANa (mg/l)	ANo (mg/l)	MC (Rs/mg/l)	TA (tonnes)
TISCO-Coke Oven	43.00	38.10	6500	6	39650	1800	3200	3250	5530	2102.4
BSP-Coke Oven	58.20	16.70	7700	14	107800	4800	2200	2250	22371	3854.4
RSP-Coke Oven	15.63	13.00	150	16	2400	3240	400	450	2378	473.0
Total									30279	6429.84

Table A.24: α of various units : Ammoniacal Nitrogen

Unit	α Value
TISCO-Coke Oven	1.22
BSP - Coke Oven	1.25
RSP - Coke Oven	1.09

Table A.25: Effluent Charge Policy (which complies with existing standard Ammoniacal Nitrogen = 50 mg/l) with a charge of Rs 3000/mg/l

Unit	ANa (mg/l)	ANo (mg/l)	TA (tonnes)	TC (Rs mil)	TR (Rs mil)
TISCO-Coke Oven	205.57	3250	135.06	38.60	8.98
BSP-Coke Oven	0.73	2250	1.28	16.70	6.60
RSP-Coke Oven	5955.09	450	7042.49	29.45	16.67

Table A.26: Effluent Charge Policy (which complies with tightened standard Ammoniacal Nitrogen = 25 mg/l) with a charge of Rs 2800/mg/l					
[illegible]	(mg/l)	(mg/l)	(tonnes)	(Rs mil)	(Rs mil)
TISCO-Coke Oven	155.71	3250	102.30	38.46	8.59
BSP-Coke Oven	0.56	2250	0.98	16.70	6.23
RSP-Coke Oven	8720.99	450	10313.44	35.68	23.23

Table A.27: Ammoniacal Nitrogen - Marginal costs of abatement (Rs/mg/l) in compliance with varying levels of effluent standard

Unit	Standard = 25 mg/l	Standard = 50 mg/l	Standard = 75 mg/l
TISCO-Coke Oven	5540	5530	5521
BSP-Coke Oven	24623	24575	24526
RSP-Coke Oven	2846	2844	2842

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT , TOTAL ABATEMENT COST AND TOTAL REVENUE

Table A.28: AMMONIACAL NITROGEN(STANDARD : 25mg/l)

Charge (Rs/mg/l)	T.A (tonne)	T.A.Cost (Rs million)	Total Revenue (Rs million)	TCS(TC+TR) (Rs million)
2000	152.23	68.05	11.46	79.52
2100	272.64	68.27	11.81	80.09
2200	482.46	68.66	11.97	80.64
2300	840.65	69.36	12.96	82.32
2400	1439.90	71.56	14.69	85.25
2500	2423.15	72.62	17.31	89.94
2600	4006.87	76.06	21.42	97.48
2700	6513.60	81.71	27.88	109.59
2800	10416.72	90.83	38.05	128.88
2900	16401.18	105.30	53.96	159.27
3000	25445.24	127.93	78.62	206.55
3100	38929.11	162.79	116.42	279.22
3200	58777.96	215.76	173.70	389.47
3300	87648.64	295.24	259.47	554.72
3400	129171.18	413.04	386.46	799.51
3500	188268.81	585.64	972.42	1150.06
3600	271502.81	835.81	841.45	1677.67
3700	387672.05	1194.73	1228.33	2443.07
3800	548340.56	1704.69	1777.38	3482.08
3900	768671.15	2422.60	2550.39	4972.90

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT , TOTAL ABATEMENT COST AND TOTAL REVENUE

Table A.29: AMMONIACAL NITROGEN(STANDARD : 50mg/l)

Charge (Rs/mg / lit)	T A (tonne)	T A Cost (Rs million)	Total Revenue (Rs million)	TCS(TC+TR) (Rs million)
2000	85.19	67.95	11.42	79.37
2100	138.76	68.05	11.89	79.94
2200	224.97	68.21	12.29	80.51
2300	361.78	68.49	12.57	81.06
2400	575.67	68.93	12.88	81.81
2500	905.09	69.63	14.05	83.68
2600	1405.01	70.72	15.64	86.67
2700	2152.95	72.43	17.87	90.30
2800	3256.78	75.02	21.05	96.07
2900	4864.84	78.94	25.62	104.56
3000	7178.82	84.75	32.24	117.00
3100	10470.12	93.29	41.79	135.08
3200	15100.32	105.69	55.48	161.17
3300	21546.76	123.48	74.99	198.47
3400	30434.24	148.74	102.58	251.32
3500	42573.88	184.26	141.25	325.51
3600	59010.72	233.72	195.01	428.73
3700	81081.51	301.98	269.13	571.12
3800	110484.53	395.39	370.48	765.88
3900	149363.47	522.16	508.00	1030.17

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT , TOTAL ABATEMENT COST AND TOTAL REVENUE

Table A.30: AMMONIACAL NITROGEN(STANDARD : 75mg/l)

Charge (Rs/mg / lit)	T A (tonne)	T A Cost (Rs million)	Total Revenue (Rs million)	TCS(TC+TR) (Rs million)
2000	55.38	67.90	11.32	79.23
2100	83.05	67.96	11.83	79.79
2200	124.35	68.04	12.31	80.36
2300	185.48	68.17	12.74	80.91
2400	275.06	68.36	13.10	81.46
2500	404.97	68.64	13.35	82.00
2600	591.37	69.07	13.80	82.87
2700	855.91	69.68	14.86	84.54
2800	1227.38	70.57	16.19	86.77
2900	1743.65	71.85	17.92	89.79
3000	2454.01	73.66	20.21	93.88
3100	3422.08	76.20	23.27	99.48
3200	4729.31	79.73	27.38	107.12
3300	6479.15	84.60	32.92	117.53
3400	8802.00	91.25	40.37	131.62
3500	11861.10	100.26	50.35	150.61
3600	15859.51	112.35	63.66	176.01
3700	21048.23	128.47	81.32	209.79
3800	27735.70	149.79	104.63	254.42
3900	36298.86	177.80	135.19	313.00

Table A.31: Implications of existing standard of SPM = 0.15 mg/l

Unit	IC	CC	Cash/H	VI	SPMn	SPMo	El. Cost	MC	TA
TISCO-Blast Furnace	14.82	8.00	18.2	11250	9.85	10.0	3.69	54	970.72
TISCO-SMS	15.37	9.50	29.9	18500	2.85	3.0	4.50	46	461.87
TISCO-Power Plant	2.00	1.20	10.1	6250	9.85	10.0	0.58	22	539.29
TISCO-Refractory	23.00	16.00	169.9	52500	2.85	3.0	11.50	238	1310.72
TISCO-Sinter Plant	22.80	12.92	16.2	10000	9.85	10.0	5.70	45	862.86
TISCO-Coke Oven	10.00	4.13	40.5	25000	9.85	10.0	0.50	174	2157.15
BSP-SMS	1633.53	422.10	502.0	394014	6.05	6.2	83.90	6462	20881.95
BSP-Refractory	233.75	60.40	91.2	141500	2.85	3.0	15.80	1202	3532.69
Total								8244	30717.24

Table A.32: α Value of various units: SPM

Unit	α-Value
TISCO-Blast Furnace	1.44
TISCO-SMS	1.58
TISCO-Power Plant	1.46
TISCO-Refractory	1.59
TISCO-Sinter Plant	1.44
TISCO-Coke Oven	1.41
BSP-SMS	1.36
BSP-Refractory	1.42

Table A.33: Effluent Charge Policy (which complies with existing standard SPM = 0.15 mg/l) with a charge of Rs 200/mg/l

Unit	SPMa (mg/l)	SPMo (mg/l)	TA (tonnes)	TC (Rs mil)	TR (Rs mil)
TISCO-Blast Furnace	194.40	10.00	19158.47	3.72	36911
TISCO-SMS	35.26	3.00	5714.80	4.50	6483
TISCO-Power Plant	1157.41	10.00	63368.24	0.74	229512
TISCO-Refractory	2.12	3.00	974.19	11.50	146
TISCO-Sinter Plant	280.95	10.00	24611.18	5.74	54220
TISCO-Coke Oven	13.88	10.00	3039.28	0.50	806
BSP-SMS	0.00	6.20	1.50	83.90	1210
BSP-Refractory	0.04	3.00	49.41	15.80	562

Table A.34: SPM - Marginal costs of abatement in compliance with varying levels of effluent standard

Unit	Standard = 0.15 mg/l	Standard = 0.10 mg/l	Standard = 0.05 mg/l
TISCO-Blast Furnace	54	54	54
TISCO-SMS	95	96	96
TISCO-Power Plant	22	22	22
TISCO-Refractory	496	497	499
TISCO-Sinter Plant	45	45	45
TISCO-Coke Oven	174		174
BSP-SMS	7718	7720	7746
BSP-Refractory	2024	2024	2032

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT, TOTAL ABATEMENT COST AND TOTAL REVENUE

Table A.35: SUSPENDED PARTICULATE MATTER(STANDARD : 0.05 mg/l)

Charge (Rs/mg /l)	T A (tonne)	T A Cost (Rs million)	Total Revenue (Rs million)	TCS(TC+TR) (Rs million)
20	816.43	126.17	0.00	126.17
40	3585.93	126.17	0.00	126.17
60	8578.02	126.17	0.01	126.18
80	15967.85	126.18	0.02	126.20
100	25889.36	126.20	0.04	126.23
120	38454.92	126.22	0.06	126.28
140	53760.04	126.24	0.10	126.35
160	71889.27	126.28	0.16	126.44
180	92918.56	126.34	0.23	126.57
200	116917.08	126.40	0.33	126.73
220	143948.46	126.48	0.45	126.93
240	174071.75	126.58	0.59	127.17
260	207342.11	126.70	0.77	127.47
280	243811.39	126.84	0.97	127.82
300	283528.51	127.01	1.21	128.22
320	326539.86	127.20	1.49	128.70
340	372889.58	127.42	1.81	129.24
360	422619.78	127.67	2.18	129.85
380	475770.77	127.96	2.59	130.54
400	532381.20	128.27	3.05	131.32

EFFECT OF CHANGING CHARGE ON TOTAL ABATEMENT, TOTAL ABATEMENT COST AND TOTAL REVENUE

Table A.36: SUSPENDED PARTICULATE MATTER(STANDARD : 0.10 mg/l)

Charge (Rs/mg /l)	T A (tonne)	T A Cost (Rs million)	Total Revenue (Rs million)	TCS(TC+TR) (Rs million)
20	811.44	126.17	0.00	126.17
40	3574.86	126.17	0.00	126.17
60	8565.45	126.18	0.01	126.18
80	15961.74	126.18	0.02	126.20
100	25901.43	126.20	0.04	126.23
120	38498.37	126.22	0.06	126.28
140	53850.49	126.24	0.11	126.35
160	72044.20	126.28	0.16	126.45
180	93157.15	126.34	0.24	126.57
200	117260.08	126.40	0.33	126.73
220	144418.07	126.48	0.45	126.93
240	174691.54	126.58	0.60	127.18
260	208136.94	126.71	0.77	127.48
280	244807.31	126.85	0.98	127.83
300	284752.75	127.01	1.22	128.23
320	328020.74	127.21	1.50	128.71
340	374656.48	127.43	1.82	129.25
360	424703.10	127.68	2.19	129.87
380	478201.86	127.97	2.60	130.57
400	535192.39	128.29	3.07	131.35

Table A.37: Implications of existing standard of TSS = 1.6 kg/tonne of finished steel: the ecoefficiency scenario

Unit	[illegible] (Rs mil)	[illegible] (Rs mil)	[illegible] (Rs)	[illegible] (cu m/day)	[illegible] (kg/t of finished steel)	[illegible] (kg/t of finished steel)	[illegible] (Rs)	[illegible] (tonnes)	[illegible] (Rs/kg/t of finished steel)	[illegible] (tonnes)
TISCO-Blast Furnace	147.55	130	6000	240000	23.09	25.02	33	210	152786	2022.7
TISCO-SMS	114.07	100	3000	84000	9.76	10.00	33	210	203842	299.2
TISCO-Rolling Mill	125.35	115	3000	84000	1.95	2.19	33	50	1041965	59.8
BSP-Blast Furnace	74.5	45	8250	395892	157.64	161.14	48	181	28907	22779.1
BSP-SMS	150.8	140	9784	136598	16.20	16.62	112	107	414088	807.7
BSP-Refractory	11.2	10	8750	84000	3.09	3.25	183	12	2141714	94.7
Total									3983302	26063.23

Table A.38: Effluent Charge Policy (which complies with existing standard TSS = 1.6 kg/t of finished steel) with a charge of Rs 82000/kg/t of finished steel

Unit	TSSa (kg/t of finished steel)	TSSb (kg/t of finished steel)	TA (tonnes)	TC (Rs mil)	TR (Rs mil)
TISCO-Blast Furnace	8.34	25.02	730.33	132.95	1.21
TISCO-SMS	3.20	10.00	98.16	102.67	0.54
TISCO-Rolling Mill	0.10	2.19	3.06	115.61	0.15
BSP-Blast Furnace	1201.82	161.14	173663.64	113.29	85.62
BSP-SMS	2.56	16.62	127.85	144.48	1.12
BSP-Refractory	0.15	3.25	4.52	10.81	0.24

Case studies: Malaysia, Netherlands, Sweden, USA, China

Annexe 3

Annexe 3

Case studies: Malaysia, Netherlands, Sweden, USA, China

I. Case Study: Malaysia's Palm Oil Effluent Charges

Malaysia introduced a combination of effluent charges and standards in 1977, which required palm oil mills to pay discharge fees to obtain a license to discharge waste in public water bodies. The fee varies according to: existing level of pollution, quantity of waste, type of pollutant, and the location of mill. This combined with increasingly stringent emission standards led to drastic reductions of BOD loadings into public water bodies.

In the first year of implementation (1978) a non-mandatory BOD standard was set at 5000mg/litre along with an effluent license fee of US$ 3 per ton of BOD discharged up to the standard. In the next year the standard was made more stringent at 2000mg/l with progressive and mandatory effluent charges, with the objective of inducing firms to install waste treatment facilities. In the event that BOD concentration exceeded the standard, a surcharge of $100 per ton was imposed. In 1984 the effluent standard was made even more stringent at 100 mg/l.

It should be noted that the charge system was not calculated on the basis of economic efficiency but rather on cost effectiveness. The rates were set so that the annual fees collected were at least as much as capital costs for constructing waste treatment facilities. Another point worth noting is that since the charge was levied on the basis of BOD loadings rather than volume, it provided an incentive for firms to dilute effluent without reducing total BOD load. A third and more serious problem with the Malaysian scheme was that it had an implicit incentive for inter media substitution from land to water. While charges and surcharges are also levied on disposal on land, the former is based on volume whereas the latter is based on BOD load above the standard. This results in more discharge into land as compared to water receiving bodies.

Despite these weaknesses, the Malaysian system can provide valuable insights to developing countries and countries in transition on the implementation of pollution charges in support of regulatory standards.

II. Case Study: Incentives for Pollution Prevention?

The Case of the Dutch Water Effluent Charge[1]

The 1969 Surface Water Pollution Act marked a turning point in Dutch environmental policy. Building on a strong tradition of decentralised management through regional water boards, the Act combined a permitting system with a requirement for all dischargers to pay a wastewater levy according to the polluter pays principle. The Surface Water Pollution Charge (SWPC) is a hybrid instrument, and can best be described as "an earmarked charge with potential incentive side effects". The charge is 'earmarked' since the revenue raised is entirely used for water quality management and the rate of the charge is derived from the financial needs of water management programmes. For large companies the charge also provides an 'incentive' since it is based on actual discharges and is set at a rate that makes prevention potentially profitable.

A standard formula is used for assessing how much polluters have to pay, based on a notion of "inhabitant equivalents" (I.E). These are defined as the average daily amount of oxygen consuming material produced by one person. While households pay a fixed rate for domestic effluent, small businesses are charged according to a system of coefficients for different industries order, while large companies (discharging more than 1000 I.E) pay according to the actual load of their effluents[2]. As a general rule, for large companies monitoring is done on a selfreporting basis, and the water boards can take their own samples without notice. In a number of court cases, judges have established a general rule that the costs of monitoring must bear a "reasonable relationship" to the charge payment due.

The rate of the charge has increased substantially since its introduction. Between 1975 and 1994, the charge has risen by 130% in real terms, from Dfl 17.5 /I.E to Dfl 40.5 /I.E. The charge provides 'closed circuit' financing for effluent treatment in the Netherlands, covering the full costs of water quality management in the Netherlands. Currently, the bulk of the revenue (80%) is spent on sewage treatment, with most of the remainder allocated to cover the costs of permit giving and monitoring; just 2.5% is given as pollution prevention subsidies to business, and a further 2.5% for the costs of the charge collection itself. There is no data available on the administrative costs for firms.

The combination of permitting and the charge system has resulted in an 80% reduction in emissions from manufacturing industry between 1975 and 1991; during the same period production levels rose by 117%. Analysis has shown that the charge has been the dominant force driving these reductions: interviews with over 130 large companies found more than half responding that the charge had been the decisive factor in stimulating pollution control investments.

Data on corporate abatement costs appear to confirm the incentive effect: A survey of abatement costs of 72 firms with emissions greater than 3000 I.E found that in 1983, the average abatement costs were Dfl56/I.E., with a variation between Dfl5 and Dfl397; in the same year, the average charge was Dfl 47.5/I.E., only slightly below average abatement costs and above the abatement costs for many sources. Despite this correspondence between charge rates and abatement costs, it is important to stress that the charge rates bear no formal relationship to a measure of either marginal damages or costs.

The Dutch water effluent charge appears to have met many of the criteria for policy effectiveness and efficiency. Experts stress that it is questionable and somewhat artificial to separate the impact of the charge from other policy instruments and the wider institutional context. Companies still have to comply with industrial pollution permits, and are subject to fines of up to USD 1.5 million if these norms are breached (although fines have never reached this level, and the highest have been in the region of USD 50-100,000). The maintenance of the parallel permitting system is seen as essential to regulate location specific pollution problems that the charge cannot respond to. Furthermore, there is

1. The authors would like to thank Mr. Jan Schoot Uiterkamp of the Dutch Institute for Inland Water Management and Waste Water Treatment (RIZA) for his assistance in preparing this case study. The information is taken from a 1995 report by A.F. de Savornin Lohman for the OECD. For more details, see *The Effectiveness and Efficiency of Water Effluent Charge Systems: Case Study of the Netherlands*. The author would also like to thank Carla van Doremalen of Hoogovens for providing information on Hoogovens response to the water charge.

2. Large industries pay according to the following formula: P= Q(COD+4.57N)/136, where P=number of I.E; Q=Effluent Volume (m3 /day); COD=Chemical oxygen demand (mg/l); N=Kjeldahl nitrogen(mg/l). In addition, companies pay according to the level of heavy metals. Thus for state waters, 100g=1 I.E for mercury, cadmium and arsenic, while for copper, lead, nickel and chromium, 1000g=1 I.E. Suspended solids are not included.

evidence that the special characteristics of Dutch water management, based on decentralised, independent water boards, which are governed by representatives from key groups such as farmers, business and local citizens, has played an important part in winning acceptability of the SWPC. This is an important achievement given that the rate has increased considerably over time.

Hoogovens and the surface water pollution charge

Hoogovens Steel operates an integrated iron and steel plant in the Netherlands and has been paying the SWPC since its introduction in 1970. Looking back over its experience, Hoogovens has found that the charge has proved a "good incentive", stimulating a considerable reduction in water pollution. Since 1985, Hoogovens' emissions in terms of "inhabitant equivalents" (I.E.) have fallen by more than half, from 220 000 I.E. to 95 000 I.E, while total crude steel production has expanded by about 15% over the same period.

The amount that the company pays in charges has not fallen in line with pollution, due to the steady increase in the charge rate and the extension of the charge base to other pollutants (such as heavy metals). The charge per inhabitant equivalent has thus almost doubled from Dfl 29.50 in 1986 to Dfl 55 in 1994. As a result, Hoogovens total payments rose to a peak of over Dfl 6 million in 1987, before stabilising at around Dfl 5 million during the early 1990s. For Hoogovens, this currently represents approximately Dfl 0.80 per tonne of crude steel. In addition to the SWPC, the company also pays an annual Dfl 400,000 levy for using fresh ground water and a Dfl 9.5 million charge on fossil fuel consumption.

Since 1987, the steelworks has operated a Safeguarding the Environment project, aiming to integrate care for the environment into all employees' daily work. As part of this overall environmental management system, Hoogovens has established an environmental accounting scheme that assigns environmental costs and charges such as the SWPC to the appropriate units. Business units that perform outstandingly in the field of environmental protection are presented with a special award.

III. Case Study: Incentives for Pollution Prevention? The Case of the Swedish Nitrogen Oxide Charge

Economic instruments have been a part of Swedish environmental policy for two decades. Starting with a charge on scrap cars, the number of economic instruments has grown gradually until a breakthrough in the late 1980s and early 1990s, when a new generation of taxes and charges targeted at air pollution (carbon dioxide, sulphur and nitrogen oxides) were introduced.

The NOX charge was adopted in 1990 and came into force in January 1992, with the aim of reducing emissions through improved efficiencies in energy production and the installation of modern combustion technology. The charge is levied on actual emissions from heat and power producers with a capacity of over 10 MW and production exceeding 50GwH; industrial process burning is excluded. The Ministry of Environment estimated that abatement costs of reducing NOx ranged between SEK 20 to 80 per kilo, and set the charge at SEK 40 per kilo of NOx emitted. According to the Ministry, "the charge may be interpreted as if the State values the damage of one kilo of NOx to at least SEK 40".

To avoid any negative impact on overall competitiveness, the charge is revenue neutral, with all income being refunded back to energy producers. However, to provide an incentive to pollution prevention, revenues are rebated in proportion to their energy production, so that boilers with relatively high NOx emissions per unit of energy generated will lose, while those with lower emissions will receive net income: in 1992, the system redistributed more than 100 million Swedish krone (SEK) between polluters.

Policy makers had estimated that emissions would fall by between 20-25%. In reality, emissions had fallen 35% by the end of 1992, with a further reduction of 25% by the end of 1994. Part of this was due to preemptive action by energy producers once the charge was approved by parliament to reduce emissions. Besides prompting investments in new equipment, the charge has provided an added incentive to minimise emissions. Some energy producers have introduced a bonus system for staff to stimulate emissions' reduction.

In terms of the cost effectiveness of the charge, the costs of measures to reduce NOx emissions have in all known cases been considerably lower than the charge. The Swedish Environmental Protection Agency has calculated that the average cost of NOx reductions has been SEK 10 per kilo. Adding in administrative costs, this means that in 1992 9000 tonnes of NOx were reduced at a cost of SEK 108 million, with net benefits to society of SEK 250 million (see table).

Benefit/Cost 1992	Amount of kilo of NOx reduced (SEK)	Total (SEK)
Environmental benefits	> 40	> 360 million
Cleaning costs	–10	–90 million
Measuring costs	–2	–18 million
Total Net to Society	> 28	> 250 million

The main administrative cost for firms has consisted of investment in and operation of continuous monitoring equipment; this equipment also has to be checked each year by an accredited laboratory.

NOTE: This case study is based on a 1994 report by the Swedish Ministry of the Environment and Natural Resources. For more details, see 'The Swedish Experience – taxes and charges in environmental policy.

IV. Case Study: US Steel Water Bubble, The US Experience with Intra-Plant Trades[3]

What is the steel water bubble?

The US Environmental Protection Agency (EPA) has developed effluent guidelines for twelve subcategories of iron and steel plants. For each subcategory the guidelines specify effluent limitations based on: best practicable technology (BPT), best available technology (BAT), new source performance standards (NSPS). In addition to these the regulation allows affected facilities to adhere to alternative effluent limitations for existing point sources. The latter policy, commonly known as the steel bubble, allows dischargers to make intra-plant trades that offer them the option of reducing pollution loads beyond discharge limits at one or more outfalls and crediting it to other outfalls at the same facility, subject to the following restrictions:

- resultant discharges cannot cause a violation of any applicable state water quality standards;
- each outfall must be assigned specific, fixed effluent limitations for the pollutants governed by the regulation (mainly for ease of administration);
- process wastewaters from coke making and cold forming are not eligible for use in these exchanges;
- the net discharge of traded pollutants must be less than the discharge allowed without the trade. The reduction factor must be approximately 15% for TSS and oil and grease, and 10% for all other pollutants.

NOTE: the outfalls may be internal (leading to further conveyance) or external (into receiving waters). Both should be monitoring points.

3. The contents of this case study are based on an investigation undertaken by Industrial Economics Incorporated for the US Environmental Protection Agency. For more details see "The Use and Impact of Iron and Steel Industry Intra Plant Trades," March 1994, by Industrial Economics Inc.

History

The "steel water bubble" policy of the US Environmental Protection Agency (EPA) was first promulgated in 1982 whereby intra-plant trading was permitted for plants subjected to the Iron and Steel Effluent Guidelines (40 CFR 420) under the Clean Water Act. The main reason for allowing these trades was to make it flexible for facilities to reduce their total pollution control costs while simultaneously achieving better overall pollution control. The actual formulation of intra-plant trading changed several times during the rule making process prior to the final outcome in 1984.

The original rule required that a discharger could qualify for alternative effluent limitations as long as total discharge met certain restrictions including water quality standards, and did not exceed the total mass of each pollutant otherwise allowed under the regulations. The revised rule requires the discharger to meet the same restrictions but achieve a net reduction in the total mass of each traded pollutant. Objections to earlier versions of the regulations were raised mainly by the Natural Resources Defense Council Inc. (NRDC). The NRDC argued that the bubble was inconsistent with the Water Pollution Control Act because the economic savings that result are not a consideration in the EPA's selection of best technologies that are economically achievable. The steel industry and the American Iron and Steel Institute however were very much in favour of the bubble due to the flexibility it provided them in achieving effluent discharge targets. The EPA too was in favour of the bubble since it would lead to a reduction in costs of environmental regulation. Subsequently the legislation was reviewed and the modified version, as outlined above, was negotiated between the EPA and the concerned parties.

How were the permits/alternative effluent limitations determined?

The bubble policy requires the permit issuing authority to determine the "appropriate net reduction amount" in the case of each pollutant (15% for TSS, oil and grease; and 10% for others). This calculation has been done by examining the "historical discharge levels [that] seek to achieve those reductions that are attainable at a facility through good engineering practices, improved operations and supervision of existing treatment systems or other feasible modifications, eg., non process flow segregation or chemical addition, if they can be achieved without requiring significant additional expenditures."[4]

An example of how the reduction for TSS may be calculated by a plant that has five outfalls is illustrated below. Assume that the effluent limitation guidelines (ELG) are as given in column 2 for each outfall (see Table 1). Using intra-plant trading , the discharger may propose to increase the limits at outfalls A, B and E by 300, 400, and 300 respectively i.e. a total of 1000 pounds[5]. In order to do so, the discharger must reduce TSS at outfalls C and D by at least 15% more than this i.e. 1150 pounds (1000 x 1.15 = 1150). Depending on the costs of control the discharger may do this by reducing the limits in C and D by 500 and 650 pounds respectively.

Table 1

Sample Calculation of Permit Limits Using Intra Plant Trading Involving Five Outfalls (pounds of TSS per day)

Outfall	ELG Limits	Limits Using Intra Plant Trading	Actual Increase in Limit	Minimum Required Reduction In Limit	Actual Reduction in Limit	Reduction in Permitted Discharge
A	5,000	5,300	300			
B	3,000	3,400	400			
C	2,000	1,500			500	
D	8,000	7,350			650	
E	1,000	1,300	300			
Total	19,000	18,850	1,000	1,150	1,150	150

4. Federal Register, part VII, US Environmental Protection Agency, 40 CFR Parts 403 and 420, May 1984

5. How the discharger decides to reallocate the limits between the outfalls is dependent on his costs of control at the different outfalls.

The EPA undertook an investigation of the impact of iron and steel industry intra-plant trades for four pollutants: TSS, oil and grease (O&G), lead and zinc. Ten facilities were engaged in these trades. The effluents associated with the outfalls involved in trades came from a number of different production processes: sintering, steel making, vacuum degassing, continuous casting, hot forming, and acid pickling operations. In cases where an outfall contains wastewaters from more than one production process including an effluent from operations that are not eligible for trades (such as cold forming), the effluent was excluded from the trading calculation.

The following paragraphs summarise the results of these investigations and the impact on: industry; environmental quality; and administrative requirements.

What has been the impact on industry?

Evidence from ten steel plants shows that trading provided permit limits that could be met without installing treatment beyond that necessary to achieve the effluent guideline limits. Cost estimates (capital and O&M) were available for seven of the ten facilities. For these cases, the present value of the reduced costs due to trading ranges from $3.2 million to $69.8 million. The present value of total reduced costs for all seven plants is $122.7 million.

Interviews with environmental engineers of the various facilities revealed that while trading had reduced pollution control costs, it had not necessarily resulted in the adoption of more innovative pollution control technologies. Reduction in costs was obtained mainly through improvements in existing technologies and better housekeeping. The fact that new and innovative technologies were not adopted may be due to the fact that alternative effluent limitations were based on administrative or negotiated settlements rather than economic criteria incorporating marginal control costs in the calculation of effluent limits and permit levels.

What was the impact on environmental quality?

The impact of trading on pollutant loads has been positive for all facilities that conducted trades. In general the net reduction in permitted loadings ranged from less than a pound per day for lead and zinc trades to several thousand pounds per day for TSS trades.

Although the trading system resulted in a reduction in total permitted discharges, it is unclear whether the actual reductions were less than those that would have been achieved with the application of standard effluent limitations as prescribed by BAT limits. In fact trades were possible because certain outfalls had already reduced discharges below levels required by the effluent guidelines. This "excess control" was applied as an offset to discharges from other outfalls, making it possible for facilities to forgo installation of extra pollution control systems. However, if one were to consider the longer run, trading may well be more effective than the standard effluent limitations, since plant managers must operate existing treatment systems at full capacities so as to maintain the excess control used to offset the pollution reductions elsewhere.

In terms of maintenance of water quality, there was no violation of water quality standards since the regulation specifically prohibits intra plant trading if it results in such violation.

Administrative Impact on Permit Authorities

The trading scheme did not pose additional administrative or resource burden on the administrative authorities i.e. the EPA. This was because the requirement that specific effluent limitations be set for each outfall involved in trading was no different from the standard permit in terms of its administrative burden.

The only administrative change in intra-plant trading schemes occurred in the permit development stage. Even this was quite minimal. The calculations were relatively easy to follow and the extra time required to do so, in relation to what was necessary to write the standard permit, was marginal.

Lessons Learnt

What implications does the US experience have for developing a bubble policy for the Indian iron and steel industry? Some ideas and implications are outlined below. These should be viewed in the context that, in India permitting systems do not exist, and the existing regulatory system makes use of effluent concentration based standards rather than mass-based standards. In some sense then, the development of a bubble policy for the iron and steel industry begins with a clean slate.

1. Calculation of the alternative effluent limitations and the permits itself should be based on criteria (e.g. marginal cost pricing) that provide incentives to plant managers to use more innovative treatment technologies, resulting in "excess control" beyond that required by the standard guidelines.
2. In the Indian case, there may be a need to develop mass-based standards applicable at the factory gate. In this context the possibility of doing away with effluent limitations (currently concentration based) at each outfall may be investigated.
3. Intra-plant trading provisions should apply to new sources as well as existing ones. If this is not the case then the number of facilities eligible to trade may decline over time as old plants shut down or as the industry employs new equipment. This was found to be a limitation in the US where the policy is applicable only for existing sources.
4. Intra-plant trading will be possible only if there are two or more outfalls for waste water in a single facility.
5. If effluent standards are based on water quality and intra-plant trades are based on negotiated settlements with technological factors as the main criteria, then the use of trades will be limited. If on the other hand, standards and permits are based on economic criteria such as marginal cost principles, the likelihood of greater and effective usage is higher.

V. Case Study: China's Experience with MBIs[6]

China enacted its first trial environmental legislation, the Environmental Protection Law (EPL) in 1979, which depended in large part on central planning and moral persuasion. Since then however, there has been a move towards combining command and control measures with economic incentives as environmental protection instruments. The latter have become especially attractive as China moves towards a market economy . Economic instruments that are in use or being tested include: discharge permits, pollution levies, rewards for environmental achievements, price reform, environmental taxes, and fines. Command and control measures include: ambient air and water quality standards, discharge standards, siting policies, closures, relocation and mergers.

Pollution levies

The EPL of China specifies that 'in cases where the discharge of pollutants exceeds the limit set by the state, a fee shall be charged according to the quantities and concentration of the pollutants released'. For air emissions, fees are based on the multiple by which concentration of pollutant exceeds the discharge standard, where air emissions standards are a mix of concentration and mass-based limits. Similarly for industrial waste water, fees are based on a multiple by which pollution concentration exceeds the standard. In the case of water however, discharge standards are only concentration based. Consequently, firms did not have any incentive to reduce discharges beyond the limit inherent in the standard, even if the marginal cost of control was small. To overcome this, a volume based, industrial waste water discharge fee was introduced in 1993. However a factory is not required to pay

6. The contents of this case study are taken from Florig et al (1995) Environmental Science and Technology, "China Strives to make the Polluter Pay."

both an overstandard fee and a waste water discharge fee. In case of conflict, the overstandard fee supersedes the wastewater discharge fee.

In an amendment to the EPL in 1982, four additional categories of penalties were introduced: enterprises that fail to meet effluent and emission standards for three consecutive years would face an increase of 5% per year on effluent fees.; old facilities that do not operate treatment equipment and facilities built after 1979 that do not meet standards, would be assessed for double fees; firms that delay payments of fees for more than 20 days would face a fine of 0.1% per day; and, penalties for false effluent and emission reporting or interference with government inspections would be mandated.

1982 also saw the introduction of a discharge permit system for large enterprises. Discharge licenses specify both the maximum pollutant concentration and the annual maximum wastewater discharge volume. Criteria for setting limits vary from region to region . Some are based on ambient quality standards and others on emissions status quo or technological capabilities. Large enterprises are required to pay fines for failure to meet permit conditions.

Twenty percent of the revenue collected from the fees and 100% from fines is used to support operations of the environmental protection bureaux (EPBs). Eighty percent of revenue from fees is used to subsidise pollution control projects for enterprises that have paid into the system.

Limitations in Design of Pollution Levies

As designed, therefore the system was a combination of the carrot and the stick. However in reality it turned out that it was more of a funding source for the EPBs rather than an incentive for reducing emissions. This is mainly because the fees are smaller than pollution control costs and are not indexed for inflation. Moreover many state owned enterprises can include fees under overhead costs and get compensation through tax deductions and price increases. Therefore they would rather pay fees than incur pollution control costs which can necessitate significant capital investment.

Introduction of the volume based discharge permit system in 1982 further added to distortions in the system in many regions where firms faced conflicting incentives on account of concentration-based fines on the one hand and mass-based fines for exceeding permit limits on the other. Conflicts have also arisen between pollution levies and the tax system. In addition, inadequate macroeconomic reforms, especially with respect to water pricing have very often negated the incentive effects of pollution levies.

Monitoring and enforcement still are major problems. Compliance is best for new large enterprises. Rural small and medium scale industries feel less pressure to comply.

To address some of these problems, the Chinese National Environmental Protection Agency launched a two year study in 1994 to correct deficiencies in the pollution levy system and propose suitable changes. The study addresses four main areas of concern: designing mass-flow levies based on marginal costs of pollution control; designing a revenue fund from pollution levies including institutional arrangements, technical assessment of loans and priorities for the use of funds; designing an information management system for calculating fees, maintaining billing and receipt records; and, addressing practical issues of implementation such as monitoring and enforcement.

A programme of Collaborative Research in the Economics of Environment and Development (CREED) was established in 1993 as a joint initiative of the International Institute for Environment and Development (IIED), London and the Institute for Environmental Studies (IVM), Vrije Universiteit, Amsterdam.

The ultimate goal of CREED is to enrich the knowledge base and widen the debate on sustainable development by strengthening research capacity in environmental economics and policy analysis in developing countries. This is achieved primarily through collaboration on research projects, information exchange and dissemination involving initially IIED, IVM and counterparts in developing countries.

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